NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP Report 360

Professional Development of Maintenance Engineers and Managers

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Report 360

Professional Development of Maintenance Engineers and Managers

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Subject Areas

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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

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.

Note: The Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers names appear herein solely because they are considered essential to the object of this report.

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The project that is the subject of this report was a part of the National Cooperative Highway Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

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, 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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FOREWORD

By Staff
Transportation Research Board

This report outlines a national framework for education and training programs for maintenance engineers and managers. Such programs will help improve the efficiency and effectiveness of today's maintenance professionals and also encourage young engineers in choosing maintenance as a career. The report will be of interest to maintenance engineers and managers considering enhanced educational opportunities and well-rounded training. Also, colleges, universities, and other organizations offering education, continuing education, or training programs for engineers and managers will find the report helpful in enhancing current activities and useful in developing new programs.

Transportation maintenance engineers and managers face complex challenges because of environmental issues, rapidly changing technology, infrastructure deterioration, and budget and resource constraints. To meet these challenges, maintenance professsionals rely upon on-the-job training supplemented by infrequently available courses and workshops. However, more formal educational programs and opportunities are needed so that today's maintenance professionals can cope with the increased demands of our transportation system.

Under NCHRP Project 14-9(6), "Professional Development of Maintenance Engineers and Managers," the University of Maryland was assigned the task of designing an educational framework and developing an implementation plan to encourage and guide universities, the professional community, and others in adapting programs to assist both existing and aspiring maintenance professionals. As a result of this project, a national framework for "Education and Training of Maintenance Engineers and Managers" has been developed. This framework includes model curricula and courses for three components: (1) education; (2) continuing education; and (3) training. To provide a widespread application of this framework, the report outlines a plan for the implementation of the identified educational and training programs. This plan suggests the establishment of an organizational structure, which is somewhat permanent in nature, to administer the implementation. Further, the plan suggests the involvement of national organizations, such as the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), the American Public Works Association (APWA), and the National Association of County Engineers (NACE), in the marketing and implementation of the education and training programs.

Readers will note that Appendixes B through F (see Table of Contents) have not been published herein. For a limited time, copies will be available on a loan basis or for purchase ($15.00) on request to NCHRP, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

CONTENTS

ACKNOWLEDGMENTS

The research report herein was performed under NCHRP Project 14-9(6) by the University of Maryland Transportation Studies Center and Bergstralh-Shaw-Newman, Inc. (BSN). The University of Maryland was the contractor for the study; work undertaken by BSN was performed under a subcontract with the University.

Everett C. Carter, Ph.D., Professor of Civil Engineering, University of Maryland, was the principal investigator. He was assisted in the research and report writing by M. Ed Shaw, BSN president, and Jeffrey E. Garmong, BSN senior engineer.

None of the developments under this project could have been possible without a solid foundation: the surveys yield maintenance manager profiles, training needs, existing training, knowledge and ability (K&A) statements, activity statements, and existing and possible educational programs. The research team extends its sincere thanks to those who generously contributed time (in some cases many hours) in responding to the surveys, reviewing K&A and activity statements, and sending copies of training lists and materials.

We owe special gratitude to the training and maintenance experts in four state transportation agencies—Delaware, Maryland, Pennsylvania, and Virginia—who allowed interviews and provided follow-up materials. In addition, completion of questionnaire surveys by several states enhanced the final product, making it more complete and representative.

PROFESSIONAL DEVELOPMENT OF MAINTENANCE ENGINEERS AND MANAGERS

SUMMARY

Transportation maintenance engineers and managers face increasingly complex challenges because of environmental issues, rapidly changing technologies, infrastructure deterioration, and budget and resource constraints. To meet these challenges, maintenance professionals rely upon on-the-job training supplemented by infrequently available courses and workshops. However, more formal educational programs and opportunities are needed to assist today's maintenance professionals in meeting these demands.

Educational opportunities must also be created or identified to familiarize, attract, and prepare people to pursue professional careers in maintenance. There are few educational opportunities available to the aspiring maintenance professional. As the complexities of highway maintenance and the magnitude of the problems continue to increase, the development of highly skilled and trained professionals will increase in importance. Further, as the emphasis shifts away from new construction to maintaining and rehabilitating the infrastructure, properly trained professionals are needed to make more efficient and effective use of limited resources.

As a first step in correcting this neglected area of civil and transportation engineering, an educational framework must be designed to encourage and guide universities, the professional community, and others in implementing programs to assist both existing and aspiring maintenance professionals. The framework must also include model curricula for the transportation maintenance professional.

Project 14-9(6) was initiated in response to this need. This report describes the research undertaken to develop a national framework for the education and training of highway maintenance engineers and managers. In addition, a training and master of science (M.S.) model program and recommended bachelor of science (B.S.) and M.S. level courses are presented.

A draft comprehensive listing of maintenance activities and tasks and the knowledge required to perform them, was reviewed by a panel of experts and the research team. This material was sent to nine states that had indicated a willingness to review it. Comments and suggestions were incorporated resulting in the comprehensive work and knowledge and ability definitions.

A preliminary survey of all states and a sample of counties (from 11 states) and municipalities (116) was mailed to obtain maintenance manager profiles and critical training needs. The responses from the states indicated the following:

a. State Maintenance Managers:	(1) 90 percent with B.S. Degrees
	(2) 25 percent with M.S. Degrees
b. District Maintenance Managers:	(1) 80 percent with B.S. Degrees
	(2) 9 percent with M.S. Degrees
c. Resident Maintenance Managers:	(1) 60 percent with B.S. Degrees
	(2) 4 percent with M.S. Degrees

The large majority (70–75%) of managers at all levels were between 41 and 60 years of age, with an average of more than 10 years of experience and more than 10 years of prior construction and design experience. Similar profiles exist for county and city maintenance managers but with less experience. The critical training needs indicated were (1) General Management, (2) Personnel Management, (3) Maintenance Work Management, (4) Computers and Computer Applications, and (5) Current Topics.

Interviews were conducted in four states, followed by another survey to determine what training now exists and how it is accomplished. The results of this survey were combined with the preliminary survey and with the maintenance activities and knowledge and ability statements to develop the training program—presented as a series of more than 50 modules and 17 courses.

The last task for this project was development of the education framework for an M.S. program in Maintenance Engineering and Management. A model M.S. program was developed, along with suggested courses at the M.S. and B.S. levels. It was then sent to a sample of 55 Civil Engineering departments for review and comment. Responses from 34 universities led to the recommended M.S. program in "Maintenance Engineering and Management" and courses at both the B.S. and M.S. levels.

Finally, recommendations for implementation of the training and education program are presented.

CHAPTER 1

INTRODUCTION AND RESEARCH APPROACH

PROBLEM STATEMENT AND RESEARCH OBJECTIVES

Transportation maintenance engineers and managers face complex challenges because of environmental issues, rapidly changing technologies, infrastructure deterioration, and budget and resource constraints. To meet these challenges, maintenance professionals rely upon on-the-job training supplemented by infrequently available courses and workshops. More formal educational programs and opportunities are needed to assist today's maintenance professional in meeting the challenges. For example, the environmental issues faced by maintenance engineers/managers include the use of salt for snow and ice control, problems of leaking fuel tanks, disposal of paint barrels, use of herbicides for roadside growth control, disposal of lead paint cleaned from bridges, and maintenance of stormwater management ponds that have now been deemed to be wetlands with all the recently adopted constraints and requirements. Technology changes include computer-controlled inventories and equipment as well as major changes in the types of personnel required to conduct certain maintenance activities.

An approach to meeting this need is to create educational opportunities to attract and prepare professionals for increasingly complex maintenance operations and management. The ultimate goal is to enhance the profession of transportation maintenance engineering and management and to familiarize, attract, and prepare people to pursue professional careers in maintenance.

As the emphasis shifts away from new construction to maintaining and rehabilitating the infrastructure, properly trained professionals are needed to make more efficient and effective use of limited resources. Yet, there are few educational opportunities available to the aspiring maintenance professional. As the complexities of highway maintenance and the magnitude of the problems continue to increase, the development of highly skilled and trained professionals will increase in importance. Thus, an educational framework is needed as a guide for professional careers for engineers and managers in highway maintenance.

The primary objective of this research was to design an educational framework and an implementation plan for the professional development and enhancement of highway maintenance engineers and managers. This included the identification, review, and development of the following:

- Programs—Graduate and B.S. levels
- Courses—Graduate and undergraduate
  —Continuing Education short courses
- Seminars/Workshops
- Training Materials

The framework developed includes model curricula for transportation maintenance professionals as well as guidance for implementation.

SCOPE OF THE STUDY

The scope of this study, like any other, was limited. An in-depth review of the current training programs of all highway/transportation maintenance organizations was not possible. However, a large sample of state departments and a reasonable sample of county and municipal maintenance organizations were surveyed. Also, the educational programs at all universities could not be reviewed. A review of the TRB Synthesis (draft) "Development of Professional Highway Maintenance Engineers" (Topic 21-06) was combined with a survey of about 55 universities to establish both a profile of existing programs and the likelihood of implementing new courses or a new program.

RESEARCH APPROACH

To achieve the project objective—a national education and training framework and implementation plan that will enhance highway maintenance engineering and management as a career profession—the project was conducted in four major steps or phases as discussed below.

Identify Responsibilities and Knowledge Requirements

This step involved the identification and description of the responsibilities and knowledge requirements for highway maintenance engineers/managers at different management levels in State DOTs and local transportation agencies. This step was divided into three tasks:

- Knowledge and ability listings were developed and matched with activities at three levels of maintenance management/supervision. This material was reviewed by a panel of experts.
- A survey form was developed and distributed to all State DOT/highway departments and to a sample of county and municipal transportation agencies. This survey obtained information on the educational and experience backgrounds as well as current and recent past involvement with continuing education—training and conferences, professional meetings, and technical management reading. The results from this survey helped develop a Maintenance Engineer/Manager Profile.

• The knowledge and ability statements were sent in a second survey to 10 states (based on their indication, from the first survey, of willingness to participate in the study) for review, and the review comments were incorporated into a final listing of knowledge and ability statements by management level.

Determine Training Needs

The first survey requested information on the most urgent training needs of the respondents *and* those they supervise. To supplement this information, the research team developed an interview format and interviewed four states. Then a third survey form was sent to nine states to determine what training they now provide for maintenance engineers and managers.

Develop Educational Framework

A draft M.S. program in "Maintenance Engineering and Management" was developed and sent to Dr. D.L. Howell (Management Professor, Emeritus, from the University of Mississippi). Then, a 1-day brainstorming session was conducted with Dr. Howell by the research team. The M.S. program and curriculum were further refined, and a brief questionnaire was sent to 55 universities to obtain suggested additions, deletions, or modifications.

Implementation Plan

How to implement both the training program and the educational program with stringent budgets is a large question. Recognizing this, the research team developed some implementation strategies.

REPORT ORGANIZATION

The report is organized into four chapters and technical appendices. Chapter Two summarizes the research findings—particularly the results of the surveys. Chapter Three contains a comparison of training available versus training desired; continuing education versus regular education; educational alternatives, and delivery alternatives. Chapter Four addresses implementation issues, conclusions, and recommendations.

Only Appendix A, "Education and Training Framework," is published herein. Additional details of the research effort are contained in Appendixes B through F, which are available for loan.

CHAPTER 2

FINDINGS

INTRODUCTION

Project findings are discussed in five major categories in this chapter. The first category defines the target group of maintenance personnel addressed in the research, as well as those to be addressed in the education and training programs recommended in later chapters. Sections that follow identify the work done by these people, the knowledge and abilities effective work performance requires, their basic educational and training-related profiles, perceived educational and training needs, and summaries of educational and training efforts currently under way.

TARGET GROUP

The scope of this project, as previously discussed, is confined to highway maintenance, and the people who manage and supervise this work. Prior research classified them into nine potential levels ranging from sectionmen and gang foremen to state maintenance engineers.[1] Because this project centers on engineers and managers, the researchers excluded the two lowest levels, and reclassified, for work analysis purposes, the seven remaining levels into the following three:

1. Agency maintenance engineers and managers;
2. District maintenance engineers and managers; and
3. Resident (area) maintenance engineers and managers.

To avoid reference tedium—engineers and managers, or engineers/managers—appropriate subsequent references will frequently refer simply to maintenance managers.

WORK ACTIVITIES, AND KNOWLEDGE AND ABILITY DEFINITIONS

Key work activities were defined for each of the three levels of maintenance management. For the purposes of this project, an activity is a major job assignment or responsibility, such as the formulation of a maintenance budget, and the development and supervision of an equipment program. To accomplish the activity, a series of discrete tasks in a natural sequence was defined. Organizational differences among state and local agencies cause significant variations from one agency to the next in where these activities are actually performed. Many organizations have separate units, outside the maintenance organization, with maintenance-related responsibilities. Typical examples include pavement management, bridge maintenance, traffic control, and maintenance contracting. And some maintenance organizations have nonmaintenance-related responsibilities such as ferry operations. Using Bergstralh-Shaw-Newman (BSN) files and highway maintenance literature, draft knowledge and ability statements were developed by BSN staff with review by the University of Maryland staff. The researchers took a broad view of highway maintenance, its responsibilities, and the knowledge and abilities people need to do the work. Professional development and the improvement of highway maintenance are the goals. Somewhere within each agency someone must be responsible for highway maintenance, regardless of where they may be organizationally housed. The professional development and work performance improvements of maintenance managers, regardless of typical or unusual organizational placement, are within the project scope.

A panel of experts was assembled to review the draft knowledge and ability statements. The panel included three professionals, each with a career spent in highway maintenance:

- Thomas Cain—Retired from the State of Alabama Highway Department,
- Edmundo Lucero—Retired from the New Mexico State Highway and Transportation Department, and
- Kenneth Mellinger—Retired from the Indiana Department of Transportation.

The research team and the NCHRP Project Engineer were also part of the panel. For 2 days, the entire group discussed each activity and corresponding knowledge requirement at three levels of responsibility and developed a revised list of knowledge and ability statements.

The completion of this task was accomplished when the revised statements were reviewed by maintenance units in 10 selected states. The survey material from this portion of the study is contained in Appendix D. Responses were received from 9 of the 10 states. Many changes in the activity statements were recommended. Some were organizationally driven—"bridge does this work in our agency." Others refined and added to the statements. In the main, where task or ability reductions were recommended, because of organizational differences, they were not incorporated into the statements. When additions were recommended, most were adopted, if functionally consistent with the scope of the statement at hand. In general, there was broad agreement among the reviewing agencies as to the scope and content of the knowledge and ability statements. Figure 1 presents the overall comments from the states regarding the complete set of knowledge and ability and activity statements. Figures 2 and 3 present the general comments from the states.

[1] Transportation Research Board Circular No. 347, *Progress Report on Maintenance and Operations Personnel*, April 1989.

STATE REVIEW COMMENTS

Summary Statements

Overall Comments	
California	The material seems to cover the area well.
Florida	The information is fairly complete and very detailed.
Iowa	The original work was 99+% accurate in describing our positions.
North Carolina	No overall comments.
Oregon Equivalencies:	Agency Maintenance Engineer/Manager = Operations Engineer District Maintenance Engineer/Manager = Region Engineer Resident Maintenance Engineer/Manager = District Manager
Pennsylvania	No overall comments.
South Dakota	The material fairly accurately covered the realm in any maintenance organization.
Texas	The descriptions appeared appropriate.
Vermont	Suggest the inclusion of an additional knowledge area: Safety Regulations. The issues surrounding safety are as far reaching as are those involving the environment.

Figure 1. State Review Comments: Summary.

STATE REVIEW COMMENTS

Knowledge and Ability Statements

General Comments	
Pennsylvania	Safety is not mentioned. "Traffic Engineering" should be at least generally included as a title. Possibly "Building and Grounds" should be a separate title. Possibly "Roadside" should be a separate title.
Vermont	Add "24 Safety Regulations" to the knowledge and ability titles. (Suggested description attached to response.)

Agency Maintenance Engineer/Manager

General Comments	
Florida	A significant proportion of the State Maintenance Engineer's time is spent on a few items: • Managing staff • Budget preparation and monitoring • Resource needs identification • Bridge inspection and monitoring • Mobile equipment programs and utilization • Technology transfer and training • All others Consider expanding the material for the Agency Maintenance Engineer/ Manager to include: • Policy, procedure and rule development • Quality assessment of district implementation of policy, etc. • Warehouse operation and management • Issuance of heavy truck permits to limit roadway/bridge damages
North Carolina	Except for Activities 8 and 9, the State Maintenance Engineer is responsible for the functions as described.
Oregon	In the Oregon State Highway Division, the Operations Engineer administers the formerly separate construction and maintenance sections. References to the maintenance department should be changed to "operations."

Figure 2. State Review Comments: Knowledge and Ability Statements.

The changes recommended by these states are reflected in the statements shown on subsequent pages.

Knowledge and Ability Statements

All activity statements and task listings were analyzed and evaluated to identify the key knowledge and abilities individuals should have, at each of the three levels of management, to effectively perform the described work. The results of these analyses were classified and categorized into 24 statements:

1. Agency operations;
2. Maintenance operations;
3. Other public agencies;
4. Maintenance work management;
5. Equipment;
6. Bridge inspection;
7. Public regulation and permits;
8. Maintenance training;
9. Management and accounting systems;
10. Policies, guidelines, objectives, and plans;
11. Personnel management;
12. Financial management;
13. Environmental protection;
14. Tort liability/risk management;
15. Maintenance work program;
16. Emergency preparedness;
17. Maintenance contracting;
18. Equipment management;
19. Field work for research, studies, and investigations;
20. Research, studies, investigations, and reports;
21. Public relations;
22. Meetings and presentations;
23. Current topics; and
24. Safety and related regulations.

Activity Statements

The activity lists for agency and district-level maintenance, not too surprisingly, are nearly identical. The primary differences are scope, emphasis, and major tasks that must be undertaken to effectively complete the activity. Whereas headquarters typically develops and monitors, districts typically have more direct supervisory responsibilities and usually more direct public contact. The key activity lists for the agency-level maintenance managers are as follows: 1) Budget; 2) Develop/monitor the routine maintenance program; 3) Develop/monitor the rehabilitation, improvements, and safety programs; 4) Develop/monitor the emergency preparedness program; 5) Develop/monitor the equipment programs; 6) Develop/monitor the bridge inspection program; 7) Manage permitting and regulatory operations; 8) Develop/monitor the facilities' operations program; 9) Develop/monitor the maintenance training program; 10) Manage system operations; 11) Manage other programs and operations; 12) Develop/monitor special studies and reports; 13) Modify/improve technology and methods; 14) Respond to complaints and inquiries; and 15) Manage staff.

Substituting the word *supervise* for *monitor* in the above list yields the activity statement titles for district maintenance managers.

The activity listing for resident maintenance managers has common elements with those for the districts and headquarters, but again with a much different scope and emphasis. The primary emphasis here is on implementation and supervision, whereas higher levels, as previously noted, center on development, monitoring, and more general levels of supervision. And the attention time span tends to be shorter at this level, with efforts centering on the management of day-to-day and week-to-week operations. Longer-term actions, such as staff balancing and the like, focus on changes that might be needed to meet seasonal demands; for example, shifting blends of staff skills (snow plowing, patching, vegetation cutting) and changing materials inventory and handling requirements (salt and asphalt).

