NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

46

RECORDING AND REPORTING METHODS FOR HIGHWAY MAINTENANCE EXPENDITURES

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

AREA OF INTEREST:
MAINTENANCE, GENERAL

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C. 1977

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.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are responsibilities of the Academy and its Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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PREFACE

There exists a vast storehouse of information relating to nearly every subject of concern to highway administrators and engineers. Much of it resulted from research and much from successful application of the engineering ideas of men faced with problems in their day-to-day work. Because there has been a lack of systematic means for bringing such useful information together and making it available to the entire highway fraternity, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize the useful knowledge from all possible sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series attempts to report on the 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 those measures found to be the most successful in resolving specific problems. The extent to which they are utilized in this fashion will quite logically be tempered by the breadth of the user's knowledge in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be of special interest and usefulness to maintenance engineers and others seeking information on methods for improved record keeping for highway maintenance expenditures. Detailed information is presented on recording and reporting systems used by highway agencies.

Administrators, engineers, and researchers are faced continually with many highway problems on which much information already exists either in documented form or in terms of undocumented experience and practice. Unfortunately, this information often is fragmented, scattered, and unevaluated. As a consequence, full information on what has been learned about a problem frequently is not assembled in seeking a solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of synthesizing and reporting on common highway problems. Syntheses from this endeavor constitute an NCHRP report series that collects and assembles the various forms of information into single concise documents pertaining to specific highway problems or sets of closely related problems.

Many state and local governments are now facing highway maintenance expenditures that have reached the limits of available sources of funds. Efficient operations must be identified and implemented in order to reduce the rate of escalation of maintenance costs. Success will depend to a great extent on the adequacy of maintenance records available to a highway agency. This report of the Transportation Research Board describes records and reporting methods that are employed in the highway maintenance field. The systems used by eleven states were studied. Recommended features for recording and reporting systems are outlined, and research needs are discussed.

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 state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researchers 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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Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of George M. Briggs, Director of Maintenance Division, New York State Department of Transportation; Paul E. Cunningham, Chief, Maintenance Branch, Office of Highway Operations, Federal Highway Administration; Kenneth J. Davis, Assistant Maintenance Engineer, Nevada Department of Highways; Gerald L. Ray, Assistant Maintenance Engineer, Louisiana Department of Transportation and Development; Stephen N. Runkle, Research Analyst, Virginia Highway and Transportation Research Council; Raymond A. Zink, Maintenance Engineer, North Dakota State Highway Department.

Adrian G. Clary, Engineer of Maintenance, Transportation Research Board, assisted the Special Projects staff and the Topic Panel.

Information on current practice was provided by many highway agencies. Their cooperation and assistance was most helpful.

RECORDING AND REPORTING METHODS FOR HIGHWAY MAINTENANCE EXPENDITURES

SUMMARY

The basic components of a maintenance management system include maintenance standards, inventory of facilities, maintenance work load, budgeting, planning and scheduling, and a management information system. The information system, which is the subject of this report, provides the basic information needed by operating managers for routine decisions and by top management for program control and improvement. The system contains data recorded at the field level and reports, generated by computer, that assemble and analyze the data. The types of reports generated should fit the end use of the report at a particular management level.

State highway maintenance organization structures vary widely. Thus no two of the eleven states studied for this synthesis have identical recording and reporting systems.

There are two types of recording systems. The single recording system uses one procedure for reporting both maintenance management information and payroll and accounting information. The parallel recording system uses separate reports for this information. The advantages of a single system over a parallel system include minimization of field records, less manpower to prepare management and fiscal information, no need for additional clerical help, and easier reconciliation of fiscal and management data. Disadvantages include difficulty of changing existing fiscal systems to accommodate management information, differences often resolved in favor of fiscal matters, and computer priority given to fiscal information.

Work location is recorded to the milepost in some states, but most record only highway segment. Although precise location is not necessary for some maintenance activities, it would be very helpful for certain activities, such as those associated with the pavement structure. This would allow maintenance data to be correlated with other data recording systems, including condition surveys, skid studies, accident reports, photologging, etc.

Time (in man-hours) is recorded by each individual in some states. In other states the crew leader reports for the crew by individual or for the crew as a whole. Equipment use is recorded by the mile for small vehicles and by the hour for larger equipment. Material quantities are also recorded in most states. Some obtain this information indirectly by applying performance standards to an accomplishment report.

Field records are filled out daily and transmitted to the district office. Keypunching is done at the district if a remote terminal is available; otherwise data are mailed to the central office. Delay time between submitting data and receiving reports range from 14 to 60 days with 20 to 30 days most common.

About one-half of one percent of a maintenance budget is expended on maintenance recording and reporting.

Reports produced from field data are quite numerous and varied. Because of the ease of producing reports with a computer, it is not uncommon for an agency to

produce too many to be useful. Reports should be tailored to the specific needs and requirements of the management level that will use them. Some are produced at regular intervals (weekly, monthly, annually), others only when requested. The types of reports generally fall into the following categories: audit, inventory, planning, equipment use, performance, budget control, special analysis, and exception reports.

Reliability of the recorded and reported data appears to be satisfactory. Training programs have been used extensively to improve recording accuracy and to promote an understanding of the system.

Among the recommendations are:

- A recording and reporting system must first of all provide for the internal management needs of the maintenance organization.
- The system should have the capability of furnishing maintenance information to the pavement management system and other management systems.
- The recording system must stress accuracy of information.
- Reports for district and central offices should be prepared monthly, with year-to-date totals.
- A standing committee on maintenance standards or maintenance management should exist in each state.

Research needs include determination of the optimum recording method and amount of data that can be accurately recorded, methods of reducing lag time between submission of data and receipt of reports, development of compatible data systems, and examination of the quality of information available through the systems.

CHAPTER ONE

INTRODUCTION

Thirty-nine states and several cities and counties have adopted or are in the process of adopting maintenance management systems (*1*, *2*). The basic components of these systems include maintenance standards, inventory of maintainable facilities, maintenance work load, budgeting, planning and scheduling, and management information systems (*3*).

The purpose of developing maintenance standards is to formally establish criteria for determining the need for work, the required quality of work, and the resources necessary to achieve that quality and expected productivity rate. Maintenance standards are developed for those maintenance activities that consume a large portion of the maintenance budget. Usually, at least 95 percent of maintenance expenditures can be defined by maintenance standards *(4)*.

Three types of maintenance standards can be identified: quality standards, quantity standards, and performance standards. Quality standards describe the results to be achieved in terms of the attendant conditions of the highway or in terms of a specific frequency of performance. They may also be expressed in terms of the specific amount of work to be done per unit of highway or the thresholds at which certain maintenance activities should be carried out. Quality standards should represent policy decisions by top management regarding the "level of service" to be provided by the highway system. Quality standards are generally thought of as subjective measures, although many (for example, mowing height or shoulder drop-off) are objective in nature.

Quantity standards, sometimes called frequency standards or work-load rates, identify the amount of work, by activity, set as a standard for a given class of highway or type

of pavement in order to sustain the facility at a particular level. These standards are usually set by policy, judgment based on past experience, historical data, or a combination of these factors. Quality standards, when stated in terms of work to be performed, become quantity standards. Quantity standards usually reflect annual resource requirements needed to attain quality standards.

Performance standards usually outline methods of performing maintenance activities and the rate at which work is to be accomplished. These standards describe work methods to be used in performing the activity; the optimum crew configuration in terms of the numbers and classification of labor; the types and numbers of equipment units; the amounts of material required per unit of work accomplishment; the unit of measurement to define accomplishment; and a standard average productivity rate for the maintenance activity described.

Highway agencies need information to formulate and evaluate policies, to plan and design highways, and to administer the construction, maintenance, and operation of the highway facility. Roadway inventories are part of the basic information that is required to accomplish these tasks. Lane miles of highway pavement by type, bridges, drainage facilities, roadside maintenance features, rest stops, and buildings are types of information that are collected. Inventory data should be collected with the end use of the data in mind. One of these end uses is formulation of the maintenance work load.

Work load is determined by the quantity of elements of the highway to be maintained, the environmental and traffic conditions under which they are to be maintained, and the level to which they are to be maintained. Examples of work-load values include quantity of paving material to be placed per lane mile of highway, and the number of times per year that right-of-way is to be mowed.

The maintenance budget should accurately reflect the proposed maintenance program. A program-oriented or performance budget is expressed in units of work to be accomplished by the various maintenance activities being programmed. The budget is achieved by developing a program of work units to be accomplished by the desired maintenance administrative subdivision and applying the appropriate unit costs to the work unit. Costs are determined from work units by use of performance standards together with standard rates of labor use and equipment rental, material unit costs, and standard production rates. The budget must also include all items to be performed by outside contract as well as those being performed by the maintenance force itself.

The basic tools used in planning and scheduling include the following:

1. A seasonal schedule of maintenance activities, which provides a general planning framework.
2. A yearly schedule of maintenance activities, often prepared during budget preparation.
3. Weekly, biweekly, or monthly crew scheduling performed by the crew leader or foreman, or a maintenance section supervisor.

The establishment of a maintenance information system that provides the information required by operating managers for routine decisions and by top management for program control and improvement is a vital element of the maintenance management system. Accurate information must be recorded and assembled for easy and timely interpretation. The basic information required must be recorded at the field level, with the individual worker or crew leader usually performing this function. Reports can be quickly assembled and analyzed through the use of electronic data processing equipment. The types of reports generated should fit the end use of the report at a particular management level.

It is the maintenance information system and, in particular, the recording and reporting components of the maintenance management system that are the subject of this report. Bridge maintenance has not been included.

It is worth a digression to delineate the position occupied by the reporting and recording components of the maintenance management system. To use one state as an example, the Washington State Maintenance Control System allows the Washington State Department of Highways to identify the specific maintenance needs in terms of work requirements, unit costs, and levels of service; to schedule and control maintenance activities; and to evaluate productivity. It is intended that the system will result in the most economic use of manpower resources, materials, and equipment to provide the over-all maintenance function. As shown in Figure 1, the Washington system is based on a "Plan"-"Do"-"Compare" premise. The recording system in part forms the link between the "Do" and "Compare" elements, and the reports form the link between the "Compare" and "Plan" elements (*4*). This system is not unique with Washington but, in one form or another, is the basic format used by many states.

The work plan to develop the information contained in this report consisted of personal visits to 11 highway agencies and a review of the limited literature available on the specific subject. State highway officials in California, Hawaii, Illinois, Louisiana, Minnesota, Nevada, North Dakota, Pennsylvania, Tennessee, Washington, and Wyoming were interviewed. References (*5*) through (*8*), which include the workshops on Maintenance Management sponsored by TRB-AASHTO, were useful in preparing the synthesis. A review was made of the recording and reporting systems, as documented in the literature, of Virginia, Washington, and Ontario (*6*); Rhode Island (*8*); and Kansas (*9*).

Typical characteristics of the states visited are given in Table 1. [Appendix A includes a detailed description of the Nevada recording and reporting system. A similar coverage of the other states in Table 1 is given in Ref. (*11*).] Table 1 was prepared to illustrate the variation in size of the maintenance program in relation to the roadway network of the various states visited. The maintenance costs per lane mile of maintained highway can be expected to vary considerably. For example, the highways maintained by the California Division of Highways are mostly Interstate and pri-

mary highways with considerable traffic, whereas those maintained by other, more rural states are largely farm-to-market highways. In addition, the maintenance budget in one state may include betterment projects and in another state may not.

State highway organizational structures also vary widely among the states. [See Table 2; maintenance personnel titles may be obtained from Ref. (*2*).] As noted, a great deal of difference exists in organization and titles of those individuals responsible for the management of the organizational unit. It is, therefore, not surprising that no two states studied for this synthesis have identical recording and reporting systems. Common features of both data recording and reporting techniques for the various states are outlined in the following chapters.

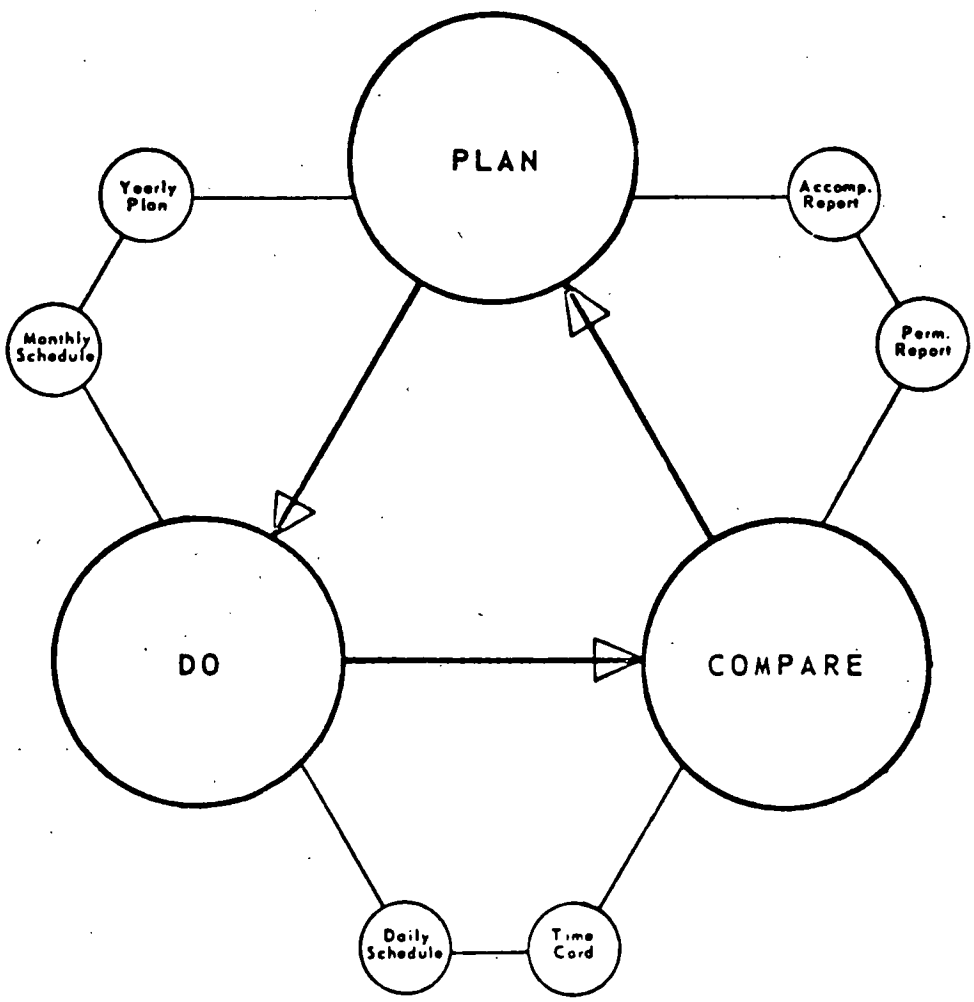

Figure 1. Maintenance control system goal (3).

