National Cooperative Highway Research Program

Synthesis of Highway Practice 282

Project Management Information Systems

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis report will be of interest to DOT chief administrative and information officers, information technology staff, project managers, and their supervisors. It describes the current state-of-the-practice for DOT project management systems. This includes information on project management framework and project management knowledge areas. In addition, several case studies and an appendix chapter on change: definition and implementation, role of personnel, processes, and cost are also provided. Information for the synthesis was collected by surveying U.S. and Canadian transportation agencies and by conducting a literature search.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

This report of the Transportation Research Board describes the process used to develop and implement automated project management systems, the source of software in use, and the extent of any modifications necessary for commercial products to fit DOT

business needs, the operating environments for systems in use, and the capabilities and limitations of the systems to track multiple projects and information sources. Information on system capabilities and deficiencies in project communications, report and problem solving, necessary resources required to implement and maintain each automated system, and how long each system has been in place and future plans for long-term enhancements, modifications, or replacements is also included.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the available information was assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the author's research in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of John E. Canepari, Program Controls Manager, Parsons Brinckerhoff; Steven D. DeWitt, State Construction Engineer, North Carolina Department of Transportation; William G. Dowd, National Capital Planning Commission; Frederick D. Hejl, Engineer of Materials and Construction, Transportation Research Board; G. John Kurgan, Senior Vice-President, Michael Baker, Jr., Inc.; Randall K. Lamoreux, Director, Project Development, Utah Department of Transportation; R. Edward Minchin, Jr., Pennsylvania State University; Donald R. Tuggle, Quality Initiatives Group Leader, Federal Highway Administration; and James Weingartz, Supervisor, Project Management Unit, Minnesota Department of Transportation.

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Crawford F. Jencks, Manager, National Cooperative Highway Research Program, assisted the NCHRP 20-5 Committee and the Synthesis staff.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance are appreciated.

PROJECT MANAGEMENT INFORMATION SYSTEMS

SUMMARY

As the primary custodians of surface transportation systems within their states, the individual departments of transportation (DOTs) are responsible for planning, designing, constructing, and maintaining state and federal highway systems. With an average state DOT's annual construction budget exceeding several hundred million dollars, the demands on the management of the overall program as well as individual projects are substantial.

Given the overall public expectations of "faster, better, cheaper," demands on the management of individual projects are increasing. With the visibility and expectations of project managers heightened, the information systems that support project managers play an increasingly important role. As DOTs continue to look for opportunities to improve the effectiveness and efficiency of their management of projects, they will necessarily also look for ways to improve their project management systems. This synthesis investigates both the current experiences and practices of DOTs, as well as current best practices in the development and installation of automated systems across other industries. The composite of these two perspectives provides valuable insights for individual chief administrative officers, chief information officers, information technology staff, and project managers as they seek to evaluate and improve their own organization's performance and approach to system development.

Thirty-five states and one Canadian province responded to the "Survey of States" questionnaire. The information provided by these agencies was most complete in the areas of system capability and satisfaction with the current system. Approximately two-thirds of the states have adopted a "strong" project manager approach to the management of their projects. That is, they have elected to put the responsibility for the delivery of the project, or at least a major phase of the project, with a single individual. This is a clear trend away from a functional or coordinator role of overseeing projects.

Unfortunately, project management information systems (PMISs) have not kept pace with the change in management direction. The lack of key graphic and analytical features coupled with the lack of system flexibility puts the strong project management approach at serious risk of failure. Fewer than one-third of the states are satisfied with their current PMIS. Users of these systems rate the following areas particularly low:

- Ability to link project resources (people),
- Ability to develop project graphics, and
- Ability to do "what if" analysis.

Within the next 3 years, 74 percent of the states expect to change their PMIS. Of this 74 percent, more than 40 percent expect to replace their systems. If past experience is an indicator of future direction, very few states will attempt to partner with other DOTs to develop their systems. Only 8 percent of the states reported that they had acquired their current system from another DOT.

Reengineering authors and change management practitioners consistently identify the following key ingredients as those necessary to successfully design and install major automated systems:

- Senior management plays a vital role in successful implementation. Successful managers tend to view the replacement of information systems as investments rather than expenses. They also make a personal commitment to stay involved to ensure that internal reengineering and change management teams remain motivated and that the initiative is sustained.

- As with so many other elements of product or service delivery, the installation of a new automated system progresses more smoothly when the effort is defined and guided by a rigorous process. The organization's internal culture deserves particular attention when defining an implementation process. The success or failure of system installation depends on a variety of factors. One of the most important is how readily people within the organization adapt to a new way of doing business. Reengineering and change management processes should include an assessment of organizational readiness and implementation steps that address specific aspects of organizational culture.

- The use of teams appears to be fundamental to successful system reengineering. Team effectiveness seems to be tied to the complex nature of reengineering work. Teams also seem to be an effective means of building broad-based understanding and acceptance of an initiative within an organization. The complex nature of reengineering also leads organizations to consider the use of consultants. Although there are advantages and disadvantages to the use of consultants, most organizations feel that they benefit from their use.

- The total cost of system installation is often misunderstood and, therefore, underestimated. Although the order of magnitude of system design or purchase costs is normally anticipated with sufficient accuracy, implementation and maintenance/upgrade costs are often overlooked. Overlooked too are the (lost) opportunity costs of having a system that is incapable of providing information to key stakeholders and decision-making bodies such as state legislative committees.

- The experience of the states profiled in the case studies paints a picture that complements the survey of current best practices. In particular, they reaffirm the important role of teams and the active involvement of senior management.

CHAPTER ONE

INTRODUCTION

BACKGROUND

As the primary custodians of surface transportation systems, state departments of transportation (DOTs) are responsible for planning, designing, constructing, and maintaining the state and federal highway systems. To accomplish that task, the state DOTs must simultaneously manage an average of several hundred projects. Because an average state DOT's annual construction budget exceeds several hundred million dollars, the demands on the management of the overall program as well as individual projects are substantial.

Given the overall public expectations of "faster, better, cheaper," the demands on the management of individual projects are increasing. Kharbanda and Pinto, in *What Made Gertie Gallop? Learning from Project Failures,* assert that project management is made more difficult than conventional line management because of one "vital" difference. "A project has but one chance of success, whereas with conventional line management there is always the opportunity to do things better next time" (*1*).

In 1993, D. I. Cleland foresaw a trend and published an article entitled "The Age of Project Management" (*2*). Since then, there have been literally hundreds of books and articles on the topic. That we are currently in the midst of a "projectization" trend; that is, viewing all business endeavors as "projects," only adds to the gravity of successful project management. With the visibility and expectations of project managers heightened, the information systems that support project managers play an increasingly important role.

For most DOTs, a key element of the project management process is an automated project management system. As these departments continue to search for opportunities to improve the effectiveness and efficiency of their management of projects, they will necessarily also search for ways to improve the responsiveness and capability of their project management systems. Knowing the current practices of other DOTs and, specifically, which DOT systems seem to be particularly effective could be a useful starting point in developing an improvement strategy for a project management system. In addition, knowing how others have successfully implemented system changes can potentially save an agency considerable time and expense. It is toward this end that this synthesis is written.

PURPOSE OF THE SYNTHESIS

Specifically, this synthesis will report on how the following functions relate to an overall state DOT program by:

- Describing the process used to develop and implement automated systems;
- Defining the source of software in use and indicate the extent of any modifications necessary for commercial products to fit business needs;
- Listing the operating environment for each automated system in use, for example, mainframe, LAN/WAN (Local Area Network/Wide Area Network) stand alone desktop computers;
- Categorizing and summarizing the capabilities and limitations of current automated systems to track multiple projects and link project resources (e.g., funding, personnel, equipment);
- Identifying current automated system capabilities and deficiencies in project communication, reporting, and problem solving;
- Identifying the necessary resources required to implement and maintain each automated system (e.g., total system cost, number of operators, number of programmers); and
- Determining how long existing systems have been in place and reporting on future plans for near and long-term enhancements, modifications, or replacements.

State-of-the-practice information was gathered primarily by means of a written questionnaire (Appendix A). This questionnaire was sent to all state and Canadian DOTs. The questionnaire was supplemented by a literature search and limited interviews.

In addition to reporting the specific findings of the survey, this synthesis reports on the current best practices on the broader topics of process/system redesign and implementation (Appendix B), as well as current practices in project management.

ORGANIZATION OF THE SYNTHESIS

This synthesis is organized on the basis of current practices in project management and project management systems as employed by the DOTs that responded to the survey. The general findings provide valuable insights

for individual chief administrative officers, chief information officers, information technology staff, and project managers as they seek to evaluate and improve their own organization's performance and approach to system development.

Chapter 2 details the current practices of DOTs in the area of project management and project management systems. This chapter identifies some key trends as well as critical gaps in current practices.

In chapter 3, several state DOTs are profiled as case studies in the design and implementation of project management systems. The experiences of these DOTs not only reiterate the best practices themes detailed in Appendix B, they offer compelling guidance on what to expect.

CHAPTER TWO

SUMMARY OF CURRENT PRACTICE

Two-thirds of the DOTs responding to the survey have adopted strong forms of project management, that is, they have changed to a style of managing that places additional expectations and responsibility on the project manager. More significantly, few DOTs have Project Management Information Systems (PMISs) that complement the new project manager role. Consequently, the majority of the DOTs are dissatisfied with their present system. These DOTs must move to change their systems or they will place their project managers at serious risk of failure. It is also likely that changing their PMISs to adequately support their shift in approach to a stronger project management orientation represents significant organizational change. "When applied well, information technology can yield dramatic successes. Frequently underestimated, however, is the fact that when neglected, it can produce failures and actually inhibit improvement efforts" (*3*). For this reason, Appendix B has been designed to provide background and guidance for senior managers and information technology professionals who must address the topic of implementing changes in their approach to project management and the corresponding mandatory change to project management. Appendix B includes descriptions on how to design, implement, and manage change; the role of senior management, teams, and consultants in this process; and defines the processes and costs.

PROJECT MANAGEMENT FRAMEWORK

To provide a framework for the DOT project management systems questionnaire, a definition of project management and an overview of key project management principles is in order. The source of this information is the Project Management Institute (PMI), a nonprofit consortium of public and private sector organizations with 45,000 members that publishes *A Guide to the Project Management Body of Knowledge* (*4*). The purpose of this guide is to identify and describe proven, traditional, widely applied practices. It also catalogs innovative and advanced practices that have seen more limited use. The following definitions are from the guide.

