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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

173

SHORT-TERM RESPONSIVE MAINTENANCE SYSTEMS

TRANSPORTATION RESEARCH BOARD
National Research Council

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SHORT-TERM RESPONSIVE MAINTENANCE SYSTEMS

L. GARY BYRD
Consulting Engineer
Alexandria, Virginia

Topic Panel

THOMAS L. CAIN, *Alabama Highway Department*
FRANK N. LISLE, *Transportation Research Board*
MICHAEL M. RYAN, *Pennsylvania Department of Transportation*
KUMARES C. SINHA, *Purdue University*
HERMAN WITTENBERG, *Minnesota Department of Transportation*

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

OCTOBER 1991

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 the National Research Council 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 National Research Council 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 the responsibilities of the National Research Council and the 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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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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The Transportation Research Board evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire highway community, 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 useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

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

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be of interest to maintenance managers, maintenance engineers, and others concerned with the periodic problems associated with the day-to-day maintenance of highways. Information is presented on discovery and response systems applicable to short-term responsive maintenance needs.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available 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 reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

The development and implementation of short-term responsive maintenance systems (STRMS) can be effective in handling permanent or temporary repairs. This report of the Transportation Research Board describes and discusses the short-term responsive maintenance systems in effect in several states. It describes how these special maintenance needs are detected, reported, evaluated, and managed, and notes how new technology can assist maintenance managers.

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 researcher in organizing and evaluating the collected data, and to review the final synthesis report.

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

CONTENTS

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Frank Lisle, Engineer of Maintenance, Transportation Research Board, assisted the NCHRP Project 20-5 Staff and the Topic Panel.

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

SHORT-TERM RESPONSIVE MAINTENANCE SYSTEMS

SUMMARY

The inevitable periodic problems associated with the physical components of a highway system, even with effective preventive maintenance programs in place, require short-term responsive maintenance activities. How these problems are detected, reported, evaluated, and managed is the subject of this synthesis. Short-term responsive maintenance systems (STRMS) can be classified by such components as: type of need, including safety, capacity, and aesthetics; method of detection, including public observation, police detection, and staff inspection; timeliness of required response, including immediate emergency response, prompt scheduled repair, and seasonal action; organization of responding team, including special call-out crews and regular crew action; and system operations, including processing information, making decisions, delegating authority and responsibility, and acting on needs.

In addition to geographic dispersion of the highway network and the maintenance organization, which can require hours of travel time to respond to STRMS needs, the needs themselves are influenced by such other network conditions as structural design, construction characteristics, age, geometrics, capacity, environment, operations, and traffic control systems.

A survey of state and toll road agencies and Canadian provinces showed that 100 percent of the respondents conduct formal in-house inspections of their systems but only 26 percent of the STRMS needs were triggered by these inspections in the states and only 44 percent in the provinces. By far the most effective detection of STRMS needs for states was by informal in-house observations (63 percent). Provinces and toll roads reported about equal effectiveness from formal and informal inspections. External reports accounted for only 11 percent of the needs discoveries in the states, 13 percent in the provinces, and 1 percent on the toll roads. However, the use of location markers (such as mileposts) and the increasing presence of cellular telephones in private vehicles, make the potential for external reports very promising where effective publicity about telephone numbers and the desire to receive reports from highway users is developed by the highway agency. While largely experimental at this time, the use of various types of remote sensors, electronic surveillance equipment, and service life forecasting techniques may further improve STRMS detection and response capabilities.

Response systems in most agencies are organized and operated on a set of principles that include: (a) the assignment of highways to classifications requiring the same types of response actions and priorities, (b) the assignment of events (failures, knockdowns, accidents, etc.) to classifications according to the type of effect the event has upon the highway (safety, capacity, service life, etc.), and (c) the establishment of organizational arrangements and operational procedures to be able to respond to an event within a targeted time period in a prescribed manner.

Snow and ice control is a special-response maintenance activity that can serve as a model for STRMS. The well-managed snow and ice control system provides for discovery by sensors or patrols, response by priorities and predetermined procedures, organization of special crews and equipment, and the use of special materials to meet the conditions encountered.

While planning, management, and training are the key ingredients in successful STRMS, new technologies such as prefabrication of "plug-in" repairs, equipment for on-site custom fabrication of highway components, electronic monitors of critical facilities, and information transmission and evaluation systems could greatly enhance these increasingly important responsibilities of highway maintenance managers.

CHAPTER ONE

INTRODUCTION

The management of highway maintenance programs represents a major responsibility for highway executives striving to provide rapid, economical transportation without sacrificing efficiency, safety, or serviceability. Over the decades of the 1960s and 1970s, most highway agencies developed and installed computer-based maintenance management systems (MMS) to monitor performance, costs, productivity, and conformity to program plans and schedules. Classic management systems also attempted to shift planning emphasis from failure repairs to preventive maintenance activities wherever current budgets, staff, materials, equipment availability, and other factors permitted.

However, even where effective preventive maintenance programs are employed, there is a practical limit or point of diminishing returns for the preventive activities that can be afforded or justified. Recognition of the inevitability that some periodic problems associated with the physical components of the highway will occur and will require immediate and effective response adds another challenging responsibility to the maintenance manager's workload. The alternative ways in which this responsibility is met by various street and highway agencies is the focus of this synthesis. Factors influencing the frequency and magnitude of short-term maintenance responses required on highway systems will be touched on, but these are not the principal focus of this study.

Another type of short-term response is the emergency response required to correct problems caused by traffic accidents, explosions, spills, floods, landslides, rockfalls, blizzards, wind storms, and other man-made or natural disasters. Emergency or disaster response systems, involving police, fire, ambulance, and other major rescue units often include road maintenance responsibilities. The processes used in assembling the proper manpower, equipment, materials, and other requirements at the right place and time for emergency responses may be modified to fit short-term maintenance response requirements that are the subject of this report. These, and particularly snow and ice control operational concepts, will be discussed later in this synthesis.

CHARACTERISTICS OF HIGHWAY MAINTENANCE SYSTEMS

To provide an overview of the highway maintenance organizations in the United States and Canada, and the highway systems for which they are responsible, as well as to learn about practices by state, provincial, and toll road agencies, a survey of all U.S. states and toll roads and Canadian provinces was conducted by mail. Responses were received from 39 states, five provinces, and three toll road authorities. To simplify communications throughout this synthesis, where references are made to the "states," "provinces," or "toll roads," they are intended to refer only to those responding agencies shown in the tabulation in Appendix A where the responses have been assembled, tabulated, and included on an agency-by-agency basis. Because of the small sample of provinces and toll roads, some of the statistical analyses discussed in the text and shown in other tables do not always include these agencies. However, where the information appears to be relevant and useful, it has been included. The analysis did not, however, lump the three types of agencies together in a single set of data since the unique characteristics of the different types of agencies (particularly the toll road authorities) did not lend themselves to this approach.

Highway systems can be characterized by many factors, but those characteristics affecting maintenance requirements and specifically quick-response maintenance are the focal points of this report. Table 1 summarizes some of the more traditional characteristics of the responding agencies and the highway systems under their responsibilities. Over 80 percent of the system mileage is still classified as rural by both the states and provinces. This is evident also in the travel distances required for maintenance crews to reach the most remote points within their assigned work sections when traveling from the crew headquarters. If travel should be required between opposing remote points, the travel requirements could be as much as double the averages shown in Table 1. In any event, travel time alone could add in excess of 1 hr to response times for maintenance crews, and over ½ day for special crews.

In addition to the geographic size and distribution of the highway network and the maintenance organization superimposed upon it, other broad categories of highway characteristics influence the need for and difficulty of short-term responses to maintenance requirements. These include conditions that do not lend themselves to easy quantification but exert significant pressure upon the maintenance "vulnerability" of the highway system. These characteristics are shown and described in Table 2.

DEFINITION OF SHORT-TERM RESPONSIVE MAINTENANCE SYSTEMS

A significant portion of the maintenance effort may involve short-term responsive work such as patching potholes, replacing damaged guardrails, fixing wash-outs, and repairing knocked-down signs and signals. However, the organizational and operational concepts required of a maintenance department to address short-term responsive maintenance needs have not been recognized always as unique by maintenance agencies and, therefore, require careful definition in order to discuss and analyze them effectively. This can be done by considering short-term responsive maintenance systems (STRMS) in their several components:

- Types of Needs. STRMS serve to meet immediate maintenance needs on the roadway in terms of safety hazards, capacity

TABLE 1
CHARACTERISTICS OF HIGHWAY MAINTENANCE SYSTEMS

	Survey of State, Provincial, and Toll Road Agencies Summary by Agency Classifications		
Characteristics	State Averages	Provincial Averages	Toll Road Averages
Miles in System (Centerline)	19,114	9,587	319
Urban, %	13	17	38
Rural, %	87	83	62
Freeway, %	11	14	N/A
Maintenance Staff Size[a]	2,270	2,136	483
Number of Districts or Regions[b]	20	6	2
Number of Section or Field Offices[c]	78	32	12
Special Teams (i.e., paint striping)[d]? Yes:	86%	100%	67%
Special Teams with STRMS duties[e]? Yes:	77%	80%	67%
Centerline Miles per Staff Member	8.4	4.5	0.7
Maximum Travel-Miles to Respond By:			
Maintenance Crews	44	110	21
Special Teams	168	341	91

[a]Staff size includes all persons employed full time in the performance of maintenance duties, including management and administration of the maintenance program.
[b]Districts or regions are designations for the largest organizational subunits of the state or provincial maintenance organization.
[c]Sections or field offices are designations for the smallest independently functioning field units of the state or provincial maintenance organization.
[d]Special teams are separate work teams, usually specially trained to perform special tasks such as paint striping, and responsible for working in more than one section or district. The teams also are included in the response group pool for STRMS in most states as shown in the survey.
[e]Travel-miles to respond (to STRMS incidents) are measured from the team headquarters location to the most remote location in that team's area of jurisdiction. The same definition applies to special team travel distances but for larger jurisdictions as revealed by the survey.

reductions, or service life reductions caused by structural or functional failures of highway components and by traffic accidents and other man-made or natural causes.

- Need Identification. STRMS include effective mechanisms for the prompt detection and reporting of needs by in-house and external observers in such a manner that the condition and location are made known to the proper maintenance agent to permit a quick and appropriate response.
- Timeliness. STRMS provide for maintenance crews, equipment, and materials to be put to work on any warranted safety or operational need at any site in the maintenance jurisdiction, at any time, within an appropriate brief period after notification of the need.
- Organization. Special organizational arrangements, which may include provisions for reassignments, split shifts, call-outs, intermediate or local reporting points, and service contracts, are used by STRMS to provide for the prompt availability of crews, equipment, and materials suitable for the spectrum of safety and operational needs that may arise.
- Operations. Receiving and acting on notifications of specific maintenance needs under STRMS requires planned and predesignated receiving posts, and preauthorized follow-up procedures. Also, the processes need to be "logged" and monitored to assure that follow-through occurs as required. Preassembled equipment, supplies and materials, and preestablished repair procedures may be warranted to expedite response by the special crews arranged under the organizational component.

In summary, STRMS can be defined as maintenance systems organized to respond at all times to immediate maintenance needs required to restore safety and essential levels of service on the highway. The systems include: needs and location discovery

procedures using both internal and other observations; operational procedures to control receipt and utilization of maintenance needs reports; organizational arrangements to assure proper assignment of people, equipment, and materials to the needs according to the highway classifications and event classifications involved; and performance standards for the timely completion of the needed maintenance and restoration.

TABLE 2

CONDITIONS INFLUENCING NEED FOR SHORT-TERM RESPONSIVE MAINTENANCE SYSTEMS

Structural design, construction characteristics, and age. Pavement and bridge (including signal and sign structures) design, construction (quality), and age characteristics and the relationship of those factors to past, current, and future traffic loads and volumes.

Geometric design and capacity. Steep gradients on mainline roadways or complicated multi-level interchanges which compound the mixed-traffic operational problems (i.e., slow trucks on uphill sections without climbing lanes or off-tracking on curves of long tractor-trailer rigs); pavement alignments which make pavement skid resistance critical and safe sight distances dependent on diligent roadside vegetation control; inadequate lane widths and/or overhead clearances that increase pavement edge wear, concentrate wheel paths and pavement stresses, and threaten through-truss bridge members which are likely to be old and vulnerable anyway,

Environmental conditions. Frequent freeze-thaw cycles; snow and ice storms; heavy rainfall; foundation conditions such as swelling clays; local materials conditions such as low quality aggregates; and instability of cut slopes with erosion, slides, rockfalls, and similar problems; unnatural or man-made environmental conditions where caustic chemicals in the atmosphere attack paints and metals; manufacturing or processing-systems-generated steam or fog blankets cause moisture, icing, loss of visibility; and vehicle exhaust particles, dripping lubricants, tire wear, and other materials coat pavements and reduce skid resistance, especially after long dry periods followed by light rainfall.

Operational conditions. Locations where access to pavements, structures, medians, and appurtenances is made difficult and dangerous or delayed for maintenance crews due to limited access designs, traffic congestion, high speeds, or remote rural sites which do not warrant near-by field offices.

Traffic control systems. Signals, signing, lighting, and pavement markings, which play a critical role in the safe operation of the highway; at-grade intersections, channelized turning movements, short distance weaving lanes, bifurcations with or without energy attenuators; ramp-metering systems, traffic signal systems with or without sensors, all requiring substantially continuous performance (and very prompt maintenance) if the safety of the users and the capacity of the system are to be realized.

Also critical and difficult to establish and maintain are worksite traffic controls, where the signing, marking, and sometimes lighting systems are inter-dependent on physical barriers, temporary roadway pavements around worksites, changes in traffic patterns, and other irregular or conflicting movements required by the worksite characteristics. It is interesting to note that the first numbered report (*1*) in the Synthesis of Highway Practice Series, published by the Highway Research Board (now the Transportation Research Board) in 1969, addressed the problems of traffic controls for freeway maintenance, obviously a longstanding concern to maintenance managers. At major worksites, where contractors are performing repairs or modifications, the contractor is often responsible for the design, installation, and maintenance of the worksite traffic controls, but the ultimate responsibility for the highway and its safe operation--either by the contractor or in his stead if he fails--still rests with the highway agency and maintenance crews that must be prepared to respond if needed.

CHAPTER TWO

DISCOVERY SYSTEMS AND PRACTICES

STRMS must start with the "discovery" of the need for prompt maintenance. Without working and effective discovery systems, the ability to respond quickly may be unused or, at best, underused and maintenance teams implicated (unfairly or fairly) in problems resulting from delayed correction of unsatisfactory highway conditions.

For purposes of the survey, discovery systems and practices were classified under three categories: Formal Inspections, Informal Inspections, and External Observations. In the following sections, the results of the survey and a review of other published information on discovery systems are discussed. Table 3 summarizes the systems and characteristics of those systems used by the states, provinces, and toll roads.

FORMAL INSPECTIONS

There are several basic resources available to solve the discovery challenge in highway maintenance programs. Formal inspections, those that are planned, scheduled, and conducted according to formal policies, regulations, or programs, constitute one method used by every responding agency for structure and roadway condition assessments. Seventy-one percent of the states, 80 percent of the provinces, and 100 percent of the toll roads reported that they conduct these general inspections at least annually, and a large majority of the survey agencies document the inspections with reports or written records of the results. On the other hand, the responding states report that only about one-quarter of STRMS activities are "triggered" by the formal inspections. This limited utility of the formal inspections in STRMS is not unexpected. The formal inspections are performed infrequently and catch only those conditions that exist concurrently with the inspection. The formal inspections are not designed or performed with momentary conditions or events in mind; instead the formal inspections are intended to reflect overall conditions, trends, program needs, pending problems, and other conditions that reflect the status of the maintenance program and the highway network from year to year.

Formal inspections are addressed differently for structures than for roadways because of the differing technical diagnoses and safety implications.

Bridges

Formal bridge inspections are mandated by the Federal Highway Administration (FHWA) as a part of the federal-aid highway program (*2*). The federally specified bridge inspection program calls for bridges, both on and off the federal-aid system, to be inspected at least once every 2 years unless the responsible agency can make a case for a different interval for specific and usually newer structures. Federal regulations mandate that state highway agencies use qualified, certified bridge inspectors to perform regular inspections of all "on-system" and "off-system" highway bridges. The inspections are intended to provide the agency-owner with information, standard ratings, and data about the bridge's functional and structural conditions at the time of the inspection. If the inspection reveals deficiencies in the structural integrity of the bridge, the agency may post special load limits on the structure or close it altogether if necessary for safety until repaired. Deficiencies rated in the federally mandated inspections include inadequate load-carrying ability, traffic volume capacity, overhead and/or lateral clearances, geometry (usually alignment problems), and other structural or operational restrictions.

