Abridgment

Preconstruction Engineering Management in Washington: Manpower Management Information System

Donald L. Lund

The Washington Department of Transportation has been involved in preconstruction staffing management in a formal sense since 1972; FY 1978, however, was the first fully operational year for the manpower management information system. Staffing standards, which are based on identified, quantifiable objects for data input, have worked out well. Project schedules have been found to be reasonably accurate, due in part to previous experience in the use of a critical-path method for scheduling engineering activities. Labor reporting has remained constant since 1973 with no major changes in the activities, titles, or coding numbers. Operational problems of the system have resulted from the programming, budgeting, and authorization processes of the department, where a close match does not exist between financial management systems and staffing management. Because there was no common data base, several coordination systems were developed to tie the financial and staffing systems together. Matching financial and staffing planning to expenditure systems has caused cross-referencing problems and some dilution of historical data. Data-processing differences between the financial and the staffing-resource management systems have delayed preparation of reports involving both. Monitoring and control of project progress and resource utilization has not been stressed greatly because of an initial lack of credibility in the system for resource estimating and project scheduling.

The manpower management information system (MMIS) of the Washington Department of Transportation is an automated, performance-standards-based, resource-estimating and scheduling tool. It provides detailed performance measuring and project schedule monitoring at numerous critical development points. The scope of MMIS runs from project inception through route location, facilities design, right-of-way purchase, and contract plan preparation to completion of construction. MMIS covers almost 1700 of the department's 2000 engineers, technicians, and right-of-way staff, ranging from entry-level technicians to project managers.

BACKGROUND

Work on MMIS was initiated in 1972. At that time, all project engineers were requested to prepare organization tables showing name, class title, and particular expertise used. Information on recently completed projects was used to provide historical data for analysis, and engineering-activities categories, previously established for labor reporting, were used to provide additional history by engineer and technician classes, project, and activity. These preliminary engineering-activities categories were based on the existing Washington automated control system, a critical-path project-scheduling tool. Having these familiar engineering activities to work with and an existing activity diagram was an advantage in creating a standards-based preconstruction-management system. Even so, considerable effort was spent in verifying the historical labor charging and in questioning the manner in which work was performed and the efficiency of the various operations. Random sampling techniques were used during field observation of all aspects of preliminary engineering. Many interviews with those working on or responsible for engineering projects were held. These interviews suggested ways to do things and estimates of the time required. These findings were then presented to a technical committee for review and final establishment of an engineering-activity staffing standard.

Once activities or groups of activities were defined and labor reported against them in sufficient quantity for analysis, work establishing appropriate units of measure was begun. These units had to be quantifiable, readily identifiable, and usually descriptive of some product delivered. Considerable effort was required to define the staffing requirements resulting from different units of measure or modifiers to the basic units of measure. The final product was a mixture of basic units and modifiers and included

1. Type—eight basic units and their lengths;
2. Feature—numerous modifiers of the project types, e.g., bridge sites;
3. Major construction additives—which modify only the major construction projects, e.g., diamond interchange;
4. General project additives—which can apply to all project types, e.g., channel change;
5. Bridge project additives—which apply to structure-only projects, e.g., railroad bridge; and
6. Network generators—which consist of all the activities available for the particular phase.

Even with the extensive listing of engineering-activities categories (more than 160), it was recognized that some percentage of the engineering labor charged to a project would consist of overhead. Overhead, in this sense, means support functions directly relatable to the project but not product related, such as on-job conferences and instructions or training. Examination of historical records provided quantities and percentages used on previous projects.

ORIGINAL DESIGN

The initial MMIS design was based on the basic functions of (a) plan and schedule, (b) measure and compare, and (c) act and react. Capabilities were built into MMIS to provide information necessary for each. In detail, the plan function consists of a project definition for each phase of a project and uses project type, features, additives, and network generators (activities). This gives a quantity of resources (staff) needed to accomplish the work. Summarizing the plan then gives a critical-path diagram that is displayed in bar-chart format and shows critical activities, float times, and durations in days. The resultant of this planning process is not calendar dependent and requires another action to establish start and complete dates. From a summation of all projects defined (planned) and put on the calendar (scheduled), a staffing requirement by skill levels is available for the project manager, the district, or the entire department. Some balancing is done to stay within staff allocations. Staffing requirements are defined by the features of the project, so that only by changing starting dates can resource balancing be accomplished. By slipping and sliding projects on a time scale, the districts attempt to balance available staff against needs. It was originally planned to balance staffing at the project manager level, but that proved to be unworkable. Each district now attempts to balance staffing requirements at a district-wide level and then provide seasonal or temporary personnel to project managers who need extra help.