- Project—A temporary endeavor undertaken to create a unique product or service. (Note that a project differs from operational efforts that have many of the same aspects as a project except that operations are ongoing and repetitive.)
- Project management—The application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project.
- PMIS—This consists of the tools and techniques used to gather, integrate, and disseminate the outputs of the other project management processes. It is used to support all aspects of the project from initiating through closing and generally includes both manual and automated systems.
- Program—A group of related projects managed in a coordinated way. Programs usually include an element of ongoing activity.

PMI suggests that the responsibility of the project manager is ultimately to integrate all key factors during the course of planning and delivering a project. If integration is the primary responsibility of the project manager, then the PMIS (automated and manual) should assist with this integration task. As *A Guide to the Project Management Body of Knowledge (4)* develops the framework for project management, it breaks the topic into two main areas: project management context and project management processes.

Project Management Framework: Context

The context is the environment in which the project manager must function. The environment includes such socioeconomic influences as stakeholders and cultural/regulatory issues. The context also includes organizational structure as well as the skills a project manager brings to his/her assignment.

In most instances, stakeholders have limited impact on the attributes of a PMIS. Their linkage to a PMIS is normally through the project manager and they typically want information about the project. For the purposes of this synthesis report, stakeholder requirements are subsumed under the project manager skill area of "communicating," which is identified in the next section. Similarly, cultural/regulatory issues aren't likely to strongly influence the attributes of a PMIS. Conversely, project management skills and organizational structure can have a substantial impact on the nature of a PMIS and are explained more fully in the next two sections.

TABLE 1
LINKAGE BETWEEN PROJECT MANAGEMENT APPROACHES AND ORGANIZATIONAL STRUCTURE *(3)*

	Organizational Type				
		Matrix			
Project Characteristics	Functional	Weak	Balanced	Strong	Projectized
Project manager's authority	Little or none	Limited	Low to moderate	Moderate to high	High to almost total
Percent of staff assigned to specific projects	Virtually none	0–25%	15–60%	50–95%	85–100%
Project manager's role	Part-time	Part-time	Full-time	Full-time	Full-time
Common titles for project managers	Project coordinator/ project leader	Project coordinator/ project leader	Project manager/ project officer	Project manager/ program manager	Project manager/ program manager
Project management administrative staff	Part-time	Part-time	Part-time	Full-time	Full-time

Context: General Management Skills Areas

PMI identifies five general management skills that provide the foundation for project management skills:

1. Leading,
2. Communicating,
3. Negotiating,
4. Problem solving, and
5. Influencing the organization.

Because a PMIS can assist a project manager in using these skills on a project, several questions are designed to determine the capability of a PMIS to support these skills. These questions deal with the ability of the system to develop graphics and charts (to assist with communicating and influencing both internal and external audiences), to do "what if" analysis (to support problem solving), and to provide accessibility by multiple users (to facilitate communication).

Context: Organizational Structural Influences

The ability of a PMIS to support a project manager and the attributes of the PMIS depend in part on the project manager's role within the organizational setting. Table 1, from *A Guide to the Project Management Book of Knowledge* (*4*), identifies how various approaches to organizational structure can effect the project's characteristics.

For the purposes of this synthesis report, respondents were asked to identify their "approach" to project management according to the following categories:

- Single-point project manager assigned "cradle to grave";
- Phased project manager, e.g., design project manager, construction manager;
- Functional discipline project manager such as bridge, roadway design, geotech; and
- Other (please specify).

Each of these approaches relates directly to the PMI table. A single-point project manager is synonymous with the project manager operating under a "projectized" or "strong matrix" organizational structure. A phased project manager relates to a manager in a matrixed organization. The functional project manager corresponds directly with the functional structure above.

Because of the influence that the organizational structure has on the role of the project manager, it similarly is expected to influence the type of PMIS as well. That is, a single-point project manager has a greater requirement to integrate all aspects of the project and, therefore, is more likely to require a PMIS that has broad analytical features. On the other hand, functional project managers have a coordinating role over only a portion of a project and are more likely to require summary data for statusing a project. They are not as likely to require analytical capabilities from the PMIS.

Project Management Framework: Processes

The second primary component of the project management framework is the series of processes necessary to deliver a project. Irrespective of the specific processes employed by a particular organization, a project will go through the five general processes from inception to completion.

1. *Initiating processes*—recognizing that a project or phase should begin and committing to do so.
2. *Planning processes*—devising and maintaining a workable scheme to accomplish the need the project was undertaken to address.
3. *Controlling processes*—coordinating people and other resources to carry out the plan.
4. *Executing processes*—ensuring that project objectives are met by monitoring and measuring progress and taking corrective action when necessary.
5. *Closing processes*—formalizing acceptance of the project or phase and bringing it to an orderly end.

For the purposes of the questionnaire, the key processes that are most likely to be supported by an automated PMIS are the planning, controlling, and executing processes. The initiating processes and the closing processes do not lend themselves as much to computerized support systems. To determine the potential use of an automated system to assist with the integration function of project management, respondents were asked to identify the phases of development, from planning through maintenance, which their PMIS covers.

PROJECT MANAGEMENT KNOWLEDGE AREAS

Although the project management context and processes define the project management framework, there remains another "domain" of topics required for successful project management. *A Guide to the Project Management Book of Knowledge* (*4*), describes this domain as "project management knowledge areas" and identifies nine such knowledge areas.

1. Project Integration Management
2. Project Scope Management
3. Project Time Management
4. Project Cost Management
5. Project Quality Management
6. Project Human Resources Management
7. Project Communications Management
8. Project Risk Management
9. Project Procurement Management.

These areas relate to either subprocesses that must be managed during the course of a normal project or to specific status indicators such as the project schedule. More simply, they are areas of an ongoing project that the manager must "know about" in order to deliver a project efficiently and effectively. Not all of these areas are addressed by the questionnaire. Project management systems tend to support the three critical control processes of scope, schedule (time), and budget (cost) as well as resource (human and other resources) loading. These particular issues are highlighted in the questionnaire by means of a series of system capability questions.

FINDINGS

Thirty-five states and one Canadian province responded to the questionnaire. The information provided by these agencies was most complete in the areas of system capability and satisfaction with the current system. Fewer states provided information regarding the attributes of the current system or the cost of maintaining the current system. This section is divided into two subsections, General Findings and Specific Findings.

General Findings

This subsection includes survey responses in the following areas:

- Project management phases
- System platforms
- Current project management approaches
- Overall system satisfaction ratings.

Project Management Phases

Project management systems are used for a variety of project management needs. Within the survey, states were given the option of selecting from the following list of project management/development phases. A state could select all options that applied.

- Planning,
- Preconstruction (those design-related activities leading to final plans, specifications, and estimates),
- Construction,
- Maintenance,
- Other.

As illustrated in Figure 1, approximately three-quarters of the states that responded report using their systems to assist with the preconstruction phase of development. Approximately as many reported that they use their system to support planning as reported that they use it to support construction. Few states reported having systems to support maintenance and "other." Slightly more than one-half of the respondents have systems that support several phases of project development.

System Platforms

State DOTs currently use an array of automated systems and software. As illustrated in Figure 2, 68 percent of the survey respondents have mainframe-based project management systems, 43 percent have LAN/WAN systems, and 25 percent report using both mainframe and LAN/WAN or stand-alone desktop computer systems. Eighteen states reported using a combination of system platforms.

Current Project Management Approaches

To provide a context for comparing project management systems, states were asked to describe their current approach to project management from the following list:

- Single-point project manager assigned "cradle to grave";
- Phased project manager, e.g., design project manager, construction project manager;

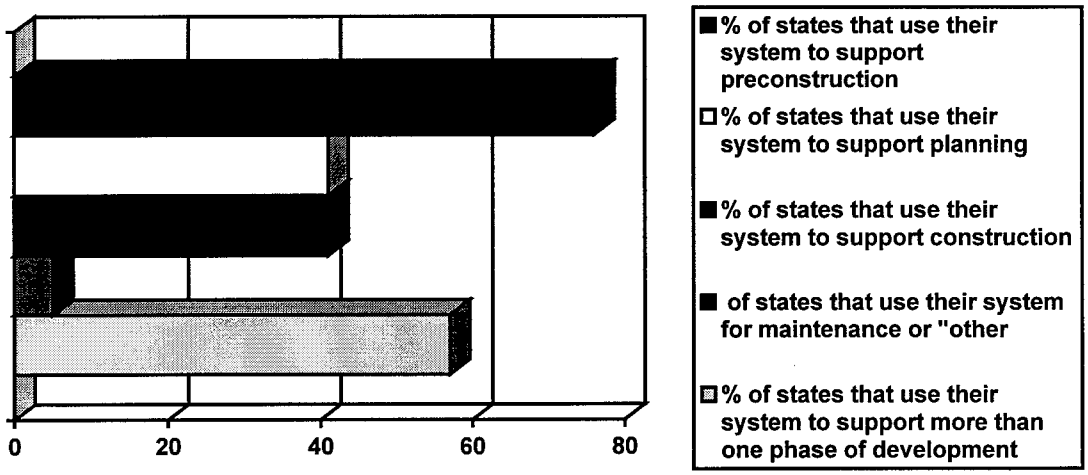


FIGURE 1 Project management phases currently supported by automated information systems.

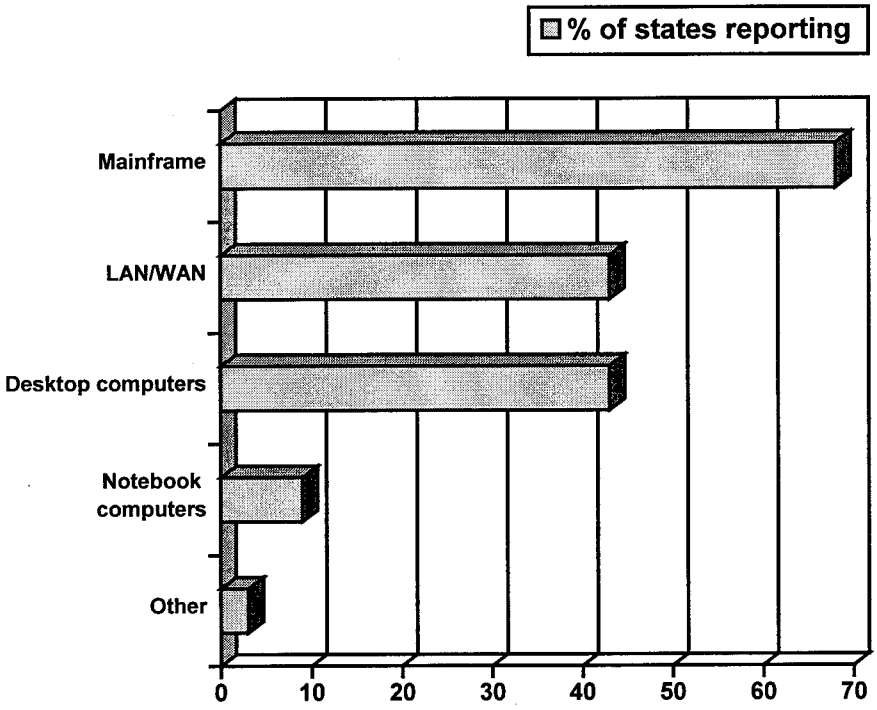


FIGURE 2 Automated systems currently in use.