The following is the activity listing developed for resident maintenance managers: 1) Implement and supervise the routine maintenance program; 2) Implement and supervise the rehabilitation, improvement, and safety programs; 3) Implement and supervise the emergency preparedness program; 4) Implement and supervise the equipment repair and maintenance program; 5) Implement and supervise permitting and regulatory operations; 6) Implement and supervise the facilities operations program; 7) Implement and supervise the maintenance training program; 8) Implement and supervise system operations; 9) Implement and supervise off-system, specially funded programs; 10) Implement and supervise other programs and operations; 11) Implement and supervise special studies and reports; 12) Modify/improve technology and methods; 13) Respond to complaints and inquiries; and 14) Manage staff.

Activity statements for each key activity were developed. They were divided into three parts. The first was a description of the activity. The second was a listing of key tasks required in the completion of the activity. The third was a listing of the knowledge and abilities people need to master to effectively complete the activity and tasks included within the statement. While activity statement titles are nearly the same for headquarters and district levels, there are significant differences in the details of the statements.

Final Knowledge and Ability and Activity Statements

A common perception of highway maintenance is the repetitive application of nontechnical, predominantly "blue-collar" work. Even a cursory evaluation of required knowledge and abilities at the lowest management level shows technical and managerial requirements covering a wide variety of subjects ranging from personnel and financial management to broadly based technical highway and bridge maintenance, and field work for research studies, and investigations.

All knowledge and ability and activity statements developed through this project, for each of the three management levels, are presented in Appendix B. The activity statements show the key tasks completed for each activity, as well as the knowledge and abilities people need to complete the work described. A typical knowledge and ability statement, Statement 4, is shown in Figure 4. A typical activity statement for a district maintenance manager for the activity, Develop/Supervise the Routine Maintenance Program, is shown in Figure 5.

SURVEY OF MAINTENANCE MANAGER PROFILES

To determine the magnitude of the educational and training needs, it is desirable to know the educational and experience levels at each management classification. A survey designed to accomplish this was sent to

STATE REVIEW COMMENTS

District Maintenance Engineer/Manager

General Comments

North Carolina	The compilation of activities, tasks, responsibilities, required knowledge and skills is pretty descriptive of the responsibilities of the position and the duties performed or subject to be performed. (Reviewer 1) North Carolina maintains all roads, except city streets, and field operations are broken into divisions instead of districts. While some of the comments may reflect these differences, I am in general agreement with the duties, responsibilities, and knowledge requirements that have been developed for this position. (Reviewer 2) References to "district" should read "division" for North Carolina. (Reviewer 2)
Oregon	The position is Region Engineer in Oregon.
Pennsylvania	Activity 16 Manage Staff should be the first priority. Add two activities: 17 Develop/Supervise a Traffic Engineering Program and 18 Human Resources Management. (Suggested activity descriptions, tasks and knowledge and ability titles attached to response.)

Resident Maintenance Engineer/Manager

General Comments

Florida	Perhaps the word "supervise" should more nearly be "implement." A maintenance engineer should be carrying out central office and district policy, etc.
Oregon	In Oregon, the title is District Manager.

Figure 3. State Review Comments: Activity Statements.

Knowledge and Ability Statement

Number 4

Maintenance Work Management

Knowledge of:

1. the descriptions, purposes, work quality requirements, and work methods for routine, periodic and preventive maintenance activities and for rehabilitation, improvement and safety improvement work;
2. maintenance worker classifications and job assignments, including applicable standards and guidelines;
3. type of maintenance equipment and its application to work activities, including the applicable standards and guidelines pertaining to operation and safety;
4. maintenance material properties and the application of materials to work activities, including the applicable specifications, standards and guidelines;
5. the nature and operational requirements of minor emergency work, such as normal traffic accidents and storms;
6. facility operations, maintenance and repair; and
7. the importance of bridge inspections and the support of the inspections.

Ability to:

1. provide technical direction and supervision of maintenance work and support operations;
2. obtain acceptable work quality, production and work site safety when directing and supervising maintenance work; and
3. incorporate the technical aspects of maintenance work in programming and budgeting functions.

Figure 4. Typical Knowledge and Ability Statement.

District Maintenance Engineer/Manager
Activity 2

Develop/Supervise the Routine Maintenance Program

Activity Description and Tasks:

Supervise the routine, preventive and periodic maintenance program for roads, rights-of-way, structures, traffic control devices, and services in the district. Participate in programming and budgeting activities as required.

1. Advise and assist the district engineer/manager and central office maintenance staff in formulating policies, guidelines, objectives and plans for routine, periodic and preventive maintenance.
2. Participate in the preparation of the routine program and budget.
3. For contracted work, coordinate, perform or direct the performance of the parts of the contracting process administered by district maintenance. Participate as needed in the parts of the process performed by others.
4. Oversee work scheduling, performance and reporting by the residencies. Direct district maintenance staff in scheduling and overseeing work and reporting performed by district maintenance crews.
5. Initiate corrective actions so that work complies with the program and budget.

Applicable Knowledge and Ability Titles:

1. Agency Operations
2. Maintenance Operations
4. Maintenance Work Management
6. Bridge Inspection
10. Policies, Guidelines, Objectives and Plans
11. Personnel Management
12. Financial Management
13. Environmental Protection
14. Tort Liability/Risk Management
15. Maintenance Work Program
17. Maintenance Contracting
21. Public Relations
23. Current Topics
24. Safety and Related Regulations

Figure 5. Typical Activity Statement.

- Each State DOT Maintenance Manager,
- All State DOT Assistant Maintenance Managers,
- All District Maintenance Managers,
- A sample of two Resident (area) Maintenance Managers per district,
- A sample of 366 county highway agencies from 11 selected states, and
- A sample of 116 municipal highway agencies from municipalities of various sizes.

Samples of the survey questionnaire and the results are shown in Appendix C. Results from the survey are discussed in the next several pages.

Over 800 state and local maintenance managers responded to the previously described survey and provided background information of educational and training significance. The sample included 40 state maintenance managers, 42 assistant state maintenance managers, 235 district maintenance managers, 386 resident engineers, 84 county maintenance engineers, and 19 city maintenance engineers.

The response rate among the states was obviously high, but it was disappointing at the local level. Only about 23 percent of the surveyed cities and 16 percent of the surveyed counties completed and returned their questionnaires.

Information provided included years of formal education, years of maintenance work experience, and age. Because all respondents did not necessarily answer all questions, tables frequently do not total to the 806 people who participated in the survey.

Education

Most respondents completed the educational portion of the survey questionnaire—799 out of 806 respondents. As shown in Figure 6, a high proportion of them have degrees, more than 70 percent, and 10 percent already have master's degrees. It is probable that managers with degrees might be more likely to complete the form, but again a high proportion of all forms at the state level were completed and returned.

Levels of educational attainment vary by position levels, in patterns that might be expected. Higher levels of educational attainment are apparent among state and assistant state maintenance managers. About a quarter of the personnel in these posi-

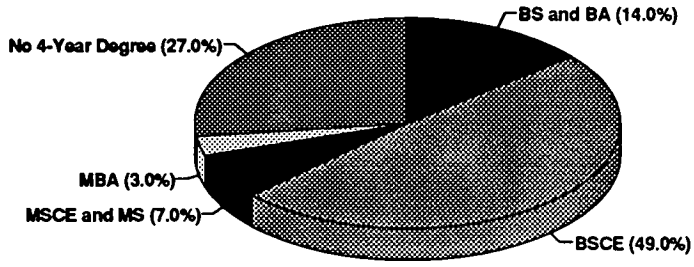

Figure 6. Levels of Formal Education Among All Maintenance Managers.

tions have advanced degrees, and higher percentages have bachelor's degrees.

1) Ninety percent of the state maintenance managers have degrees, and 28 percent have master's degrees. All of the state maintenance managers without degrees have completed continuing education courses of one type or another, as have most other personnel.

2) Ninety-three percent of the assistant state maintenance managers have degrees, and 24 percent have master's degrees.

3) Eighty percent of the district maintenance managers have degrees, and 9 percent have master's degrees.

4) Sixty percent of the resident maintenance managers have degrees, and 4 percent have master's degrees.

5) As noted, sampling rates among city and county maintenance managers are low. Of the county managers who responded (82 people), approximately 84 percent have degrees; 16 percent have master's degrees. Only 18 city maintenance managers responded; all but one had a bachelor's degree.

Of the 799 maintenance managers, 506 (63%) have bachelor's degrees and are potential candidates for a formal graduate-level educational program in maintenance. Virtually all are potential candidates for continuing education and training programs.

Age

To facilitate survey completion, respondents simply checked a space to show their current age. Age groupings used were under 30, 31 to 40, 41 to 50, 51 to 60, and over 60 years old. Most respondents (803) provided this information. Only 19 percent were under 40 years old, and only 3 percent were age 30 or less. The large majority of respondents were between the ages of 41 and 60. Six percent were over 60 years old.

Figure 7 shows that there was not as much difference in age by position as was expected. It was initially thought that many of the younger people would be found at the residency level. However, Figure 10 shows a similar distribution of age groups for all levels.

- Using the midpoint of the ranges checked, the weighted average age ranged only from 51 at the state maintenance manager level to 47 at the assistant state and district levels, and to 46 at the resident, county, and city levels.
- Among the resident engineers, about 2 percent are 30 or younger, and only 19 percent are in the 31 to 40 category. Most resident engineers (71%) are in the 41 to 60 categories, and they are split in about the same proportion between the two groupings (39 and 32%, respectively).

The sample group is older than expected. To attract these personnel to formal graduate training programs will require special incentives, if it can be done at all to any significant degree. And it will definitely be necessary to design programs targeted toward younger graduate engineers, to include those currently employed in transportation agencies performing maintenance and nonmaintenance functions, as well as new engineers not currently working for the agency.

Work Experience

Most respondents (804) also provided descriptions of their work experience and functional areas (planning, construction, etc.). A surprising number have very broad work backgrounds—careers that include significant levels of work experience in transportation planning, design, and construction, as well as maintenance. Figure 8 shows a position breakdown for managers in different functions. The average maintenance manager working in state transportation agencies and participating in this survey had about 24 years of work experience. Nearly 11 of those years were in maintenance. About 10 years were spent in construction and design (7 and 3 years, respectively). About a year, again on the average, was spent in planning, and 2 years were spent in other transportation functions.

Local government maintenance managers reported about 22 years of work experience on the average. They characteristically have less maintenance experience (about 6 years), more planning (5 years), more design (5 years), and less construction (6 years), than the researchers anticipated.

There are fewer differences in the work experience histories of state maintenance managers by levels than were originally expected. On the average, all have broad-based experience that includes some planning and significant amounts of design and construction. And, again on the average, the years of maintenance experience state managers have was fairly consistent across the board for all, regardless of the level at which they were working. There were, of course, variations; for example,

- One state maintenance manager (of 39) had less than 1 year of total agency experience; 8 had from 1 to 4 years; and 6 had more than 20 years.
- Eight assistant state maintenance managers (of 40) had less than 2 years of total agency experience; 10 had from 2 to 7 years; and 10 had more than 10 years.
- Nearly 12 percent of the district maintenance managers had less than 2 years of total agency experience, and about 45 percent had 10 or more years.
- About 17 percent of the resident maintenance managers

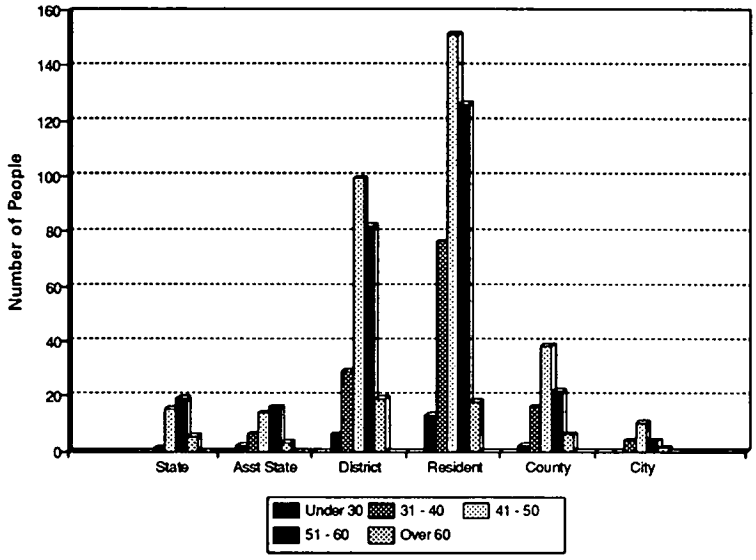

Figure 7. Distribution of Maintenance Managers by Age Group.

had less than 2 years of total agency experience, and about 43 percent had 10 or more years.

Progression

The career paths of maintenance managers can have significant impacts on the design of educational and training programs, and inducement strategies. It has been shown that the average age and experience patterns of people currently in maintenance management positions are such that most are not likely to be interested in advanced degree programs, even with significant incentives. Such managers are experienced, older, and settled into their careers. Thus, the major question remains: Were they young enough when they embarked upon the maintenance path to have a greater likelihood of having any interest in furthering their formal education and earning an advanced degree? Figures presenting this information are shown in Appendix C; actual results are discussed in the following sections. As earlier noted, the questionnaire allowed people to classify their prior experience, by the type of work done, in their first and subsequent position assignments.

State Maintenance Managers

The amount of time state maintenance managers spent in their entry-level positions ranged from a half year to 15 years. Only one person started his or her career in maintenance. Most, 19, started in construction, 10 started in design, 2 started in planning, and 8 started in other areas such as training programs, survey, and traffic. For those starting in construction, their first assignments ranged from 2 to 15 years, and averaged more than 5 years. Assignments for those starting in design ranged from 1 to 8 years, and averaged about 4. And the people in the other categories had initial assignments that ranged from a few months to 8 years, and averaged nearly $3\frac{1}{2}$ years.

Respondents also classified their position assignments as either managerial or technical in nature. Thirty-six classified their initial assignments as technical, two classified them as managerial, and two said they were both. All personnel reported serving in at least three positions before attaining their current status as the state maintenance manager.

More state maintenance managers were becoming involved in maintenance by the time they were in their second positions. Nine then served in maintenance capacities that ranged from about 2 to 31 years, and averaged nearly 8 years (including one person who characterized the assignment as planning, construction, and maintenance). The second-position construction assignment of 16 people who eventually became state maintenance managers ranged from a few months to 15 years, and averaged about 5 years. Second-position design assignments of 10 people (including one who characterized his or her assignment as both design and construction) ranged from a half year to 11. Five people were in traffic and administrative assignments that ranged from 7 to 13 years. Twenty-seven managers characterized their second-level position as technical (including three who classified them as both technical and managerial), and 15 saw their second-level positions as managerial.

Again, more of the state maintenance managers were in maintenance by the time they were in their third-position assignments. Thirteen people (again including 2 who had maintenance, construction, design, and planning responsibilities) reported from 1 to 20 years of experience at this level. The average was nearly 6 years. Eight people were in construction in the third positions, 6 were in design, 6 were in planning, and 7 were in traffic, administration, or materials laboratories. Most, 26, classified their assignments as managerial at this level (including 3 that classified them as both managerial and technical). The people in maintenance at the second- and perhaps the beginning of their third-level positions could be target candidates for a master's degree program, but certainly special incentives would be required, especially for those well into their third-level assignments.

Thirty-six people reported a fourth-level assignment. Again,

more were in maintenance at this point. The 16 participants who were in maintenance reported assignments ranging from 1 to 31 years, and averaging about 6 years. Five people were in construction, 3 were in design, 2 were in planning, and 10 were in other assignments. Most respondents classified their assignments as managerial.

Twenty-seven of the state maintenance managers reported completing a fifth assignment before gaining their current positions. Twelve were in maintenance for about 6 years on the average. Six were in construction, 1 in design, 1 in planning, and 7 had other assignments. Nearly all (22 people) classified their jobs at this level as managerial.

Twenty-two reported completing a sixth-level assignment. Eleven were in maintenance for an average of 6 years. Six were in construction, 1 was in planning, and 4 were in other assignments. Only 2 people classified their assignments at this level as technical.

Twelve completed a seventh position assignment. They included 8 who were then in maintenance, 1 in construction, 1 in planning, and 2 in other assignments. Eleven completed an eighth-level assignment that included 7 in maintenance, 2 in construction, and 2 in other assignments. Five completed a ninth-level assignment. Four were in maintenance and 1 was in administration. Two completed a tenth-level assignment. All had then attained their current position as state maintenance managers.

Clearly the path to the chief maintenance manager's position was often circuitous, and most who attained the position did not embark upon a maintenance path early in their careers. It appears probable that many agencies seek people with broad-based backgrounds for this position, and that advanced degrees are at least a factor in selection decisions.

Assistant State Maintenance Managers

A comparable but somewhat less circuitous career development path was reported by the 42 assistant maintenance managers who participated in the survey. Only one person at this level started his or her career in maintenance. Twenty-one started in construction, 9 in design, 6 in planning, and 5 in other areas. The average of the nonmaintenance assignments ranged from about 2 to 4 years. Most people (36 of 42) viewed their assignments at this level as technical rather than managerial.

Eight people were working in maintenance in their second-level positions. Their assignments ranged from 3 to 12 years and averaged nearly 7 years. The 9 people in construction averaged about 6 years in that assignment, the 10 in design averaged nearly four years, and the 5 in planning averaged more than 7 years. Seven people were in other assignments that averaged about 6 years. Most (25) regarded these assignments as technical rather than managerial. The people in maintenance assignments, at this point, were potential targets for a graduate educational program.

Thirteen assistant state maintenance managers were working in maintenance in their third-level positions. Their assignments ranged from less than one year to 23 years. The average maintenance assignment was about 5 years. Six were then working in construction, 10 were in design, 3 were in planning, and 5 were in other agency assignments. The range in the length of the nonmaintenance assignments was from 1 to 9 years, and averaged nearly 4 years.

Forty of these managers completed a fourth-level assignment, 17 in maintenance. Twenty-five completed a fifth assignment, 13 in maintenance. Fourteen completed a sixth assignment, 10 in maintenance. Eight completed a seventh assignment, 3 in maintenance. Three completed an eighth assignment; all were then in maintenance.

The same pattern seen for state maintenance managers is seen for their assistants. Very few started in maintenance. Those in maintenance at their second-level assignment, and those early in their third assignments, were, with proper incentives, potential candidates for degree programs.

District Maintenance Managers

A comparable career development path for district maintenance managers was reported by the 234 people completing this portion of the questionnaire. However, a greater proportion of them had settled into maintenance careers by the time they were in their third-level assignments. Nearly 14 percent, 32 people, started their careers in maintenance (including 13 who considered their first assignments as composites of maintenance and other functions). The length of maintenance assignments ranged from less than a year to 25 years, and averaged about 4 years. Fifty-six percent (including 28 people with composite assignments) had assignments that included construction, 30 percent (with 28 people with composite assignments) included design, 10 percent (12 people with composite assignments) included planning, and 30 people had initial assignments in other areas such as materials, traffic, structures, surveys, and research. The length of the nonmaintenance assignments ranged from less than a year to 23 years, and averaged about 3 years in both planning and design, and nearly 6 years in construction. Most (83%) characterized their initial assignments as technical rather than managerial. Managers starting their careers in district maintenance were obvious candidates for advanced degree programs.

