NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE 110

# MAINTENANCE MANAGEMENT SYSTEMS

TRANSPORTATION RESEARCH BOARD
National Research Council

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SYNTHESIS OF HIGHWAY PRACTICE **110**

# MAINTENANCE MANAGEMENT SYSTEMS

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NATIONAL RESEARCH COUNCIL
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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## PREFACE

A vast storehouse of information exists on nearly every subject of concern to the transit industry. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire transit community, the Urban Mass Transportation Administration of the U.S. Department of Transportation has, through the mechanism of the National Cooperative Transit Research & Development Program, authorized the Transportation Research Board to undertake a series of studies to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on measures found to be successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

## FOREWORD

*By Staff*
*Transportation Research Board*

This synthesis report will be of interest to highway administrators, maintenance engineers, and others seeking information on the application of management principles to highway maintenance. Detailed information is presented on benefits, problems, solutions, and special features of maintenance management systems used by highway agencies.

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Administrators, engineers, and researchers are continually faced with problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to the available methods of solving or alleviating the problem. In an effort to correct this situation, NCTRP Project 60-1, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common transit problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCTRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific problems or sets of closely related problems.

Some form of maintenance management is being used by virtually every state highway agency. This report of the Transportation Research Board contains information on elements of current practice such as data collection, planning, budgeting, and measurement of standards; and problems, solutions, and benefits related to systematic processes for managing a highway maintenance program.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of public transportation agencies. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

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# MAINTENANCE MANAGEMENT SYSTEMS


## SUMMARY

Maintenance management systems (MMS) began in the 1950s with research into management of maintenance operations in Connecticut and Iowa. The idea of applying management principles to highway maintenance gained popularity as the systems were better defined and their benefits became obvious. By 1982, 49 states had either adopted or were developing some form of MMS.

Maintenance management is a method of controlling resources to accomplish a predetermined level of service through planning, budgeting, scheduling, reporting, and evaluating. Planning consists of defining maintenance activities; compiling a features inventory; establishing priorities; establishing quality, quantity, or performance standards; and compiling cost data.

Budgeting may be line-item, lump-sum, or program, depending on local laws and regulations. The MMS can provide the basis and support for the maintenance budget. The accounting procedures that go with the budgeting process require much the same information that an MMS does; however, the format and timeliness are different. A better understanding between finance and maintenance personnel of each other's needs is desirable.

An overall work plan is a result of the planning and budgeting activities. This plan becomes the basis for scheduling and organizing the work to be done, with weekly, biweekly, and monthly work schedules based on the annual work plan. Daily work schedules are prepared by local supervisors and include the type of work, size of crew, amount of equipment, and type of materials to be used.

Reporting of data for an MMS can be from the same forms that are used for payroll or from a separate system. Electronic data processing is used by all agencies for reporting and recording data and only a few agencies report problems with the services provided. The information reported provides a means of evaluating overall performance of the maintenance program as well as performance of maintenance crews. However, most agencies have had little success in using their MMS for the latter purpose.

From the responses to a questionnaire for this synthesis, it was apparent that each agency uses some systematic process to manage its maintenance program; most of these could be defined as a maintenance management system. Each system uses some form of electronic data processing to store data. These data are often used by others, especially for accounting and pavement management purposes. Most agencies include physical inventories in their MMS and use MMS data for planning and budgeting. The major problems encountered in implementing an MMS were employee resistance to change and a lack of understanding and thus use of the system at middle man-

agement levels. The major benefits reported include reduced costs, increased productivity, uniform levels of service, and improved quality of maintenance work.

The general concept of managing maintenance in a rational systematic way is well accepted. However, the premise that management systems result in optimum use of personnel and equipment is often not confirmed unless there is constant attention and review of the system. Maintenance management systems appear to be excellent planning and budgeting tools but their operational potential has not been realized. MMS development has centered around responses to administrative needs and any required improvements in this area can be readily made. For operational needs, however, the original goal of improving worker efficiency and reducing costs has not been attained to the degree desired. One problem has been that the standards imposed often were developed without worker input. Standards based on work studies, directly involving workers, give credible results that are more readily accepted. System practices can be best improved by a program of obtaining employee involvement in development or redesign of the elements of management systems.

CHAPTER ONE

# INTRODUCTION

## GENERAL

An evaluation of how maintenace organizations manage work programs will provide all maintenance managers an insight into the state of the art of highway maintenance management systems (MMS). The term "state of the art" applied here means the current level of sophistication in the development of maintenance management. The level at which individuals or groups of administrators use systems or other management techniques is called the "state of the practice." The degree of sophistication in maintenance management practices will vary among agencies and reflects an agency's requirements, resources, and its staff's attitudes on reaching the agency's goals.

Information on current maintenance management practice used in this synthesis came from several sources:

1. maintenance management survey results reported in AASHTO's Maintenance Aid Digest No. 26 (*1*) (see Appendix A);
2. the responses to a survey on maintenance management systems sent to all states, several Canadian provinces, and a few local government agencies in September, 1982 (see Appendix B);
3. a literature search;
4. interviews with state highway maintenance personnel at all levels; and
5. personal experience.

Responses to the September 1982 survey were received from all but two states, from three Canadian provinces, and from five local jurisdictions. All states and three Canadian provinces had responded to AASHTO's 1981 survey.

## BACKGROUND

The reason for diversity in maintenance management practices becomes apparent when MMS practitioners are studied individually. For example, composition of state and local highway organizations is different, therefore the management needs of each are not necessarily constant. Local political climates, public attitudes, environments, and available resources also greatly influence the range of development or use of maintenance management systems.

The way a system is developed and implemented can affect the way it is accepted by maintenance personnel within an organization. Uninterested managers and an uneducated work force will inevitably allow a system developed by others to fail or be misused. On the other hand, progressive administrators will normally foster and encourage the effective use of management systems. The overzealous use of a system, however, can result in too many reports and an unnecessary burden on people in the field who must collect and report the information. This unnecessary burden of collecting useless data is often the reason systems become cumbersome and ineffective.

With few exceptions, transportation agencies have a single maintenance organization that is responsible for facility maintenance. Some organizations form special groups for bridge, traffic control devices, and equipment maintenance.

Many states provide aid to municipalities or counties that perform road or street maintenance operations separately from state highway maintenance. A few states contract with local governments to maintain state roads and highways. For example, Wisconsin's legislature allocates highway funds to each of its counties for the routine maintenance of roads that are considered to be state highways. The department does maintain its traffic control devices with its own forces, however. Michigan has arrangements with 62 of its 83 counties to complete most of its routine maintenance activities. It is common for states to have cooperative agreements with local governments to perform selected maintenance work on routes within a city when there is a mutual advantage. In some cases, the maintenance of all city streets, county roads, and state highways is the responsibility of the state maintenance organization. In addition, there are differences among the states as to how maintenance and construction seals or overlays are classified in agency programs. These differences make a direct comparison among maintenance programs difficult (*2*).

To assume that a common MMS could serve such a diverse community of managers is obviously incorrect. There are, however, several aspects or principles concerning management systems that are similar in all systems. Each aspect is treated differently by each maintenance organization because of the factors controlling its individual climates and is the reason each system is unique.

NCHRP Synthesis 52 on management and selection systems for highway equipment speaks of "The Maintenance Challenge" of the late seventies (*3*). Unquestionably during the first half of this century, highway maintenance was based on intuition and practical considerations rather than factual knowledge and scientific principles. The results of this process were reasonably adequate and most maintenance organizations were satisfied with the status of their management and thus had no real reason to adopt more sophisticated ways (*4*).

The extent of the challenge to maintenance administrators began to be appreciated in the mid to late 1950s. It was then that transportation systems began to grow and become more complicated as the demand for more and better highways became greater.

Vehicle registration has increased at a rapid pace since the 1950s. Inflation, shrinking resources, and other adverse factors have decreased the ability of highway agencies to respond to these demands. As the pressure continues, it becomes apparent that the maintenance challenge of the seventies will reach into the eighties and beyond.

## HISTORY OF MAINTENANCE MANAGEMENT

In June 1950, a series of events began that led to organized MMS development. It started with the Connecticut Maintenance Study, a joint venture of the Bureau of Public Roads (now the Federal Highway Administration) and the Connecticut Highway Commission.

The Bureau of Public Roads (BPR) continued to emphasize management research during the years following the Connecticut study. About 20 small-scale studies were conducted on the field operations of other organizations. The results of these studies were not conclusive but they did serve to verify that the Connecticut study described the situation in other states and that management problems were common to all, varying only in degree.

Development of maintenance management systems received a boost in 1959 when the BPR and the Iowa State Highway Commission joined in a study that was larger in scope than any done before. This study was "designed to produce facts which could be used by management for controlling and improving the economy of maintenance operations. It involved collection of basic data concerning the performance of labor and equipment on field operations, variations in total work-loads, work units, utilization of supervisory personnel, and other aspects of maintenance management" (*4*). The findings of the Iowa study were published in the Highway Research Board's Special Report Number 65 (*5*) published in 1961. Other notable studies, such as the Virginia, Louisiana, and Oklahoma projects, to name a few, added significantly to the store of knowledge about maintenance management.

At its annual meeting in 1967, the Highway Research Board decided to sponsor a maintenance management workshop the following year. The Ohio State University was chosen as the site of the three-day seminar. There were 134 participants, representing all but eight states and two Canadian provinces. The proceedings of the workshop were published in HRB Special Report 100 (*6*).

Another workshop was sponsored by the Group Three Council of HRB with the cooperation of the University of Illinois and the Illinois Division of Highways in August, 1970. The workshop brought together individuals who were participating in maintenance management programs; that is, maintenance managers and system engineers from the public and private sector. The forum provided the place to discuss solutions to problems encountered in implementing and using management reporting systems, maintenance levels of service, performance standards, organizational structures, and training. A summary of these discussions was published in the Highway Research Record Number 347 (*7*).

Maintenance management systems continued to be developed and refined in the next five years. As these systems matured, it became obvious that many legislative bodies were not allocating adequate resources to maintenance. In 1975, a third workshop was held in Las Vegas, Nevada to focus on the interface between maintenance managers and other decision makers in the hope of improving this situation. The proceedings of this session were not published.

Transportation Research Record 781 contains a combination of reports reflecting the experience of participants in a fourth workshop on maintenance management held in Hilton Head, South Carolina in July, 1980. These discussions involved reports from those who were managing mature systems and included presentations on refinements of system components and concepts that were just beginning to attract the attention of maintenance managers and highway administrators.

The idea of applying management principles in highway, local road, and street maintenance continued to gain popularity as maintenance management systems were better defined and their benefits became obvious. Published results of studies by the National Cooperative Highway Research Program (NCHRP), the Federal Highway Administration (FHWA), and others added significantly to the state of the art of maintenance systems.

By 1982, 49 states had either adopted or were developing some form of an MMS. Only one state, Wisconsin, had no plans to organize a formal MMS at the state level because individual counties within the state maintained its highway network.

Local governments were equally concerned about the increasing demands being placed on their limited resources. These demands were the result of high growth rates and urbanization of unincorporated areas.

San Diego County's early approach is perhaps typical of the initial efforts in routine maintenance management. It took the form of scheduling work according to need by local and division-wide specialty crews. Eventually, a more comprehensive cost-accounting program, including maintenance-work reporting codes, was initiated. Work orders were issued for projects previously reported as routine maintenance but which were really betterment works. A total program in six road-maintenance stations began. This program consisted of scheduling work one week in advance and reporting actual man- and equipment-hours used on each scheduled maintenance project. This effort resulted in formal and improved maintenance scheduling, planning, and a cost-accounting process (*8*).

Other countries were also becoming interested in highway maintenance management. In Great Britain, for example, highway authorities had given much thought to improving the management of highway maintenance. County councils had introduced new schemes aimed at greater administrative efficiency. The County Surveyor's Society, which represents the highway engineers of rural authorities in Great Britain, had a committee on highway maintenance. A major step forward was taken in September, 1967 when a joint committee on highway maintenance was formed by local authorities and the Ministry of Transportation to study, among other things, the management of maintenance and all its aspects (*9*).

CHAPTER TWO

# THE ART OF MAINTENANCE MANAGEMENT

## GENERAL

The art of maintenance management has evolved to such an extent that it is safe to say that most, if not all, of the management principles that have been applied to highway maintenance have been tried and proven to be successful. Most technological changes have been considered and their application has been tried in at least one jurisdiction with some success. A consistent, systematic approach to gathering and interpreting maintenance data for use by maintenance managers has been devised and the process is well documented in manuals or other documents by jurisdictions throughout the United States and Canada.

## DEFINITION

Maintenance management can be simply defined as controlling resources to accomplish a predetermined level of service through

- *Planning* of work requirements.
- *Budgeting* to meet work requirements.
- *Scheduling* to achieve budget objectives.
- *Reporting* of accomplishments and resources used.
- *Evaluation* of accomplishments compared to work objectives.

These basic elements of management systems are normally linked together in a sequence illustrated in Figure 1. When all the element activities are completed in this sequence, it can be said that system concepts have been applied and the requirements of the process of performance budgeting have been met.

Some basic features of maintenance management systems have been identified and include

- an inventory and a features referencing system;
- standards;
- a planning, budgeting, and work-control procedure;
- an information gathering and reporting system; and
- a work force.

These features, when properly aligned, form a cycle of planning, doing, and comparing; a premise followed by most effective management systems. Supportive activities, such as data gathering, interpreting, and reporting, coupled with human intuition and experience, are the driving forces that allow the cycle to be completed in an optimum manner. How these features are interconnected is shown by Figure 2.

## SYSTEM COMPONENTS

### Planning

The planning component consists of the total process of examining and selecting the best course of action. Maintenance program planning requires

- specific goals and objectives,
- an estimate of the type and amount of work to meet prescribed levels of service,
- a timetable to do the work,
- an allocation of budgeted resources, and
- a data collection and feedback system.

Planning activities result in a maintenance work plan that becomes the basis of monthly operating plans, daily schedules, and performance evaluations. But several steps need to be taken before planning activities and program development can occur.

*Step 1—Define Maintenance Activities*

Each significant maintenance work activity must be clearly defined to accurately identify the condition to be corrected, the purpose of the work, and the general procedure to follow. A maintenance work activity is simply the name given to the

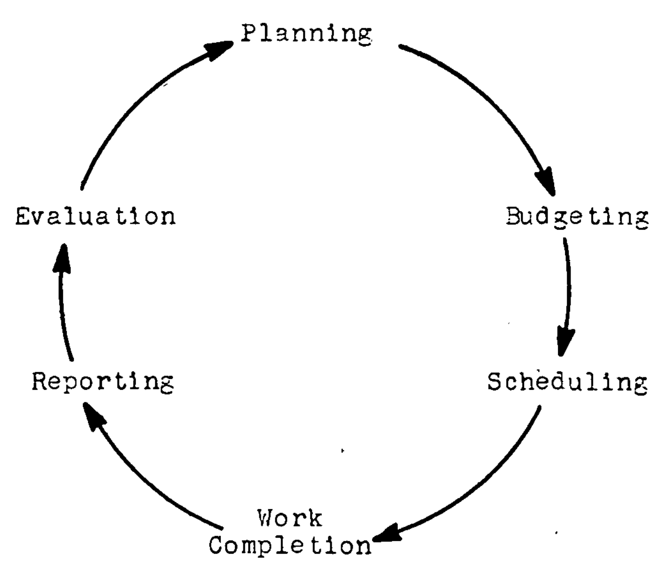



FIGURE 1 Relationship of system activities.

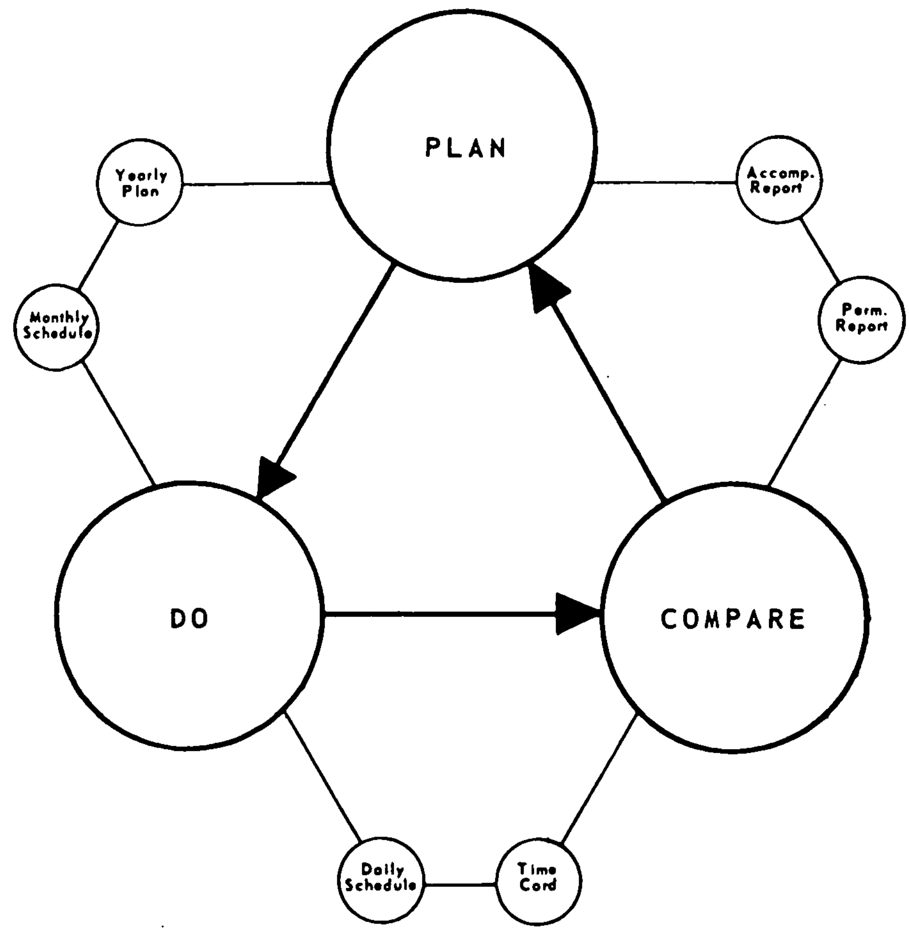



FIGURE 2 Maintenance management cycle.

different types of work performed. Normally, only work that is performed frequently and in significant amounts is identified. An activity should not be defined so broadly as to include numerous alternative objectives; however, it need not be so restrictive as to be limited to one step within a completed operation. Work measurement units for work activities should be easily identified and reasonable. Coding of maintenance work activities usually follows the format associated with the organization's financial recording system (see Appendix C).

