

An Overview of the Highway Maintenance Management Research Program in the United States

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Historically, highway maintenance management in the United States has experienced many changes during the past 50 years. Most of these changes came about through a process of gradual evolution and were based on intuition and pragmatical considerations rather than factual knowledge and scientific management principles. Results of this process were reasonably adequate during the era between 1920 and 1949. Most maintenance organizations were satisfied with the status of their management and thus had no real reason to adopt a more sophisticated procedure. It is therefore not surprising to discover that maintenance management research was of little consequence during these years. Studies were few in number, limited in scope and uncoordinated. Most were carried out informally, making it difficult to even document their existence. It would definitely be misleading to say either that these efforts had a significant impact or that they constituted any kind of a research program.

In June 1950, an event occurred which signaled the beginning of an organized, formal maintenance management research program in the United States—the initiation of the Connecticut Maintenance Study—a joint venture of the Bureau of Public Roads and the Connecticut State Highway Department. Its principal objectives were to: (a) develop basic facts concerning the performance of labor and equipment on field operations, and (b) appraise management problems. Study results indicated that there were a number of deficiencies and problems associated with field operations and showed the need for continued research. Prophetically, the report stated:

The further development and extension of the groundwork encompassed by this study can lead to the establishment of units of work and standards of maintenance accomplishment, thus making possible the estimation of labor and equipment requirements to perform the maintenance obligation in a particular area under certain given conditions.

The program continued during the eight years which followed the Connecticut Study primarily because the Bureau of Public Roads retained an interest in such research. About 20 small-scale studies were conducted on the field operations of state maintenance organizations. Results were not extensive enough to fully delineate management problems, but did serve to verify two hypotheses: (a) results of the Connecticut Study provided a good picture of the situation in other states; and (b) many management problems were common, varying only in degree from organization to organization.

The program received an impetus in 1959 when the Bureau of Public Roads and the Iowa State Highway Commission joined to conduct a study which was considerably larger in scope. The Iowa Maintenance Study was primarily designed to produce facts which could be used by management for controlling and improving the economy of maintenance operations. It involved collection of basic data concerning the performance of labor and equipment on field operations, variations in total work-loads, work units, utilization of supervisory personnel, and other aspects of maintenance management. Considerable emphasis was placed on analysis of data to pinpoint problems and develop possible solutions. In a few cases, proposed solutions were tested for practicality.

The Iowa Study received considerable publicity during 1960 and 1961. Its findings were accepted by many maintenance managers as indicative of the situation in their

own organizations. About the same time other forces began operating to change these managers' attitudes toward management and management research.

Between 1960 and 1967, maintenance organizations in this country were subjected to a number of external pressures which caused severe internal stresses. Among the most intense pressures were those due to:

1. Addition of new facilities on the Interstate and other systems.
2. Public demands for higher and higher levels of maintenance.
3. Rapid changes in the technology of highway design, materials and equipment.
4. A labor market which could not supply an adequate number of qualified personnel.
5. Constrictions on maintenance budgets to make the maximum amount of funds available for badly needed construction projects.
6. Campaigns to tighten up the fiscal and administrative control of highway organizations.

The type of management which had been getting by for many years was not able to cope with the stresses induced by these pressures. Problems multiplied and managers became painfully aware of what was happening. Many concluded that their organization's management was deficient and needed to be improved. As attitudes toward management changed, there was increased interest in all kinds of management research. The organized, formal program expanded considerably between 1960 and 1967 with studies covering a wide variety of subjects.

In Louisiana, there were three studies which related to costs for maintaining specific types of roads. These studies, conducted by Louisiana State University, were aimed at developing a procedure for estimating costs through the use of mathematical regression models based on historical fiscal records. A study conducted in Idaho by the University of Idaho had a similar objective and used much the same procedure. The Oklahoma Department of Highways also undertook a study of maintenance costs for specific types of roads using a technique which took into consideration both historical fiscal data and deterioration ratings for selected test sections.

A major study of maintenance costs was conducted for the National Cooperative Highway Research Program by a consultant, Bertram D. Tallamy Associates. This study was primarily directed toward developing a method for predicting Interstate System maintenance requirements. The technique used was similar to techniques used for the aforementioned state studies. Cost data from selected test sections across the nation were analyzed to develop mathematical models for seven groups of maintenance activities which could be used to predict "requirement units." A secondary objective of the study was to develop a new maintenance expenditure index.