Roadways, Roadsides, and Appurtenances

All the state and provincial highway agencies and toll road authorities responding to the survey conduct formal roadway inspections. Table 3 shows that about three-quarters of them perform the inspections at least annually, using division or regional level inspection leaders, and 85 percent produce formal records or reports as a result of the inspections. The formal inspections, if tied to MMS, usually include observations and records of deficiencies found in all of the maintainable elements of the highway, including such items as pavement and paved

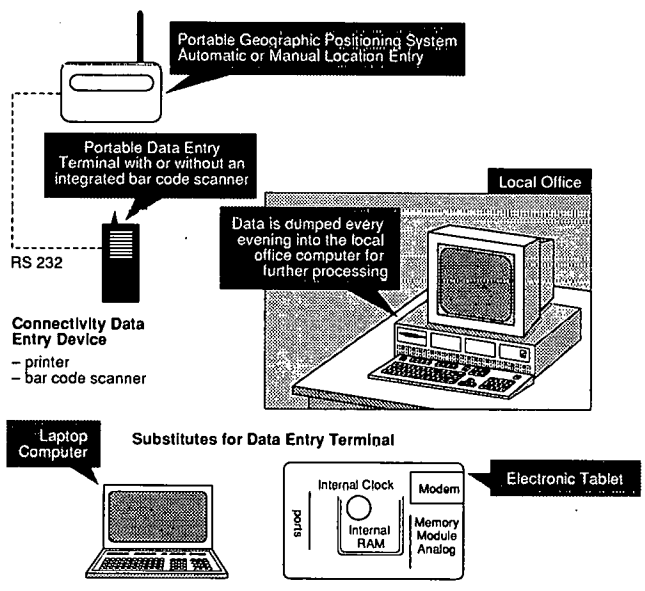

FIGURE 1 Portable field data reporting system.

TABLE 3

MAINTENANCE NEEDS DISCOVERY SYSTEMS AND PRACTICES

Survey of State, Provincial, and Toll Road Agencies Summary of Reported Discovery Systems			
	States	Provinces	Toll Roads
Formal inspections, in-house	100%	100%	100%
Frequency of 1 year or less (yes)	71%	80%	100%
By Div. Reg. or higher authority (yes)	78%	60%	100%
Report or record made (yes)	85%	80%	100%
Informal inspections, in-house			
Encouraged? (yes)	45%	60%	67%
Report forms distributed? (yes)	37%	60%	33%
Number using other techniques	16	3	1
Observation by external sources such as Highway Patrol, other agency employees, and general public			
Encouraged and assisted? (yes)	44%	40%	33%
Telephone "hot line"? (yes)	38%	60%	33%
Effectiveness ratings			
Formal, % repairs triggered	26%	44%	52%
Informal, in-house, % of repairs	63%	43%	47%
External reports, % repairs	11%	13%	1%
Sensing and monitoring devices installed and used for			
Snow and ice detection	39%	20%	33%
Pavement condition sensors	23%	20%	0%
Traffic Controls	38%	80%	0%
Accidents, congestion, other operations	41%	20%	0%

shoulder surfaces; vegetative cover on shoulders, medians, and slopes; culverts, ditches, and other drainage structures; guardrail, impact attenuators, sound barriers, median barriers; and sign structures, signs, lights, signals, delineators, pavement markings, and other traffic controls.

Reporting

Formal inspection records are usually entered manually on field record sheets and delivered to a headquarters location for entry into the agency information system. A strong interest in alternative systems for direct entry of field data into electronic data systems has led to a number of research studies in this area. One study design (*3*) of a data reporting system as shown in Figure 1 has potential application for making deficiency reports by patrol crews on a real time basis using essentially existing technology. The system design employs a laptop computer or electronic tablet for data entry supplemented by a bar code reader and bar coded menu of activities (or deficiencies could be used) to eliminate the need to enter the reported item manually. A portable geographic positioning system identifier for either automatic or manual entry of location information completes the system design. The systems can be powered by battery packs or converters connected to vehicle electrical systems.

INFORMAL INSPECTIONS, IN-HOUSE

Informal in-house inspections were defined for purposes of the survey and this discussion as those inspections that are not planned or controlled but occur in the course of other activities by in-house highway agency people, including maintenance and engineering staff people and management, administrative, and

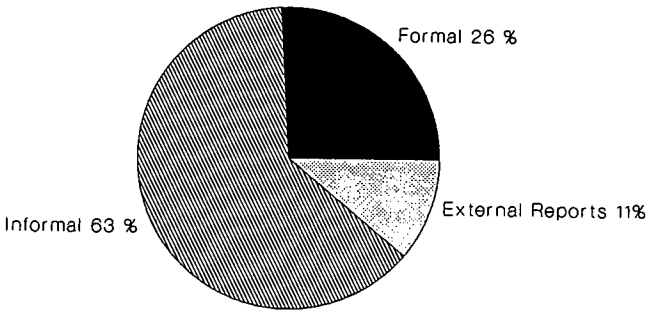

FIGURE 2 Effectiveness of state discovery systems.

support staff members. Most common in this category are the inspections that occur as employees travel the streets and highways from headquarters to preassigned work sites or to predetermined inspection sites. Longer distance travel to meetings and for other business and personal trips provides additional opportunities to observe conditions as do commuting trips to and from work. When given the tools and information to use in observing and reporting, all agency employees can be a valuable force in monitoring and advising the maintenance organization on the roadway conditions.

EXTERNAL OBSERVATIONS

Another effective method for the discovery of STRMS needs is to use, as informal observers and reporters: law enforcement and other regulatory and operations people in sister agencies; individual and commercial highway users; Adopt-a-Highway volunteer groups; and the general public.

The use of internal and external observers is not mutually exclusive and may be mutually supportive. The survey revealed that less than half of the states encouraged either informal in-house or external observations, yet they reported that 63 percent of the STRMS repairs were triggered by informal in-house observations or reports and 11 percent by external observations or reports, or a total of 74 percent (56 percent for provinces and 48 percent for toll roads) from informal sources. Over one-third of the agencies distributed forms for informal in-house reports, and 38 percent of the states and 60 percent of the provinces employed a telephone "hot line" for external reporting of observations. Other techniques reported by 20 of the surveyed agencies included: comment cards placed in rest areas; special liaison with the highway patrol and other government agencies; establishment of a 24-hr communications center for public access; local contacts by the Administrator; a pothole hot line; newspaper publicity about a hot line; and various forms of cooperation with other government agencies. Figure 2 shows the relationships of the formal inspections, informal inspections, and external observations in terms of the average percent of the STRMS activities triggered by each source.

With the increasing presence of cellular telephones in private automobiles, and the already present short-wave radios in most private commercial vehicles and essentially all highway patrol vehicles, there is a large group of candidate external inspectors, traveling the highway system and capable of immediate communications with highway maintenance agencies, if the "inspectors" know who to contact and how to report. Many vehicle operators can provide a valuable extension of staff inspection teams, where a problem or deficiency is readily visible on or from the surface of a pavement or bridge deck. Obviously, this process is underway regardless of the current level of encouragement provided by the highway agencies.

The growing interest by private citizen groups in providing community support for attractive and litter-free highways under the innovative concept of the "Adopt-A-Highway" program, offers highway departments another informal but already institutionalized source of information about conditions within the right-of-way that are in need of prompt maintenance.

AGENCY PROGRAMS

Some examples of agency programs for discovery of maintenance needs include:

- Tennessee. Tennessee, which encourages informal inspections by in-house observers, and uses a simple widely-distributed form, shown in Figure 3, reported that 80 percent of the short-term maintenance repairs are triggered by the informal inspection process.
- Manitoba. The province of Manitoba, while reporting that only 10 percent of its STRMS events are triggered by the informal inspections, does have a well-organized Summer Road Pa-

DT-0114
FORM NO. MM-9

TENNESSEE
MAINTENANCE NEEDED FORM

Rte.: _____ Date: _____

System (circle one): State Interstate

Work Description: _____

_____

_____

Location: _____

_____

Est. Amount of Work: _____

_____

_____

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Comments: _____

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FIGURE 3 Tennessee Maintenance Needed Form.

trol visual inspection program. The performance standard for the Manitoba program is included in Appendix B. The first two objectives of the Manitoba program are (1) the regular observation of all roads and road facilities and (2) the correction of deficiencies that may be hazardous to motorists. The patrol is carried out by the foreman while performing other duties that include traveling over the assigned roads, or by specific inspection if otherwise not observed. High-priority routes are inspected twice each week; others are inspected weekly except the lowest-priority routes that are inspected once every two weeks.

- Virginia. With 53,855 centerline miles on the state highway system, 95 percent of the STRMS needs are reported to be triggered by informal in-house inspections. This major role for informal inspections is probably attributable in part to the large system (Virginia has no county road system except in two urban counties) with substantial suburban residential street mileage in the eastern and northern counties which reduces the geographic spread of many maintenance sections and increases the opportunity for frequent informal observations by maintenance forces and other Virginia Department of Transportation (VDOT) personnel.

Although only 10 percent of the STRMS activities were reported to be generated by external reports in Virginia, VDOT has several active citizen-involvement programs. Highway Helpline is a publicly promoted invitation to citizens to "Keep Our Highways In Good Shape" by using an 800 number to place telephone calls reporting concerns about highway conditions needing action. The program is monitored by VDOT using a simple one-sheet form, shown in Figure 4, which includes information about the caller, the location of the reported problem,

1-800 367-ROAD HIGHWAY HELPLINE

Virginia Department of Transportation

OFFICE OF PUBLIC AFFAIRS
1401 EAST BROAD STREET
RICHMOND, VIRGINIA 23219

DATE

NAME

ADDRESS

PHONE

CITY

ZIP

REFERRED TO DISTRICT

REFERRED TO RESIDENCY

REFERRED TO AREA

COUNTY AND ROUTE LOCATION OF CITIZEN'S CONCERN

NATURE OF CALL

Pavement breaking	
Bushes/grass cut	
Limbs/dead trees	
Sign down	
Low shoulders	
No shoulders	
Drainage	
Blading/shaping	
Dusty/muddy	
Signal	

DATE AND RESPONSE

Keep Our Highways In Good Shape:
1-800-367-ROAD
HIGHWAY HELPLINE

sticker

WHERE DID THEY HEAR ABOUT HELPLINE?

ONCE A RESPONSE IS MADE, RETURN COMPLETED FORM TO PUBLIC AFFAIRS, CENTRAL OFFICE

FIGURE 4 Virginia Helpline telephone call record.

the classification of the problem, the action taken in response to the call, and the follow-up. For easy reference by citizens, the telephone "Helpline" number is printed on small stickers, available to motorists and others to fix to convenient surfaces in vehicles and elsewhere for ready reference. A full-size copy of the sticker is also shown in Figure 4, as an insert to the form. Virginia also has an active Adopt-A-Highway program, called "Dare-To-Care." Individuals, organizations, and businesses are invited to agree to keep selected 2-mile sections of highway cleared of litter for a 2-year period which may be renewed. VDOT provides safety and collection materials and a sign with the name of the adopter shown at the beginning of each adopted two-mile section.

- Oakland County, Michigan. A "pink slip" program, named after the report form used, was instituted by the Oakland County Road Commission to enlist employees in an on-going road hazard identification effort. Over 500 employees were trained in what, how, where, and to whom to report potential road hazards. The program included a positive feed-back process in which the submitting employee received a written response after action was taken on the reported hazard.
- Pennsylvania. The Pennsylvania Turnpike has made use of the cellular telephone system by providing a free call service for motorists to use in reporting problems. The Turnpike also has installed motorist call boxes to transmit information to a central control center. The Pennsylvania Department of Transportation (PennDOT) has preestablished detour routes for incidents that would close major expressways or interstate highways. In some instances the detour routes are already marked with colored arrow signs in place except for the introductory signs. In other instances the signs are prepared, assembled, and stored on trailers at appropriate locations for immediate access and installation on short notice.

LOCATION INFORMATION

One important requirement for successful external observation services is clear and ready location identification. Mile post markers, bridge-crossing names and/or route numbers, interchange names and numbers, and other location information is more common on interstate and urban express highways than on other primary and secondary highways. A commitment by a highway agency to use external observers in addition to staff for repair reports, carries with it a need to make an assessment of existing location information available to users on the highway and a plan to improve it where warranted, if external information is to be useful and reliable.

SENSING DEVICES

Scientific developments have advanced to a point where highway agencies now have a technological capability to monitor roadway conditions but often lack the financial ability to do so. However, many agencies are incorporating sensing devices in the highway system at strategic locations as budgets permit.

The survey respondents indicated that 39 percent of the states, 20 percent of the provinces, and 33 percent of the tollroads use sensing devices (moisture and temperature sensors) for snow and ice detection.

Sensors used for pavement (structural) conditions were reported by 23 percent of the states and 20 percent of the provinces. Under the category of pavement sensors, the survey respondents included photo logging, thermistor probes, weigh-in-motion devices, strain gauges, deflection measuring equipment, and the ARAN (automatic road analyzer). Generally, these instruments are less applicable to detecting STRMS conditions than to detecting longer-range performance characteristics, but they may prove useful in predicting the need for preventive maintenance or, alternatively, STRMS activities.

An Iowa State University demonstration project (*4*) has been initiated to develop technology to monitor pavement performance through sensors installed at a site that can transmit the collected data to remote recording and observation points. The sensors used included concrete strain gauges; dowel bar strain gauges; pavement temperature sensors; pavement deflection sensors; moisture and density gauges; and traffic volume, speed, and weight sensors. The study seeks to establish calibrations for the sensors and correlations between sensor data and pavement conditions.

Sensors used for traffic control were reported in the survey by 38 percent of the states and 80 percent of the provinces. The types of control devices reported included loop detectors, lane sensors, closed circuit television cameras, computer-controlled central systems for diagnosis and coordination of signals, ramp metering, message signs, radio broadcasts, traffic counters, speed detectors, wind gauges, motorists information systems, video-logging, and remote controllers which phone in problem messages. The diagnostic sensors offer direct and specific information about failures and breakdowns in the traffic control equipment. Many of the other sensors that detect the volumes, speeds, and densities of traffic can provide indirect information or clues about potential problems on the highway or bridge that may be the cause of abnormal traffic flow, and in the case of television observation and lane sensors, more specific information may be obtained for use in taking prompt STRMS action.