- Functional discipline project manager such as bridge design, roadway design, geotechnical design;
- Other.

The responses are summarized in Figure 3.

Only one-third of the reporting DOTs still rely on "functional" project managers. The PMI guidelines that were outlined in the beginning of this chapter suggest that functional project managers generally have limited authority over project decisions and are more apt to coordinate only elements of the project. Two-thirds of the states have adopted an approach that gives more complete authority to a project manager. This approach suggests that the project managers in these DOTs will require a PMIS that has broader capabilities than those with functional project managers.

Overall Satisfaction

Of particular note was that only five of the states surveyed were very satisfied with their system. These five states combined with those states reporting that they were somewhat satisfied, represented only one-third of the states surveyed. Independently, 63 percent of the states plan to change their project management systems within 3 years. Another 11 percent expect to change their systems

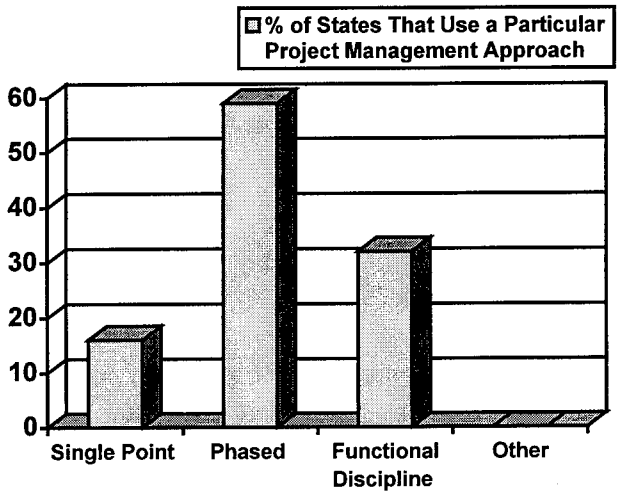


FIGURE 3 Current project management approaches.

within 3–5 years. As later findings demonstrate, the development of systems has not kept pace with the shift DOTs have made to a stronger role for project managers. The dissatisfaction that DOTs expressed about their PMISs is likely the result of the incompatibility between their current approach to project management and the analytical as well as reporting capabilities of their current systems.

Specific Findings

This subsection summarizes responses in the following areas:

- Development and implementation approaches
- Survey of automated systems and software
- Resource requirements to operate and maintain automated systems
- Capabilities and deficiencies of current systems
- Future plans for project management systems.

Development and Implementation Approaches

DOTs have approached the development of their project management system in a variety of ways. States were split almost equally across three approaches. Slightly more states favored using an internal team, but nearly as many states used an external IS/IT consultant or purchased an off-the-shelf system. Figure 4 illustrates how the current systems have evolved.

Some states used a number of these approaches. Those states that answered "Other" generally described a process where their internal team worked with an external consultant to develop and install their system. Most off-the-shelf systems were modified to better integrate with existing systems and databases. Other modifications included screen revisions and the incorporation of different internal system modules. Specific comments related to the type of system purchased and the nature of the internal development team can be found in Appendix C, Table C-1. In some instances, respondents treated their project management system and software as one in the same, so that their responses tended to be similar for both sections of the survey.

Given that so many states expect to replace their current system within 5 years, development and implementation of automated systems appears to be a particularly important area to consider. Potentially, the answers provided by the states that are most satisfied with their current systems will point toward an effective approach that other states could adopt. Unfortunately, the data do not appear to

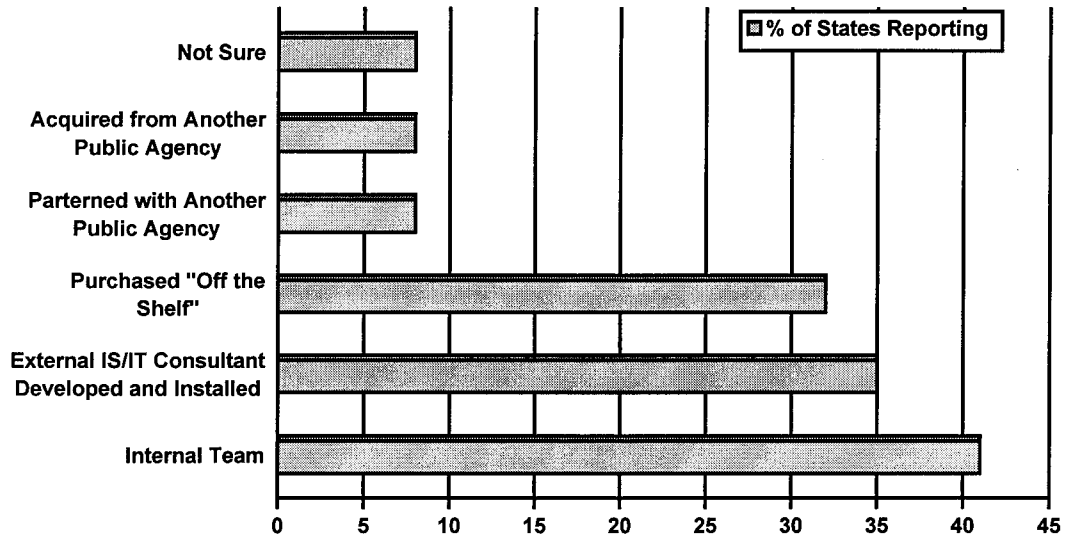


FIGURE 4 Evolution of current automated systems.

offer any singular approach that works well enough to be adopted as a "preferred method"; however, those states that reported the greatest satisfaction (a rating of "5") with their systems developed their software internally.

Surprisingly, only 8% of the states reported that they partnered with another DOT during the development of their system. Given the similarity of purpose across the DOTs, as well as the similarity of their business environment such as sources of financing and regulatory environment, one would expect that joint development would be an attractive approach to development. Joint development also appears to be a reasonable way to reduce the development cost for an individual agency by spreading the cost among several organizations.

Survey of Automated Systems and Software

Figure 5 illustrates how states approached the development of their current project management software. Those states that reported are nearly equally split between those who developed their software internally and those who purchased commercially developed software. As previously noted, survey responses tended to be similar for both system and software development. Although most states did not name the commercial software, several states reported using such proprietary software as Artemis and IBM AS (4.1 and 4.2). Other software packages included Microsoft Project, Primavera, CIS, Fieldbook, and Site Manager. The list of detailed responses and remarks concerning software are found in Appendix C, Table C-2.

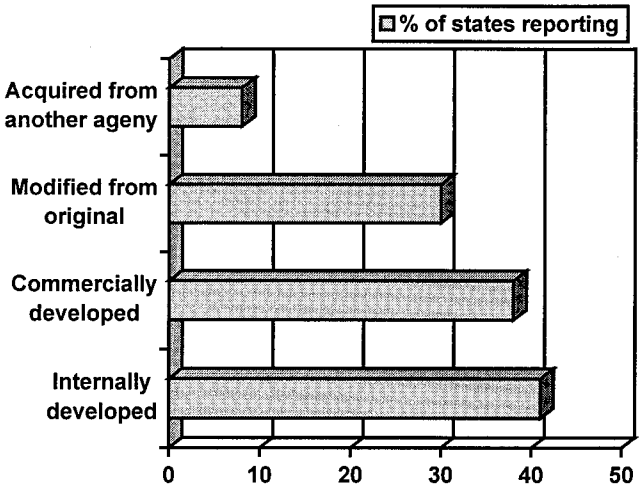


FIGURE 5 Approaches used to develop current systems.

Although all but two of those states that are most satisfied with their systems report using mainframes, nearly one-half also employ distributed systems through LAN/WAN. Only one of these states, Utah, has acquired (a portion of) its system from another state.

Resource Requirements to Operate and Maintain Automated Systems

Table 2 summarizes the information provided on annual system costs as well as the number of staff required to program and operate the system. Many states were not able to provide information on this topic. For those who did, the costs and staffing vary considerably. Eight states reported that they don't track the costs or, based on their internal system of accounting, they show the costs as negligible.

Of those states that provided the number of programmers and operators, small staff sizes were consistently reported. The maximum number of staff members in either category is 5. Two states show the number of operators to be 20 and 100. These answers reflect the number of project managers and others who use rather than maintain the project management system.

Capabilities and Deficiencies of Current Systems

When compared with the project management approach currently employed by two-thirds of the reporting states, the relative strengths and weaknesses of current project management systems provides valuable insight as to why so many of these states are dissatisfied with their current systems. In summary, states were first asked to provide an overall or "general" satisfaction rating. Satisfaction ratings could vary from a low of "1" (very dissatisfied) to high of "5" (very satisfied). In addition, states were asked to further evaluate their relative degree of satisfaction/dissatisfaction in the following areas using the same rating scale:

- Ease of data entry,
- Ease of data modification,
- Ease of information retrieval,
- Accuracy and timeliness of information,
- Ability to link project requirements to people,
- Ability to link project requirements to dollars,
- Ability to do "what if" analysis,
- Ability to access multiple users,
- Ability to create graphs and charts,
- Ability to track life-cycle costs, and
- Ability to track multiple projects.