TABLE 1

GENERAL INFORMATION FOR INTERVIEWED STATES (*2, 9, 10*)

State	Annual Maintenance Budget (Dollars)	Lane Miles of Highway	Approximate Cost Per Lane Mile	Population	Motor Vehicles	People Per Vehicle	Maintenance Cost Per Vehicle ($/year)	Area of State, Square Miles	Range of Annual Average Moisture, Inches	Temperature Extremes, Average Cold and Hot Month, °F	Range in Elevation, Feet
California	153,000,000	45,000	3,400	20,601,000	13,413,000	1.5	11.40	158,693	4-96	8-116	-282 to 14,494
Hawaii	10,000,000	2,200	4,550	832,000	477,780	1.7	20.90	6,450	10-450	63-86	0 to 13,796
Illinois	79,000,000	38,000	2,100	11,236,000	5,952,000	1.8	13.30	56,400	32-48	14-90	279 to 1,235
Louisiana	86,000,000	36,225	2,400	3,764,000	2,057,000	1.8	41.80	48,523	48-64	36-94	-5 to 535
Minnesota	53,000,000	29,000	1,800	3,897,000	2,452,616	1.5	21.60	84,068	20-32	-8-88	602 to 2,301
Nevada	15,500,000	11,794	1,300	548,000	437,000	1.2	35.50	110,540	4-28	4-110	470 to 13,143
North Dakota	14,350,000	15,160	950	640,000	490,000	1.3	29.30	70,655	14-20	-10-88	750 to 3,506
Pennsylvania	201,000,000	75,559	2,660	11,794,000	6,800,000	1.7	29.50	45,333	36-52	14-88	0 to 3,213
Tennessee	38,485,000	23,500	1,600	4,126,000	2,467,000	1.6	15.40	42,244	40-76	22-92	182 to 6,643
Washington	40,000,000	17,000	2,400	3,429,000	2,370,000	1.4	16.90	68,192	8-120	8-92	0 to 14,410
Wyoming	17,000,000	14,620	1,160	353,000	294,000	1.2	51.00	97,914	8-56	-8-92	3,100 to 13,804

1 lane mile = 1.6 lane km $1000 per lane mile = $625/lane km

1 sq mi = 2.59km^2 1 in. = 25.4mm 1 ft = 0.3084m

TABLE 2

STATE ORGANIZATIONAL STRUCTURE AND EMPLOYEE TITLES

State	State Maintenance	Assistant State Maintenance Engineer	District Engineer	District Maintenance Engineer	Assistant District Maintenance Engineer	Resident Maintenance Engineer	Area Supervisor	Gang Foreman	Sectionman
California	Chief Office of Maintenance		District Director of Trans.	Deputy District Director Systems Operations	District Maintenance Engineer		Super-intendent	Super-visor	Lead Worker
Hawaii	Chief Highway Division	Asst. Chief Const. and Maint.	District Engr.	Dist. Maint. Engr.			Hwy. Const. and Maint. Supt.	Hwy. Const. and Maint. Supervisor	Supervisor
Illinois	Engr. of Maintenance	Maintenance Section Chief	District Engr.	District Maintenance Engineer		Maintenance Field Engineer		Lead Worker	Highway Maintenance Man
Louisiana	Chief Maint. and Oper-ations Engr.	Bridge Road Maint. Engr.	District Engr.	Assistant Dist. Engr. for Maint.	Assistant Dist. Maint. Engr.		Super-intendent	Foreman	
Minnesota	State Maintenance Engineer	Road Services Engineer	District Engineer	Area Maintenance Engineer	Maintenance Operations Engineer	District Methods Engineer	Hwy. Maint. Supt.	Hwy. Maint. Foreman	Highway Maintenance Worker
Nevada	Chief Maintenance Engineer	Assistant Maintenance Engineer	District Engineer		Assistant Dist. Engr. for Maint.		Highway Maint. Supt.	Senior Hwy. Maint. Foreman	Highway Maintenance Foreman
North Dakota	Maintenance Engineer	Assistant Maintenance Engineer	District Engineer	Assistant District Engineer			Maint. Supt.	Foreman	Leadman
Pennsylvania	Director, Bur. of Maintenance		District Engineer	District Maintenance Engineer	Assistant Dist. Maint. Engineer		Hwy. Maint. Supt.	Hwy. Foreman	
Tennessee	State Maintenance Engineer	Assistant Maintenance Engineer	Regional Engineer	Regional Maintenance Engineer	Assistant Reg. Maintenance Engineer	District Maintenance Engineer	Foreman II	Reg. Maint. Supt.	Foreman
Washington	Asst. Dir. of Hwys. for Maintenance	Assistant Maintenance Engineer	District Engineer	District Maintenance Engineer	Assistant Dist. Maintenance Engineer	Highway Maint. Supt.		Br. Maint. Lead Tech.	Maint. Lead Tech.
Wyoming	State Const. and Maint. Engineer		District Engineer	District Maintenance Engineer			Highway Foreman II	Highway Foreman I	

CHAPTER TWO

RECORDING SYSTEMS

The key to the control and improvement of an ongoing maintenance management system is the use of assembled information. Data concerning manpower, material, and equipment are obtained for specific maintenance activities and, frequently, on specific roadway segments. The major portion of these data is recorded in the field by the individual maintenance employee or the work-crew leader. The recorded information is then used for developing maintenance management reports or accounting reports or both. If a single reporting procedure is used for both maintenance management and for payroll and accounting information, it is called a "single recording system." If separate reports are filled out by field personnel, the term "parallel recording system" is used to describe the reporting system.

SINGLE VS. PARALLEL RECORDING SYSTEMS

Of the states surveyed, five states used a single recording system approach and six states used the parallel recording system (Table 3). For the single recording systems, reports were filled out by the individual employee or by crew leaders. Field work activities for all parallel recording systems except in Washington were filled out by the crew leader or his equivalent. Forms in the states of California, Nevada, and Wyoming reported labor for the crew as a whole. Individual crew members were not identified. The states of Hawaii and Tennessee assigned labor use to individual workers.

The advantages and disadvantages of single and parallel recording systems have long been debated. The obvious advantage of the parallel recording system is that improved data accuracy for maintenance activities should be obtained by removing the data recording task from the individual employee and placing it with the crew leader or foreman. The converse of this argument is that the individual employee will take great care to record work-time spent to assure that he is paid for all hours worked.

If maintenance management and fiscal reporting are integrated into a single field source record, the following advantages have been advanced:

1. The number of input documents in the field is minimized.
2. Little additional manpower is required to prepare both management and fiscal information if on the same input form.
3. Because the maintenance performance reports are computer processed along with the fiscal reports, no additional clerical help is needed at any level to process the information.
4. Fiscal information can be easily obtained from the same input record for management reporting.
5. Fiscal and management input data can be more easily reconciled if obtained from the same record.
6. Fiscal data can be more easily used for budget development.

The disadvantages of using a single recording system originally developed for fiscal purposes are as follows:

1. Most fiscal accounting procedures were established a number of years ago. If the management needs are to be integrated into the accounting procedures, changes must be made in the accounting systems. These changes are usually resisted.
2. Differences involving fiscal matters and management matters are often reconciled in favor of fiscal considerations.
3. Fiscal matters receive priority computer time. Thus, management reports derived from fiscal documents are often prepared weeks after the end of the reporting period.

It is also argued that the number of recording forms required by a parallel system may be excessive. It is of interest to note, however, that in one state the actual number of line entries was reduced by revising the old single recording system and subsequently developing a parallel recording system.

With the exception of North Dakota and Pennsylvania, most of the more recent recording systems have been parallel recording systems using crew leaders or foremen to record the information. In North Dakota, the individual maintenance employee fills out the "Maintenance Time Card"; however, information on this form is transferred to additional input forms titled "Employee Time Distribution Sheet," "Vehicle Use Report," and "Disposal Report," all of which are filled out at the district level by clerical employees or by warehouse employees. The North Dakota system thus exploits some of the advantages of both the single and parallel recording systems.

Three of the 11 states interviewed also use centralized clerical personnel to transfer basic field input information to summary forms. The states of Louisiana and Tennessee use centralized clerical staff to transfer information from the daily basic input form to summary-type biweekly forms, and Minnesota uses additional input forms for reporting on hired equipment and requesting and issuing stock.

WORK LOCATION

The variation encountered in recording maintenance work location for the 11 states interviewed is given in Table 3. It should be noted that three states (California, Nevada, and Wyoming) report the work location to the milepost or between mileposts as required for specific maintenance activities. A fourth state, Washington, is considering recording location information to this same detail. Eight of

11 states identify location to a particular highway segment, the length of which may vary considerably.

It has been charged that reporting by milepost may entail a degree of precision that is unwarranted (*10*). For example, the following problems have been identified by states that have attempted to maintain a precise milepost identification with each maintenance activity:

1. It is difficult to accurately record many activities in this detail.
2. The reports prepared by specific location are too voluminous to be useful.
3. The number of work occurrences actually related to a specific work location (milepost or highway segment) are so limited that analyses of the data are inconclusive.
4. A great deal of time is misdirected through attempts to analyze the detailed data, causing more important issues to be overlooked.

It is fair to state, however, that most of these problems

TABLE 3

STATE RECORDING SYSTEMS

State	Type of Reporting System	Basic Field Input Data Recorded By	Data Recorded For	Basic Field Input Form Title	Additional Input Forms
California	Parallel	Supervisor of Crew	Crew For Crew as Whole	Maintenance Daily Report	
Hawaii	Parallel	Foreman of Crew	Crew By Individual Crew Member	Daily Maintenance Report	
Illinois	Single	Individual Employee	Individual	Maintenance and Traffic Time Card	
Louisiana	Single	Foreman of Crew	Crew By Individual Crew Member	Daily Work Report	Biweekly Activity Report
Minnesota	Single	Individual Employee	Individual	Uniform Time and Cost Report	Time Report Requisition and Distribution Sheet
Nevada	Parallel	Foreman of Crew	Crew For Crew as Whole	Activity Report	
North Dakota	Single	Individual Employee	Individual	Maintenance Time Card	Employee Time Dist. Sheet Vehicle Use Rp Disposal Rpt.
Pennsylvania	Single	Foreman of Crew	Crew By Individual Crew Member and By Individual	Crew and Individual Daily Project Time Record	
Tennessee	Parallel	Foreman of Crew	Crew By Individual Crew Member	Crew Day Card	Maintenance Activity Summary
Washington	Parallel	Individual Employee	Individual	Maintenance and Shop Labor Reporting Form	
Wyoming	Parallel	Lead Man of Crew	Crew For Crew as Whole	Maintenance Activity Record	

arise because the milepost identification system has been implemented without sufficient advance planning. Consequently, instead of merely obtaining data on required activities and storing these data for special use reports, all activities have been reported, and locational identification has been integrated throughout the reporting system with undesirable detail.

Notwithstanding this, a strong case can be made for more precision in recording the location of certain maintenance activities, such as those associated with the pavement structure. In this instance, precise information is essential to the development of a predictive capability for future planning. Additionally, this would allow most states that have other recording systems that use precise locational information to be compatible with maintenance recording systems. The recording systems used by the various states include roadway sufficiency index (condition surveys), skid trailer surveys, accident reporting systems, photologging, pavement serviceability index (or pavement rideability index), and maintenance scheduling system. With the exception of the maintenance scheduling system, these systems identify location by milepost and also by lane.

Location Identified	No. of Maintenance Activities	Manpower Report Unit	Equipment Reporting Unit	Materials	Accomplishment	Data Recording and Reporting System Implemented	
District (11) Superintendent's Territory Supervisor's Crew County Route Post Mile	470	0.5 hr			X	1971	California
District (4)	36	hour	mile or hour	X	X	1969	Hawaii
District (9) Maintenance Field Engineer's Team Sections Team Section (104) Subsection (Hwy. Segment)	49	0.5 hr	0.5 hr	X	X	1967	Illinois
District (9) Parish Gang (62) Parish System Control Unit (Hwy. Segment)	124	0.5 hr	mile or hour	X	X	1969	Louisiana
District (9) Maintenance Area (16) Sub-Areas (76) Control Section Numbers (Hwy. Segment)	Numerous	hour	mile or hour	X		1950's	Minnesota
District (6) Maintenance Station (70) County Highway Milepost	72	hour	mile or hour	X	X	1974	Nevada
District (8) Highway Section (Hwy. Segments)	63	hour	mile or hour	X	X	1971	North Dakota
Engineering District (11) Maintenance District (67)	218	0.5	mile or hour		X	1972	Pennsylvania
Region (4) District (23) County (95) System	71	hour	mile or hour	X	X	1971	Tennessee
District (6) Maintenance Division (31) Section (134) Control Section (Hwy. Segment)	373	0.1 hr	mile or hour		X	1968	Washington
District (5) Station (55) Route Section (Hwy. Segment) (409) Milepost	46	hour	mile or hour	X	X	1971	Wyoming

Certainly, from a management viewpoint the location should be identified by a milepost and preferably by lane for multilane highways. Another way to address this problem is by use of special study sections throughout the highway system. Illinois' system, to a degree, is an example of this approach.

Table 3 indicates that a number of different techniques are used to record location. In all states except Hawaii and Pennsylvania, the district and its first subdivision are recorded. Data are recorded so that "cost control centers" can be defined for reporting purposes. These cost control centers are normally under the jurisdiction of a supervisor or foreman.

No state identifies the location of the maintenance activity to the lane. This information would be useful to answer questions concerning both the maintenance cost of the travel lanes as opposed to the passing lanes and the damage caused by trucks traveling loaded in one direction and unloaded in another direction. Additionally, such information would be most beneficial for those types of facilities that have widely different maintenance demands. As a case in point, it is not unusual to find four-lane divided highways with the lanes constructed at different times to be designed with different pavement thicknesses. Unquestionably, good, reliable maintenance information not only would prove to be an invaluable aid to highway design, it also would permit the designer to integrate realistic, anticipated maintenance costs into his design alternatives. Unfortunately, design engineers have not generally expressed a strong demand for this information—perhaps because they do not know what can be made available to them. Maintenance engineers, on the other hand, are reluctant to generate more detailed information until someone has expressed a need for it.