Comprehensive central network traffic control systems are in operation in many major North American cities including Chicago, Detroit, Houston, Los Angeles, Minneapolis-St. Paul, Seattle, and Toronto. Typical of these is Detroit where the Michigan Department of Transportation is applying state-of-the-art technology to the problem of detecting and responding to incidents on the Detroit area freeways in a project (*5*) called The Detroit Area Freeway Surveillance Control and Driver Information System (SCANDI). The project uses vehicle detectors, ramp metering devices, driver information devices, communications including transmission lines with multichannel telemetry, data acquisition and control systems, closed circuit television, an information analysis system, and motorist-aid voice-type call boxes. The vehicle detectors are installed throughout the freeway system at approximately $\frac{1}{3}$-mile spacings on all lanes and on all entrance and exit ramps. Ramp metering, employing modified traffic signals, controls access to the freeway. The call boxes are installed at $\frac{1}{3}$-mile intervals along the freeway and the closed-circuit television cameras are placed at locations at approximately $\frac{1}{2}$-mile intervals to give optimum visual coverage of the designated freeway sections. Using these technologies to create an integrated information system housed in central and satellite control centers, the program will permit real time responses to changes in the freeway traffic stream and will provide accurate, current information to the motorists on or entering the freeway

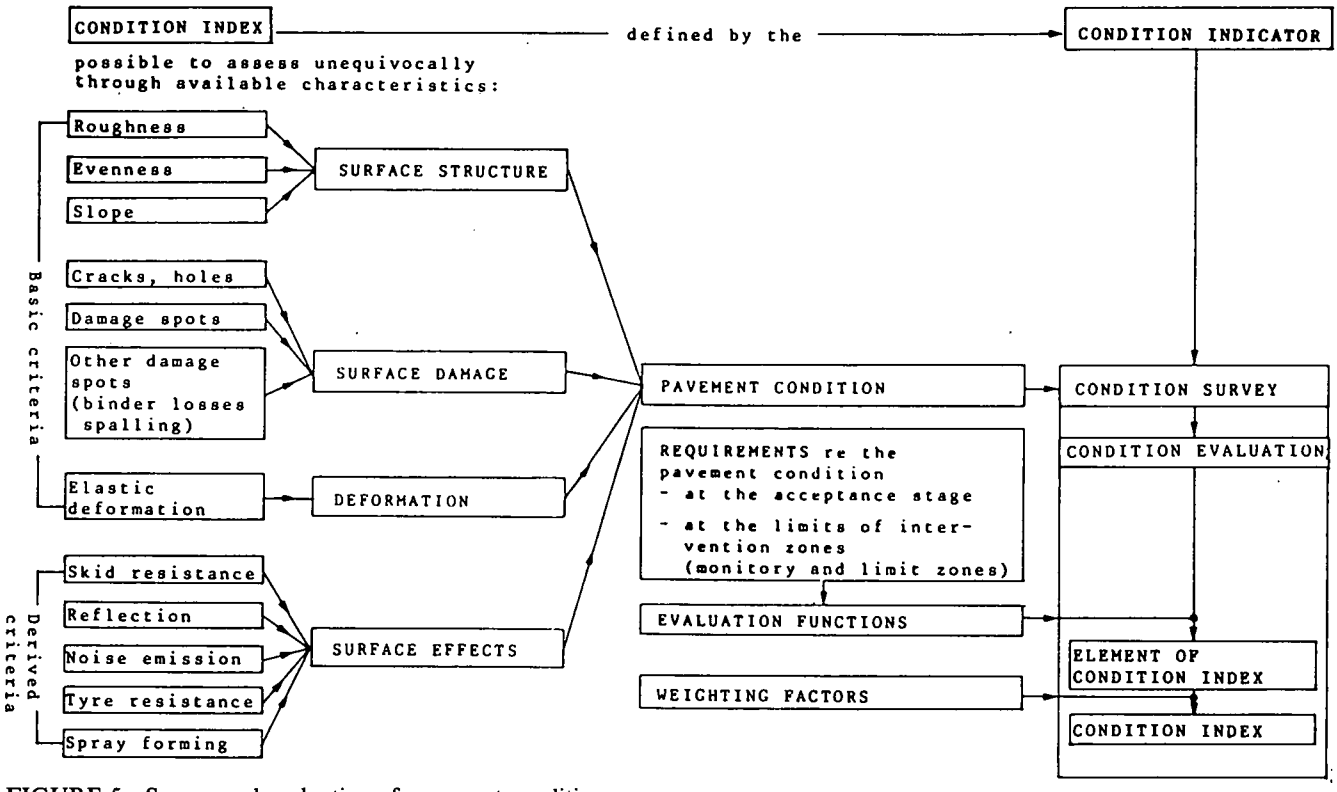

FIGURE 5 Survey and evaluation of pavement conditions.

network. Response times to incidents by maintenance, police, fire, and other emergency personnel are expected to be significantly reduced with the early and reliable detection by the SCANDI system. In conjunction with the installation of the SCANDI system, sophisticated "incident management teams" were planned to further improve the response capabilities of the service agencies.

FORECASTING NEEDS AND RESPONSES

There are several ways in which STRMS needs are forecasted by highway maintenance agencies. MMS are generally designed to provide projections of maintenance needs based on a frequency factor applied to the inventoried quantities of maintainable components on the highway network. While these forecasts are less reliable on specific roadway sections, results are usually acceptable for needs on larger networks where averages apply. Although frequency-factor models are empirical, careful monitoring of performance curves by progressive maintenance agencies has provided those agencies with increasingly more accurate forecasting models over time. Models usually include other variables such as climate and traffic volumes as well as quantities of maintainable components.

The costly and growing problem of pavement performance has instigated a major effort nationwide to find better models to predict pavement performance under a variety of loading and environmental variables. The Long Term Pavement Performance (LTPP) studies initiated by the Strategic Highway Research Program (SHRP) (*6*) and to be continued by FHWA, will represent a 20-year, $200 million effort when completed in the first decade of the 21st century.

The German Road and Transportation Research Association has developed a national system (*5*) to assess road conditions using both a visual and technical (instrumented) condition survey. For pavements, as shown in Figure 5, both basic criteria for surface structure, surface damage and deformation; and derived criteria for surface effects are considered in the German system.

The participants at an international pavement conference (*6*) identified the major factors influencing pavement conditions and performance as: deflection, roughness, distress, and skid resistance. These factors, shown in Figure 6, are a measure of structural capacity, serviceability, physical condition, and safety, respectively.

Lytton (*7*) reported on the "ranking" methods used by agencies to select projects for future rehabilitation or maintenance programs. All of the methods used condition data, threshold criteria and rehabilitation or maintenance alternatives to select projects for current and estimated future programs. Figure 7, from the Lytton paper, shows the use of ranking methods in a conceptual diagram that includes cost and benefit values. A typical state highway needs survey and program budgeting process is illustrated in the information flow diagram shown in Figure 8, prepared by the Illinois Department of Transportation.

SUMMARY

Discovery systems use a variety of resources and technology, some formal and some informal, to provide a prompt and reliable flow of information about roadway conditions to the mainte-

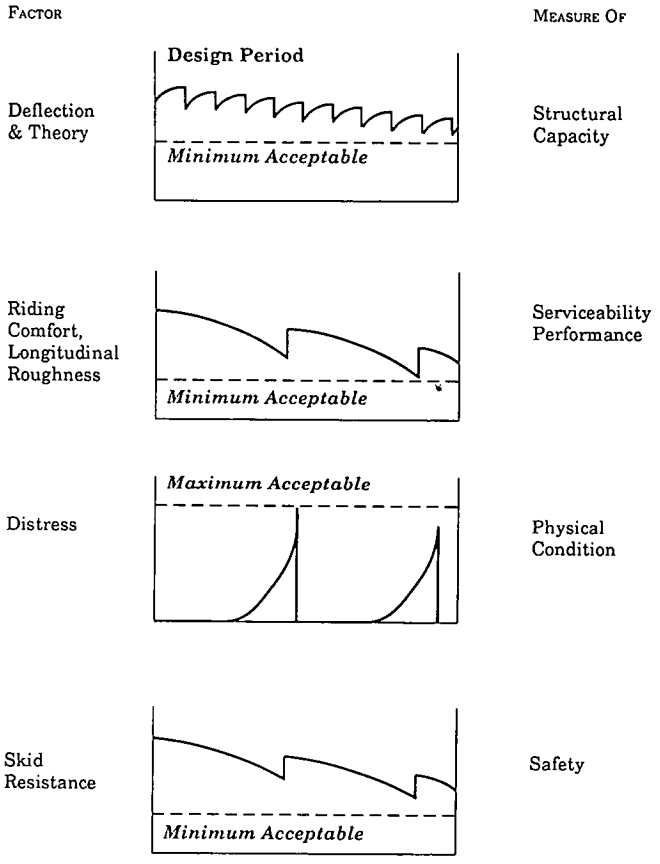

FIGURE 6 Important factors influencing pavement condition and overall performance.

nance organization. The most effective systems employ formal inspections, forecast models, sensing devices, informal in-house reports and external observations for prompt and extensive information about the roadway system. The systems require planning and organization to be effective. Formal inspections are structured by MMS to capture information about work required on specific maintainable components of the roadway, or in the case of bridges, about the load carrying and functional conditions of the structure.

Forecasting models, developed in conjunction with MMS or pavement management systems, serve to provide budgeting information and general workload projections. Sensing devices can provide environmental and stress data on pavements and structures; information about operational conditions on the roadway (and clues to physical conditions); and diagnostic data about malfunctioning traffic control and lighting equipment installations. Informal in-house reports extend the capacity of the maintenance staff to the full complement of agency employees traveling the roads and noting conditions. External observations (by highway users and other citizens,) provide an additional resource for monitoring the roadway system. The use of that resource is dependent upon the investment of an outreach effort

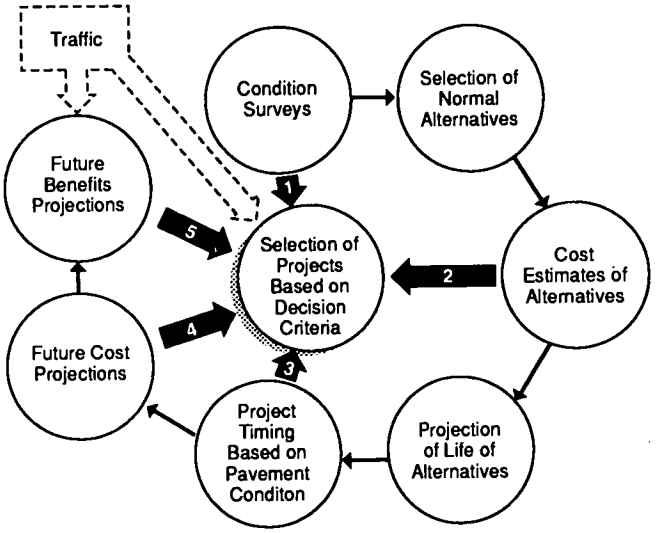

FIGURE 7 Pavement ranking methods.

(publicity, telephone lines, response systems) by the highway maintenance organization. There is likely to be a point of diminishing returns in this outreach investment that limits the use of this "free" resource. The outreach effort involves preparation of a reporting system (forms, hotline telephones, etc.), the establishment of organizational units to receive reports/calls and to respond to STRMS needs, the placement of location information on the road system network suitable for public use in identifying sites of reported needs, and the operation of a public communications program (radio, television, newspapers, posters, etc.) to inform and enlist public participation in the observation and reporting program.

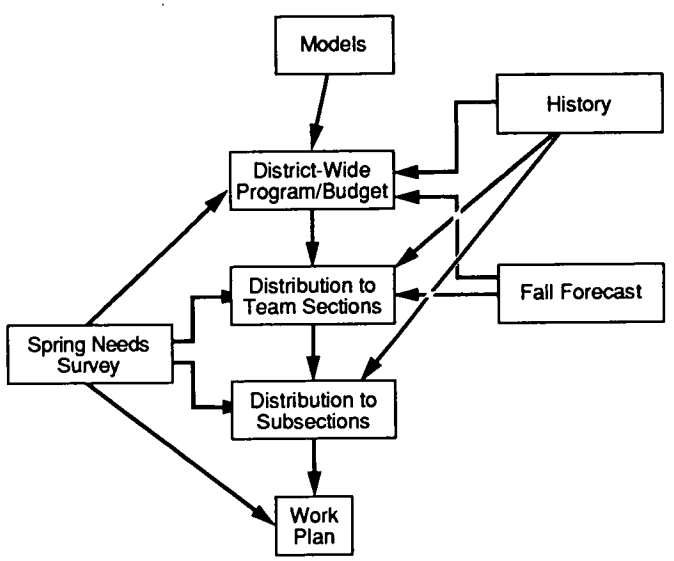

FIGURE 8 Illinois program budgeting process.

CHAPTER THREE

RESPONSE SYSTEMS

The establishment of maintenance short term response systems is an integral yet unique part of the overall management responsibility for maintenance programs. Most highway agency maintenance managers agree that STRMS require and benefit significantly from management action. State, provincial, and toll road managers recognize that systems are aging and deteriorating; traffic volumes and loads are increasing; vehicle speeds and sizes are increasing; labor, equipment, and materials costs are increasing; budget levels are not increasing proportionately and often fail even to maintain equivalency over time and inflation; and traditional sources of highway revenues are being used for deficit reduction and other non-highway uses by the federal government.

It is difficult to establish the direct correlation of these trends with the need for STRMS but it is difficult also to believe that there is not a reciprocal effect. At the same time, positive changes are taking place in the field of highway maintenance: public and political attention is being focused more sharply on the need for and benefit of highway maintenance than it has been since the road system was paved to "get the farmer out of the mud"; research recognition is being given to the need for new technologies specifically developed to serve maintenance programs; and an ever stronger case is being made of the real cost of inadequate maintenance.

CLASSIFYING NEEDS AND RESPONSES

As shown in Table 4, a large majority of the survey respondents indicated that they have formal classifications of conditions requiring short-term responses, response decision authority, communications protocol, and planned procedures for common types of repairs. All of the toll roads, 80 percent of the provinces, and 74 percent of the states have formal classifications systems for STRMS activities. Most systems include both classifications of the highways or roads as well as classifications of the types of deficiencies or problems requiring responses and categories of responses that are determined by a combination of the two classifications. This is illustrated in the matrix shown in Table 5. The concepts illustrated in Table 5, four event classifications, six highway classifications, and events and actions cited, are not portrayals of any specific programs but are examples of the principles around which STRMS are being organized and operated by highway maintenance agencies. Those principles are: the assignment of categories of highways to classifications requiring the same type of response action and priorities, the assignment of events (failures, breakdowns, accidents, etc.) to classifications according to the type of effect the event has upon the highway (i.e., affects safety, capacity, service life or durability, aesthetics, etc.), and the establishment of organizational arrangements and operational procedures to be able to respond to the event within a "targeted" time period in a prescribed manner.

Formal classifications of STRMS events vary in the responding agencies from general categories such as safety, capacity, service life or structural condition, and aesthetics to a more detailed description of such potential problems as the critical dimensions of a pothole. Informal systems usually rely upon the foreman or supervisor to make judgments about the need in response to each specific problem as it is discovered. Presumably, the responsible individual or an alternate would have to be accessible for such judgments at all times—a burden that could be difficult to carry for long periods of time in busy jurisdictions.

The Illinois Division of Highways has established a duty officer system that represents a well-structured plan to provide a responsible staff member from the Central Bureau of Maintenance, assigned on a rotating basis, to administer routine highway-related matters and emergency situations which occur anytime during the assigned week including those occurring during nighttime hours, weekends, and holidays. Excerpts from the *Duty Officer Manual* covering the tour of duty, scheduling plan, roster, use of pagers, duties and responsibilities, and reporting procedures are included in Appendix C.

DECISION LEVELS

A pragmatic view was evidenced in the answers to the question about the decision-level required for response to STMRS. Almost all (92 percent) of the states indicated that the availability of local crews, equipment and materials was a key factor in establishing the level of authority required to respond. Where special arrangements for crews, equipment, or materials to be transferred and reassigned between jurisdictions were required, the decision usually rested with the authority level spanning the affected organizational units involved. Seventy-three percent of the respondents include roadway classifications as a factor, and about half listed costs and prearranged contract services as factors. This suggests that most states delegate authority to the field operations level to the extent that the resources are locally available to respond and require higher authority only in the event that special resources outside of that jurisdiction are required. The toll roads indicated about uniform influence of all factors in the establishment of decision levels, which suggests that authorizations in smaller organizations may be retained at higher levels without the same degree of difficulty or delays that might occur in large, dispersed organizations.

COMMUNICATIONS

Preestablished communications protocols were reported in the survey by over 90 percent of the states, for obtaining authorizations, shifting on-duty workers, and calling out off-duty workers,

TABLE 4

RESPONSE SYSTEMS MANAGEMENT

Survey of State, Provincial, and Toll Road Agencies Summary of Reported Systems for Short-Term Response to Maintenance Need	% of Respondents with Affirmative Answers		
	States	Provinces	Toll Roads
Classifications of Conditions Requiring Short-Term Maintenance Response			
Formal	74	80	100
Other	26	20	0
Response Systems Procedures Decision Responsibility Level Based on			
Roadway Classifications	73	80	100
Costs and Budgets	58	100	33
Local Crew, Equipment, Materials Availability	92	100	100
Prearranged Contract Services	55	100	100
Communications Protocol Preestablished for			
Obtaining Authorizations	94	100	100
Shifting On-Duty Worker Assignments	91	100	100
Calling out Off-Duty Workers	95	100	100
Calling out Contractors and Other Outside Help	83	60	67
Repair Procedure and Technology Section			
Preplanned Standards for Specific Types of Repair	86	100	67
Preplanned Assembled Repair "Kits" of Materials, Tools, Equipment	26	40	0
Predetermined Use of Permanent or Temporary Options	58	80	67

with 83 percent reporting procedures for calling out contractors and other outside help. In an earlier study of state contract maintenance practices (*8*), 11 states indicated that from 1 to 89 percent of their emergency repair work was done by contractors.

REPAIR PROCEDURES AND ORGANIZATION

A large majority (86 percent) of the states plan specific types of repairs (such as management system performance standards), but only one-fourth of them preassemble repair kits. About half attempt to predetermine and specify the use of permanent or temporary repair options as standard operating procedures in STRMS.