To help identify patterns relative to system strengths and weaknesses, two statistical tests were applied to the ratings. The average (mean) score and the mode (the number most often recorded) were applied to each category of answers. The mean and mode scores are shown in parentheses and are based on the same 5-point rating system as the original survey. The three highest average scores across the DOTs' systems are:

TABLE 2

OPERATING AND MAINTENANCE COSTS FOR CURRENT SYSTEMS

	Total O&M Costs of Project Management System*				Number of People to Maintain the System	
DOT Name	Total	Equipment Costs	Programmer Costs	Operator Costs	Programmers	Operators
Arkansas	26	20	N/A	6	3	2
Georgia	85	25	35	25	1	1
Kansas	1,200	200	800	200	5	2
Kentucky (preconstruction)		Normal PC upgrades	2–3 staff months	1–2 staff months	1	1
Louisiana	—[1]	—[1]	—[1]	25	0	1
Maine	60	0	10	50	1	1
Manitoba	450	250	100	100	1	1
Maryland (highway development)	—[1]	—[1]	—[1]	—[1]	2	100
Massachusetts	—[1]	—[1]	—[1]	—[1]	2	1
Minnesota	235	10	120	105	3	20
Missouri	—[2]	—[2]	—[2]	—[2]	5	0
Montana	—[3]	—[1]	—[1]	—[1]	1	3
Nebraska	133.6	30	63.6	40	1.5	2.5
New York	500	50	50	300 + 85 for licensing	1	12
North Carolina	—[2]	Not sure	30	Not sure	1	1
Oregon	100	20	—[1]	15	0	1
Pennsylvania	—[4]	—[4]	—[4]	—[4]	3	5
South Carolina	—[2]	—[2]	—[2]	—[2]	3	4
Tennessee	—[3]	—[3]	—[3]	—[3]	0	5
Texas	—[5]	—[5]	—[5]	—[5]	2	0
Utah	115	35	30	50	0.5	1.5
Vermont	—[2]	—[2]	—[2]	—[2]	3	3
Virginia	—[1]	—[2]	—[2]	250	1	5
Wisconsin	120	20	100	0	2	0
Wyoming	—[1]	—[1]	—[1]	—[1]	1	0

*In thousands of dollars. N/A = not available; —[1] = no answer; —[2] = not tracked; —[3] = unknown; —[4] = in development; —[5] = negligible.

1. Accessibility by multiple users (4.08),
2. Ability to track multiple projects (3.80),
3. Ease of data modification (3.48).

The three lowest average scores were:

1. Ability to link project resources (people) (2.63),
2. Ability to develop project graphics and charts (2.40),
3. Ability to do "what if" analysis (2.32).

The system attribute with the highest mode score, that is, the number most often reported was "accessibility by multiple users"; its score was 5.

Four system attributes had a mode score of 1. They were:

1. Ability to track life-cycle costs,
2. Ability to link project resources (people),
3. Ability to develop project graphics, and
4. Ability to do "what if" analysis.

When these results are compared with PMI's project management framework and the answers that states provided to the question regarding their project management approach, some clear patterns emerge.

The attributes of current automated PMISs are incompatible with the project management approach that most states have adopted. Approximately two-thirds of the states have adopted an approach to managing projects that requires strong project managers as opposed to project coordinators. That is, they have adopted either single-point project managers or project managers who oversee entire phases of development such as design. This approach puts a demand on project managers to orchestrate and integrate

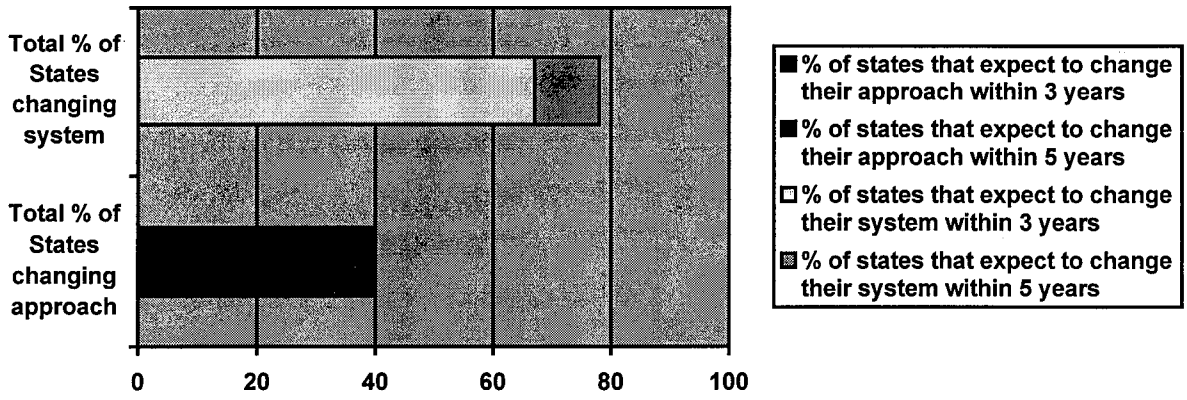


FIGURE 6 Percentage of states that expect to change their project management approach and systems.

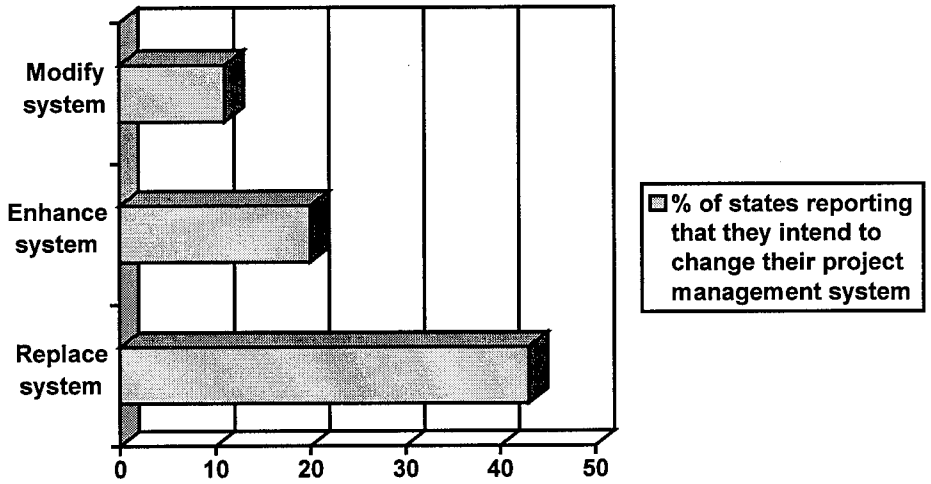


FIGURE 7 Expected change in project management systems.

the various aspects of their projects. To recap the PMI key points, key skill areas for project managers include communicating and problem solving. Management knowledge areas include time, cost, resource, and scope management. As their scores indicate, states have a sense of importance about these factors and the need for their systems to support them. Those states that consistently rate their systems low uniformly rate system performance low in these same areas.

Future Plans for Project Management Automated Systems

Forty percent of the DOTs intend to change their approach to project management. Thirty-seven percent expect to change within 3 years. For the most part, these changes will focus on better role definition for project managers or expanded reporting capabilities. Several states will expand their project management role from a "functional" manager to either a "single-point" or "phased" project manager. Four of the reporting states expect to implement "Site Manager" for their construction project managers. (Although only four states in this survey reported the expected use of Site Manager, considerably more states are expected to implement it.) Three states are currently in the midst of a reengineering effort, and their future approach is not yet defined.

Clearly, the vast majority of states will be operating with phased project managers or single-point project managers within several years. In addition, most of these states report that their automated systems support several phases of project development. For project managers to be effective and efficient with their time, this approach will require automated systems that are flexible and interactive.

Compared with the 40 percent who expect to change their project management approach, 74 percent of the states expect to change their PMIS within the next 5 years. Of this 74 percent, 67 percent expect to change their systems within 3 years (Figure 6).

Figure 7 illustrates further the extent of the changes that DOTs expect to make in their project management

systems. System enhancements typically include changes in screens or reporting formats. Modifications include new features such as "inception to completion" project tracking or a resource loading capability. Those states that reported that they intended to replace their system generally intended to replace their mainframe systems and anticipated having a capability to better integrate the project management system with other systems.

CHAPTER THREE

CASE STUDIES

This chapter includes a more detailed view of how successful DOTs are approaching their project management systems. The states that were chosen for this review include those states that provided an overall satisfaction rating of 4 or 5 for their systems. These states also took three different approaches to the development and implementation of their systems. North Carolina used an internal team to develop their system and software. New York used two different external consultants during the development and implementation of their system, and they purchased a commercially developed software package. Utah used a combination of internal teams and an external consultant. They also used the core of a system/software package that was developed by South Carolina. In addition, suggestions for successful system implementation from Maine and Ohio are also included.

NORTH CAROLINA

North Carolina has developed a project management system that it rates highly in all phases of system capabilities except for life-cycle analysis. Because the system was designed to only support the development phase of projects, life-cycle analysis isn't a factor. This system was developed internally 14 years ago by DOT staff. The system, known as PMSS, is used to support the preconstruction phase of project development from planning through bidding. North Carolina has an annual construction program of $1.1 billion and manages an average of 360 projects annually.

The purpose of the system is to track the on-time delivery of projects. Right-of-way clearance and bid letting dates are the "hard commitments" at the end of the process. PMSS tracks all of the activities and delivery dates that lead to these hard commitments. The system has the ability to accommodate a variety of users and track multiple projects. It is interactive so an individual can do "what if" analyses. Users can toggle easily to various screens and print directly from screens.

New projects are assigned a project number, and all subsequent tracking is based on that number. Updates to the system can be made as needed. If it appears that an activity will require additional time that could effect the right-of-way or letting dates, the branch submits a request to the Program Development branch for a time extension. Only the Program Development branch has the authority to approve a time extension. The Program Development branch has the on-going responsibility of monitoring the overall progress and schedule of projects.

The development process was guided by an internal team who began by gathering input from each of the preconstruction branches, such as structures and highway design. This input included a listing of all activities that had schedule impacts. From this input, written activity flow diagrams (such as a critical path method or process chain diagram) were developed. These diagrams were reviewed with each branch and reworked until all parties agreed that they accurately represented the way business was conducted.

Computer screens were developed based on the data requirements developed from the agreed upon activity diagrams. The screens from the old computer system (DSR) were also considered. The development of these screens and the development of the software, as well as the installation of the system, was accomplished by in-house computer staff.

The system is updated and modified as user requirements change. The "status section" monitors the use of the system. Elements of the system that are no longer used are dropped.

NEW YORK

The New York DOT began the development of its current system in 1993. New York has an annual construction program that averages $1.5 billion and typically includes about 550 projects. The New York DOT considers the system to still be in the implementation phase. Although the program management element of the system has been mostly implemented, the project management elements are still only partially complete.

New York began its initiative by redesigning its approach to program/project management. In the early 1990s, the planning and implementation of projects was performed centrally. The agency then decided that it wanted to decentralize the authority to its 11 regions. Their primary interest was to gain better coordination among management levels. Therefore, they did not undertake to do a complete detailed design at the production process level such as right-of-way. The DOT wanted to develop a strong project manager orientation wherein the cost, schedule, and scope for a project resides with the project manager. Under this concept, resources (production staff) would still be held by functional units.

Because the agency did not have the resources to develop a PMIS internally, they chose to use external consultants. Although they employed various internal committees throughout the course of the initiative, they relied heavily on outside staffing. They first retained a consultant to do a conceptual, high-level design. This design charted the course for subsequent work.

