MAINTENANCE DATA

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The questions of what type, how much, how accurate, at what cost, and for what purpose--related to maintenance data--are timely. Maintenance management has evolved in the last 30 years from a 1951 federally financed work methods research study in the Connecticut Highway Department through the development and implementation of sophisticated maintenance management systems in most of the states in the United States. Since the first comprehensive system was designed and implemented almost 15 years ago, much has been learned about making systems more effective. Many modifications have been incorporated. Many additional opportunities for improvement still exist.

Recent discussions have centered around the types and amounts of data necessary for the effective management of the maintenance function. These discussions have been motivated by the following realizations:

1. Reporting requirements have become so detailed that field input data are often invalid and therefore raise serious doubts about report credibility;
2. Existing systems generate reports too numerous and voluminous to provide practical assistance in managing maintenance operations;
3. Expectations regarding data accuracy exceed the practical abilities and/or capacities of the field recording personnel;
4. The full costs of maintenance data collection have become excessive when the very real costs of frustration and the resulting loss of interest by the field personnel are included; and
5. Emphasis has been on computerized reports for upper- and middle-management whereas management system effectiveness depends on lower-level managerial control.

Some proposed solutions to these developments include simplifying data input processes by using hand-held portable recording devices. It has also been suggested that solutions lie in the development of improved management report formats. These certainly represent opportunities that warrant pursuit. However, there is a more basic need to step back and reassess the types, amounts, and accuracy of that maintenance data necessary to effectively manage operations.

Satisfying that need for reassessment involves a look back at the results of the maintenance management research conducted some 15 years ago. The purpose of this is to once again identify those factors most influential in determining maintenance effectiveness. It is the collection of data related to those factors with which maintenance management reporting systems need to be primarily concerned.

The intent of this paper is to stimulate thought about and suggest an approach to reevaluating maintenance management reporting systems through

1. A review of the key management factors;
2. Consideration of how much reporting detail is enough;
3. A review of the full costs of reporting systems; and
4. A review of their use to field management.

KEY FACTORS

What, then, are the data needs that are practical and key to effective operation?

Early maintenance management research findings identified the influence of management decisions on the costs of maintenance. Managers' decisions regarding work methods, crew sizes, and service levels were defined as major determinants of cost effectiveness.

Figure 1 illustrates the point well. Two management units, "A" and "B", in one agency were selected as being comparable in terms of work load, traffic volume, traffic type, age of pavement, weather, and terrain. The managers of both units reported to the same supervisor. The supervisor, upon questioning, felt both managers were performing satisfactorily and results were equal. The supervisor's conviction as to comparability was further demonstrated by his allocation of essentially equal financial resources to both units "A" and "B" ($879.58 and $894.09 per mile, respectively). Yet from an evaluation of the ways in which each unit manager expended his resources, it is apparent they made different "management decisions" affecting costs.

Given the comparability of all other factors, each supervisor's decisions regarding crew size, work method, and/or service level had significant economic impact. A combination of those decisions resulted in unit "A" expending (a) 50 percent less on surface work; (b) 50 percent less on shoulders;

Figure 1. Comparison of per-mile maintenance costs for units A and B.

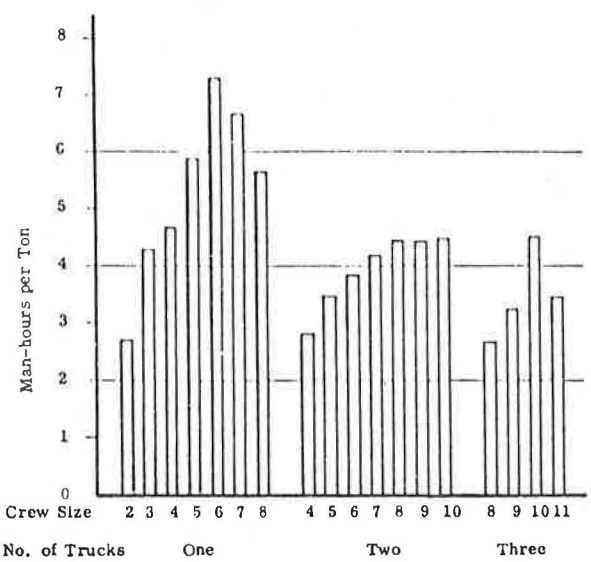
Maintenance Activity	Total $/Mile Unit A	Unit B
Surface	$ 85.20	$166.10
Shoulders	94.92	176.33
Mowing	102.82	83.41
Forestry	39.03	83.80
Clean R.O.W.	43.52	57.61
Parks and Picnic Sites	30.70	.63
Drainage and Structures	251.39	138.40
Bridges	44.83	4.54
Signs	115.01	98.66
Other Miscellaneous	72.16	84.61
TOTAL	$879.58	$894.09

These are three-year average annual costs.
Units A and B are adjacent with comparable roads and terrain.

