WHAT IS AN AUTOMATED SYSTEM FOR HIGHWAYS?

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During the past 20 years, automation has become one of the major tools used in highway operations. Most highway departments recognize that automation provides more than a means of handling routine accounting and engineering tasks. Automation also significantly affects methods of management and the organization and conduct of business. Although the use of automation has not proved to be the solution to all management problems, those who take advantage of advanced data processing and communication techniques will benefit greatly.

It is easily forgotten that, by means of automation, we do many things today that we could not even attempt to do just a few years ago. For the engineer, automation has changed the rules of what is possible and what is practical. Through simulation processes, we have been able to develop additional design alternatives that just a few years ago might have been considered too time-consuming or costly to investigate. We know from experience, for example, how automation can contribute to the design and construction of bridges.

Many highway operations have been affected by automation. Most accounting functions are wholly or in part dependent on data processing results, and many complex engineering functions effectively use automation techniques. Other areas of operation that are traditionally slow in adopting new ideas, such as highway maintenance management, are beginning to demand their share of the automation dollar. It has been estimated that in Washington the development and implementation of a maintenance work plan, based on established standards, saved the state 311,974 man-hours and $1,762,700 during the first year it was used. The development of these standards, as well as the timely reporting of performance, simply could not have been achieved without the availability of high-speed computers. Highway maintenance personnel feel that they have barely scratched the surface in this area, and these plans are being further implemented and refined.

Many of the first attempts at automation were made by highway planners. Currently, some of the most useful benefits of automation are in planning-related areas. Washington, along with many other states, uses the computer to develop and maintain PERT or critical path networks of the myriad of activities, constraints, and priorities in its highway construction program. The Washington Automated Control System (WACS) has been in use for about 4 years. This computer-based system is one that uses the critical path method for scheduling precontract engineering and related activities for the state's highway construction program. The objectives for such a system are the scheduling and control of engineering activities at the district level and the coordination of those activities among the several headquarters units that are responsible for testing of materials, design checking, financing, and advertising of contracts. The system provides for the generation of an initial critical path schedule for review, revision, and further revision by all of the affected organizational units resulting in a schedule that is mutually satisfactory. This system can be cycled whenever desired to produce "hot" lists and other monitoring reports.

The WAC system provides mutually approved schedules for monitoring progress and also provides information retrieval for planning work loads. For control, the system provides for changing activities and events so that the remainder of the schedule is both current and realistic. The initial function of the critical path method was to

provide management with a review procedure that would assist in improving and accelerating methods of operation on a single project. We can do this with as many as 500 projects. We can compare them with one another, we can include a time span up to 6 years, and each project can have as many as 1,000 activities. The system provides exception batch reporting in the form of the "hot" lists and also provides for immediate inquiry, via video terminals, from the on-line data base.

By using a single system, diverse organizations in various locations can make decisions based on the same facts. Top management uses the same facts, available in the same time period, as does the man in the field. The system highlights the exceptional condition—the schedule conflict or the missed commitment—rather than the routine one. It meets, to some degree, all four of the following criteria that I think are necessary for a good automation system:

1. It is economical;
2. It produces information faster than does the manual system;
3. It is more accurate than a fragmented manual system; and
4. It performs work much too complex to be done by human beings.

AUTOMATION CHANGES IN THE 1960s

Everyone who has been closely involved in highway automation activities has felt at times that the pace of change is too slow. Yet when we look over a long period of time, such as the past 20 years, we find that remarkable and fundamental changes have occurred.

At first computers were primarily used to speed up the accounting process—budgeting, accounting, and payroll work. A few pioneers, however, began to use the computer for engineering tasks. This use has expanded and become accepted to the extent that most large engineering organizations now consider the computer an indispensable tool. Several new management techniques involving the use of computers were developed in the 1960s, and highway departments have now had the opportunity to evaluate the results of these techniques and to determine their validity. Labor reporting systems, scheduling and control techniques for all phases of transportation-oriented programs, and many other innovations involving automation are being analyzed.