*Step 2—Compile a Maintainable-Features Inventory*

Ideally, a maintainable-features inventory will include a count of all maintainable features of a highway system within a specified area. The specified area is usually a control section, route, county, or maintenance area. The record includes at least the features, location, and dimensions and may include its condition.

In some jurisdictions, the inventory, or portions of the inventory, is used to calculate expected work amounts by multiplying the inventory quantity by a quantity standard to determine the number of work units required to provide a predetermined level of service. Table 1 gives typical work unit calculations using inventory values.

*Step 3—Establish Priorities*

Changes in policy, available funds, equipment, or personnel often affect the level of service provided by a maintenance organization. At least four categories or levels of importance are normally assigned to maintenance work activities:

1. Safety of road user
2. Structural integrity of the road structure
3. User convenience
4. Aesthetics

These categories are priorities to be followed when adjustments to established work programs are made.

*Step 4—Establish Standards*

Standard values are necessary if a consistent method is expected to estimate resource requirements of maintenance programs and to evaluate individual or crew performance. When standards are adopted, a tool is created—what is done with them determines the real degree of success of the management system. There are three types of standards used in maintenance management systems:

1. *quality standards* to describe the results to be achieved;
2. *quantity standards* to identify the amount of work and resources necessary to meet the quality standard or a predetermined level of service; and
3. *performance standards* to describe a general method of performing a task, the resources required, and rate at which the work is to be performed.

*Quality Standards* Quality standards provide definite criteria on how each completed maintenance activity should look or act as a result of the maintenance effort. They are considered the representation of an agency's maintenance or level of service policy. They also indicate the threshold or tolerance levels, when reached, when work should be performed. Figure 3 illustrates a form of a quality standard used by one western state and

TABLE 1

TYPICAL WORK UNIT CALCULATIONS USING INVENTORY VALUES

| Activity Description | Roadway Inventory | X | Quantity Standard | = | Work Units |
|---|---|---|---|---|---|
| Pothole Patching | 1000 lane-miles | | 0.5 tons per lane-mile | | 500 tons |
| Mowing | 2,500 mowable acres | | 4 mowings per acre per year | | 10,000 acres |
| Joint Filling | 600 lane-miles | | 12 gallons per lane-mile | | 7,200 gallons |
| Section Patrol | 1000 lane-miles | | 100 times per year | | 100,000 miles |

1.200 FLEXIBLE AND RIGID PAVEMENT MAINTENANCE

The purpose of this standard is to establish the guidelines by which the roadway surfaces of the Interstate and other functional classes of highways shall be maintained and to establish the degree each type of distress can be tolerated before remedial physical maintenance measures must be undertaken.

1.210 FLEXIBLE PAVEMENTS

1. Rutting will be tolerated to the degree specified in Table 1. Where rutting occurs in excess of that specified, the deficiency shall be corrected at the earliest opportunity.

| | Interstate | Principal | Major | Collector | Other |
|---|---|---|---|---|---|
| Maximum allowable depth of rut on multilane or 70 mph highways | 1/2" | 1/2" | 1/2" | 1/2" | 1/2" |
| Maximum allowable depth of rut on two lane 60 mph or under highways | 1/2" | 1/2" | 1/2" | 3/4" | 1" |
| Maximum allowable depth of rut on bituminous treated roadway surface | 1/2" | 3/4" | 3/4" | 1" | 1" |

TABLE 1

FIGURE 3 Typical quality standard.

shows the tolerance limits for rutting of flexible pavements. When these limits are reached, corrective action should be scheduled.

Disclaimers are often included with quality standards because they are often considered to be binding criteria used to establish levels of service and may have legal implications. They are an attempt to recognize that changes in funding, equipment, or personnel will require the occasional adjustment of levels of service provided by the government agency.

There is at least one study that suggests a method of making policy decisions to ensure optimum levels of service on highway elements for a given amount of resources (*10*).

The prime use of quality standards, however, is to act as goals to pursue or guidelines to follow, while completing projects of similar natures. Only 27 of the 53 agencies responding to the AASHTO questionnaire indicated that they had developed quality standards (*1*).

*Quantity Standards* Quantity standards establish work amounts required of maintenance operations to meet quality standards of predetermined levels of service. They may also be used to estimate labor, equipment, and material needs of a maintenance work program. A sample calculation for determining labor needs by using maintenance quantity standards is given in Table 2. An estimate of equipment-hours and material quantities involved in the proposed work program can be calculated in a similar manner.

Quantity standards are a key element in an MMS. They establish measurable goals and objectives of an agency in terms of units of work to be completed and establish attainable levels of service expected from a maintenance work program. If there is a need to change the amount of funds budgeted for maintenance programs, the quantity standards are usually modified to reflect the change. When quantity standards are modified, there is an implied change in overall level of service to the road user. The quality of the product of an operation should remain the same as noted in its performance standard.

In general, quantity standards note the frequency of an operation and are based on accomplishment, experience, or engineering judgment. A standard based on accomplishment is usually expressed as the number of times an operation takes place per year, for example, "five mowings per year per mowable acre."

A quantity standard based on experience can be derived if the extent of past accomplishments is known. For example, if 10,000 tons of asphalt mix are placed annually on 20,000 lane miles of highway according to accomplishment records, the standard is 0.5 tons per lane mile.

$$\frac{10{,}000 \text{ tons}}{20{,}000 \text{ lane miles}} = 0.5 \text{ tons per lane mile}$$

Infrequently, an operation occurs for which there is no adequate record so engineering judgment is followed to establish a suitable standard. These standards are usually modified after production data are collected for a period of time. Quantity standards of most mature systems have been adjusted to reflect actual experience.

Thirty-six of the 53 states and provinces responding to the AASHTO survey reported that they have developed quantity standards. Thirty-four of these use the standards to calculate labor and equipment amounts while two calculate their labor requirements with the standards.

*Performance standards* Performance standards, occasionally called maintenance standards, list the type and number of persons, equipment, and materials necessary to complete a unit of work at an optimum rate or pace by the workers (Figure 4). Practically speaking, the manpower class and equipment type that is available often will not meet the requirements of the standard and therefore a precise application of the standard to each work situation is not always possible. A performance standard is actually a benchmark to measure work activities and helps provide consistent and realistic bases for planning and uniform evaluation of worker performance.

Without standards of performance, wide variations in staffing patterns and work procedures can be expected. When the rate of accomplishment is not predictable, there is no realistic basis for defining resource requirements. Agencies without performance standards, therefore, are dependent on historical production information data without assurance that these data represent the most economical way of doing work. Well-defined performance standards will provide this assurance.

Performance standards identify:

TABLE 2

TYPICAL LABOR CALCULATIONS USING QUANTITY STANDARDS IN THE FORM OF DAILY PRODUCTION RATES

| Activity Description | Work Units | ÷ | Daily Production | = | Crew Days | X | Crew Size | = | Man Days |
|---|---|---|---|---|---|---|---|---|---|
| Pothole Patching | 500 tons | | 5 tons per day | | 100 | | 5 | | 500 |
| Mowing | 10,000 acres | | 17.5 acres per day | | 571 | | 32 | | 1,713 |
| Joint Filling | 7,200 gallons | | 125 gallons per day | | 58 | | 9 | | 522 |
| Section Patrol | 100,000 lane-miles | | 320 lane-miles per day | | 313 | | 1 | | 313 |

| WASHINGTON STATE HIGHWAY COMMISSION<br>DEPARTMENT OF HIGHWAYS<br>MAINTENANCE STANDARD | Operation Number 1122<br>Effective Date March 1, 1976 |
|---|---|

| OPERATION | STANDARD HOURS PER UNIT * |
|---|---|
| MANUAL-PREMIX SPOT PATCH (Hand Spreading and Roller) | 0.95/Ton |

**OPERATION DESCRIPTION**

PURPOSE: To repair road surface failures by hand spreading and compacting with a roller or other available means.

PROCEDURE: Two workers establish traffic control in accordance with the Maintenance Manual and apply a coat of tack. The third worker obtains premix. The workers hand spread and rake the premix. One worker rolls the patched area. At the end of the shift or operation, signs are removed. If needed, one worker obtains more premix during the operation.

QUALITY STANDARD: The edge of the patch should be flush with the surrounding pavement and should not deviate more than 1/4 inch in height from the surrounding surface. If a truck is used for compaction a crown of 1/2 inch should be built into the patch.

* Flagging NOT included

**OPERATION REQUIREMENTS**

| LABOR | | EQUIPMENT | | MATERIAL | |
|---|---|---|---|---|---|
| Number | Skill | Number | Type | Amount | Class |
| 3 | 7109-Maint. Tech. II | 1 | 14-2 Roller | 1.5 Gal. | Liquid Asphalt |
| | | 2 | 6-1 to 6-6 Dump Truck | 1 Ton | Premix (Other materials may be used as directed) |
| | | 1 | 10-5 Trailer | | |

**OPERATION TIME DATA**

| Unit of Measure | Standard Hours | Labor Hours | Units Per Hour | Planning Units |
|---|---|---|---|---|
| Ton | 0.95 | 2.85 | 1.05 | Level<br>1 - Hot Mix<br>2&3 - Cold Mix |

| Prepared By | Date | Approved By | Date |
|---|---|---|---|
| D. J. Schmitt | 10/6/68 | [signature] Asst. Dir. for Maint. | 1/2/76 |

HWY FORM 541-009 REVISED 1/76

FIGURE 4 A performance standard.

- appropriate crew sizes,
- the kinds and numbers of equipment units best suited to complete the work activity,
- the materials to be used,
- the step-by-step method or procedure to do the work in the optimum time and quality level,
- a realistic estimate of the average daily production expected,
- the expected rate of productivity in terms of man-hours or crew-hours per unit of work, and
- scheduling criteria.

The majority of states and provinces that have developed performance standard values have relied on the consensus of experienced maintenance engineers and supervisors. Only a few states have taken the time and effort to complete work measurement studies to establish performance standards.

Some of the work measurement techniques widely used to determine performance standards follow.

*Staffing pattern,* because it measures work performance by gross measure, is the least accurate type of work measurement. For example, the procedure uses ratios of one type of worker to another; i.e., one equipment operator to five laborers.

*Supervisors' estimate,* as a technique, is generally a long and involved process. It requires breaking the total task down into small segments of work that can be clearly visualized and understood by a supervisor. The basic premise of the technique assumes that a more accurate estimate can be made if each of the segments is considered alone. The method offers little in the way of work simplification opportunities and it is difficult to convince other supervisors or field crews that it is a dependable tool.

*Statistical standards* are based on past performance. They are usually expressed as man-hours per unit of work. For example, in one year, 800 tons of asphalt were used in pothole patching requiring 200 man-hours of effort or 0.25 man-hours per ton. If this figure is used as a standard during the following year, management could then conclude that 400 man-hours would be required to lay 1600 tons of asphalt. If the initial performance was only 50 percent of what it should have been, then the estimated man-hours would be in error by 200 man-hours. Statistical standards can tell only what *was* done, not what *should* have been done.

*Work sampling* is done by sampling or observing work elements to determine the percentage of time spent on various types of work. The resulting standard is based on the assumption that the true long-run percentages approximate the sample percentage. The samples or observations may be made at random or constant intervals. Because work sampling requires a longer interval of time, workers tend to relax and follow typically normal work habits and rates. The accuracy of a work sampling study depends on the number and frequency of readings taken. The more samples that are taken, the more accurate the standard will become.

The technique has been used for product quality control, machine operation analysis, and employee work distribution analysis.

*Time-motion study* is the time-honored work measurement approach of industrial engineering. It dates back to Frederick W. Taylor's efforts in the late 1800s. The technique appraises work in terms of time to do each work element measured by direct observation of a worker or workers.

Steps involved in a time-motion study include:

- defining the operation and setting up the study,
- breaking the job into its elements or steps and recording the method,
- recording the times for each of the elements or steps,
- rating or relating performance to standard pace,
- applying allowances, and
- balancing the work load of each worker and computing the standard time.

Method improvements become obvious as the observer times the job and examines the work place. This is particularly true if several individual observations are made of similar activities done by separate crews in various locations. Time-lapse photography and video tapes have been used successfully for time-motion studies.

*Predetermined time standards* is a procedure that requires an analysis of the work to be performed so that it may be separated into its basic motions. Each motion is assigned a predetermined time value and summarized to determine the total time to do the job. Basic times have been developed by several specialists for setting up or evaluating production time activities.

*Standard Data* is a technique that combines time-motion or predetermined time standard results from a number of job classes, which are usually completed by several crews. This produces standard values that cover the full range of work within the job class. The method:

- provides greater consistency of standards,
- provides greater reliability,
- predicts the time for jobs before production starts,
- achieves standards more quickly for a broad range of job categories,
- aids in improving work methods, and
- allows accurate comparisons of alternative job methods.

Organizations establishing standards normally use whichever work measurement technique best suits the requirement of the problem. The choice of standard setting method, therefore, depends on the task to be measured. Proper selection is an important consideration because it has a direct bearing on the time required to develop the standard, the resulting level of accuracy, and the cost of setting the standard.

### *Step 5—Compile Cost Data*

The subject of reliability predicting highway maintenance requirements has been pondered by researchers and maintenance managers for some time. This interest was based on the supposition that a uniform estimating procedure would materially aid highway maintenance management in planning maintenance activities.

Since 1930, the Transportation Research Board has spent much time and money in analyzing maintenance costs and relating the costs to causal factors. In addition, the federal government, most state governments, and numerous local agencies have been continually working to find better methods of estimating maintenance costs (*11*). Several researchers have written reports on maintenance cost determinations and have suggested mathematical models that were designed to predict the yearly maintenance costs of a given mile of roadway section.

The conclusion one can derive from these efforts is that the "development of adequate mathematical models for predicting various categories of maintenance cost requirements creates an extremely useful tool" (*11*) to verify the otherwise intuitive and subjective estimates by individual maintenance engineers. "Although the use of such models will not eliminate the problems of overmaintenance and undermaintenance, estimated maintenance requirements should be more consistent by being correlated to the causal factors that generate maintenance activities" (*11*).

Another author has described models based on demand-response concepts for maintenance planning and policy formulation. His description is based on work conducted in separate projects for the Commonwealth of Massachusetts and the United States Department of Transportation. Components of demand-response approach include:

> (1) numerical measures of maintenance levels of service, or quality standards; (2) quantitative model to predict the condition or deterioration of specific road features as a function of relevant physical, environmental and traffic factors; and (3) quantitative models to assess the impacts of maintenance performance. . .(*12*).

The modeling of simulation approach to determine future maintenance requirements is said to offer a simple, direct means of estimating future budget requirements. Here, too, the extent to which individual jurisidictions use these processes depends mainly on the talents of their managers. These approaches have not been accepted by field personnel who face the variable day-to-day problems of highway maintenance as they do not offer useful tools or devices that can help them make immediate decisions.

Most management systems collect costs for each work activity defined by the system, internally or by periodic surveys of the local marketplace. These are usually described in terms of costs for labor equipment and materials and are often stored in the computer cost-data file.

In 1981, 42 states and provinces reported that their MMS provided a means of determining unit costs for each activity, while 9 reported that their MMS did not. Only 19 systems have the ability to provide unit costs directly while 23 systems obtain cost data through an interface with their fiscal/financial systems. The cost data are available for use by other systems in 25 transportation agencies (*1*).

### Budgeting

Budgeting for governmental programs follows a process established by law, ordinance, or regulation. The process described in AASHTO's "Manual of Uniform Highway Accounting and Financial Management Procedures" (*13*) reflects the generally accepted practices for budgeting and accounting for maintenance activities. The manual suggests that maintenance programs be divided into at least three main program activities:

1. Physical or general maintenance
2. Traffic services
3. Unusual or disaster maintenance

The expected expenditures associated with these activities are further divided into functions for each.

NCHRP Synthesis 80 (*2*) identifies three basic types of state highway maintenance budgets in use today. They are: (a) line item, (b) lump sum, and (c) program.