Figure 2. Productivity related to staffing (man-hours per ton of premix patching).

Organization Unit	One Truck Number of Men in Crew				
	2	3	4	5	6
1	7.27	10.57	12.38		
2		7.48	10.23		13.18
3		11.06	13.82		15.39
4	5.05	5.73	10.40		
5	2.95	3.05	3.85	4.20	5.86
6	6.57		11.23	11.40	15.69
Average All	3.34	4.12	6.17	8.82	11.60

Figure 3. Productivity related to staffing (man-hours per ton of skin patching).



(c) 25 percent more on mowing; and (d) 50 percent less on forestry--to point out just some of the differences. The significant point is that the results--as far as their supervisor was concerned--were both satisfactory and essentially comparable, yet the differences from a cost-effective standpoint were striking. This example from early research in Ontario, and duplicated in numerous agencies since then, represents convincing evidence that management decisions regarding what is to be done (service level) and how it is to be done (work method and crew size) are key controllable determinants to effective highway maintenance management.

Work method decisions affect the crew size, equipment types and numbers, and the material types and quantities that are required to perform a maintenance activity. By ensuring the consistent selection of the most appropriate method, major cost and effectiveness factors are predefined.

Figure 2 illustrates the clear impact of various crew sizes on the productivity in one agency for one activity--premix patching. The average productivity--as measured by man-hours per ton of materials placed--ranges from a low of 3.34 for a crew size of two, up to a high of 11.60 for a crew size of six. Crew size, a controllable variable, obviously has a direct impact on productivity and therefore is a key factor in effectiveness.

Figure 3 illustrates the effect on productivity by varying both crew size and truck complement for one agency's skin-patching activity. As seen in Figure 3, a direct and significant relation exists between the crew size, equipment complement, and resulting productivity effectiveness.

The results of differing service level decisions being made by individual supervisors--in the absence of guidance--is illustrated by the data in Figure 4. Work quantities are used as a measure of service level. Mowing quantities on high-type, two-lane roadways are shown for each of nine management areas. A low of two mowings, a high of seven, and an average of three and one-half point out significant service level variations. Accepting some influence by variations in rainfall, the remaining variations in service levels and resulting cost effectiveness identify work quantities (service

Figure 4. Typical mowing quantities on high-type two-lane roadways.

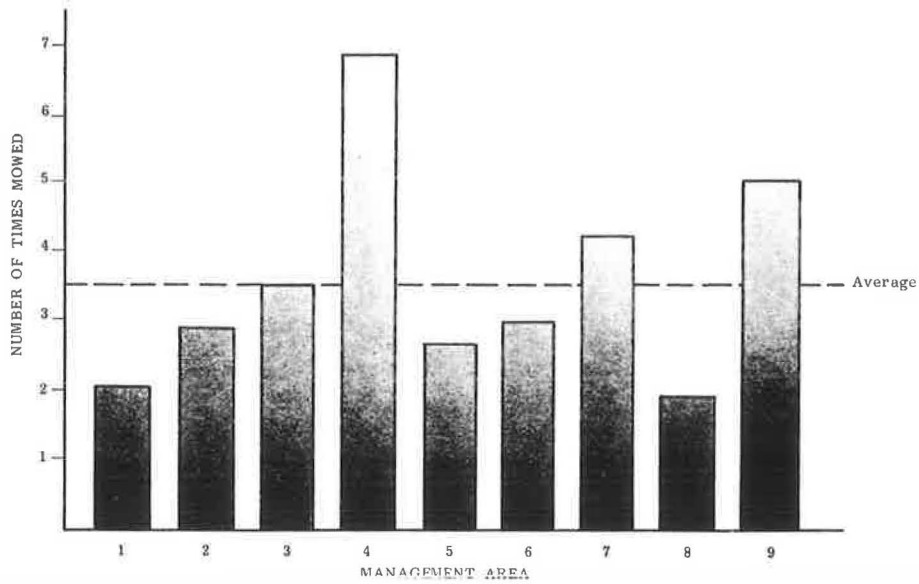


Figure 5. Example of the vital few maintenance activities.

Activities	% of Total Dollar Expenditures	Cumulative % of Total Expenditures
1. Snow & Ice Control	39.2	39.2
2. Asphalt Patching--Manual	9.7	48.9
3. Asphalt Patching--Mechanized	6.1	55.0
4. Base Repair	5.5	60.5
5. Surface Treatment--Mixer Paver	4.3	64.8
6. Surface Treatment--Liquid Bitumen	3.5	68.3
7. Unpaved Shoulder Patching	2.5	70.8
8. Ditching	2.4	73.2
9. Sign Installation and Repair	2.0	75.2
10. Stabilize Unpaved Shoulders	1.9	77.1
11. Brush Cutting	1.5	78.6
12. Pipe Placement	1.4	80.0
13. Shoulder Grading	1.3	81.3
14 through 140 Activities	18.7	100.0%
	100.0%	

Figure 6. Maintenance man-hour distribution for organization units, fiscal year 1979.