Highway characteristics and components influence the STRMS organizational structures established to respond promptly to urgent maintenance needs. Managers appear to make people, equipment, materials, and organizational arrangements to meet the unique demands of the specific highway network for which they are responsible. In complex urban networks, the critical nature of response time may warrant directing call-out employees to report directly to a problem site rather than the maintenance headquarters when notified. In remote rural locations, intermediate storage sites with essential equipment and supplies on stand-by, may be used as reporting stations when local emergencies arise. Many agencies assign patrols or key observers to an around-the-clock schedule during periods of potential need such as winter snow and ice control. For winter snow and ice control, some agencies use advanced weather forecasting systems with pavement sensors to forecast the call-out time for maintenance crews.

For some predictable types of STRMS activities, "kits" of special tools, equipment, and supplies can be preassembled, packaged, or bundled together so that they can be quickly loaded (or preloaded on stand-by or patrol units) for use in immediate

TABLE 5

EXAMPLES OF STRMS RESPONSES BY HIGHWAY AND EVENT CLASSIFICATIONS AND TARGETED TIMES

Classification of Highway	Classification of Event (Example /Action)			
	Safety	Capacity	Service Life	Aesthetics
Urban Expressway	Roadside exit sign damaged by truck/Replace post and sign (temporary if necessary)	Severe spalling on bridge deck/Temporary patch until off-peak repair using permanent materials	Pumping joints at low oints in pavement profile/Mudjack/ subseal in off-peak period	Debris caught in median plantings/Schedule early clean up in off peak
Time Target	1 hour	4 hour	2 weeks	5 days
Urban Aterial	Major pothole in center pavement lane/Temporary patch until off-peak work can be done	Severe spalling on bridge deck/Temporary patch until off-peak repair using paermanent materials	Pumping joints at low points in pavement profile/Mudjack/ subseal in off-peak period	Debris caught in median plantings/Schedule early clean up
Time Target	2 hours	1 day	2 weeks	2 days
Urban Distributor	Damaged STOP sign at intersection/Place temporary sign while resetting post and new sign	Severe spalling on bridge deck/Temporary patch until off-peak repair using permanent materials	Pumping joints at low points in pavement profile/Mudjack/ subseal in off-peak period	Debris caught in roadway plantings/Schedule regular clean up
Time Target	1 hour	3 days	4 weeks	1 week
Rural Expressway	Major pothole in center pavement lane/Temporary patch until off-peak work can be done	Severe spalling on bridge deck/Temporary patch until off-peak repair using permanent materials	Pumping joints at low points in pavement profile/Mudjack/ subseal in off-peak period	Debris caught in median plantings/Scedule early clean up
Time Target	2 hours	1 day	2 weeks	2 days
Rural Principal	Damaged STOP sign at intersection/Place temporary sign while resetting post and new sign	Severe spalling on bridge deck/Patch off-peak using permanent materials and procedures	Pumping joints at low points in pavement profile/Mudjack/ subseal in off-peak period	Debris caught in roadway plantings/Schedule regular clean up
Time Target	1 hour	4 days	2 weeks	1 week
Rural Local	Damaged STOP sign at intersection/Place temporary sign while resetting post and new sign	Severe spalling on bridge deck/Patch off-peak using permanent materials and procedures	Pumping joints at low points in pavement profile/Mudjack/ subseal in off-peak period	Debris caught in roadway plantings/Schedule regular clean up
Time Target	4 hours	2 weeks	4 weeks	1 week

responses. Examples might include such items as flame-resistant blankets for tire fires; hooks, chains, and other towing equipment for moving disabled vehicles, debris, and other obstacles off of the roadway; metal cutting and welding equipment; manageable containers of cold mix, paint, key sign faces such as STOP signs, and other supplies for minor but time-sensitive repairs; and basic traffic control items including cones, flags, caution signs, detour signs, flashing lights, small barricades, and similar items.

The California Department of Transportation (Caltrans) has developed and adopted a carefully defined set of Maintenance Levels of Service that provide clear and specific instruction on how to assign priorities and schedules to maintenance work at the crew level where specific locations and projects must be sorted out, often in a very short time frame. In outline form, the Caltrans categories of maintenance are shown in Table 6. Further description of the system as prepared by Caltrans is included as Appendix D.

PennDOT offers an effective format for recording deficiencies for various highway components inspected in standard, regularly scheduled condition surveys. An example is shown in Figure 9.

An Australian study team (*9*) felt that a single classification was not sufficient for all maintenance works and instead adopted three types of maintenance:

- Routine Maintenance that encompasses groups of activities which, due to their extent, location, time of occurrence, or means of execution, are not amenable to planning in detail, although the annual extent of such maintenance can be estimated on the basis of the level of service accepted by the road authority;

TABLE 6

TYPES OF MAINTENANCE BY CALTRANS

Responsive Maintenance Urgent Quick Routine Seasonal Delayed
Scheduled Maintenance Frequency Range
Planned Maintenance Programmed Work (by Headquarters)
Highway Class Class 1, 2, or 3 (based on type and volume of traffic served) Rural or Urban
The Priority or "Why" Code 1. Safety-Related 2. Preservation of Investment 3. Traffic Service

• Specific Maintenance encompasses groups of activities that can normally be predicted and planned for by extent, location, and nature and lend themselves to rigorous management techniques; and

• Restoration Works performed to restore roadway and structures following damage or disturbance by events beyond the control of the road authority.

Patrol leaders, with fixed crews and assigned to defined road lengths, are responsible for the detection, priority assessment, and execution of routine maintenance works within the patrol area in the Australian system.

The discovery system used by Manitoba includes the classification of STRMS activities by both the category of highway on which they are needed and the relationship, if any, to highway user safety. Eighty percent of the provinces responding to the survey, use formal classification systems for conditions requiring STRMS.

INCIDENT MANAGEMENT

There are several types of incident management systems that can serve as models for STRMS.

Snow and Ice Control

The most common special response maintenance activity, and one that is well organized in many northern states, is snow and ice control. Snow and ice control systems have many of the elements that are desirable in STRMS. These include:

• Discovery. Early detection of the need for snow and ice control activities is provided by sensors installed in bridge decks and other strategic locations on the roadway, weather forecasting systems, by commercial forecasters and weather services, and in critical areas by patrols of snow fighting crews and equipment on the roadway monitoring conditions and prepared to act immediately if needed. Some states with severe winter conditions schedule split shifts for crews to provide a full 16 hours of coverage and immediate response to snow conditions. Others use skeleton patrols to monitor conditions, respond to emergencies and relay information when a storm hits and full crews are needed. In most states, storm conditions and snow-fighting activities are reported on a continuous real time basis by radio-equipped crews.

• Response. Early and effective response to snow storms is a primary objective of the storm-fighting plan and organization. Roadways are usually classified according to priorities and receive treatment in accordance with those priorities. Levels of treatment also are usually classified and different levels of activity are assigned to different classifications of roadway. Examples of such classifications are the assignment of top priorities to urban expressways and the levels of treatment that include use of chemicals and plowing to achieve a skid-resistant pavement during the storm and clearing as soon thereafter as possible.

• Organization. Crews are preorganized for snow and ice control activities, assigned to specific units of equipment and to specific road locations and routes in most cases. Call-out procedures during off-duty hours are well established with stand-by assignments rotated where staff sizes permit. In regions of constant or very frequent snow and ice control activity, crews may be assigned to separate shifts to provide around-the-clock on-duty coverage.

• Equipment. As warranted, special snow and ice control equipment such as plows, blowers, spreaders, and other material handlers is purchased, kept at ready and used exclusively for snow and ice control activities. Equipment is designed and stored in a manner to permit quick and reliable activation when needed. For instance, hopper-body salt spreaders are stored on elevated racks that permit truck drivers to position the truck under the rack and lower the spreader body onto the truck bed in minutes without extra help. Hydraulic systems to power the spreaders can be connected to the trucks by quick couplings that do not require special tools or much time. Snow plows are racked for quick drive-in engagement to trucks already fitted with plow frames under the truck bodies.

Another type of equipment used effectively in snow and ice control is snow fence. Properly placed, snow fences can interrupt the air flow carrying snow drifts across pavements and cause the snow to be deposited adjacent to paved areas instead. Good snow and ice control programs call for strategic placement of snow fences at the beginning of the winter season.

• Materials. Chemicals and abrasives used in snow and ice control programs are pre-mixed if required by the agency's policy, stockpiled for ready access to loaders or placed in elevated bins for gravity loading, and replenished throughout long storms from on-site inventories or contractor inventories under supply contracts.

Other Incident Management Systems

Many systems have been established to deal with major catastrophes. Dudek, in looking at traffic problems generated by incidents and special events (*10*), identified eight primary methods for incident detection: electronic surveillance, closed circuit tele-

CONDITION SURVEY FORM — **PENNSYLVANIA DEPARTMENT OF TRANSPORTATION** — **CONCRETE PAVEMENT**

COUNTY NO.	COUNTY NAME	SR	SEGMENT NO.	SEGMENT LEN(FT)	DIR	NET	COMMON STREET NAME	DESCRIPTION BEGINNING	DESCRIPTION ENDING	SURF TYPE	PREDOM. WIDTH	NO. OF LANES	OBSERVERS #1	OBSERVERS #2	OBSERVERS #3	SURVEY MM/DD/YYYY
25	ERIE	0090	0310	2654	E	INT	PA THRUWAY	SR MARKER	SR MARKER	70	24	02	__	__	__	__/__/1991

CONDITION	EXTENT				SEVERITY
JOINT SEAL FAILURE	NONE	<10%	10-30%	>30%	JOINTS
		7	8	9	> 50% MISSING
		4	5	6	> 1' SEALANT MISSING
	0	1	2	3	BOND LOSS > 2' / JOINT
LONGITUDINAL JOINT SPALL	NONE	<10%	10-30%	>30%	LENGTH
		7	8	9	> 6"
		4	5	6	1" - 6"
	0	1	2	3	< 1"
TRANSVERSE CRACKING	NONE	<10%	10-30%	>30%	SLABS
		7	8	9	> 1"
		4	5	6	1/4" - 1"
	0	1	2	3	< 1/4"
TRANSVERSE JOINT SPALLING	NONE	<10%	10-30%	>30%	JOINTS
		7	8	9	CRUSHED JOINT
		4	5	6	ISOLATED SPALL > 2"
	0	1	2	3	MINOR SPALL < 2"
FAULTING	NONE	<10%	10-30%	>30%	NUMBER JOINTS
		7	8	9	> 1/2"
		4	5	6	1/4" - 1/2"
	0	1	2	3	< 1/4"
BROKEN SLAB	NONE	< 5%	5-15%	>15%	SLABS
		7	8	9	LOOSE PIECES
		4	5	6	INTERLOCKING PIECES
	0	1	2	3	HAIRLINE CRACKS
BITUMINOUS PATCHING	NONE	< 5%	5-15%	>15%	SLABS
		7	8	9	POOR CONDITION
		4	5	6	FAIR CONDITION
	0	1	2	3	GOOD CONDITION
SURFACE DEFECTS	NONE	< 5%	5-15%	>15%	SLABS
		4	5	6	5 OR MORE PER SLAB
	0	1	2	3	< 5 PER SLAB
RUTTING > 1/2" OVER 50% SECTION LENGTH	NO	YES			
	0	1			

REMARKS:

SHOULDERS PAVED AND UNPAVED			
LEFT AVERAGE WIDTH		RIGHT AVERAGE WIDTH	
TOTAL	PAVED	TOTAL	PAVED
04	04	10	10
TYPE:		TYPE:	

SIGN ADEQUACY			
MISSING		LABEL	
0	BOTH OK	0	BOTH OK
1	AHEAD	1	AHEAD
2	BACK	2	BACK
3	BOTH	3	BOTH

PAVED PORTIONS ONLY

CONDITION	LEFT EXTENT				SEVERITY	RIGHT EXTENT			
LANE/SHOULDER SEPARATION	NONE	<10%	10-30%	>30%	LENGTH	NONE	<10%	10-30%	>30%
		7	8	9	> 1"		7	8	9
		4	5	6	1/4" - 1"		4	5	6
	0	1	2	3	< 1/4"	0	1	2	3
DETERIORATION	NONE	<10%	10-30%	>30%	LENGTH	NONE	<10%	10-30%	>30%
		7	8	9	HOLES/SEV CRKNG		7	8	9
		4	5	6	ENT PAVED WIDTH		4	5	6
	0	1	2	3	MINOR CRACKING	0	1	2	3

PAVED AND UNPAVED PORTIONS

CONDITION	LEFT EXTENT				SEVERITY	RIGHT EXTENT			
SLOPE	NONE	<10%	10-30%	>30%	LENGTH	NONE	<10%	10-30%	>30%
	0	1	2	3	DOES NOT DRAIN	0	1	2	3
BUILDUP	NONE	<10%	10-30%	>30%	LENGTH	NONE	<10%	10-30%	>30%
	0	1	2	3	DOES NOT DRAIN	0	1	2	3
DROPOFF	NONE	<10%	10-30%	>30%	LENGTH	NONE	<10%	10-30%	>30%
		7	8	9	> 4"		7	8	9
		4	5	6	> 2" - 4"		4	5	6
	0	1	2	3	1" - 2"	0	1	2	3

REMARKS:

FIGURE 9 Pennsylvania DOT Condition Survey Form for concrete pavements.

vision, aerial surveillance, emergency call boxes, emergency telephones, cooperative motorist aid systems, CB radios, and patrol vehicles (police, mechanical service, and maintenance).

Many state and local highway agencies have organized expressway patrols assigned to busy urban expressways. The patrols have a primary mission to assist disabled motorists but also undertake activities such as debris removal, observation and reporting of highway conditions requiring action by maintenance crews or others, and temporary emergency traffic control and assistance at the scene of an accident or other emergency. Patrol vehicles usually are equipped with those tools and supplies most likely to be needed in carrying out the aforementioned duties.

A study of freeway emergencies and special events (*11*) suggested that incident management must focus on total time—the time to detect the problem, the time to make decisions and handle traffic, the time to clear obstructions and restore traffic, the time to make repairs, and the time to dissipate congestion and restore normal traffic flow.

In Los Angeles, the incident management teams are volunteer, multi-agency, multi-disciplinary groups. Teams operate similar to a volunteer fire department, taking equipment home with them, are on-call 24 hr a day, go into action when (preclassified minimum or greater) incidents occur (i.e., blocking two lanes for 2 or more hrs). Teams meet at the incident site and set up

an on-site command post. A traffic operations center monitors network traffic conditions and relays information to the command post.

The "Minuteman" operation, an incident management team on the Chicago expressways, is committed to the removal of damaged vehicles and debris from the travel lanes and storage in a safe temporary location as soon as possible. The priority objective in the Chicago operation is to restore the flow of traffic, minimize delays, and prevent additional accidents resulting from the congestion.

PennDOT, working with the Pennsylvania Emergency Management Association, holds occasional disaster simulation exercises to test and refine response systems.

PREVENTION OR REDUCTION OF NEED FOR STRMS ACTIVITIES

For the long term, maintenance managers must be active participants in the effort to find economical means to modify existing roadway maintenance problem areas and to prevent the development of future problems by sharing with planners and designers the valuable experience they have acquired "in the field." Future designs that can reduce maintenance needs and simplify maintenance performance will benefit from the shared experiences of maintenance managers as well as those of researchers and designers. A 1978 study for FHWA (*12*) addressed the need to include accommodations for maintenance access and activities, as well as planning and design concepts to reduce the need for maintenance in highway preconstruction activities. The resulting report offered a set of guidelines to promote adequate consideration of maintenance requirements in all phases of preconstruction activities. Preventive maintenance also can play an important role in reducing the demand for short-term responses to failures.

An SHRP project (*13*) is studying the effects of pavement surface treatments on service life for various pavement conditions and operational conditions. The research effort attempts to establish the relationship between pavement conditions and treatment strategies in order to find optimum timing and economical treatments to extend pavement service lives. Another concept for preventive maintenance is illustrated by the use of group relamping programs on street lights, expressway lighting and similar area lighting installations. A group relamping program provides for the replacement of all lamps in an area installation at the same time on a preset schedule. A schedule is established to fit the average service life of the lamps, adjusted to reduce the number and duration of burn-outs to an acceptable level, and is used if total costs for group relamping are less than the total costs of independent relamping as burn-outs occur.

While preventive measures in design, construction, maintenance, operations, material selections, and processes can be employed or advocated by the maintenance engineer to reduce the demand for short-term responsive maintenance activities, maintenance managers cannot eliminate the need for STRMS. In addition to the practical limits which stop well short of perfection in design and construction and in preventive maintenance, the dynamics of highway operations guarantee that a number of incidents and accidents caused by the highway-vehicle interface or natural disasters will occur. The inevitable need for STRMS activities makes the development of effective response systems an important part of maintenance management.