The actual software was to be provided by a second consultant. The agency issued a request for proposal (RFP), which required a demonstration of software as part of the selection process. In addition to software, the agency required the consultant to provide a "migration path" from the mainframe to a PC environment. At the time the original RFP was issued, the client-server capability was still in its infancy and could not adequately support multiple users; however, this was expected that to change as client-server capabilities matured.

The demonstration of software was a key piece of the selection process because the DOT's requirements were different than those of many of the other large project management practitioners of the time. For example, the nuclear and aerospace industry developed much of the early project management software. Their project environment was characterized by a single project with thousands of activities. The DOT environment is one of hundreds of projects with hundreds of activities. The agency wanted to ensure that the software would support their environment. Three consultant teams were invited to interview and to demonstrate their software. The selected team was responsible for providing a full-time project manager to oversee implementation and to complete the customization necessary to fit the DOT environment. The agency provided a part-time project manager. Other agency staff members were provided on a similar basis.

As the agency continues with its implementation, the following factors have been key to their success:

- Because their system has required years to implement, senior management resolve has been critical.
- As senior managers have changed positions, it has been important to stop and reconsider/reconfirm direction.
- Using two tiers of consultants for conceptual design and implementation has provided a breadth of experience and ensured independent thinking.

UTAH

Utah is in the final stages of implementing a sweeping change in their approach to project management. This endeavor adopts a phased project management implementation approach that will lead to single-point project managers. The Utah DOT has an annual construction program of approximately $160 million, with an average of 60 projects. The Utah DOT has also developed and implemented a new project (program) management system to support their change in approach. This system, known as PPMS (Preconstruction Program Management System) is intended to serve the following four purposes:

1. As a *management tool* to provide management with timely and accurate information about the project development process.
2. As a *guide to the project development process* that ensures that multiple projects are efficiently developed on time through the consistent use of defined processes.
3. To *model possible alternatives* that signal changes, that could potentially alter a project's delivery schedule.
4. To *monitor actual performance,* particularly in the areas of cost and schedule control.

Utah chose to use a combination of an external consultant and an internal team to develop their PPMS. This approach was chosen for several reasons. First, they did not have sufficient budget to hire a consultant to do all aspects of development and implementation. Second, they reasoned that they had to understand the system in order to successfully operate and maintain it once the consultant was gone; an understanding that was best gained by being involved during development and implementation. Third, they believed that agency staff was more likely to buy-in and use the system if they had a significant role in creating the system.

The internal team was small. It consisted of six members that included:

- A project manager for the reengineering system development effort,
- An engineer/project manager to develop engineering standards for the system,
- Two system programmers,
- One system analyst, and
- Administrative support.

The consultant's team consisted of their project manager and four systems programmers. During the course of development, the number of consultant programmers was reduced to two.

From the agency's perspective, the advantage of this internal/external approach is severalfold.

1. Consultants bring experience from other engagements that can help reduce or eliminate false starts and wasted effort.

2. Consultants can bring a sense of urgency about getting the project completed that is not always possible if only internal staff works on the initiative.
3. Because consultants have experience from other organizations, they can push staff to consider new and better ways of doing business.
4. Because the internal team was fully involved and committed to the development of the system, the implementation phase went much smoother. In particular, the development of a training program for agency staff was much easier.

A number of important lessons were learned from this experience that can benefit others. These lessons include:

- Maintaining the leadership of the initiative; that is, do not turn over responsibility to the consultant. By maintaining leadership responsibility, the agency is assured that their business rules will drive the development process. The Utah DOT defines a business rule as a particular style of operating, such as defining which reports are produced and where they're sent.
- Requiring site visits to other agencies helps team members rapidly gain understanding for the type of effort being undertaken. For Utah, the agency director accompanied staff on one such site visit. His attendance sent a powerful message to his own organization that their project management initiative was real.
- Having an engineer as a member of the internal team to ensure that the agency's way of doing business was reflected in the software that was developed. The presence of this individual on the team also established the credibility of the initiative with other engineering staff.
- Focusing efforts during the development phase on key organizational leaders such as region managers and preconstruction engineers to determine what the change in software would mean to them. The actual implementation will go much easier once several of these leaders support the development of the software and are committed to its implementation.
- That leadership understands that it is imperative that the development and implementation of the software is not a one-time thing; that is, the software must evolve through time if it is to remain relevant to its users.
- That leadership also understands that the direct cost of implementing a project management system is likely to also be the smaller portion of the implementation cost. User training and the time required for people to truly adopt a new way of doing business represent real (but often hidden) costs.

SUGGESTIONS FROM MAINE AND OHIO

In 1995, the Maine DOT published a report that outlined a suggested approach for the implementation of their program/project management initiative. In this report they provided a list of suggestions from the Ohio DOT that was based on the Ohio DOT's experience with implementation. In addition, Maine identified 12 keys to successful implementation, which are based on their own research and experience. The following are seven suggestions from the Ohio DOT:

1. Fix processes first. Do not purchase a system and try to fit it to outdated processes.
2. Determine what should be automated and why.
3. Determine if the system should be mainframe or PC based.
4. Develop the system. Do not ignore the users.
5. A good reporting system is a must.
6. Enter the data at the source.
7. Do not duplicate an automated system with a paper trail.

The Maine DOT continues by noting that the successful management of their program depends on the following:

1. Managing projects within the context of the entire program.
2. Accepting and consistently using sound program and project management principles.
3. Committing to the preparatory work necessary to implement these principles. Preparatory work should include the development of a common definition, language, and knowledge base as well as the development of uniform performance measures.
4. Committing to "stick with it" for the long term.
5. Committing to training indefinitely.
6. The willingness of users to provide accurate data into the system and to use the output from the system.
7. The willingness of managers and executives to act upon information/recommendations provided by the system.
8. The willingness of upper-level management to adequately fund the project management initiative.
9. Perceiving the system as user friendly.
10. Having the system provide accurate, timely information in understandable formats.
11. Having the system designed by people who know what they are doing.
12. Having the system include vital information and not be cluttered with "nice to know" information.

CHAPTER FOUR

CONCLUSIONS

Thirty-five states and one Canadian province responded to the Survey of States questionnaire. The information provided by these agencies was most complete in the areas of system capability and satisfaction with the current system. Fewer states provided information regarding the attributes of the current system or the cost of maintaining the current system.

Based on the information provided by the reporting states, it is clear that PMISs play an important role in the management of each state's projects. Although states use their systems for a variety of project management tasks, the greatest usage, 76 percent, is in the preconstruction phase of development.

Although these systems are used extensively, they are increasingly at odds with the needs of project managers. Two-thirds of the states have adopted an approach to management that gives broad responsibility to a project manager, yet only one-third of the states are satisfied with their current systems. Survey results demonstrate that current systems lack the ability to provide needed information in such areas as life-cycle costing and linking project resources. They also lack the flexibility to conduct any "what if" analysis or to develop graphics.

Seventy-four percent of the states expect to change their system within the next 5 years. Approximately 30 percent will enhance or modify their existing systems. Nearly 45 percent expect to replace their systems. Unless the approach to systems development changes, few states will work to jointly develop their systems. Recently, only 8 percent of the states partnered on system development.

Survey findings do not lead to a preferred approach to system development. States have used a combination of external consultants and internal teams to develop and install their systems. Many states acquired off-the-shelf systems. Software was generally purchased commercially and modified to interface with in-house systems. On the other hand, those states that are most satisfied with their systems developed their software and system internally.

Because so many states anticipate replacing their project management systems, the focus for best practices is on system reengineering and implementation. Experienced practitioners suggest that automated system replacement represents significant organizational change, and they caution against underestimating the level of effort required to succeed.

Senior management plays a vital role in successful implementation. Successful managers tend to view the replacement of information systems as investments rather than expenses. They also make a personal commitment to stay involved to ensure that internal reengineering and change management teams remain motivated and that the initiative is sustained.

As with so many other elements of product or service delivery, the installation of a new automated system progresses more smoothly when the effort is defined and guided by a rigorous process. The organization's internal culture deserves particular attention when defining an implementation process. The success or failure of system installation depends on a variety of factors. One of the most important is how readily people within the organization adapt to a new way of doing business. Reengineering and change management processes include an assessment of organizational readiness and implementation steps that address specific aspects of organizational culture.

The use of teams appears to be fundamental to successful system reengineering. The reason behind team effectiveness appears to be tied to the complex nature of reengineering work. Teams also seem to be an effective means of building broad-based understanding and acceptance of an initiative within an organization. The complex nature of reengineering also leads organizations to employ consultants. Although there are advantages and disadvantages in consultant use, most organizations feel that they benefit.

The total cost of system installation is often misunderstood and, therefore, underestimated. Whereas order of magnitude of system design or purchase costs are normally anticipated with sufficient accuracy, implementation and maintenance/upgrade costs are often overlooked. Overlooked too are the (lost) opportunity costs of having a system that is incapable of providing information to key stakeholders and decision-making bodies such as state legislative committees.

North Carolina, New York, and Utah were chosen as case studies because they each represent a different approach to successful system development. When the experience of these states is combined with the suggested approaches from Maine and Ohio, they paint a picture that complements the survey of current best practices. In particular, these approaches reaffirm the important role of teams and the active involvement of senior management.

Most states have adopted a form of the "strong" project manager approach to develop their projects. The current capability of their automated systems is incompatible with this approach. The lack of key graphic and analytical features coupled with system inflexibility puts this management approach at serious risk of failure. Although the lack of responsiveness from current systems places a tremendous demand on project managers, it represents a potential source for significant gains in organizational performance and reductions in production costs.

In the development and implementation of their automated systems, states have tried a variety of approaches. Although no single approach seems to be preferred, maintaining overall control of the process with internal staff seems to be a key to success. The use of internal teams is the key to understanding and managing the complexity of issues surrounding the installation of a new system. The active and continuous involvement of senior management is necessary to ensure the organization's commitment to install and use the system.

Organizations generally do a good job of defining and committing to paying for system design and purchase costs. However, they generally miss the mark on estimating implementation costs, maintenance and upgrade costs, and opportunity costs. Training and system upgrade costs can be significant. These costs are also the necessary ingredient to ensure that the system is used and remains responsive to project management needs. Understanding and defining opportunity costs can be key to building a funding commitment among decision makers. Unless an agency is willing to estimate and commit to funding all cost components, it shouldn't attempt to implement a new system. As spelled out by the GAO (*3*), when a system is neglected, it can actually inhibit improvement efforts.

It was discovered that few states have partnered with other DOTs to develop their automated systems. Because so many DOTs expect to replace their systems within 3–5 years, they should strongly reconsider the partnering alternative. Although the investigation of other joint development activities is beyond the scope of this research, initiatives like the development of Site Manager could be a good prototype for the development of new project management systems.