Reporting Category	UNIT "X" % Man-hrs.	UNIT "X" Est. Labor Cost	UNIT "Y" % Man-hrs.	UNIT "Y" Est. Labor Cost
PRODUCTION	64.2%	$2,118,356	59.3%	$1,181,089
SUPPORT:				
Travel	0.9	29,676	1.8	35,850
Other Types	34.9	1,151,566	38.9	775,137
GRAND TOTAL	100.0%	$3,299,598	100.0%	$1,992,076

levels) also as key controllable factors.

In summary, it is apparent from research findings that the key controllable variables in highway maintenance management are service levels, work method, and crew size. Therefore, maintenance management systems must focus on data about these key factors.

HOW MUCH DETAIL?

Several considerations limit the amount of data detail that should be routinely collected for purposes of managing maintenance. The first is the limit all managers have on the time that can be devoted to data review and evaluation. A manager properly using his time cannot routinely get involved in the small details of operations. His attention must be directed toward those operations of greatest importance from the standpoint of resource expenditures. By so doing, he limits his focus of attention and maximizes his impact and effectiveness.

Figure 5 illustrates this point by ranking the activities of a maintenance organization by the percentage of total dollar expenditures in descending order. It is apparent that of the more than 140 maintenance activities identified and programmed by that agency's maintenance management system, 13 account for 81.3 percent of the effort. By directing primary attention toward the effective performance of those 13 activities, the manager will maximize his limited time and attention. Data-collection requirements, procedures, and report formats should be designed to assist the manager in maximizing his energies and effectiveness.

A manager's time to evaluate data is not limitless. A field recorder's ability to record field operations in detail is also not limitless. Experience has shown that the greater the detail requested, the lesser the validity. This occurs because typically the recorders are working members of the crew or supervisors who already have other pressing demands on their time. The recorders likely see no practical value in highly detailed data requests and, therefore, are not inclined to conscientiously record the detail. Assuming an enlightened supervisor, he may judge his time identifying maintenance needs, ensuring consistent use of best work methods, and scheduling work as taking priority over detail recording.

Figure 6 seems to illustrate the results of unrealistic expectations for two organizations, units "X" and "Y" in one agency. In addition to recording the maintenance activity worked on, the field recorder in that agency also is required to record production time separately from support time. Further detail is required regarding whether the support work is hauling, safety, travel, or other. The data in Figure 6, taken from the agency's records, show, over the one-year period covered, an average of 0.9 percent of the man-hours was expended on travel in unit "X". Unit "Y" expended 1.8 percent on travel. Expressing this in other terms means that on the average, each crew

Figure 7. Sample of one agency's snow and ice control activities.

Activity	Unit of Measure
1. Plow with a truck	Miles
2. Plow with a grader	Miles
3. Plow with a loader	Miles
4. Apply abrasives	Miles
5. Apply salt	Miles
6. Plow and spread simultaneously	Miles
7. Wing back	Man-hours
8. Patrol	Miles

NOTE: Excludes material mixing activities, and snow fence erection and removal.

member in unit "X" spent only four minutes in a travel status each day and eight minutes per day by unit "Y" personnel.

When expressed in minutes per day, the time reported for travel to and from work sites is of questionable validity. Obviously, the expectations exceed the recorder's ability or willingness. Perhaps the recorder fails to appreciate the value in such detail or feels that such data might be better obtained by sampling techniques.

The value of the data in planning and controlling work should also limit the amount of detail that ought to be routinely collected by a reporting system. In Figure 5, the snow and ice control activity represented almost 40 percent of total expenditures for maintenance activities for one agency. In that instance, how much detailed data should be routinely reported for that activity? Such major importance suggests justification for reporting considerable detailed data.

Figure 7 shows the detail required by that agency--eight separate activities. This detail implies that the snow and ice control activities can be planned and controlled in great detail. Unfortunately, that is not the case. Because of the great unpredictability of snowfall occurrence and intensity, development of a maintenance work program and controlling against that plan is at best an interesting academic exercise. Collection of detail data for those purposes must be recognized as contributing to that sort of exercise--not as bases for meaningful evaluations of performance. In addition to the questionable value of the data for planning and control purposes, it must also be recognized that information recorded under storm conditions must be of questionable accuracy.

It is generally recognized that effectively managing snow and ice control activities lies in developing good routing plans, appropriate treatment strategies, and providing field supervision during storm conditions to ensure the plans and strategies are properly implemented. After-the-fact data are of little value for evaluating performance.