Line-item budgets list allocated funds by objects of expenditure, activities, or projects. A lump-sum budget lists a single sum for a maintenance program or program activity without regard to where the funds are to be spent. Program budgets, commonly called performance budgets, show the cost of labor, equipment, and material for each maintenance operation. The information is often summarized into categories when considered by budget-approving authorities. Justification for the budget often accompanies the proposal in narrative form. One popular method of providing a credible justification is through a process called "zero-based budgeting."

Maintenance management system elements are the basis (or support) for the budget proposal of most states. A few states have reported that their work plan is used directly in their agency's budget but most jurisdictions must convert their work plan into whatever form is required by law.

Defined in its most general sense, a budget is a plan of operation, combining estimates of expenditures for a given period of time and the proposed means of financing the plan. The budgetary process involves three steps: preparation, adoption, and execution (*14*). Budget formation is usually the responsibility of a chief executive and it is accomplished by correlating financial data (accounting records) to projected program requirements of the various functions and activities performed by government. Regardless of the type of budget system used, it is presented to the governmental unit's legislative body for consideration, possible modification, and final enactment.

The expenditure side of the budget is enacted into law by an appropriation act or ordinance. The appropriations included in the act constitute a maximum authorization to spend during the fiscal year and cannot be exceeded without permission of the legislative body. Financing of appropriations is also the responsibility of legislatures. It begins with the passing of statutes or ordinances, adopting appropriate taxes, levees, or fees to finance the proposed programs.

A mention of the interrelationship of accounting and budgeting practices is proper in any discussion of the budgeting process. Agency budgeting, both in its preparation and execution phase, is dependent on correct and properly classified data from the agency's accounting system. Administrative agencies of government are controlled by legal provisions in constitutions, statutes, charters, appropriations acts, and administrative regulations having the force of law; therefore, managers must be able to determine whether actual financial operations comply with them.

Ordinary governmental accounting reports provide essential financial information to legislative and other governing bodies. The responsible exercise of their legal authorities and responsibilities requires reliable financial information as a basis for

1. program evaluation and budget planning,
2. a means of determining compliance with legal and budgeting restrictions,
3. a means of determining the efficiency of departments and their officers, and
4. a basis for reporting and defending the legislative authorities actions and stewardship to the electorate.

In meeting the diverse and complex informational needs of various groups, governmental accounting uses many of the accounting concepts, conventions, practices, and procedures applicable to private business enterprises (*14*). As in any good business, public officials must account for every public dollar they spend. Ideally, governmental accounting and recording practices should result in records that are timely, complete, and accurate and in a form that officials responsible for the operation of an agency can use for management purposes. Maintenance engineers, however, have found that the financial control system of their organization is generally inadequate for their daily management needs. The lag between actual expenditures and receipt of expenditure information from financial records is usually so great that the data are difficult to reconcile with known expenditures. Maintenance management systems are designed to overcome these shortcomings so that they can be used for timely field management of maintenance expenditures.

There should be no controversy or misunderstanding between engineers and accountants as to the requirements of an accounting system or the purpose of a maintenance management system. An accounting system is designed primarily to account for public fund expenditures; whereas, a maintenance management system has the objective of identifying and controlling a program of maintenance work. The two systems can actually duplicate services if both are used as systems for recording total program expenditures.

Budgeting formats used to comply with the commands of governmental budgeting and accounting are normally different than those used to plan and execute maintenance programs. Initial maintenance planning documents that stress work activity units and unit costs often need to be converted to a budgeting format that can be joined with requests from other departments or divisions to form a consolidated request.

Because maintenance work plans are generally measured representations of maintenance goals, they are important documents and are useful in supporting official budget requests. A maintenance work plan is an expenditure plan followed by engineers as it expresses the official agency maintenance budget in terms of work units and is more applicable to their daily needs. The difficulty in reconciling the differences between the two systems, particularly when the information collected by both may come from separate sources, still remains a concern of maintenance engineers and other public officials. To ease that concern, agency executives should foster and encourage better understanding between financial and maintenance staff personnel of each other's needs and concerns.

#### Work Programming

Programming the use of operating resources is clearly an extension of the planning element of maintenance management systems. It is best completed after the budgeting process is over because many of the uncertainties of funding and manpower controls are removed.

Work planning is an integral part of the budgeting process and can take several forms. Performance budgets usually associate work activities and their amounts to costs; i.e., "the budget." Normal agency budgeting processes, however, usually require the extension of these costs in more detail and to categories common to all department programs, as shown in the agency's Chart of Accounts, which are usually different from the activities identified in the agency's yearly maintenance work plan.

When a proposed expenditure plan is approved by a legislative authority and funds are appropriated to do the work, an operating plan is usually established. Normally the work plan or expenditure plan, which is the basis of the legislative appropriation, is adjusted to reflect the most current maintenance needs or the administrative changes made during the final budget approval phase.

Past work accomplishments provide an excellent base upon which to build a work program. The State of Washington, for example, uses the average of the past four years' accomplishments as the basis for determining the type and amount of the work activities for its next annual work plan. Adjustments may be made to the initial computer printed plan at the discretion of the local maintenance engineer but he or she must be prepared to justify any major deviation from previous experience. Changes are also allowed to account for additions or deletions to the highway system in the local area. The adjusted work quantities are converted into labor, equipment, and material units and their costs are automatically determined through data processing from stored cost data. If total funding and manpower ceilings are exceeded, or not met, another round of adjustments is made. The end result is a practical and attainable yearly work plan.

There are, of course, other ways to program resources for budgeting and work control purposes. California, for example, utilized information generated from its MMS along with the cooperative input from the Division of Maintenance and the Division of Budget Development and Administration. The Division of Maintenance provides data concerning the physical inventory of maintainable items, identifies maintenance deficiencies and recommends the level of service for various maintenance activities. The Division of Budget Development and Administration provides resource estimates for the highway maintenance budget proposal. The two divisions jointly prepare the documentation to justify the number of Person Years (PYs) involved in the 19 categories of activities contained in the Caltrans maintenance budget. The joint recommendation is presented to a Budget Review Committee, which is the final decision-making body within the department (*1*).

In Pennsylvania a legislative act sets into motion the mechanism by which motor license funds are apportioned to the 67 counties there. Budgeting, therefore, is no longer a part of Pennsylvania's MMS; it has become primarily a planning, monitoring, and control system (*15*).

The mechanics of preparing an operating maintenance work program involves all levels of management and is subject to so many external pressures and internal interpretations that a universal strategy is not possible. Each plan or program must be tailored to meet local conditions.

#### Work Scheduling

Work scheduling begins the execution phase of the budget process. The first step normally taken by field force managers is to update their annual work plan to account for unforeseen events that make the initial plan impractical. In most states, the updating process is the combined responsibility of the field or district organization and a central office. Effective scheduling or organizing requires a thorough understanding by all levels of management so that each knows what the tasks are and how they interrelate with the goals of the agency. Annual plans document these goals and become the basis for future evaluation of the maintenance program.

It has been argued that it is extremely difficult to plan precisely over a long period of time and execute a plan completely because of the many unforeseen factors involved in maintenance work. System developers all have recognized this concern and encourage flexibility in work scheduling. An annual plan *is* necessary to ensure that monthly plans, daily work schedules, and performance evaluations are aligned with the objectives of the agency's maintenance program, however.

Long-term projections, which at first glance may seem to be more difficult to make than for the short term, are found to be actually easier to make and are more reliable because

1. maintenance work performed daily is immediately affected by weather changes and emergencies. In the long term, the influence of these changes is less and they become easier to predict;
2. the bulk of maintenance activities consists of innumerable work variations, but each can be identified by several basic categories that are similar in scope (e.g., patching, mowing, ditching, etc.);
3. much of routine maintenance work is seasonal in nature and must be performed within a given period of time. Snow and ice control activities occur during the winter months, bituminous surface treatment in the summer, and pesticide treatments in the spring and fall; and
4. basic work requirements are easily identified from past experience and work records.

#### Short-Term Scheduling

Short-term scheduling is usually the responsibility of a local supervisor. It is the method by which the annual plan is translated into action. Daily work schedules take into account (a) the type of work needed to be performed immediately; (b) the size of crews, the amount of equipment, and the type of materials readily available; and (c) the work expected to be completed for that time of year.

Scheduling occurs at the time closest to the moment when work will be completed so that it is effective in reducing delays caused by unnecessary travel, shortage of material, or lack of equipment. Short-term schedules are most affected by unexpected weather changes or local emergencies; therefore, an alternative is developed to allow crews to revert to a new schedule at a moment's notice.

Weekly, biweekly, and monthly work schedules normally emphasize the goals set forth in the annual work plan. A realistic plan will allow for the unexpected but, in a more general sense, the annual work plan is the medium used to anticipate work that can be completed by available manpower and equipment.

Second-level supervisors prepare work orders for crew leaders or first echelon managers. Work assignments of individual crews are made in a variety of ways. One common way is to issue work authorizations in the form of crew-day cards (Figure 5). These cards authorize the performance of certain maintenance activities associated with the approval maintenance work program.

One crew-day is defined as representing one 8-hour day of any activity with a standard-size crew, a standard equipment complement, standard materials, and standard work methods. The card, when used by a foreman to schedule the daily activities of the crews, is posted in crew work areas. The procedure usually allows each foreman to respond to unforeseen events by issuing special crew-day cards to cover these contingencies.

Other agencies allow the discretionary scheduling of daily work so that immediate needs are met. This method is based on the idea that it fosters better crew initiative and motivation than a formal approach. Supervisors are expected to work toward the goals authorized in the annual work plan and monthly or weekly work schedules, however.

#### Performance Evaluation

The evaluation of individual crew performance is a major element of effective work-control processes. Work performance can be judged by either of two methods: (a) compare the amount of work accomplished with the amount of work planned, or (b) compare the time recorded to do work to a performance or production standard.

The two methods are interrelated but often serve different purposes. The first provides useful information to agency administrators who are interested in tracking the overall performance of agency programs. The second provides information on how well individuals or crews are performing their daily tasks and are meeting predetermined quality levels. Either method identifies areas where special emphasis may be needed or work methods modified. It is in the latter case, however, where managers can improve levels of service without increasing costs.

Performance or production standards are the "benchmark" or point of reference used in the evaluation process. Whenever crews deviate from the methods proposed by standards, their performances are usually found to be less or greater than expected. If less, managers are expected to investigate the problem and perhaps change the crews' work habits or provide training. If performance is found to be greater than standard, the standard was probably ill prepared, a new method or more effective equipment was used, or quality levels were sacrificed. If necessary, the standard should be amended so that it is more realistic and includes the better procedure.

The majority of the states responding to the synthesis survey indicated little or no success with the use of performance standards when they were used to evaluate worker performance. No reason was suggested for this phenomenon, but it seems likely that it was caused by the lack of faith or understanding of the standard, accented by the natural human resistance to any process that suggests change or criticism of an existing practice.

#### Data Reporting and Recording

NCHRP Synthesis 46 (*16*) describes two types of recording systems: (a) a single system, which uses a single document to record payroll and MMS data; and (b) a parallel system, which uses different source documents for payroll and MMS reporting.

The survey made for this synthesis revealed little to indicate that any state uses other processes to report maintenance data. All but 2 of 53 states and provinces canvassed in 1981 use electronic data (EDP) processing methods to accumulate, record, and translate maintenance data.

HM-701 UNL
JAN. 73

**ALABAMA HIGHWAY DEPARTMENT**
**MAINTENANCE CREW DAY CARD**

| ACTIVITY NO. | ACTIVITY NAME | | RD. CLASS | CREW SIZE |
|---|---|---|---|---|
| 601 | SPOT PREMIX PATCHING | | OSH | 5 |
| MGMT. UNIT | MANAGEMENT UNIT NAME | PLANNED | REMAIN | MONTH |
| 0101 | LAUDERDALE | 30 | 6 | JUL |
| ASSIGNED TO: | | COUNTY | | DATE |
| | | | | / /72-3 |

LOCATION AND SPECIAL INSTRUCTIONS:

| LABOR | | | EQUIPMENT | | | |
|---|---|---|---|---|---|---|
| R.T. | EMPLOYEE | O.T. | EQUIP. NO | DESCRIPTION | CODE | USAGE |
| | | | | FLAT TRUCK | 000025 | |
| | | | | | | |
| | | | | DUMP TRUCK | 001025 | |
| | | | | | | |
| | | | | HOT POT | 001118 | |
| | | | | | | |
| | | | | PORTABLE ROLLER | 002120 | |
| | | | | | | |
| | CONVICTS | | | | | |
| | TOTAL HOURS | | | | | |

MATERIALS

| CODE | DESCRIPTION | AMOUNT | UNIT |
|---|---|---|---|
| 000365 | LIQUID ASPHALT | | GALLON |
| | | | |
| 000366 | BITUMIN PREMIX | | TON |
| | | | |

| SIGNATURE | DAILY ACCOMPLISHMENT | AMOUNT | UNIT |
|---|---|---|---|
| | | | TON MIX |

FIGURE 5 Typical crew-day card.

Problems identified with the use of data processing are related primarily to the timeliness and accuracy of the data and the methods by which the data are processed.

Data processing systems can, if properly designed and programmed, process large amounts of data efficiently into usable information. It is evident that a clear understanding of the objectives of data processing and the management system it supports is necessary if the EDP is to be developed properly and accurately evaluated. Without this understanding, data processing systems can be developed under the misconception that they will always produce useful information. Seldom will an EDP designer or manager know, in advance, what specific information or degree of detail will be needed for each of the wide range of problems that confront managers. Information produced by EDP should highlight areas that need management attention, establish trends, show the limitations within which a manager can take a decisive action, and be the medium for statistical communication.

Experience has shown that the lack of timeliness and accuracy blamed on EDP is actually caused by the lack of dedication to the manual procedures required to accompany the computer operation, rather than being the direct fault of the computer operation itself (*17*).

The majority of the states using data processing services profess little or no difficulty with the adequacy of the service provided. This may be explained by the fact that most states have departmental control over their EDP services or that the manager tolerates the service provided. Some common complaints did surface, however:

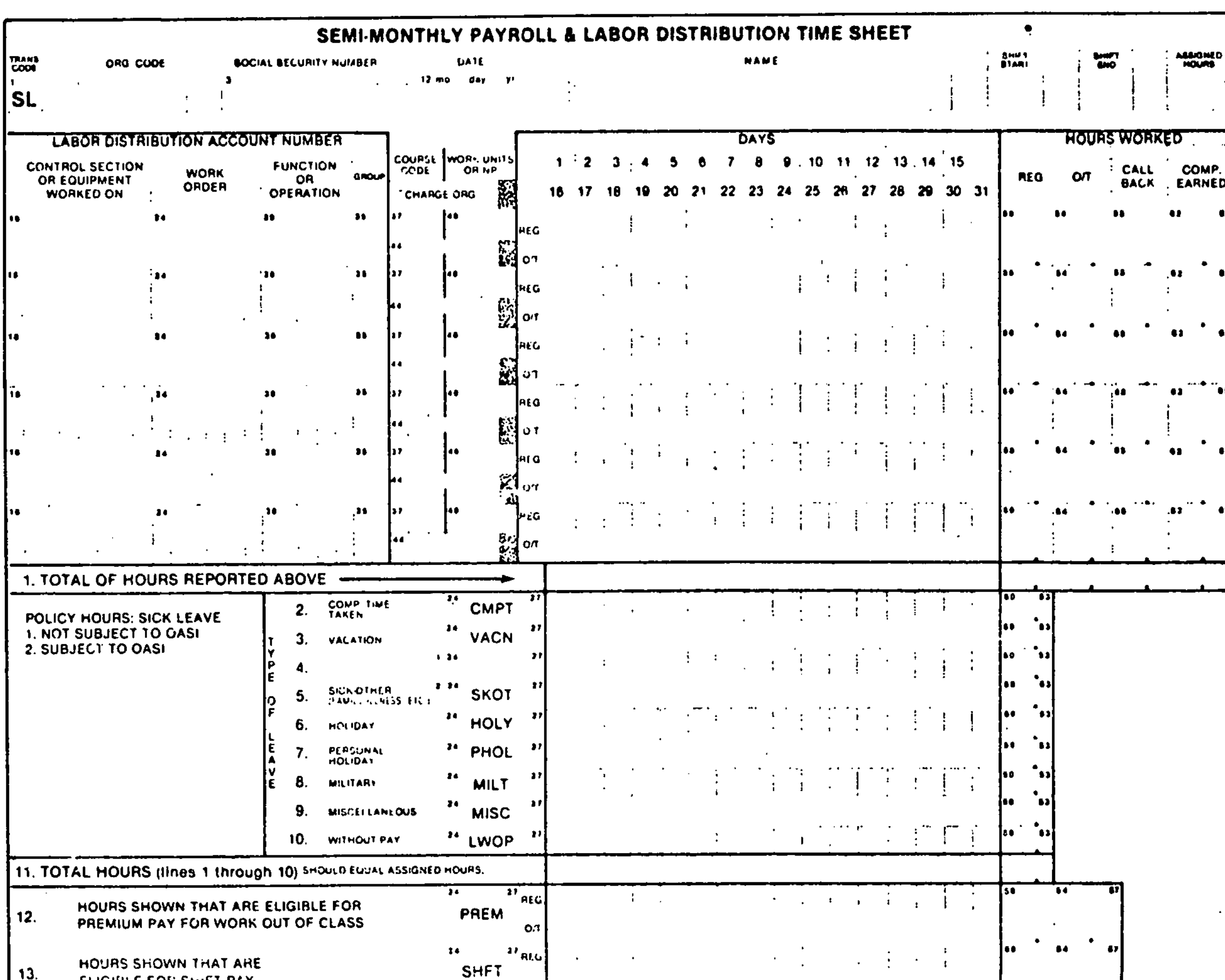
- The hardware is old and outdated
- Lack of priority in receiving services
- Lack of personnel to update programs
- Data input processes are cumbersome
- Excessive paper work

Standard data processing steps have been identified (*17*). They are

1. Data capturing—the recording of data in permanent and reusable form.
2. Date collection—the gathering of individual data items in processible groups.
3. Data conversion—the transfer of data from human readable to computer readable form.
4. Data purification—the correction and improvement of data incorrectly recorded or converted, or the regeneration of lost data.
5. Data transmission—the sending of data to a computer site for processing. (This step may be separate or a part of the data collection operation.)
6. Processing of data into information.
7. Information display and transmission.