To date, MMIS has provided resource information only and has not been used to dictate whether a project can proceed or not because of resources. Any work load in excess of existing staff resources is done by consultants. This practice, and a statewide staff pool in the land management office, has been very helpful in meeting schedules while maintaining a relatively fixed work force.

Project Numbering

Washington has a unique numbering scheme for its capital-improvement projects. Each project has a number that is carried in some form, either as a basic or as a secondary identifier, throughout the life of the project. Critical to this numbering scheme is the planning unit, a particular stretch of highway that has homogeneous qualities. Each state highway in each district has its own series of planning-unit numbers; for example, a project on a hypothetical highway could be identified as 53031B—Lofall to Keller Ferry—as shown below:

Position	Example	Description
First numeric	5	District number (1 through 6)
Second numeric	3	Functional class number (1, 2, 3, 5, or 6, where 1 = principal arterial, 2 = minor arterial, 3 = major collector, 5 = Interstate, and 6 = other)
Third, fourth, and fifth numeric	0, 3, and 1	Planning-unit number, unique to the particular highway
First alpha	B	Unique project within the planning unit

The project numbering system allows the department to sort, group, and arrange project estimates in numerous ways. Other data are attached to the project number, including project type, benefit codes, and estimates of costs for engineering, right-of-way, and construction.

One problem with the project-number concept is that a project can consist of almost anything and can range from the entire scope of work in a given geographic area to a series of related activities that result in a product. Because of this problem of defining a project, MMIS uses the term "phase", e.g., design, to identify the parts of the total project. The sum of all MMIS phases will result in something that behaves like a project. The MMIS project matches the financial project number by using the project number and adding three digits to the end to signify the particular phase. For example, the design phase of the project example described above would be identified as 53031B-203—Lofall to Keller Ferry: bridge design.

Authorizations

The accounting system in Washington assigns work orders for design; plans, specifications, and estimates; and right-of-way portions of a project. This authorization provides clearance to begin work on a particular project by the assignment of still another six-digit number, e.g., 0L4163 or RW2364. This number may encompass part, all, or more than one project. When more than one project number is incorporated into a work-order authorization, dollar prorations are made to the included projects; hence, the match of planned dollars and actual labor expenditure dollars will never be good at the project level. This pro rata of dollars to projects has caused some problems in matching staffing requirements to the financial system.

Measure and Compare

MMIS currently provides eight reports that show relationships between planned quantities and expenditures. Their range of detail runs from that of the individual project or phase status report through those of headquarters-organizational- and district-level summaries. These reports more than cover the demand for expenditure comparison information. Project performance was intended to be a primary responsibility of the project manager in the field but, because labor reporting occurs only once a month, it is several weeks before the results of all labor charges are known. The comparison process is used extensively by MMIS staff during standards validation. Many cuts of historical data (completed phases and projects) are made by organization and activity. These are matched against new planned quantities generated by completed project features and additives. Measurement is made by MMIS staff, on a statewide or district level, to compare known performance with that projected by the standards. This gives a check on a proposed program and whether it can be delivered by the staff on hand. Emphasis is being placed on this level of comparison because it can identify areas of future problems.

Design Shortcomings

As originally designed, MMIS was to provide information on staff planning, scheduling, and expenditures for project managers to use in laying out work. It was also to provide project-monitoring capabilities by using development points for checks on progress. All support organizations would receive scheduling and resource information for their use in staffing to the work flow. Project managers do not have the autonomy they once had, because most of the program control is exercised at the district level. Washington now has a strong, decentralized organization that schedules projects to fit available staffing levels and does not tolerate large fluctuations in staff.

IMPROVED DESIGN

Right-of-Way

During the data-collection and work-analysis period (1972-1974), the scope of MMIS was limited to engineering aspects of project development in both preliminary and construction engineering. Right-of-way acquisition was not made part of the MMIS effort because the department already had a right-of-way staff-estimating system. In 1976, this system was eliminated and a separate phase was created in MMIS to cover right-of-way acquisition. The MMIS right-of-way phase normally runs parallel with the plans, specifications, and estimates phase. The staffing standards for all right-of-way functions were recently reviewed and updated, and some major cuts in the support functions, recognizing changes in review procedures, were made. Because right-of-way acquisition can be a major factor in project completion, bringing the right-of-way-acquisition function into MMIS now provides a better picture of project development.