Identification of where the maintenance is performed on the right-of-way is usually adequately defined by the maintenance activity codes. However, these codes, in general, are not sufficiently detailed to differentiate between work performed on flexible as opposed to rigid pavements, and, even though individual activity codes exist for maintenance activities characteristic of flexible and rigid pavements, improper assignment of maintenance cost by pavement type may result. An additional difficulty arises when a portland cement concrete pavement is overlaid with a bituminous material. It is usually not clear whether flexible or rigid maintenance activity codes should be used, although, in road-life studies, such pavement is customarily classed as flexible. If a detailed inventory system exists, it may not be necessary to have activity codes for pavement type.

TABLE 4

MAJOR GROUPINGS OF MAINTENANCE ACTIVITIES (WYOMING)

1.	Surface maintenance
2.	Shoulder and side approach
3.	Roadside and landscape
4.	Drainage
5.	Structures
6.	Snow, ice, and sand control and removal
7.	Traffic services
8.	Rest areas and parks
9.	Maintenance houses
10.	General

ACTIVITY

Maintenance activities are defined by function codes or maintenance activity codes. The number of codes used by a particular state varies from about 40 to in excess of 400, although the trend is toward reducing these numbers. Maintenance performance standards often exist for the maintenance activities. Major groupings of maintenance activities are similar to those identified in the AASHTO accounting manual (*12*) and used by Wyoming (see Table 4).

Special function codes or types of coding can be used to identify specific categories of maintenance, such as betterment, special, extraordinary, and emergency, to name a few. The California system codes and reports support activities including travel, haul, flagging, other traffic control, delays, special equipment operation, and additional equipment operation. Minnesota uses maintenance operations numbers, accomplishment numbers, maintenance account numbers, and commodity numbers to define maintenance activities in great detail. Tennessee uses such categories as special authority, overhead, routine variable, routine limited, and routine unlimited. Among other factors, this categorization is based on the likelihood that the activity described will remain within its programmed use.

MANPOWER

Individuals report their own time, or crew leaders or foremen report man-hours for the individual (Table 3). In most cases where a single recording system is used, the individual reports his own time. In the parallel recording systems two different methods are used. In some states, the crew foreman or leader reports for the crew by individuals; in others, a combined report is used for the crew as a whole. The Nevada system is unique in that the number of employees in the crew is reported together with the regular and overtime hours worked by each employee. The total crew hours are determined during data processing.

As indicated in Table 3, of the states interviewed, California, Illinois, Louisiana, and Pennsylvania report man-hours to the nearest 0.5 hr and Washington reports to the nearest 0.1 hr. All other states report to the nearest whole

hour. Entries are normally made on the basic time card for regular and overtime work. Special codes can be used to identify time off for, for example, vacation, sick leave, holiday pay, jury leave, and military leave. Some reporting systems require start and stop times for individual employees. Travel time to the job is charged to the maintenance activity, although some states have special codes to identify this time. Times for supervisory personnel are usually charged to special codes.

Differences in the level of precision and accuracy between the single and parallel recording systems were difficult to identify. It was not apparent that the single recording system, which is accounting-oriented, was more precise in accounting for all time worked; nor did the data from the states with parallel systems indicate that less accuracy was maintained in the dual system.

EQUIPMENT

Equipment used for a particular function is recorded on all of the basic field-input documents. Its use is charged by the mile for small passenger types of vehicles (cars, pickups, and station wagons) and by the hour for larger pieces of equipment (Table 3). Some states report only the actual times a piece of equipment is in use, whereas others report the time the equipment is located on the job site. For example, if a piece of equipment (such as a travel vehicle, standby vehicle, or piece of specialty equipment) is at the job site and idle, it would not be reported as being in use by one recording system (California and Wyoming). It would be reported in use and charged to the job by the other recording system (Illinois and Louisiana); in these latter states, any piece of equipment located on the job site is considered to be in use because it can not be used for another activity away from that site.

Equipment downtime can be accounted for in most of the recording systems. Downtime can be coded, as necessary, to either shop repair or field repair in some systems.

Equipment identification is by class, by equipment number, or by class and equipment number. Equipment use rates are determined by class and, in some cases, by individual piece of equipment. In other words, data are recorded that report equipment use identified either by class or by individual piece and, as previously stated, to the nearest hour or mile. Thus, it is presupposed that the data collected will improve equipment management or highway maintenance functions, or both. It has been suggested that this logic should be questioned if the agency has a performance-based program and budgeting system because (1) the maintenance work program for each basic management unit has been defined in quantitative terms and (2) the necessary resources in terms of the amounts and types of manpower, equipment, and material have been defined and allocated. Further, the equipment data that are valuable within the performance budgeting system concern the percentage of time equipment is under repair and not available for use (*10*).

It should be noted that this reasoning presupposes that all maintenance activities are carried out according to the prescribed allocations. However, in actual practice, it is not always possible to perfectly match activities to allocations; thus, data on equipment use will be of value even within performance budgeting systems. Such data will provide both overutilization and underutilization information that is useful in performance evaluation as well as in future budgeting. Equipment management systems are the subject of another synthesis (Topic 8-08); an FHWA pooled-fund HPR study of equipment management is also currently under contract. For more detail, references should be made to those studies.

MATERIALS

Materials are usually assigned to a maintenance activity as they are used. The quantity of material is normally given to the nearest whole reporting unit, except in Tennessee, which records to the nearest 0.1 unit. The unit of measure is that used to report accomplishments and productivity as obtained from the maintenance performance standard.

The types and quantities of materials used for a particular maintenance activity are not recorded in the California and Washington systems but are obtained indirectly from the accomplishment report by use of the performance standard (Table 3). Illinois, Minnesota, and North Dakota do not record material quantities on their basic field-input forms; this information is recorded centrally by warehouse clerks or central office clerks. When material types and quantities are recorded, material class codes are normally used. The appropriate unit of measurement for the materials as well as the quantities of materials in each code are recorded. The Nevada system is an excellent example of an acceptable materials reporting system (see Appendix A).

Material stockpile activities are used by some states. Wyoming has a detailed system for coding stockpiling activities and location.

ACCOMPLISHMENT

Accomplishments in terms of productivity units, as obtained from maintenance performance standards, are recorded for most maintenance activities. Tons or cubic yards of materials placed are common accomplishment units. Accomplishments for specific maintenance activities can be converted to man-hours, type of equipment and material use, and quantities, provided accurate performance standards exist. If accurate average-cost information exists, then quantities can be used to furnish cost information.

The recording of accomplishments also can be obtained indirectly from a report of the material quantities used for the maintenance activity. This shortcut system requires an accurate set of standards and a close record of material assignments. Hawaii's system is an example of this approach.

CHAPTER THREE

COLLECTION AND PROCESSING OF RECORDED DATA

Once the basic field information has been recorded it must be collected, processed, and stored in order to be available for use. The exact procedure used by a state to collect and process its information will depend on the recording system it uses; the type, availability, and accessibility of its computer system; and the type of reporting system it has developed.

Each system, however, begins with the basic field-data form that is filled out daily by either the individual employee or the crew leader. In some states these are the only source documents used. In those cases, the information is assembled locally, checked for accuracy, and transmitted to the central office either weekly, biweekly, or monthly. If the state has a remote-terminal computer capability, the information is normally keypunched at the district office and transmitted to the state office through the terminal. Otherwise, it is mailed. For states with a single recording system the transmission of all maintenance activity information is generally keyed to the payroll cycle.

For states (such as North Dakota) that use additional input forms in a single recording system, the basic field-data card is forwarded to the district office each day. A clerk then prepares a time distribution sheet and a vehicle use report from the basic data. These data are then mailed to the state office each month.

In the California parallel system, a Maintenance Daily Report Form is filled out each day by the maintenance supervisor for his crew. This information is sent weekly to the superintendent's office for checking and approval. The information on the daily form is keypunched monthly and transmitted by remote computer terminal to the state office.

Delay, or lag time, between receiving the data and furnishing reports to the maintenance unit ranges from 14 to 60 days for reports produced by electronic data processing. There does not appear to be a great improvement in turnaround time through the use of remote terminals. Because

TABLE 5

COLLECTION AND PROCESSING OF RECORDED DATA

State	Basic Field Data Filled Out	Additional Input Forms Filled Out	Transmitted to Central Office	Form of Transmission	Lag or Delay Time, Days	Approximate Cost of Recording and Reporting System, % of Maint. Budget	Annual Data Processing Charges, Dollars
California	daily	not used	monthly	remote terminal	10-15	0.4	
Hawaii	daily	not used	biweekly	mail	60		
Illinois	daily	not used	biweekly	remote terminal	30	0.6	66,000
Louisiana	daily	daily	biweekly	remote terminal	30	0.4	100,000
Minnesota	daily	biweekly	biweekly	mail	45	0.5	60,000
Nevada	daily	not used	weekly	mail	20	0.2	9,000
North Dakota	daily	daily	monthly	mail	20	1.0	10,000
Pennsylvania	daily	not used	daily	remote terminal			
Tennessee	daily	biweekly	biweekly	mail	4-30		
Washington	daily	not used	monthly	remote terminal	15-24	0.3	80,000
Wyoming	daily	not used	weekly	mail	14	0.5	24,000

most of the states have centralized computer facilities, obtaining priority in the system appears to be a limiting factor. Payroll and fiscal operations of the state tend to take higher priority at the beginning of the month. Also, high-capacity computer systems tend to encourage the distribution of work load through the month in order to gain more uniform use of the system. As a consequence, some states manually prepare summaries of some of their more time-sensitive needs; Tennessee, for example, prepares a report that is available 4 days after the end of the reporting period.

Approximate costs for recording and reporting maintenance management information together with annual computer costs are given in Table 5. About one-half of 1 percent of the maintenance budget can be expected to be expended on data recording and reporting. Recording of data by individuals normally requires about 10 min per day. Recording of crew time by the crew leader requires about 30 min per day. Input data review by the supervisor or superintendent takes about 1 to 2 hr per pay period. Keypunching requirements are about 1 to 2 days per district and the correction of errors one-half to 1 day at the district level.

CHAPTER FOUR

REPORTING SYSTEMS

Automated data processing equipment can draw tremendous quantities of information from input files and display it in numerous reports, the detail and scope of which are limited only by the imagination of those requesting them. Because of the relative ease of production, it is not uncommon for reports to become too numerous to be useful. Thus, it becomes important to be continually reminded of the purpose of maintenance management reports.

The objective of maintenance management reports is to communicate a record of performed activities so that they can be compared with established or planned activities and to provide a basis for decision making in setting the next period's planned activities or objectives. On the basis of these general statements, the purpose of maintenance management reports can be expanded to include the functions outlined as follows:

A. Planning and Scheduling
   1. Schedule work.
   2. Prepare budget.
   3. Establish equipment rental rates.
   4. Predict future maintenance needs.
   5. Predict future rehabilitation needs.
   6. Optimize equipment replacement time.
B. Analysis
   1. Analyze expenditures.
   2. Review and/or compare performance of subdivisions.
   3. Evaluate research needs.
   4. Provide feedback to planning, design, and construction.
   5. Evaluate maintenance standards.
C. Control
   1. Maintain fiscal control.
   2. Monitor program execution (work progress).
   3. Optimize preventive maintenance program for equipment.
D. Allocation
   1. Allocate funds.
   2. Allocate manpower.
   3. Allocate materials.
   4. Allocate equipment.

It is apparent from this wide range of possible functions for maintenance reports that the reports should be directed or tailored toward a specific management level; for example, central office, district, section, or foreman. A management report should have a well-defined objective, accomplishments should be expressed in terms of measurable work, and timing of reports should meet the need of the manager for whom the report is prepared (*10*). Examples of the report needs of three levels of maintenance management (area superintendent, district maintenance engineer, and central office engineers) are summarized in the following paragraphs.

The superintendent, who is in charge of a district subdivision (such as an area, a parish, a county, or a section) and may be responsible for four or five crews, plans weekly or biweekly and schedules activities on a daily basis. The annual work plan is used as an over-all guide to prepare weekly activities. Because of these planning responsibilities, there is a need for both daily reports from which to control and schedule the next day's activities and weekly or biweekly reports to plan by the week. The superintendent can receive daily reports either verbally from the crew leaders or by review of their daily work records. It is reasonable to assume that this reporting system can not be automated.