The make-up of the maintenance and data processing organizations has a major impact on the procedures that are selected for each of the data processing steps. All the data processing steps are interrelated, so that a method selected for one may determine the one employed by another.

Improvements in the timing and accuracy of reports can be made if these steps are reviewed periodically and modified to include the latest techniques and software in data processing.


SEMI-MONTHLY PAYROLL & LABOR DISTRIBUTION TIME SHEET

TRANS CODE | ORG CODE | SOCIAL SECURITY NUMBER | DATE (mo day yr) | NAME | SHIFT START | SHIFT END | ASSIGNED HOURS

SL

LABOR DISTRIBUTION ACCOUNT NUMBER: CONTROL SECTION OR EQUIPMENT WORKED ON | WORK ORDER | FUNCTION OR OPERATION | GROUP | COURSE CODE | WORK UNITS OR NP | CHARGE ORG

DAYS: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 / 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

HOURS WORKED: REG | O/T | CALL BACK | COMP. EARNED

REG / OT

1. TOTAL OF HOURS REPORTED ABOVE

POLICY HOURS: SICK LEAVE
1. NOT SUBJECT TO OASI
2. SUBJECT TO OASI

TYPE OF LEAVE

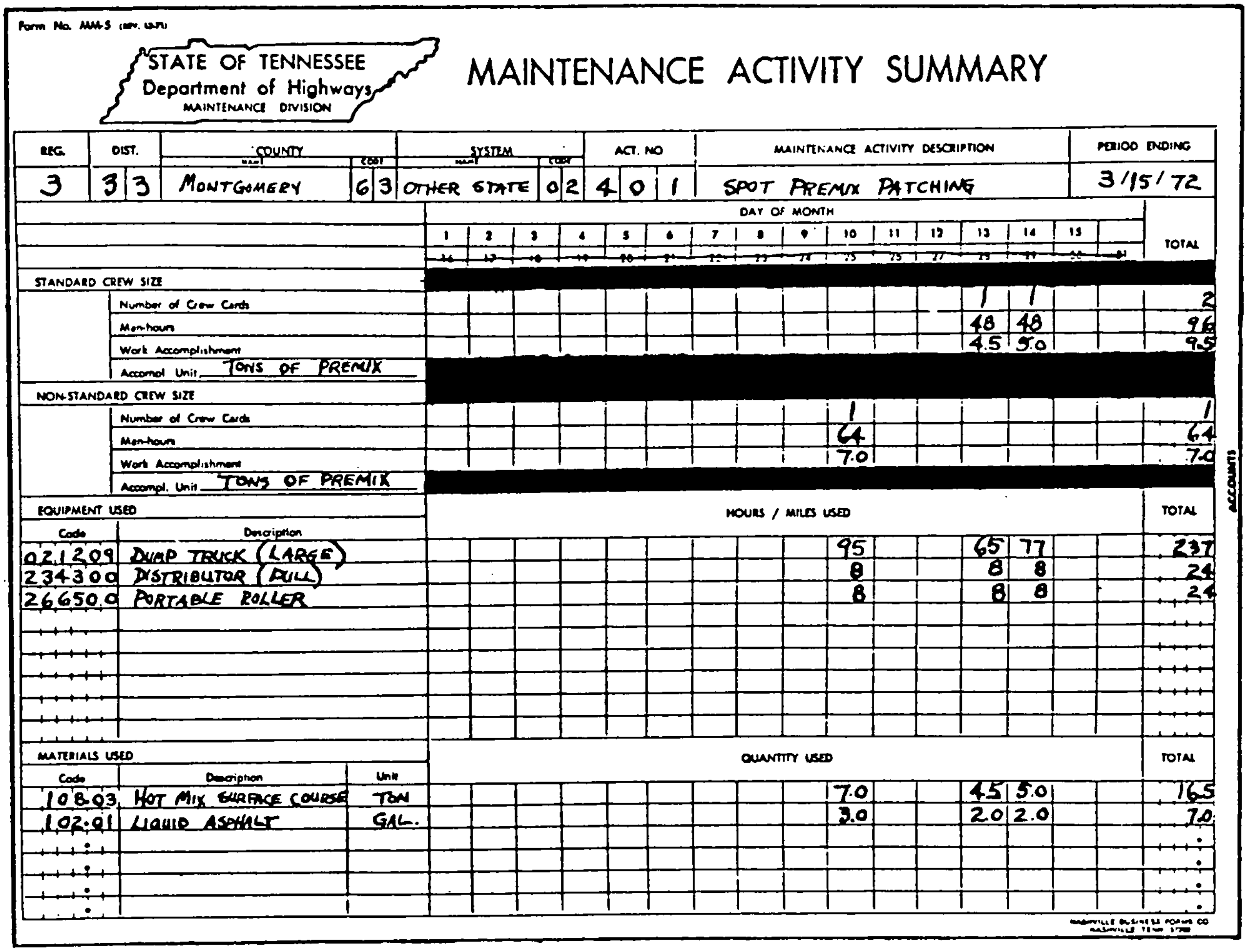
2. COMP TIME TAKEN — CMPT
3. VACATION — VACN
4.
5. SICK-OTHER — SKOT
6. HOLIDAY — HOLY
7. PERSONAL HOLIDAY — PHOL
8. MILITARY — MILT
9. MISCELLANEOUS — MISC
10. WITHOUT PAY — LWOP

11. TOTAL HOURS (lines 1 through 10) SHOULD EQUAL ASSIGNED HOURS.

12. HOURS SHOWN THAT ARE ELIGIBLE FOR PREMIUM PAY FOR WORK OUT OF CLASS — PREM — REG / OT

13. HOURS SHOWN THAT ARE ELIGIBLE FOR SHIFT PAY — SHFT — REG / OT

FIGURE 6 Time sheet for single reporting system.



Form No. MM-5 (REV. 12-71)

STATE OF TENNESSEE
Department of Highways
MAINTENANCE DIVISION

# MAINTENANCE ACTIVITY SUMMARY

| REG. | DIST. | COUNTY NAME | COUNTY CODE | SYSTEM NAME | SYSTEM CODE | ACT. NO | MAINTENANCE ACTIVITY DESCRIPTION | PERIOD ENDING |
|---|---|---|---|---|---|---|---|---|
| 3 | 3 3 | MONTGOMERY | 6 3 | OTHER STATE | 0 2 | 4 0 1 | SPOT PREMIX PATCHING | 3/15/72 |

DAY OF MONTH

| | 10 | 13 | 14 | TOTAL |
|---|---|---|---|---|
| **STANDARD CREW SIZE** | | | | |
| Number of Crew Cards | | 1 | 1 | 2 |
| Man-hours | | 48 | 48 | 96 |
| Work Accomplishment | | 4.5 | 5.0 | 9.5 |
| Accompl. Unit: TONS OF PREMIX | | | | |
| **NON-STANDARD CREW SIZE** | | | | |
| Number of Crew Cards | 1 | | | 1 |
| Man-hours | 64 | | | 64 |
| Work Accomplishment | 7.0 | | | 7.0 |
| Accompl. Unit: TONS OF PREMIX | | | | |

EQUIPMENT USED — HOURS / MILES USED

| Code | Description | 10 | 13 | 14 | TOTAL |
|---|---|---|---|---|---|
| 021209 | DUMP TRUCK (LARGE) | 95 | 65 | 77 | 237 |
| 234300 | DISTRIBUTOR (PULL) | 8 | 8 | 8 | 24 |
| 26650.0 | PORTABLE ROLLER | 8 | 8 | 8 | 24 |

MATERIALS USED — QUANTITY USED

| Code | Description | Unit | 10 | 13 | 14 | TOTAL |
|---|---|---|---|---|---|---|
| 108.03 | HOT MIX SURFACE COURSE | TON | 7.0 | 4.5 | 5.0 | 16.5 |
| 102.01 | LIQUID ASPHALT | GAL. | 3.0 | 2.0 | 2.0 | 7.0 |

ACCOUNTS

FIGURE 7 Typical activity report for parallel system.

Maintenance management system reports generated by computers fall into several categories:

- Fiscal information
- Work accomplishment data
- Crew performance
- Personnel use
- Material use
- Other (physical features inventory, parts inventory, equipment use, etc.)

Reporting of data begins with the individual worker but its coordination is usually the direct responsibility of a crew supervisor.

A single reporting system normally uses one document to report payroll and management system data. Figure 6 illustrates this type of form.

A parallel reporting system uses a separate document to report payroll information and a maintenance activity report to record maintenance data (see Figure 7).

Very few states or provinces have actually considered the cost of collecting data and distributing information. Illinois was the only state to report a cost study in the 1982 survey. They determined that it will cost about $1.5 million per year to collect data for their new system. They justify the cost by determining that it will assist in managing a $125 million operation, including the cost of managing 2,500 full-time employees and an $85 million equipment inventory.

Several considerations limit the amount of data that should be routinely collected for the purpose of managing maintenance: (a) the amount of time managers have to review data, (b) the data recorders' abilities, and (c) the value of data for planning and control.

There is a real direct cost associated with collecting and analyzing management data. Data processing systems have reduced this cost somewhat so that indirect costs have begun to play a significant role.

One of these indirect costs relates to reduced staff motivation. As field managers' paper work becomes excessive or unrealistic, the desire to do a conscientious job is hampered. This deterrent can also be reflected in a loss of interest in using standard crew sizes and work methods and can result in a deterioration of the effectiveness of an MMS.

Similarly, when middle managers begin to question the credibility of highly detailed and presumably accurate reports they receive, an indirect cost occurs. When this happens, the intended purpose of the reports are no longer served. Managers then short-circuit the system and generate their own reports to satisfy the key management requirements (*18*). This action then diminishes the value of the original system even though its cost remains.

Several states have recognized the need to evaluate their original management system goals and have initiated a variety of actions to change or reaffirm them. Experience has shown that the average data processing system or management information system needs an overhaul about every five to seven years. In that short period of time, circumstances or changing needs occur and there is a need for major modifications or, perhaps, a complete redesign.

CHAPTER THREE

# THE PRACTICE OF MAINTENANCE MANAGEMENT

## FINDINGS

The findings of this synthesis are based on information published in the June 1982 issue of AASHTO's Maintenance Aid Digest, MAD-26 (Appendix B) and on responses to a questionnaire specially designed for this synthesis. The synthesis questionnaire was sent to all the 50 states, Guam, Puerto Rico, five Canadian provinces, and several local governments. Responses were received from all but two states, from three Canadian provinces, and from five local jurisdictions. All states and three Canadian provinces had responded to the AASHTO survey for MAD-26.

A compendium of each agency's maintenance management system was prepared based on responses to the synthesis questionnaire and on information in MAD-26. A common outline was followed for reporting the data. An example of the information contained in the compendiums is given in Appendix D. Because of the length of these compendiums, they have not been published in this synthesis; however, they are available from TRB. See Appendix D for ordering information.

In a very broad sense, each responding agency uses some type of process involving electronic data processing (EDP) to help manage its maintenance affairs. The varied nature of the replies made it difficult to decide whether an agency's handling of affairs could be defined as a maintenance management system. The synthesis followed the assumption that any method that constitutes a systematic approach to planning, executing, and evaluating a maintenance work program was a management system.

## SYSTEMS OUTLINE

### Development

Of the 53 agencies responding to AASHTO's survey, 41 reported that their system was five years old or older. Thirty-one systems were developed by a consultant or by department staff with the help of a consultant. Most of the older systems were developed with the aid of consulting firms whereas the newer systems were generally developed by in-house teams who often copied existing systems or relied on the experience of their neighbors.

### Modifications

The basic principles of maintenance management have changed very little. Major procedural changes that have occurred in some of the mature systems generally reflect an updating of data processing hardware and software or advancements in other technology.

### Elements

The emphasis on the use of the elements common to all vary throughout the group. Table 3 lists the common elements and the number of systems that use them.

### Assessments

The utility of each system varies, but most agencies reported that the planning and budgeting aspects of their system are the most valuable. None of the responders reported that a continued record has been kept of the cost of operating the system or that costs have been compared to measurable benefits. Washington made a study early in 1972 and documented an improvement in worker performance that resulted in about $1.7 million savings. These savings were redirected into other programs or used to perform lower priority maintenance work that increased the maintenance service levels. No comparison of operating costs to these savings was made.

TABLE 3

COMMON MAINTENANCE MANAGEMENT ELEMENTS

| Element | Users |
|---|---|
| Planning | 51 |
| Budgeting | 47 |
| Programming Resources | 36 |
| Scheduling Work | 46 |
| Directing Work | 33 |
| Performance Evaluation | 43 |
| Other | 11 |

## DATA COLLECTION

### Data Processing

A computer is universally used by agencies to store financial and other data. These data are translated into information that is periodically reported on hard copy. Although most EDP support systems provide satisfactory service, there are several adverse factors that influence the service. These include

1. capacity of the computer,
2. priorities set by others,
3. service provided by others,
4. availability of trained data processing personnel,
5. number of terminals, and
6. administrative attitudes.

Data are usually updated on a semimonthly basis in most of the systems and turnaround reports issued monthly. This frequency is considered to be adequate in most cases but an earlier turnaround is desirable.

### Type of Data Collected

Table 4 lists several types of data commonly collected by maintenance management systems.

### Reporting Data

A "single" reporting system is one in which maintenance management information, payroll, and other accounting data are reported on one document. A "parallel" reporting system uses separate documents to collect this information (*16*). About half of the responding agencies use a single reporting system with some special reporting for equipment or materials expenditures. The detail of the reporting varies but there appears to be a trend for organizations to report in increasing detail, particularly in those states that are developing pavement management and other management systems.

The responsibility for completing forms and reporting field data usually falls on field supervisors. When payroll documents are used to report MMS data, individual workers are often required to report each activity, the location, and hours worked each day. This information is verified by a field supervisor or clerk before entering the data processing cycle. The accuracy of the information reported to field managers is considered satisfactory, in most cases. The spectrum of data verification is broad, varying from manual field checks to sophisticated system edits. When the MMS data are used mainly to evaluate work accomplishments and performance, the level of accuracy need

TABLE 4

TYPE OF DATA COLLECTED

| Type | Number of Agencies |
|---|---|
| Type and amount of work accomplished | 49 |
| Funds expended for labor, equipment, and material | 50 |
| Hours used by labor | 50 |
| Hours used by equipment | 45 |
| Material used by type and amount[a] | 38 |
| Equipment types or classes used | 43 |
| Personnel classifications used | 22 |
| Other[b] | 5 |

[a]Three collected data on the amounts used in terms of dollars spent.

[b]Location by mileposts or efficiency information.

not be as high as when the data are also used for the organization's accounting records.

Regardless of how, by whom, when, or why management data are reported, the problem of obtaining consistently accurate and timely data is universal. Constant attention and training of personnel is identified as needed to minimize this "human problem."

### Use of Data

Data collected through maintenance management systems are often used by others. Twenty-three organizations use MMS data for at least a portion of their pavement management system. Thirty-eight agencies incorporate the information into their accounting system.

A majority of the responders consider their accounting record as a part of their MMS but they all are concerned that financial information is not reported in a usable form and in a timely manner. Many of them do not completely rely on the reports as a management tool.

Although not clearly defined by the survey, it seems that most organizations' accounting records show actual expenditures by "objects of expenditure" rather than by unit work activities. It is, therefore, difficult to reconcile accounting reports with maintenance accomplishment data. MMS data are associated with equipment management systems in at least nine of the states having systems. Transportation planning, construction and design management, personnel control systems, and monitoring of maintenance programs are other uses of MMS data.

Of the 53 organizations responding to the AASHTO survey, 19 report their MMS provides a means of directly determining unit costs for each activity of work performed. Twenty-three make this determination through a system interface with accounting records. Only 25 departments claim that cost data are available to aid in determining various rehabilitation or overlay strategies. Five states and two Canadian provinces consider their MMS capable of providing a method of measuring the results of their maintenance effort by rating the condition of their roads and bridges.

## PLANNING / BUDGETING

Physical inventories are a part of the majority of maintenance management systems. Most are updated at least yearly or on a random "as needed" basis. How this information is used in most planning/budgeting processes is unclear, but one can assume that the data are useful for determining budget priorities and the amount and type of work to be accomplished. The results of pavement condition surveys, accident data analysis, and skid surveys often influence maintenance budgets.