Given that unique requirements exist for all DOTs, a full-scale joint development of a singular system is not likely. For example, costing systems and human resource/payroll systems used by DOTs typically reflect the broader systems used within their state government. To that extent, it is not likely that a common platform can be developed to serve a wide DOT audience. On the other hand, there appears to be an opportunity for DOTs to pool their resources and talents to develop systems with capabilities in other areas such as program and project scheduling, as well as work planning. Other possibilities include graphics, life-cycle, and resource loading packages. Some DOTs already have these packages, which makes them attractive prototypes from both a cost standpoint as well as from the standpoint that they've already been through beta testing.

Given that the majority of DOTs are not satisfied with their current project management systems, there are real opportunities for additional research. A logical research area would be a detailed investigation of the development and implementation of systems and software. An excellent candidate would be the 20-state effort to develop Site Manager; however, the research would not/should not be limited to just DOT project management systems. Because the critical issue is to determine an expedient/cost-effective way to implement systems that meet user needs, a variety of systems should be reviewed.

Supplemental research in this area would not require the rigor of a National Cooperative Highway Research Program synthesis. For example, the American Association of State Highway and Transportation Official's committees or committees at the regional associates such as the Washington Association of State Highway and Transportation Officials could develop "best practices" clearinghouses on the development and implementation of project management systems. They may want to also share development costs for systems or software modules.

Although the focus of this synthesis is on project management systems, the larger issue of project management seems to be an area that can benefit from additional research. Given the present demand for stronger project accountability, including cost and schedule control, many organizations appear to be adopting a strong project manager approach. Two-thirds of the DOTs appear to be moving in this direction. Such a move represents significant organizational and cultural change. A research effort focused on lessons learned in the areas of effectiveness, efficiency, and transitioning to these approaches would be beneficial. The benefits would extend to both those DOTs that have adopted one of these approaches and to other DOTs that currently use a functional approach, yet are considering changing their approach.

REFERENCES

1. Kharbanda, O.P. and J.K. Pinto, *What Made Gertie Gallop? Learning from Project Failures*, Van Nostrand Reinhold, New York, N.Y., 1996.
2. Cleland, D.I., "The Age of Project Management," *Project Management Journal*, Vol. 22, No. 1, 1993, 19–24.
3. *Improving Mission Performance Through Strategic Information Management and Technology*, GAO/AIMD-94-115, U.S. General Accounting Office, Washington, D.C., May 1994.
4. PMI Standards Committee, *A Guide to the Project Management Book of Knowledge*, Project Management Institute, Upper Darby, Pa., 1996.

APPENDIX A

Survey of States Questionnaire

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Project 20-5, Topic 29-04

DOT *Project Management Systems*

QUESTIONNAIRE

Name of respondent: _____
State DOT: _____
Title: _____
Phone number: _____ *E-mail Address* _____

The following questionnaire seeking information on current practices regarding the development and use of DOT project management systems. Project management systems are defined as those systems that support the daily management and completion of individual projects. Project management systems are differentiated from program level management systems which have the ability to status a variety of projects, level resources across projects and track project funding sources.

The five page questionnaire is divided into seven parts: Part 1 seeking general information about the DOT's annual program and management system, Part 2 asks to identify the current project management approach, Part 3 deals with system development and implementation, Part 4 asks for information on the project management system and related software, Part 5 asks for an evaluation of the system's capabilities and deficiencies, Part 6 seeks information on future plans, and Part 7 asks for candidates for case studies.

It may be appropriate for different individuals to fill out various parts of the questionnaire. If so, please ensure that the respondent for each part is identified and that the complete questionnaire is returned as a single response from the agency.

Please return the completed questionnaire and supporting documents to:

Don Forbes
CH2M HILL
P.O. Box 428
Corvalllis, Oregon 97339-0428

If you wish to fax your response, the fax number is 541–752–0235. The questionnaire is also available electronically. Please submit your request for the electronic version to dforbes@ch2m. com.

We would appreciate your response by_____

THANK YOU FOR YOUR TIME AND EFFORT!!

NCHRP Synthesis Topic 29-04 Questionnaire

Agency Responding_____

Part 1: General

1. Total size of annual construction program in dollars (average of past three years): _____

2. Total number of projects in annual program (average of past three years): _____

3. Total size of the annual highway maintenance budget in dollars (average of past three years): _____

4. Do you have an automated project management system(s) ? yes__ no __

5. Total operating and maintenance costs of project management system (average of past three years): _____.

   a. Equipment costs _____
   b. Programmer costs _____
   c. Operator costs _____

6. Number of people to maintain the system(s): programmers_____ operators _____

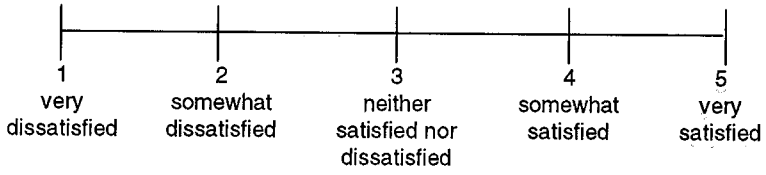
7. What phases of development does your project management system cover? (check as many as apply.)

   __Planning __Pre construction __Construction __Maintenance __Other (please specify)

   _____
   _____
   _____

8. How long has your current system(s) been in place? _____ years

9. In general, how happy are you with the ability of your system to help you manage your projects? (use 5-point scale below) If you have more than one system, please use the scale for each system.



NCHRP Synthesis Topic 29-04 Questionnaire

Agency Responding_____

Part 2: Project Management Approach

1. Please describe your agency's approach to project management (Choose one)

____Single point project manager assigned "cradle to grave"
____Phased project manager, e.g., design project manager, construction manager
____Functional discipline project manager such as bridge, roadway design, geotech
____Other (Please specify)

_____
_____
_____

Part 3: Approach to System Development and Implementation

1. Please describe your agency's approach to the development and implementation of your project management system(s) (check as many as apply for each system).

____External IS/IT consultant developed and installed our system

____We partnered with (an)other DOT(s) (please clarify)
_____
_____
_____

____We purchased an "off-the-shelf" system Modified? no___ yes___ (how?)
_____
_____
_____

____We used an internal team. (list the job titles of the team members)
_____
_____
_____

____We acquired our system from another public agency (please specify)
_____
_____
_____

_____Not sure (we just "evolved" over time)

_____Other (please specify) _____

NCHRP Synthesis Topic 29-04 Questionnaire

Agency Responding_____

Part 4: System and Software Profile

1. Please describe the attributes of your agency's project management system

____Mainframe
____LAN/WAN (if yes, are project files shared?) YES____ NO ____
____Desktop computers
____Notebook computers
____Other (please specify)
_____
_____

2. Please describe your project management <u>software</u>

____Commercially developed (name software & release)
_____

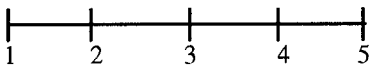
____modified? no__ yes__ (how so?)
_____
_____

____Internally developed
____Acquired from another public agency (name software & release)
_____
_____

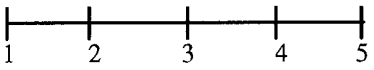
Part 5: System Capabilities and Deficiencies

Identify the capability of your current system(s) to fully support your project management function in the following eleven areas (see rating guide on next page):

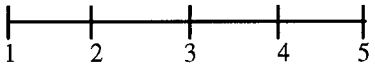
a. Ease of data entry



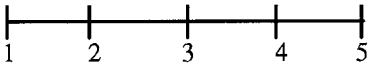
b. Ease of data modification



c. Ease of information retrieval information



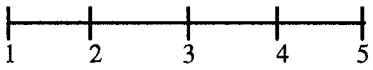
d. Accuracy and timeliness of project



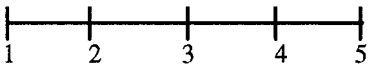
NCHRP Synthesis Topic 29-04 Questionnaire

Agency Responding_____

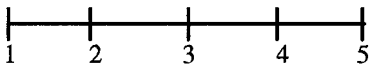
e. Ability to link project resources (people)



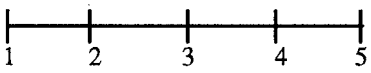
f. Ability to link project resources ($)



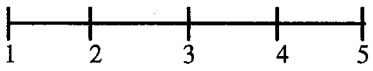
g. Ability to do "what if" analyses



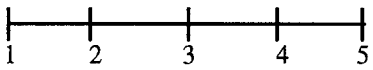
h. Accessibility by multiple users



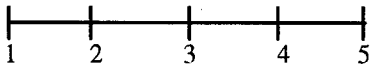
i. Ability to develop project graphics, e.g., work break structure, PERT/Gantt/CPM charts, staff requirements/loading charts



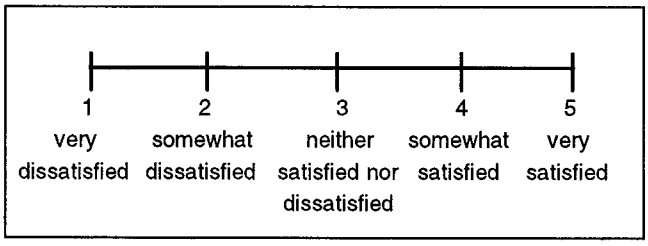
j. Ability to track project costs throughout its lifecycle (planning thru maintenance)



k. Ability to track multiple projects



RATING GUIDE:



NCHRP Synthesis Topic 29-04 Questionnaire

Agency Responding_____

Part 6: Future Plans

1. Are you planning to change your agency's approach to project management (see **Part 2: Project Management Approach** for reference.)

   a. Within 1-3 years? yes__ no__ (If yes, please specify the nature of the change)

   _____
   _____
   _____

   b. Within 3-5 years? yes__ no__ (If yes, please specify the nature of the change)

   _____
   _____
   _____

2. Are you planning to enhance, modify, or replace your existing system(s)

   a. Within 1-3 years? yes__ no__ (If yes, please specify the nature of the change)

   _____
   _____
   _____

   b. Within 3-5 years? yes__ no__ (If yes, please specify the nature of the change)

   _____
   _____
   _____

Part 7: Case Study Suggestions

If you are aware of any DOT's/project management systems that you can suggest for a case study, please specify (include reasons that you suggest the project management system for a case study).

_____
_____
_____
_____
_____
_____

APPENDIX B

Change: Definition and Implementation, Role of Personnel, Processes and Cost

Although process/systems reengineering approaches vary, most organizations find that understanding and managing the following six areas is key to their success:

1. The vital role of senior management,
2. Defining a reengineering/implementation process,
3. Defining and understanding costs,
4. The use of teams to design and implement change,
5. The use of consultants, and
6. Managing change.

