# Trends and Countertrends in Maintenance Management Systems

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ABSTRACT

There are a number of trends and countertrends in the evolution of systems being used to manage road and street maintenance. Current trends appear to help satisfy the need for better information and to promote broader acceptance of system concepts. Managers in several maintenance agencies have combined the traditional financial and performance budgets common to maintenance management systems. Many more have integrated maintenance management and cost accounting systems. The resulting plans are far more realistic and the accounting for expenditures is far more accurate than the model system designed nearly 20 years ago. Advances in automated data processing have significantly increased the value of system concepts and procedures; and the need for better information is being satisfied by better pavement maintenance data. Pavement management systems are beginning to provide data that are helpful in defining the kinds and amounts of work that need to be done. Other trends include (a) maintenance standards that take into account local and regional needs and (b) increased use of data from system components in making decisions about contract maintenance and in determining equipment needs. Countertrends--trends that seem to ignore the historical perspective--include a reduced life expectancy for maintenance work programs, fewer defined activities, and simplified inventory procedures.

Nearly 20 years ago engineers in two state highway departments began changing the way they managed road and street maintenance. Today the resulting model--a maintenance management system--serves the needs of almost all state highway and transportation agencies, hundreds of county and local maintenance agencies, and dozens of foreign nations. During those 20 years the model has been refined repeatedly, and some solid trends have evolved from these refinements. These trends can be grouped under three major headings:

1. Trends that help satisfy the need for better information,
2. Trends that promote broader acceptance of system concepts, and
3. Countertrends that appear to ignore the historical perspective.

A number of trends and countertrends are presented in this paper. They are drawn from a review of maintenance management literature and the author's work in designing and implementing maintenance management systems.

## TRENDS THAT PROVIDE BETTER INFORMATION

Many trends in the design and operation of maintenance management systems reflect the need for better information to support decision makers and to make the system more acceptable to maintenance managers. Trends toward better budgeting and cost information and increased use of automated data processing are already well established. Another trend toward better use of pavement maintenance data is beginning to supplement traditional approaches to establishing maintenance service levels.

### Better Budgeting and Cost Information

System models have been widely used to support budget requests for maintenance. The typical practice is to prepare two budgets--a financial, line-item budget and a performance (or program) budget that provides details of planned work quantities and costs, by maintenance activity. The elected official makes budgeting decisions based on the financial budget, and the performance budget is used mainly for internal justification.

Some county and local agencies, however, have combined financial and performance budgets in ways that satisfy fiscal requirements and, at the same time, relate service-level and performance objectives to planned expenditures (1). Some are presenting financial and performance data side by side. For example, one side of the page specifies, by function and object of expenditure, the proposed budget; the other side lists, by activity within the function, the total quantity and frequency of the planned work. Another format illustrated in Figure 1, describes the reason for doing the work, the planned service level, total cost, and line-item values for each activity. These and similar formats require far more preparation time and effort than a traditional line-item budget, but they make clear to the elected official the services that will be provided.

Far more common is the trend toward integrating maintenance management and cost accounting systems. Almost all early system designs (and most of the designs in the 1970s) rely on existing cost accounting systems to capture actual maintenance costs, typically by line item. For separate maintenance management accounting, average unit costs or standard costs are used to estimate the amount of money spent on a given activity, function, or program. As a result maintenance managers and accountants often cannot agree on how much money has been spent. Even in instances where adjustments are made in an attempt to account for the differences, a 4 to 7 percent spread, by function and in total dollars, is common (2). The total spread in a typical state maintenance agency can amount to $4 or $5 million--a spread that is not ignored by top management or elected officials.

Differences in accounting systems have been eliminated or at least minimized in several state agencies, including those in Florida, Kansas, New Hampshire, and Oklahoma (3). The majority of new systems provide a full accounting of expenditures

**PROGRAM**

A budget category

*Example:* *"Road and Street Maintenance"*

**PROGRAM OBJECTIVES**

A brief listing of objectives related to major activities

*Example:* *"Pavement line striping performed annually or as needed to delineate traffic lanes and thereby promote traffic safety."*

**PLANNED SERVICE LEVELS AND COSTS**

Specific effort levels or annual work quantity values along with total funding requirements

*Example:* *"3,950 miles of lane line and pavement edge striping - $643,000"*

**RESOURCE NEED AND PROPOSED BUDGET**

| Object of Expenditure | Resource Quantity | Actual/Proposed Budget |
|---|---|---|
| Line item code | Total current and proposed quantities of people, equipment, materials and services | Total of last year's actual expenditures, current budget values and proposed budget |
| *Example: "101-320-002* | *Mtce. Worker II 1.2. 1.2* | *$19,872 $20,050 $20,610"* |