The vast majority of agencies follow a similar pattern while developing their maintenance expenditure plan and translating it into a budget request. After budgeting instructions are issued, field personnel are asked for an estimate of their future maintenance needs. This information is usually reviewed and coordinated into a local budget request by district or regional officers before submitting the proposal to the central office for final processing. After a favorable review by the agency chief executive, it is then submitted to the jurisdiction's budget officer before final consideration by budget-approving authorities. The presentation and justification for the proposed agency budget is normally the responsibility of the agency head.

One distinct aspect of the planning and budgeting process followed by most states emerged in the synthesis. It is evident that the budgeting format required by most states' executive branch and legislature follows a prescribed convention. With very few exceptions, the official state or provincial budget lists the dollar amounts expected to be spent on each governmental program by objects of expenditure, in accordance with the state, province, or local jurisdiction's legal requirements.

Most MMS expenditure plans (yearly maintenance work plan) list the amount and type of work to be done and are extended to include labor- and equipment-hours and material costs for each maintenance work activity. Departmental overhead and other indirect costs are not always identified. This difference is often a cause of misunderstanding or controversy between maintenance and fiscal managers. Because maintenance management and fiscal systems are different, and often have dissimilar goals, it is usually very difficult to reconcile the information gathered and reported by the two separate systems.

## STANDARD MEASURES

Quality standards that establish criteria for undertaking an operation and the desired level of workmanship are used by 27 of the maintenance management systems included in the survey. Sixteen systems do not have quality standards. Quantity standards, which establish work units required of normal maintenance operations to meet quality standards, are used in at least 36 systems. These are either a separate standard that establishes the number of work units and resources needed per mile of roadway or other planning unit, or they are a part of a performance standard that describes the resources needed to complete a standard unit of work. In either case, the amounts of labor, equipment, and materials, and their costs to complete a maintenance activity, are readily calculated and summarized.

Standards are normally developed and reviewed by a standards committee within an organization. A few states have relied on consultants to develop their system's initial standards, but these standards are reviewed and adjusted in-house as experience is gained. Other states have considered the advice of a consultant while forming standards but the standards committee made the final decision on standard values. Several states used time-motion or work sampling techniques as a way to determine standard values, but most relied on available historical data or the experience of committee members for this determination.

Standards are monitored and verified by comparing them to periodic production reports or by special studies. Adjustments are made when work techniques change, when new equipment or material becomes available, or when it is obvious that the standard rates are in error.

A majority of the states and provinces use performance standards as a means to estimate needed resources to do planned maintenance work. Seventeen agencies do not. Most of these same organizations use the standards to evaluate employee or crew performance. Field crews generally seem to accept performance standards when they are used for planning purposes but are skeptical of them when they are used for performance evaluation. Continuous education and training of personnel is necessary if acceptance and proper use of the standards is to be expected.

## SYSTEM PROBLEMS AND SOLUTIONS

The major problem in implementing an MMS is overcoming the natural fear of or resistance to change. Employee involvement in the development of the new system helps reduce the fear or resistance in most cases. Continued encouragement and support of top management is also a necessary component of the process of implementing change.

Some systems seem to lose their effectiveness because of lack of interest or understanding by new executives or operating personnel. Therefore, continued review and training on system objectives are needed if the system is to be kept viable and usable.

System expectations, in some cases, have been too great; managers have become discouraged or become convinced that the data reported through MMS are not accurate and, therefore, not useful. Continued emphasis on accurate and consistent reporting will minimize the concern but executive support is necessary if this effort is to be successful.

Overemphasis on reconciling MMS data with accounting data can lead to MMS failures. Both engineers and accountants should recognize the differences in single-purpose management systems and accounting systems, and use each to complement the other. Training in the aspects of both will help encourage an understanding of the goals and concerns of each system.

## BENEFITS

Top level managers are inclined to weigh benefits by reduced costs, increased productivity, uniform levels of service, and improved quality of maintenance work. They are also impressed by a system's ability to provide information that can be used to answer public and legislative inquiries and to add the important dimension of credibility to their agency's budget request.

Benefits enjoyed by field personnel are less apparent, but no less important. When most systems were implemented, an added work load in paper work and reporting requirements was imposed on field personnel. These requirements have never changed dramatically. Crews are able to work more effectively when system attributes are applied and where information collected through an MMS has led to improved working conditions and procedures. Work improvement studies have resulted in a realignment of work activities and in the purchase of new equipment and tools better suited to do a particular maintenance project. They have also led to a useful balance of work load among crews. This all should result in an improvement in employee morale and motivation.

It has been found that systems do increase awareness of the extent and type of maintenance problems occurring on transportation systems at all levels of management. Communication between crews and supervisors is enhanced because the visibility offered by the scheduling and work control aspects of an MMS help crew members and supervisors anticipate their daily work activity needs. They are, thus, able to properly arrange for the right equipment, tools, and material to complete the job.

A few organizations have used historical MMS data to evaluate their organizational structure or subdivision boundaries and adjust them with the assurance that a more efficient operation will occur.

CHAPTER FOUR

# CONCLUSIONS AND RECOMMENDATIONS

The general concept of managing maintenance in a rational systematic way is well accepted. Most states, provinces, and local governments have developed some formal method to plan and budget for maintenance activities. These plans or budgets are translated into work programs by local managers through a formal or semiformal method of scheduling for work control, but the idealized goals of the plan are seldom met. Allocated dollars and other resources are normally completely expended by maintenance organizations, but there usually is little guarantee that they are used effectively. The premise that management systems result in reorganized work practices that provide uniform and standard methods that optimize the use of manpower and equipment is often not confirmed unless constant attention and review of the system occurs.

Agency executives seem to view their management systems as an excellent program planning and budgeting tool but have little regard for its operational potential. It appears that most workers, who must work directly with a system, feel oppressed and often frustrated by the system's demands. Consequently, midlevel managers either have begun to ignore this element or have abandoned any attempt to systematically control work activities in the field.

Despite these shortcomings, MMS development has made substantial strides forward in giving maintenance organizations information that is useful. Recent increased limitations on resources has caused a ground swell of interest in maintenance activities in both the private and public sector. Questions are being asked and answers demanded about all aspects of maintenance programs. It seems top maintenance managers spend most of their time and energy responding to these stresses. Little time is available to review and improve worker habits and working processes. As a result, there seems to be little done to initiate work improvement programs that will improve worker environment and use available funds more effectively.

Most mature systems need to be revitalized if they are expected to continue to be useful. Any system over five years old should be analyzed and its objectives and processes should be reviewed.

The systematic approach to management has expanded into almost all areas of transportation administration. As a result, a proliferation of management systems, covering areas of maintenance, equipment, pavement, fiscal control, and so on, have been developed. All these systems rely on each other to some degree but may have conflicting goals. Each attempts to optimize its own potential, and in so doing, may detract from or be in competition with another. As a result, most systems' goals are compromised so that they do not reach their own theoretical potential.

Electronic data processing has aided the effort to optimize systems. Its ability to rapidly collect and analyze vast amounts of data and translate it into usable information has given all program managers types of information never before available. The results of this synthesis show that their new capability is beginning to overwhelm individual managers and often works contrary to their expectations. The role of managers is being compromised by a growing belief that the systems are managing people rather than people managing systems. This, coupled with growing demands for maintenance information in a form usable by other systems, adds to a growing skepticism about MMS in general.

There are ways that many of the shortcomings of management practices can be overcome. The success or failure of the effort depends entirely on the attitude and knowledge of the people involved. An analysis of individual maintenance systems leads to the conclusion that there is no individual maintenance system that fulfills all of its expressed objectives. When viewed in total, however, there are elements in individual systems that, if combined with others, will provide a system that is current with the state of the art.

Most states have fine-tuned their planning and budgeting process to meet their unique needs and a large variation in their effectiveness still remains. The successful use of standards to plan for needed resources and to evaluate worker performance varies. The degree of success of the use of standards is influenced by a vast set of variables, from lack of interest to lack of resources.

In the final analysis, the performance of a system can be divided into two categories: administrative and operational.

## ADMINISTRATIVE NEEDS

System evolution has centered around responding to administrative needs. Improvements in this area can be readily made within existing technology although changes or compromises in the goals of maintenance management or other systems may be required.

Systems that feed a common data bank and have the ability to withdraw information in a usable form by individual managers seem to have the most promise.

Technical advances in electronic data processing hardware and software should be considered as they occur and utilized where possible.

## OPERATIONAL NEEDS

The original goal of many management systems was to improve control over worker activities so that they would perform more efficiently and with reduced costs. System emphasis on scheduling and directing work activities has improved this aspect but little overall success has been recorded on improving work methods or data recording procedures. Many in the work force perceive an MMS as a device that controls their activities rather than as a tool to make their work easier. This perception is reinforced when system demands becomes excessive, complicated, and time-consuming. In many cases, their lack of understanding is augmented by the fact that unreasonable standards were imposed without their input. The credibility of these standards are questioned, particularly when they are used to evaluate individual performances.

There is a need to bring the work force more directly into the management and standard-setting process. The first step in accomplishing this act is to provide training in management skills, equipment operation, and material quality control. Relating management system data to these processes will help workers understand their vital role as part of system management.

More emphasis is needed in the area of work-improvement activities. Experience indicates that time spent on analyzing worker performance in actual or job situations often reveals better and easier ways to do things. Too often standards based on consensus or old data perpetuate bad work practices or provide unrealistic bases for performance evaluations. Standards based on work studies, directly involving crews or individual workers, give realistic, credible results and are more readily accepted by other employees.

Most workers realize that there must be an accounting of their activities. Very few employees resent filling out a time card, but employees do question the need to collect payroll or other information in great detail if there seems to be no benefit to them. If their effort provides them usable information, they are more apt to accurately complete detailed reports. An aggressive review by top management of their information needs and elimination or reduction of paper work involved in data processing will pay dividends.

System practices can be best improved by a continuous program of obtaining employee involvement in the development or redesign of individual elements of total management information systems.

Maintenance engineers and staff managers want to manage their maintenance affairs properly and effectively. It is in their agency administration's best interest to support them by allowing the introduction of new management techniques and to ensure that their efforts do not falter because of shortsighted restrictions on their activities or resources. Major changes should be implemented consistently but slowly with maximum regard to the needs of the agencies' employees. As one author explained, systems should not be built, but grown; not delivered, but infused.

Highway maintenance needs will continue to change in the decades to come. However, if they are to be accommodated, management practices must keep pace with them.

Viable management systems will continue to be a key factor in managing the change so that the present high level of public service will continue.

### RESEARCH NEEDS

More research is needed in ways to improve maintenance-worker performance. Investigations of generally accepted ways of doing things usually result in a better balance of work load allowing crews to work together more effectively. Changes in equipment and materials often result in increased performance and improved service to the public.

Enhancement of quality control through research is another promising area for investigation. Value engineering techniques applied to maintenance operations should result in more cost-effective routines and lessen overall maintenance costs.

Major steps will be taken in maintenance management if consistent and accurate ways can be developed to report cost and accomplishment with a minimum of human involvement. The use of the more economical microcomputer and its software should be investigated as a means of providing rapid and timely data to field supervisors independent of the mainframe computer in the central office or elsewhere.

Better ways of ensuring technology exchange between lower echelon managers and workers and middle and upper management is needed. Newsletters and technical bulletins are helpful but seldom printed for or distributed to the right people. Information exchange between agencies is particularly poor and should be enhanced through research.

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# APPENDIX A

## AASHTO MAINTENANCE MANAGEMENT SURVEY (MAD-26)

AASHTO

# MAINTENANCE AID DIGEST

AASHTO Committee on Maintenance

MAD-26 Washington, D.C. June 1982

MAINTENANCE MANAGEMENT SURVEY

A questionnaire was sent to the committee members in 1981 through the Task Force on Maintenance Management headed by Mr. Charles R. Miller of Florida. Information was requested concerning various aspects of the State's maintenance management system (MMS) such as performance standards, computer usage, inventory and reporting, and cost data. All of the States responded along with 3 Canadian provinces.

Of the 50 States reporting, 41 stated that they operate under an MMS. Seven of the nine that do not have a formal system plan to develop one.

Several of the States reported that cost data is collected to aid in determining various rehabilitation or overlay strategies. A separate request for additional information was sent to these States and the results of those responses are included in this publication.

Mr. Miller extends his appreciation to all of the members for their cooperation and wishes to acknowledge the very valuable assistance rendered by those who assisted in the distribution and collection of the questionnaires.

M. C. (Bob) Adams - North Carolina
Frank E. Aldrich - Vermont
H. M. Anrig - Nevada
Edward J. Kehl - Illinois
Ernest J. Kjellson - Connecticut
Gorman S. Pounders - Louisiana
Douglas L. Shaffer - Colorado
Ray Zink - North Dakota

Questions asked the various State highway agencies are answered in the table below. The numbers at the head of each column of the table refer to the question numbers.

EXISTENCE OF AN MMS

1. Does your agency operate under an MMS?
2. If YES, how long?
3. Have you had an MMS and abandoned it?
4. If you have abandoned an MMS, how long a trial period was allowed?
5. What were the major reasons for abandonment?
   a. poor cost/benefit
   b. lack of top management support
   c. inaccurate/untimely reporting
   d. lack of interest
   e. other
6. If your answer to Question 1 was NO, do you have plans to develop one?
7. How was the system developed?

STANDARDS

8. If you currently have an MMS, does your system contain, either separately or in combination:
   a. Quality standards that establish criteria for undertaking an operation and the desired level of workmanship and end results?
   b. Quantity Standards that establish work units required for normal maintenance operations to meet quality standards.
   c. If (b) is YES, do your Standards quantify labor, equipment, or both?
9. How were your Performance Standards derived?
   a. In-house committee
   b. Consultant
   c. Time and motion studies
   d. other
10. How are your Performance Standards verified?
   a. Production/productivity reports
   b. Time and motion studies
   c. other
11. How often are your Performance Sandards reviewed and updated?
   a. Quarterly
   b. Semi-annually
   c. Annually
   d. As needed

COMPUTER USAGE

12. Is a computer used for collecting and disseminating MMS data?
13. Is computer operated in-house (IH) or others? (Specify)
14. How many computer terminals are available for transmitting and reciving MMS data in:
    a. District Offices CRT's_____ other_____
    b. Sub-district Offices CRT's_____ other_____
15. How often do these terminals update MMS data?
    a. Daily
    b. Weekly
    c. Bi-weekly
    d. Semi-monthly
    e. Monthly
    f. Bi-monthly
16. How much turnaround time is involved between data transmitted to the central office and receipt of reports in the field?
    a. 1 - 7 days
    b. 8 - 14 days
    c. 15 - 21 days
    d. 22 - 28 days
    e. More than 29 days
17. In your opinion, how much turnaround time, as described in Question 16, is desirable?

INVENTORY & REPORTING

18. Is an inventory of physical features a part of your MMS?
19. How often is it updated?
    a. Monthly
    b. Quarterly
    c. Yearly
    d. As needed or more than yearly
20. Which of the following are used for maintenance planning/budgeting in your State?
    a. Pavement condition surveys
    b. Accident data
    c. Skid surveys

21. Does your MMS provide a method of measuring the results of your maintenance effort by rating the condition (quality) of your roads and/or bridges?

22. Does your MMS report separately?
    a. Preparatory time
    b. Travel time
    c. Safety setup and flagging
    d. Time lost - weather
    e. Time lost - equipment down

COST DATA

23. Is maintenance cost data collected in such a manner to be useful in planning, designing, and construction?
24. Does your system provide a means of determining unit cost for each activity?
25. If the answer to Question 23 is YES, does your MMS provide data:
    a. Directly
    b. By interface with Fiscal/Financial System
26. Is cost data available to aid in determining various rehabilitation or overlay strategies?