Eighty-two people, 35 percent of the district maintenance managers (including 10 people who classified their assignments as multifunctional), were in maintenance in their second-level assignments. The duration of these assignments ranged from 1 to 30 years and averaged more than 8 years. As earlier shown, 80 percent of this group have bachelor's degrees, and they can be expected, at this level, to be young enough to have an interest in continuing education, with proper incentives. This is an excellent group to target for an advanced degree, if identified early enough in their careers. About 35 percent of the district maintenance managers were involved in construction, and 24 percent were involved in design (including, in both cases, 18 people whose assignments crossed functional lines). About 10 percent (9 people crossing functional lines) were involved in planning and other assignments. The length of the nonmaintenance assignments ranged from less than a year to 22 years and averaged nearly 5 years. A bit more than half of the respondents regarded their second-level assignments as technical.

More than 200 of the resident maintenance managers reported completing a third-level assignment. About half were then involved in maintenance. The length of the maintenance assignment varied from less than a year to 26 years and averaged nearly 7 years. Most (65%) viewed their third-level assignment as managerial. It is possible that a few of these people could

also be targets for a graduate degree program, if identified early in their third-level assignments.

About 60 percent of the district maintenance managers reported completing a fourth-level assignment, and about half were then in maintenance. The average length of the maintenance assignment at this level was nearly 6 years. Although all personnel at this and subsequent levels were candidates for training and short-course programs, it is doubtful that many, if any, would be candidates for advanced degrees.

Resident Maintenance Managers

Despite relatively high levels of work experience and maturity, resident maintenance managers gained that level in the organization more quickly than the other levels, as might be expected. About 40 percent had attained resident maintenance manager status by the time they were in their second-level position.

Eighty-two people (including 15 whose assignments involved more than maintenance), about 21 percent of the respondents, started their careers in maintenance. The length of these assignments ranged from a couple of months to 35 years, and averaged 8 years. Eleven people started their careers at the resident maintenance manager level. Two hundred, more than half of the group, had assignments that included construction (38 of them had assignments that crossed functional lines). About a quarter, including 34 with multiple assignments, started in design. And 32, half with multiple assignments, were involved in planning. Thirty-seven people had initial assignments in other areas. The nonmaintenance assignments ranged from a few months to 20 years and averaged 5 years. Nearly 85 percent classified their initial assignment as technical.

About 68 percent of the resident maintenance managers were in maintenance by the time they completed their second-level assignments, and 21 percent were then at the resident level. While only 60 percent of resident managers have degrees, a higher proportion of those advancing to this level quickly can be expected to be 4-year graduates. Personnel in maintenance in their first- and second-level assignments can be expected to be advanced degree candidates. Their second-level maintenance experience ranged from less than a year to 27 years, and averaged nearly 9 years. Nearly an equal number of resident maintenance managers were still in construction in their second assignment. Those assignments ranged from less than a year to more than 25 years, and averaged about 5 years. Experience records of the lesser numbers of people involved with design, planning, and other assignments were roughly 3 to 4 years. Technical and managerial classifications were split about 50–50.

About half of the respondents had reached the resident level by the time they completed their third-level assignment. Maintenance experience at this level ranged from less than a year to 25 years, and averaged 5 years. About 20 percent of people holding level three assignments continued to report positions that included some combination of construction, design, planning, and maintenance. About a quarter still had construction involvement, 16 percent had design involvement, and 11 percent had planning involvement. Only a few people were in other assignments. The majority (64%) said their assignment at this level was managerial.

Eighty percent had attained resident maintenance manager status by the time they completed their fourth-level assignment. While many continued to report multifunctional assignments, more than 90 percent were involved in maintenance at this level. And as might be expected, nearly 75 percent viewed these assignments as managerial rather than technical.

Perceptions of Educational and Training Needs

The survey requested respondents to list educational and training needs in two categories: urgent agency needs and urgent personal needs. State maintenance managers named 81 urgent agency needs, and 59 urgent personal needs; their assistants cited 69 agency and 69 personal needs; district maintenance managers identified 431 agency and 352 personal needs; and resident maintenance managers noted 601 agency and 512 personal needs. When grouped, these needs resulted in a listing of 175 educational and training needs ranging from AASHTO guidelines and accounting, to win-win negotiating. The first analysis step was to group and classify related educational and training needs. For example, the computers and computer applications group covered perceived critical needs such as basic computer knowledge, computer applications, computer basics, computer cost programs, computer graphics, computer literacy, and computer proficiency. And financial management covered needs such as budgeting, budget management, and fiscal management.

In the main, the summary titles used for these groupings, as shown in Table 1, are self-descriptive. However, a few require explanation. Maintenance Work Management covers items such as asphalt, asphalt procedures, double chip seals, and patching. Maintenance Operations Management includes identified needs such as priority setting, cost management, and "do more with less." Current topics cover changing technology, new asphalt technology, new equipment, and new techniques. General management includes defined needs such as administration, administrative training, business management, and business skills.

Reported critical education and training needs shown in Table 1 were ranked by the number of respondents identifying the same category of need. The ranking technique used ranged from 1 as the highest priority to 8 as the lowest. Because these needs were perceived as critical, it was felt that the rating system should show all responses, no matter how small the percentage received. Rankings were based on the following criteria:

1) A ranking of 1 was made if more than 17.5 percent of the classified respondents (state manager, assistant, etc.) named the same category of need.
2) A ranking of 2 was used if 15 to 17.5 percent designated the category; and
3) Subsequent categories were based on 2.5 percent intervals, but category 8 was used for all responses less than 2.5 percent, even if mentioned by only one person.

There is some consistency in the educational and training needs cited, and the frequency with which they were noted by the four levels of management. But as the analysis went lower in the organization, more needs were cited with less frequent repetition among respondents.

- The most frequently cited training need by state and district maintenance managers, for both their agencies and themselves, was general management. Resident maintenance managers, most

TABLE 1. Perceived Critical Education and Training Needs

Critical Training Needs	State Maintenance Manager		Assistant State Maintenance Manager		District Maintenance Manager		Resident Maintenance Manager	
	Agency Rankings	Personal Rankings	Agency Rankings	Personal Rankings	Agency Rankings	Personal Rankings	Agency Rankings	Personal Rankings
General Management	1	1	1	1	1	1	2	3
Personnel Management	2	5	3	5	3	3	5	4
Maintenance Work Management	4	4	2	8	1	5	1	4
Current Topics	5	5	5	7	4	5	5	6
Financial Management	5		4	6	5	7	6	7
Computers and Computer Applications	6	4	8	1	8	1	8	2
Agency and Maintenance Orientations	7	7	4	7	3	8	5	8
Management and Accounting Systems	7	8	4	6	4	7	5	8
Maintenance Training	7	8	7		7	8	7	8
Tort Liability and Risk Management	7	8	8		7	8	7	8
Maintenance Operations Management	7	4	8	5	7	7	7	7
Infrastructure Management	7		6		6	8	7	8
Bridge Inspection	8		8		6		7	8
General Engineering	8	7			8	8	8	8
Environmental Protection	8	6		8	8	8	8	8
Research, Studies and Investigations			8		7		8	
Emergency Preparedness					7		8	
Public Relations		5		5	8	5	8	6
Maintenance Contracting					8	8	8	8
Equipment Management		8		7	8	8	8	8
Safety		8			8	8	8	8

Note: "1" is the highest ranking; "8" is the lowest.

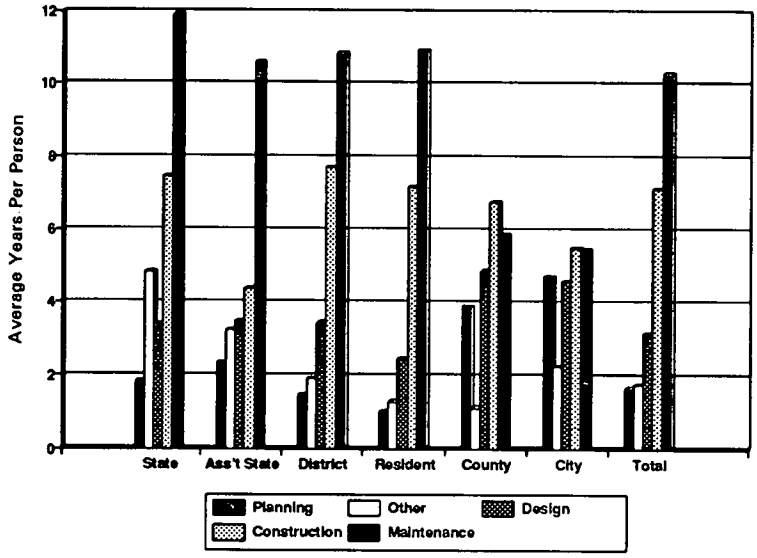

Figure 8. Average Years of Work Experience by Position and Function.

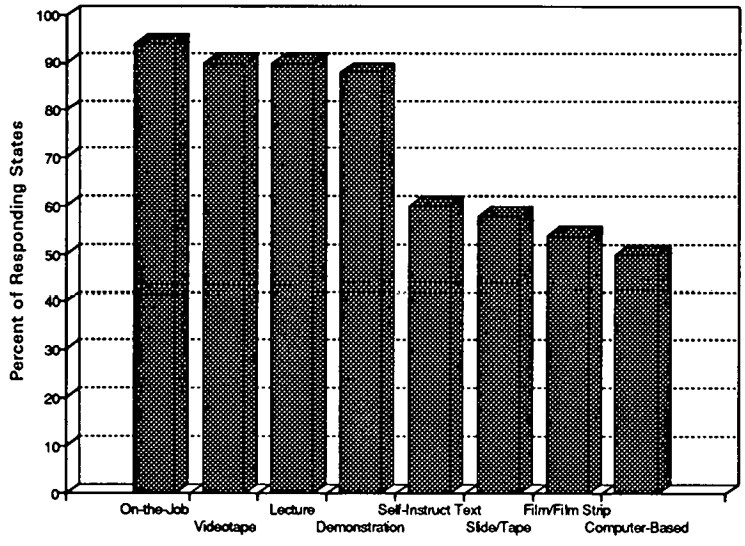

Figure 9. Training Techniques Used.

frequently, suggested maintenance work management for others, with fewer of them feeling the same need for themselves.

- Personnel management was frequently mentioned as an agency need by state managers and their assistants, with fewer of them seeing it as a personal need. The districts saw it as both an agency need and a personal need. The residents also frequently mentioned it as an agency need, but more saw it as a personal need.
- Keeping abreast of current (primarily technical) topics was mentioned as roughly equal needs for both themselves and their agencies by all management levels.
- Interestingly, state maintenance managers frequently mentioned financial management as an agency need. None of the assistants mentioned it as an agency need, but some felt it was a personal need. More district and resident managers referenced it as an agency need rather than a personal need.
- Computers and computer applications was one of the most frequently cited personal needs by assistant state maintenance, district, and resident managers. Few of these people mentioned it as a critical agency need. And more state maintenance engineers cited it as a personal need, rather than an agency need.
- Agency and maintenance orientations were frequently cited as agency needs by the assistants, districts, and residencies. Few saw it as a personal need.
- Maintenance operations, as might be expected, was frequently cited as a personal need at the state and assistant state maintenance manager levels. Few saw it as either an agency or a personal need below these levels.
- Public relations was a frequently cited personal need. A few district and resident managers cited it as an agency need.

TRAINING TECHNIQUES

Responding state agencies reported current usage of a wide variety of training techniques, which are shown in Figure 9.

- 94 percent of maintenance managers at all levels reported using on-the-job training;
- 90 percent are using videotape training courses;
- 90 percent reported using classroom and lecture techniques;
- 88 percent are using on-site demonstrations;
- 60 percent are using written self-instruction texts;
- 58 percent are using slides with synchronized audio tapes;
- 54 percent are using films and filmstrip training programs; and
- 50 percent said they are using computer-based training programs.

TRAINING AND EDUCATION FRAMEWORK

The training and education framework for maintenance managers evolved quite naturally from the elements of this project. From the first survey to states, counties, and municipalities a profile of the education and training background of maintenance managers was obtained. Also, a profile was provided of anticipated training needs for themselves and for the engineers/managers they supervised for each responsibility level. (See discussion in the previous section; detailed results are contained in Appendix C.) The Knowledge and Ability and activity statements are also a source of "What the Manager Needs to Know How to Do"; thus, they are an indication of training required.

To supplement and confirm the results of the first survey and the K&A statements, on-site interviews were conducted in four nearby states: Delaware, Maryland, Pennsylvania, and Virginia.

A third survey was developed (see Appendix E for survey and results) and sent to eight states to determine what training is now available to their maintenance engineer/managers at each level. Also, it was determined how much is provided or taught within the agency and which training is provided by other state agencies (e.g., general management) and by universities or outside consultants.

Training Framework

The interviews and third survey results indicated that all states provide training in the traditional maintenance areas such as road surface. Training, however, is not provided by all states in the less traditional areas such as landscaping or environmental issues. Organizational differences showed up such as

- Materials—handled by other division in Louisiana,
- Bridge—handled by Bridge division in Maryland, and
- Equipment—handled by Equipment division in Arizona.

On the other hand, all states offer some training in computers.

Similarly in management training, all states responded that they offer training in management principles, affirmative action, and employee safety. All except one state indicated training in leadership, supervisor behavior, and other management subjects. On the other hand, less than half offered training in areas such as stress management, communications, labor relations, and recruitment/retention. One-third did not offer training on their maintenance management systems.

Using a review of the K&A statements, the results of the first and third survey (and interviews), and a general knowledge of state maintenance operations, the research team developed a training framework. This framework has been organized along functional lines (for technical training) and by general management areas. It has also been recognized that the depth of technical training needed decreases with the level of management and that the depth (and breadth) of management training needed increases with the level of responsibility. The list of courses in a training program is shown in Figure 10. Appendix A shows more detail on courses.

In summary, there is a reasonable amount of technical training being provided in some states, but not all. Some states have developed management training programs, but such training varies from very little to only general management (e.g., office management and "first-line supervisor" training) to good (but still general) management short courses to specifically developed management courses for maintenance engineers/managers. There is a need, however, to improve training in order to recruit and retain capable young people into maintenance management as a career.

Educational Framework

A draft educational framework was developed from the two surveys, a review of the draft report for NCHRP Project 20-5 (topic 21-06) "Development of Professional Highway Maintenance Engineers" (and an interview with Adrian Clary, a former TRB maintenance engineer), and telephone conversations and face-to-face discussions with faculty (and administrators) from dozens of universities as well as personal knowledge. This draft was reviewed by Dr. D.L. Howell (Management Professor, Emeritus, from the University of Mississippi), and a 1-day interview/workshop was conducted with Dr. Howell, by the research team. A revised educational framework and model M.S. program resulted. These were sent, along with a brief questionnaire, to 55 universities. (See Appendix A for the complete framework and Appendix F for the questionnaires.)

The materials include the following:

1. Model M.S. program in Maintenance Engineering and Management;
2. Potential courses at the B.S. level (senior electives);
3. Potential Graduate Courses—to be included in existing M.S. programs; and
4. The addition of *one* senior elective at the B.S. level.

The letter and questionnaire were sent to the universities with two scenarios. Half received the first scenario and half received the second.

SCENARIO 1. If the importance of Maintenance Engineering and Management has been recognized and strongly endorsed by AASHTO, Federal Highway Administration, ASCE, and other organizations, would you be likely to implement the program?

SCENARIO 2. If a bill has been passed in Congress that will provide training grants for up to 15 schools for funding both faculty members and graduate fellowships in Maintenance Engineering and Management, would you be likely to implement this program?

The 11 universities with APWA-approved programs oriented to "Public Works Engineering and Management" were included in the sample of 55 universities.

Equipment

- Basic Equipment
- Special Equipment
- Equipment Safety
- Operator Certification
- Inspection
- Disposal and Replacement

Traffic Control

- Traffic Control Devices
  - Signals
  - Signs
  - Markings
  - Other TCDs
- Work-Zone Traffic Control
  - Planning and Scheduling
  - Design and Operations
- Geometrics and Traffic Control
- Roadway Illumination
- Roadside Safety Hardware

Materials

- Soils/Aggregates
- Concrete Materials
- Bituminous Materials
- Special Materials
- Hazardous Materials
- Waste Management
  - Hazardous
  - Routine
- Quality Control

Management

- Quality Control/Quality Circles
- Financial Management
- Creative Problem Solving
- Interpersonal Relations for Staff
- Tort Liability/Risk Management
- Schedule Monitoring
- EEO & Labor Compliance/Relations
- Project Documentation
- Statistical Analysis
- Leadership Development
- Managing Resources
- Time Management
- Communications
  - Technical Writing
  - Public Speaking
  - Public/Personnel Relations
- Organization Structure Overview
- Policies and Operations
- Standards and Performance
  - Development
  - Evaluation

Computers

- Hardware
- Software
  - Word Processing
  - Database and Spreadsheets
  - DOS/Others
- Maintenance Management Systems
  - Overall Systems
  - Pavement Management
  - Bridge
  - Equipment
- Engineering/Maintenance Software
  - Drainage
  - Design
  - Bridge
  - Pavement
  - Traffic

Winter Service (Snow and Ice Control)

- Organization and Policy
- Safety/Environmental Concerns
- Snow/Ice Control
  - Snow Plowing
  - Salting
  - Chemicals
- Planning and Scheduling

Pavement/Surface

- Pavement Design & Construction
  - Bituminous Pavements
  - Concrete Pavements
- Seal Coats, Chip & Seal, Slurry Seal, etc.
- Pavement Repair
  - Bituminous
  - Concrete
- Pavement Rehabilitation
- Overlay

Bridge/Reconstruction

- Bridge Inspection
- Preventive Maintenance/Painting
- Structural Repair
- Deck Replacement

Drainage

- Drainage Design Overview
- Drainage Structure Replacement
  - Pipes
  - Manholes
  - Inlets
  - Culverts
- Routine Drainage Facility Maintenance

General

- Routine/Recurring Maintenance
- Roadside Maintenance
- Emergency Maintenance
- Rehabilitation
- Plan Reading
- Environmental Concerns
- Laws and Regulations
- Maintenance Contracting and Administration Safety
  - Worker
  - User
- Value Engineering
- Outdoor Advertising
- Utilities

Figure 10. Training Program for Maintenance Engineers and Managers.

Several universities have the basic institutional framework/ infrastructure to at least partially implement the model M.S. program (or one quite similar and "equivalent"). For example, seven universities indicated they have such a program now: Oregon State University, Purdue University, West Virginia University, The University of Texas, University of Illinois, Marquette University, and The Ohio State University.

At least three or four of these schools have a graduate program with emphasis on pavement management rather than maintenance management. However, they have the momentum to allow rapid development (expansion) of a maintenance management and engineering program.

On the other hand, several universities indicated concern about developing a new program for the following reasons:

- Budget problems and limited capability to initiate new programs,
- Lack of current faculty with both the background and interest required,
- Lack of administrative support to initiate new programs, and
- Uncertainty about demand for the program.

The survey of 55 universities resulted in 34 reviews returned. Twenty-five percent of those who received a form indicating endorsement (by FHWA and AASHTO) stated they would initiate a graduate program. Of those receiving a form indicating faculty and fellowship funding, 37 percent said they would initiate a graduate program.

In general, the university reviews showed agreement with the model M.S. program as well as with the course listings. This interpretation is discussed in more detail in Chapter Three.

CHAPTER 3

INTERPRETATIONS AND APPLICATIONS

INTRODUCTION

Considering the major product of this project, a recommended national framework for "Education and Training of Maintenance Engineers and Managers," this chapter provides an outline and discussion of the various components. The framework is divided into three components: education (university courses), continuing education (nondegree), and training.

EDUCATION

Although a model M.S. program in Maintenance Engineering and Management has been developed, so also have other scenarios for educational enhancement. An underlying premise is that there is a recognition of the importance of and complexity of modern highway maintenance. Following this premise, the educational framework is presented "from the ground up" for a traditional civil engineering curriculum.