In Louisiana, the University undertook a study to establish optimum equipment and work methods for mowing highway roadsides. A second study on mowing roadsides was conducted by the Indiana State Highway Commission. Emphasis was placed on developing comparative costs for different types of roadsides and mowing methods. The Ohio State University also carried out a research study to determine the most effective means of caring for Interstate roadsides.

In Illinois, New Jersey, New York, and Wisconsin, Bertram D. Tallamy Associates conducted a series of studies for state highway departments and toll road authorities. They were designed to establish long-range requirements for major maintenance on high-type facilities. These studies utilized new techniques for predicting pavement deterioration in conjunction with detailed field inspection of facilities.

A major study was undertaken by H. B. Maynard and Company and the City of Los Angeles. The objective was to develop a program which would improve the planning, directing and controlling of labor and equipment assigned to various field activities. An important feature of this study was the use of the methods-time measurement industrial engineering technique to analyze each activity and to develop standards for work methods and performance. The same consultant recently worked with the San Diego County on a study which had a similar scope and objectives.

Booz-Allen and Hamilton carried out a study in Minnesota which utilized industrial engineering techniques to develop improved work methods, establish performance

standards, and improve the maintenance reporting system. The same firm conducted a similar study of somewhat smaller scope in New Jersey.

The largest single study was carried out by the Virginia Department of Highways with the assistance of Roy Jorgensen and Associates. This effort lasted for three years and was designed to cover nearly every major aspect of maintenance management. It involved collection of data concerning performance of labor and equipment, development and testing of improved work methods; establishment of quality, quantity and performance standards; development and testing of a new reporting system; development and testing of a budgeting system; development and testing of training material; and work in several other areas.

These studies were all started and essentially completed during the eight years ending in June 1968. They provide a good indication of the extent and scope of activities during this period but do not account for the entire research program. Nine other studies started between 1960 and 1967 have not been listed because they are still active and will be described subsequently. A few other studies, generally of limited scope, were omitted because of space limitations.

One other aspect of completed studies deserves mention. More than half were funded through the Federal-Aid Highway Planning Research Program. This program provides for joint state-federal financing of research in areas which have a significant influence on highway transportation in the United States. For many years, maintenance management has been recognized as one of these areas. In 1964, this position was emphasized when a project for maintenance operations and management was included among the 27 top priority projects of the National Program for Research and Development in Highway Transportation. Partly as a result of this emphasis, annual Federal-aid expenditures in this area have more than doubled in the last 5 years.

Currently, the maintenance management research program includes 13 formal studies which are fully active. Eleven of these are being financed through the Federal-aid HPR program. Their estimated total cost is over \$2,000,000 and annual expenditures are about \$700,000. The other two studies are financed entirely with state funds. Their estimated total cost is over \$500,000 and annual expenditures are about \$150,000. The nature and scope of these studies varies considerably. Six can be classed as comprehensive because they cover several aspects of maintenance management, five deal with the equipment and methods for specific activities or functions, and two are concerned with costs. The following summaries present pertinent facts about each study:

<u>Study title:</u>	Maintenance Practices
Sponsoring agency:	Arkansas State Highway Department (Federal-Aid HPR Program)
Conducting agency:	Arkansas State Highway Department
Estimated total cost:	\$169,000
Period:	July 1967-July 1972
Objectives:	<ol style="list-style-type: none"> 1. Evaluate the maintenance accounting system and revise as needed. 2. Define maintenance standards. 3. Evaluate existing maintenance practices and develop improved practices. 4. Identify training needs; develop and test training materials.
Current status:	Work plan approved. Recruiting staff.
<u>Study title:</u>	Maintenance Management
Sponsoring agency:	Louisiana Department of Highways (Federal-Aid HPR Program)
Conducting agency:	Joint-Louisiana Department of Highways-Roy Jorgensen and Associates
Estimated total cost:	\$575,000

Period: September 1965-July 1969

Objectives:

1. Define responsibilities and functions for various management levels.
2. Evaluate training needs; develop and test training materials.
3. Develop and pilot test a maintenance work reporting system.
4. Determine the most effective methods and staffing for maintenance activities.
5. Establish maintenance standards for quality, quantity, and productivity.
6. Develop and test an overall maintenance management system.