CHAPTER FOUR

SUMMARY AND CONCLUSIONS

The importance of quick response to many special street and highway maintenance needs is growing on the aging and crowded road systems of the developed nations of the world. This activity, however, has not yet been fully recognized by many maintenance agencies as a unique and critical responsibility. There have been more formal efforts to organize discovery procedures for the identification of maintenance needs than to organize the response process itself. This can be explained in part by the fact that the need for this special activity has been growing steadily but unobtrusively over the last decade and is only recently making its importance felt in the management ranks of maintenance organizations. Management as a system is still a developing science in highway maintenance organizations, and short-term responsive maintenance is a concept that is yet to be incorporated in many still-evolving management systems.

MODELS FOR STRMS

The organization and operation of several special maintenance activities offer models of the systems that can have application for STRMS. The best example is snow and ice control. Well-organized systems include weather forecasting systems, sensing devices, and patrols for early detection of needs. Equipment and materials are prearranged and available when needed, crew members are preassigned to specific routes, time assignments or call out stand-by assignments assure availability of needed crews, and specific procedures for specific routes under specific conditions are planned and prepared for by crew training and logistical arrangements.

Disaster response plans for maintenance organizations, for such events as earthquakes, floods, blizzards, hurricanes and tornadoes, or accidents, traffic incidents, and congestion also offer some planning models for STRMS. Emergency plans provide for an analysis of the highway network and the vulnerable locations; emergency response actions that can be taken for various types and severity of damage at specific locations; predetermination of the types and amounts of materials and equipment needed to respond to the emergencies and arrangements for making them available; and well-planned personnel arrangements to assure availability; notification, and response when needed.

IDEAL SYSTEM ELEMENTS

When considering existing STRMS, other partial systems that are more typical of current highway organizations, and the external "models" that are supplied by emergency preparedness systems, there are a number of key characteristics for effective STRMS that can be identified. When assembled, these characteristics describe the elements of an "ideal" STRMS.

Characterization of the Road Network

The individual routes or segments of routes need to be assigned to classes or categories that designate the relative priority for action when concurrent needs occur, the immediacy of response when various needs are addressed, the types of repairs or restoration warranted, and other guidelines that direct the consistent action of maintenance crews involved in the STRMS activities.

Maintenance Activity Performance Standards

Those basic maintenance activities that are likely to be encountered in STRMS programs need to be planned. Most MMS include the needed planning tools which are called "performance standards." The performance standards or the STRMS alternatives describe the roadway condition requiring action; the step-by-step repair activities to be performed; people, equipment, and materials to be used; and the average productivity rate to be achieved in doing the work. Some special performance standards may need to be prepared for STRMS in order to include a range of levels of restoration or repair for a range of locations or circumstances. For example, a major pavement pothole may need to be filled with temporary cold mix and compacted with truck tires on a busy expressway during peak traffic periods (awaiting full repair during an off-peak period) while a rural highway may warrant full restoration of the pavement surface at the time that the STRMS work is undertaken.

Response Action

Specific maintenance action needs to be predetermined and predesignated for various situations. The selection of the type of response action to be taken needs to be based upon several factors:

1. the immediacy of the need for correction (usually to restore safety or capacity);
2. the level of repair or restoration required (temporary patch, detour, or permanent repair or replacement);
3. road classification;
4. location;
5. time of day and traffic conditions;
6. weather conditions; and
7. availability and concurrent demands on maintenance crews, equipment, and required supplies.

Assignment of Personnel

Specific duties, time assignments, stand-by assignments, patrol assignments and other arrangements need to be made to assure that crews are prepared and adequately staffed to respond to STRMS needs when called during duty hours and off-duty hours. Personnel assignments need to include clear and specific responsibilities for receiving and acting on notification of deficiencies on the roadway, either from internal sources or external sources including the general public. Also, assignments should include instructions to crew members on alternative reporting stations where applicable.

Equipment and Materials

Equally as important as personnel is the assignment of equipment to respond to STRMS needs. Typically crews and equipment are assigned as a "unit" to perform STRMS activities. This permits personnel to be familiar with the equipment to be used, responsible for its readiness and for the adequacy of the supplies on board or available. Major equipment units such as trucks, loaders, cranes, and street cleaning tankers usually are active on routine assignments during normal working hours as are crews. Where possible, the crews and equipment will function as a "unit" on regular work assignments as well as on STRMS duties. For some predictable types of STRMS activities, "kits" of special tools, equipment and supplies can be preassembled, packaged, or bundled together and stored in convenient locations so that they can be loaded quickly or preloaded on stand-by trailers, pallets, or patrol vehicles for use in immediate responses.

Lines of Authority and Responsibility

A well-documented and clearly described arrangement for the exercise of authority and responsibility at various organizational levels is needed to permit appropriate response and efficient use of both in-house and contractor teams as required. Typically, authorization systems may assign authority at different levels based upon the emergency nature of the action needed, anticipated costs, use of special personnel, or other considerations that have wider implications than immediate crews and equipment. In any event, the system must include arrangements for immediate contact with the responsible person (or alternate) at the authorizing level to assure that the authorization process is not a source of delay in the response chain.

Management System

While STRMS is an integral part of a good MMS, it is clearly an important and distinct subsystem of MMS. In addition to the traditional records of expenditures and work accomplished that are incorporated in MMS, the STRMS management information should include records of discovery reports, sources, timeliness, and accuracy, report receipts, by whom, action taken, timing of response, and results. Also, STRMS management information should include site-specific and problem-specific records that permit better anticipation of future needs and better preventive measures where possible.

NEW TECHNOLOGIES NEEDED

Improved STRMS can be realized through a recognition of the need for unique commitments to the management and operation of these special systems. Unorganized volunteer discovery and spontaneous responses to short-term maintenance needs are inadequate on the crowded and aging roads that comprise a majority of the network miles today on most systems. While many tools are currently available to maintenance managers to use in establishing STRMS, there are additional technological needs in materials, equipment, and sensors that, if available, could enhance both the discovery and response phases of the systems.

Materials

There has been an interest in preformed and precast replacement components for both bridge decks and pavements in the past and this technology still offers great promise for STRMS, if perfected. Prefabrication of "plug-in" replacement units for expendable components of mechanical and electronic equipment is commonplace today and has proven to be both efficient and economical in many instances. The highway industry needs to consider this concept in its broadest terms when studying the opportunities that exist for prefabrication of replacement units for expendable components, the design and construction changes that would be needed to accommodate this alternative operating mode, the conceptual design of the replacement system, and the economic trade-offs between conventional repair-in-place systems and component replacement systems. Out of such study can emerge specific research proposals and targets to improve STRMS and other routine maintenance activities as well. Additionally, STRMS and conventional repair systems will benefit from improved materials that demonstrate high tolerance for varying application conditions, are quick setting, attain early strength, have long pot-life, are strong bonding, nontoxic, nonhazardous, and, of course, inexpensive (however, costs should be evaluated in terms of costs per unit of service life rather than just bare first costs).

Equipment

Mobile (at highway speeds) units for rapid, on-site batching of paving materials mixes is a technology already in operation for some pavement materials. The same concept for on-site custom fabrication of other frequently damaged highway components could be of benefit to STRMS activities involving such repairs or replacements as signs, guardrails, energy-attenuation devices, and other appurtenances. If used as an alternative to prefabricating and transporting replacement components that might not be the right units for the specific needs encountered, both time and costs might be reduced by on-site fabrication.

The ability to move large wrecks and debris from the roadway with speed and minimum additional damage is a continuing need for major expressway emergency operations. Existing equipment offers many opportunities for innovative improvements.

Sensing Devices

Significant advancements have been made in the use of moisture and temperature sensors for signaling the presence of snow

and ice on pavements and bridge decks. Electronic monitors permit the remote assessment and control of traffic movements, and diagnostic circuits monitor the functioning of traffic control devices. Communications equipment and data processing equipment permit the rapid acquisition and transmission of field data to central management organizations for the management of maintenance programs and organizations. All of these tools need to be assessed and evaluated as candidates for enhancing the capability to monitor and identify highway conditions requiring STRMS action. New sensing devices that detect pavement failures or report the loss of critical mechanical traffic control devices (i.e., signs, energy attenuation devices) could be valuable contributors to the effectiveness of STRMS and the resulting safety of roads and highways.

CONCLUSIONS

The survey of the U.S. states and Canadian provinces indicated that the highway maintenance organizations have moved slowly into meeting the growing need for formal management subsystems dealing specifically with the discovery and response to short-term maintenance needs on the road and highway network.

All of the survey respondents reported the use of formal inspections with most on an annual basis, but only one-fourth of the STRMS needs were triggered by these inspections. On the other hand, less than half of the respondents encouraged informal inspections, yet 63 percent of the state STRMS repairs were triggered by this method. The well-developed systems use both formal and informal procedures to assure maximum coverage of the highway conditions by the maintenance staff, other department employees, other governmental organizations, and the general public.

Response systems generally are formalized in the responding agencies, where levels of authority are preestablished for various STRMS events and locations, the decision level being set by most agencies based upon availability of crews, equipment, and materials needed to respond. Communications protocols are in place for about 90 percent of the respondents to assure rapid authorization for action where higher-than-field authority is required. Most of the agencies plan specific types of repairs, but only slightly over half set predetermined guidelines for selecting permanent or temporary repairs and only one-fourth use preassembled repair kits for any repair work.

From the developed systems or partial systems in effect in the Survey agencies and the principles illustrated in other special maintenance programs such as snow and ice control, the basic characteristics of good STRMS can be identified to include: classification (for priorities, response urgency, and type of activity to be taken) of the routes and segments of the road network; established standards for common STRMS activities; assignment of personnel and equipment to response teams; preparation and storage of kits of tools, supplies, and materials for quick and convenient access in STRMS activities; designated levels of authority and responsibility for quick response; and an effective maintenance management subsystem continuously monitoring and improving STRMS performance.

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APPENDIX A

SURVEY OF STATE DEPARTMENTS OF TRANSPORTATION, CANADIAN PROVINCES, AND U.S. TOLL ROADS

		Alabama	Alaska	Arkansas
	Characteristics of Highway System and Agency			
1	Miles	11500	5500	16165
2	Percent that is: Urban	4	8	6.7
3	Rural	88	90	89.9
4	Freeway	8	2	3.36
5	Maintenance Organization Staff Size	1350	430	2300
6	Number of districts or regions	9	26	10
7	Sections or field offices	41	Sec 404, FO 150	75
8	Special teams/equipment?	Yes	No	Yes
9	w/short-term response repair duties	Yes	n/a	Yes
	Maximum miles for short-term response by:			
10	Maintenance crews	40	40	40
11	Special teams	200	n/a	60
	Discovery Systems & Practices by Persons			
12	Formal Inspections (Planned, regular basis)	Yes	Yes	Yes
13	Frequency?	1 or 2 per year	Quarterly	Weekly/semi-annual
14	By whom?	1 Div. & Dist.	Manager	Area foreman
15	By whom?	2 Matls. & Test	n/a	Dist bridge insp.
16	Report or record	Yes	Maj. probs. only	Yes
17	Effectiveness (repairs triggered as % of total)	80	n/a	
	Encouraged by:			
18	Publicity and inviting reports	No	No	Yes
19	Preparing & distributing concise report forms	No	No	Yes
20	Other techniques	Preprinted forms	No	n/a
	Effectiveness of In-house Reporting			
21	Useful	Yes	n/a	Yes
22	Repairs triggered as % of total	10	<1	
	External Observ. by Hwy. Patrol, Public & Others			
	Encouraged and Enhanced by:			
23	Publicized and invited?	No	No	No
24	Information distributed to all?	No	No	Yes
25	Telephone "hot line"?	No	No	No
26	Other techniques?	n/a	n/a	n/a
	Discovery Systems, Electronic and/or Mechanical			
	Sensing/Monitoring Devices, Installed and Used For:			
27	Snow and ice control?	No	No	Yes
28	Pavt. struct. (strain gages, weigh-in-motion)?	Yes	Yes	No
29	Traffic control?	Yes	No	No
30	Acc., congestion, & other operating conditions?	Yes	n/a	No
	Response Systems Management			
31	Classifying, Categorizing, Prioritizing Cond. for STRMS	Yes	Yes	Yes
32	Basis for classifications	Emerg./sched.	By priority	No formal classif.
	Response Systems/Procedures			
	Decision Responsibility and Delegation Based on:			
33	Different levels for different classifications?	Yes	Yes	Yes
34	Based on costs of response & budgeted or not?	Yes	Yes	No
35	Based on availability of crews, equip., & materials?	Yes	Yes	Yes
36	Delegated to contractors for specified conditions	Yes	n/a	No
	Communications Systems/Protocol Pre-established For:			
37	Obtaining authorization at appropriate level	Yes	Yes	Yes
38	Shifting on-duty worker assignments	Yes	n/a	Yes
39	Calling out off-duty workers	Yes	Yes	Yes
40	Calling out contractors & other outside help	Yes	Yes	Yes
	Repair Procedure/Technology Selection			
41	Planned repair procedure?	Yes	No	Yes
42	Pre-assembled repair kits?	No	No	Yes
43	Predetermined use of temporary vs. perm. repairs	Yes	No	Yes

APPENDIX A (continued)

	California	Colorado	Delaware	Florida	Georgia	Hawaii
1	48747	9200	4,775	11,745	17,823	867
2	34	20	24	34.5%	12.7%	12%
3	66	80	75	65.5%	87.3%	83%
4	50	n/a	1	11.8%	7%	5%
5	Varies	12	563	3,366	3,300	417
6	42 reg., 12 dist.	6	3	7	7	4
7	133	10	12	32	n/a	17
8	Yes	Yes	Yes	Yes	Yes	Yes
9	Yes	Yes	Yes	Yes	Yes	Yes
10	57	60	10	60	75	30
11	200	210	30	120	300	50
12	Yes	Yes	Yes	Yes	Yes	Yes
13	Varies	Semi-annual	2 years	3/yr-hwy, 2/yr-br	Annual	In procedure doc.
14	Varies	Staff maint. super.	PM technician	State forces	Area engrs. - dist.	--
15	n/a	Dist maint. super.	n/a	--	Maint eng.-gen. off.	
16	Yes	Yes	Record	Ratings	Record	Yes
17			Ont. sys. (PURD)			
18	Yes	No	No	Yes	Yes	Yes
19	No	No	No	Yes	No	Yes
20	Yes	n/a	Yes	n/a	n/a	Phone hot lines
21	Yes	Yes	Yes	Yes	Yes	Yes
22						
23	Yes	No	Yes	Yes	Yes	Yes
24	Yes	No	Yes	Yes	Yes	Yes
25	No	Yes	No	No	Yes	Yes
26	n/a	n/a	n/a	[a]	[b]	--
27	Yes	Yes	No	No	No	n/a
28	No	No	No	No	No	No
29	No	No	Yes	No	Yes	No
30	Yes	No	Yes	No	Yes, traffic studies	No
31	Yes	No	Yes	Yes	n/a	n/a
32	Public safety	n/a	[c]	By priority	n/a	No
33	Yes	Yes	Yes	Yes	Yes	Yes
34	No	Yes	Yes	Yes	Yes	No
35	No	Yes	Yes	Yes	Yes	Yes
36	No	No	Yes	Yes	No	No
37	Yes	Yes	Yes	Yes	Yes	Yes
38	Yes	Yes	Yes	Yes	Yes	Yes
39	Yes	Yes	Yes	Yes	Yes	Yes
40	Yes	No	Yes	Yes	Yes	Yes
41	Yes	No	Yes	Yes	Yes	Yes
42	Yes	No	No	No	Yes	Yes
43	Yes	No	No	Yes	None	No

[a]Encourage citizen and law enforcement reporting.

[b]Comment cards in rest areas.

[c]Immediate, short-term, long-term.