Introduce maintenance as an integral part of civil engineering endeavors, that is: Planning/Design/Construction/Operation/Maintenance. This concept should be weaved into the very fabric of civil engineering courses.

Civil Engineering Courses

- **B.S. courses**—Develop and implement one or more courses, probably as senior electives. One course could be "Highway/Transportation Maintenance" or "Infrastructure Maintenance." Other courses may be maintenance or with some maintenance emphasis; for example, a materials course with emphasis on materials used for maintenance operations.
- **Area of concentration at the B.S. level**—This scenario consists of the provision of three or more maintenance courses as senior electives. One could also have a junior level introductory course on maintenance. The idea is that some civil engineering students would choose to concentrate on maintenance as a career choice and would take at least three maintenance courses as an area of concentration within their B.S. program.
- **Area of concentration at the M.S. level**—Three or more courses within an M.S. program would be maintenance or maintenance-oriented courses. For example, "Advanced Pavement Design," "Pavement Management Systems," or "Advanced Materials" are maintenance-related courses. On the other hand, an informal minor in management could be arranged by choosing appropriate courses related to maintenance management. Such courses include "Personnel (or human resources) Management," "Management Principles," and many other existing management courses in Business/Management/Public Affairs schools, which exist at many universities.
- **Development of one or two new courses and reorientation of one or two courses** could result in a reasonable concentration minor in "Maintenance Engineering," which is quite feasible at many schools.
- **M.S. program in maintenance engineering and management**—This program places emphasis on the relationship between maintenance and management in a public arena. Although the courses are divided into technical and management disciplines, the courses complement each other. The model M.S. program is shown in Figure 11. A more detailed description of the courses, as well as outlines (or a syllabus), are included in Appendix A.

Because there are differences in philosophy and approach, we fully expect that graduate programs in maintenance engineering/management will vary among universities (or from state to state). The model program was developed strictly as a guide with the intent that different schools could use it as a starting point to develop their own program. Courses will be slightly different in both content and emphasis and how "core" versus "elective" courses are handled (which courses are core?). For these reasons, the most important thing about the framework is probably the concept itself—establish a graduate program for maintenance engineers/managers.

Full Time Versus Part Time

Traditionally, most university programs have been established around the concept that students in the program would be full time. However, especially in urban areas, many traditional graduate programs have undergone substantial modifications (especially in philosophy) to accommodate the part-time graduate student.

This program is envisioned as one that can fit either mold. If AASHTO and FHWA (or others) were to initiate a fellowship program to send people to school for 1 year with full or partial salary plus tuition, and if young engineering graduates can be enticed to pursue a maintenance career (also supported by fellowships and research assistantships), the full-time scenario is very plausible.

Even if several universities initiate M.S. programs in Maintenance Engineering and Management, most highway/transportation agencies are not currently in a position to send employees (maintenance engineers) away for 12 months, or more, to pursue an M.S. degree program. Perhaps in some urban areas, some universities would implement the new M.S. program, oriented

This program is a combination of Engineering and Management Courses. A 12-month, 33-semester-hour program is proposed to include a 3-semester-hour "capstone" type masters project course in Maintenance Management Systems.

Core Technical Courses:

1. Advanced Materials Selection—Structural components and types of failures; methods and techniques for rehabilitation and maintenance using carbon and alloy steels, polymers, fibers, particulate and foamed composites, timber, concrete, and other materials.

2. Pavement Management Systems—Maintenance issues analyzed in a management framework.

3. Maintenance Alternatives and Strategies: Design and Planning—Agency policy and philosophy, planning and operations.

4. Facilities Rehabilitation and Maintenance—An overview of critical issues in rehabilitation and maintenance with emphasis on administration and management, safety, pavement and bridge evaluation, maintenance and rehabilitation.

Elective Technical Courses:

5. Advanced Pavement Design—The components, technical aspects, performance evaluation, and rehabilitation of pavement systems.

6. Decision Theory and Statistics I—Development of information collection, data interpretation and models used for the decision-making process.

7. Decision Theory and Statistics II—Application of statistical concepts to solution of complex engineering problems; laboratory use of computer packages.

8. Value Engineering—Analyze factors influencing reliability and implement quality control measures. Management of reliability and quality control.

Core Management Courses:

1. Management Principles I—An examination of research and theory concerning the forces which contribute to the behavior of organization members. Principally, leadership and implementation of the management are addressed.

2. Human Resources Management—The human resource function in organization. Human resource planning, procurement and selection, training and development, performance appraisal, wage and salary administration, and equal employment opportunity.

3. Management Principles II—The influence of the behavioral sciences on the theory and practice of management. Motivation, leadership, and international styles of management; quality control, quality circles, negotiating.

4. Management Accounting and Budgeting—This class will approach the material from the point of view of a public agency department program. Much emphasis will be given to the budget cycle and fund accounting.

Elective Management Courses:

5. Management Strategies in Public Organizations—The day-to-day problems faced by public sector managers, including setting goals, obtaining and protecting a mandate for a new program, designing a service delivery system, implementing a new program, supervising, and marketing.

6. Management Information Systems—Introduction to practical techniques for information systems design. Design requirements for information processing systems. Models and tools for requirement analysis.

7. Operations Research—Concepts and applications of linear programming models, theoretical development of the simplex algorithm, and primal-dual problems and theory.

Maintenance Management Systems—A Capstone M.S. Final Project using a real world situation.

Recommended Refreshers:

1. Communication and Public Relations
2. Group Psychology
3. English
4. Microcomputers

Figure 11. Model M.S. Program.

to part-time students, either evening courses or convenient (late afternoon) day courses, possibly offered through closed circuit TV.

CONTINUING EDUCATION

There is that group of maintenance engineers who are not eligible for admission to an M.S. program because of poor undergraduate grades, or because they have no bachelor's degree. Thus, there is a need for training and continuing education. Some of the courses listed for the educational framework could be presented either in whole or in part as a "short course" or continuing education (nondegree) course. On the other hand, the course can be divided into modules and given as a series of 1-day courses or seminars. Some subjects may be suitable to "home study" or correspondence courses. Thus, continuing education includes regular university courses taken on a nondegree basis as well as semester-long courses (noncredit) provided to an agency. For example, some state agencies have developed programs that provide such training for engineering technicians in construction, design, hydrology, and maintenance—with the training available either during the workday, partially during the day (e.g., 3:30–6:30 p.m. with the workday ending at 5:00 p.m.), or completely in the evening (e.g., 6:00–9:00 p.m.).

The private sector (and others) offer continuing education management courses such as evening or multiday courses. Some agencies are currently sending selected employees to these management courses and paying the tuition. In other states, such management continuing education is under a statewide agency for all state agencies (including transportation). In those cases, additional attention is needed to assure that maintenance engineers receive this education.

TRAINING

Training in a broad sense includes education. Taken in a somewhat narrower sense in this project, the researchers define training to be short courses (1 day to 1 week—with a few exceptions of more than a week); seminars and workshops ($\frac{1}{2}$ day or less normally); conferences; academies and less formal training such as reviewing videos, computer- or video-programmed learning; and on-the-job training.

Training modules were developed from the two surveys discussed earlier, from knowledge of state and local agency training (including Technology Transfer [T^2] programs), and from materials supplied by several states. Figure 12 shows the modules in 10 major areas from equipment to a general area, which is used to list training that *is* important but does not fit neatly into the other nine areas. These modules can be packaged as shown in Figure 12 or in other ways to best fit the needs and desires of the particular agency. Module descriptions are shown in Appendix A.

Training Philosophy

There are over 1,000 highway maintenance managers at the state level, from the resident maintenance manager upward, and many times that number at the local level. All are potential candidates for short course training of one type or another. Using the perceived critical training and educational needs identified by maintenance managers at all levels, and descriptions of ongoing training efforts, an outline of 17 short courses was prepared and ranked according to priority. Although these are referred to as courses, they are in many cases academies or conferences. The proposed basic content of these courses was guided by the activity statements, knowledge and ability statements, and descriptions of current programs. Some of the latter are courses currently conducted within agencies, and through cooperative programs involving organizations such as AASHTO, HUFSAM, and the FHWA. However, need evaluations indicate that current efforts are not fulfilling critical needs. The reasons vary from one agency to the next.

- Budget constraints are always a factor. The first program fatality as funding becomes tight is typically training, despite the realization that doing more with less will require improvements and systemic changes in day-to-day operations—changes that are not likely to occur without widespread understanding of why they are needed or how they are to be realized.
- Top-level attitudes and public perceptions toward maintenance itself (nondemanding, routine, and repetitive work) are likely factors. Who needs to travel out of state for a week, or even travel 20 miles, to learn how to fill a pothole?
- It is admittedly difficult to quantify the benefits of training and educational investments. The easier path is to apply the resources to road building or expansion—especially when needed to relieve congestion, which is so apparent to everyone. Even though one is a small percentage of the other, construction is less likely to become an issue.
- The basic design of training programs can also be an inhibiting factor. A common approach is to train a trainer at a central point. That person is then frequently expected to return to his or her agency to replicate the training. Usually such programs are technical. And often the people with the technical capabilities needed to master the course have limited training skills. The result may be no training replication at all, or training with limited benefits.
- The frequency with which programs are conducted may be another factor. There is a tendency to provide a program, or to send people to central programs, and then assume the training need has been fulfilled without regard for new maintenance personnel entering the management structure, or the need most of us have to periodically refresh and update.
- Much of the needed training is simply not available to those who need it. The fact that one state has a broad-based maintenance training program does little for a neighboring state without one.
- Training development cost is probably another major factor. Every agency has its own way of doing things—policies, standards, equipment, materials, weather, terrain, and so on. And every agency wants its own practices to be reflected in the training materials. With traditional training techniques, that typically meant individual developments, or at least tailoring, for each agency undertaking a training program. Emerging technology, as discussed later, may eliminate or at least reduce the need for such repetitive developments.

Training Techniques

There is a tendency to categorize training techniques, and to conclude that classroom instruction, for example, involves only

I. Equipment

- Basic Equipment
- Special Equipment
- Equipment Safety
- Operator Certification
- Inspection
- Disposal and Replacement

II. Traffic Control

- Traffic Control Devices
  - Signals
  - Signs
  - Markings
  - Other TCDs
- Work-Zone Traffic Control
  - Planning and Scheduling
  - Design and Operations
- Geometrics and Traffic Control
- Roadway Illumination
- Roadside Safety Hardware

III. Materials

- Soils/Aggregates
- Concrete Materials
- Bituminous Materials
- Special Materials
- Hazardous Materials
- Waste Management
  - Hazardous
  - Routine
- Quality Control

IV. Management

- Quality Control/Quality Circles
- Financial Management
- Creative Problem Solving
- Interpersonal Relations
- Programming and Scheduling
- EEO & Labor Compliance/Relations
- Project Documentation
- Statistical Analysis
- Leadership Development
- Managing Resources
- Time Management
- Communications
  - Technical Writing
  - Public Speaking
  - Public/Personnel Relations
- Organizational Structure
- Policies and Operations
- Standards and Performance
  - Development
  - Evaluation

V. Computers

- Hardware
- Software
  - Word Processing
  - Database and Spreadsheets
  - DOS/Others
- Maintenance Management Systems
  - Overall Systems
  - Pavement Management
  - Bridge
  - Equipment
- Engineering/Maintenance Software
  - Drainage
  - Design
  - Bridge
  - Pavement
  - Traffic

VI. Winter Service (Snow and Ice Control)

- Organization and Policy
- Safety/Environmental Concerns
- Snow and Ice Control
  - Snow Plowing
  - Salting
  - Chemicals
- Planning and Scheduling

VII. Pavement/Surface

- Pavement Design & Construction
  - Bituminous Pavements
  - Concrete Pavements
- Seal Coats
- Pavement Repair
  - Bituminous
  - Concrete
- Pavement Rehabilitation
- Pavement Overlays

VIII. Bridge/Reconstruction

- Bridge Inspection
- Preventive Maintenance/Painting
- Structural Repair
- Deck Replacement
- Routine Bridge Maintenance

IX. Drainage

- Drainage Design Overview
- Drainage Structure Replacement
  - Pipes
  - Manholes
  - Inlets
  - Culverts
- Routine Drainage Facility Maintenance

X. General

- Routine/Recurring Maintenance
- Roadside Maintenance
- Emergency Maintenance
- Rehabilitation
- Plan Reading
- Environmental Concerns
- Laws and Regulations
- Maintenance Contracting and Administration Safety
  - Worker
  - User
- Value Engineering
- Outdoor Advertising
- Utilities
- Tort Liability and Risk Management

Figure 12. Recommended Training Modules.

lectures, or that maintenance-work methods training is only done using audiovisual techniques (e.g., videotape, slide-tape). While it is possible to make generalizations about techniques that should be used in conducting short courses, what is critically needed is an all-resource approach that capitalizes on what is known about training, and on the resources at hand.

On-the-Job Training

On-the-job training can be one of the more effective techniques, if done correctly. It frequently is not.

- Subject matter control is a major problem with on-the-job training. Did trainees learn everything they should have, and did they learn it correctly? Or was the training simply the passing of traditional practices, handed down from one maintenance supervisor to another, that may or may not be in compliance with current agency practices and requirements, or even good engineering practices? This area is particularly difficult for maintenance managers, who daily make myriad corrective decisions without the benefits of explorations, tests, or designed solutions.
- Did any training occur at all? There is growing pressure to be more effective and efficient at all levels. On-the-job training can provide a major future benefit, but not on the days in which the training is done. If properly done it is likely that some operations will be slowed, and some may be stopped, while explanations are given as to cause, the effect of not correcting, and the rationale for the selected corrective action. Priority may shift to getting the job done, with expectations that training will be done later, when there is more time to do it.
- Good maintenance managers are not necessarily good trainers. Many know what needs to be done, and how to do it, but have great difficulty trying to explain all the factors they weigh in setting priorities; organizing work crews and equipment; and ensuring that the work gets done as planned, budgeted, and scheduled. For instance, a long-experienced maintenance manager without a degree may have difficulty tutoring a young graduate engineer.
- Finally, no matter how viewed, two people are doing one job whenever on-the-job training is used.

The major on-the-job training advantage is that learning is taking place at the regular work place, under normal working conditions, with all the variables of traffic, weather, absent workmen, and equipment breakdowns that have been, at least until now, difficult to emulate in central training programs. Still, despite technological developments, training will not be complete, no matter how it is done, until the activities covered by the training are correctly and successfully applied at the regular work place.

Audiovisual Training

Audiovisual training, especially videotape, has gained widespread acceptance in transportation agencies; 90 percent of the survey participants use this type of training. It has major advantages and some drawbacks.

- Most Americans are television watchers. Videotape is a medium they are accustomed to and like.
- Subject matter can be, and usually is, tightly controlled. Typically, agencies appoint panels of experts to review and approve course content prior to production of any training materials. Full coverage of the subject at hand is assured, and each trainee gets exactly the same message.
- Training courses can be developed or tailored specifically to the needs of each agency—their own equipment, people, terrain, work practices and quality-control criteria can be specifically addressed in each course.
- Videotape effectively demonstrates field conditions. It tells and shows people how specific tasks should be performed and displays the expected result.
- Videotape proceeds at the speed the course designer selects. The speed, however, may be too slow for some trainees and too fast for others.
- Videotape sessions are best conducted by trainers. Without them, an important part of training, opportunities for participation, is lost. The role of the trainer is to repeat sections that may cause questions, and lead sufficient discussion to ensure that most trainees comprehend the materials presented. Under ideal circumstances, trainers would then lead trainees in actual field applications to reinforce the training through doing and to ensure an acceptable level of understanding by all.
- Videotape playback units, and the tapes themselves, are sufficiently inexpensive to allow agencies to decentralize training programs and thereby reduce the costs of bringing people to central locations. Of equal importance, the training is available near the regular work place, for use whenever it is needed. Rather widespread training of trainers, among regular maintenance supervisors, is required for full program effectiveness.

While audiovisual techniques are often used for maintenance work methods, and for equipment operation and maintenance training courses, they have also been used in management courses for such subjects as time management, delegation, and total quality control. Typically, these courses are included as a part of a management training program and would use highly trained instructors rather than maintenance supervisors.

Written Programmed Instruction

Written programmed instruction was a very popular training technique in the 1960s and 1970s. And it is still used in paperwork-oriented tasks—contract plan reading, mathematics, PERT and CPM, and so on. The basic idea is that people are given new information in relatively small increments and immediately quizzed to determine their understanding. Active participation and immediate reinforcement are the objectives. The theory is good, but the practical application is difficult. Making the answer readily available after the trainee responds, but not before, led to upside-down printing at the bottom of the page, color-shielded printing that becomes legible with special film, and answers that appear when colored with special pens. The latter is the least frustrating for trainees, but the most expensive. The text can only be used once.

The concepts developed with programmed instruction are important. They are reflected in current interactive programs—but without the paper and printing restrictions.

Lectures and Conferences

Lectures, seminars, workshops, and conferences can be, and are, important training techniques for maintenance managers—especially when principles rather than accepted practices are involved. Effective classroom instruction, depending on the subject matter at hand, will often include the usage of a broad array of techniques—films, videotape, slides, charts, graphs, transparency projectors, etc.

Computer Instruction

A few years ago, broad-based computer utilization, for technical training, was foreseen by a only few, high-tech researchers. More than half of the maintenance managers participating in the survey for this project reported current usage of computers in training, in one fashion or another—a trend that will undoubtedly continue at an accelerated pace.

Trainers have devoted a great deal of attention to designing programs that enable participation, thereby greatly increasing what trainees learn and retain. Current *interactive computer and compact disc training* programs *require* participation. A passive trainee will not progress much, if at all. Moreover, systems exist that record the number of errors made, the length of time responses require, and the accuracy with which trainees identify problems and correct solutions. An individual course completion profile can be maintained for each course taken, and a complete training record can be established and maintained by individual, by organizational unit, and for the total agency. Such record systems can obviously be used to evaluate the effectiveness of the courses themselves, the progress of individuals, the identification of current training needs, and the prioritization of future programs.

Trainers constantly strive for positive reinforcement. Participation by trainees is one way to get it. But in the classroom it also introduces a risk for embarrassment when trainees provide incorrect responses, some of which may invoke group reactions that are anything but positive. Interactive training can become a powerful training tool for maintenance personnel.