**FIGURE 1 One format for combining financial and performance budgets.**

that satisfies both management and fiscal control needs. Many maintenance management and cost accounting systems are integrated to the extent that the accounts balance to the dollar. The effort needed to achieve the balance, illustrated in Figure 2, varies from one organization to another but, in general, includes at least four actions:

Single source reporting. All maintenance management and cost-related data are reported daily in one document by the individual or crew. The labor, equipment, and materials used are translated into dollars, usually by means of automated resource cost tables that are updated daily or by accessing regular accounting ledgers.

Modified account coding. The agency's chart of accounts is refined to accept maintenance activity codes and to relate each activity to various sources of revenue, objects of expenditure, or account element.

Modified materials accounting. The function of the traditional inventory account is expanded, so maintenance materials can be costed out as they are used rather than when the invoice is paid. Adjust-

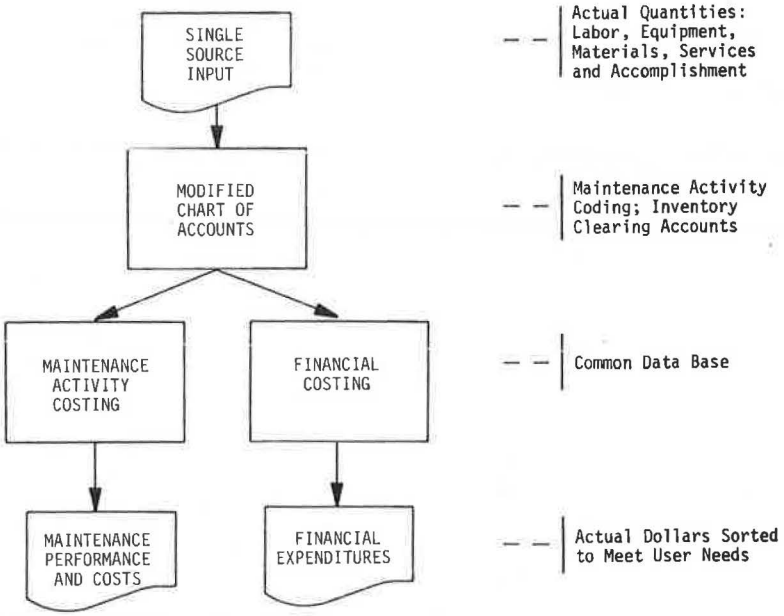


**FIGURE 2 Overview of a typical integrated maintenance management and cost accounting system.**

ments also are made to account for maintenance materials manufactured or processed by the staff.

Informal account closing. The official closing or posting periods are retained, but accounts are also informally closed each day.

Indirect and administrative costs are handled in the normal manner and are usually added to maintenance activity reports. In any event the maintenance manager and the accountant are reporting the same dollar expenditure, and both are looking at the expenditure in ways that are meaningful to the other (4).

## Increased Use of Automated Data Processing

Recent advances in computer hardware and computer programming techniques have promoted increased use of automated data processing to support maintenance management systems. Both district and headquarters offices have replaced centralized data entry with remote terminal entry of both planned and actual values. Batch processing is being replaced by online, interactive handling of a variety of maintenance management data. A number of state organizations, such as Arizona, Minnesota, and Montana, also have adopted a data-base technology that allows agency managers to create performance and cost analyses that are displayed in a wide array of screen and hard-copy formats.

Maintenance staffs in a few county and local public works agencies, such as Clallam County, Washington, and Little Rock, Arkansas, also are advancing the state of the art. Systems in these agencies incorporate capabilities that were on the drawing boards (or in computer files) just 3 or 4 years ago. For example, microcomputers or microcomputers linked to mainframes have been programmed to provide answers to "what if" questions in a matter of seconds instead of hours. The programs recalculate maintenance work plans, budgets, monthly work load distributions, and resource needs to reflect a host of actual or projected circumstances. Some of the programs automatically update feature inventories, create and monitor specific work orders, and assist in establishing work priorities (5).

Other programs store work quantity and expenditure data, by activity and general location, in ways that will be helpful in projecting future maintenance needs and costs. All are designed to produce performance and cost reports in tabular or graphic displays, usually in real time. Actual work accomplished, productivity, unit cost, and total cost, by maintenance activity, can be determined as soon as the files are updated. Turnaround time has been minimized to the point where an activity or project can be monitored day by day without the need for a separate, manual set of records.