Current status: Work on first three objectives nearly complete. Three reports published. Reporting system implemented.

Study title: Comprehensive Maintenance

Sponsoring agency: North Carolina State Highway Commission (Federal-Aid HPR Program)

Conducting agency: North Carolina State Highway Commission

Estimated total cost: \$220,000

Period: July 1966-December 1972

Objectives:

1. Determine the adequacy of the maintenance organization to carry out its assigned responsibilities and functions.
2. Evaluate the present maintenance management system with emphasis on reporting.
3. Determine the relationship between maintenance costs and factors such as traffic.
4. Determine major maintenance operations whose efficiency and economy can be improved; develop improved methods, etc.
5. Evaluate maintenance facilities and materials.

Current status: Work now in progress on first objective.

Study title: Highway Maintenance Management

Sponsoring agency: South Dakota Department of Highways

Conducting agency: Joint-South Dakota Department of Highways-Roy Jorgensen and Associates

Estimated total cost: About \$300,000

Period: July 1968-October 1970

Objectives:

1. Develop and test quality, quantity and productivity standards for maintenance activities.
2. Develop and test a maintenance work reporting system.
3. Develop and test a maintenance work scheduling process.
4. Develop and test a maintenance budgeting process.
5. Develop a methods and training unit.
6. Conduct a performance laboratory to test developments.

Current status: Work just getting under way.

Study title: Maintenance Management

Sponsoring agency: Utah State Road Commission (Federal-Aid HPR Program)

Conducting agency: Joint-Utah State Road Commission-Roy Jorgensen and Associates

Estimated total cost: \$285,000

Period: April 1967-August 1969

Objectives:

1. Establish quality, quantity and productivity standards for maintenance activities.
2. Develop and test a maintenance work reporting system.
3. Design, develop and test an overall maintenance management system.
4. Evaluate the field organization and resource utilization.
5. Prepare a plan for improving maintenance performance.

Current status: Work under way on most objectives.

Study title: Maintenance Improvement Program

Sponsoring agency: Washington State Highway Commission

Conducting agency: Joint—Washington State Highway Commission-Booz-Allen and Hamilton

Estimated total cost: About \$250,000

Period: July 1967-December 1968

Objectives:

1. Develop standards for measuring performance of maintenance operations.
2. Establish procedures for maintenance planning and scheduling.
3. Provide data for improved maintenance budgeting and control.
4. Train maintenance supervisors.

Current status: Work under way on all objectives. Several training manuals prepared.

Study title: Tunnel Cleaning Method

Sponsoring agency: California Division of Highways (Federal-Aid HPR Program)

Conducting agency: California Division of Highways

Estimated total cost: \$117,000

Period: July 1967-June 1972

Objectives:

1. Develop a tunnel cleaning method that is rapid, economical, nonhazardous and nondestructive.

Current status: Work under way on equipment design.

Study title: Cost Effectiveness of Anti-Skid and De-Icing Programs in Pennsylvania

Sponsoring agency: Pennsylvania Department of Highways (Federal-Aid HPR Program)

Conducting agency: Pennsylvania State University

Estimated total cost: \$20,000

Period: July 1968-June 1970

Objectives:

1. Study and evaluate existing snow and ice control practices.
2. Develop improved methods, equipment and materials for snow and ice control.

Current status: Work just getting under way.