- This technique has the capability to provide a comfortable, personal atmosphere that is totally free of negative comments or the risk of embarrassment, even if unusual or even dumb answers are given. It can help stimulate people to be more creative in their approaches to problem solving. It can provide indications of expected outcomes of specified courses of action (stop all but emergency patching, minimize mowing to sight distance needs, stop spot sealing, maximize full-width sealing); all without the risk of negative group response, or the wrath of an unhappy supervisor.
- While PCs are now commonly used, and there is less concern about those who "freeze" at the keyboard, techniques can be provided to minimize fears, and even to eliminate keyboards. Touch screens, joysticks, mice, and even audio recognition can be used to minimize typing, ease the process of entering information, and minimize fears of doing something that might damage hardware or software.
- The difficulty in structuring training to individual needs has been a matter of great concern in all types of training developments. To be effective, trainees must relate to the materials at hand. One technique has been to design the training for managers by the organizational levels at which they work. That has helped but major differences remain from state to state and region to region in the problems faced, resources available, and the solutions applied. Interactive techniques have the potential to truly personalize the training to individual needs. Trainees could be given opportunities to input the information the course will use—equipment types and numbers (gradalls, snoopers), road and condition inventories, traffic volumes and peak hours, staff availability, weather conditions (Florida, North Dakota), materials availability (cold mix, plant mix), and perhaps even the identification of special problem areas.
- Interactive systems can be designed to provide modeling as well as training. After inputting the road inventory, it is conceivable that trainees could try different mowing and snow plowing patterns and priorities to identify the amount of deadheading that alternate patterns produce.
- It is also conceivable that routines could be incorporated into maintenance training programs to enable managers to evaluate the benefits and costs of alternate work programs on individual road sections, or even road networks (elements of programs such as the World Bank's Highway Design and Maintenance analyses). Again through modeling, managers could try different patterns of patching, sealing, overlaying and the like in efforts to maximize maintenance benefits within the actual resources currently at hand in the real working situation. Such modeling could assist the manager in decisionmaking as well as learning.
- A program of this type could be used by individuals alone or in group training sessions. In the group situation, trainees could experiment with the computer to develop feasible solutions to actual problems. They could then prepare presentations for the group and defend them, much as they may have to do with higher-level managers during budget development cycles and performance reviews.
- Development costs will be significant, but not when prorated over the large numbers of people that could be trained using the same or nearly the same basic format. And it will be possible to develop the needed programs in a modular format. The basic training module could be developed first, and later embellished with more sophisticated modules, such as those used in benefit-cost modeling.

This does not imply that computers will replace classrooms, audiovisual techniques, programmed instruction, transparency projectors, instructors, or any of the other training techniques. It is more likely that computer training will incorporate these techniques and help make them more effective and less costly.

However framed, effective maintenance management training will use an all available resource approach, and will simulate or duplicate actual working conditions, insofar as that can reasonably be done. It will be done best with the computer. But it could also be done in a properly designed written case study approach that is designed specifically for highway maintenance training. In developing a solution to a case study problem of this type, trainees would use their own systems and resources to identify possible alternatives, and to develop recommended courses of action within the framework of a generic maintenance management problem. After completing the recommended course of action, the trainee could prepare a presentation and defend it to a group of trainees. This approach could provide attractive supplements to, or perhaps even temporary replace-

ments for, computer-interactive programs. While the traditional business school case study may be of value for general management training, few are currently available that deal specifically with transportation or highway maintenance. When developed, case studies such as these should not be based on the imagination of trainers. They should be based on the real-world examples that are readily available.

The potential array of training techniques that may be effective is broad. Trainee groups—with experienced maintenance, materials, and equipment managers as discussion leaders—can substitute for expert systems. Maps of the trainee's own work area with inventories of resources actually available can be used to establish and justify snow plowing routes, to prepare periodic surface maintenance programs, and to prepare emergency response plans. The pitfall of this approach is the level of expertise discussion leaders will need to have, and the number of disciplines that need to be covered. That is another major advantage of the interactive approach: the experts can be brought together for program design, with the training itself being conducted by people with lesser levels of expertise.

Interactive training is not a dream for the 21st century; it is here, now. AASHTO, with the sponsorship of 13 states and the FHWA, started the development of an interactive training program in mid-1992. The program is called CATT (computer-assisted transportation training). Initial developments are based on the compact disc interactive (CD-I) platform. The first two training courses under development are initial modules of traffic control through construction work areas, and snow and ice control. There are also significant developments outside transportation with maintenance management implications. They range from SHRP "expert systems" to games. The latter are intriguing.

> With price tags of around $50 each, these programs allow users to conduct sophisticated simulations on personal computers that might have required a supercomputer just a few years ago. The programs have been made possible by breakthroughs in computer programming, more powerful PCs, and the increasing demand for games.
>
> Yes, games—that's how the simulations are marketed, even though they usually deal with a myriad of serious concepts and are beginning to carve out a niche in the educational markets. . . . Maxis is one of the leaders in the new genre of computer games, which is less than five years old. Its first "software toy," SimCity—which lets the user create and run a city, from deciding on zoning and taxes to dealing with problems like crime and pollution—is one of the best-selling computer games of all time. . . . Although they say they did not intend their simulation software to be used in educational settings, both Maxis and Microprose have gained a devoted following among teachers and college professors who use the games as teaching aids.[2,3]

PROPOSED SHORT-COURSE STRUCTURE

The recommended listing of training courses is shown in Figure 13. The basic elements, design, and development status are discussed in the sections that follow. Some of these "courses" are, in reality, academies or conferences. Modules from Figure 12 may be included in these courses.

[2] *The Washington Post*, August 30, 1992.

[3] Note: The Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers names appear herein solely because they are considered essential to the object of this report.

Basic Management

The Highway and Transportation Management Course currently sponsored by AASHTO and HUFSAM is the model program to fulfill basic management training needs. While the contents of the program are constantly updated, the program typically includes sessions covering elements such as

- discussions by industry leaders—current transportation problems, opportunities, trends, and legislative developments;
- roles of transportation managers in the present and the future—changing environments, the management process, principles and techniques, characteristics of effective management, problems, excellence, and quality management;
- motivational theory and practices—emerging concepts, changing value systems, quality-of-life concepts, and quality circles;
- personnel management—personnel classification and salary plans, changing work force mix, emerging criteria, and mandated practices;
- communications—barriers, styles, negotiation, and conflict resolution;
- establishing effective work environments—positive and negative factors, unions, time management, delegation, organization politics, harassment, leadership, superior and subordinate relationships; and
- personal management—stress and burnout.

Advanced Management (Academy)

The 3-week Transportation Management Institute course, sponsored by AASHTO and currently conducted by the University of Indiana, is the model for the advanced management course. The program is designed to cover management concepts from basic fundamentals to advanced current concepts as those fundamentals and concepts apply in the public sector, and to transportation agencies of government. The course is designed and conducted at a graduate level of instruction, and targets senior managers and executives. Major topic areas are functional management, communications, human relations, effective self-management, and management in the transportation setting.

Basic Maintenance Management (Academy)

The basic maintenance management course should target trainees from first-level supervisors up through resident maintenance managers, district maintenance managers, and perhaps assistant state maintenance managers with limited field experience. While there certainly are shared generic needs among maintenance managers at these levels—the basics of planning, budgeting, scheduling, and controlling—the training will be most effective if tailored to the individual systems, procedures, working conditions, work loads, resources, and policies of individual agencies. As earlier noted, such tailoring may be built into the training through well-designed computer or disc interactive systems, or by the careful design of case studies. Minimum elements of the program should include the basic elements of field maintenance management, and the agency's management systems and practices that have field maintenance impacts:

Short Course Title	Recommended Priority	Basic Training Technique	Estimated Time Requirement
Basic Management	1	Seminar	1 Week
Advanced Management	1	Seminar	3 Weeks
Basic Maintenance Management	1	Workshop	1 Week
Emerging Maintenance Management	1	Seminar	1- to 3-Day Sessions
Basic Maintenance Work Management	1	Workshop	Series of Two 3-Day Sessions
Advanced Maintenance Work Management	1	Workshop	1 Week
Basic Computer Usage	1	Workshop	3 Days
Computer Usage in Maintenance	1	Workshop	3 Days
Equipment Usage for Maintenance	2	Workshop	2 Days
Equipment Management for Maintenance	2	Workshop	3 Days
Maintenance and the Environment	2	Workshop	2 Days
Maintenance and Tort Liability	3	Seminar	2 Days
Emergency Preparedness	3	Seminar	1 Day
Basic Bridge Management	3	Workshop	3 Days
Advanced Bridge Management	3	Seminar	1 Week
Training	3	Workshop	2 Days
Current Maintenance Topics	3	Workshop	1 Day

Figure 13. Recommended Short Courses.

- field inventory data collection and recording techniques for all systems the maintenance manager will be responsible for, or expected to assist—roads and bridges, rights of way, pavement management, congestion management, traffic control devices, etc.;
- facilities condition ratings used, how they are made and updated, their impacts on maintenance managers, and their work performance expectations;
- work-programming alternatives and their potential short- and long-term impacts;
- development of work programs and budgets, and how they are adjusted by facility and field conditions;
- the program and budget review and approval processes, and how adjustments are made in response to them;
- maintenance contracting pluses, minuses, and policies, as well as their impacts on, and interrelationships with, budgeting and programming;
- cyclical impacts on staffing and equipment demands;
- staffing and workload leveling within budgetary limits and staffing policies;
- definition of the levels of latitude managers have with programs and budgets, as well as the change and approval processes, when approvals are required;
- day-to-day maintenance work scheduling, including the need for alternate work schedules when planned work cannot be done because of the weather, absences, or equipment breakdowns;
- theories and practices of effective control—productivity values and their usage, unit cost computations and usage, costs and effectiveness of alternate staffing and equipping strategies;
- the importance of communications and how effective communications are realized;
- work-reporting requirements, procedures, and how the information reported is used; and
- generalities of other agency systems that can have field maintenance significance—pavement and bridge management systems, present serviceability ratings, and so forth.

Emerging Maintenance Management (Academy)

The emerging maintenance management course should target district and state maintenance managers. It should be a seminar conducted by maintenance and other experts, and should center on new requirements, as well as emerging and innovative concepts with maintenance significance. The seminar should be conducted on a national basis, twice annually at central regional points. It should range from 1 to 3 days depending on the scope of the subject matter at hand. Examples of the types of materials to be presented include the following:

- SHRP pavement findings and conclusions, and the new pavements that maintenance managers can expect to encounter in the near future;
- new and alternative maintenance techniques these pavements may require, as well as the technical specifications for the materials to be used and problems that can be anticipated;
- total quality management concepts as they relate to maintenance work, including improved materials testing and process controls;

- emerging requirements and concepts for improved maintenance management — management systems, data collection techniques, information processing, communication systems, positioning systems, geographical information systems, integration of management systems and information interchange, etc.;
- promising developments in field maintenance equipment and materials;
- maintenance contracting limitations, advantages, and pitfalls; and
- interrelationships of planning, preconstruction, construction, and maintenance systems of significance to maintenance managers.

Basic Maintenance Work Management

The basic maintenance work management course should target first- and second-level maintenance managers. It should cover the basics of how routine and periodic maintenance work activities should be done in the field. The minimum elements of the training course should include the following:

- work steps taken, their sequences, seasonal limitations, and final product quality controls in completing all significant maintenance activities from pavements and structures to drainage, rights of way, traffic control facilities, and motorist facilities;
- equipment typically used, equipment type alternatives, typical equipping patterns used and how they may be varied with haul distance, field conditions, and traffic patterns, as well as the costs and benefits of basic options;
- materials typically used, quality controls, mixing and placement requirements, and hazards;
- work place safety for both maintenance crews and the traveling public;
- human relations, communications, and motivation from the supervisor's perspective;
- personnel policies and procedures, and field applications;
- basic techniques used in routing and scheduling snow plowing and mowing equipment over established routes, problems encountered, solutions, and end-result expectations in terms of both costs and services to the public;
- the supervisor's role in administering maintenance contracts; and
- basic techniques used in preparing and making presentations to supervisors and subordinates.

Advanced Maintenance Work Management

The advanced maintenance work management course should target resident and district maintenance managers. Minimum course elements should include the following:

- decision-making theories, strategies, systems, and models as they apply to field maintenance;
- benefit-cost analyses of alternate maintenance interventions, and how results can shift if all factors, including user costs, are considered;
- techniques, systems, and strategies used in establishing and refining snow plow and mower routing, and locating field maintenance units, materials stockpiles, salt storage, etc.;
- maintenance work program and budget developments, and how they are affected by the condition of facilities;
- the significance of reported information, identification of actual and potential problems, the need for timely intervention, and the need for and characteristics of effective control;
- the basics of pavement management and related systems that produce information of value to the maintenance manager in making resource allocation and intervention decisions;
- the basics of the agency's financial and accounting systems, output information of value to the maintenance manager, interpretation of the information, and interrelationships among maintenance and financial information;
- basic organizational and policy structure of the agency, goals, objectives, and the possibilities for maintenance to enhance or detract from attainment of goals and objectives;
- interrelationships among agency planning, materials, construction and maintenance functions, and the basic characteristics of the major systems used by each;
- human resources management, and personnel management criteria and guidelines; and
- techniques used in preparing and making effective presentations.

Basic Computer Usage

Few transportation professionals are computer "illiterate" in comparison to the status of just a few years ago. Nonetheless, provision must be made for those who have little or no experience with microcomputers and standard applications.

New reference materials need not be developed for this workshop; manufacturers' and developers' documentation for both hardware and software can—and should—be issued to all trainees, because they will rely on commercial documentation after the training. Coverage should include the following:

- basic components—microprocessor and RAM for data manipulation, diskettes and hard disks for data and program storage, screen and keyboard for user control of other components;
- diskettes—characteristics, types, formatting, duplication, and manipulation of files (copying, renaming, deleting);
- operating systems (tailored to the user's specific requirements)—MS-DOS, Unix, OS/2, Microsoft Windows environment, and System 7;
- typical applications—word processors, spreadsheets, databases, graphics applications, project managers, and personal information managers (specifics depend on the applications and operating systems available to the user);
- data backup procedures; and
- basic network features—client/server principles, file sharing, and electronic mail.

Computer Usage In Maintenance

This course will target all maintenance supervisors who do not have a basic understanding of how and why computers are used within their agency. Personnel taking this course should already have a basic understanding of personal computer use. Minimum elements of this course should include the following:

- a basic orientation to the agency's data processing and communication equipment, systems, and techniques, as well as upgrading changes that can be expected;
- agency policies and procedures for the use of personal computers and software, and access to and restrictions on software and computer use, as well as major systems information inputs and retrievals;
- the use of spreadsheets, word processors, data collectors, and other related equipment as they are practically used in maintenance;
- the use of equipment and systems as needed for work they perform—inventories, condition ratings, programming and budgeting, scheduling, performance reporting, and standards and guidelines updating;
- a brief orientation to emerging systems and their potential impacts upon maintenance — voice recognition, GPS, GIS, etc.; and
- hands-on practice in making all computer inputs they will be expected to do, or show others how to do.

Equipment Use for Maintenance

Maintenance supervisors use a variety of equipment types and combinations. Patching potholes, for example, can be completed with traditional hydraulic jackhammers and tampers, or with more complex and more costly self-contained pothole patchers. Each approach to matching equipment and work activities has advantages and drawbacks. This course would be aimed at providing the objective information that managers need to decide on equipment complements. The following are examples:

- Dump trucks: 6-wheel versus 10-wheel—functional variations and operating characteristics, dump body capacities, suitable/unsuitable applications, and purchase and maintenance/repair costs.
- Track loaders versus wheel loaders.
- Manual versus mechanized pothole patching and crack sealing.
- Gradalls versus motorgraders and loaders in drainage—typical applications, expected productivity, and cost per unit of work.
- Articulated versus rigid-frame motorgraders in ditching.
- Mowers—flail and rotary, and batwing attachments.
- Mechanical versus chemical vegetation control — initial and recurring costs, and environmental concerns.
- Pneumatic versus steel-wheeled rollers—applications.
- Snow and ice—reversible plows, V-plows, wings, and blowers; insert and tailgate spreaders.
- Emerging types of equipment they may expect to see in the foreseeable future through SHRP and other developments—patching machines, improved snow plows.

Equipment Management for Maintenance

In the United States, maintenance managers are by definition equipment managers as well. Naturally, the fleet make-up varies widely from one agency to the next, but there is one constant: Equipment purchases, maintenance, and repair constitute a major budget item and therefore warrant training. Primary topics include the following:

- Overview of management systems and objectives—control systems, servicing and repair management, parts management, cost systems, funding practices, and procurement and disposal;
- Control systems—unit numbering/identification, inventory controls, and utilization records;
- Servicing and repair management — preventive maintenance, and workshop scheduling and control;
- Parts management—objectives, storage facilities, procurement and supply, inventory control, stock level control, and shop tools and equipment;
- Cost systems—cost elements, cost data compilation, and equipment "rental" rates;
- Funding practices—funding concepts and actions;
- Planning, procurement, and disposal—equipment complement planning, procurement methods, and replacement planning;
- Operational and shop safety; and
- Hazardous materials handling, control, and disposal.

Maintenance and the Environment

The environmental challenges for maintenance managers are many, and will probably grow in the future. The minimum elements of this training course should include discussions of environmental laws, rules and regulations as they apply to maintenance work, the reasons they have been adopted, and the specific actions managers will take to comply. Examples include the following:

- salt storage, usage, and spreading techniques and limitations;
- materials procurement, container management, and disposal of asphalt, paint, etc.;
- materials removal management, control and disposal of lead-based paints, asphalts, oil, grease, etc.;
- fuel and lubricants storage, management, and control tank testing, leaking countermeasures, new construction requirements, removal and disposal;
- inspection and reporting requirements and procedures;
- waterways and wetland protection;
- responsibilities and authorities of the agency as well as those of other governmental units; and
- noncompliance responsibilities and penalties.

Maintenance and Tort Liability

The following minimum elements of the maintenance and tort liability course should be included:

- definition of the legal terms, processes, and basic authorities and responsibilities of agencies of government, the agency itself, and key officials;
- potential individual responsibilities and liabilities;
- degrees of immunity afforded to the agency and personnel attending the course;

- laws and rulings associated with negligence, discretionary power and its abuse, public nuisances, etc.;
- problem areas where maintenance managers have elevated levels of risk—traffic control through work areas, snow and ice control, noise, roadway defects, material hauling, etc.;
- agency policies and practices that minimize or contribute to risk—adequate record keeping, condition inspections, repair and intervention response requirements, operational certifications, etc.;
- risk management as established by the agency and incorporated into budgeting, programming, and work performance; and
- reporting requirements and procedures.

Emergency Preparedness

Minimum elements of the emergency preparedness course should include the following:

- descriptions of the agency's responsibilities as well as those of other agencies of government and private industry—civil defense, FEMA, law enforcement, utilities, etc.
- detailed discussion of the agency's emergency plans, and the individual authorities and responsibilities of maintenance managers in executing those plans—road closures, hazardous spills, natural disasters, major accidents, etc.;
- coordination and reporting plans and requirements;
- programming and budgeting requirements, and adjustment policies and procedures made in response to or after an emergency; and
- organizing and dispatching work crews, equipment, and materials in response to emergencies.

Basic Bridge Management

The basic bridge management course should target first- and second-level maintenance managers. Minimum elements should include the following:

- types and classifications of bridges and drainage structures;
- inventory requirements, procedures, data collections and reporting;
- condition inspections, ratings, and reporting;
- environmental requirements and reporting as they apply to basic bridge maintenance operations—paint removal, painting;
- clear definitions of bridge maintenance authorities, responsibilities, and limitations of actions to be taken by each level of maintenance management;
- identification of maintenance needs, evaluation of maintenance intervention alternatives, identification of actions to be taken, and identification of actions that should be undertaken by other agencies;
- detailed descriptions of techniques, work steps, and sequences—staff, equipment, and materials to be used by managers at these levels in completing each bridge maintenance activity that is within their level of responsibility;
- worker and traffic safety requirements and procedures;
- contract administration requirements, authorities, and responsibilities; and
- work programming, budgeting, scheduling, reporting, and control.