SYSTEM SIZE

27. What is the size of the system maintained by your State forces?
    a. Centerline miles
    b. Lane miles
    c. Maintenance field personnel
    d. Total maintenance personnel
    c. Maintenance field personnel
    d. Total maintenance personnel

| STATE | EXISTENCE OF AN HMS | | | | | | | STANDARDS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Separate or Comb. | | | Derivation | | | | Verification | | | Review and Update | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8a) | (8b) | (8c) | (9a) | (9b) | (9c) | (9d) | (10a) | (10b) | (10c) | (11a) | (11b) | (11c) | (11d) |
| Alabama | Yes | 9 | No | | | | Jorg. | No[a] | No[b] | - | x | x | - | - | x | - | - | - | - | x | - |
| Alaska | No | | No | | | No | | | | | | | | | | | | | | | |
| Arizona | Yes | 11 | No | | | | Jorg. | No | Yes | Both | x | x | - | - | x | - | - | - | - | x | - |
| Arkansas | Yes | 11 | No | | | | Jorg. | Yes | Yes | Both | x | x | - | - | x | - | - | - | - | - | x |
| California | Yes | 10 | No | | | | I.H.& | | | | | | | | | | | | | | |
| | | | | | | | Young | No | No | - | - | - | x | - | x | - | - | - | - | - | x |
| Colorado | Yes | 5 | No | | | | BTML | Yes | Yes | Both | x | x | - | - | x | - | - | - | - | x | - |
| Connecticut | Yes | 11 | No | | | | Jorg. | Yes | Yes | Both | x | x | - | - | x | - | - | - | - | - | x |
| Delaware | Yes | 8 | No | | | | I.H. | Yes | Yes | Both | x | - | - | - | - | - | x | - | - | - | x |
| Florida | Yes | 8 | No | | | | I.H. | No | Yes | Both | x | - | - | - | x | x | - | - | - | - | x |
| Georgia | Yes | 9 | No | | | | Jorg. | No | Yes | Both | x | - | - | - | x | - | - | - | - | - | x |
| Hawaii | No | | No | | | Yes | | | | | | | | | | | | | | | |
| Idaho | Yes | 6 | No | | | | BTML | Yes | Yes | Both | x | - | - | - | x | - | - | - | - | x | - |
| Illinois | Yes | 15 | No | | | | Mels | No | Yes | Both | x | - | - | - | x | - | - | - | - | - | x |
| Indiana | Yes | 8 | No | | | | Jorg. | Yes | Yes | Both | x | x | - | - | x | - | - | - | - | - | x |
| Iowa | Yes | 7 | No | | | | I.H. | Yes | No | - | x | - | - | - | x | - | - | - | - | x | - |
| Kansas | Yes | 2 | No | | | | Aust. | Yes | Yes | Both | x | - | - | - | x | - | - | - | - | x | - |
| Kentucky | Yes | 7 | No | | | | I.H. | No | No | - | x | - | - | - | x | - | - | - | - | x | - |
| Louisiana | Yes | 15 | No | | | | Jorg. | Yes | Yes | Both | x | - | x | - | x | x | x | - | - | - | x |
| Maine | Yes | 5 | No | | | | Jorg. | Yes | Yes | Both | x | x | - | - | x | - | - | - | - | - | x |
| Maryland | Yes | 8 | No | | | | Jorg. | No | Yes | Both | x | - | - | - | x | - | - | - | - | x | - |
| Massachusetts | Yes | 4 | No | | | | I.H.& | | | | | | | | | | | | | | |
| | | | | | | | BTML | Yes | Yes | Both | x | x | - | - | x | - | - | - | - | x | - |
| Michigan | Yes | 11 | No | | | | Jorg. | No | Yes | Both | x | - | - | - | x | - | - | - | - | x | - |
| Minnesota | No | - | No | | | Yes | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Mississippi | Yes | 10 | No | | | | I.H. | Yes | Yes | Both | x | - | - | - | x | - | - | - | - | x | - |
| Missouri | Yes | 2 | No | | | | I.H. | Yes | Yes | Labor | x | - | - | - | x | - | - | - | - | - | x |
| Montana | No | | No | | | Yes | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nebraska | Yes | | No | | | | I.H. | No | No | - | x | - | - | - | x | - | - | - | - | x | - |
| Nevada | Yes | 9 | No | | | | BTML | Yes | Yes | Both | x | - | - | - | x | - | - | - | - | - | x |
| New Hampshire | No | | No | | | Yes | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| New Jersey | Yes | 15 | No | | | | I.H. | No | Yes | Both | x | - | x | x | x | x | - | - | - | - | x |
| New Mexico | Yes | 5 | No | | | | Jorg. | No | Yes | Both | x | x | - | - | x | - | - | - | - | x | - |
| New York | Yes | 11 | No | | | | I.H. | Yes | Yes | Both | x | - | - | - | x | - | - | - | - | - | x |
| North Carolina | Yes | 7 | No | | | | I.H. | No | Yes | Both | x | - | - | x | - | - | x | - | - | x | - |
| North Dakota | Yes | 10 | No | | | | I.H. | No | Yes | Labor | x | - | - | - | x | - | - | - | - | - | x |
| Ohio | Yes | 4 | No | | | | BTML | Yes | Yes | Both | x | x | - | - | x | - | - | - | - | x | - |
| Oklahoma | Yes | 10 | No | | | | I.H. | No | No | - | x | - | - | - | x | - | - | - | - | - | x |
| Oregon | Yes | 8 | No | | | | Jorg. | - | Yes | Both | x | - | - | - | x | - | - | - | - | x | x |
| Pennsylvania | Yes | 7 | No | | | | Young | No | Yes | Both | - | - | x | - | x | x | - | - | - | - | x |
| Rhode Island | Yes | 7 | No | | | | Boeing | Yes | - | - | - | - | x | - | x | x | - | - | - | - | - |
| South Carolina | No | | No | | | Yes | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| South Dakota | Yes | 12 | No | | | | Jorg. | Yes | Yes | Both | x | x | x | - | x | - | - | - | - | - | x |
| Tennessee | Yes | 12 | No | | | | Jorg. | Yes | - | - | x | x | - | x | x | - | - | - | - | x | - |
| Texas | No | | No | | | Yes | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Utah | Yes | 13 | No | | | | Jorg. | Yes | Yes | Both | x | x | x | - | x | - | - | - | - | - | x |
| Vermont | No | | No | | | Yes | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Virginia | Yes | 17 | No | | | | Jorg. | Yes | Yes | Both | x | x | x | - | x | - | - | - | - | x | - |
| Washington | Yes | 14 | No | | | | I.H.& | | | | | | | | | | | | | | |
| | | | | | | | Allen | Yes | Yes | Both | x | x | x | - | x | x | - | - | - | x | - |
| West Virginia | Yes | 9 | No | | | | I.H. | Yes | Yes | Both | x | - | - | - | x | - | - | - | - | - | x |
| Wisconsin | No | | No | | | No | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Wyoming | Yes | 9 | No | | | | I.H. | Yes | Yes | Both | x | - | - | - | x | - | - | - | - | - | x |
| New Brunswick | Yes | 10 | No | | | | Jorg. | Yes | Yes | Both | x | x | x | - | x | x | - | - | - | x | - |
| Ontario | Yes | 14 | No | | | | Jorg. | Yes | Yes | Both | - | - | x | - | x | - | - | - | - | x | - |
| Quebec | Yes | 5 | No | | | | I.H. | Yes | Yes | Both | x | - | - | x | x | - | - | - | - | x | - |

## COMPUTER USAGE

## INVENTORY AND REPORTING

| | Specify (12) | (13) | Dists. (14a) | Sub-Dists. (14b) | MMS Data Update (15a) | (15b) | (15c) | (15d) | (15e) | (15f) | Turnaround for Reports (16a) | (16b) | (16c) | (16d) | (16e) | (17) | (18) | Inventory Update (19a) | (19b) | (19c) | (19d) | Planning/Budgeting (20a) | (20b) | (20d) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AL | Yes | O.A | 9,0 | 0,0 | - | - | - | - | x | - | - | - | - | x | - | 16b | Yes | - | - | x | - | - | - | - |
| AK | | | | | | | | | | | | | | | | | | | | | | | | |
| AZ | Yes | I.H. | 14,7 | 0,0 | - | - | - | x | - | - | x | - | - | - | - | 16a | Yes | - | - | - | x | x | - | x |
| AR | Yes | I.H. | 10,0 | 0,0 | x | - | - | - | - | - | x | - | - | - | - | 16a | Yes | - | - | x | - | x | - | - |
| CA | Yes | I.H. | 11,11 | 0,0 | x | - | - | - | - | - | - | - | x | - | - | 16b | Yes | x | - | - | - | x | - | - |
| CO | Yes | DOT | 0,7 | 0,11 | - | x | - | - | - | - | - | - | - | - | x | 16e | Yes | - | - | x | - | - | - | - |
| CT | Yes | DOT | 4,4 | 0,0 | - | x | - | - | - | - | - | - | - | - | x | 16a | Yes | - | - | x | - | x | x | x |
| DE | Yes | DOAS | 0,0 | 0,0 | - | - | - | - | - | - | - | - | - | x | - | 16a | Yes | - | - | - | x | - | - | - |
| FL | Yes | DOT | 6,0 | 12,0 | - | x | - | - | - | - | x | - | - | - | - | 16a | Yes | - | - | x | - | - | - | - |
| GA | Yes | O.A. | 0,0 | 0,0 | - | - | - | - | - | - | - | - | - | x | - | 16b | Yes | - | - | x | - | - | - | - |
| HI | | | | | | | | | | | | | | | | | | | | | | | | |
| ID | Yes | DOT | 18,0 | 0,0 | - | x | - | - | - | - | - | - | - | x | - | 16d | Yes | - | - | x | - | x | x | x |
| IL | Yes | DOAS | 0,9 | 0,0 | - | - | - | - | - | x | - | x | - | - | - | 16a | Yes | - | - | - | x | - | - | - |
| IN | Yes | I.H. | 6,0 | 0,0 | - | x | - | - | - | - | - | - | - | - | - | - | Yes | - | - | x | - | - | - | - |
| IA | Yes | DOT | 0,6 | 0,0 | - | - | - | - | - | - | - | - | x | - | - | 16a | Yes | - | - | - | x | - | - | - |
| KS | Yes | S.C. | 12,12 | 0,0 | - | - | - | - | x | - | - | - | - | - | x | 16a | Yes | - | - | - | x | x | - | - |
| KY | Yes | - | - - | - - | - | - | - | - | - | - | - | - | - | x | - | 16a | Yes | - | - | x | - | x | x | x |
| LA | Yes | DOT | 27,0 | 0,0 | - | - | x | - | - | - | - | - | - | x | - | 16a | Yes | - | - | x | - | x | x | x |
| ME | Yes | I.H. | 0,0 | 0,0 | - | - | - | - | - | - | x | - | - | - | - | 16a | Yes | - | - | - | x | - | x | x |
| MD | Yes | DOT | 0,0 | 0,0 | - | - | - | - | - | - | - | - | - | x | - | 16c | Yes | - | - | x | - | - | - | - |
| MA | Yes | I.H. | 0,8 | 0,0 | - | x | - | - | - | - | - | x | - | - | - | 16b | Yes | - | - | x | - | - | - | - |
| MI | Yes | I.H. | 1,0 | 0,0 | - | - | x | - | - | - | x | - | - | - | - | 16a | Yes | - | - | x | - | - | - | - |
| MN | - | - | - - | - - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | x | x |
| MS | Yes | S.C. | 0,0 | 0,0 | - | - | - | - | - | - | - | - | - | - | x | 16c | Yes | - | - | x | - | x | - | - |
| MO | No | - | - - | - - | - | - | - | - | - | - | - | - | x | - | - | 16a | Yes | - | - | x | - | x | x | - |
| MT | - | - | - - | - - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| NE | Yes | S.C. | 0,0 | 0,0 | - | - | - | - | - | - | - | - | - | x | - | 16b | Yes | x | - | - | - | - | - | - |
| NV | Yes | I.H. | 0,0 | 0,0 | - | x | - | - | - | - | - | - | - | x | - | 16c | Yes | - | - | x | - | - | - | - |
| NH | - | - | - - | - - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| NJ | Yes | DOT | 0,0 | 0,0 | - | - | - | - | - | - | - | x | - | - | - | 16a | Yes | - | - | x | - | x | - | - |
| NM | Yes | I.H. | 0,5 | 0,0 | - | x | - | - | - | - | - | x | - | - | - | 16b | Yes | - | - | x | - | x | - | - |
| NY | Yes | I.H. | 0,0 | 0,0 | - | - | - | - | - | - | - | - | - | x | - | 16a | Yes | - | - | x | - | x | x | x |
| NC | Yes | DOT | 14,0 | 35,0 | - | - | x | - | - | - | - | - | x | - | - | 16a | No | - | - | - | - | x | - | - |
| ND | Yes | O.A. | 0,0 | 0,0 | - | - | - | - | - | - | - | - | x | - | - | 16a | No | - | - | - | - | x | - | - |
| OH | Yes | I.H. | 12,0 | 0,0 | - | x | - | - | - | - | - | - | x | - | - | 16b | No | - | - | - | - | x | - | - |
| OK | Yes | DOT | 8,0 | 0,0 | - | x | - | - | - | - | - | - | - | x | - | 16b | Yes | - | - | x | - | x | - | - |
| OR | Yes | DOT | 0,0 | 0,0 | - | - | - | - | - | x | - | - | x | - | - | 16a | Yes | - | - | x | - | x | x | x |
| PA | Yes | I.H. | 11,0 | 67,0 | x | - | - | - | - | - | - | - | - | - | x | 16b | Yes | - | - | x | - | x | - | x |
| RI | Yes | I.H. | 0,0 | 0,0 | - | - | - | - | - | - | - | x | - | - | - | 16a | Yes | - | - | - | x | x | - | - |
| SC | - | - | - - | - - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SD | Yes | I.H. | 5,0 | 1,0 | - | x | - | - | - | - | - | - | x | - | - | 16b | Yes | - | - | - | x | x | x | x |
| TN | Yes | DOT | 0,0 | 0,0 | - | - | - | - | - | - | x | - | - | - | - | 16a | Yes | - | - | x | - | - | - | - |
| TX | - | - | - - | - - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UT | Yes | S.C. | 0,0 | 0,0 | - | - | - | x | - | - | - | x | - | - | - | 16b | Yes | - | - | - | x | x | - | x |
| VT | - | - | - - | - - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| VA | Yes | DOHT | 0,8 | 0,0 | - | - | - | - | x | - | - | - | x | - | - | 16a | Yes | - | - | x | - | x | x | x |
| WA | Yes | I.H. | 6,0 | 24,0 | - | - | - | - | - | x | x | x | - | - | - | 16a | Yes | - | - | - | x | x | x | x |
| WV | Yes | O.A. | 0,0 | 0,0 | - | - | - | - | - | - | - | - | - | - | - | - | Yes | - | x | - | - | x | x | x |
| WI | - | - | - - | - - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| WY | Yes | O.A | 5,0 | 0,0 | - | x | - | - | - | - | - | x | - | - | - | 16a | No | - | - | - | - | x | x | x |
| NB | No | I.H. | 0,12 | 0,0 | x | - | - | - | - | - | x | - | - | x | - | 16a | Yes | - | - | - | x | x | x | x |
| Ont | Yes | I.H. | 18,0 | 0,0 | - | - | x | - | - | - | - | x | - | - | - | 16a | Yes | - | - | x | - | x | - | - |
| Que | Yes | I.H. | 0,0 | 0,0 | - | x | - | - | - | - | - | - | x | - | - | 16a | Yes | - | - | - | x | x | - | x |