Before each of these key areas is profiled, it is important to determine the nature of change, whether proposed change is significant, and the potential impact of change on the organization.

WHAT IS SIGNIFICANT CHANGE?

The destiny of all organizations rests with their ability to adapt to their changing environment. That adaptation relies squarely on the organization's ability to: (1) perceive the need for change, (2) design an appropriate course of action, and (3) expeditiously implement the necessary change.

Depending on the scale or magnitude of change, it can, at one extreme, be done through the course of daily business with little or no disruption. This type of change is exemplified by the TQM (Total Quality Management) style of continuous improvement. At the other extreme, change can have a profound impact on the organization. Change of this nature frequently includes modification/installation of automated management systems. Although simple in concept, managing this type of change can be profoundly difficult. Organizations the size of most state DOTs are very complex. Successful change requires sophisticated thinking, dedication, courage, and the expenditure of more resources than the uninitiated are apt to expect. "It is time to stop perpetuating the myth of simplicity. The system of organization of mankind generates problems that cannot be solved by simple solutions" *(1)*.

In their book, *The Wisdom of Teams*, Katzenbach and Smith suggest that an organization answer the following four questions to determine whether a proposed change initiative represents major change *(2)*:

1. Does the organization have to get very good at one or more basic things it is not very good at now (e.g., new skills and values)?
2. Do large numbers of people throughout the entire organization have to change specific behaviors (i.e., do things differently)?
3. Does the organization have a track record of success in changes of this type?
4. Do people throughout the organization understand the implications of the change for their own behaviors and urgently believe that the time to act is now?

A "yes" to 1 and 2 and a "no" to 3 and 4 indicates a major change situation. When these questions are applied to the topic of project management systems, DOTs may find that PMIS installation represents major change for their organization. Table B-1 provides a second means of assessing whether a change in project management and project management systems represents incremental change (Quality Improvement) or significant change (Reengineering). The table was developed by the Oregon DOT as a guide for assessing the magnitude of a proposed change as well as the corresponding involvement required of senior managers and others. This table outlines two approaches to change and suggests how a Key Factor (column 1) varies between these two approaches. To use this table to determine the magnitude of change a proposed initiative represents, begin with one or several key factors and determine from the narrative which type of change better describes the situation. For example, examine Key Factors, Breadth of focus and Dependence on information systems, as they relate to an initiative to install a modification to an existing project management information system. It is likely that the narratives that most apply are "addresses processes that span entire business units" and "information systems are frequently used as a key enabler and typically provide on-line access." Therefore, it is likely that this initiative represents a reengineering level of effort.

When the initiative is judged a reengineering effort, review the narratives under the other key factors to better understand the type of effort involved. In the case of Key Factor, Senior management involvement, reengineering requires a high level of senior management involvement throughout the effort.

THE VITAL ROLE OF SENIOR MANAGEMENT

Perhaps the most significant key to success, because it represents the most "leverage," is the sustained commitment of senior management. In a venture such as the changing

TABLE B-1

GUIDE FOR ASSESSING KEY FACTORS IN ORGANIZATIONAL CHANGE

Key Factor	Quality Improvement	Reengineering
Senior management involvement	High initial involvement becoming more support oriented.	High involvement maintained throughout the effort.
Team member involvement	On-going, as needed.	On-going, full time for specific assignments.
Improvement goals	On-going, incremental goals based on philosophy of continual improvement.	Breakthrough goals based on one-time, major revisions.
Implementation approach	Emphasis on improving current work processes.	Emphasis on creating new processes based on new ways of working.
Magnitude of organizational change	Limited disruption to both existing processes and systems. Minimum impact on organizational culture.	Radical revisions to existing processes and systems. Profound impact on organizational culture.
Breadth of focus	Addresses narrowly defined work processes and subprocesses.	Addresses processes that span entire business units.
Use of benchmark data	Used after process improvement to evaluate specific performance areas.	Used at beginning to assist with process design and again during implementation to confirm benefits.
Dependence on information systems	Information systems are used for data collection and interpretation.	Information systems are frequently used as a key enabler and typically provide on-line access.

Source: Adapted from ODOT's *Case for Action*, 1994.

approach to project management and the accompanying change in a PMIS, this commitment must come from the chief executive. In a 1994 report to the U.S. Congress on how information systems can help improve the "mission performance" of federal agencies, the General Accounting Office (GAO) reported that

> . . . senior management in the leading organizations (both public and private sector) we studied made a personal commitment to improve by (1) recognizing the need to fundamentally change information management, (2) creating line management ownership to incorporate information management into business planning, and (3) taking specific actions to maintain momentum over time. Such action resulted in a serious, motivated, sustainable improvement effort that had a wide impact throughout the organization *(3)*.

The GAO further stated that these leaders

> took information management very seriously. Increasingly asked to do more with less, they have learned to focus carefully on the stream of dollars invested in information technology and critical information resources and knowledge assets *(3)*.

The notion of organizational leverage or influence that is wielded by a chief executive cannot be understated. This notion is particularly important to DOTs. Because their chief administrative officers (CAOs) turnover regularly, the impact on the implementation of change initiatives, like the implementation of a PMIS, can be severe. Perhaps Ichak Adizes says it best. Adizes is an expert on organizational change and the author of *Corporate Lifecycles*, which is a guide to implementing change. On the topic of how intimately tied to senior leadership the change initiative can be, he states

> It is interesting to note that the ratio of building to destroying is at the cost of building. What took me three years to build, could be destroyed in three months–a new president comes in who does not understand the methodology and the new culture of mutual respect and trust that was so carefully nourished goes out the window *(4)*.

The reasoning behind a CAO's personal involvement also has to do with the nature of the risk involved with the implementation of a new system, as well as the magnitude of the costs associated with these systems. The GAO summarizes these issues this way:

> Successful organizations manage information systems projects primarily as investments, rather than expenses. As information management capability increases, projects are viewed more as mission improvement projects and less as information technology efforts. Senior management teams become personally involved in project selection, control, and evaluations . . . The investment focus systematically reduces inherent risks while maximizing benefits of complex projects. It does so by concentrating top management's attention on assessing and managing risk and regulating the tradeoffs between continued funding of existing operations and developing new performance capabilities *(3)*.

One of the potential errors that a CAO can make is believing that he or she must be an expert in information systems and technology in order to provide necessary leadership

and guidance. The research conducted by Gouillart and Kelly refute this notion. In their book, *Transforming the Organization*, they report

> Almost without exception, we have found leaders who have revolutionized their industries through technology aren't particularly knowledgeable about technology. They are at heart creative strategists, with an interest in the role of technology in business and a quiet confidence that technology, like infantry, will follow their lead *(5)*.

Gouillart and Kelly go on to say

> . . . they (leaders) shouldn't worry about rapid prototyping, relational databases, and parallel processing any more than they should worry about what's under the hood of their BMW. Business creativity is what's needed, not nerd magic *(5)*.

DEFINING A REENGINEERING/IMPLEMENTATION PROCESS

As those organizations that implemented TQM programs know, sustainable performance depends on well-defined processes. Similarly, sustainable design and implementation of a PMIS also depends on well-defined change processes. Within this subsection on reengineering, there are two separate themes. The first theme is about **key functions**. The second theme is about **key process steps**. Although there are a variety of reengineering processes, the three-step process that follows is a good starting point.

According to the GAO, the following three key functions are critical to building a modern information management infrastructure:

1. Deciding to work differently ***(Decide to Change);***
2. Directing resources toward high-value uses ***(Direct Change)***; and
3. Supporting improvement with the right skills, roles, and responsibilities ***(Support Change)*** *(3)*.

These three functions are the responsibility of senior management. Only senior management can make the decision to change that also carries the authority to direct sufficient resources and support to ensure the successful installation of a new system. Although the decision to change can be made by senior management without input, a better approach is to make the decision based on a "case for action" developed by staff within the agency. The case for action should be built on current performance data so that it demonstrates in a compelling way that the current way of doing business is no longer acceptable and that a new business approach must be designed and implemented. In Figure B-1, Part II of the reengineering process is used to build the case for action.

The three-step process in Figure B-1 was developed by Tenner and DeToro. In their book, *Process Redesign—The Implementation Guide for Managers (6),* they developed this particular process to respond to what they believe are the three reasons why organizational improvement efforts fail. The first reason is that the organization lacks an internal culture that is supportive to change. The second reason is that the organization fails to plan sufficiently for the change. The third primary cause of failure is that there is a lack of skills or competence in systematically improving the organization. The key aspects of the process are summarized here.

Cultural Requirements

Tenner and DeToro *(6)* assert that ensuring that the organization's culture is conducive to change is a basic requirement of successful implementation. Among key attributes of a conducive culture is the organization's focus on efficiently and effectively serving the customer's needs. Additionally, the organization must be driven by leaders who can articulate and inspire the need for excellence and a means of moving toward the desired goal. Finally, the

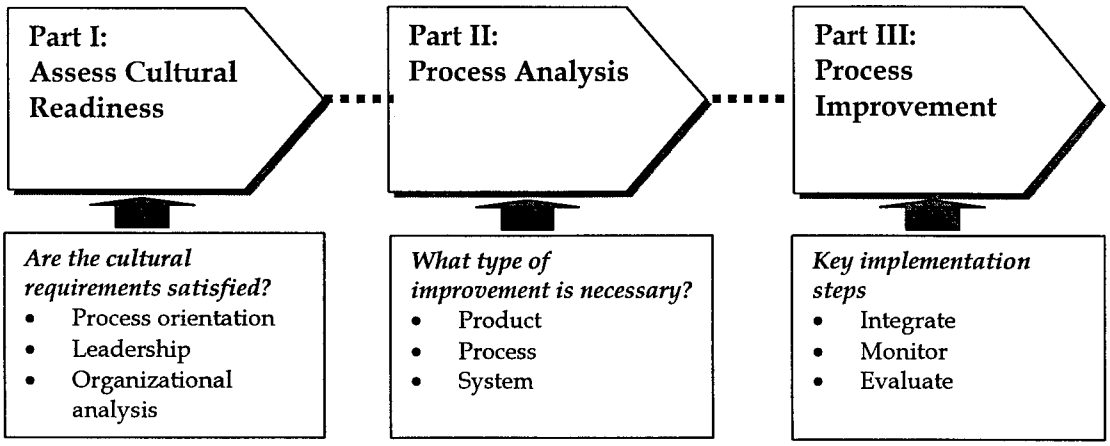


FIGURE B-1 Reengineering process *(6)*.

organization must be able to understand and analyze itself well enough to chart a course from its current approach to doing business to the new approach.