A number of other hardware and software configurations being applied today represent experiments in the use of computer-generated information rather than solid trends. Some of these applications will, no doubt, become trend setters.

## Better Pavement Maintenance Data

One of the weaker links in maintenance management is the system(s) used to estimate the effort level, service level, or work quantity standard. This weakness is being strengthened by the data provided by pavement condition surveys and, to a limited extent, pavement management systems. The majority of maintenance management systems implemented during the last two decades define planned amounts of maintenance as a function of the quantity of maintainable physical features and a calculated estimate of the average amount of effort, service, or work quantity needed to meet certain objectives. The actual condition of the features is not specifically considered in the equation. Over the last few years, however, the typical "inventory times quantity standard" calculation has been supplemented by field condition surveys that help establish total work quantities by activity and route section or organizational unit. State maintenance agencies in Illinois, Louisiana, North Dakota, Ohio, and several others, for example, are known to use pavement condition data in a planned, systematic manner.

Another trend--development and refinement of pavement cost models and pavement management systems--is generating considerable interest. Models and systems designed several years ago have been refined and are now being used by several agencies to (a) create an appropriate data base of point-in-time pavement conditions, (b) categorize pavement conditions through various indicies, and (c) establish certain maintenance and rehabilitation strategies on both a project and network level. Because some of the sophisticated models and systems have been simplified, maintenance managers are beginning to take advantage of pavement management concepts.

A number of officials in transportation and public works agencies have retained pavement management consultants to help establish overall maintenance and rehabilitation programs and to project the costs of various alternative strategies. Maintenance engineers and maintenance management specialists, however, are somewhat skeptical of the improved cost models and systems. In general, three problems are cited.

Lack of validity. One system being tested and publicized on a broad scale for use in county and local governments assumes that pavements deteriorate in a straight-line manner. Actual observations, however, indicate that the rate of deterioration accelerates as pavement age increases, especially toward the end of its useful life. Another popular system assumes that (on an agency-wide basis) the history of maintenance efforts and expenditures has no influence on current and future maintenance or rehabilitation needs. Both assumptions are discounted by many maintenance engineers and maintenance management specialists.

Misinterpretation of actual cost data. Many road and street maintenance agencies provide maintenance cost data that is used as input to the models and systems. This accumulation of information based primarily on cost factors can be interpreted in several ways. For example, it is not clear whether a high maintenance cost reported for a given location means that rehabilitation is needed or that the effort associated with the cost has significantly reduced the need for maintenance. Negligible maintenance costs for another location might be associated with a portion of old but solid pavement or one that is being ignored because the maintenance supervisor thinks he is throwing good money after bad by patching a portion of deteriorated pavement that is in the program for rehabilitation or resurfacing.

Limited application. The models and systems focus on paved surfaces. They do not address a significant number of other features and related maintenance activities--work that in some agencies accounts for well over one-half the total work load and budget.

Many of these and related problems are being overcome. In the meantime maintenance management systems are employing techniques that rely on historical data, feature inventories, and simple condition assessments to help define appropriate levels of effort, service, or work quantity.

## TRENDS THAT PROMOTE BROADER ACCEPTANCE OF SYSTEM CONCEPTS

The literature on managing highway and street maintenance contains several references to refinements of system models. Many refinements focus on improved standards or an increased use of system elements. Both reflect a trend that promotes a broader (and a more realistic) acceptance of system elements.

### Improved Standards

The work quantity and performance standards used in several of the earlier system designs reflected an agency-wide approach. They rarely considered the variety of factors that influence actual maintenance needs and crew performance, especially from one geographical area to the next. Also, the amount of effort needed to achieve a given level of service or performance was treated as a constant: X amount of effort equaled Y service level, and X combination of people and equipment, on the average, produced Y results.

By 1970 some of the constant values for a few activities were being treated as variables, usually through exception routines. Today the exceptions have become common. Quantity and performance standards in many state systems take into account differences in local or regional factors such as facility conditions, traffic volumes, local climates, and regional drainage characteristics (6).

The current process for developing standards also reflects increased levels of involvement by the field staff. Several agencies, especially in county and local jurisdictions, are employing quality circle techniques to help with decision making in areas where the field supervisor is directly involved, including work methods, crew and equipment arrangements, and work scheduling procedures.