APPENDIX A (continued)

	Idaho	Illinois	Indiana	Iowa	Kansas	Kentucky
1	4956	45,000	11,285	10,481	9639	27,000
2	20%	7.4%	14%	12%	5.8%	n/a
3	80%	71.2%	86%	88%	87.4%	n/a
4	12%	21.4%	10%	10% (1,032)	6.8%	n/a
5	475	2,920	2600	1,665	1682	-
6	6	9	6	6	6	12
7	37 (foreman areas)	107/63 team/sub	37	24	115	122
8	Yes	Yes	Yes	Yes	No	Yes
9	Yes	Yes	Yes	Yes	No	Yes
10	60	35	25	30+	30	40
11	400	200	40	240+	200	100
12	Yes	Yes	Yes	Yes	Yes	
13	1/yr-hwy, 2/yr-br.	NBIS bridge insp.	Annual	Hwys - annually	Annual	Yes
14	Hwy maint forem.	Varies by type	Dist. main. bridge	Structures - 2/yr	Area engineer	n/a
15	--	Bridge insp. staff	Inspector	Hwy maint. off.	Bridge eng.	n/a
16	Yes	Yes	Yes	Yes	Yes	--
17						--
18	No	No	No	Yes	Yes	No
19	Yes	No	No	No	Yes	No
20	Yes	Yes	No	Yes	Yes	No
21	Yes	Yes	Yes	Yes	Yes	
22						Yes
23	Yes	No	No	Yes	No	
24	Yes	Yes	No	Yes	No	No
25	Yes (Boise only)	Yes	No	No	No	No
26	Yes	[a]	n/a	[b]	Highway patrol	No
27	Yes	No	No	Yes	Yes (one location)	No
28	Yes	No	No	Yes	n/a	No
29	Yes	No	No	No	No	No
30	No	Yes	No	No	No	No
31	n/a	Yes	Yes	Yes	Yes	n/a
32	Yes	Needs survey	[c]	n/a	Emergency/routine	n/a
33	Yes	Yes	Yes	Yes	Yes	Yes
34	Yes	Yes	No	Yes	No	Yes
35	Yes	Yes	Yes	Yes	Yes	Yes
36	Yes	No	No	Yes	No	Yes
37	Yes	Yes	Yes	Yes	Yes	n/a
38	Yes	No	Yes	Yes	Yes	n/a
39	Yes	Yes	Yes	Yes	Yes	n/a
40	Yes	No	Yes	Yes	Yes	n/a
41	Yes	Yes	Yes	Yes	Yes	n/a
42	Yes	No	Specialty items	No	Yes	n/a
43	No	No	Yes	No	Yes	n/a

[a]Reports from other government agencies.

[b]External reports from law and public officials.

[c]Signs, signals, roadways.

APPENDIX A (continued)

	Louisiana	Maryland	Michigan	Minnesota	Mississippi	Montana
1	17,218	5,183	25,000lm	12,100	10,351	19005
2	9.7%	20%	14.6%	4%	7%	Chart attached
3	90.3%	80%	85.4%	79%	93%	n/a
4	5.4%	6%	16%	17%	7%	
5	2,724	1500	630+	2,282	1591	10
6	233	7	9	9	6	5
7	424	29	[a]	[b]	-	134
8	Yes	Yes	Yes	Yes	Yes	Yes
9	Yes	Yes	Yes (named)	No	Yes	Yes
10	109	20	20	60	40	46
11	272	50	500	Statewide	200	No special dist.
12	Yes	Yes	Yes	Yes	Yes	Yes
13	Bi-weekly	Daily	Monthly	Annual FHWA	Weekly	Bi-annual
14	Parish maint. supr.	Bridge insp. div.	Foreman promot.	Maint. eng. super.	Maint. superint.	Construction div.
15	Informal	--	--	Bridge insp/maint	--	--
16	--	Report	--	n/a	n/a	Report
17						
18	No	Yes	No	Yes	Yes	Yes
19	No	Yes	Yes	No	No	Yes
20	Yes	No	Yes	Yes		No
21	Yes	Yes	Yes	Yes	Yes	Yes
22						
23	No	Yes	No	Yes	Yes	Yes
24	No	Yes	Yes	Yes	Yes	Yes
25	No	Yes	Yes	Yes	No	Yes
26	[c]	[d]	Rest areas	Patrol informer	n/a	n/a
27	No	No	Yes	Yes	No	No
28	No	No	Yes	No	No	No
29	No	No	Yes	No	No	No
30	No	Yes	Yes	Yes	No	No
31	Yes	Yes	Yes	Yes	No	No
32	Parish super.	Res. maint. eng.	By priority	By priority		
33	Yes	Yes	Yes	Yes	Yes	No
34	Yes	Yes	Yes	No	n/a	Yes
35	Yes	No	Yes	Yes	Yes	Yes
36	Yes	No	Yes	Yes	n/a	Yes
37	Yes	Yes	Yes	Yes	n/a	Yes
38	Yes	Yes	Yes	Yes	n/a	Yes
39	Yes	Yes	Yes	Yes	Yes	Yes
40	Yes	Yes	Yes	Yes	n/a	Yes
41	Yes	Yes	Yes	Yes	Yes	No
42	No	No	No	Yes	No	No
43	Yes	Yes	Yes	Yes	Yes	No

[a] 13 areas, 62 county road commissions

[b] 132 trunk, 15 main, 73 sub

[c] Local contacts by District Administrator

[d] 24-hr communications center, toll-free number - snow desk

APPENDIX A (continued)

	Nebraska	Nevada	New Hampshire	New Jersey	New York	North Carolina
1	9,946	5,437	4,217	2,340	40,000	76,547
2	3%	4.5%	5.6%	57%	25%	6.7%
3	92%	95.5%	94.4%	43%	75%	93.3%
4	5%	10%	9.8%	4%-fwy;14% Interst	20%	1.6%
5	975	438	984	1,600	5,000	6201
6	8	I-144;II-152;III-142	6	4	11	14 div. 36 distr.
7	102	3	93	77 (5 other categ.)	68	100 counties
8	Yes	Yes	Yes	Yes	Yes	No
9	No	No	Yes	Yes	Yes	-
10	67	65	15	25	30	30
11	Bi-annual	235	165[a]	90	100	75
12	Yes	Yes	Yes	Yes	Yes	Yes
13	Bi-annual	Annual (structure)	Annually	Annual	Bi-annual	Bi-annual
14	Bridge division	Bridge division	FHWA	Spec. eng. staff	Bridge insp. unit	State personnel
15	–	–	–	& consultant	–	
16	n/a	Yes	Report	Annual report	Yes	Report
17						
18	No	No	No	Yes	No	-
19	No	No	No	Yes	No	
20	Yes	No	Yes	Yes	No	No
21	Yes	Yes	Yes	Yes	Yes	Yes
22						
23	Yes	No	No	Yes	No	No
24	Yes	Yes	Yes	Yes	Yes	No
25	No	No	No	Yes	No	No
26	n/a	n/a	n/a	[b]	–	n/a
27	Yes	Yes	No	No	Yes	No
28	No	Yes	No	No	No	No
29	Yes	Yes	No	No	Yes	No
30	No	No	No	No	Yes	No
31	No	Yes	No	Yes	Yes	No
32		On-going routine	n/a	[c]	Hwy. res. eng.	n/a
33	No	Yes	Yes	Yes	Yes	No
34	Yes	Yes	No	Yes	Yes	No
35	n/a	Yes	Yes	Yes	Yes	Yes
36	No	Yes	No	Yes	No	No
37	Yes	Yes	No	Yes	Yes	Yes
38	Yes	Yes	Yes	Yes	Yes	Yes
39	No	Yes	Yes	Yes	Yes	Yes
40	No	Yes	Yes	Yes	Yes	Yes
41	Yes	Yes	Yes	Yes	Yes	Yes
42	No	No	No	No	No	No
43	No	No	Yes	No	Yes	Yes

[a]115 for traffic signals, 50 for bridges

[b]Traffic signal defects, potholes

[c]Safety, traffic service, structural sensitivity

APPENDIX A (continued)

	North Dakota	Oregon	Pennsylvania	South Carolina	South Dakota	Tennessee
1	16,600	7,600	(Lengthy chart	40,702	9,214.64	13,820
2	1% (or less)	9%	county by county	15%	3.9%	15%
3	99%	91%	attached)	18%	78.4%	85%
4	14%	9.6%		2%	17.7%	8%
5	5(in control office)	1320	9098	3300	502	2,125
6	8	[a]	11	7	4	260
7	72	83	67	47	12	1,865
8	No	No	Yes	Yes	Yes	Yes
9	-	-	Yes	No	Yes	Yes
10	50	73	35	20	60	50
11	n/a	100	75	60	198	150
12	Yes	Yes	Yes	Yes	Yes	Yes
13	Every 4 mo (struct)	Varies	Annual	Bi-annualy	Annual	Roads - bimonthly
14	District personnel	Reg. br. inspec.	College students	Bridge insp. team	Bridges - inspect	Struct. - bi-annually
15		traffic sign unit	Asst. manager		Hwys. - foremen	Overhead staff
16	Record	Attached	Yes	Yes	Yes	Yes
17				Attached		
18	No	No	No	Yes	Yes	Yes
19	No	No	No	Yes	No	Yes
20	No	Yes	No	No	No	n/a
21	Yes	Yes	Yes	Yes	Yes	Yes
22						
23	No	Yes	Yes	Yes	No	No
24	No	Yes	Yes	No	No	No
25	Yes	No	Yes	No	No	No
26	n/a	Pothole hotline	Yes	n/a	No	Yes
27	No	Yes	No	Yes	No	No
28	No	Yes	No	- WIM	No	No
29	No	Yes	Yes	No	No	No
30	No	No	No	Review acc. repts	No	No
31	Yes	Yes	Yes	Yes	Yes	Yes
32	Emerg./non-emerg.	Emerg'y, other structural sensitivity	Worth activity	By priority	Type of condition	Local, dist., region
33	Yes	Yes	Yes	Yes	No	Yes
34	No	Yes	Yes	No	No	No
35	Yes	Yes	Yes	Yes	No	Yes
36	Yes	Yes	No	No	No	Yes
37	Yes	Yes	Yes	Yes	No	Yes
38	Yes	Yes	Yes	Yes	No	Yes
39	Yes	Yes	Yes	Yes	No	Yes
40	Yes	Yes	Yes	Yes	No	Yes
41	-	Yes	Yes	Yes	Yes	Yes
42	No	Yes	No	No	No	No
43	Yes	Yes	Yes	No	Yes	Yes

[a] 5 admin. regions, 16 road, 2 bridge

APPENDIX A (continued)

	Texas	Utah	Vermont	Virginia	Washington	Wyoming
1	77,244	5794	3100 (2 lane miles)	53,855 (centerline)	7,030	7,000 +
2	15%	11.6%	5%	Not avail.	3%	2.5%
3	85%	88.4%	75%	Not avail.	97%	97.5%
4	5.2%	16.1%	20%	Not avail.	17%	14.7%
5	6,500	[a]	600	5400	2217	490
6	24	6	9	9	6	5
7	288	80-111	39	45 Res 237 Area	25	54
8	Yes	Yes	No	Yes	Yes	Yes
9	No	Yes	No	Yes	Yes	No (ex.guard rail
10	20-30	75	35-50	20	41	50-55
11	60-70	270	n/a	100	270	n/a
12	Yes	Yes	Yes	Yes	Yes	Yes
13	Pavts. - annual	Semi - annual	All are informal	Bridges-bi-annual	Annual	Hwy - weekly
14	Bridges - bi-annual	[b]	Dist. adm. & staff	VDOT and contract	Pavement engineer	struct.- bi-annual
15	Pavts.- state pers.	Superv-analysts				Hwy-local foreman
16	Yes	Yes	No	Yes	Yes	Yes
17		–	–	Attached	Attached	
18	No	No	No	Yes	No	No
19	No	No	No	No	No	No
20	Yes	No	n/a	n/a	No	Yes
21	Yes	Yes	Yes	Yes	Yes	Yes
22						
23	No	No	Yes	Yes	No	No
24	No	No	Yes	Yes	No	No
25	No	No	No	Yes	Yes	No
26	Yes	No	n/a	Yes	n/a	[c]
27	No	Yes	No	Yes	Yes	Yes
28	No	Yes	No	No	No	No
29	Yes	Yes	No	Yes	Yes	Yes
30	Loop detectors	Review acc. repts	No	Yes	Loop detectors	No
31	No	No	No	Yes	Yes	Yes
32	n/a	–	–	[d]	Emerg/non-emerg	Informally
33	Yes	No	Yes	Yes	Yes	No
34	Yes	Yes	Yes	Yes	Yes	No
35	Yes	Yes	Yes	Yes	Yes	Yes
36	Yes	No	Yes	Yes	Yes	Yes
37	Yes	Yes	n/a	Yes	Yes	Yes
38	Yes	Yes	No	Yes	Yes	Yes
39	Yes	Yes	n/a	Yes	Yes	Yes
40	Yes	No	n/a	Yes	No	Yes
41	Yes	Yes	No	Yes	Yes	No
42	No	No	No	No	No	No
43	No	Yes	No	Yes	Yes	n/a

[a]Maintenance 524; equipment 100

[b]District engineer, maintenance engineer

[c]Accept input as received

[d]Emergency, safety, permanent, temporary

APPENDIX A (continued)

	Washington, D.C.	Illinois Tollway	Ohio Turnpike	Penna. Turnpike	Manitoba	Northwest Terr.
1	1102	247	241.2	470	12,358	[a]
2	98%	50%	26%	n/a	1%	1%
3	None	50%	74%	n/a	99%	99%
4	2%	n/a	100%	n/a	2.5%	0
5	114	332	367	750	810	176 (incl. contr.)
6	n/a	4	2	5	12	2
7	6	10	8	19	92	13
8	Yes	Yes	Yes	No	Yes	Yes
9	Yes	Yes	Yes	No	Yes	No
10	10	22	15	25	90	106-126
11	10	103	80	n/a	600	466
12	Yes	Yes	Yes	Yes	Yes	Yes
13	Annual	Annual	Annual	Annual	Structures - annual	Varies
14	Section foreman	Consulting engr.	General consult.	Consulting engrs.	Roads - annual	Director of oper.
15	–	–	–	–	Work superv diary	–
16	Yes	Yes	Yes	Yes	Yes	Yes
17		Attached	Attached	–	–	Attached
18	Yes	Yes	No	Yes	No	Yes
19	Yes	No	No	Yes	No	Yes
20	Yes	No	Yes	No	Yes	No
21	Yes	Yes	Yes	Yes	Yes	Yes
22						
23	Yes	No	No	Yes	No	Yes
24	Yes	Yes	No	Yes	No	Yes
25	Yes	No	No	Yes	No	No
26	[b]	n/a	n/a	n/a	None	n/a
27	No	Yes	No	No	No	No
28	No	No	No	No	No	No
29	Yes	No	No	No	No	Yes
30	No	No	No	No	No	No
31	Yes	Yes	Yes	Yes	Yes	Yes
32	Perm/temp repair	[c]	Immediate sched.	Immed./next day	[d]	Emergencies
33	Yes	Yes	Yes	Yes	Yes	Yes
34	Yes	No	Yes	No	Yes	Yes
35	Yes	Yes	Yes	Yes	Yes	Yes
36	Yes	Yes	Yes	Yes	Yes	Yes
37	Yes	Yes	Yes	Yes	Yes	Yes
38	Yes	Yes	Yes	Yes	Yes	Yes
39	Yes	Yes	Yes	Yes	Yes	Yes
40	Yes	Yes	No	Yes	Yes	Yes
41	Yes	Yes	Yes	No	Yes	Yes
42	No	No	No	No	No	Yes
43	Yes	Yes	Yes	No	Yes	No

[a]All weather 1520, winter 858

[b]Newspapers publicize hotline; encourage calls

[c]Bridge, drainage, roadway, building

[d]Surface, shoulder, roadside

APPENDIX A (continued)

	Nova Scotia	Newfoundland	Ontario
1	16,000	5,200	21,431 km
2	90%	2%	73.4 (Kings)
3	n/a	98%	25.6 (secondary)
4	10%	n/a	30.8
5	5000	1,196	3,500
6	7	4	5
7	17	[a]	18
8	Yes	Yes	Yes
9	Yes	Yes	Yes
10	40	200	200 km.
11	100	200	n/a
12	Yes	Yes	Yes
13	Annual	Daily	Annual
14	[b]	Operations superv	Reg. geotech. &
15	--		structural offices
16	n/a	Yes	Yes
17	--		
18	No	Yes	Yes
19	No	Yes	Yes
20	No	Yes	Yes
21	Yes	Yes	Yes
22			
23	No	No	Yes
24	No	Yes	Yes
25	No	Yes	Yes
26	None	n/a	Yes
27	No	No	Yes
28	No	No	Yes
29	Yes	Yes	Yes
30	No	Yes	No
31	No	Yes	Yes
32		By priority	Surface
33	No	Yes	Yes
34	Yes	Yes	Yes
35	Yes	Yes	Yes
36	Yes	Yes	Yes
37	Yes	Yes	Yes
38	Yes	Yes	Yes
39	Yes	Yes	Yes
40	No	No	Yes
41	Yes	Yes	Yes
42	No	Yes	No
43	Yes	Yes	Yes

[a]21 divisions, 70 work units

[b]Superintendent and area foremen

APPENDIX B

MANITOBA SUMMER PATROL

MANITOBA HIGHWAYS MAINTENANCE

PERFORMANCE STANDARD

STANDARD M- 700-1 ACTIVITIES 702 PAGE 1 OF 3 DATE April 1971

SUMMER ROAD PATROL

APPROVED Maintenance Engineer

PURPOSE AND DESCRIPTION

Summer Road Patrol is the visual inspection of assigned mileage conducted in order

(a) to insure that all roads and road facilities are observed on a regular basis.