Advanced Bridge Management

The advanced bridge management course should target district and headquarters maintenance managers. Minimum elements should include the following:

- clear definitions of bridge maintenance and repair authorities and responsibilities;
- detailed definitions of all elements of the agency's current bridge management system;
- discussions of emerging bridge management concepts and the agency's plans for system changes in the foreseeable future;
- bridge maintenance and repair programs and budgets development, and the interaction of the agency's management systems in preparing these programs;
- condition inspection and evaluation criteria;
- actions to be taken, by management level, under emergency conditions;
- the role of contract maintenance and repair in the bridge maintenance program, as well as contract administration responsibilities;
- techniques, procedures, and resources to be used in completing major bridge maintenance and repair activities; and
- work reporting, performance evaluations, and reporting requirements and procedures.

Training

Personnel is, of course, a major budget item in maintenance. Managers are responsible for orienting new hires and for advancing the knowledge of—and improving the versatility of—the existing work force. Topics to include in a course include

- Training as a managerial responsibility;
- Formalized OJT—advantages and disadvantages of on-the-job training, necessity for hands-on training, and benefits of instituting formal technical training programs;
- Work and training needs analyses;
- Instructional design—scope definitions, behavioral objectives, and applicable training media;
- Resources available through FHWA, RTAP/LTAP, and Technology Transfer Centers;
- In-house versus consultant production of training materials and conduct of training sessions; and
- Technical topics for maintenance employees include hazardous materials storage and handling, first-aid procedures, maintenance traffic control and flagging, maintenance hand tools, heavy-equipment operation, base and subbase repairs, ditching and drainage, vegetation control, rigid pavements, flexible pavements, structures, signs and pavement markings, safety appurtenances, and snow and ice control.

Current Maintenance Topics

As noted earlier, the current maintenance topics should center on emerging concepts, developments, and strategies. It should be designed for upper-level maintenance managers, and it should be conducted by experts in their fields.

In summary, the training discussed in the last several pages, the training modules shown in Figure 12 (and Appendix A) and the training courses shown in Figure 13 are related in that the modules may be packaged in any way that a particular agency feels can best serve its needs. On the other hand, the 17 courses cover more than 50 modules. Both have been presented to provide flexibility of implementation. Chapter Four contains a discussion of implementation of the proposed program.

CHAPTER 4

IMPLEMENTATION, CONCLUSIONS, AND RECOMMENDATIONS

IMPLEMENTATION OF THE FRAMEWORK

The education and training framework that has been developed during this project is just that—a framework. For the project results to have widespread application, they must be implemented. Implementation is not a quick fix, but rather must be approached from a long-range point of view, which includes an organizational structure to market and monitor the application of training and education. Expecting various agencies to read the recommendations from this project and to develop and present the entire program (even assuming they currently have 60% of the training in place) is simply not realistic, given the low priority placed on training by most agencies. For this reason, it is essential that an organizational structure that is somewhat permanent in nature be established for the express purpose of implementing an improved educational and training program for maintenance engineers/managers. The organization that best represents the potential clients who will benefit from this program is the American Association of State Highway and Transportation Officials (AASHTO). Thus, AASHTO is a logical choice to charge with implementing the recommendations from this project. On the other hand, counties and municipalities will also benefit from the training and educational programs presented in this report, thus an organization that represents state DOTs, county and municipal agencies, and other agencies (e.g., national park or forest roads) would also be logical.

Training

An excellent example and procedure for an AASHTO organizational unit to have responsibility for implementation of the "Education and Training for Maintenance Engineers/Managers" is the very successful "Transportation and Civil Engineering Careers Center" (TRAC), which operates under a steering committee. A special steering committee patterned after TRAC should be established with staff support and responsibility for marketing the professional development of maintenance engineers and managers. A first step in establishing a special steering committee should be an AASHTO task force with representation from TRB (NCHRP and the appropriate technical committees) and FHWA (NHI). The task force should be charged with implementing the training program recommended in this project, considering the establishment of the suggested special steering committee and other methods of implementation.

Other possibilities for implementation might involve organizations at the national and local levels and professional societies: American Public Works Association (AWPA); National Association for County Engineers (NACE); the National Association of Town and Townships; Federal Highway Administration (FHWA); and American Society of Civil Engineers (ASCE). The 50 T^2 (Technology Transfer) Centers can also be extremely helpful in implementing training and in publicizing the program.

The decision on a vehicle for implementation is beyond the scope of this project. However, the researchers urge the NCHRP Panel for Project 14-9(6) or the TRB to undertake some marketing at least to the point of establishing the implementation organization. The organization selected must be committed both philosophically and with the necessary resources (time and funding) to accomplish timely implementation of the training program. The highway infrastructure simply cannot wait.

Education

Implementation of the education program faces one major hurdle. The schools most likely to implement a new (full) M.S. graduate program in Maintenance Engineering and Management are the state universities. However, most state universities have very stringent budgets, reflecting the national economic posture and the statewide budget reductions. Thus, they are not in a position to initiate new programs that involve additional resources, unless outside resources can be made available. These outside resources should logically come from those who will benefit from the new programs—the general public or the traveling public. Preservation of the infrastructure and protection of the public investment in our highway system must be a priority, and the logical funding for an educational program, as proposed in this project, would be at the federal level [1991 legislation such as Intermodel Surface Transportation Efficiency Act (ISTEA) may have the flexibility for such funding, or new legislation may be required]. This is true for the following reasons: (1) it would ensure some consistency in programs among universities and states; (2) course development costs can be minimized; and (3) the federal/state relationships and the transportation leadership and example of the FHWA would lead to timely acceptance and implementation.

Funding could be established through the U.S. DOT University Research Centers Program, by creating one or more new centers (charged as "Training Centers of Excellence") to develop and implement the model program(s). These could then be modified, if necessary, and adopted by other universities.

Although the program funding could be administered by the National Science Foundation (NSF) or other entity, the FHWA or possibly FHWA/AASHTO is a much more familiar (to highway/transportation agencies) and logical choice for implementation of funding.

The academic acceptance, development, and initiation of pro-

grams might work through ASCE and Accreditation Board for Engineering Technology (ABET). However, at the graduate level, most universities do not seek accreditation of courses or programs, which would negate ABET interest, but not ASCE.

CONCLUSIONS

This project has developed a framework for education and training programs for maintenance engineers/managers, which will enhance highway maintenance as a career. The program may not only improve the efficiency and effectiveness of existing maintenance engineers/managers, but may also help to attract young engineers in choosing maintenance as a career.

Training

The training program developed includes many (more than 30) modules, which should be presented as overview training to familiarize and provide background understanding for maintenance managers. That is, the maintenance manager does not need to know all the details of a technical subject, but he or she should be able to determine when something is being done incorrectly and occasionally to recognize better ways to do things (see Chapter Three).

The researchers also discussed the techniques for training but left recommendations to the implementation body, recognizing that there are differences in philosophy, training equipment, and facilities among agencies. We foresee future development in compact disc and programmed learning by computer/video, which will undoubtedly change the training delivery needs. But the major emphasis of this project is identification and packaging of training modules, with packaging being quite flexible.

There is substantial training in some states (agencies) and very little in other states (except for on-the-job training). However, among those states with good maintenance training programs, some of the training needs upgrading and repackaging to improve both effectiveness and efficiency.

Particularly in regard to management training, there is much variety and inconsistency among states, with most states importing the training from another state agency or from outside (consultant or university). The monitoring and evaluation of management training ranges from questionable to nonexistent in many agencies.

Opportunities for exchange of course materials and instructors among agencies need to be seized on—primarily by breaking down parochial barriers. Implementation of the proposed training program will provide a substantial improvement in many agencies and some improvement even among those with good existing training.

Education

According to the last survey on this project, there are three or four universities with some graduate concentration in maintenance engineering, and three or four others with some related courses, such as pavement management, advanced pavement design, and advanced materials. Several other universities have one or two related courses but not a program. However, over one-third indicated they could be convinced through funding to initiate an M.S. program in maintenance engineering and management.

If funding can be provided by the federal government, and if the need for this program can be properly monitored, it will be implemented at many universities. The program will, and probably should, differ among schools—just as differences exist among faculty orientation and interests. This difference enhances competition among schools and brings out the strengths of the faculty of each school.

RECOMMENDATIONS

The recommendations resulting from this project are as follows:

1. Establish the organizational structure that is charged with implementing (a) Training program—The 50 T^2 centers can be very helpful in implementing the training. (b) Educational program—Funding for fellowships and faculty support is essential, as is a set of guidelines for program theme and format.
2. Develop a professional marketing video to educate (a) the general public; (b) the various agencies, at all levels; (c) universities; (d) agency officials; and (e) elected officials.
3. Integrate engineering and management so that future maintenance managers have a combination of technical (engineering) and management skills. Many areas of endeavor have experienced recent integration; for example, (a) Construction Engineering and Management; (b) Manufacturing Engineering and Management; and (c) System Engineering and Management.

These graduate programs are working and attracting large numbers of students. Likewise, the recommended integration of maintenance engineering and management has a high likelihood of success.

APPENDIX A

EDUCATION AND TRAINING FRAMEWORK

MAINTENANCE ENGINEERING AND MANAGEMENT MODEL M.S. PROGRAM

This program is a combination of Engineering and Management Courses. A 12-month, 33-semester-hour program is proposed to include a 3-semester-hour "capstone" type masters project course in Maintenance Management Systems.

Core Technical Courses:

1. Advanced Materials Selection - Structural components and types of failures; methods and techniques for rehabilitation and maintenance using carbon and alloy steels, polymers, fibers, particulate and foamed composites, timber, concrete, and other materials.

2. Pavement Management Systems - Maintenance issues analyzed in a management framework.

3. Maintenance Alternatives and Strategies: Design and Planning - Agency policy and philosophy, planning and operations.

4. Facilities Rehabilitation and Maintenance - An overview of critical issues in rehabilitation and maintenance with emphasis on administration and management, safety, pavement and bridge evaluation, maintenance and rehabilitation.

Elective Technical Courses:

5. Advanced Pavement Design - The components, technical aspects, performance evaluation, and rehabilitation of pavement systems.

6. Decision Theory and Statistics I - Development of information collection, data interpretation and models used for the decision making process.

7. Decision Theory and Statistics II - Application of statistical concepts to solution of complex engineering problems; laboratory use of computer packages.

8. Value Engineering - Analyze factors influencing reliability and implement quality control measures. Management of reliability and quality control.

Core Management Courses:

1. Management Principles I - An examination of research and theory concerning the forces which contribute to the behavior of organization members. Principally, leadership and implementation of the management are addressed.

2. Human Resources Management - The human resource function in organization. Human resource planning, procurement and selection, training and development, performance appraisal, wage and salary administration, and equal employment opportunity.

3. Management Principles II - The influence of the behavioral sciences on the theory and practice of management. Motivation, leadership, and international styles of management; quality control, quality circles, negotiating.

4. Management Accounting and Budgeting - This class will approach the material from the point of view of a public agency department program. Much emphasis will be given to the budget cycle and fund accounting.

Elective Management Courses:

5. Management Strategies in Public Organizations - The day-to-day problems faced by public sector managers, including setting goals, obtaining and protecting a mandate for a new program, designing a service delivery system, implementing a new program, supervising, and marketing.

6. Management Information Systems - Introduction to practical techniques for information systems design. Design requirements for information processing systems. Models and tools for requirement analysis.

7. Operations Research - Concepts and applications of linear programming models, theoretical development of the simplex algorithm, and primal-dual problems and theory.

Maintenance Management Systems - A Capstone M.S. Final Project - Using a real world situation.

Recommended Refreshers:

1. Communication and Public Relations
2. Group Psychology
3. English
4. Microcomputers

ADVANCED MATERIALS SELECTION

This course includes structural components and types of failures; methods and techniques for rehabilitation and maintenance using steel, polymers, fibers, particulate and foamed composites, timber, concrete, and other materials. Also covered are testing behavior and selection of materials including bituminous ore, aggregate, and soil stabilization.

Objectives:

(1) Understand the characteristics of materials in the selection process;
(2) Emphasize the role of quality control;
(3) Introduce materials and how to evaluate their effectiveness; and
(4) Develop knowledge of materials for safe, economical and durable design.

Course Outline of Topics:

1. Overview of Materials for Infrastructure Maintenance
2. Failure Criteria
3. Mechanical and Chemical Degradation
4. Steel, Polymers and Fibers
5. Concrete and Asphalt
6. Various Composites
7. Stress-Strain Relationships, Load Carrying Capabilities
8. Design Criteria for Materials, Selection Processes
9. Mix Design Procedures
10. Material Stabilization
11. Developing a Quality Control Program for Materials Selection, Design and Use
12. New Materials
13. Issues, Trends, and Policies
14. Conclusions

PAVEMENT MANAGEMENT SYSTEMS

This course covers the basic components of pavement management systems (PMS), with emphasis on pavement evaluation, planning pavement investment, rehabilitation design alternatives and pavement management program design and implementation.

Objectives:

(1) Describe PMS principles and the PMS process;
(2) Demonstrate benefits of PMS; and
(3) Analyze pavement management issues.

Course Outline of Topics:

1. Introduction, Principles of PMS
2. Getting Started - Inventory of the Pavement System
3. Databases, (e.g. GIS, GPS)
4. Monitoring and Operating a PMS
5. Single-Year Prioritization
6. Performance Prediction
7. Multi-Year Prioritization
8. Periodic Reevaluation of Status of the System
9. Optimization
10. Project Level Analyses - Rehabilitation and Reconstruction Alternatives
11. Network Level Analyses
12. Institutional Issues
13. Training
14. Overview/Summary

MAINTENANCE ALTERNATIVES AND STRATEGIES: DESIGN AND PLANNING

This course will include the design of alternative maintenance course of action and the impact of agency policy and philosophy on such designs. The planning of maintenance, including assignment, scheduling, and costing (alternative analyses) will also be included. This is a foundation course for Maintenance Management Systems (MMS).

Objectives:

(1) Describe traditional alternatives analysis with policy and budget constraints;
(2) Understanding trade offs and consequences of strategy selection;
(3) Knowledge of alternatives within an MMS; and
(4) Learn planning principles applied to maintenance.

Course Outline of Topics:

1. Understanding the Impacts of Agency Policies and Philosophies on Maintenance
2. Formulation of Maintenance Alternatives
3. Evaluation and Selection of Alternatives
4. Developing Strategies for Maintenance
5. Strategy/Alternatives Analysis
6. Planning for Implementation
7. Evaluation of Selected Alternatives
8. Working Effectively with the MMS

FACILITY REHABILITATION AND MAINTENANCE

This course is designed to teach maintenance policy formulation in the context of the public infrastructure. The development of rehabilitation and maintenance engineering procedures is also stressed. Rehabilitation and maintenance alternatives are discussed to assist in decision making.

Objectives:

(1) Understand procedures to recognize pavement failures and problems;
(2) Knowledge of new materials and methods associated with rehabilitation and maintenance;
(3) Utilize advanced technology and concepts through decision making measures;
(4) Evaluate transportation systems performance from a maintenance standpoint; and
(5) Recognize quality standards in rehabilitation and maintenance.

Course Outline of Topics:

1. System Concept and Identification
2. Infrastructure - Policies and Approaches
3. Infrastructure - Regulations, Compliance and the Current Crisis
4. Quality Assurance and Control
5. Multidisciplinary Issues - Geotechnical and Structural
6. Multidisciplinary Issues - Environmental and Water Resources
7. Goals and Considerations of Rehabilitation Engineering
8. Goals and Considerations of Maintenance Engineering
9. Work Zone Traffic Control and Management
10. Bridge Maintenance
11. Legal and Liability Considerations
12. Economic Issues Affecting Rehabilitation and Maintenance

ADVANCED PAVEMENT DESIGN

Principles relative to the design construction and rehabilitation of highway pavement systems. Discussion of multi-layered elastic and slab theories, properties of pavement materials and methods of characterization, stochastic treatment of design variables, economic principles of design alternatives and the effect of environment on pavement performance. Review of existing rigid and flexible design methods as well as major fundamentals relative to the rehabilitation of existing pavement systems.

Objectives:

(1) Knowledge of flexible and rigid pavements;
(2) Understanding factors affecting pavement design;
(3) Recognizing pavement design related problems (e.g. failures); and
(4) Knowledge of pavement maintenance requirements and needs.

Course Outline of Topics:

1. Flexible Highway Pavement
   - AASHTO Design Procedure
   - Traffic Mix Analysis and Design Applications
2. Flexible Heavy Vehicle Pavements
   - USACE Design Procedure
   - Equivalent Single Wheel Load Analysis
   - Traffic Mix Analysis and Design Applications
3. Rigid Highway Pavements
   - Stresses in Rigid Pavements
   - Steel Reinforcement
   - Thickness Design Procedures/Equations
   - Design Applications
4. Pavement Evaluation and Rehabilitation
   - Approach/Procedures/Design Applications
   - Overlay/Design Procedures

DECISION THEORY AND STATISTICS I

This course covers the application of statistical and systems engineering techniques in the analysis of information necessary for the design or characterization of transportation and infrastructure systems. Also covered is an emphasis on basic strategies for the development of information collection programs, data interpretation methods and statistical models used to support the decision making process.

Objectives:

(1) General understanding of data quality;
(2) Knowledge of statistical techniques for interpreting maintenance data; and
(3) Understanding of the use of statistics in decision making.

Course Outline of Topics:

1. Probability Distributions
2. Frequency Analysis
3. Hypothesis Testing (Mean, Variance, Distributions)
4. Confidence Intervals
5. Tolerance Limits
6. Correlation Analysis
7. Bivariate Regression
8. Principle of Least Squares
9. Reliability of a Regression Equation
10. Hypothesis Tests and Confidence Intervals
11. Multiple Regression Analysis
12. Stepwise Regression Analysis
13. Non-linear Regression Analysis

DECISION THEORY AND STATISTICS II

This course introduces complex regression modeling techniques, computer applications for statistical problems and an introduction to operations research. Optimization, simulation and probabilistic modeling are also discussed. This course introduces methods of evaluating statistical models to determine the effectiveness of the model.

Objectives:

(1) Effective use of the maintenance management database;
(2) Advanced statistical techniques for interpreting data and models;
(3) Use of advanced techniques in decision making; and
(4) Familiarity with statistical software.

Course Outline of Topics:

1. Principal Components Analysis
2. Principal Components Regression Analysis
3. Analysis of Variance
4. Non-Parametric Methods
5. Semivariogram Analysis and Kriging
6. Numerical Optimization
7. Subjective Optimization of Complex Methods
8. Time Series Analysis
9. Sensitivity Analysis and Probabilistic Modeling
10. Simulation
11. Bayesian Statistics
12. Linear Programming

VALUE ENGINEERING

This course is designed to familiarize the student with alternative approaches, methods and techniques for consideration of highway maintenance problems. The basic concept of value engineering (VE) will be covered, followed by cost studies and examples of application of value engineering principles to maintenance.

Objectives:

(1) Introduction and familiarization to the basic principles of VE;
(2) Differentiation between VE and other cost reduction and problem solving techniques;
(3) Identify where VE applications have potential for financial and/or material resource savings; and
(4) Demonstrate VE as a management tool for product improvement and cost reduction.

Course Outline of Topics:

1. Introduction, VE in Context
2. Fundamentals of VE
3. Principles in Application
4. Selection Phase
5. Investigation Phase
6. Functional Analysis
7. Speculation, Team Applications
8. Evaluation
9. Development
10. Presentation
11. Implementation
12. Audit
13. Human Relations
14. Case Studies

MANAGEMENT AND ORGANIZATIONAL THEORY (MANAGEMENT PRINCIPLES I)

This course deals with understanding and effectively managing others in an organizational context. Human and organizational factors and influence of behavioral science on the theory and practice of management are also considered. Some topics covered are decision making, ethics, and basic management principles.