- Study title:** Winter Maintenance for Bituminous Pavements
- Sponsoring agency:** Texas Highway Department (Federal-Aid HPR Program)
- Conducting agency:** Texas Transportation Institute
- Estimated total cost:** \$36,000
- Period:** September 1967-August 1969
- Objectives:**
1. Evaluate existing practices for winter pavement maintenance.
 2. Develop improved methods, equipment and materials for winter pavement maintenance.
- Current status:** Work on first objective completed.
- Study title:** Snow Removal and Ice Control Techniques at Interchanges
- Sponsoring agency:** National Cooperative Highway Research Program (Federal-Aid HPR Program)
- Conducting agency:** Bertram D. Tallamy Associates
- Estimated total cost:** \$50,000
- Period:** September 1967-July 1969
- Objectives:**
1. Identify and evaluate the factors which influence the efficiency of snow removal and ice control operations at interchanges.
 2. Develop operational systems that will provide for efficient snow removal and ice control procedures on interchanges in both rural and urban locations.
- Current status:** Field work completed on first objective.
- Study title:** Develop Performance Budgeting System to Serve Highway Maintenance Management
- Sponsoring agency:** National Cooperative Highway Research Program (Federal-Aid HPR Program)
- Conducting agency:**
- Estimated total cost:** \$250,000
- Period:** September 1968-October 1970
- Objectives:**
1. Develop and test a model highway maintenance budgeting system.
- Current status:** Contractors selected for Phase I preparation of detailed work plan.
- Study title:** Maintenance Formula Application
- Sponsoring agency:** Louisiana Department of Highways (Federal-Aid HPR Program)
- Conducting agency:** Louisiana Department of Highways
- Estimated total cost:** \$60,000
- Period:** July 1963-July 1969
- Objectives:**
1. Accumulate accurate cost data for testing and revising mathematical models to predict maintenance costs.
- Current status:** Data collected and summarized for 5-year period.

Study title:	Maintenance Cost
Sponsoring agency:	Ohio Department of Highways (Federal-Aid HPR Program)
Conducting agency:	Ohio Department of Highways
Estimated total cost:	\$380,000
Period:	July 1961-July 1972
Objectives:	<ol style="list-style-type: none"> 1. Determination of reliable maintenance costs. 2. Determine the influence of major factors which contribute to maintenance costs. 3. Measurement of the level of maintenance and determination of the extent to which deficiencies exist in the current maintenance and operation of the highway system.
Current status:	Data collected and summarized for 6-year period. Preliminary analysis made and several interim reports published.

The descriptions of the studies which constitute the current program were, of necessity, lacking in detail. However, they do give an indication of its depth and breadth. It should also be recognized that there are other current informal research efforts such as those under way in Illinois, New Jersey and New York which may ultimately become a part of the formal program.

Up to this point, emphasis has been placed on describing the research studies which have been or are being conducted under the program. Now, it is time to look at some of the significant results which have come out of these efforts.

1. It has been clearly demonstrated that management in most highway maintenance organizations is beset by a number of problems including:
 - a. Inadequate factual data concerning field activities.
 - b. Nonuniform standards or a lack of standards.
 - c. Ineffective procedures for planning and scheduling work.
 - d. Widely varying quality, productivity and unit costs for field activities.
 - e. Ineffectual means of comparing actual and desired quality, service level and unit cost for maintenance activities.
 - f. Lack of a reliable means to forecast long-range maintenance requirements.
 - g. Lack of a means to evaluate alternative policies.
 - h. Shortage of trained personnel.
2. New systems for maintenance field reporting have been developed and proved capable of supplying the kind of information needed for management, fiscal accounting and research purposes.
3. Quality, quantity and performance standards for maintenance activities have been developed and proved practical for operational use.
4. Techniques for planning and scheduling maintenance activities on a long-range and daily basis have been developed and proved practical.
5. A large fund of data concerning the work methods, time utilization and productivity of labor and equipment under typical field conditions has been accumulated and analyzed to determine some cause-effect relationships.
6. Procedures for determining optimum staffing patterns and work methods have been developed.
7. New equipment and methods have been developed and proved practical and economical for several maintenance activities.
8. Performance budgeting systems for maintenance are being developed and tested for practicality.
9. Procedures and data for forecasting long-range maintenance requirements have been developed and proved useful.
10. Techniques to enable management to evaluate alternative policies for investments, resource allocation, staffing and other aspects of maintenance are being developed.

11. Some materials and procedures for training maintenance personnel have been developed and tested.

At the present time it would be unrealistic to state that these research results have been widely translated into improved management. The current attitudes of administrators and managers have created a favorable climate for such use but, unfortunately, each maintenance organization must operate under its own set of conditions and constraints. Thus, it is usually necessary to undertake some additional research just to adapt results for a particular situation. This takes time. Still more time is required for the actual implementation. Hopefully, a significant number of organizations will soon begin to make use of available research results, but even so, it may be five years before there will be widespread improvement in maintenance management and operations.

Finally, everyone involved in maintenance management research needs to keep in mind that the objective is not simply improved management. That is only the key which unlocks the door leading to the ultimate goal—effective and efficient maintenance for the highway systems of this nation.