The second report required by the superintendent is the weekly or biweekly report. It is possible to obtain a sum-

HIGHWAY INVENTORY SUMMARY
TEAM SECTION REPORT
SECTION 712

	SUB SECTION 128	SUB SECTION 129	SUB SECTION 140	SUB SECTION 185	SUB SECTION 156	SUB SECTION 370
SPECIAL SUBSECTION CODE	N	N	N	N	9	N
ROUTE NUMBER	S12800	S12800	S14000	S18500	S18500	S03700
MUNICIPAL OR RURAL CODE	R	R	R	R	R	R
COUNTY	FAYETTE	FAYETTE	FAYETTE	FAYETTE	FAYETTE	FAYETTE
CITY						
AVERAGE WIDTH OF RIGHT OF WAY-FEET	80	80	60	80	80	80
AVERAGE DAILY TRAFFIC - 100	18	18	10	9	15	8
TOPOLOGY CODE	1	2	2	1	1	1
SURFACE CODE	2	1	2	1	3	2
AVERAGE WIDTH OF PAVEMENT - FEET	24	18	20	18	20	24
LANE MILES - 8 FOOT WIDTH	0.0	0.0	0.0	0.0	0.0	0.0
LANE MILES - 9 FOOT WIDTH	0.0	20.5	11.4	37.1	0.0	0.0
LANE MILES - 10 FOOT WIDTH	0.0	0.0	5.4	0.0	17.7	0.0
LANE MILES - 11 FOOT WIDTH	0.0	0.0	0.3	0.8	0.0	0.0
LANE MILES - 12 FOOT WIDTH	5.3	0.0	0.0	1.4	0.0	13.8
LANE MILES-13&14 FOOT WIDTHS	0.0	0.0	0.0	0.0	0.0	0.0
LANE MILES-15 FOOT WIDTH	0.0	0.0	0.0	0.0	0.0	0.0
LANE MILES - VARIABLE WIDTH	0.0	0.0	0.0	0.0	0.0	0.0
LANE MILES OF RAMPS	0.0	0.0	0.0	0.0	0.0	0.0
CURBS,CURBS/GUTTERS,GUTTERS-100/FT	0	248	117	300	45	55
DRAINAGE STRUCTURES	0	38	4	63	27	39
HISTORICAL MARKERS	0	0	0	0	0	0
FULL ACCESS CONTROL	N	N	N	N	N	N
LANE MILES OF FRONTAGE ROADS	0.0	0.0	0.0	0.0	0.0	0.0
SEWERS - UP TO 36 INCH DIAM.-10/FT	0	0	39	47	0	189
SEWERS - OVER 36 INCH DIAM.-10/FT	0	0	0	0	0	0
DITCHES - PAVED - 100/FT	0	1	1	10	0	4
DITCHES - SOIL - MILES	5	16	16	34	17	12
SHLDRS - SURFACED,HIGH - MILES	0	0	0	1	0	0
SHLDRS-SURFACED,HIGH-AVG WIDTH-FT	0	0	0	10	0	0
SHLDRS - SURFACED,LOW - MILES	0	0	0	0	0	0
SHLDRS - SURFACED,LOW-AVG WIDTH-FT	0	0	0	0	0	0
SHLDRS - AGGREGATE - MILES	0	0	0	0	0	0
SHLDRS - AGGREGATE - AVG WIDTH-FT	0	0	0	0	0	0
SHLDRS - TURF - MILES	5	16	16	36	17	12
SHLDRS - TURF - AVG WIDTH - FEET	5	8	6	11	11	8
CULVERTS - CROSSROADS	8	33	24	51	26	28
CULVERTS - SIDE APPROACHES	21	73	93	238	105	51
ENTRANCES & SIDE APPROACHES	25	141	156	345	142	128
STRUCTURES - LINEAL FEET	0	351	287	326	192	107
NO. OF STRUCTURES - UNDER 100 FEET	0	4	2	8	1	0
NO. OF STRUCTURES - OVER 100 FEET	0	1	1	0	1	1
SPECIAL STRUCTURES - TYPE	0	0	0	0	0	0
SPECIAL STRUCTURES - AGE IN 19o7	0	0	0	0	0	0
SPECIAL STRUCTURES - LINEAL FEET	0	0	0	0	0	0
GUARD RAIL - STEEL PLATE - 10/FT	0	150	175	180	303	26
GUARD RAIL - CABLE GUARD - 10/FT	0	0	0	0	0	0
GUARD RAIL - o000 - 10/FT	0	0	0	0	0	0
FIELD ENGINEERS NUMBER	10	10	10	10	10	10
SUPERVISORS NUMBER	12	12	12	12	12	12
LANDSCAPING - INDIVIDUAL PLANTING	0	64	273	83	5	83
LANDSCAPING - MASS PLANTING-SQ YDS	0	37375	0	0	0	49860
LANDSCAPING - ACRES OF TIMBER	0	0	0	0	0	0
TURF ACRES	16	72	37	42	36	41
RIGHT OF WAY FENCE - MILES	0.0	0.0	0.0	0.0	0.0	0.0
REST AREAS - FLUSH	0	0	0	0	0	0
REST AREAS - PIT	0	0	0	0	0	0
REST AREAS - MINOR	0	0	0	0	0	0
WEIGH AND INSPECTION FACILITIES	0	0	0	0	0	0
PUMP HOUSE	0	0	0	0	0	0
WALLS, CRIBBING, AND RIPRAP-10/FT	0	0	0	0	2	0
EXPRESSWAY/INTERSTATE CODE	0	0	0	0	0	0

Figure 2. Inventory report (Illinois).

WASHINGTON STATE HIGHWAY COMMISSION

DEPARTMENT OF HIGHWAYS

YEARLY WORK PLAN - SKILL REQUIREMENTS

DISTRICT 10000

MONTHLY SKILL REQUIREMENTS (MANHOURS)

SKILL TITLE	SALARY RANGE	ACTIVITY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
HWY MT.MAN 1	19A	041	9099	8187	12413	15467	11550	5921	3795	9146	12288	10698	11516	11255	121335
HWY MT.MAN II	20A	041	1145	1154	1156	1580	835	197	44	437	516	1495	1416	1481	11456
HWY MT.LEADMAN	22A	041	628	613	807	447	200	378	209	607	835	607	1025	1093	7549
BRIDGE MT.MAN	20A	041	441	404	988	591	906	275	285	574	1470	1489	1862	5067	14352
BRIDGE MT.SPEC	24A	041	121	114	276	139	240	72	74	150	410	368	402	1345	3731
HWY EQP OPR II	22A	041	643	549	906	2053	1186	978	396	896	1519	1018	864	879	11786
HWY EQP OPR III	24A	041			86	466	426	71	2	42	163	151	113	13	1533
	ACT TOTAL		12077	11020	16632	20743	15443	7792	4805	11852	17201	15826	17198	21153	171742
ELECTRICIAN	21A	042	226	216	186	146	217	218	206	219	169	150	172	188	2316
HWY MT.MAN 1	19A	042	6060	6328	8389	8359	10550	10982	12501	9713	7219	8607	10312	7768	106788
HWY MT.MAN II	20A	042	8	9	20	27				3	42	60	51	29	249
HWY MT.SPEC	21A	042	433	556	424	310	282	182	195	222	302	447	749	706	5123
HWY MT.LEADMAN	22A	042	41	77	24						6	13	82	25	268
HWY MT.FOREMAN	24	042	1	2	1						1	1	1	4	11
BRIDGE TENDER	16A	042	1696	1696	1696	1696	1696	1696	1696	1696	1908	1908	1908	1908	21200
TRAF SIG TECH 1	19A	042	398	261	290	263	251	198	212	292	229	311	211	345	3251
TRF SIG TECH II	25A	042	435	300	331	283	302	248	215	335	265	337	226	369	3646
ELECT TECH I	19A	042	14	14	13	12	15	13	12	14	13	12	14	13	159
ELECT TECH II	24A	042	14	14	13	12	15	13	12	14	13	12	14	13	159
ELECT TECH III	25A	042	667	406	479	461	459	419	555	455	504	454	424	387	5564
HWY EQP OPR II	22A	042	131				360	781	1483	1004	512	522	156		4953
COOKS HELPER	17	042	91	80	80	80	80	201	201	201	221	100	80	80	1485
COOK	19	042	91	80	80	80	80	201	201	201	221	100	80	80	1485
CARETAKER	16	042	159	160	160	160	160	403	403	403	443	200	160	160	2970
	ACT TOTAL		10324	10299	12389	11892	14461	15555	17892	14782	12068	13234	14660	12075	159631
ELECTRICIAN	21A	043	39	19	19	61	17	27	49	27	17	59	17	32	383

Figure 3. Yearly planning report for a district (Washington).

mary of the previous week's report from an automated system. In all probability, however, this would require a remote terminal and a parallel recording and reporting system. It would also require a high priority at the central computer to assure its getting into the system each week. A manual reporting system is presently providing a biweekly "Work Performance Report" to the county supervisors in Tennessee.

The district maintenance engineer is in charge, among other responsibilities, of scheduling district-wide crews and, therefore, requires a reporting system similar to that described for the superintendent. Additionally, the district maintenance engineer must monitor the performance of field crews and superintendents in order to provide guidance and assistance when and where needed. Allocation of manpower, materials, equipment, and funds on a district basis also becomes the responsibility of this individual. Monthly reports are normally sufficient for the district maintenance engineer to perform management responsibilities.

The central office staff is usually concerned with long-term objectives and the development of the annual work program and budget for the entire state. Quarterly and annual reports may be required at this level of management.

From the interviews with the states it is apparent that a vast number of reports are presently produced by the state highway agencies for the various levels of management. For discussion purposes, the following types of reports can be recognized:

1. *Transmission and audit or error reports.* These reports are usually listings of all input data together with a listing of input errors in need of correction.

2. *Inventory reports.* These reports contain listings of the highway features that must be maintained (Fig. 2). They are essential to predict the maintenance requirements of the system. Not all states conduct inventories as a part of their maintenance management reporting system, but they do have access to inventories prepared in other parts of the state system.

3. *Planning reports.* These reports are prepared yearly or biannually in the central office, with input from the districts and district subdivisions. An example of a planning report is shown in Figure 3.

4. *Equipment use reports.* These reports, although not of primary interest to this study, are furnished by some states.

5. *Performance or work accomplishment reports.* These reports are usually prepared monthly, with both monthly and year-to-date performance totals reported. Planned quantities are usually displayed together with actual performed work units. The reported work unit is that used in the performance standard. It is not uncommon to display the performance standard for the maintenance activity. These reports are produced for the basic district subunit, the district, and the state as a whole. In some cases, these types of reports are detailed to the crew level.

6. *Budget or fiscal control reports.* These reports display cost data for labor, equipment, and materials as well as total costs for individual maintenance activities for the basic district subdivision, the district, and the state. Many fiscal control reports do not include planned expenditures as determined from planned work units.

7. *Analytical reports.* These reports offer full details on a given activity, a location, or data and are available routinely in many states. These types of reports should probably be prepared on request.

8. *Exception reports or reports that recognize crews, districts, etc., that are either above or below expected productivity standards.* These reports are not commonly produced in the states. Nevada, however, does have such a reporting system.

The majority of all reports reviewed for this synthesis are presented for a "work center" or "cost center" and displayed by maintenance function code. Monthly and year-to-date totals are most commonly displayed. Some reports, especially those for central office use to prepare budgets, are prepared quarterly and/or annually. Because of the varied nature of the numerous reports, the reader is encouraged to review individual state reporting systems with regard to the previously mentioned objectives and report classifications to obtain the detail desired. Additional information may be found in Appendix A and Reference (*11*).

CHAPTER FIVE

RELIABILITY OF RECORDING AND REPORTING SYSTEMS

Most of the states surveyed in this study are satisfied with the reliability of the reported information. Those that rely on the individual employee to record time devoted to specific activities believe that they encounter some errors in time assignment and that these errors are difficult to correct. Those states using crew leaders to record information rather than the individual maintenance employee believe that data reliability is improved. The three states using clerical staff to summarize the daily work reports probably have more accurate data reported than some of the other states.

All recorded data are reviewed by the employee's or crew leader's immediate supervisor. Clerical errors are normally eliminated by use of a computer audit routine. In Louisiana's audit program, which is unique, predetermined variance levels are established such that reported data are rejected if the calculated productivity for a particular maintenance activity is significantly in excess of or below the productivity standard. It appears that audit programs for rejecting inputs that are outside predetermined ranges of reasonableness are not difficult to incorporate in the computer programming.

Many states, including Nevada, have used extensive training programs to instruct field personnel in the use of the maintenance recording and reporting systems. A continuing training program is essential to the development of high-quality data. A formalized training program also should be followed up by personal visits and periodic checks on reported data. Most of the states that have formal training programs follow this procedure.

Changes in the maintenance recording and reporting system originate from the central office in all the states surveyed. These changes are normally the result of field recommendations or special studies conducted by the central office staff. Changes that are made normally coincide with the beginning of a fiscal year; however, some changes that were considered to be critical were initiated during the year. Some states have annual meetings of district and central office personnel to discuss the maintenance management system, whereas other states have no formal meetings.

Maintenance standards committees in some states meet regularly; in other states they meet only as the need arises. The majority of the states interviewed do not presently have standing committees on maintenance standards, although most states used such committees to prepare the original maintenance standards.

None of the states interviewed had a formalized procedure for bringing other elements of the department together with maintenance management for the purpose of evaluating the need for different types of maintenance experience data. The point has been made that the maintenance force is reluctant to develop additional design or construction-oriented data until someone expresses a need for that type of information—and yet, no formal mechanism has been established to acquaint other elements of the organization with the capabilities of the information system. Until such a mechanism is created, it appears that changes in existing recording and reporting systems will continue to conform to the internal requirements of the maintenance organization alone.

CHAPTER SIX

CONCLUSIONS, RECOMMENDATIONS, AND RESEARCH NEEDS

CONCLUSIONS

No two surveyed states have identical recording or identical reporting systems. State maintenance organizational structures differ, as do the methods of establishing the location at which the maintenance activity was performed. Both parallel and single reporting systems are used. Data are recorded either by the individual or the crew leader for the single reporting system, whereas the crew leader records for the crew as a whole or for the individual when parallel reporting systems are used.

All systems surveyed record labor in man-hours and equipment use in miles or hours. Material quantities are not recorded in all systems surveyed. Some obtained this information from performance standards by using the recorded accomplishments for the activity.

The basic field-data report is filled out daily. This information is checked by the immediate supervisor of the

individual filing the report and transmitted through the district office for processing and reporting. Keypunching is performed in the district office, and the data are transmitted by remote terminal from the district office in those states with terminal capability. Those without terminals send data to the state office for keypunching. Data are transmitted weekly, biweekly, and monthly to the central office. Delay, or lag time, between supplying the data and furnishing reports is most commonly 20 to 30 days. However, occasional delays of more than 30 days are not uncommon, and one state has a routine response time of 60 days. All reports except one, in Tennessee, are produced by electronic data processing. About one-half of 1 percent of the maintenance budget is expended on the maintenance recording and reporting system.

The types of reports produced are quite numerous but, for convenience, may be summarized into the eight broad categories of audit, inventory, planning, equipment use, performance, budget control, special analytical, and exception reports. Because of the speed of the computer and the relative ease of generating different treatments of the base data, a state may produce reports that have only limited usefulness. In the early stages of their system, many states have tended to produce very large numbers of reports. Upon later evaluation, many of them have drastically reduced the number they produce on a routine basis. Some that began as monthly reports, such as inventory reports and rest-area cost reports, are now issued on an annual basis. Others are prepared only when a particular need for the information exists. Most states now insist that a real need be defined before a report is prepared as a routine output of the reporting system.

The reliability of the recorded data and, thus, the reported data are acceptable to most of the states. Extensive training programs have been used to improve recording accuracy and to promote an understanding of the reporting system.

Changes in the maintenance recording and reporting systems originate from the central office. Field input is normally obtained before changes are made. Maintenance standards committees do not exist in all states, and no state surveyed has a formal procedure for bringing other elements of the department into the evaluation process.

RECOMMENDATIONS

A recording and reporting system must first of all provide for the internal management needs of the maintenance organization. The existing systems are designed toward this objective. However, it could, and should, provide broader capabilities as well. As a part of the total highway organization, maintenance can make available information that is essential to the efficient management of the system as a whole.