When considering the amount of detail that is appropriate for routine recording, it is necessary to realistically consider the limitations of the recorder and the practical value of the data for planning and controlling the specific highway maintenance activity.

AT WHAT COST?

To a large extent, the cost of data collection is a function of the detail required. Historically, the costs recognized as significant include the time of the recorder, the time of his supervisor in reviewing the data, clerical review time for completeness, cost for manual and/or machine processing, and time for review of prepared reports. With the improved efficiency of computers, the direct unit costs for data processing have encouraged further application. Computer capabilities have also increased tremendously in recent years. The combination of reduced unit costs and increased capabilities contributed to sophisticated system designs that require detail data. As a result, indirect costs have begun to play significant roles.

One of those indirect costs relates to the indirect--but very real--cost of reduced field staff motivation. As data-collection requirements imposed on field personnel become excessively detailed or unrealistic, the desire to do a conscientious job is affected. Often the loss of that desire extends beyond the area of reporting. It can be reflected in a loss of interest in such vital areas as the use of standard crew sizes and work methods.

Similarly significant indirect costs occur when the middle managers frequently question the credibility of highly detailed and presumably accurate reports they receive. Once this happens, the intended purposes of the reports are likely no longer served. Managers are then forced to short-circuit the system and generate their own bootleg reports to satisfy the key management requirements.

When either of the above indirect costs are observed, it is past time to reevaluate the maintenance management reporting system.

In summary, it is the indirect costs of reporting systems that have become significant and in the process strongly suggest the need for reassessment.

FOR WHAT PURPOSE?

To this point, the focus has been on identifying the data crucial to effective field management. Of equal importance is the need to recognize the proper role of that data in guiding the management decisions of the first-line supervisors.

Effective management of field maintenance operations is achieved when the first-line supervisor knows what service levels to provide (as defined in his work program), and what crew sizes and work methods to use (as defined in standards). In addition, he must be constantly aware of how his actual performance compares with the work program and standards. That kind of feedback is vital if the first-line supervisor is expected to manage to those objectives. To be useful, these data must be timely and serve as the bases for the short-term (weekly or biweekly) scheduling processes.

Timeliness of the data is most important. Monthly or quarterly summary reports are not satisfactory. Weekly computer or manually prepared data reports are a must if the scheduling process is to be meaningful and continually directed toward the objectives.

In addition to the need for short turnaround times, it is necessary that the short-term scheduling processes themselves are designed to direct first-line supervisor attention toward work program and standard compliance.

It is necessary in the reevaluation process to both identify the key management data and also to provide for and ensure its proper use. Unless both functions are performed by maintenance management staff and operating personnel, systems will continue to operate at less-than-full effectiveness.

OTHER DATA REQUIREMENTS

It is recognized that maintenance management systems in some cases are expected to provide data for other purposes. Two of the more frequent sorts of data requests relate to fiscal data and research data.

The process of incorporating those needs with maintenance reporting systems must be done with

great deliberation and recognition that the end result should serve all functions in the most cost-effective way--including consideration of all indirect costs.

For example, the nature of research data is such that they are unique and highly detailed, require absolute degrees of accuracy, usually involve specific locations or operations, and are of a specific time duration. Because of their nature, research data needs can frequently be satisfied without imposing additional reporting requirements on existing maintenance reporting systems. Sometimes the solution is a specially designed data-collection system and special recorders or the development of a sampling plan. Whatever the solution, it must avoid jeopardizing the integrity of the basic agencywide maintenance reporting system.

Close scrutiny of data requests tends to eliminate "nice-to-know" information and the associated direct and indirect costs.

SUMMARY

Maintenance management systems developed over the past 15 years deserve continual review. They are crucial to the management of millions of dollars of maintenance expenditures annually. Improved design features--developed in recent years--must be incorporated to ensure continued effectiveness.

One of the basic system elements currently in need of reevaluation is the reporting system element. The basic maintenance management research of 30 years ago provides direction for that reevaluation by identifying the management data related to service level, work method, and crew size as the keys to effective management. More recent experience with the consequences of excessive reporting detail suggests the need to carefully re-define data needs. Recognition of the relative significance and controllability of specific maintenance activities is important. Important also is consideration for the practical limitations on the time and capacities of the field managers and field recorders.

The significant costs of data collection must now be recognized to include the indirect costs resulting from ineffective systems. Those indirect costs include reduced field staff motivation and lost management report credibility.

To date, considerable emphasis has been placed on computerized reports for upper and middle management. However, management system effectiveness depends on lower-level management control. It is toward improvement of the first-line supervisor's managerial control that reporting system reevaluations must direct attention. In addition to identifying the data crucial to the management decision-making process, that attention must also ensure that the scheduling processes and procedures are in place and functioning.