We have learned that management techniques should be designed with sufficient flexibility to permit modification in order to respond to changing requirements or demands. At the same time, the development of these programs must be in accordance with carefully specified plans. Today we can see the implementation of ideas that were conceived during the past 15 years and that contain at least some elements of totally automated design and administration of a highway system. We also learned during the 1960s that a highway system cannot be entirely administered through automation. No one has yet automated the ingredient of management judgment.

Environmental factors are essential elements in highway design. Automated design programs have had to be modified to take these factors into account. There has been extensive and increasing use of computer-simulation techniques and development of alternatives because of the growing and frequently vocal interest of citizens who formerly took highway locations for granted.

During the latter part of the 1960s, highway automation programs became increasingly oriented toward serving the needs of highway management and engineering, and record-keeping received less emphasis. Now that third-generation computing equipment is beginning to fulfill its promise, the scope of things that you can do with computers is limited largely by imagination and budget. The 1960s were pioneering years; the 1970s will be years of maturity and achievement in highway automation.

ACHIEVING ECONOMIC BENEFIT

Top highway department management must participate in the development of automation systems to ensure that the most economic benefit is derived from these large and expensive operations. Many judgments about automation matters that administrators do not like to make appear to be highly technical. In many cases, management is

required to establish a new policy and take the risks of disrupting an operation that is, to all appearances, stable and reliable.

There is no easy answer as to how top management can effectively direct the automation function. Yet the potential consequences of their failure to direct these activities are so important that the problem must be faced. Widely reported studies have shown that the majority of all computer installations in the United States are unsuccessful or barely adequate. The most prevalent reason for this failure is lack of top management involvement. Computer personnel, although their skills are highly technical, can be evaluated by top management. Their judgment, their ability to plan, and their ability to explain in detail existing and proposed systems in terms of costs, benefits, and alternatives can be evaluated by management.

Computer personnel can also be evaluated in terms of how effectively they manage their own resources. It frequently occurs that the department specifically charged with the responsibility for automation and better management techniques is the one most in need of putting those techniques into practice internally. We have found that to be the case in Washington; consequently we are revamping our computer organization. Wherever possible we are setting specific performance objectives and then using the computer to report compliance with those objectives, preferably on an exception basis. For example, we now provide our operations manager with a daily computer-produced chart, a histogram that shows at 5-min intervals which programs were executed, and how much memory and time they required. Each programming team leader receives a daily printout indicating which tests each of his crew ran, how long each one ran, and the kind of resources it used. We have exception reports that list all tests that required more than a minute of computer time, which in turn allow us to check productivity. All systems and programming projects are tracked against initial time and budget objectives, and exception reports are made of overruns and probable overruns. Production, work flow, and reliability statistics are produced as a by-product of our billing and cost-accounting functions.

The effect of the system is to give us objective measures both of how well we are doing today and, equally important, of whether our situation in relation to past periods is improving or worsening. One strong means of ensuring vital top management support lies in computer professionals' being able to demonstrate that they employ up-to-date techniques and judgment in managing their own resources.

We must face up to the cost-related problems of automation. When computers are used to do other than repetitive tasks, the work begins to get complicated and cost justification no longer is clear-cut. Management must then decide whether doing something with a computer that simply could not be done before is worth the extra cost—not only the computer time but also the time and effort to retrain people and change familiar habits. Management must answer such questions as: Can an expensive materials control system result in enough savings to justify the cost of programming, computer time, and reporting? Are the theoretical labor savings being realized? Unless management plays a direct and positive role, chances are that the labor saved by the new computer system will be frittered away on nonessential tasks, and overall costs will increase.

ORGANIZING FOR AUTOMATION

Most highway departments have skillfully applied computers to the high payoff parts of their organizations. This certainly indicates that automation activities are as amenable to sound management techniques as are the traditional areas. Whenever organization is discussed, the controversial matter of centralization versus decentralization arises.

Although the answer to centralization versus decentralization depends on the specific circumstances involved, it is becoming increasingly practical to have the best of both worlds. In Washington we are planning to place the power of the computer, through remote terminals of various kinds, along with access to its banks of data, information, and programs in the hands of the person who most needs it to do his job. This is decentralization of control and of computing power; yet the same computer and systems will be providing higher management the summary information taken from the basic field records.