A recording and reporting system should have the capability of furnishing maintenance activity and cost information to the pavement management system or to the highway designer who is concerned with alternative life-cycle analyses. It should provide data for other management systems, such as for equipment and materials. It should provide comparable maintenance information for accident analyses, for skid trailer surveys, for photologging, and for evaluation of roadway quality reporting as in the sufficiency index and the pavement serviceability index.

In order to accomplish these objectives, it is necessary to record the location of certain maintenance activities to a milepost system or otherwise identify maintenance activities more precisely. The concept of special study sections is good, provided the selection process is performed adequately and maintenance practices are carried out in an acceptable manner. The use of a milepost system to record location provides great flexibility and capability and is the preferred approach. As conversion to the functional classification system is instituted, an even greater need for precise location is envisioned. The use of this milepost system will also allow the rational development of quality standards by combining road conditions and evaluation data with maintenance activity information. The recording system presently used by Nevada appears to supply the information desired. The California system is also good, although it does not include material quantities that are required for certain system development.

A desirable recording system must stress accuracy of information. The systems that obtain data input from the crew leader are considered to be more accurate than those relying on the individual employee to record the information. It is doubtful if the summary reports produced by district clerical staffs are necessary for data accuracy; however, they do supply a quick return of the manually developed reports. For those states with remote terminal capability, input data should be filled out daily, checked daily, and keypunched and transmitted to the central office by remote terminal biweekly. A biweekly accomplishment report should be processed at the central office computer and returned to the district within a day for use by the district subsection manager.

Reports for district staff and central office staff should be prepared monthly with year-to-date totals. The types of reports presently prepared by the Nevada system appear to be as desirable as those of any other state. An advantage of the Nevada reporting system is that several analytical reports can be received by request and thus are a valuable research, planning, and scheduling tool.

A standing committee on maintenance standards, or maintenance management, or both, should exist in each state. This committee should be composed of both central office and field personnel. Regular meeting times should be established to assure that the committee meets on at least an annual basis with provision for more frequent meetings if necessary. A separate meeting should be held at least once each year between the maintenance management staff and other executives of the department for the purpose of exploring needs for maintenance information, developing coordinated reporting formats, and developing needed special reports.

RESEARCH NEEDS

On the basis of the data reviewed for this synthesis, the following research appears warranted:

1. Pavement condition surveys, accident reports, skid surveys, and information from other roadway evaluation tools should be integrated into the maintenance planning and budget process.
2. Maintenance cost or activity data should be collected in such a way that a meaningful input can be made into the planning, pavement design, and construction processes as well as into the selection of various rehabilitation strategies.
3. The accuracy of recorded data should be determined by a careful field study to indicate the optimum recording method and to determine the amount of data that can be expected to be accurately recorded.
4. Methods should be studied to reduce report lag time as well as to determine the length of tolerable lag time for specific types of maintenance reports.
5. Research to develop compatible data systems should be undertaken to assure that resources expended to develop data in one area produce data that are fully usable in other areas of need.
6. Defining output in terms of work standards has been accomplished, but a need exists to more carefully design output in terms of public satisfaction. Many management decisions are based on empirical information; it would be helpful to learn more about the nature and utilization of this information at district- and central-headquarters management levels.
7. A computer simulation model of a highway maintenance operational unit should be developed to reflect the impact of changes in various management and operational policies on the productivity of the unit.
8. Research should be initiated to examine the quality of information made available through the recording systems. Particular attention should be paid to evaluating the extent to which recorded data reflect actual maintenance activities and needs by assignment area.

REFERENCES

1. KEEFE, R. A., "A Proposed Framework for a Maintenance Management System in Massachusetts." Presented at the TRB-AASHTO workshop on Maintenance Management, Las Vegas, Nevada (1975).
2. "Progress Report on Maintenance and Operations Personnel." Transportation Research Circular No. 183 (Jan. 1977).
3. BYRD, L. G., and BUTLER, B. C., "Maintenance Management Concepts." *Public Works* (Aug. 1974).
4. ANDERSON, D. R., "Maintenance Brief." Washington State Department of Highways (March 1975).
5. "Maintenance Management." *HRB Special Report 100* (1968) 204 pp.
6. "Maintenance Planning and Supervision." *Highway Research Record 347* (1971) 229 pp.
7. "TRB-AASHTO Maintenance Management Workshop Papers." Las Vegas, Nevada (July 7-9, 1975).
8. *State Highway Maintenance Cost Accounting Manual.* Rhode Island Department of Public Works (June 1966).
9. SHOFNER, G. N., "Cost Effectiveness Maintenance-Management Systems." *Transp. Eng. J., ASCE,* Vol. 102, No. TE2 (May 1976) pp. 331-46.
10. JORGENSEN, R. E., Personal correspondence with C. V. Wootan concerning NCHRP Synthesis on "Recording and Reporting Methods for Highway Maintenance Expenditures" (Oct. 22, 1975).
11. EPPS, J. A., ET AL., "The Development of Maintenance Management Tools for Use by the Texas State Department of Highways and Public Transportation." *Report No. 151-4F,* Texas Transp. Insti. (Dec. 1976) 162 pp. + App.
12. *Manual of Uniform Highway Accounting and Financial Management Procedures.* American Association of State Highway Officials (1970).
13. Roy Jorgensen Associates, "Performance Budgeting System for Highway Maintenance Management." *NCHR Report 131* (1972) 213 pp.

APPENDIX A

NEVADA DEPARTMENT OF HIGHWAYS RECORDING AND REPORTING METHODS FOR HIGHWAY MAINTENANCE EXPENDITURES *

INTRODUCTION

The 548,000 residents of Nevada operate 437,000 motor vehicles on 49,704 mi (80 000 km) of highways, of which 6,366 mi (10 250 km) are under state control. The state occupies 110,540 sq mi (286 300 km²) from an elevation of 470 ft (143 m) to 13,143 ft (4 006 m) above sea level. Mean minimum and maximum temperatures are 4 and 110 F (-16 and 43 C), with average annual moisture ranging from 4 to 28 in. (100 to 711 mm).

The Nevada Department of Highways has a $15,500,000 annual maintenance budget. This budget will be used by its six districts to maintain 11,794 lane-mi (18 980 km) of highway [5,486 center-line mi (8 830 km) of highway are maintained by the state].

The Nevada Department of Highways has six districts. Each district is divided into maintenance stations, requiring about 70 maintenance crews throughout the state.

Foremen are in charge at the maintenance station, with assistance from lead men. Foremen report to a supervisor, who is responsible for the activities of several foremen. The supervisor may or may not reside at the location of the district office. Maintenance supervisors report to the superintendent, who works out of the district office. The superintendent reports to the assistant district engineer for maintenance; the assistant district engineer, in turn, reports to the district engineer. The administration of the maintenance program for the state highway engineer of the Nevada Department of Highways is performed at the central office level by the maintenance engineer and his staff.

The basic maintenance recording and reporting system was developed in the 1972-to-1974 period with the assistance of a consultant. A parallel recording system is being used. Manual recording of data is practiced in the field; electronic data processing is used to compile and produce reports. Two years of reliable maintenance cost data are now available from the recording and reporting system.

RECORDING SYSTEM

Nevada Department of Highways Form NHD-034-012-10-72, an activity report, is used to collect maintenance activity information (Fig. A-1). The type of information obtained on this form includes:

1. Activity performed.
2. Location of activity performed.
3. Manpower used.
4. Equipment used.
5. Material used.
6. Accomplishments.

Information is coded daily on the activity report by the foreman for the maintenance crew. A discussion of the details follows.

Location

Each maintenance activity is performed at a specific location on the highway system. This location is designated by recording the following information:

1. *District.* A number from 1 to 6 is used to designate the district. This number is the first number of the three-character numeric code for the division code as shown on the activity report.
2. *Maintenance Station.* There are approximately 70 maintenance stations with an area of responsibility headed by a foreman. Foremen numbers, which are the last two numbers of the division code, are used to identify the maintenance stations.
3. *County.* The county is identified by use of the county designation shown on milepost markers. County abbreviations are used; for example, EL designates Elko County.
4. *Highway.* The highway is designated by a five-character alphanumeric code. The first two characters designate the highway system (IR for Interstate route and SR for state route). The final three characters designate the highway number; for example, Interstate Route 80 would be recorded as IR 080.

These data are recorded in the columns marked "System and Route or Special Facility." Special facility numbers are used for such items as rest areas.

5. *Milepost.* Begin and end mileposts, which designate the boundaries within which the maintenance activity was performed, are recorded. Items such as structures and interchanges are located by a single milepost entry. Mileposts can be reported to the nearest 0.01 mi.

Information is not recorded to show in what lane the maintenance activity was performed. Designation of the maintenance activity indicates if the maintenance action was performed on the pavement or shoulder for pavements of portland cement concrete only; however, maintenance performed on the pavement can be separated from other activities; for example, roadside activities and snow and ice control.

* The Nevada system is presented as an example of a maintenance recording and reporting method. Similar reports on the other ten states visited are available in Reference (*11*).

MAINTENANCE MANAGEMENT SYSTEM

STATE OF NEVADA
DEPARTMENT OF HIGHWAYS

MMS RPT I-1

ACTIVITY REPORT

DIVISION CODE [1 3]

WEEK ENDING _____, 19____

DATE	SYSTEM AND ROUTE OR SPECIAL FACILITY	ALTERNATE	COUNTY	INTERCHANGE, STRUCTURE OR BEGINNING MILEPOST	ENDING MILEPOST	ACTIVITY NUMBER	ACCOMP.	LABOR			MATERIAL		EQUIPMENT							HAUL
								NO.	R	OVT.	CLASS	QUANTITY	MILEAGE	CLASS	HOURS	CLASS	HOURS	CLASS	HOURS	
4	8	13	14	16	21	26 27	32	37	39	40	42	44	49	52	54	56	58	60	62	64 65

7032

The spaces below are provided to allow the Foreman to describe any activity that reflects any unusual accomplishment or unusual labor, equipment, and material. (Example: Accomplishment that greatly exceeds the standard; reported labor, equipment, and material with no accomplishment; material not included as part of the standard; etc.)

Date Comments:

_____ _____

_____ _____

_____ _____

_____ _____ _____ _____

Figure A-1. Activity report.

Activity

Maintenance activity codes designate the maintenance activity performed (see Table A-1). The 74 maintenance activities presently used are divided into 13 programs:

1. Planning and Scheduling.
2. Flexible Pavement.
3. Rigid Pavement.
4. Repairing Miscellaneous Concrete Appurtenances.
5. Roadside Maintenance.
6. Roadside Cleanup.
7. Roadside Facilities.
8. Roadside Appurtenances.
9. Traffic Service.
10. Snow and Ice Control.
11. Structure Maintenance.
12. Betterments.
13. Stockpile.

The activity codes are five-character numeric codes; the first three numbers indicate the program number and the last two numbers indicate the activity number. It

TABLE A-1

MAINTENANCE ACTIVITIES

6.1.0 Work Programs

PROGRAM NUMBER	ACTIVITY NUMBER		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 - Premix (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		RIGID 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. Yds.
	131.07	Unpaved Shoulder Slope Maintenance (Blading)	Shoulder Miles
	131.08	Vegetation Control (Mowing, Flailing, Burnings, Etc.)	Shoulder Miles
	131.09	Vegntation 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	
	134.01	Maintenance of Rest Stops	Man Hours
	134.02	Maintenance of Roadside Parks	Man Hours
	134.03	Maintenance of Landscape Areas, with Turf	Man Hours
	134.04	Maintenance of Landscaped Areas without 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

TABLE A-1 (*continued*)

PROGRAM NUMBER	ACTIVITY NUMBER		ACCOMPLISHMENT UNIT
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
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
	280.05	Purchase Chips	Cu. Yds.

should be noted that special activity codes are used for maintenance on pavements of portland cement concrete. Special codes also exist for snow and ice removal.

Manpower

Manpower for a particular function is recorded to the nearest full hour for the entire crew by the foreman. The division code identifies the foreman. In recording the labor utilized, three entries are made in the columns headed "NO.," "R," and "OVT" on the activity report as follows:

- NO. Record the number of employees working on the job during the day.
- R Record the regular hours worked by each employee.
- OVT Record the overtime hours worked by each employee.

A typical entry on the activity would be 481, indicating that four employees each worked eight regular hours and each worked one overtime hour. If four employees worked eight regular hours and three worked two overtime hours and one worked one overtime hour, a double entry would be made; the first entry would be 382 and the second entry 181. Special codes are used for supervisory personnel.

Equipment

Equipment used for a particular function is recorded and identified by class, and the number of hours or miles operated is recorded depending on the type of equipment. Fifty-three equipment class codes can be used. Examples of some of the class codes are given in Table A-2.

Total mileage for those items of equipment requiring daily mileage reports is placed in the "Mileage" column on the activity report (Fig. A-1). Coupes, sedans, station wagons, and survey wagons are in this category of equipment.

Reporting Equipment Use

All equipment that is at the job site must be charged for the entire time it is required at the site, regardless of how much it was actually used. For example, if a loader was required to be at a job site for 8 hr to load a truck intermittently throughout the day, and only four or five loads were loaded so the actual use time was only 30 min, the loader would be charged for the full 8 hr it was at the site.

If aggregates or other material hauled is involved in the performance of the maintenance activity, the one-way haul distance is recorded in the "Haul" column of the activity report. Mileage is reported to the nearest mile and hourly use to the nearest full hour.

Materials

The quantity and class are reported for all materials used to perform a maintenance activity. A partial list of material classes is given in Table A-3. Quantity is reported to the nearest whole unit as designated on the material class list. If a material is not assigned to a specific material class, the code 99 is used.

Material stockpiling activities have activity codes as given in Table A-1. Stockpiles can be assigned a coding number and material purchases can be identified for certain materials by the use of these codes.

Accomplishments

Accomplishments are reported for all maintenance activities in the units assigned to the specific activity (cubic yards, man-hours, square feet, tons, etc.). Accomplishments are recorded to the nearest whole unit.