### Increased Use of System Components

The use of a maintenance management system tends to evolve in response to certain interests and issues. Traditional interests, such as improved maintenance planning and increased productivity, have fostered the use of system components to address a given issue. For example, during the 1973 fuel shortage maintenance management analysts in Arizona, California, and several other states used work programs and performance standards to help identify fuel consumption patterns and to define the effects of fuel allocations on maintenance plans and budgets. Today the issues are contract maintenance and equipment needs, and both reflect a trend toward increased use of system components.

#### Component Use in Contract Maintenance

The decision to contract out certain kinds of maintenance is being influenced by traditional concerns and by analyses of data generated by certain system components (7). System-generated data related to staffing levels, equipment needs, work load distributions, and work performance can be used to evaluate the potential costs and benefits of using contractors. In several instances, the decision to employ a contractor has been based on an analysis of data from the system components. This analysis provided an indication of how such an arrangement would affect the overall function of the maintenance activity. For example it provided answers to questions such as the following:

- What specific impacts will a contract have on staffing levels and equipment needs?
- What specific impacts will a contract have on current work load distributions?
- To what extent will a contract reduce peak-season work loads or create slack-season problems?
- Can a contractor be expected to employ standard work methods? Can the standard help define the work?

Several public works and transportation agencies, especially local maintenance agencies in California, Colorado, and Oregon are taking advantage of these system capabilities.

#### A New Focus on Equipment Needs

The need for specific numbers and types of equipment, as documented by many maintenance management systems, has been largely ignored by top management and elected officials. More recently, however, interest in obtaining better data on equipment management is prompting some officials to carefully examine the relationships between actual utilization and equipment needs. Hard questions are being asked about the need for certain units; and maintenance management systems are providing some answers. Sometimes these answers verify that low utilization is the result of a work program that requires far fewer units than are on hand.

## COUNTERTRENDS

The foundation of traditional maintenance management concepts is being repaired and rebuilt in an evolutionary manner. Some of the trends, however, appear to ignore the historical perspective and are proceeding in the opposite direction. Changes in the expected life of a maintenance work program, refinements in defining activities, and simplified inventory procedures are among the countertrends.

### Work Program Duration

The useful life of an annual maintenance program is being challenged. The original system models provided for an annual work program, i.e., one that was expected to be valid for an entire year. Adjustments were acceptable only in instances where natural disasters or unusually severe weather prohibited compliance with the plan.

Work programs prepared today are still developed on an annual basis, in conjunction with budget preparation, but very few serve as a 12-month plan. Most are subjected to relatively minor, but formal, adjustments at least once or twice a year. The result tends to be a work program that is more effective and far more responsive to changing maintenance needs and conditions, such as a growing season that calls for one more mowing than planned or an early fall that curtails the planned amounts of preventive maintenance. Midyear budget adjustments, becoming common in county and local agencies, also demand midyear refinements in maintenance plans.

### Redefining Maintenance Activities

A number of maintenance management systems implemented before 1980 have more than 100 defined activities. Some describe almost 400 kinds of work; and the general trend has been toward defining activities even more precisely. On the other hand, some agency managers are consolidating activity lists. The Oklahoma DOT, for example, uses less than one-half of the 125 kinds of work that were defined at the outset. Many of the systems being implemented today define less than 50 activities. Pavement

maintenance tends to be defined in a traditional manner; but roadside, sign, and drainage maintenance are being described in far broader terms than in earlier system designs.

## Simplified Inventory Procedures

The traditional approach to conducting an inventory of maintainable features calls for a physical count or measurement of all features. Pavement management systems demand considerably more detail of pavement surface characteristics. Recent research, however, (and some simple logic) suggests that there may be no need for a complete and detailed inventory of all features. Carefully structured, random sampling of such features as roadway signs and minor drainage facilities appears to provide sufficiently accurate data for developing work programs and budgets.

For example, in 1982 the maintenance staff in Shasta County, California, concluded that because a complete inventory of road and street surfaces and bridges already existed, there was no need for a recount of these features or an initial count of all other maintainable items. A 10 percent random sample of the other maintainable items, such as signs, culverts, and maintainable ditch areas, was inventoried. Extensive follow-up inventories indicated that the samples were within 13 percent of the actual number of items in the inventory (8). Comparable techniques and levels of accuracy have been verified in two other county road maintenance agencies.

The savings associated with not taking a complete inventory of these features can be significant. In addition, the sampling technique appears to be a sensible way to inventory features that represent minor portions of the maintenance budget, especially in view of how effort, service, or work quantity standards are established for maintaining these features.

These and other trends (and countertrends) suggest that maintenance management systems are becoming more responsive to user interests and, as a result, more effective than the pattern that was established nearly 20 years ago.

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