| | COST DATA | | | | | | | | | | SYSTEM SIZE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (21) | (22a) | (22b) | (22c) | (22d) | (22c) | (23) | (24) | (25a) | (25b) | (26) | (27a) | (27b) | (27c) | (27d) |
| AL | No | No | No | No | Yes | No | Yes | Yes | | x | No | 11,207 | 27,592 | 1,231 | 1,365 |
| AK | | | | | | | Yes | No | | | No | 5,364 | 12,356 | 425 | 509 |
| AZ | No | No | No | No | Yes | No | Yes | Yes | x | | Yes | 8,192 | 16,578 | 639 | 742 |
| AR | No | No | Yes | No | No | Yes | Yes | Yes | | x | Yes | 16,091 | 34,706 | 1,806 | 1,969 |
| CA | No | Yes | Yes | Yes | No | No | Yes | Yes | x | | Yes | 15,200 | 47,623 | 4,186 | 5,565 |
| CO | No | No | No | No | No | No | Yes | Yes | x | | Yes | 9,800 | 30,815 | 1,200 | 1,600 |
| CT | No | No | No | No | No | Yes | No | No | | | No | 4,036 | 10,160 | 1,628 | 1,756 |
| DE | No | Yes | Yes | No | No | Yes | | Yes | x | | No | 4,650 | 9,850 | 441 | 540 |
| FL | No | No | No | Yes | Yes | Yes | Yes | Yes | | x | No | 11,996 | 34,538 | 2,205 | 3,197 |
| GA | No | No | No | No | Yes | No | Yes | Yes | x | | Yes | 18,400 | 46,000 | 3,049 | 3,219 |
| HI | No | No | No | No | No | No | No | No | | | No | 868 | 2,287 | 405 | 424 |
| ID | No | No | No | No | No | No | Yes | Yes | x | | No | 4,950 | 11,400 | 472 | 615 |
| IL | No | No | No | No | No | No | Yes | Yes | x | | Yes | 15,751 | 38,612 | 2,474 | 2,975 |
| IN | No | No | No | No | No | No | No | No | | | No | 11,500 | 30,000 | 1,971 | 2,446 |
| IA | Yes | No | No | Yes | No | No | Yes | Yes | | x | Yes | 10,414 | 24,256 | 1,411 | 1,708 |
| KS | No | No | No | No | No | No | Yes | Yes | | x | Yes | 10,092 | 23,793 | 1,408 | 1,786 |
| KY | No | No | No | No | Yes | Yes | No | Yes | | x | | 24,750 | 53,900 | 3,244 | 3,503 |
| LA | Yes | No | No | No | Yes | Yes | No | Yes | | x | Yes | 16,937 | 38,009 | 3,155 | 3,358 |
| ME | No | No | No | Yes | No | Yes | No | Yes | | x | No | 10,582 | 21,655 | 1,197 | 1,402 |
| MD | No | No | No | No | No | No | No | Yes | | x | No | 7,433 | 19,169 | 1,509 | 1,791 |
| MA | Yes | No | Yes | No | No | No | Yes | Yes | x | | Yes | 2,843 | 11,994 | 1,600 | 2,100 |
| MI | No | No | No | No | No | No | Yes | Yes | | x | Yes | 2,490 | 7,412 | 526 | 1,264 |
| MN | | | | | | | Yes | No | | | | 12,100 | 28,489 | 1,773 | 2,180 |
| MS | No | No | No | No | No | No | Yes | Yes | | x | Yes | 10,170 | 21,710 | 1,110 | 1,273 |
| MO | No | No | No | No | No | No | No | Yes | | x | No | 32,231 | 72,200 | 3,044 | 3,592 |
| MT | | | | | | | | | | | | 8,330 | 18,683 | 524 | 694 |
| NE | No | No | No | No | No | Yes | Yes | Yes | | x | Yes | 9,881 | 21,745 | 856 | 1,098 |
| NV | No | No | Yes | No | No | No | Yes | Yes | x | | Yes | 5,396 | 14,183 | 391 | 427 |
| NH | No | No | No | No | No | Yes | Yes | Some | | x | No | 4,070 | 8,558 | 705 | 770 |
| NJ | No | No | No | Yes | Yes | Yes | No | Yes | x | | No | 2,315 | 10,321 | 1,585 | 1,800 |
| NM | No | No | No | No | No | No | Yes | Yes | x | | No | 13,950 | 26,963 | 960 | 1,113 |
| NY | No | No | No | Yes | No | No | Yes | Yes | x | | No | 14,700 | 36,000 | -5,000 | 5,500 |
| NC | Yes | No | No | No | No | No | Yes | Yes | | | Yes | 76,032 | 158,200 | 6,031 | 7,000 |
| ND | No | No | No | No | No | No | No | Yes | | x | Yes | 7,270 | 15,832 | 370 | 441 |
| OH | No | No | No | No | No | No | No | Yes | x | | No | 17,397 | 42,158 | 1,995 | 4,016 |
| OK | No | No | No | No | No | No | No | Yes | | x | Yes | 11,631 | 25,804 | 1,300 | 1,500 |
| OR | No | No | No | No | No | No | No | Yes | x | | No | 7,678 | 19,302 | 1,403 | 1,522 |
| PA | No | No | Yes | Yes | Yes | Yes | Yes | Yes | | x | Yes | 44,245 | 78,068 | 7,413 | 7,826 |
| RI | No | No | No | Yes | No | Yes | No | No | | | No | 1,164 | 2,980 | 426 | 482 |
| SC | No | No | No | No | No | No | No | No | | | No | 39,454 | 83,869 | 2,390 | 3,111 |
| SD | No | Yes | Yes | No | Yes | Yes | Yes | Yes | | x | Yes | 7,817 | 18,234 | 640 | 700 |
| TN | No | No | No | No | Yes | Yes | Yes | Yes | x | x | No | 12,030 | 25,088 | 1,895 | 1,997 |
| TX | No | No | No | No | No | No | No | No | | | No | 72,000 | 168,000 | 7,439 | 7,601 |
| UT | Yes | No | No | No | Yes | Yes | Yes | Yes | x | | No | 5,583 | 13,021 | 611 | 768 |
| VT | No | No | No | No | No | No | Yes | No | | | Yes | 2,618 | 6,011 | 465 | 645 |
| VA | No | No | No | No | Yes | No | No | Yes | | x | No | 52,716 | 112,250 | 4,653 | 5,800 |
| WA | No | No | Yes | Yes | No | Yes | Yes | Yes | | x | Yes | 6,888 | 16,778 | 947 | 1151 to 1201 |
| WV | No | No | No | No | Yes | Yes | Yes | Yes | x | | No | 33,500 | 51,428 | 2,622 | 3,548 |
| WI | | | | | | | Yes | | | | No | 11,436 | 25,775 | 564 | |
| WY | No | No | No | No | No | No | Yes | Yes | | x | Yes | 6,262 | 15,611 | 467 | 508 |
| NB | Yes | No | No | No | Yes | Yes | Yes | Yes | - | x | Yes | 11,300 | 22,000 | 650 | 700 |
| Ont | No | No | No | No | No | No | Yes | Yes | x | - | Yes | - | 31,000 | 1,776 | 2,684 |
| Que | Yes | No | No | No | No | No | Yes | Yes | x | - | Yes | 23,330 | 77,700 | 5,418 | 5,774 |

Jorg. = Roy Jorgenson Associates
Young = Arthur Young
BTML = Byrd, Tallamy, McDonald and Lewis
Meis = Meiscon
Aust. = Austin
Allen = Booz, Allen and Hamilton
a. except for mowing
DOAS = Department of Administrative Services
S.C. = State Central
DOT = Department of Transportation
DOHT = Department of Highways and Transportation
O.A. = Other Agency
I.H. = In-House
CRT = Cathode Ray Tube

## COST DATA COLLECTED TO AID IN REHABILITATION STRATEGIES
## FOLLOW-UP TO NO. 26

ARIZONA - A model in the pavement management system (PMS) computer program predicts the routine maintenance costs as a function of percent cracking and degree of roughness of the pavement surface. The predicted routine maintenance cost is an alternative action which is compared to rehabilitation strategies, such as overlay, seal coats, etc., to derive an "optimal" set of strategies for each year for each mile of our highway system.

The routine maintenance cost prediction models were developed on the basis of historical cost data from the maintenance management system (MMS).

ARKANSAS - Cost data as collected by our data processing system is available on an "as needed" basis. This information is used by our 10 District Engineers and their staff to determie if expenditures on suspected high maintenance routes justifies more extensive research concerning specific roadway conditions and possible reconstruction or more extensive corrective action.

COLORADO - The MMS provides average costs of materials, equipment use, labor that is used as a factor in determining whether certain types of surface activities are cost effective using State forces or, if not, should rehabilitation and overlays be diverted to bid contract work.

GEORGIA - While we do have information from our MSS to determine costs for various methods of rehabilitation, this information is not related to specific routes or locations. The information from the MMS is directed more toward the unit cost for the various rehabilitation techniques.

ILLINOIS - All work accomplished and the corresponding costs of labor and material to perform maintenance is available for each of our highway segments know as subsections. These subsections are based on a continuous route through a maintenance area and may be modified by pavement width or traffic lanes. Data of this type is mot useful information relevant to a specific location. In each District, special subsections have been assigned from 10 separate catagories for the purpose of studying various surface types under specific traffic densities. The cost data for these special subsections is useful for comparison purposes.

MICHIGAN - Cost data indicating an inordinate amount expended for maintenance purposes on a given route would be a "triggering" mechanism indicating need for a closer look at the expenditures and the types of maintenance being performed. Cost data alone would not be the only basis for determination for the various rehabilitation or overlay strategies. Field review would be indicated by excessive expenditures. The review would be for the purpose of determining the cause and/or nature of failures indicated such as: age of the facility, subbase corrections needed, drainage corrections needed, etc. The fire review would be used in an effort to determine what would be required to correct the causes and if necessary to proclude recurrence.

NEVADA - An output report from the PMS entitled "Maintenance Repair Strategies" gives the repair strategy for each mile of inventories roadway which falls within the maintenance category. The repair strategies are the recommended corrective activities which have been determined by analysis of survey data for the represented mile. The estimated cost for each type of specified corrective activity are extracted from the MMS using current maintenance costs for 1 mile of activity.

The PMS "Maintenance Cost" report gives the maintenance cost that were expended on each mile of roadway within the system for the previous 5 years with a 3 year and 5 year average. The 3 year average is used to weight the maintenance cost into the PMS priority rating system. All costs are extracted from the MMS files.

NORTH DAKOTA - There are two levels of response for "Pavement Preservation" in the PMS. The first level of response is "Preventive Maintenance." This means if the pavement surface is in good condition, the usual response is to "level and patch" and then apply a maintenance funded chip seal. If the pavement surface is not in good condition, the response is a construction overlay, usually 1½ inches in depth. The two levels of response are minimum in nature and the cost is really not a factor in the decision.

OKLAHOMA - The work on surface maintenance activities is recorded by subsections. Cost data is available which may indicate excessive expenditures for routine maintenance on particular sections. These sections are given higher priority for overlay strategies.

PENNSYLVANIA - The work accomplished by State forces and contract for surface activities is listed showing dollars expended for labor, equipment, and materials. The cost information is not recorded by roadway section or milemarker.

SOUTH DAKOTA - In our MMS costs are accumulated by work function within mileage Reference Marker. This allows us to determine how much money was expended on each function for each mile of road maintained. At the end of each fiscal year these records are used to help produce the "Highway Needs Analysis and Project Analysis Report" for all State maintained roads. This report contains much of the data necessary for a pavement management system. The maintenance cost information on these reports gives the 3 year average maintenance cost for each mile of road on a given project. Costs are divided into surfacing costs, structure costs, contract costs, and total costs.

VERMONT - All contract and maintenance paving operations are analyzed to determine unit costs. This work is further evaluated so that costs are determined for each method selected. The unit costs thus obtained are then factored by a percentage to counteract the difference between historical costs and those we anticipate for the coming season. These cost data provide the necessary ingredients for the evaluation of the cost effectiveness of each of the types of treatment utilized.

WYOMING - Our roadways are broken down into various maintenance sections by the county in which they are located. The cost for maintaining each of these sections is tracked for each maintenance function. We also track the material and labor hours in each of these areas and store all the data for individual fiscal years on computer files. We are also tracking some maintenance functions such as leveling, chip sealing, etc. by mile post to further identify their exact location.

This method of tracking material, labor, and equipment costs will enable us to identify areas of relatively high maintenance and evaluate the effectiveness of various pavement management strategies.

## MAINTENANCE BUDGET DEVELOPMENT PROCESS - CALIFORNIA

The California Department of Transportation (CalTrans) is currently in the process of developing a systematic process to arrive at resource requirements for highway maintenance. This approach utilizes information generated from the MMS along with cooperative input from the Division of Maintenance and the Division of Budget Development.

Specifically, the Division of Maintenance provides data as to physical inventory of maintainable items, identifies maintenance deficiencies, and recommends the levels of service for various maintenance activities. The Division of Budget Development provides resource estimates for the highway maintenance budget proposal and concurs in proposal to the budget review committee which is the financial decision making body within Caltrans. The two divisions jointly prepare documentation as to the number of person years (PY's) necessary for each highway program and level of service.

Basically the highway maintenance program PY's are established from computations of the following.

A. Direct production (quantity output or deficiency X work standard).
B. Historical trend projected (direct production activities with no future year predictable measures).
C. Position count of organization structure controls (supervision and auxiliary services).
D. Production support (travel time, delays, traffic control, etc) per policy trend for each maintenance activity.
E. External support to maintenance (computer services, equipment division, etc.)

Calculation Method A - Levels of service are prepared for each direct production activity based upon safety, preservation of investment, user service, and appearance. In CalTrans these elements are referred to as safe, save, serve, and seen. A correlation, based upon the service levels, is prepared between inventory or deficiency or condition data from the MMS and PY's needed.

Calculation Method B - Activities with no production units (snow removal, brush control, major damage, etc.) are analyzed in terms of trends and statistical probability rather than in terms of average occurrence. This information is extracted from the MMS historic expenditure file and PY's required for these activities are computed.

Calculation Method C - PY's for position count of organization structure controls is derived from Headquarters, district, region, and area staff plans, training plans, and miscellaneous history files.

Calculation Method D - Data pertaining to non-production time (travel, delay, setup, extra equipment service) are captured through the MMS and used to develop a rational procedure for incorporating these factors into PY's required for support of each maintenance program activity.

This ongoing effort by CalTrans appears to address in detail the components of the highway maintenance program in terms of resources necessary to maintain to an established service level for the highway network. The Committee would be most interested in receiving the final report on this process upon completion. If additional information is desired on this, you may want to contact Mr. Karl W. Kampe, Senior Transportation Engineer, Department of Transportation, 1120 N Street, Sacramento, California 95814; telephone (916) 445-3163.

# APPENDIX B

## MAINTENANCE MANAGEMENT QUESTIONNAIRE

QUESTIONNAIRE

on

MAINTENANCE MANAGEMENT SYSTEMS

This questionnaire is designed to give you the opportunity to describe the basic details of your organization's maintenance management system. The inquiries will verify or expand upon information gathered in 1981 by Mr. Charles R. Miller and his Task Force on Maintenance Management. For more details of his findings, please refer to AASHTO's Maintenance Aid Digest, No. 26, dated June 1982.

It is important that each question be answered as thoughtfully and frankly as possible. There is room for additional comments necessary to enhance your answers.

SECTION A

*Answers to the following questions should assist this investigation on how federal, state, and local transportation agencies manage the maintenance activities of their organization.*

A-1. Does your agency use a systematic process, commonly called a Maintenance Management System or MMS to manage its maintenance activities?

a. _____ Yes
b. _____ No

A-2. If your answer to question A-1 was No, feel free to comment on the way you manage the maintenance affairs in your organization.

A-3. Has your agency's MMS undergone any major conceptual or technical modifications since its adoption?

a. _____ Yes
b. _____ No

A-4. If your answer to question A-3 was Yes, or you feel changes are necessary, please describe below.

A-5. A complete MMS may contain several modules representing maintenance management system elements, either in terms of functions, activities, phases, etc., that may be used without the others. For example, a planning module may work satisfactorily without a work control or performance evaluation module.

Considering this assumption, please note which of the following management elements are included or supported within your MMS.

a. _____ Planning
b. _____ Budgeting
c. _____ Programming Resources
d. _____ Scheduling Work
e. _____ Directing Work
f. _____ Controlling Work
g. _____ Performance Evaluation
h. _____ Work Improvement Activities
i. _____ Others (Please Specify)

A-6. Information collected and stored by an MMS can be used by other information or control systems. Does your MMS collect and provide data to other systems?

a. _____ Yes
b. _____ No

If so, what type or types of systems use the MMS data?

a. _____ Pavement Management Systems
b. _____ Agency Accounting and Recording Systems
c. _____ Construction Planning Systems
d. _____ Others (Please Specify)

A.7 In your opinion, what is the most useful element or module included or supported within your system? Why?

A-8. Does your organization's financial records provide you sufficient information in time for you to adequately manage your maintenance activities?

a. _____ Yes
b. _____ No

A-9. Does your MMS provide only those reports containing data that augments information found in your organization's financial record?

a. _____ Yes
b. _____ No

A-10. Do your maintenance field managers use most of the management reports given to them?

a. _____ Yes
b. _____ No

A-11. What have you done to motivate employees, particularly field force managers, to use information and reports given them by higher authorities?

SECTION B

*The following questions relate to your agency's budgeting process. Please feel free to provide any additional comments you believe to be appropriate concerning this subject.*

B-1. Do your State's financial officials follow the principles published in the Governmental Accounting Auditing, and Financial Reporting (GAAFR) publication published by the National Committee on Governmental Accounting (NCGA)?

a. _____ Yes
b. _____ No

If your answer was No, what accounting practices are followed?

B-2. Briefly, please describe the sequence of events that result in the maintenance portion of your agency's proposed transportation budget. Your comments should show:

- What level of managers initially identify highway or local road maintenance needs;
- Who provides the justification for resources to satisfy these needs;
- Who presents your agency's maintenance work plan and justification to an approving authority within your organization. (Highway Department, Department of Transportation, Public Works Department, etc.);
- Who, within your organization, accepts the proposed maintenance budget or expenditure plan before it is presented to the Governor or legislature; or, in the case of county or city government, to the body deciding the final distribution of local funds; and,
- Other information you believe to be appropriate.

*NOTE: The answer to this and the following questions may indicate why there seems to be so many differences between Accountants and Engineers regarding the level of detail needed to track an agency's maintenance expenditures.*

B-3. Is there a difference in the level of detail within your maintenance work plan as compared to your agency's budget?

a. _____ Yes (Please describe the difference)
b. _____ No

B-4. In your opinion, your relationship with your organization's financial control people is:

a. _____ Good (Have a general knowledge of each others interest and problems. Work well together.)

b. _____ Fair (The staff of each office contact one another, occasionally, but only have a minimum understanding of each others problems or concerns.)

c. _____ Poor (Maintenance and Financial Officers work independently without knowledge of each others concerns.)

## SECTION C

*Electronic data processing plays an important role in the operation of most management systems. The following inquiry is intended to probe its role in the information systems used by maintenance engineers. Please feel free to make any additional comments on this subject that you believe will be helpful to this study.*

C-1. Are your electronic data processing services adequate for your immediate needs?

a. _____ Yes
b. _____ No (Please explain)

C-2. Please list the type and frequency of reports generated through your computer.

TYPE (Name) FREQUENCY

C-3. Has anyone within your agency recently assessed the cost of the way information is collected and gathered in your organization and compared it to the value received from the use of this information?

a. _____ Yes
b. _____ No

If your answer is Yes, what conclusions were reached?