COLLECTION AND PROCESSING OF RECORDED DATA

The activity report is filled out daily by the foreman for the crew for the work week and submitted weekly to the foreman's supervisor. The supervisor edits the report and mails it to the headquarters maintenance office, where it is subjected to another manual edit and then a final machine edit. The computer edit includes date, system, route, county, milepost location, accomplishment, labor, equipment, and material. Headquarters maintenance management coordinators discuss apparent errors with the district maintenance superintendent prior to making corrections on the activity report. A corrected copy of the activity report is then returned to the foreman through the district chain of command. Secretarial employees are not used at the station level to record the data.

It is estimated that about two-tenths of 1 percent of the maintenance budget is spent on recording and reporting maintenance activities. Nine thousand dollars for computer charges was expended in the 1975-1976 fiscal year. The foreman requires about 10 min per day to record the information. The district superintendent requires about 2 hr per week, and the central office staff requires about 8 to 10 hr per week to review and edit the recorded data.

Monthly reports are returned to the district by the 20th of the month following data collection.

REPORTS

Thirty-eight maintenance management reports have been prepared. A listing of the programs according to the function they perform follows:

1. Eleven programs list inventory information, control files, and edit errors.
2. Four programs are budget-related.
3. Three programs are on organization and performance.
4. There is one control program.
5. There are four informational summary programs.
6. One program is an exception report.
7. Two programs contain analysis detail.
8. Five programs are for file creation.
9. Seven programs concern support or housekeeping.

Nineteen management reports are produced; they fall into six categories:

1. Budget reports.

TABLE A-2

EQUIPMENT CLASS CODES

6.3.0 MOBILE EQUIPMENT CLASSIFICATION CODES

CLASS CODE	DESCRIPTION		
(Mileage)	Coupes, Sedans and Station Wagons	55	Tractors; Crawlers
(Mileage)	Survey Wagons, Units w/spc. Bodies	57	Snow Tractor w/Dozer
(Mileage)	Pickups and Scouts	58	Carryall Scrapers
11	9,000 GVW Trucks (Garbage Trucks)	59	Rippers
12	Trucks Dump Single Axle	60	Trailers, Cargo, Tilt
13	Trucks Dump Tandem Axle	62	Trailers, Dump
14	Trucks; Tractor	64	Classrooms
15	Trucks; All Wheel Drive	65	Trailers, Utility (Arrowboard, LPG Trailers, Small Water Tanks w/pumps, etc.)
16	Trucks: Flatrack		
17	Trucks; Service (Includes Lube, Sign Service, Boom, Mechanic Truck, Concrete Drill, Guardrail Washer, Sterilant, Spray Truck, etc.)		
21	Line Striper		
23	Traction Broom		
24	Street Sweeper (Self-propelled)		
25	Street Flusher - Semi-Mount		
26	Compressors		
27	Cranes and Fork Lifts (does not include truck-mounted cranes)		
28	Distributors (truck or semi-mounted)		
30	Maintenance Distributors (pot type to 600 gal., usually used for small patch operations (including petrolastic pots)		
31	Motor Graders		
33	Pulvimixer (Includes self-propelled and towed-type)		
34	Chip Spreader Box and Windrow Sizer (towed)		
35	Loaders (except Industrial Style Tractors)		
37	Conveyors		
38	Conveyor w/Screens or Feeder		
39	Concrete Mixers		
40	Patcheaters (towed)		
41	Mowers, Rockpickers, Roto Shreaders, Maintainer (If mower is towed, a class 54 tractor should also be coded.)		
42	Rotary Plows		
44	Rollers Pulled		
45	Rollers, Steel Wheel (includes vibratory)		
47	Rollers, Pneumatic Tired		
48	Shovel & Backhoe Combination, Truck Mounted		
50	Welders, Trailer Mounted		
51	Electric Plants		
53	Water Tanks, Trailer Mounted		
54	Tractors Industrial w/Attachments (Includes Sickle Mower, Loader, Auger, etc.)		

TABLE A-3

MATERIAL CLASS CODES

6.2.0 MATERIALS CLASSIFICATION CODES

CLASS CODE	DESCRIPTION	UNITS
1	AGGREGATE - This class includes gravels, sand, concrete aggregate.	Cu.Yd.
2	CHIPS - This class includes only those that meet gradation requirements of screenings. (See Standard Specifications for Road and Bridge Construction)	Cu.Yd.
5	PREMIX - This class includes premix produced by state or commercial sources. (Produced with a liquid asphalt such as SC 800).	Cu.Yd.
6	CHLORIDES (Salt)	Cu.Yd.
7	SALT AND SAND - This class includes all salt and sand mix used for snow and ice control.	Cu.Yd.
8	PLANTMIX - This class includes all plantmix purchased from a commercial scurce that is directly applied to the road surface. (Produced with an Asphalt Cement).	Ton
9	EXPANSION JOINT FILLER MATERIAL	Lin.Ft.
10	CEMENT	Sack
11	CONCRETE - This class is limited to ready mixed concrete from a batch plant or commercial source.	Cu.Yd.
12	LIQUID ASPHALT - This class includes liquid asphalts, asphalt cements, emulsions, etc.	Gals.
13	CRACK AND JOINT FILLER	Pounds
14	FERTILIZER	Pounds
15	FERTILIZER	Gallons
16	INSECTICIDES AND HERBICIDES	Pounds
17	INSECTICIDES AND HERBICIDES	Gallons
18	PROPANE CYLINDERS - This class includes only the propane purchased in cylinder containers having 100 lb. capacity.	Each
19	PROPANE - This class includes only the propane purchased for filling trailer-mounted L.P.G. Trailer Tanks.	Gallons
20	GUIDE POSTS - This class includes only the physical metal posts and does not include the sight plate or panel.	Each
21	SIGHT PLATES - This class will include snow delineators (1-1/2" x 4"), sight plates (4" x 12" with silver or yellow scotchlite), and guard rail delineators (3" x 14").	Each
22	MARKER PLATES - This class will include milepost panels and hazard marker plates.	Each
23	SNOW POLES - This class includes manufactured snow poles which are installed on guide posts.	Each
24	SIGNS - All signs will be included in this class.	Sq. Ft.
25	WHITE PAINT - This class includes paint used on traffic lines, pavement markings or guardrail.	Gals.
26	GLASS BEADS	Pounds
27	YELLOW PAINT - This class includes paint used on traffic lines and pavement markings.	Gallons
28	PAINT THINNER	Gallons
29	SIGN POSTS - This class includes only 1", 2" and 3" pipe used in the replacement or original installation of signs.	Lin.Ft.
30	FENCE POSTS - This class includes metal and wood fence posts.	Each
31	BARBED WIRE FENCING - This class includes only barbed wire.	Lin.Ft.
32	STEEL GUARDRAIL - This class will include all panels and hardware necessary for erection of guard rail.	Lin.Ft.
33	STEEL CATTLEGUARD - This class will include only prefabricated portions of cattleguards. When portions of cattleguards are constructed, the materials incorporated in the work would be coded (concrete, cement, aggregate, etc.).	Lin.Ft.
34	CULVERT PIPE - Includes 18" culvert pipe and excludes end sections or headwalls.	Lin.Ft.
35	CULVERT PIPE - Includes 24" culvert pipe and excludes end sections or headwalls.	Lin.Ft.

2. Performance reports.
3. Control reports.
4. Summary reports.
5. Exception reports.
6. Analysis reports.

The types of data reported for selected reports are summarized as follows:

1. *Productivity and Unit Cost Report.* The district productivity and unit cost report displays an individual foreman's crew productivity and unit cost and permits a comparison to the district-weighted-average productivity and the district-weighted-average cost for every maintenance activity reported by the foreman (see Fig. A-2). The district-weighted average is the criterion that enables the foreman to evaluate the crew's productivity and unit cost. Percent productivity is the crew productivity measured in terms of units produced per man-hour divided by the district productivity. The report is produced monthly with monthly and year-to-date values and is supplied to the foreman. Figure A-2 is an example of this report.

2. *State Productivity Report.* The state productivity report permits a comparison of productivity among districts. The standard productivity obtained from work standards and the computed, state-weighted-average productivity for the reported year are displayed on the report. Information is presented by maintenance activity. The report is prepared annually and distributed to the central office staff. Figure A-3 is an example of a state productivity report.

3. *Productivity/Unit Cost Exception.* This exception report summarizes the productivity and costs that vary widely from district means. The report identifies those items that fall outside two standard deviations of the mean productivity value for a given activity. It is prepared monthly and distributed to the district engineer. Figure A-4 is an example of a productivity/unit cost exception report.

4. *District and State Operations Reports.* These reports display district totals from processed activity report and accounting report totals. Administrative, overhead, and all other accounting charges (including labor, equipment, and material costs) against the district budget are displayed for the reporting month and the year to date. Totals are presented for the district by the foreman's division. The district operations report is prepared monthly and distributed to the district engineer. The state operations report is in basically the same format. Figure A-5 is an example of a district operations report.

5. *Man-Hour Utilization Report.* The district man-hour utilization report displays the district man-hours expended for each month of the year. Figure A-6 is an example of this report, which is prepared annually for district office use. The state man-hour distribution report has an identical format and is prepared annually for central office use.

6. *State Unit Cost Report.* This report displays the standard unit cost, the state-weighted-average unit cost, and the weighted-average unit cost achieved by each district for each maintenance activity on a yearly basis. It is prepared annually for district office use. Figure A-7 is an example of this report.

7. *Summary of Equipment Hours and Material Quantities Statewide.* Two reports, one for equipment and one for materials, are generated for each district and for the state as a whole. Monthly material quantities coded by material class and equipment use coded by equipment class are displayed by the month and totaled for the year. These reports are issued annually for the central office and district staff. Figures A-8 and A-9 are statewide reports for materials and equipment, respectively.

8. *System Route-Activity Summary.* This report permits information to be requested in total or limited to district, activity, route, specific location on route, or specific data. Labor, equipment, and material costs are reported together with accomplishment units. The report is produced on request. Figure A-10 is an example of a system route-activity summary report.

9. *Location Analysis Report.* This report summarizes information on specific units within requested milepost limits for a specified period of time. Maintenance activities, units accomplished, labor costs, equipment costs, and material costs are reported. The location analysis report is produced on request. Figure A-11 is an example of such a report.

10. *Activity Analysis Report.* The activity analysis report summarizes information on a specific maintenance activity for a particular section, a district, or a state as a whole. Items reported include location at which the activity was performed; labor, equipment, and material costs; net productivity; and net unit cost. The report is produced on request. Figure A-12 is an example of an activity analysis report.

11. *District Performance Report.* This report ranks district productivity and composite costs for a given month. High and low productivity and unit costs are reported by maintenance activity. This summary is a form of an exception report. It is produced on request. Figure A-13 is an example of a district performance report.

12. *Work Accomplishment Report.* The work accomplishment report (Fig. A-14) displays the units of work completed and dollars expended together with the units of work scheduled and dollar budget. This report enables a comparison by maintenance activity and maintenance program for the current month and year to date. Planned quantities and budget amounts shown on the report are obtained from an established planning and scheduling program as follows. Preceding year man-hour efforts and costs are supplied to the districts by the central office in the form of management reports. District estimates of man-hour requirements by the month by activity (Fig. A-15) are based on the data supplied by the district office and by the use of a road evaluation program. Man-hours are adjusted by the month to reflect available man-hours, and a tentative budget is formulated. A report is generated delineating this tentative budget by activity, man-hours, work load, and costs (Fig. A-16).

An inventory system is also a part of the Nevada maintenance management system. A discussion of the inventory as well as the budget preparation program is contained in the references listed in the Bibliography.

It should be noted that in all of the aforementioned reports man-hours are reported for the entire working crew.

PRODUCTIVITY AND UNIT COST REPORT — MNS RPT D-1
FOREMAN: GARRISON (451) FOR DECEMBER RUN 01/22/75

ACTIVITY	DESCRIPTION	UNIT	MAN HOURS CREW	MAN HOURS DIST	UNIT/MNHRS CREW	UNIT/MNHRS DIST	% PROD.	UNIT COST CREW	UNIT COST DIST	% COST
100.01	PLANNING & SCHEDULING	MN HR	31	69	1.00	1.00	100	9.01	9.35	96
	YTD TOTALS:		73	347	1.00	1.00	100	8.88	8.87	100
101.01	BASE & SURFACE REPAIR	CU YD								
	YTD TOTALS:		114	305	2.36	1.40	169	5.51	10.87	51
101.02	SURF PATCH PREMIX HAND	CU YD	10	10	.13	.13	100	70.11	70.11	100
	YTD TOTALS:		617	1,095	.13	.13	77	110.87	85.46	130
101.03	SURF PATCH PREMIX MACH	CU YD								
	YTD TOTALS:		959	3,779	1.47	1.20	123	19.14	23.21	82
101.04	SURF PATCH SPOT SEAL	SQ YD	164	204	508.30	415.72	122	.06	.07	86
	YTD TOTALS:		164	284	508.30	375.50	135	.06	.07	86
131.02	CLEAN CULVRT OPEN & DI	EACH								
	YTD TOTALS:		34	34	1.21	1.21	100	6.94	6.94	100
131.03	DRESS & SHAPE DITCHES	LN FT	131	147	720.46	661.78	109	.02	.02	100
	YTD TOTALS:		131	147	720.46	661.78	109	.02	.02	100
131.04	CLEANING DITCHES	CU YD	60	242	6.70	8.42	80	2.09	1.41	148
	YTD TOTALS:		192	519	4.63	6.55	71	2.71	1.84	147
131.06	ROAD SECTION RESTORE	CU YD	117	682	3.75	5.20	72	3.44	2.65	130
	YTD TOTALS:		145	1,367	5.34	5.33	100	2.32	2.53	92
131.08	VEGETATION CONTROL MOW SH	MI		408		.53			22.50	
	YTD TOTALS:		154	1,900	.96	.81	119	15.69	17.12	92
131.10	VEGETATION CONTROL HND	MN HR		98		1.17			7.47	
	YTD TOTALS:		111	665	1.02	1.09	94	8.31	7.86	106

** ACTIVITY 100.01 HAS BEEN PRORATED

Figure A-2. Productivity and unit cost report.