(b) to correct deficiencies which may be potentially hazardous to the motorist.

(c) to provide basis for a weekly road report.

(d) to identify road conditions or facilities requiring future attention.

NOTE: All Manitoba Highway employees have a continuing responsibility, whether on duty or off duty, to correct or report, as may be appropriate, any observed deficiencies which are potentially hazardous to the motoring public.

FREQUENCY OF INSPECTIONS

Summer Road Patrol is to be conducted by the Foreman or his designated representative while carrying out other duties (e.g., routine maintenance of orbits, cleaning right-of-way and while travelling to and from work sites, etc.).

Formal Summer Road Patrol -- inspection of assigned mileages for the express purpose of observing and correcting potentially hazardous conditions -- is to be scheduled and conducted as indicated below only if highways are not inspected during the normal course of other duties:

	Foreman	Superintendent
Class 1 (Red)	Twice/week	Once/Two weeks
Class 2 (Blue)	Twice/week	Once/Two weeks
Class 3 (Yellow)	Once/week	Once/Two weeks
Class 4 (Green)	Once/week	Once/Two weeks
Class 5 (Orange)	Once/week	Once/Two weeks
Main Market and School Bus Routes (L.G.D.)	Once/Two weeks	Once/month

It is suggested that a Foreman inspect his roads on Monday and Friday when two formal inspections are required, and on Friday when one formal inspection per week is required. Superintendents will conduct their inspections during the normal course of their duties, with special emphasis placed on their responsibility to see that all gravel roads are properly dragged.

The District Engineer may, under special circumstances, order additional road patrols.

Examples of special circumstances are: during and after heavy rain; on Halloween, and on concrete surface highways during extremely hot weather.

METHOD

The following checks are to be made during both formal Summer Road Patrols and those made in conjunction with other maintenance duties. Deficiencies will be corrected or reported as indicated.

(1) Check for surface and shoulder deficiencies which are a hazard to the motorist. Temporary warning devises (flags, flares, etc.) must be placed immediately.

If warranted, temporary repairs are to be made immediately. Permanent repairs are to be made as soon as possible. Appropriate signs must be erected, if permanent repairs cannot be made within a reasonable length of time.

(2) Check for traffic signs which are missing, damaged, turned around, defaced or destroyed. Arrange for the repair of regulatory signs, which are required by law, as soon as possible (e.g., "Stop", "Yield", "Do Not Enter", "No Left Turn", "Maximum Speed", etc.).

If a "Stop" sign is missing, it must be replaced immediately.

(3) Check for traffic signals which are not functioning properly. Report all defects in traffic signals, as soon as possible, to the R.C.M.P. and to the Highways District Office. If necessary, flagmen are to be stationed at the intersection until relieved by the R.C.M.P., or until repairs are made.

(4) Check for and remove debris or dead animals from the travelled portion of the road or shoulders.

(5) Check for damaged guard rail installations. Arrange for repairs as soon as it can be scheduled.

(6) Check for signs, buildings or entrances which have been, or are being, erected or constructed without permits. Report any such violation to the District Office as soon as possible.

(7) Check for noxious weeds adjacent to cultivated land. Such conditions are to be reported to the District Office.

(8) Check and note for future correction any conditions which do not meet the appropriate quality standard.

(9) Check for stranded motorists and assist by arranging, in co-operation with the motorist, for appropriate assistance from a local service station.

(10) Report abandoned cars to the R.C.M.P.

(11) Check for problems peculiar to a given area (e.g., beaver dams, scour areas, slides, etc.).

SCHEDULING CONSIDERATIONS

Formal Road Patrol should be scheduled on a routine basis. Items requiring correction should be scheduled and performed in accordance with the severity of the damage.

Manitoba Highways and Transportation

MAINTENANCE PLANNING VALUES

1986/87

ACT.	DESCRIPTION	ACCOMPLISH -MENT	PLAN UNIT	QUANTITIES BY CLASS 1	2	3	4	5	PRODUCTIVITY	UNIT COST
	1986 Summer Maintenance Period March 29 to November 7									
	32 Weeks - 160 Man Days - 1,280 M.H. Available									
111	Premix Patching	m^3	E 2Lkm	0.2	0.7	0.7	0.7	0.7	6.00	199.50
112	Premix Patching	m^3	E 2Lkm	0.5	2.6	2.6	2.6	2.6	1.00	98.00
113	Premix Patching	m^3	E 2Lkm	0.5	2.6	2.6	2.6	2.6	0.56	84.77
115	Spray Patching	L	E 2Lkm	150 L AST/70 L Hot or Cold Mix					0.03	0.97
116	Crack Filling	L	Beat	District Estimate					0.06	1.60
118	Seal Coat	Lane km	Beat	Seal Coat Program					25.00	2888.00
119	Base & Subgrade Repair	m^3	E 2Lkm (Bit)	0.3 m^3/E 2Lkm					1.00	26.00
120	Route & Crack Fill	Lin. m							0.10	2.40
129	Other	M.H.							- - - -	26.00
131	Patch Concrete	m^3	Beat	District Estimate					8.00	245.00
132	Joint Repair (Poured)	Lin. m	Beat	District Estimate					0.10	2.97
133	Concrete	M.H.	Beat	District Estimate					- - - -	26.90
134	Mud Jacking	m^2	Beat	District Estimate					0.30	9.90
137	Panel Replacement	m^2	Beat	District Estimate					2.16	76.48
139	Other	M.H.	Beat	District Estimate					- - - -	24.00
140	Gravel Reclamation	Slope km	Map km	80%					0.15	10.00
141	Dragging	Pass km	E 2Lkm	--	80	66	40	28	0.12	6.38
142	Reshaping	km Reshaped	Beat	District Estimate					0.68	28.00
143	Grade Rep. & Spot Patching	m^3	E 2Lkm	1.2 m^3/E 2Lkm					0.27	16.00
144	Gravelling	m^3	E 2Lkm	--	50	50	40	35	Cost by	District
145	Stabilizing Gravel	km	Beat	District Estimate					15.00	1400.00
146	Dust Control (Calcium Chloride)	tonnes	# of sites	0.5 - 0.7 tonnes/site					Cost by	District

EXAMPLE

INSTRUCTIONS

GENERAL MAINTENANCE

If above standard quantity requested, put a red star next to the total cost.
If below standard quantity requested, put a blue star next to the total cost.
Activity 112 & 113 - Take one or the other - see activity definitions.
144 - Unit cost for gravel should be by beat.
241 & 242 - Take one or the other.
244 - Restoring Gravel Shoulder - Total district quantities should be used in one or two beats.
313 - Brush Cutting - Additional dollars but no man hours should be planned for cutting brush next winter.
331 - Orbits - Plan extra dollars but no man hours for emptying orbits in winter - i.e. once every two weeks.
541 - Maintain Signs - Plan extra dollars and no man hours = (i.e. 1/3 of total cost) for sign maintenance in winter.

Most "Other" activities require a district estimate for hours. Check activity definition, previous requirements, etc., before deciding on man hour estimate.

Crew planning sheets should be completed for all special crews and operators.

The following activities are all beat 99 and will appear only on district summary sheets. Note: Beat crews charge activity 752 to actual beat.

Activity 701 - Superintendent
711 - Grader Operator Truck & Caboose
713 - Hydro in Maintenance Yards
715 - Communications
752 - Weight Restrictions
769 - Miscellaneous Charges
Operator Overheads (see sample summary sheet)

EXAMPLE

MAINTENANCE SPECIALS

When making up your maintenance budget, Maintenance Specials are not to be included with the general maintenance plan. They are to be planned for on the "Maintenance Specials" sheets. The man hours and total cost for all specials must be shown on the specials line page 5 of maintenance planning work sheets.

CREW NUMBERS

1 Beat Works Supervisors
2 Beat Operator(s)
3 Municipal Operator(s)
5 District Wide Operator(s)
8 Mechanical Division Pool Operator(s)
9 Province Wide Specialty Crew(s)
411 Sign Crews(s)
416 Bridge Crew(s)
426 Patching Crew(s)
441 Other District Crew(s)

MAN HOURS AVAILABLE - PERMANENT BEAT STAFF

Works Supervisor (1280 M.H./Summer Season) _____

_____ Laborers (1280 M.H./Summer Season) _____

Total Man Hours Available _____

MAN HOUR SUMMARY

Regular Maintenance _____

Specials _____

Const. by Beat Crews _____

Accounts Collectable _____

Unorganized _____

Beat 99 _____

Total M.H. Required _____

M.H. Available _____

Difference (+) _____

Crew Size Required _____

JANUARY 1986 DISTRICT _____ BEAT _____

Manitoba Highways and Transportation

MAINTENANCE PLANNING WORKSHEET

1986/87

District: COL. 1-2 Beat: COL. 3-4

Date: _____ 19____

ACC. UNIT	PLAN UNIT	ACTIVITY DESCRIPTION	NO. COL 5-7	ROAD CLASS	NO. PLAN UNITS X	ACC/ PLAN= UNIT	TOTAL PLANNED ACC. COL. 8 - 15	STD. X PROD. = MH/ACC.	MAN HOURS REQUIRED BEAT	DIST.	PROV.	TOTAL COL.16-23	CREW NO.	UNIT COST	TOTAL COST COL. 24-32	REMARKS
m^3	E 2Ukm	Premix Patch	111	1		0.2		6.00						199.50		
m^3	E 2Ukm	Premix Patch	111	2 - 5		0.7		6.00						199.50		
m^3	E 2Ukm	Premix Patch	112	1		0.5		1.00						98.00		
m^3	E 2Ukm	Premix Patch	112	2 - 5		2.6		1.00						98.00		
m^3	E 2Ukm	Resurfacing	113	1		0.5		0.56						84.77		
m^3	E 2Ukm	Resurfacing	113	2 - 5		2.6		0.56						84.77		
L	E 2Ukm	Spray Patch	115	H.Mix		70		0.03						0.97		
L	E 2Ukm	Spray Patch	115	AST		150		0.03						0.97		
L	Beat	Crack Fill	116	- - -	- - -	- - -		0.06						1.60		
m^3	E 2Ukm(Bit)	Base & Subgrade Rep.	119	ALL		0.3		1.00						26.00		
Lin. m	Beat	Route & Crackfill	120	- - -	- - -	- - -		0.10						2.40		
M.H.	Beat	Other	129	- - -	1	24	- - - - -	- - -						26.00		
m^3	Beat	Patch Concrete	131	ALL	- - -	- - -		8.00						245.00		
Lin. m	Beat	Joint Repair(Poured)	132	ALL	- - -	- - -		0.10						2.97		
M.H.	Beat	Concrete Repair	133	ALL	- - -	- - -	- - - - -	- - -						26.90		
m^2	Beat	Mud Jacking	134	ALL	- - -	- - -		0.30						9.90		
m^2	Beat	Panel Replacement	137	ALL	- - -	- - -		2.16						76.48		
M.H.	Beat	Other	139	ALL	- - -	- - -	- - - - -	- - -						24.00		
Slope km	Map km	Gravel Reclamation	140	ALL		0.8		0.15						10.00		
Pass km	E 2Ukm	Dragging	141	3		66		0.12						6.38		
Pass km	E 2Ukm	Dragging	141	4		40		0.12						6.38		
Pass km	E 2Ukm	Dragging	141	5		28		0.12						6.38		
km Resh	Beat	Reshaping	142	ALL	- - -	- - -		0.68						28.00		
m^3	E 2Ukm	Grade Repair	143	ALL		1.2		0.27						16.00		

EXAMPLE

APPENDIX C

ILLINOIS DUTY OFFICER MANUAL

January, 1990

Bureau of Maintenance
Duty Officer Manual

GENERAL.

The Bureau of Maintenance (BOM) Duty Officer (DO) is a staff member of the Central Bureau of Maintenance who is assigned on a rotating basis to administer routine IDOT highway related matters and emergency situations which occur any time during the assigned week including these occurring during night time hours, weekends, and holidays.

TOUR OF DUTY.

1. BOM staff personnel are scheduled to serve as the DO for a one week period on a rotating basis. An example schedule is shown on page 2.

2. Tour of duty begins at 1100 (11:00 a.m.) on Monday of each week and ends at 1100 on Monday of the following week.

3. If Monday is a State holiday, transfer of duty occurs at 1100 on the following Tuesday.

4. The DO must be available by either telephone, pager or IDOT mobile radio at all times during their scheduled tour of duty and is expected to stay within a 25 mile radius of Springfield in order that he/she may respond in person when necessary.

5. In the event that the DO will not be available for contact, it is their responsibility to obtain a replacement from the duty roster and to inform the Communications Center (Station 1) in writing of the name and time period the replacement will be serving as DO. Arrangements to provide the replacement person a pager must also be made.

6. If the Duty Officer cannot be contacted, the Communications Dispatcher will contact in sequence, the next listed BOM staff member on the Duty Officer roster for necessary assistance.

BOM PAGERS

1. Primary DO 744-2876
2. Back-Up One 744-2878
3. Back-Up Two 744-2880

To access any Pager, dial the Pager Number (744 is a Springfield Exchange). If calling from a touch-tone phone, the return phone number may be entered after the signal tone. This number will appear on the Pager Screen. When accessed from rotary or pulse phones it is not possible to enter a return message number. The Pager will indicate a message "Tone only." Each Pager will store up to six messages.

The Pager operates on one "AA" battery which under normal conditions should last approximately 30 days. When the battery weakens a "low cell" message will appear on the readout screen. The Communications System Administrator (M-12) maintains a supply of replacement batteries.

DO's are encouraged to keep their pager on at all times.

NOTE: Effective 12-12-89, Pager 467-3528 will be assigned to the Engineer of Maintenance.

DUTY OFFICER DUTIES AND RESPONSIBILITIES.

The following summarizes the responsibilities of the Maintenance DO. Detailed guidelines for each area make up the remaining sections of this manual.

1. Respond to all requests from Station 1 dispatchers for assistance and direct them in the appropriate action to follow for unusual/or emergency situations reported to Station 1.

2. Be responsible for initiating Division of Highways action in response to emergencies such as road closures, bridge problems, floods, tornadoes, earthquakes, etc.

3. Review all highway incidents reported to the Communications Center and notify appropriate IDOT executives as may be required.

4. Take action through district Maintenance management personnel to commit available manpower and equipment in the Division of Highways needed to respond to emergency requests from the Emergency Services and Disaster Agency (ESDA).

5. During winter operations, prepare Road Condition Reports as required.

6. Advise FHWA Division Office of incidents as requested by FHWA and outlined in their letter of January 4, 1989. (See pp. 30)

7. Maintain a personal log of emergency and/or unusual incident situations that result in calls received, calls made, and actions taken.

8. Assist Station 1 dispatcher in Communications Room during emergency situations and during periods of unusually heavy phone and/or radio traffic, day or night.

9. Review the Station 1 Daily Communications Log (DCL) to check for any unusual incidents or reports which may have occurred during the night or weekend. Determine and perform what, if any, follow-up may be necessary.

10. Ensure that Station 1 dispatchers are following all procedures outlined in the Communications Center Manual for the specific type of reported incident.

HIGHWAY INCIDENT REPORTING.

Various types of highway related incidents will be reported to the Communications Center (Station 1). These highway related incidents are usually something unusual or other than a routine operation or report.

The Communications Center dispatcher will determine the "Who," "What," "When," and "Where" for each reported incident and take appropriate action in accordance with the guidelines outlined.

Major highway related incidents fall into the following major categories:

Vehicle Accident
Natural Disaster
Highway Failure
Construction Zone
Other

PROCEDURES FOR HANDLING EMERGENCY INCIDENT REPORTS ARE AS FOLLOWS:

A. Upon notification of a HIGHWAY INCIDENT reported by another State Agency or IDOT district, the STATION 1 Dispatcher will enter the reported information in the Daily Communications Log (DCL) and then start a Highway Incident Report Form. See page 15 for copy of report form.

   At this time the Highway Incident Report Form becomes the DCL for all transactions regarding the reported incident. The dispatcher will be simultaneously using the Incident Report Form for recording messages pertaining to the incident and the standard DCL for recording all other messages for routine traffic to and from Station 1.

B. The dispatcher is to record all information regarding the "Who," "What," "Where," and "When" reported to Station 1. Once the initial information has been received and recorded, the dispatcher will determine the proper time for informing the Bureau of Maintenance Duty Officer of the reported incident.