Preconstruction versus Construction Engineering

Preliminary engineering and construction engineering followed separate paths during detailed MMIS design. Although both paths are well designed for their separate purposes, points of dissimilarity have caused some problems. The preliminary engineering phases have eight project types, whereas the construction phases have only six. Another difference between preliminary and construction engineering is the manner in which staff-time standards are applied. All preliminary engineering standards are individually planned at the activity level, while construction engineering staff time is planned by activity groups that summarize 1-20 activities.

Modifications to MMIS

MMIS has been modified as a result of changes in emphasis by the department, the necessity to provide information in slightly different formats, a desire for coverage that would better match the financial system, and addition of project information for budgeting purposes. One of the earliest requests was for the addition of a subprogram designator.

The capital construction program in Washington is divided into various subprograms; for example, A1 = rehabilitation work on non-Interstate highways and B1 = Interstate construction. Unfortunately, because new subprograms are added each biennium, historical records by subprogram are difficult to maintain.

An offshoot of the subprogram request was the development of a new format for an existing report so as to mesh with budgeting formats. The new format is by subprogram within each district, condenses the staffing detail into quarters to match the financial system, and prints both the staff and dollar information in the same report. This report is used extensively by the districts during budget development.

One of the control reports, District Milestone Status and Exception Report, has been extensively modified to provide more information at the project level. The tardiness by the districts in updating status reports caused many to exceed the exception limit, which made the original report very cumbersome. By revising the report format, all planned stages on a given project are now shown with the status of each. The new title, Project Status Report, is indicative of the shift in emphasis to the project itself. This should become the key informant for a scheduling, monitoring, and control function.

Systems changes involving the data-handling package purchased by the department are complex but require some explanation. The data-base system purchased was a state-of-the-art system, and the vendor was not intimately familiar with it. Thus, considerable time was needed for the systems development staff to learn to use the data-base system and costs to develop MMIS were higher than normal.

Some of the MMIS reporting requirements did not use the data-base capability efficiently. The particular data-base system is very good for ready access of all types of single- or small-group information needs but is not adequate for large summaries and reports. Much reprogramming was done to remove production summaries and expenditure reports from the data base. Once the extracts were made, processing costs decreased appreciably. Systems support has improved over time and the MMIS data base is no longer a novelty, but it is still used as the department training ground for new programmers. It would, however, be impossible to process the data contained in MMIS by using older methods of data processing.

Even after several years of experience and an effort to simplify the basic system, MMIS is still complex and not well understood. It is also expensive to update because of the large amounts of data maintained.

Thus, MMIS is not cheap to maintain. A major portion of the costs are for computer processing and systems support. MMIS staff consists of four people in headquarters who handle the operational aspects and standards validation and provide training and troubleshooting expertise. These four are supported by a systems analyst and a design programmer who are familiar with the data-base system. The six districts collectively have approximately 4.8 staff years of support with which to keep the MMIS data base current.

The costs for FY 1980 break down as follows:

	Cost ($)		
Item	Districts	Headquarters	Total
Labor	120 000	90 000	210 000
Data processing	5 000	165 000	170 000
Travel		5 000	5 000
Printing		3 000	3 000
Systems support		90 000	90 000
Total	125 000	353 000	478 000

MMIS development costs, from the beginning in 1972 to the point when the system was declared operational in 1977, exceeded $1 million. In addition, much of the current effort on modifications should also be called developmental, as it is attempted to fit MMIS to a different environment than originally anticipated.

MMIS IN THE FUTURE

After a couple of years of operational status and a full biennium of project history, the questions are, Was it worth it? And is it still necessary to plan staffing requirements to the nth detail? The answer is that we still think so! It was a formidable task to try to provide staffing planning for both preliminary engineering and construction engineering at the same time, establish a new data-base system, and base staffing standards on individual project details. It may have taken several years longer than originally planned, but the results are now coming in. The extensive work done in establishing standards is resulting in good performance overall. The system may be more complex than needed for its current use, but times have changed since the early 1970s when gasoline was cheap, construction was booming, and many large projects were on the drawing boards. It is much easier to trim back than to add on to a system of this size.

Now that major new construction projects (on which the MMIS was primarily based) are almost extinct, rehabilitation is the commonest operation, and both gasoline and money are scarce, the department must consider its efficiency and do a good job of utilizing scarce resources. MMIS as a management tool is being changed to fit that new task. Eliminating excess paperwork, processing fewer reports, working more quickly, and broadening the audience for the system are under way now. Joining forces with the financial system is a necessity. Staffing needs cannot be estimated separately and managed without some relationship to the programming and expenditure of funds. Commonality of data in resource management systems seems the way to go.

Publication of this paper sponsored by Committee on Manpower Management and Productivity.