STATE PRODUCTIVITY REPORT — MNS RPT D-3
JULY 1974 THRU OCTOBER 1974 RUN 12/03/74

ACTIVITY DESCRIPTION	ACCOMPLISHMENT UNITS	STANDARD UNIT/MH	STATE	DIST. ONE	DIST. TWO	DIST. THREE	DIST. FOUR	DIST. FIVE	DIST. SIX
101.01 B & S REPR	CU YD	1.200	1.219	1.039	1.136	1.126	1.461	2.762	
101.02 SUR PACH H	CU YD	.125	.139	.294	.120	.241	.139	.077	.075
101.03 SUR PACH M	CU YD	1.700	1.293	.650	1.905	1.248	1.267	.828	.934
101.04 SUR PACH S	SQ YD	155.000	113.148	133.333	6.522	112.357		115.918	100.885
101.05 SEAL COT S	SQ YD	480.008	351.513	331.401	575.931	592.325	389.320	216.849	257.556
101.06 SEAL COT F	SQ YD	725.005				136.912		538.933	
101.07 CRACK FILL	LB	45.000	50.337	23.895				107.130	
101.08 HEAT PLAN	SQ YD	55.000	52.892		59.205	32.095			
101.09 SL COT CHP	SQ YD	374.995	288.127					295.648	
111.01 PAT SPAL T	CU YD	.111							
111.02 P & FD PAT	CU YD	.035							
111.03 PV SH MA P	CU YD	1.000							
111.04 PV SH SL S	SQ YD	480.008							
111.05 JOINT SEAL	LB	10.000							
111.06 EXP JNT RP	LN FT	1.600	7.312	7.312					
112.01 RPR CON AP	CU FT	6.000	.857	.100	.200	1.778			
131.01 CLEAN CULV	EACH	.225	.313	.819	.201		.714	.063	.083
131.02 CLN CO DI	EACH	1.000	.929	.990	.935	.797	.938	.733	.736

Figure A-3. State productivity report.

DISTRICT NO. 1 — PRODUCTIVITY/UNIT COST EXCEPTION FOR DECEMBER — RUN 01/22/75

STATION	ACTIVITY	DESCRIPTION	PRODUCTIVITY EXCEPTIONS	DISTRICT MEAN PROD.	COST EXCEPTIONS	DISTRICT MEAN COST
123	133.04	REMOVE ROADWAY DEBRIS			43.80 TR MI	1.02
126	133.02	EMPTY LITTER BARRELS			6.62 EACH	3.16
128	133.02	EMPTY LITTER BARRELS	6.75 EACH /MAN HR.	3.00		
129	131.02	CLEAN CULVRT OPEN & DI			234.24 EACH	5.69
152	141.11	MAINTAIN POSTS-MARKERS			13.91 EACH	4.87

Figure A-4. Productivity/unit cost exception.

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DISTRICT: 5 — DISTRICT OPERATIONS REPORT FOR THE PERIOD 3-18 THRU 4-15 — MMS RPT 0-4 RUN 06/03/75

MAINTENANCE, STOCKPILES, BETTERMENT EXPENSES:	LABOR HOURS	LABOR COSTS	EQUIPMENT COSTS	MATERIAL COSTS	TOTAL COSTS	YEAR TO DATE LABOR HOURS	YEAR TO DATE LABOR COSTS	YEAR TO DATE EQUIPMENT COSTS	YEAR TO DATE MATERIAL COSTS	YEAR TO DATE TOTAL COSTS
ACTIVITY REPORT TOTAL	6,270	43,436	41,187	8,012	92,635	61,916	433,329	364,064	288,676	1,086,070
ACCOUNTING TOTALS	6,125	36,256	40,164	7,482	83,902	59,864	396,919	318,671	372,971	1,088,562
CONST SERVICES										
MAINT ACTIVITIES	6,125	36,256	40,164	7,482	83,902	59,864	396,919	318,671	372,971	1,088,562
OPERATIONAL EXPENSES:										
ADMINISTRATION	1,011	8,534	1,057	1,092	10,685	9,749	95,541	12,009	7,962	115,513
MAINTENANCE STATIONS	644	3,935	716	9,086	13,739	6,066	42,043	6,237	61,284	109,565
EQUIPMENT SERVICE	551	3,230	496		3,727	4,857	32,519	5,250	63	37,833
NON RENT EQUIP	16	80		498	578	16	80		498	578
OTHER AGENCIES						234	1,495	182		1,678
MISCELLANEOUS	155	1,196	392	421	2,010	2,704	21,791	4,856	12,450	39,098
PURCHASED STOCK (INVENTORY CREDITS)				2,537	2,537				22,583 (166,509)	22,583 (166,509)
ACTUAL DISTRICT TOTALS:	8,502	53,234	42,828	21,117	117,180	83,490	590,392	347,207	311,304	1,248,903
OPERATIONAL EXPENSES CREW ANALYSIS										
STATION: 501										
MAINTENANCE STATION	88	589	120	150	859	856	6,457	1,161	3,795	11,414
EQUIPMENT REPAIR						16	120			120
NON RENT EQUIP										
OTHER AGENCIES						94	660	12		672
MISCELLANEOUS	1,148	9,595	1,308	1,233	12,137	11,280	109,146	14,990	8,834	132,971
STATION: 521										
MAINTENANCE STATION				1,187	1,187				7,898	7,898
EQUIPMENT REPAIR										
NON RENT EQUIP				33	33				33	33
OTHER AGENCIES										
MISCELLANEOUS				88	88				6,958	6,958
STATION: 522										
MAINTENANCE STATION	68	398		1,440	1,838	328	2,120	97	8,587	10,805
EQUIPMENT REPAIR	52	269			269	599	3,802	528		4,330
NON RENT EQUIP	16	80			80	16	80			80
OTHER AGENCIES										
MISCELLANEOUS						57	325		1,027	1,353

Figure A-5. District operations report.

MAN-HOUR UTILIZATION REPORT FOR 1973

MMS RPT 0-13
RUN 07/29/74

DISTRICT: ONE

ACTIVITY DESCRIPTION	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	TOTAL
135.02 MAINT CATTLE GUARDS	17	20		6	4			42	4	12	6		111
135.03 REMOVE ENCROACHMENTS	5			16					75	3	4	4	107
135.04 INSPECT RW FENCES GATE	24		7	32	33	54	36	42	16	64	32	32	372
141.01 MAINT ROUTE-WARN SIGNS	435	402	395	394	437	387	417	403	206	306	376	473	4,631
141.02 GUARDRAIL REPAIR	240	75	71	54	85	193	76	86	55	56	24	48	1,063
141.03 GUARDRAIL PAINTING	136	26	472	250	146				16				1,046
141.04 GUARDRAIL CLEANING						5							5
141.05 PAVEMENT STRIPE DASHED	203	228	135	21	284	264	144	174	181	180	104	272	2,190
141.06 PAVEMENT STRIPE SOLID	48	164	164			76		237	210	250	32	56	1,237
141.07 PILOT LINING	452			120		96	8		32	24	22	96	850
141.08 PAVEMENT MARKINGS	384	305	274	444	306	165	321	186	155	264	532	324	3,660
141.09 RDWY LIGHTING SYSTEM													
141.10 PATROLLING	18		25	10		47	63	59	101	120	80	32	555
141.11 MAINTAIN POSTS-MARKERS	246	426	366	267	334	425	375	344	189	277	249	266	3,764
151.01 SNOW REMOVAL						123	55	1,027	30	133	10		1,378
151.02 SNOW PLOW ROTARY PLOW													
151.03 SNOW & ICE PATROLLING							9	76	6		14		105
151.04 INST/REM SNOW MARKERS					44	44					30		118

Figure A-6. District man-hour utilization report.

STATE UNIT COST REPORT
JULY 1974 THRU OCTOBER 1974

MMS RPT 0-9
RUN 12/03/74

ACTIVITY DESCRIPTION	ACCOMPLISHMENT UNITS	STANDARD UNIT COST	STATE	DIST. ONE	DIST. TWO	DIST. THREE	DIST. FOUR	DIST. FIVE	DIST. SIX
100.01 PLAN & SCD	MN HR	6.96	7.49	7.99	7.26	7.49	9.47	7.89	7.06
101.01 B & S REPR	CU YD	18.02	14.09	17.06	14.79	20.73	10.77	8.95	
101.02 SUR PACH H	CU YD	99.12	70.06	40.37	89.88	50.89	83.01	138.00	136.38
101.03 SUR PACH M	CU YD	18.08	20.98	29.80	16.52	20.49	22.73	26.15	26.08
101.04 SUR PACH S	SQ YD	.18	.18	.15	.09	.18	.16	.23	
101.05 SEAL COT S	SQ YD	.08	.11	.15	.09	.07	.10	.12	.16
101.06 SEAL COT F	SQ YD	.05	.05	.06	.04	.16	.04	.06	.05
101.07 CRACK FILL	LB	.30	.29	.52				.19	
101.08 HEAT PLAN	SQ YD	.29	.31		.28	.51			
101.09 SL COT CHP	SQ YD	.22	.22					.22	
111.01 PAT BPAL T	CU YD	89.00							
111.02 P & FO PAT	CU YD	324.00							
111.03 PV SH MA P	CU YD	21.62							
111.04 PV SH SL S	SQ YD	.00							
111.05 JOINT SEAL	LB	1.07							
111.06 EXP JNT RP	LN FT	6.02	3.37	3.37					
112.01 RPR CON AP	CU FT	2.66	13.00	72.27	45.00	9.24			

** ACTIVITY 100.01 HAS BEEN PRORATED

Figure A-7. State unit cost report.

SUMMARY OF EQUIPMENT HOURS AND MATERIAL QUANTITIES STATE WIDE — QUANTITY — MMS RPT D-15 RUN 07/30/74

MATL. CLASS	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	TOTAL
1 AGGREGATE	39,478	47,719	21,212	9,999	9,295	5,529	5,644	1,447	2,123	3,166	8,645	28,363	182,620
2 SCREENINGS	2,700	1,288	65	3,859	46	257	714	434			533	1,256	11,152
5 PREMIX	34,064	45,765	17,305	4,615	284	274	430	450	586	1,329	1,312	17,000	123,414
6 SALT				574	2,043	1,280	764	134	187	4			4,986
7 SALT-SAND				74	5,825	6,193	7,934	3,050	2,172	919	39		26,206
8 PLANTMIX		125	4,851	269						13	1	638	5,897
10 CEMENT	5	15	32	46	56	42	69	60	20	56	44	69	514
11 CONCRETE	6		9		14	3			9	3	8		52
12 LQD ASPH	1,001,497	1,198,535	645,341	271,934	17,622	30,812	20,626	24,232	20,648	65,496	333,413	762,785	4,392,541
13 CRACK FILL		170	400		7,600	52,100	73,900	76,800	60,200	27,500	3,523		302,193
14 FERTILIZER	1,773	1,215	460	80	80			2,293	30	1,470	180	1,340	8,921

Figure A-8. Material quantity summary report.

SUMMARY OF EQUIPMENT HOURS AND MATERIAL QUANTITIES STATE WIDE — HOURS — MMS RPT D-15 RUN 07/30/74

EQUIP. CLASS	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	TOTAL
24 ST SWEEPER	447	443	469	454	334	327	405	426	538	428	615	509	5,395
25 ST FLUSHER	48	114	161	59	43	53	8	37	89	172	218	320	1,322
26 COMPRESSOR	82	75	95	109	96	230	119	131	228	223	98	82	1,568
28 DISTRIB	469	641	689	295	118	96	170	240	225	157	134	307	3,541
30 MAINT DIST	1,248	1,467	996	869	272	918	1,279	1,607	1,307	1,309	421	643	12,036
31 GRADERS	4,990	5,560	3,314	2,588	1,728	1,738	1,281	1,518	2,234	2,875	3,449	4,000	35,275
33 PULVIMIXER	970	837	451	127		8				24	92	680	3,189
34 CHIP SPRD	664	903	385	161	44			6	32	95	95	574	2,960
35 LOADERS	4,798	4,984	3,975	3,697	4,033	3,668	3,616	2,942	4,042	4,352	4,495	5,009	49,611
37 CONVEYORS	1,182	902	909	1,269	1,143	1,040	952	884	636	1,140	854	362	11,273
38 CONVEY W/S	350	238	160	134	296	240	376	360	272	249	206	94	2,975

Figure A-9. Equipment use summary report.

SYSTEM ROUTE-ACTIVITY SUMMARY

MMS RPT O-14
RUN 12/06/74

SYSTEM ROUTE	FROM DATE	TO DATE	DIST	CTY	FROM MILEPOST	TO MILEPOST	ACTIVITY	ACCOMPL. UNITS	TOTAL LABOR	TOTAL EQUIP.	TOTAL MATL.	TOTAL COSTS
FA 534	7- 1	6-30	1				141.05	35	1,037	503	1,439	2,979
FA 538	7- 1	6-30	1				141.05	26	362	177	3,825	4,364
FA 806	7- 1	6-30	1				141.05	13	295	163	453	911
FA 812	7- 1	6-30	1				141.05	9	108	48	198	354
FA 815	7- 1	6-30	1				141.05		43	25	50	118
FR 403	7- 1	6-30	1				141.05	4	108	49	91	248
FR 406	7- 1	6-30	1				141.05	1	43	23	52	118
FR 407	7- 1	6-30	1				141.05	5	135	71	94	300
FR 416	7- 1	6-30	1				141.05	1	41	23	45	109
FR 419	7- 1	6-30	1				141.05	1	108	44	25	177
FR 420	7- 1	6-30	1				141.05		22	11	440	473
IR 015	7- 1	6-30	1				141.05	232	2,904	1,326	3,797	8,027
RP 808	7- 1	6-30	1				141.05		22	11	6	39
SR 005	7- 1	6-30	1				141.05	22	421	233	478	1,132
SR 007	7- 1	6-30	1				141.05	1	65	53	27	145
SR 012	7- 1	6-30	1				141.05	30	584	391	543	1,518
SR 029	7- 1	6-30	1				141.05	37	756	472	593	1,821
SR 039	7- 1	6-30	1				141.05	4	173	111	102	386
SR 041	7- 1	6-30	1				141.05	19	421	216	384	1,021
SR 060	7- 1	6-30	1				141.05	14	173	123	267	563
SR 068	7- 1	6-30	1				141.05	19	226	135	229	590

Figure A-10. System route activity summary.