C-4. Data collected by your MMS Includes:

a. _____ Type and amount of work accomplished.
b. _____ Funds expended for:

(1) _____ Labor
(2) _____ Equipment
(3) _____ Materials

c. _____ Hours used by:

(1) _____ Labor
(2) _____ Equipment

d. _____ Material type used
e. _____ Material amounts used
f. _____ Equipment types or classes used
g. _____ Personnel classifications used
h. _____ Others (Please specify)

C-5. The information described in the previous question is reported on:

a. _____ Payroll documents
b. _____ Special reports (Please describe)
c. _____ Other means (Please specify)

C-6. Who generally reports information contained in the documents described in question C-5.?

a. _____ Payroll Clerks or Time Keepers
b. _____ Foremen or Crew Supervisor
c. _____ Individual Worker
d. _____ Other (Please specify)

C-7. How do you rate the accuracy of the information collected for your MMS through your data processing system?

a. _____ Satisfactory
b. _____ Not Satisfactory

C-8. Does your system allow you to periodically edit or verify data accumulated by your MMS?

a. _____ Yes
b. _____ No

If your answer is Yes, please describe the process.

C-9. What is the most serious problem you have encountered with the method by which your maintenance data is collected?

C-10. Have you resolved any of the problems you discussed in your answer to question C-9.? If yes, how was it accomplished?

## SECTION D

*The following questions consider the development and use of performance standards for maintenance work. Please feel free to provide any other comments you believe to be appropriate.*

D-1. According to Mr. C. R. Miller's findings, performance or work standards are developed in several ways. Please select the portion of this inquiry that applies to your standards and respond accordingly.

A. In-house Committee

Standards were developed by:

1. ___ Reaching a consensus
2. ___ Approving results of time-motion studies
3. ___ Approving results of simulation studies
4. ___ Accepting standards developed by others
5. ___ Using historical data
6. ___ Other (Please specify)

B. Consultant

Briefly, please describe how you believe your performance standards furnished by your Consultant were developed.

C. Time and Motion Studies

Was this type of study the most predominate way your performance standards were developed?

a. _____ Yes
b. _____ No

D. Other

Please specify what other ways your agency's performance standards were developed.

D-2. Do you use performance standards to estimate needed resources to maintain highways or local roads?

a. _____ Yes
b. _____ No

Are work performance standards used to evaluate worker or crew performance?

a. _____ Yes
b. _____ No

D-3. How well are work performance standards used for planning accepted by your field managers?

a. ___ Very Well (Gen. accepted without question)
b. ___ Adequately (Questioned occasionally but used)
c. ___ Marginally (Resisted but used)
d. ___ Poorly (Ignored)

D-4. How well are work performance standards accepted by your field personnel when they are used to evaluate their actual work performance?

a. ___ Very Well (Generally without question)
b. ___ Adequately (Questioned but attempts are made to improve performance)
c. ___ Marginally (Work performance comparison to standards are accepted with skepticism and very little change is made)
d. ___ Poorly (Ignored)

D-5. If you have successfully implemented the practice of using work performance standards, what process did you use? Feel free to comment even though you believe you are only partially successful.

## SECTION E

*There are implied benefits from using management systems but often they are not documented. The following questions are aimed at discovering benefits that have been verified by a user agency.*

E-1. Do the users of your MMS periodically evaluate the results of your agency's reported maintenance effort?

a. _____ Yes
b. _____ No

E-2. What are some important measurable benefits you believe result from your management process?

E-3. What are some of the intangible (non-measurable) benefits your system provides?

E-4. Have you suffered any non-favorable reactions as a result of your entering into a MMS? If so, what are they?

# APPENDIX C

## TYPICAL MAINTENANCE WORK ACTIVITIES

Maintenance work activity titles are the designations given to the different types of work maintenance forces perform. The type and amount of work each agency performs will vary depending on such factors as location, climate, type of facility, and public and political demands. Most maintenance organizations have developed a list of work activities that best fits their own situation. The following list, developed by the state of Nevada, is typical.

| PROGRAM NUMBER | ACTIVITY NUMBER | ACTIVITY OR PROGRAM DESCRIPTION | ACCOMPLISHMENT UNIT |
|---|---|---|---|
| | | MAINTENANCE | |
| 100.00 | | PLANNING & SCHEDULING PROGRAM | |
| | 100.01 | Planning & Scheduling | Man Hours |
| 101.00 | | FLEXIBLE PAVEMENT PROGRAM | |
| | 101.01 | Base and Surface Repair | Cu. Yds. |
| | 101.02 | Surface Patching - Premix (Hand) | Cu. Yds. |
| | 101.03 | Surface Patching - (Machine) | Cu. Yds. |
| | 101.04 | Surface Patching - Spot Seal | Sq. Yds. |
| | 101.05 | Seal Coat - Sand | Sq. Yds. |
| | 101.06 | Seal Coat - Flush | Sq. Yds. |
| | 101.07 | Crack Filling | Lbs. Filler Material |
| | 101.08 | Heater Planing | Sq. Yds. |
| | 101.09 | Seal Coat - Chips | Sq. Yds. |
| 111.00 | | RIDGID PAVEMENT PROGRAM (P.C.C.) | |
| | 111.01 | Temporary Patching of P.C.C. Pavements | Cu. Yds. |
| | 111.02 | Permanent Patching of P.C.C. Pavements | Cu. Yds. |
| | 111.03 | Paved Shoulder Repair (Premix) | Cu. Yds. |
| | 111.04 | Paved Shoulder Seal - Sand | Sq. Yds. |
| | 111.05 | Joint Sealing | Lbs. Filler Material |
| | 111.06 | Expansion Joint Repair | Lin. Ft. |
| 112.00 | | REPAIRING MISC. CONCRETE APPURTENANCE PROGRAM | |
| | 112.01 | Repairing Miscellaneous Concrete Appurtenances | Cu. Ft. |
| 131.00 | | ROADSIDE MAINTENANCE PROGRAM | |
| | 131.01 | Cleaning Culverts | Each |
| | 131.02 | Cleaning Culvert Openings & Drop Inlets | Each |
| | 131.03 | Dressing and Shaping Ditches | Lin. Ft. |
| | 131.04 | Cleaning Ditches | Cu. Yds. |
| | 131.05 | Culvert Repair and Replacement | Lin. Ft. |
| | 131.06 | Fill Slope Repair | Cu. Ft. |
| | 131.07 | Unpaved Shoulder Slope Maintenance (Blading) | Shoulder Miles |
| | 131.08 | Vegetation Control (Mowing, Flailing, Burnings, Etc.) | Shoulder Miles |

| PROGRAM NUMBER | ACTIVITY NUMBER | ACTIVITY OR PROGRAM DESCRIPTION | ACCOMPLISHMENT UNIT |
|---|---|---|---|
| | 131.09 | Vegetation Control (Chemical Weed Spray) | Shoulder Miles |
| | 131.10 | Vegetation Control (Hand Weeding) | Man Hours |
| 133.00 | | ROADSIDE CLEANUP PROGRAM | |
| | 133.01 | Remove Debris, Litter, Trash | Shoulder Miles |
| | 133.02 | Empty Litter Barrels | Each |
| | 133.03 | Sweeping: Traveled Way, Shoulders & Gutters | Sweeping Miles |
| | 133.04 | Remove Roadway Debris | Traveled Miles |
| 134.00 | | MAINTENANCE OF ROADSIDE FACILITIES PROGRAM | |
| | 134.0L | Maintenance of Rest Stops | Man Hours |
| | 134.02 | Maintenance of Roadside Parks | Man Hours |
| | 134.03 | Maintenance of Landscape Areas, with Turf | Man Hours |
| 135.00 | | MAINTENANCE OF ROADSIDE APPURTENANCES PROGRAM | |
| | 135.01 | Repair of Right-of-Way Fences and Gates | Lin. Ft. |
| | 135.02 | Cattle Guards and Wings | Each |
| | 135.03 | Removal of Encroachments (Advertising Signs, etc.) | Each |
| | 135.04 | Inspection of Right-of-Way Fences and Gates | Fence Miles |
| 141.00 | | TRAFFIC SERVICE PROGRAM | |
| | 141.01 | Maintenance of Directional, Route and Warning Signs | Sq. Ft. |
| | 141.02 | Guardrail - Repair and Replacement | Lin. Ft. |
| | 141.03 | Guardrail - Painting | Lin. Ft. |
| | 141.04 | Guardrail - Cleaning | Lin. Ft. |
| | 141.05 | Pavement Striping - Dashed and Solid | Striping Miles |
| | 141.06 | Raised Pavement Markers | Each |
| | 141.07 | Pilot Lining | Pilot Line |
| | 141.08 | Pavement Markings and Painted Cattle Guards | Sq. Ft. |
| | 141.09 | Roadway Lighting Operations: Highway Lighting, Bridge and Approach Lighting | Man Hours |
| | 141.10 | Patrolling for Protection of Public Traffic | Traveled Miles |
| | 141.11 | Maintenance of Guideposts, R/W Markers and Milepost Markers | Each |
| 151.00 | | SNOW AND ICE CONTROL PROGRAM | |
| | 151.01 | Snow Removal, Plowing, Blading, Application of Abrasives, Chemicals | Man Hours |
| | 151.02 | Plowing with Rotary Snowplow | Man Hours |
| | 151.03 | Patrolling for Snow and Ice Control | Man Hours |
| | 151.04 | Installation or Removal of Snow Markers | Each |

| PROGRAM NUMBER | ACTIVITY NUMBER | ACTIVITY OR PROGRAM DESCRIPTION | ACCOMPLISHMENT UNIT |
|---|---|---|---|
| 161.00 | | STRUCTURE MAINTENANCE PROGRAM | |
| | 161.01 | Maintenance and Repair of Structures | Man Hours |
| | 161.02 | Inspection of Structures (Bridges and Culverts) | Each |
| | | BETTERMENTS | |
| 254.00 | | A & B GRADING PROGRAM | |
| | 254.01 | Roadway Grade Improvement | Cu. Yds. |
| | 254.02 | Flood Control and Drainage Grading | Cu. Yds. |
| | 254.03 | Install Drainage Structures | Lin. Ft. |
| 256.00 | | A & B SURFACE TREATMENT PROGRAM | |
| | 256.01 | No Activity Assigned | |
| | 256.02 | Bituminous Surface Treatment | Cu. Yds. |
| 261.00 | | A & B TRAFFIC SERVICE PROGRAM | |
| | 261.01 | Erection of Route, Safety and Direction Signs | Sq. Ft. |
| | 261.02 | No Activity Assigned | |
| | 261.03 | Construct Cattle Guards | Each |
| | 261.04 | Construct Guardrail | Lin. Ft. |
| | | STOCKPILE | |
| 270.00 | | MATERIALS PRODUCTION PROGRAM | |
| | 270.01 | Aggregate Production | Cu. Yds. |
| | 270.02 | Premix Production | Cu. Yds. |
| | 270.03 | Mixing Salt and Sand | Cu. Yds. |
| | 270.04 | Hauling Materials | Cu. Yds. |
| | 270.05 | Chip Production | Cu. Yds. |
| 280.00 | | MATERIALS PURCHASE PROGRAM | |
| | 280.01 | Purchase Aggregate | Cu. Yds. |
| | 280.02 | Purchase Premix | Cu. Yds. |
| | 280.03 | Purchase Plantmix | Tons |
| | 280.04 | Purchase Chips | Cu. Yds. |

# APPENDIX D

## EXAMPLE OF COMPENDIUMS OF MAINTENANCE MANAGEMENT SYSTEMS

The three pages appearing here are an example of the information contained in the compendiums of maintenance management systems that were prepared for this synthesis. The information in the compendiums was drawn from responses to a questionnaire for this synthesis and from data contained in the June 1982 issue of the AASHTO Maintenance Aid Digest (MAD-26) (see Appendix A). The full 107-page set of compendiums, which includes information from all states (except West Virginia and Wisconsin), the District of Columbia, New Brunswick, Nova Scotia, Ontario, the City of Los Angeles, San Diego County, and the Los Angeles County Flood District, is available at a cost of $10.00 from:

Publications Office
Transportation Research Board
2101 Constitution Avenue, N.W.
Washington, DC 20418

# ALABAMA

## SYSTEM OUTLINE

### Development
Developed jointly by a team consisting of consultants from the firm of Roy Jorgenson Associates and personnel from the Alabama Highway Department Maintenance Bureau - Management and Training Section. The system was implemented February 14, 1973.

### Modifications
No major conceptional changes; however, accounting (actual) expenditures have been incorporated into the conformance reports.

### Elements
1. Planning.
2. Budgeting.
3. Programming resources.
4. Scheduling work.
5. Directing work.
6. Controlling work.
7. Performance evaluation.
8. Work improvement activities.

### Assessment
Although there has been no objective assessment of the benefit gained from the use of the information collected compared to the cost of collection, certain aspects of the system are accepted by its users as useful, that is: the determination of budget and work load based on inventory count enables managers to make an equitable distribution of available funds.

## DATA COLLECTION
The department's data processing service is provided by another state agency. No difficulty has been reported in receiving adequate service.

a. Nine terminals in district offices transmit and receive MMS data.
b. Data are updated monthly.
c. Reports are available within six to eight days in the central office and within ten to fifteen days in the division and district offices.

### Data Collected
1. Types and amounts of work accomplished.
2. Funds expended for labor, equipment, and materials.
3. Hours used by labor and equipment.
4. Material type and amounts used.
5. Equipment types or classes used.

### Reporting
1. Maintenance data are reported on crew-day cards completed by the crew supervisor.
2. The crew-day card data are summarized monthly by activity, road class, crew size, and accomplishment at the district office.
3. The district office summaries are forwarded to the division where the data are further summarized into state totals.
4. The actual crew-day card is used as input source for entry into the computer at the division office.
5. The accuracy of the input data is considered acceptable after discrepancies are corrected and when a direct comparison of the manual summaries and computer totals agree.

6. The most serious problem identified is the practice of charging maintenance activities to general "catch-all" codes rather than to specific activities. Distributing performance standards to more field personnel and providing them with a detailed list of work reported on "catch-all" activities is expected to help resolve this problem.

Use of Data

1. Future pavement management system.
2. Accounting and recording system - Information from crew-day cards is used to complete personnel time reports and equipment use reports. The material-use data on these cards are used in the inventory control system.
3. The department's financial records are considered adequate for management purposes and the MMS data do not augment them.
4. Field managers are motivated to use their management reports because they recongize that limited budgets and personnel are demanding closer attention to expenditures and staffing. Training in the use of all phases of the MMS has increased the ability of field managers to make better decisions.
5. Managers of the smallest geographical unit are included in annual meetings to assist in the past year's maintenance operations.
6. The MMS data are collected in such a way that, after going through the accounting and recording system, the data can be used in planning, design, and construction decisions.
7. Unit costs for maintenance activities are determined but these cost data are not normally used in determining rehabilitation or overlay strategies.

PLANNING/BUDGETING

1. An inventory of physical features is maintained and updated yearly.
2. The total highway budget is determined by the income from road-user taxes and fees. The major parts of the budget are:
   - Administration (general offices)
   - Supervision (division and district offices)
   - Operations (revolving accounts)
   - Construction (federal-aid matching)
   - Construction (100% state financed)
   - Maintenance

The Highway Director will determine the fund distribution among these programs.

3. Before developing the final routine annual budget, a meeting is held with personnel from the central office, divisions, and districts. Input is considered from various levels of maintenance management regarding any necessary changes in performance or quality standards to assure the operating plan will be based on updated standards. The Maintenance Bureau Management and Training Section then develops the department's maintenance work plan for each division and district.

STANDARD MEASURES

1. Separate quality and quantity standards have not been developed.
2. Performance standards were developed by a team of department and consultant personnel. The team used historical data from several surrounding states after review and modification to meet local conditions.
3. The standards are reviewed annually by a technical advisory committee. The committee includes people from administration, management, and supervisory levels of the maintenance operation.
4. Performance standards are not based on time-motion or work sampling studies.
5. The standards are verified by comparison with production reports.
6. Performance standards are quantity standards used to estimate resources needed to maintain highways. They are also used to evaluate worker or crew performance.

7. The use of a performance standard for both purposes is accepted adequately well by field personnel.
8. The successful implementation of the use of performance standards required several sessions with area and local managers on the use of the MMS. Quarterly meetings are held to review and compare work programs and accomplishments. Because the field-level manager had input in the decision process, he knows he is a part of the system and uses it as best he can.

BENEFITS

1. The results of periodic evaluations of the system show that:
   a. budgets have increased but personnel requirements remain the same or have been reduced.
   b. budget increases have not kept up with inflation.
   c. the level of maintenance services has not been severely reduced, but some deferred maintenance has occurred.
   d. work methods have changed as the result of the system.
   e. the system causes local managers to ask questions.
2. One benefit has not been identified:
   There have been isolated cases where old-time managers did not want to accept the change. These managers believed their district had unique problems because of terrain, personnel, weather, traffic, politics, or pay scales. They argued that these factors would prevent the useful application to their district's maintenance work. These problems are now resolved.

## ALASKA

SYSTEM OUTLINE

Development

The consulting firm of Peat, Marwick, Mitchell & Co. designing a management information system for the state. A portion of this system will be used by the Division of Maintenance and Operations to manage the maintenance of state airports, buildings, and highways.

Modifications

Not applicable

Elements

1. Planning.
2. Budgeting.
3. Programming resources.
4. Scheduling work.
5. Directing work.

Assessment

The new system is intended to provide timely financial data to department managers that is not now available.

DATA COLLECTION

No information available except that data processing services are available.

Data Collected

1. Hours used by labor and equipment.
2. Equipment types or classes used.
3. Personnel classifications used.

Reporting

1. Data are reported by individual workers on payroll documents.

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