Objectives:

(1) Learning major concepts and theories about management;
(2) Becoming familiar with managerial terminology;
(3) Developing an appreciation for the basic skills necessary for managerial success; and
(4) Understanding how effective managers operate.

Course Outline of Topics:

1. The Challenge of Management, Pioneering Ideas in Management
2. Understanding Internal and External Environments, Social Responsibility and Ethics in Management
3. Establishing Organizational Goals and Plans, Strategic Management
4. Managing Innovation and Change, Managerial Decision Making, Planning and Decision Aids
5. Basic Elements of Organization Structure, Strategic Organizational Design
6. Human Resource Management, Motivation
7. Leadership, Managerial Communication, Managing Groups
8. Controlling the Organization, Managerial Control Methods
9. Operations Management, Information Systems for Management
10. International Management, Entrepreneurship and Small Business

HUMAN RESOURCES MANAGEMENT

The course is designed to help participants develop knowledge and skills to manage human resources effectively. This course targets the human resource function in organizations. Some of the issues are human resource planning, procurement and selection, training and development, performance appraisal, wage and salary administration, and equal employment opportunity.

Objectives:

(1) Effective and efficient personnel/human resource management (P/HRM) strategies, systems and programs;
(2) Critical knowledge of the external and internal environments for effective P/HRM;
(3) Applications of acquired knowledge to diagnose P/HRM problems and prescribe remedies;
(4) Developing, defending and implementing P/HRM strategies, prescriptions and programs; and
(5) Interpersonal skills to effectively manage human resources and implement P/HRM strategies and programs.

Course Outline of Topics:

1. Overview of Human Resources Management
2. External Conditions
3. Organizational Conditions
4. Legal Context of Collective Bargaining - Taft Hartley and Other Related Acts
5. Individual Differences
6. Performance and Attendance
7. Setting Objectives and Evaluating Results
8. Employment Planning
9. Recruitment
10. Employee Selection
11. Internal Staffing
12. Training, Development and Orientation
13. Competitiveness and Consistency, Motivation
14. Payroll, Employee Contributions and Administration
15. Benefits
16. Labor Relations
17. Collective Bargaining
18. Mediation and Negotiations
19. National Emergencies
20. Employee Separations, Workforce Reduction and Retention
21. Emerging Human Resource Issues
22. Employee Relations

MANAGEMENT PRINCIPLES II

Included in this course is the influence of the behavioral sciences on the theory and practice of management. Topics to be covered are motivation, leadership, international styles of management, quality control and quality circles; also ethics and integrity in public organizations and public policy are discussed.

Objectives:

(1) Achieve an understanding of advanced management principles;
(2) Develop confidence in negotiation and conflict management techniques;
(3) Characteristics of effective leadership techniques; and
(4) Knowledge of individual and work group diversity.

Course Outline of Topics:

1. Introduction
2. What is Organizational Behavior & Where Does it Belong in Management Education?
3. Business Ethics
4. The Individual: Attitudes, Perceptions, Motivation
5. Work Group
6. Leadership - Principles and Applications
7. Conflict Management and Negotiations
8. Individual and Group Decision Making
9. Organizational Design
10. Management of Organizational Change
11. Productivity
12. Organizational Careers, Work, Health
13. International Aspects of Organizational Behavior/Conclusions and Integration

MANAGEMENT ACCOUNTING AND BUDGETING

This course introduces the concepts and issues of financial accounting and reporting and budget development and implementation in the public sector. Analytical techniques and application will be stressed. Major issues covered are resource allocation, long and short-term debt instruments, and analysis of public economic development projects.

Objectives:

(1) Knowledge of principles and procedures of accounting;
(2) Understanding of entire budgeting process;
(3) Learning the budget process applied to public arena and accounting; and
(4) Knowledge of record keeping requirements for federal, state and local agencies.

Course Outline of Topics:

1. Overview and Goals of the course
2. Concepts in Valuation
3. Capital Investment
4. Risk Analysis in Capital Budgets
5. Evaluation of Risk in Investments
6. Principles of Bookkeeping, Balance Sheets, Income Statements
7. Accounting Cycles, Cash Flows
8. Inventory, Liabilities
9. Borrowing and Other Methods of Financing, Financial Markets - The Rating Procedure
10. Working Capital, Cash Management
11. Budget Development for State and Local Government Agencies
12. Leasing versus Purchasing
13. Long Term Financing, Debt
14. Budget Planning

MANAGEMENT STRATEGIES IN PUBLIC ORGANIZATIONS

The day-to-day problems encountered by public sector managers are covered in this course. Included are setting goals, designing a service delivery system implementing a new program, supervising and marketing. Management strategies are discussed in the context of decision support systems (DSS) and expert systems (ES) used to achieve good, sound decisions.

Objectives:

(1) Gain an understanding of DSS, and their support of managerial decision making;
(2) Characterize features, and structure of DSS and ES;
(3) Understand the managerial decision making process and how it can be enhanced by DSS and ES;
(4) Understand the group decision support system concept, its importance, structure and accomplishments;
(5) Learn to operate software to build group decision support systems (e.g. VisionQuest);
(6) Characterize major DSS and ES software tools and generators and desirable ways to evaluate them;
(7) Describe the characteristics, features, structures, limitations, and benefits of ES;
(8) Describe the development process of ES with and without using a shell; and
(9) Learn to operate software to build, edit and run small size ES (e.g. EXSYS).

Course Outline of Topics:

1. Fundamentals of a DSS
2. Designing a DSS
3. DSS Development Tools, Spreadsheet Software
4. Fundamentals of an ES
5. ES/DSS Tools (e.g. EXSYS)
6. ES Tools (e.g. PROLOG)
7. Group DSS, VisionQuest Software
8. User Interface, Software Demonstration
9. Implementation and Integration of Management Support Systems

MANAGEMENT INFORMATION SYSTEMS

This course provides an introduction to practical techniques for the analysis and design of information systems to support a wide range of organizational functions. The design requirements for development and operation (processing of information) of large data bases will be covered. Finally, models and tools for information systems will be included.

Objectives:

(1) Develop an understanding of the current managerial issues in effectively utilizing information technology;
(2) Develop an understanding of computer hardware, software, and telecommunications technologies;
(3) Understand the various types of computer-based information systems used in organizations;
(4) Understand the technology required to implement each system, and types of system development approaches; and
(5) Develop an ability to identify and exploit information technologies to gain competitive advantages.

Course Outline of Topics:

1. Introduction to Information Systems
2. Systems Development Paradigms and Processes
3. Black Box Behavior, State Box Behavior
4. Clear Box Behavior
5. Box Structural Systems Development
6. System Development Methods, Structured Analysis and Design, Introduction to Excelerator
7. Object-Oriented System Development
8. Computer Aided System Engineering
9. Reusability in Development
10. Real-Time Systems
11. Quality Control of System Development, Cleanroom Software Engineering
12. Reverse Engineering
13. Working with People in Systems Development

OPERATIONS RESEARCH

The application of operations research and the operations management concept to solve maintenance management problems is stressed. The course also emphasizes an integrated approach to management decision making. Some material covered the concepts and applications of linear programming, theoretical development of the simplex algorithm, primal-dual problems, and introduction to other operations research elements.

Objectives:

(1) Understanding of linear programming techniques;
(2) Knowledge of advanced operations research techniques;
(3) Understand application of operations research to solution of management problems; and
(4) Recognize tools available to formulate operations research problems.

Course Outline of Topics:

1. Introduction to Management Science/Operations Research
2. Linear Programming - Model Formulation
3. Linear Programming - Graphical Solution
4. Linear Programming - Simplex Method
5. Linear Programming Software (e.g. LINDO)
6. Sensitivity Analysis and the Dual Problem
7. The Transportation Problem
8. Network Models
9. Integer Programming
10. Goal Programming
11. Dynamic Programming, Markov Processes
12. Summary and Overview

MAINTENANCE ENGINEERING AND MANAGEMENT SELECT COURSES FOR AN AREA OF CONCENTRATION

B.S.-Level Courses:

If only one course is to be offered, course #1 is recommended. For an area of concentration, three of the four courses would be taken.

1. Introduction to Infrastructure Maintenance - Engineering and management.

2. Maintenance Equipment and Methods - Evaluation and selection of equipment and methods for engineering maintenance on projects.

3. Decision Support Systems for Maintenance - Information technology and computer applications.

4. Design of Maintenance Systems - Scope, components, relationships, system operations.

M.S.-Level Courses:

Recommended courses for a student to concentrate (3 or more courses) in maintenance engineering as part of an M.S.C.E. or M.S. Program. The descriptions, objectives and outline of topics to be covered for these M.S. courses were presented on the previous pages under the model M.S. program core and elective technical course lists.

1. Advanced Materials Selection - Structural components and types of failures: methods and techniques for rehabilitation and maintenance using carbon and alloy steels, polymers, fibers, particulate and foamed composites, timber, concrete, and other materials.

2. Pavement Management Systems - Maintenance issues analyzed in a management framework.

3. Maintenance Alternatives and Strategies: Design and Planning - Agency policy and philosophy, planning and operations.

4. Facilities Rehabilitation and Maintenance - An overview of critical issues in rehabilitation and maintenance with emphasis on administration and management, safety, pavement and bridge evaluation, maintenance, and rehabilitation.

5. Advanced Pavement Design - The components, technical aspects, performance evaluation, and rehabilitation of pavement systems.

6. Value Engineering - Analyze factors influencing reliability and implement quality control measures. Management of reliability and quality control.

INTRODUCTION TO INFRASTRUCTURE MAINTENANCE

This is a first level (senior civil engineering student) course to introduce the student to maintenance engineering and management. The context of the course will be the infrastructure with some emphasis on transportation and highway maintenance.

Objectives:

(1) Know the importance of maintenance in the entire process - plan—design—construction—maintenance;
(2) Recognize both failures and conditions requiring maintenance attention;
(3) Understand materials and methods of infrastructure maintenance; and
(4) Knowledge of quality, standards and the total cost approach to infrastructure.

Course Outline of Topics:

1. Maintenance as Part of the Overall Engineering System
2. Maintenance Levels versus Infrastructure Status
3. Maintenance Quality Trade-offs
4. Engineering of Maintenance - Materials, Equipment, Alternatives and Resources
5. Maintenance Methods/Activities
6. Economics of Selection of Maintenance Methods, Level and Application
7. Consequences of Deferred Maintenance
8. Total Cost Approach to Integrating Maintenance into the System
9. Maintenance Engineering/Management as a Career
10. Summary

MAINTENANCE EQUIPMENT AND METHODS

This course will introduce the various types of equipment used in maintenance, the activities to which each piece of equipment is assigned and how it is used. In addition, methods of conducting maintenance activities will be covered.

Objectives:

(1) Understanding of various types of equipment and the usage;
(2) Knowledge of various aspects of equipment decisions;
(3) Understanding of how equipment choice affects the achievement of maintenance goals; and
(4) Understanding maintenance objectives and the methods used.

Course Outline of Topics:

1. Equipment Types and Applications
2. Fleet Purchase, Replacement, Disposal and Maintenance
3. Equipment Costs - Operational, Ownership and Overhead
4. Equipment Shop Requirements
5. Preventive Maintenance
6. Equipment Management Systems
7. Methods of Pavement Maintenance
8. Methods of Bridge and Drainage Maintenance
9. Methods of Routine and Roadside Maintenance
10. Other Maintenance Methods
11. Summary

DECISION SUPPORT SYSTEMS FOR MAINTENANCE

Maintenance systems and maintenance management in general require rather large databases to support decision making. This course will introduce these support systems. Principles of information technology and computer applications of GIS and other databases will also be covered.

Objectives:

(1) Familiarization with maintenance systems and required support;
(2) Understand information technology and databases;
(3) Introduction to common computer software; and
(4) Knowledge of how to integrate a sub-system into a system.

Course Outline of Topics:

1. Maintenance Systems Overview
2. Required Support Systems
3. Databases - Data Collection and Storage
4. Principles of Information Technology
5. GIS, GPS
6. Pavement Databases and Other Maintenance Related Databases
7. Computer Applications/Software
8. Enhancement of Support Systems
9. Integration/Merging Databases
10. Summary

DESIGN OF MAINTENANCE SYSTEMS

This course deals with the process of formulating a maintenance system. Items to be covered are basic maintenance activities, policies, and procedures. The intention of the course is to tie all elements of maintenance together and address them from a systems approach.

Objectives:

(1) General understanding of maintenance activities;
(2) Knowledge of physical and financial limitations on maintenance systems;
(3) Ability to combine various elements to create a maintenance system; and
(4) Recognizing important information for system to report.

Course Outline of Topics:

1. Introduction
2. System Elements - Physical Features
3. Network Identification
4. Maintenance Performance Standards
5. Activity Resources
6. Performance Budgeting
7. Work Program
8. Resource Requirements
9. Scheduling
10. Reporting Systems
11. Evaluation and Control of Work

TRAINING MODULES FOR MAINTENANCE ENGINEERS AND MANAGERS

I. Equipment
Basic Equipment
Special Equipment
Equipment Safety
Operator Certification
Inspection
Disposal and Replacement

II. Traffic Control
Traffic Control Devices
- Signals
- Signs
- Markings
- Other TCDs

Work-Zone Traffic Control
- Planning and Scheduling
- Design and Operations

Geometrics and Traffic Control
Roadway Illumination
Roadside Safety Hardware

III. Materials
Soils and Aggregates
Concrete Materials
Bituminous Materials
Special Materials
Hazardous Materials
Waste Management
- Hazardous
- Routine

Quality Control

IV. Management
Quality Control/Quality Circles
Financial Management
Creative Problem Solving
Interpersonal Relations
Programming and Scheduling
EEO & Labor Compliance/Relations
Project Documentation
Statistical Analysis
Leadership Development
Managing Resources
Time Management
Communications
- Technical Writing
- Public Speaking
- Public/Personnel Relations

Organizational Structure
Policies and Operations
Standards and Performance
- Development
- Evaluation

V. Computers
Hardware
Software
- Word Processing
- Database and Spreadsheets
- DOS/Others

Maintenance Management Systems
- Overall Systems
- Pavement Management
- Bridge
- Equipment

Engineering/Maintenance Software
- Drainage
- Design
- Bridge
- Pavement
- Traffic

VI. Winter Service (Snow/Ice Control)
Organization and Policy
Safety/Environmental Concerns
Snow/Ice Control
- Snow Plowing
- Salting
- Chemicals

Planning and Scheduling

VII. Pavement/Surface
Pavement Design & Construction
- Bituminous Pavements
- Concrete Pavements

Seal Coats
Pavement Repair
- Bituminous
- Concrete

Pavement Rehabilitation
Pavement Overlays

VIII. Bridge/Reconstruction
Bridge Inspection
Preventive Maintenance/Painting
Structural Repair
Deck Replacement
Routine Bridge Maintenance

IX. Drainage
Drainage Design Overview
Drainage Structure Replacement
- Pipes
- Manholes
- Inlets
- Culverts

Routine Drainage Facility Maintenance

X. General
Routine/Recurring Maintenance
Roadside Maintenance
Emergency Maintenance
Rehabilitation
Plan Reading
Environmental Concerns
Laws and Regulations
Maintenance Contracting and Administration
Safety
- Worker
- User/Public

Value Engineering
Outdoor Advertising
Utilities
Tort Liability and Risk Management

PLEASE NOTE: The training modules described in the next several pages have been written without mention of the training medium. These modules are intended to be stand alone or part of a short course, seminar, workshop, academy or conference. The possible training medium ranges from advanced methods such as compact disc training to more basic approaches such as lectures and discussions.

I. EQUIPMENT

Module Topics:

1. Basic Equipment (1-2 days) - This module should provide information on the basic day-to-day equipment used in maintenance. The maintenance manager need not be an expert in equipment, but he does need to have good understanding of capabilities and limitations, maintenance service requirements, costs and activities which various pieces of equipment can be effectively assigned. A reasonable understanding of operation, inspection, and monitoring of the equipment is desirable.

2. Special Equipment (1-1.5 days) - Some maintenance activities require very special equipment (e.g., underwater bridge inspection or cleaning of some types of drainage facilities). The manager should know enough about the special equipment to make decisions on job assignments, purchasing and similar decisions.

3. Equipment Safety (1.5 days) - Safety is a foremost concern in maintenance equipment from inspection and monitoring at the shop to operation out on the road. This includes how to safely inspect equipment and constantly practice safety when around equipment. Also of concern is safety built into the equipment (e.g., rollbars, lights/brakes, etc.) and proper and safe procedures for equipment operation.

4. Operator Certification (1.5-2 days) - The manager should be concerned with making sure all his operators are certified. Instilling pride (possibly through equipment rodeos with prizes, etc.) in good operation from all aspects including safety and productivity is also important. The manager must ensure an operator becomes certified.

5. Inspection (1-1.5 days) - Equipment inspection from daily inspection prior to leaving the yard (shop) to periodic inspection (safety and preventive maintenance) will be covered. The manager needs to understand the role and importance of inspection in order to motivate operators to conduct needed inspections. The economics, safety and cost liability benefits should be stressed.

6. Disposal and Replacement (1 day) - This module includes discussion of procedures to dispose of equipment which is obsolete or worn out as well as how to make decisions on when to dispose. Also included will be material on replacement alternatives including: (1) different types of equipment; (2) lease versus buy; (3) when to replace; and (4) purchasing hints. The maintenance manager will either make decisions concerning equipment or provide input for decisions including using an Equipment Management System, if one exists.

II. TRAFFIC CONTROL

Module Topics:

1. Traffic Control Devices (TCDs) - This module should include an overview of the design and construction of TCDs and the maintenance and operation of TCDs. The material can be divided into sub-modules such as:

    a. Traffic Signals - 1 day
    b. Traffic Signs - 1/2-1 day
    c. Markings - 1/2 day
    d. Other TCDs - 1/2 day

2. Work Zone Traffic Control (WZTC) - Since most maintenance operations are conducted under traffic, it is important that all maintenance managers understand the basic principles, and be knowledgeable of the proper procedures and devices as contained in the state manual and/or the MUTCD. Two natural sub-modules are:

    a. Planning and Scheduling Work - 1-2 days
    b. Design and Operation of Work Zones (T.C. in W.Z.) - 2-3 days

3. Geometrics and Traffic Control (1 day) - An overview will be presented of the relationship of geometric features to traffic control requirements. Especially treated will be sight distance versus signing, reduced speed limits etc. Maintenance Managers should be able to recognize potential problem areas and request a traffic study.

4. Roadway Illumination (1 day) - Many parts of the highway system require illumination. Understanding the importance of illumination and general illumination design and layout will assist in planning, scheduling and conducting needed maintenance on the illumination system.

5. Roadside Safety Hardware (2-5 days) - This module will first cover the design and selection of roadside appurtenances such as guardrail, median barriers, utility poles, sign standards, crash cushions, etc. Understanding of the Clear Zone concept and recognizing unsafe features will be covered. A second element should cover the maintenance and repair requirements for these appurtenances to provide the safety intended.

III. MATERIALS

Module Topics:

1. Soils and Aggregates (1-1.5 days) - This module covers the basic properties of soils and aggregates, various tests required to maintain quality. Importance of moisture, density, compaction, etc., will be covered. Also compaction and construction of bases and sub-bases will be included. Selection and use of materials to facilitate the effectiveness of maintenance activities will be highlighted.

2. Concrete Materials (2 days) - This module will discuss the characteristics/properties of cement, sand, aggregate reinforcing steel and composite (concrete). Relationships of materials and performance will be covered, as will standard tests, specification and applications.