LOCATION ANALYSIS REPORT

MMS RPT O-11
RUN 12/11/74

ROUTE: SR 027 WA FROM: 14.00 TO: 24.53 FOR: 7- 1 TO: 10-30

ACTIVITY	UNITS	UNITS ACCOMPLISHED	NET MAN HRS	NET LABOR COSTS	NET EQUIP. COSTS	MATL. COSTS	TRAVEL TIME	AVE. HAUL DISTRICT	NET PROD.	NET UNIT COSTS
101.02 SUR PACH H	CU YD	8	77	535	172	81	2.14		.104	98.65
131.07 SH SLP MNT	SH MI	10	165	1,133	956		6.24		.061	209.00
133.03 SWEEPING	SW MI	48	14	101	107		.77		3.429	4.34
135.03 RMV ENCRHM	EACH	24	4	27	5		1.84		6.000	1.38
141.01 MNT SIGNS	SQ FT	248	13	87	45	93	3.35		19.077	.91
141.11 MNT MARKER	EACH	137	62	434	206	156	5.42		2.210	5.82
151.01 SNOW REMOV	MN HR	28	28	265	231		2.58		1.000	17.74
151.04 SNOW MARK	EACH	520	27	191	74		1.14		19.259	.51

Figure A-11. Location analysis report.

ACTIVITY ANALYSIS REPORT

MMS RPT 0-12
RUN 08/22/74

REQUESTED ACTIVITY 141.07 PILOT LINING — REQUESTED DIVISION 127 — REQUESTED MONTH — TO

DATE	LOCATION				UNITS ACCOMPLISHED	NET LABOR HOURS	NET LABOR COSTS	NET EQUIP COSTS	MATERIAL COSTS	TRAVEL TIME	HAUL DISTANCE	NET PRODUCTIVITY	NET UNIT COST
6-17	SR 068	CL	.00	1.50	1	32	216	24		1.12		.03	240.32
6-18	SR 068	CL	1.50	3.00	2	32	216	24		1.02		.06	120.22
6-19	SR 068	CL	3.00	5.60	2	32	216	20		.90		.06	118.54
6-20	SR 068	CL	6.40	10.30	4	32	216	18		.68		.13	58.58
6-21	SR 068	CL	10.30	14.20	4	32	216	18		.46		.13	58.58
6-24	SR 068	CL	14.20	18.60	4	32	216	18		.22		.13	58.58
6-25	SR 068	CL	1.90	5.00	3	32	216	18		.96		.09	78.11
6-26	SR 068	CL	5.10	9.20	4	32	216	18		.74		.13	58.58

Figure A-12. Activity analysis report.

DISTRICT PERFORMANCE REPORT
FOR DECEMBER

MMS RPT 0-6
RUN 01/22/75

DISTRICT NO.	COMPOSITE PRODUCTIVITY RATING %	DISTRICT NO.	COMPOSITE UNIT COST RATING %
6	127	6	89
3	124	3	95
2	119	5	97
5	114	2	99
1	97	1	107
4	96	4	114

MAX-MIN PRODUCTIVITY/UNIT COST

ACTIVITY		PRODUCTIVITY HIGH STATION	PRODUCTIVITY RATE	PRODUCTIVITY LOW STATION	PRODUCTIVITY RATE	UNIT COST HIGH STATION	UNIT COST RATE	UNIT COST LOW STATION	UNIT COST RATE
101.01	B & S REPR	128	1.56	234	.02	234	398.75	128	6.55
101.02	SUR PACH H	350	.71	234	.05	234	208.39	123	14.68
101.03	SUR PACH M	253	1.07	350	.55	128	29.72	253	25.97
101.04	SUR PACH S	451	508.30	429	30.45	429	1.02	451	.06
101.05	SEAL COT S	623	259.18	623	259.18	623	.14	623	.14
101.06	SEAL COT F								
101.07	CRACK FILL	351	94.87	227	12.42	227	.87	351	.17
101.08	HEAT PLAN	650	65.15	650	65.15	650	.24	650	.24

Figure A-13. District performance report.

DISTRICT: SIX
MONTH: DECEMBER

WORK ACCOMPLISHMENT REPORT

MMS RPT 0-3
RUN 01/22/75

ACTIVITY	MONTHLY UNITS COMPL	MONTHLY UNITS SCHED	MONTHLY DOLLARS EXPENDED	MONTHLY DOLLARS BUDGETED	YEAR TODATE UNITS COMPL	YEAR TODATE UNITS SCHED	YEAR TODATE DOLLARS EXPENDED	YEAR TODATE DOLLARS BUDGETED
			*	*			*	*
100.01 PLANNING & SCHEDULING	33	65	223	485	262	390	1,828	2,910
			223*	485*			1,928*	2,910*
101.01 BASE & SURFACE REPAIR						192		2,908
101.02 SURF PATCH PREMIX HAND	23	38	4,192	3,592	84	203	12,808	19,159
101.03 SURF PATCH PREMIX MACH					1,082	1,360	20,462	22,944
101.04 SURF PATCH SPOT SEAL		15,500		1,773	7,654	31,000	1,801	3,546
101.05 SEAL COAT SAND	2,851		438		341,444	384,006	55,583	26,984
101.06 SEAL COAT FLUSH					351,285	652,505	12,000	32,685
101.07 CRACK FILLING	4,744	27,000	3,325	7,798	11,593	54,000	8,520	15,595
101.08 HEATER PLANING	29,122		7,781		33,194	11,000	8,971	2,874
101.09 SEAL COAT-CHIPS							277	
			16,736*	13,163*			128,422*	126,695*
111.01 PATCH SPALL AREAS TEMP								
111.02 PART & FUL DEPTH PATCH								
111.03 PAVD SHO MAINTENANCE P								
111.04 PAVD SHO SEAL SAND								
111.05 JOINT SEALING								
111.06 EXPANSION JOINT REPAIR								
			*	*			*	*
112.01 REPAIR MISC CONC APURT						150		390
			*	*			*	390*
131.01 CLEANING CULVERTS					5	22	241	1,136
131.02 CLEAN CULVRT OPEN & DI	12	30	176	344	111	180	2,206	2,064
131.03 DRESS & SHAPE DITCHES					2,525	60,000	403	2,576
131.04 CLEANING DITCHES		262		648	14,569	2,361	5,100	5,832
131.05 CULVERT REPAIR REPLACE	2	8	96		2	24	96	
131.06 ROAD SECTION RESTORE	4,387	3,375	7,917	6,241	9,891	15,525	24,797	28,709
131.07 SHLDR SLOPE MAINT BLAD	7		298		26	80	1,973	4,745
131.08 VEGETATION CONTROL MOW	32	165	416	4,260	1,052	880	24,816	22,720
131.09 VEGETATION CONTROL SPR	87	100	1,486	2,352	372	200	6,601	4,704
131.10 VEGETATION CONTROL HND					8	50	94	
			10,389*	13,845*			66,327*	72,486*
133.01 REMOVE DEBRIS LITTER	10		350		85	240	2,127	5,370
133.02 EMPTY LITTER BARRELS	217	150	779	442	1,791	1,500	3,106	4,420
133.03 SWEEPING TRVLD WY & SH	27	80	344	705	333	480	6,538	4,230
133.04 REMOVE ROADWAY DEBRIS	1,202	1,013	1,753	1,324	9,477	6,078	12,794	7,944

Figure A-14. Work accomplishment report.

DISTRICT NO. 6 BUDGET INPUT REPORT

MMS RPT B-2
RUN 05/02/74

ACT. NUMBER	ACTIVITY DESCRIPTION	ESTIMATED MAN HOURS BY MONTH JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL EST MN HRS	TOTAL BUDGET MN HRS	CREW DAYS	CREW SIZE	UNITS / MN HRS PATIO	DOLL / MN HRS RATI
100.01	PLAN & SCD	65	65	65	65	65	65	65	65	65	65	65	65	780	1020	128	1	1.000	7.4
101.01	B & S REPR			80	80					80	80			320	71	1	2	1.000	19.7
101.02	SUR PACH H	100	100	100	500	500	300	300	300	500	500	200	100	3500	5470	171	4	.113	11.9
101.03	SUR PACH M	200	300	200	100							100	100	1000	3215	80	5	1.541	28.6
101.04	SUR PACH S					100	100	100	100	100	100	100		700	320	13	3	141.991	17.7
101.05	SEAL COT S	400	300	100								500	800	2100	3223	40	10	435.765	33.7
101.06	SEAL COT F	400	400	100								200	600	1700	3538	63	7	657.647	36.2
101.07	CRACK FILL				200	400	600	1000	1000	1000	500			4700	2833	71	5	40.326	12.9
101.08	HEAT PLAN				200							200		400	859	21	5	50.066	14.3
101.09	SL COT CHP													0	1207	11	14	342.235	76.7
111.01	PAT SPAL T													0			5		
111.02	P & FD PAT													0			8		
111.03	PV SH MA P													0			7		
111.04	PV SH SL S													0			7		
111.05	JOINT SEAL													0			5		
111.06	EXP JNT RP													0			5		
112.01	RPR CON AP	5	5	5	5	5					5	5	5	40	72	5	2	5.750	15.7
131.01	CLEAN CULV				50	50				50	50			200	325	14	3	.197	11.3

Figure A-15. Budget input report.

DISTRICT 6 — PRELIMINARY COMPUTED DISTRICT — MMS RPT B-1
FISCAL YEAR 74 — MAINTENANCE BUDGET — RUN 05/02/74

ACTIVITY	MAN HOURS	WORK LOAD	COSTS
100.01 PLANNING & SCHEDULING	1,020	1020	7,619
	1,020 *		7,619 *
101.01 BASE & SURFACE REPAIR	71	78	1,290
101.02 SURF PATCH PREMIX HAND	5,470	617	65,506
101.03 SURF PATCH PREMIX MACH	3,215	4954	92,215
101.04 SURF PATCH SPOT SEAL	320	45437	5,676
101.05 SEAL COAT SAND	3,223	1404470	108,714
101.06 SEAL COAT FLUSH	3,528	2326756	128,493
101.07 CRACK FILLING	2,833	115659	36,919
101.08 HEATER PLANING	859	43007	12,343
101.09 SEAL COAT-CHIPS	1,207	413078	92,645
	20,736 *		543,706 *
111.01 PATCH SPALL AREAS TEMP			
111.02 PART & FUL DEPTH PATCH			
111.03 PAVD SHO MAINTENANCE P			
111.04 PAVD SHO SEAL SAND			
111.05 JOINT SEALING			
111.06 EXPANSION JOINT REPAIR			
	*		*
112.01 REPAIR MISC CONC APURT	72	414	1,135
	72 *		1,135 *
131.01 CLEANING CULVERTS	325	64	3,692
131.02 CLEAN CULVRT OPEN & DI	649	584	7,449
131.03 DRESS & SHAPE DITCHES	3,100	840390	39,936
131.04 CLEANING DITCHES	2,908	13804	37,696
131.05 REMOVE SAND DRIFT			
131.06 ROAD SECTION RESTORE	2,799	17811	34,940
131.07 SHLDR SLOPE MAINT BLAD	769	138	9,129
131.08 VEGETATION CONTROL MOW	7,533	3743	106,973
131.09 VEGETATION CONTROL SPR	516	469	12,136
131.10 CULVERT REPAIR REPLACE			28
	19,599 *		251,984 *
133.01 REMOVE DEBRIS LITTER	3,334	1221	29,856
133.02 EMPTY LITTER BARRELS	1,012	2746	8,252
133.03 SWEEPING TRVLD WY & SH	633	979	8,931
133.04 REMOVE ROADWAY DEBRIS	3,130	21147	27,634
	8,109 *		75,374 *
134.01 MAINTENANCE REST STOPS	416	416	3,669
134.02 MAINT OF ROADSIDE PARK	2,496	2496	19,930
134.03 MAINT LNDSCAP AREA WT			
134.04 MAINT LNDSCAP AREA NOT			
	2,912 *		23,599
135.01 REPAIR RW FENCE GATES	200	4612	3,954
135.02 MAINT CATTLE GUARDS	915	52	3,313
135.03 REMOVE ENCROACHMENTS	238	107	2,611
135.04 INSPECT RW FENCES GATE	72	461	654
	825 *		10,463
141.01 MAINT ROUTE-WARN SIGNS	2,052	13270	38,560
141.02 GUARDRAIL REPAIR	478	1272	7,299
141.03 GUARDRAIL PAINTING	670	23401	14,574
141.04 GUARDRAIL CLEANING	321	95647	2,665
141.05 PAVEMENT STRIPE DASHED	1,480	814	41,240
141.06 PAVEMENT STRIPE SOLID	739	404	37,626
141.07 PILOT LINING	567	67	4,796
141.08 PAVEMENT MARKINGS	1,084	40770	12,746
141.09 SIGN LIGHTING SYSTEM	107	107	955
141.10 PATROLLING	249	4273	2,719
141.11 MAINTAIN POSTS-MARKERS	4,712	10686	56,174
	12,459 *		219,571
151.01 SNOW REMOVAL	4,182	4182	67,874
151.02 SNOW PLOW ROTARY PLOW			
151.03 SNOW & ICE PATROLLING			
151.04 INST/REM SNOW MARKERS			
	4,182 *		67,874
161.01 MAINT REPAIR STRUCTURE	281	263	2,498
161.02 INSPECT STRUCTURES	689	3431	6,104
	970 *		8,602
DISTRICT TOTALS	69,884 *		1,209,357

Figure A-16. Preliminary maintenance budget.

These hours are transferred to dollar values by use of an average cost per hour for an individual in the crew. The standard productivity rates are obtained from the maintenance work standard. Additionally, all of these reports are used to perform the following functions:

1. Establish staffing levels for crews and the district.
2. Establish fiscal control.
3. Identify economic maintenance activity methods.
4. Compare station and district costs.
5. Prepare budget.

OTHER ITEMS

The Nevada Department of Highways is satisfied with the reliability of the existing system. Salient features of the recording and reporting method, which are believed to improve the reliability of the information, include the use of foremen rather than the individual maintenance employee to record the data. Training programs are an integral part of implementing the maintenance management system. Conferences as well as follow-up reviews are held with individual foremen after implementation of the program. The recording and reporting system is under constant review by central office staff, with input from the districts and stations. Changes in the system originate from the central office, with input from the field. Although a standing committee on maintenance standards does not exist, maintenance standard committees have been used to formulate the maintenance work standards. Under the present system, data collected can be stored on tape indefinitely.

BIBLIOGRAPHY

DAVIS, K. J., "Examples of Use of a Maintenance Management System." Presented to the Transportation Research Board, Maintenance Management Workshop, Las Vegas, Nevada (July 1975).

"Final Report on the Development and Implementation of a Maintenance Management System." Prepared by Byrd, Tallamy, MacDonald, and Lewis for the Nevada Department of Highways (July 1974).

"Maintenance Management System Manual of Instruction." State of Nevada, Department of Highways (July 1973).

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