C. The dispatcher will contact the Bureau of Maintenance Duty Officer as follows.

1. "Immediately" for the following types of incidents:

   . Any requests for IDOT assistance.

   . Any natural disaster which results in road closures and/or detours.

   . Any accident involving IDOT personnel which results in serious injury or death of the employee or public individual(s).

   . Any reported bus accident involving fatalities.

   . Any reported vehicle accident involving trucks which results in multiple fatalities numerous injuries, fires, explosions, release of hazardous materials and/or reported evacuation of an immediate area.

   . Any reported problem involving a bridge failure or closure.

   . Any reported bomb threat which involves a transportation facility.

   . Any reported nuclear power plant problem.

   . Any time the dispatcher is having difficulties in verifying the reported incident details.

2. The dispatcher will for all other reported incidents contact the Bureau of Maintenance Duty Officer immediately except between the hours of 2300 and 0600. Miscellaneous incidents reported during these hours will be reported to the DO at 0600.

D. All Emergency Disaster Incident matters and the NAMES OF ALL CALLING AND CALLED PARTIES relative to these emergency incidents will be recorded on the HIGHWAY INCIDENT REPORT FORM along with the telephone number(s) to contact which then can be given to the Duty Officer upon request.

E. Dispatchers have been instructed not to give information regarding any emergency, such as the exact location, the names of people involved, and IDOT activities will not be released to anyone except IDOT officials when properly identified. Dispatchers will not inform the general public, newspapers, radio or television stations without the express permission of either the Duty Officer, the Engineer of Maintenance (M-1), his designee, or someone from the Office of Public Affairs. Unless the dispatcher has been authorized to release the information, all requests for such information will be referred to one of the following:

   Office of Public Affairs (during normal office hours).
   Duty Officer (during nights, weekends and holidays).

   Dispatchers will record all information regarding such requests and action taken on the Incident Report Form.

F. If the emergency incident or disaster results in a weather related highway closure(s), the Weather Related Emergency Road Closure Form will be completed by the dispatcher.

G. When the incident has been reported as resolved (highway closure opened, debris cleaned up, etc.) the HIGHWAY INCIDENT REPORT form will be finalized and a copy made available for Duty Officer.

H. TYPES OF INCIDENTS AND DISPATCHER ACTION REQUIREMENTS

The following table indicates the required dispatcher action based on type and severity of incident.

Action Codes:

A - Initiate Incident Report Process.
B - Verify Reported Incident Details Using Reference Materials (maps, etc.) and with district personnel (if available), ISP, or ESDA.
C - Notify Bureau of Maintenance Duty Officer.
D - Request Updated or Status Information Regarding Incident.
E - Notify Bureau of Maintenance - Bridge Engineer.
F - Notify ESDA, if reported by someone other than ESDA.

Codes For When Action Required:

1 - Immediately
2 - During normal office hours - immediately.
3 - For night, weekend and holiday periods - Immediately between 0600 and 2300 and at 0600 for incidents occurring between the hours of 2300 and 0600 of the following day.
4 - Every 2 hours until incident closed.

Incident	Required Action	When Action Required
Vehicle Accidents:		
. Any reported vehicle accident resulting in two or more deaths.	A B C	1 1 2 or 3
. Any reported vehicle accident where vehicles are involved in a chain reaction collision regardless of deaths, injuries, or length of time a highway will be closed.	A B C D	1 1 2 or 3 4
. Any reported vehicle accident involving a school bus or commercial bus which has fatalities, serious injuries or a combination of both.	A B C D	1 1 1 4
. Any reported vehicle accident involving commercial vehicles (trucks) which results in multiple fatalities, numerous injuries, fires, explosions, release of hazardous materials and/or reported evacuation of an immediate area.	A B C D F	1 1 1 4 1
Vehicle Accidents:		
. Any reported vehicle accident which results in the closing of an Interstate highway.	A B C D	1 1 1 4
. Any reported vehicle accident which results in the closing of a State Highway.	A B C D	1 1 2 or 3 4
. Any reported railroad crossing accident.	A B C	1 1 2 or 3
Accidents Involving IDOT Personnel, Vehicles, or Equipment:		
. Any reported accident involving IDOT personnel which results in serious injury or death of the IDOT employee or public individual(s).	A B C D	1 1 1 4
Natural Disasters:		
. Any reported tornado. . Reported flooding. . Reported severe thunderstorm damage. . Reported earthquake. . Reported landslide. . Unusually heavy snowfall. . Reported ice storm.	If incident results in highway closure: A B C D F	 1 1 1 4 1
Highway Failures:		
. Any reported problem involving the highway pavement (travel surface.	A B C	1 1 2 or 3
. Any reported problem involving a bridge over a stream, river, other highway or railroad.	A B C E	1 1 1 2 or 3
. Any reported problem involving an intersection.	A B C	1 1 2 or 3

Type	Required Action	When Action Required
Construction Zone Involved:		
. Any reported accident within a construction or maintenance work zone resulting in death(s) or serious injuries to workers and/or to the general public	A B C	1 1 2 or 3
. Any reported accident within a construction or maintenance project which involves one or more of the following: Failure of a structure. Collapse of a structure. Scaffolding problems. Rigging problems. Incidents which might delay project completion.	A B C D	1 1 2 or 3 4
Other:		
. Any reported problems with highway appurtenances listed below that result in vehicle accidents or highway closures: Traffic lights. Highway signs. Detour signs. Guardrail. Railroad crossing signals.	A B C	1 1 2 or 3
. Any reported problem involving an IDOT building such as district headquarters, maintenance storages, Day Labor buildings or Interstate Rest Area facility.	A B C D	1 1 2 or 3 4
. Any reported bomb threat or incident which affects a transportation facility (highway, bridge, airport, railroad, or building).	A B C D	1 1 1 4
. Any reported incident that causes a State or Interstate highway to be closed for two hours or more.	A B C D	1 1 1 4
. Any reported incident that results in the closing of all directional lanes of an Interstate or multiple lane divided highway.	A B C D	1 1 2 or 3 4
. Any reported incident that results in the closing of an Interstate highway ramp.	A B C	1 1 2 or 3
. Any reported highway closure resulting from a utility service disruption (power line down, gas line rupture, etc.)	A B C D	1 1 2 or 3 4
. Nuclear power plant problem	A B C D F	1 1 1 4 1
. Any reported hazardous material accident or nuclear moisture-density gauge incident.	A B C D F	1 1 2 or 3 4 1
. Any reported problems and/or shutdowns of the Illinois River ferries.	A B C D	1 1 2 or 3 4

I. The Maintenance Duty Officer must determine if one or more of the following persons should be informed about the incident:

James W. Shay, Engineer of Maintenance

Jack Hook, Deputy Director of Highway Operations and Administration

R. L. Adorjan, Director of Public Affairs

R. C. Wehner, Director of Highways

H. W. Monroney, Deputy Secretary

E. J. Kehl, Engineer of Construction

R. W. Jones, Engineer of Traffic

Bill Piland, Unit Chief of Workman's Compensation (If incident involves serious injury or death to an IDOT employee)

As a general guideline any incident classified in Paragraph C-1 of this section should be reported to the first five executives listed above. Notification is normally made by providing each Executive Office with a copy of the initial Incident Report, copies of updates and the final report.

The Duty Officer is responsible for copy preparation and distribution which is to be completed as soon as possible during normal working hours. For incidents occurring outside of normal working hours the Duty Officer must determine the seriousness of the situation and decide on appropriate notification. Many "Off Hours" incidents will be of a nature to permit holding distribution of the Incident Report until the next business day. Under this circumstance, the Director of Highways expects copies of all overnight, weekend, and holiday incident reports to be in his office by 0700 the next business day. Other distributions should be handled accordingly.

SPECIAL NOTE: A copy of any Incident Report distributed to any of the above-listed executives must also be provided to Secretary Lane's Administrative Assistant, Donna Ley, Room 300, in accordance with the distribution procedures above.

In the event an off-hour incident is judged to be of a very serious nature and/or may be expected to generate immediate political or news media interest, direct telephone calls from the DO to appropriate executives is in order.

Notification by copy of the Incident Report to the Engineers of Construction and Traffic are required only when the incident involves construction work zones or members of their respective Bureaus.

Incidents involving serious injury or death of an IDOT employee must be reported to the Worker Compensation Unit, Bill Piland or his designee.

The Duty Officer is responsible for making any contacts with Department Executives during non-working hours. Dispatcher may assist with providing telephone numbers and or transferring calls when possible. Do not ask the dispatcher to make these calls.

Common sense and judgment should always be applied to the guidelines in the final determination of the severity of the incident and the need for distributing the report form or calling Executive staff members.

Illinois Department of Transportation
Bureau of Maintenance
Communications Center

Highway Incident Report

Informant : _____ Report: ☐ Initial ☐ Update ☐ Final

Agency : _____ Return telephone number : _____

Type of Incident	Timing	Date	Time
☐ Vehicle Accident	Incident Occurred At:	_____	_____
☐ Natural Disaster	Incident Reported To Sta. 1:	_____	_____
☐ Highway Failure	Incident Confirmed At:	_____	_____
☐ Construction Zone Involved	Incident Closed At:	_____	_____

☐ Other Describe: _____

Location of Incident:

County: _____ Nearest City or Town: _____

Incident Log Sheet

Time	Details

Dispatcher Name: _____ Duty Officer: _____ Phone: _____

Record reviewed by:

Chief Dispatcher - Initials: _____ Time: _____ Date: _____

BOM Duty Officer - Initials: _____ Time: _____ Date: _____

Record Number: _____

APPENDIX D

CALTRANS MAINTENANCE LEVELS OF SERVICE

STATE OF CALIFORNIA—BUSINESS, TRANSPORTATION AND HOUSING AGENCY GEORGE DEUKMEJIAN, Governor

DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAY MAINTENANCE

MAINTENANCE LEVELS OF SERVICE

THE LEVELS OF SERVICE

Included in this section are intended to promote consistent Maintenance Practices statewide while recognizing the differences in the types of traffic the highways serve, and the differing needs of rural and urban areas. The direction given in this section is an expression of Headquarters intent.

The 1985-86 Fiscal Year was a period of transition and adjustment. Problems encountered in applying these LEVELS OF SERVICE, such as, not being able to meet, or exceed these levels should be reported promptly to the Resource Utilization Branch in Headquar- ters through your Area and Region Managers.

TYPES OF MAINTENANCE

RESPONSIVE MAINTENANCE

This type of maintenance activity is to be handled on an as needed bases. The levels of service indicate how rapid a response is normally appropriated. The types of responses used are described below.

URGENT - An immediate response is authorized including the use of overtime and after hours call back if necessary.

QUICK - This work requires early attention and should be undertaken within two weeks. Some work may require a response within one to two days.

ROUTINE - This work should be underway within two months.

SEASONAL - This work should be accomplished during the appropriate season of the year.

DELAYED - This work needs to be done but may be deferred for a reasonable period of time to accumulate a sufficient quantity of work, or allow for workload leveling.

MAINTENANCE LEVELS OF SERVICE

SCHEDULED MAINTENANCE

This type of maintenance is performed on a scheduled bases. The Levels of Service indicate the number of maintenance cycles to be performed each year.

F-XX - Number of times work is done per year.

Examples - servicing equipment, inspections, relamping signals or cleaning sump pumphouses.

F-1/2 - Work done once every 2 years.

F-M - Per operating manual

F-S - Per master schedule

PLANNED MAINTENANCE

This type of maintenance is not considered routine and should only be undertaken when it has been included in an approved maintenance plan such as the Major Maintenance Plan or the Bridge Painting Program. Headquarters concurrence is usually required for this type of work.

P-M - Per maintenance manual.

HIGHWAY CLASS

THE STATE HIGHWAY SYSTEM routes have been classified as Class 1, 2 and 3 highways based on the type and volume of the traffic they serve. At times the *LEVELS OF SERVICE* will be different between Highway Classes. When this occurs use the map and route list at the beginning of this Section to determine the appropriate Highway Class for any County Route and Postmile.

HIGHWAY CLASS

RURAL - URBAN HIGHWAYS

THE STATE HIGHWAY SYSTEM routes have been classified as either Rural or Urban. At times the *LEVEL OF SERVICE* may be different between Urban and Rural Highways. When this occurs use the route list at the beginning of this section to determine the appropriate classification for any desired County, Route and Postmile.

PRIORITY - WHY CODE

THE PRIORITY OR "WHY" CODE usually used with the activity is shown in last column. When necessary a different "Why" code may be the used.

APPLICATION OF THE LEVELS OF SERVICE

WORK WITH DIFFERENT DEGREES OF URGENCY

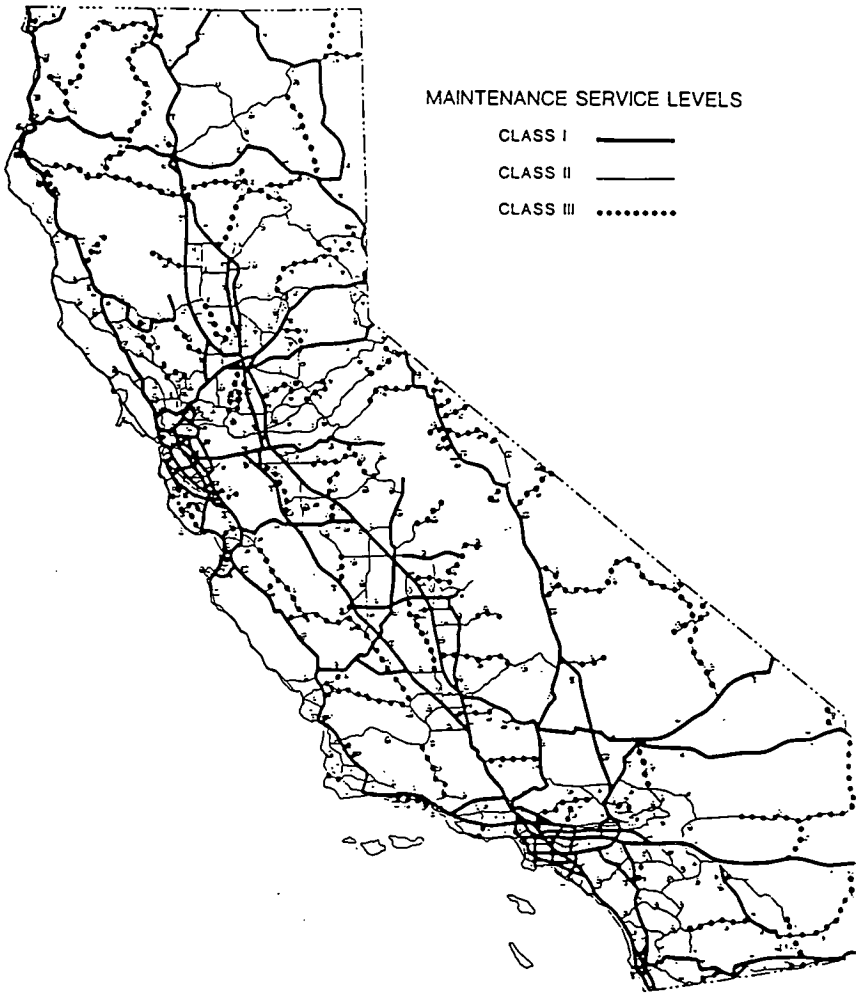
When planning maintenance operations, work with the highest degree of urgency (i.e., Urgent or Quick, should be completed prior to undertaking Routine, Seasonal or Delayed activities). Scheduled Maintenance should be treated the same as routine maintenance when developing weekly and/or monthly workplans. At the appropriate time of the year seasonal responsive maintenance should also be treated the same as routine maintenance.

WORK WITH THE SAME DEGREE OF URGENCY

When planning maintenance operations that include several activities having the same degree of urgency, i.e., several items all designated as Quick, then the work should be undertaken in order of priority. Work assigned a "Why Code" of 1 (safety related) should be completed before doing work the "Why Codes" of 2, Preservation of Investment, or 3, Traffic Service. This general statement may be modified by the Area Superintendent or Regional Manager in unusual circumstances.

CONFLICTING INSTRUCTIONS

In the event there are conflicts between the Levels of Service contained in this section and those found in Volume 1 of the Maintenance Manual, Those contained in this section are to be used.



THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. It evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Robert M. White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Stuart Bondurant is acting president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Frank Press and Dr. Robert M. White are chairman and vice chairman, respectively, of the National Research Council.

TRANSPORTATION RESEARCH BOARD
National Research Council
2101 Constitution Avenue, N.W.
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