BALANCING OF RESOURCES

There should be a good balance of automation resources among the major segments and functions of highway operations. Likewise, automation activities must strike a balance between the reduction in manual effort and the cost and effort required to make this reduction. Because the cost of automation increases as the square of the complexity, a basic aim of highway management must be to carefully allocate its automation budget. Therefore, the balancing of resources and allocation of automation budgets among competing users is a top management task that ought not to be overlooked or avoided.

Because automation is expensive and scarce, particularly in regard to highly skilled system designers and implementers, it is necessary for management to require that all data processing operations be economically justified and that the automation department's implementation priorities be the management's priorities, not vice versa.

LONG-RANGE PLANNING

Highway departments, much more so than most organizations, are accustomed to dealing with long-range planning. The need for careful long-range planning in automation development is fully as important as in any other departmental area. The effect of automation decisions made today will be felt several years from now.

Plans ought to consider the increasing level of coordination and information interchange that is taking place between agencies at all levels. Agencies with which highway and transportation agencies traditionally did little business now are creating systems and procedures to which we must respond. One example is the requirement for population statistics. So-called birth-to-death records are being created at the state level, and perhaps national records will result from this work. Highway management must respond and furnish these statistics to feed that system. Conversely, transportation agencies will be able to use the information derived in making better projections of transportation needs as they relate to total long-range planning.

The impact of the demands of others on our departments is measurable in terms of additional time and money. However, this type of requirement is going to be imposed on highway departments in the coming years, and we must be prepared to meet these demands and at the same time control the cost.

How we can best manage automation to meet the information needs of others is an important question. A first step is an understanding of information requirements among the various legislative contacts and formal or informal communication among executives of the various agencies. In state government, a central authority should be established for developing information requirements that affect other agencies. This has been done in Washington and several other states. In this way needs of statewide impact can be evaluated, judged, developed, and implemented in a relatively objective manner because decisions are based on statewide goals and objectives. Such an authority can and generally will result in top management of individual agencies becoming more involved in the agency program. The success of this kind of program is heavily dependent on a willing, cooperative attitude among all involved agencies.

COORDINATION AMONG AGENCIES

Automation is taking an increasingly large share of government resources, including highway funds. Obviously, coordination among transportation agencies using computers makes good sense. Highway agencies, including local government road authorities, have the most to gain by working together and by sharing automation facilities and knowledge.

Traditionally, close cooperation has been practiced in road building among the federal, state, and local units of government. Counties and cities have generally welcomed the exchange of ideas and techniques in the design and material-testing aspects of highway construction. Now it is time to extend this exchange of ideas and techniques to the automation area. We cannot overemphasize the importance of the existing exchange programs, which are key elements in the coordination of highway automation programs.

Expansion of such exchange programs is essential for the most effective expansion of the data processing system and the total automation program. Participation in the exchange programs by agencies and industry helps to ensure the use of progressive automation systems that are in the best interests of both government and industry.

SHARING OF FACILITIES

Small agencies cannot afford the investment in equipment and personnel required to perform many complex engineering and administrative functions. Many of these applications are available at state highway facilities. Increased use of state-managed automation facilities and systems will benefit local government. The direct cost to these units will be lessened because the state has already paid for the system developmental costs, while major operating expenses are allocated to the larger users. In Washington, we foresee a greatly expanded program of training, promoting, and assisting the small local users—particularly the engineering users—in the use of our computing facility. We see evidence of a strong need and a strong demand, and, at the same time, the additional drain on our resources is not too great.

CONCLUSION

Highway automation systems are so diverse in type and complexity that they defy ready classification; however, in general, the good systems meet the criteria of lower costs, faster results, greater accuracy, and facility for handling complex tasks. In many cases, especially for those programs dealing with administration and management activities, it is extremely difficult to apply these criteria to demonstrate conclusively the likely achievement of tangible monetary benefits. Consequently, management must understand the systems that are being developed and the elements that constitute those systems. Management must continue to relate its decisions regarding system development to the long-range goals and objectives of the agency. Management must also have the courage to make conclusive decisions based on information and judgment that cannot always be defined in strictly monetary terms.