3. Bituminous Materials (2 days) - This module will include the characteristics and properties of asphalt, emulsified asphalt, road tar, and other bituminous materials. Also, to be covered, will be standard tests (e.g., consistency), specification, selection, and applications of these materials.

4. Special Materials (1-1.5 days) - Over the last several years, several specialized materials have been developed such as geotextiles, epoxies, sulfur asphalt, and rubberized asphalt. Included will be discussion of the properties of these and other new materials, applications, and results. Evaluation, costs and other aspects will also be covered.

5. Hazardous Materials (2-3 days) - This module covers topics from understanding containment of a spill, recognition of hazardous materials and the associated problems and risks, identification of material release, initiation of an emergency response sequence, role of the first responder, documentation and form filing and planning and communication during emergency responses.

6. Waste Management - This module should be divided into two sub-modules as follows:

    a. Hazardous Wastes (1-2 days) - This area is very important to maintenance operations. With recent identification/definition of what hazardous material is and how it can safely be disposed of, managers must be informed on: (1) How to use restricted or hazardous materials and (2) How to dispose of hazardous materials that are used. A general understanding of procedures which insure both employee and public safety, as well as minimizing environmental affects, is required.

    b. Routine Waste (1/2 day) - This module will cover the basic principles of both solid and liquid waste within an urban setting with water and sewage systems and in remote settings without such services.

7. Quality Control (1-2 days) - This module is designed to foster an understanding of the concepts of evolution of the quality of materials used and work performed in maintenance. Procedures, standards, and specifications will be covered as will the basic statistical principles of quality control that should lead to improved quality in both materials selection, handling and use, and in work performance.

IV. MANAGEMENT

Module Topics:

1. Quality Control/Quality Circles (2-3 days) - The concepts of quality control and the process will be highlighted through flow charts and other graphics. The benefits of quality circles and management's role as well as techniques for implementation will be covered.

2. Financial Management (2 days) - This module provides an overview of the financial management information system and process. Also covered will be levels and types of spending controls, encumbrance, invoice and lapse processes.

3. Creative Problem Solving (2 days) - The creative problem solving process will be central to this module. The rules and responsibilities of managers, meeting effectiveness and questioning techniques will be covered as will overcoming conflicts. Workshop problems will be used extensively.

4. Interpersonal Relations (1-1.5 days) - Managing people requires that one have a good understanding of how to treat everyone as an individual, while keeping even and fair treatment to all and yet being able to work with many people during the course of a day. Special skills in working with people must be developed and applied.

5. Programming and Scheduling (1.5 days) - In addition to developing an annual maintenance program, managers must be aware of how the program is accomplished. The actual scheduling of projects and activities is usually the tool for program implementation. Schedule monitoring is a very important management action.

6. EEO and Labor Compliance/Relations (1.5-2 days) - Students will be exposed to the legal requirements on the job, principles of collective disciplinary grievance handling, and alternative courses of action to meet all legal requirements as well as shape a better working environment. Discrimination and harassment will be defined and discussed.

7. Project Documentation (1-1.5 days) - This module will emphasize the importance of good quality data use in documenting every maintenance project. Such data then become part of a maintenance management system and assist in improving maintenance operations decisions.

8. Statistical Analysis (2-3 days) - Various, rather straight-forward statistical analyses can be performed with data from the maintenance management system as well as on other data bases (e.g., pavement management system). Some of these analyses will result in products useful in budget discussions and other activities.

9. Leadership Development (1.5 days) - Principles of leadership; authority versus responsibility; persuasion, setting examples, and knowledge of when and how to compromise. The art of getting your way. Practices that lead to improvements in the ability to lead. The fairness doctrine.

10. Managing Resources (3-4 days) - To be covered will be working with individuals and groups, responses to individuals and groups, responses to individual behavior, how to motivate individuals to get involved. Persuasion versus consensus and the creative problem solving process. Other topics covered are benefits, classification and pay, workman's compensation, labor relations, developing performance standards and dealing with complaints. Also retirement counseling and benefits will be discussed as will payroll, interviewing and recruiting.

11. Time Management (2 days) - An important aspect of good management is the effective use of resources. One resource in limited supply is time. How to schedule activities so as to minimize waste of time and to assure that others do not waste your time will be included. The use of lists and development of schedules, ranking activities so that the most important always get done will be discussed.

12. Communications - This module has been divided into three sub-modules:

    a. Technical Writing (2.5-3 days) - This module including a quick overview of basic grammar followed by discussions of the use of a good handbook. Also covered are the topics of writing, important points, developing drafts, revisions, editing, etc. The importance of spelling, sentence structure, and punctuation. Style and personalizing will also be covered.

    b. Public Speaking (1.5-2 days) - This module will cover the basic principles of speaking in public--the do's and don'ts, eye contact, clear speaking, body language, etc. will be covered. Workshops will be a part of this module.

    c. Public/Personnel Relations (1/2-1 day) - This module deals with improving the effectiveness, competency and responsiveness of direct contact with the public. In addition, the same coverage applied to contact between managers and personnel will be covered.

13. Organizational Structure (1 Day) - This module will describe various types of organizations from linear to vertical to pyramid. The advantages of various

structural arrangements will be discussed. The students are expected to flow chart their organization and to understand the strengths and weaknesses.

14. Policies and Operations (1/2-1 day) - This module will include discussions of various policies and operations pertaining to maintenance. In particular the reasons for the policies, the consequences of non-compliance as well as similar coverage of operations will be included.

15. Standards and Performance - This module has been divided into two sub-modules:

    a. Development of Standards (1.5-2 days) - This module is concerned with the development of performance standards which can be used to realistically measure performance (overall effectiveness).

    b. Evaluation (1.5-2 days) - This module deals with evaluation of: (1) the standards and (2) individual performances. How close to standard is acceptable as well as the percent $\geq$ standard is to be stressed.

V. COMPUTERS

Module Topics:

1. Hardware (1/2 day) - This module provides an introduction to computer hardware. Specifically, the aims of the module are to inform the individual about current technology and background into various computer systems (IBM, Apple, etc.). The module also provides insight into the necessary components for building a system and networking. This information will be valuable in making hardware purchasing decisions.

2. Software - This module will be an introduction to mainstream software. It can be divided into three sub-modules:

    a. Word Processing (1 day) - The goals of this module are to teach the basic elements of word processing. Specifically, creating a document, basic editing, altering page format, using text enhancements and using the spell check and help screens.

    b. Database and Spreadsheets (2 days) - In this module, the student will learn how to create a database, open files, add and edit records, use the help screen and retrieve and order information. The second part of this module teaches spreadsheet concepts, creating worksheets, entering commands and formulas and saving, retrieving and printing worksheets.

    c. DOS (1 day) - This module teaches how to enter and edit DOS commands, list files, prepare disks, copy files and make back-up copies of disks and troubleshoot DOS error messages and correct them.

3. Maintenance Management Systems (1 week) - This module covers the theory and practice of highway maintenance management, practical field applications in budgeting, scheduling program adjustments, including all PC applications, data entry procedures and report generation operation and introduces other management systems. Feedback of this system to decision making will also be discussed.

4. Engineering/Maintenance Software (1 week) - This module introduces various software available to maintenance managers for the solution of maintenance problems. This module is designed to be a cursory introduction to computer software for engineering activities, with maintenance requirements as only one element. Elements to be covered include: bridge, drainage, design, pavement and traffic.

VI. WINTER SERVICE (SNOW/ICE CONTROL)

Module Topics:

1. Organization and Policy (1.5-2 days) - Preparation for Winter through late Spring clean-up; levels of service and cost-effective measures; agency policies on plowing and use of chemicals to meet management goals in a cost-effective manner. Also considered are equipment, personnel, and material requirements, training and planning and scheduling.

2. Safety/Environment Concerns - This module could be divided into two sub-modules as follows:

    a. Safety Aspects of Winter Services (1-2 days) - This module covers the importance of practicing good safety in (1) equipment inspection and operation, (2) operations for winter services, (3) employee activities. Also to be discussed is safety to the public during operations and as a result of good operations.

    b. Environmental Issues (1-1.5 days) - This module will include discussion of the environmental issues with salt and chemicals including stream and groundwater impacts, vegetation effects, others. Also covered will be storage and handling, good spreading practices, alternatives to chemicals, etc. The maintenance manager should have a good understanding of environmental issues and how they are resolved.

3. Snow/Ice Control - This module covers the operation of the maintenance agency for snow and ice control, and reflects the overall agency policy. It also reflects agency decisions on general procedures. It has been divided into three sub-modules:

    a. Snow Plowing (1 day) - This module will cover the actual methods/procedures used in plowing snow, and will include some details on blade height and angle; operation with street and road hardware/appearances; special problem areas.

    b. Salting (1 day) - This module will include the determination of: (1) when to salt; (2) how much salt to use; (3) spreader setting (operation) to achieve desired amount and coverage as well as minimizing salt in sensitive areas (e.g. across the curb or grass strips). The supervisor/manager needs to have a good overview understanding of policies and procedures and on how to make good decisions regarding salting.

    c. Chemicals and Other Materials (1/2 day) - This module will discuss the use of chemical (other than salt), and sand and others materials (e.g. cinders). To be discussed will be:

        (1) Use of calcium magnesium acetate (CMA)
        (2) Use of liquid, calcium chloride
        (3) Use of sand
        (4) Use of mixtures of sand and chemicals (including salt)

4. Planning and Scheduling (2 days) - This module is very important for maintenance managers and will cover planning for winter maintenance which should begin with Spring clean-up of the previous season. It includes a broad overview of:

    o Requirements - personnel, equipment, materials and contracting, if any;
    o Stockpiling, equipment procurement, repair and maintenance;
    o Storm prediction and use of weather information to determine when to begin operation;
    o Establishment of operating routes including priority of treatment;
    o Scheduling of equipment and crews;
    o Coordination, communications, monitoring; and
    o Evaluation and debriefing, lessons learned, recommendations.

VII. PAVEMENT/SURFACE

Module Topics:

1. Pavement Design and Construction (1 week) - The principles of pavement design both rigid and flexible, considering loading, stress, types of materials and properties of all components will be covered. Also, the general construction procedures and methods will be discussed. Maintenance requirements and procedures will also be included.

2. Seal Coats (1-2 days) - This module will present the various methods (seal coats, slurry seals, chip and seal, etc) for sealing small cracks and providing a new wearing surface cover. This is a widely used pavement maintenance action and proper procedures, materials and equipment are important to good performance.

3. Pavement Repair - This module will cover the principles and procedures for performing pavement repairs and should be divided into two sub-modules:

    a. Bituminous Pavement Repair (1-2 days) - The methods for performing the repairs as well as the determination of need and type of repair necessary will be covered. Topics include crack sealing, pot hole repair, removal and replacement of sections, base and subbase repair.
    b. Concrete Pavement Repair (1-2 days) - This module will cover both methods for conducting the repairs and procedures to determine when and how to repair. Included will be joint repair (sealing) and replacement, crack repair, section replacement, mud-jacking, undersealing, etc.

4. Pavement Rehabilitation (3-9 days) - Although this module is shown here as one module it can be divided into modules such as: (1) Recycling (2) Resurfacing, (3) Restoration. Topics to be covered will be how to determine when rehabilitation is needed (distress type, coring, non-destructive testing); principles of preparation for rehabilitation; principles of recycling, etc.

5. Pavement Overlays (3 days) - This module will include development of overlay strategies, types of materials, milling, recycling, why failures occur. Procedures for overlay design, remaining life, current pavement conditions, will be included. Finally, overlays of both bituminous and portland cement concrete pavements will be covered.

VIII. BRIDGE MAINTENANCE/RECONSTRUCTION

Module Topics:

1. Bridge Inspection (2-4 days) - An overview of bridge inspection will be presented covering basic concepts such as: (1) Bridge type and members (2) Materials Types and Properties, (3) Relationship between stress and strain, (4) Types of deterioration from weathering, loading, etc., (5) Material distress, (6) secondary elements and features of bridges, and (7) Overall bridge inspection. Various inspections techniques will also be covered.

2. Preventive Maintenance/Painting (1-2 days) - To prevent metallic corrosion of steel bridges, proper painting is covered. Corrosion of reinforcing steel as well as steel members under a concrete deck can also be prevented by crack repair, sealing and other procedures. Replacement of reinforcing steel with treated bars will also be discussed. Other routine maintenance planning and procedures for bridges will be included.

3. Structural Repair (2-3 days) - This module will cover an overview of all aspects of repair of structure members of bridges (except painting and other non-structural activities). To be included are materials selection, equipment, work methods, and evaluation of alternatives. Planning and scheduling of repairs will also be discussed.

4. Deck Replacement (2 days) - When bridge decks have deteriorated to some level (to be determined) at which repairs are no longer viable, the deck must be scheduled for replacement. Methods for replacement as well as materials and equipment, alternatives analysis and improved decks will be covered.

5. Routine Bridge Maintenance (1-2 days) - This module covers the conduct of routine day-to-day preventive maintenance of both concrete and steel bridges. It includes cleaning and flushing, both superstructures and substructures and making routine (minor) repairs or replacements. In addition to procedures and methods, planning and scheduling of these activities will be covered in the context of a bridge maintenance management system.

IX. DRAINAGE

Module Topics:

1. Drainage Design Overview (3 days) - This module covers practical hydrological methods and techniques for analysis and design of highway drainage facilities. Included are estimations of peak flows, risk analysis.

2. Draining Structure Replacement - This module can be divided into four sub-modules dealing with an overview of analysis, design and construction/placement methods.

    a. Pipes (1-2 days) - Sizing (design), grade, excavation, placement, (trenching) bedding, back filling, end treatment and compaction. Replacing will include newer techniques of installation inside older pipes.

    b. Manholes (1-2 days) - Location design, installation and inspection will be covered as well as maintenance and replacement.

    c. Inlets (1-2 days) - Location, design, installation as well as maintenance and repair will be discussed. Replacement will also be covered.

    d. Culverts (1-2 days) - This will be an overview of culvert design, (normally a 4 day course) covering materials, hydrology, structural design, installation and inspection. Also maintenance repair and replacement will be covered.

3. Routine Drainage Facility Maintenance (2 days) - This module will cover maintenance requirements and procedures for various types of drainage facilities including frequency of maintenance action, planning and scheduling of work, inspection and record keeping. Alternative maintenance procedures could also be discussed.

X. GENERAL

Module Topics:

1. Routine/Recurring Maintenance (2 days) - This module will cover an overview of routine maintenance to include minor surface maintenance, minor drainage facility maintenance, and other activities which are conducted on a routine, repetitive basis.

2. Roadside Maintenance (1-1.5 days) - This module includes mowing, shoulder repair, slope maintenance to prevent erosion, planting, slope stability, and other maintenance activities related to the roadside. An overview, sufficient for a manager to understand and appreciate the scope and content of roadside maintenance is the goal.

3. Emergency Maintenance (1-2 days) - This includes all maintenance operations due to emergencies which result in temporarily closing a facility to traffic until permanent repairs/rebuilding are performed. The intent of this module is to familiarize the manager with requirements that involve mobilization, establishment of field office, communications, etc. to complete repairs in a timely fashion.

4. Rehabilitation (2 days) - Beginning in the middle 1970's, this category of activities was in both the construction (3R/4R) and maintenance arenas. Thus, some maintenance agencies are responsible for rehabilitation. The two most common methods of rehabilitation of pavements, milling and recycling, will be covered as will any new procedures for rehabilitation.

5. Plan Reading (1 day) - This module will provide basic concepts and principles of highway plans which should lead to understanding and reasonably proficient plan reading. An important output will be the ability to understand plan and construction notes in all disciplines (drainage, structures, etc.) of facility designs.

6. Environmental Concerns (2 days) - This module covers the various environmental issues related to maintenance activities and includes wetlands, erosion control, use of herbicides, paint, asphalt and other materials. Disposal of material containers is also of concern as is water and air pollution.

7. Laws and Regulations (1.5-2 days) - Several laws and regulations apply very much to maintenance while others are only peripheral to maintenance. This module will include coverage of all related laws and regulations with more detail on the most important ones, such as commercial drivers licensing, environmental and labor laws and regulations, OSHA regulations and many others. This is intended as a comprehensive overview.

8. Maintenance Contracting and Administration (2 days) - This module will cover the basic concepts for managing and administering a maintenance contract. Some types of maintenance contracting are pavement overlays and standby for winter maintenance. Some of the topics introduced are contractor/owner relationships, inspection and work orders.

9. Safety - This module is divided into two sub-modules

    a. Worker Safety (1.5-3 days) - This module covers safety of maintenance workers, in the field and in the shop/office and includes the following: (1) defensive driving; (2) CPR; (3) using the proper "tool" for each job, etc. Managers should know job safety analysis and its relationship to improved productivity, quality and safety. Safety inspections are also covered including identification of hazards and corrective actions.

    b. User/Public Safety (1.5-2 days) - This module will highlight the legal responsibility of the agency to provide reasonable safety to the highway users and general public through good work zone traffic control while performing maintenance activities. Specifically, this means complete and safe maintenance and environmental practices and general awareness of the public needs.

10. Value Engineering (3-4 days) - This module will familiarize the student with creative approaches, methods and techniques for making maintenance decisions. The basic concepts of value engineering, life cycle costing, hidden costs, total costs and engineering economic principles will be discussed.

11. Outdoor Advertising (1/2 day) - This module covers the agency policies and federal requirements (ISTEA) for regulation of outdoor advertising and junkyard screening and removal. Monitoring, reporting and facilitating the outdoor advertising and junkyard program for the agency will also be covered.

12. Utilities (1 day) - This module covers utility relocation activities and processes and their relationship to the highway agency. Responsibilities of each party and standards pertaining to repair of disturbed areas (trenching, digging etc.) will also be discussed.

13. Tort Liability and Risk Management (1.5 days) - This module will cover the legal/tort situation in the particular state and the general process of tort liability from inception of a suit through the deposition and court testimony steps. The real emphasis here is on risk management and how to minimize: (1) the likelihood of being sued, but (2) if sued, the likelihood of being liable. This second item is minimized by following standards and good practice and thorough and timely documentation of work.

APPENDIXES B, C, D, E, F

UNPUBLISHED MATERIAL

The Appendixes B, C, D, E, and F contained in the report as submitted by the research agency are not published herein. Their titles are listed here for the convenience of those interested in the subject area. For a limited time, qualified researchers may purchase copies of the agency report by sending $15.00 to the Transportation Research Board, Business Office, 2101 Constitution Avenue, N.W., Washington, DC 20418.

The available appendixes are titled as follows:

Appendix B—Knowledge and Ability Statements and Activity Descriptions
Appendix C—Survey of Maintenance Engineer/Manager Profiles
Appendix D—Survey for Review of Knowledge and Ability Statements and Activity Descriptions
Appendix E—Survey of Maintenance Training
Appendix F—Survey for Review of Educational Program

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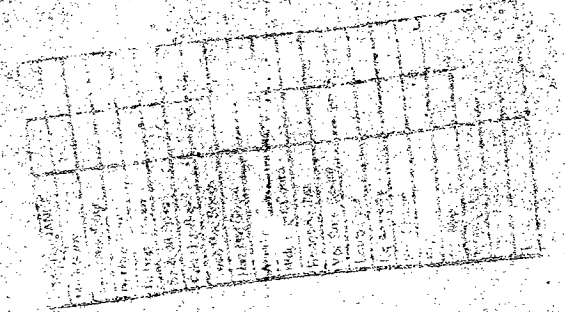

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