Process Analysis

Thorough preparation, planning, and senior management involvement is necessary for successful long-term organizational improvement. Analyzing the performance of key processes is necessary before adequate planning can be completed. Tenner and DeToro recommend using a process inventory as the basis of planning for change rather than an organizational chart. They envision a process inventory as a set of maps that cross organizational lines to define the steps of how things get done. The performance of each process should be measured against two criteria: effectiveness and efficiency. The degree of process effectiveness defines how well the process leads to the right product or level of service. Process efficiency defines in relative terms how much of each resource (labor hours, materials, dollars) was expended to generate the product or service. The process analysis is used to define the critical gaps between the desired situation and the current situation. This gap can be used to develop a "case for action" to mobilize the organization into changing.

Process Improvement

Whether the organization uses continuous improvement, benchmarking (borrowing processes and practices from similar organizations to achieve a step-change level of improvement), or reengineering (breakthrough level of improvement) depends on the extent of the gap as well as the following factors:

- Which level of intervention is indicated based on the importance of the performance gap and the opportunity to close the gap?
- Similarly, what is the feasibility of the improvement effort?

If this evaluation shows that incremental improvement is sufficient, then continuous improvement is the appropriate course of action. If a dramatic breakthrough is required, then reengineering is necessary. Somewhere between the two approaches is a third course that is characterized by a discrete step up in performance. This "stair-step" level of change is characterized by benchmarking.

UNDERSTANDING AND DEFINING COSTS

The replacement and implementation of a new project management system represents significant cost. These costs can be broken down into the following four cost components:

1. System design/purchase cost,
2. System implementation cost,
3. System maintenance and upgrade costs, and
4. Opportunity costs.

System design/purchase costs are those explicit costs of acquiring a new system. They should include the quoted purchase price, additional vendor/contractor costs, and internal staff costs. An agency will likely have a variety of options that range from a wholly internal effort to develop a new system to an externally supplied and installed system. Costs are frequently a significant determinant of which option to pursue. Therefore, it is important to value all internal labor at a "loaded" rate, which includes salary fringes and overhead contribution costs in order to accurately compare internal costs with external costs.

Implementation costs should include all costs related to making the system fully operational. A key, but frequently under budgeted, cost component is training. The Utah DOT has budgeted 40 hours of training for each user of the new system. As much as 15 percent of their entire budget for system development and implementation is dedicated to training.

If a system is to fully support the project management effort, it must be adequately maintained and upgraded. An agency should expect that a new system will undergo refinement as users attempt to apply it to their work requirements. If this particular cost component is not adequately addressed, the agency risks being in the position of responding to enhancement requests from project managers by stating that, "Sorry, the system won't do that." This type of response leaves project managers in an untenable position.

The aforementioned cost components comprise a set of explicit costs for system design and implementation. As such, these represent a substantial expenditure that may be difficult for an agency to get approved. The fourth cost component, opportunity cost, is a way to help clarify the benefit for paying the explicit costs. Opportunity costs represent those things that cannot be done because an agency does not have an adequate system. Although somewhat difficult to quantify, opportunity costs can be calculated. For example, if a DOT cannot respond to a legislative committee inquiry concerning costs and schedule for a class of projects, the agency suffers a loss of credibility. In a legislative process, this loss of credibility can easily result in a reduced operating budget or the lack of legislative approval for revenue increases.

Organizations generally do a good job of defining and committing to paying for system design and purchase

costs. Conversely, they generally miss the mark on the other three cost components. One possible explanation is that it is much easier to estimate purchase costs than upgrade or opportunity costs. Unless an agency is willing to estimate and commit to funding all cost components, it shouldn't attempt to implement a new system. As the earlier GAO citation admonishes, when a system is neglected, it can actually inhibit improvement efforts.

TEAMS

The use of teams appears to be fundamental to the successful design and implementation of process/system reengineering. The reason behind their effectiveness has to do with the nature of reengineering work. This work deals with complex issues that require the real time integration of skills, experiences, and perspectives that are unlikely to reside in a single individual. Additionally, the successful implementation and sustained use of a new process or system depends on its broad-based understanding and acceptance within an organization. The use of teams during the creation and roll out of a system begins to build a broader basis of acceptance. Katzenbach and Smith summarize this notion by stating,

> . . . in the kinds of broad-based change that organizations increasingly confront today, teams can help concentrate the direction and quality of top-down leadership, foster new behaviors, and facilitate cross-functional activities. When teams work, they represent the best proven way to convert embryonic visions and values into consistent action patterns because they rely on people working together. They also are the most practical way to develop a shared sense of direction among people throughout an organization *(2)*.

Although there are a variety of successful approaches to developing and implementing teams, the following guidelines will serve in many instances. These guidelines have been developed primarily for "reengineering teams." Often the development and implementation of automated systems are a critical element of reengineering efforts. Even when system development is an independent initiative, the parallels to reengineering are significant.

The BPR OnLine Learning Center's *Selecting the Right Team for Your Project* suggests that the team should be well rounded with a mix of people and skills *(7)*. Based on the recommendations of the Learning Center and others, the team should include:

1. Some individuals who intimately understand the current system (the technical wizards);
2. Some individuals who actively use the system and understand the project management process that the system is intended to support;
3. Some individuals who are completely objective toward the system and outcome (consultants normally fall into this category); and
4. Some individuals who are not familiar with either the organization's system or process (someone who brings a fresh perspective and outlook to the team).

The effective size for teams is generally considered to be between 4 and 12 members. Smaller teams (4 to 6 members) work faster and tend to produce results more quickly. Teams of greater than 8 members often benefit from third party facilitation and may require subteams for effective performance.

Teams with more than eight members are sometimes necessary to ensure representation throughout the affected organization. This broader representation also ensures diverse business perspectives and a greater knowledge base. The trade-off is that larger teams move more slowly through the creative process and, given resource constraints, the members are often part-time.

A good compromise is to have a design team of eight or fewer members who report periodically to a larger representative group. This structure enables a design team to move quickly, while benefiting from the knowledge and insights of a larger group.

USE OF CONSULTANTS

Organizations often seek the services of outside consultants when installing new systems or software. The use of consultants, however, can be a two-edged sword; that is, there can be both advantages and disadvantages to their use. Ahmed Shabana *(8)* points out some of these pros and cons. Among the advantages are:

- Consultants can provide specialized skills, experience, and know-how that the organization cannot afford or only needs sporadically.
- Consultants can effectively bridge across the organization by providing both technical and administrative innovations.
- Consultants can bring their wealth of experience gained from implementing similar projects in other organizations and, thereby, direct the development effort to areas where it can have the most beneficial results.
- At the same time, as outsiders to the organization, consultants can take a fresh look at existing systems and uncover inefficiencies or gaps.
- Finally, they can bring an objective vision to the project and thus act as facilitators of the change process by mediating the inevitable conflicts that arise when changes are introduced *(9)*.

They can also have a negative impact on implementation because:

- As outsiders, consultants have a limited knowledge of the existing systems and processes. Their acquisition of basic information will take some time, which may have a negative effect on the completion time of the project at hand.
- Even after they've acquired the basic information, consultants still might recommend actions that, although successful in other organizations, are incompatible in the particular organization.
- If the consultant takes too strong a role in the effort, the staff within the organization may disengage *(10)*.
- If the solution is seen as the consultant's rather than the organization's, the likelihood of successful implementation is diminished *(10)*.

For those organizations that choose to use consultants, it should be noted that they don't all use consultant services in the same manner. Although some organizations use consultants to design and implement projects, other organizations limit their involvement to either the design or the implementation stages of the project.

There is another way of defining the potential role of a consultant. Hammer and Stanton *(11)* suggest that consultants can be used to address (either singularly or in combination) three needs. They describe these needs as head, heart, and hands. In addressing the "head" issues, the consultant is hired for their particular knowledge and expertise. Consultants can also fulfill the "heart" role by providing the emotional support to the organization as it journeys through design and implementation. Finally, consultants can serve as the "hands" that are required to complete the design or implementation.

As to whether consultants provide that expected benefit, the data are mixed. Once again, the available data focus on the success of consultants in the design and implementation of business process reengineering (BPR) efforts. Shabana *(8)* found that the level of consultant "intervention" had little influence over the success of BPR projects. He suggests that one probable cause is inherent in the relative quality/experience of individual consulting firms. Another possible cause is identified by Bashein et al. *(12)*. They point out that organizations that hire consultants can fall into the trap of expecting the consultant to do the work with little or no contribution from the organization. The resulting product can differ greatly from what the organization expected. In contrast, the results of a 1997 benchmarking study of 57 BPR projects *(7)* demonstrated that more than three-quarters of the respondents felt that their consultant was critical or very critical to the success of the project. Over one-half of the respondents would use consultants again.

MANAGING CHANGE

The design or purchase of an information system is only an early phase of the change process, not the end. Frequently, the more difficult work involves installing the system in a way that fulfills its operational requirements and that ensures that the system is routinely used by its intended audience.

> Major change, by its nature, is intentionally disruptive and largely unprogrammable. In comparing the management of major versus normal change, one top executive said, 'It used to be like I-75. You lay it out from Toledo to Tampa. Now it's more like a white-water raft ride. You try to get the right people in the raft and do the best you can to steer it *(2)*.

Unless senior management has experienced the difficulties of organizational change, there is a tendency to believe that change can be dictated; that it is a linear, predictable process from point A to point B, and that once initiated, only a caretaker is necessary to monitor progress toward inevitable success. Unfortunately, none of this is true. Hammer and Stanton state that 50 to 70 percent of all reengineering (major change) efforts fail to meet their intended objectives because organizations lose focus and make avoidable mistakes *(11)*.

Perhaps the most serious mistake is to underestimate the effort necessary to change an organization's culture. "Culture" is the sum of how employees in an organization expect to be treated, what they value, and how they conduct business. Whenever significant change is introduced, one or more of these three elements of culture must change. Organizational cultures can be supportive and positive, that is, they can help the organization deliver effective, efficient products and services in a manner that also inspires employees. Organizational cultures can also have the opposite characterization and impact. Whether a new process or system is used depends on whether the existing staff within an agency embraces or rejects the change. Of all of the elements necessary for successful implementation, organizational acceptance and use is the most critical. When Tenner and DeToro refer to "cultural readiness," they are referring to a culture that is supportive and positive about the intended change.

> One of the difficulties in bringing about change in an organization is that you must do so through the persons who have been most successful in that organization, no matter how faulty the system or organization is. To such a person, you see, it is the best of all possible organizations, because look who was selected by it and look who succeeded most within it. Yet these are the very people through whom we must bring about improvements.
>
> —George Washington, Second Inaugural Address *(6)*

Figure B-2 outlines a set of six critical success factors for successfully managing change. Although these factors

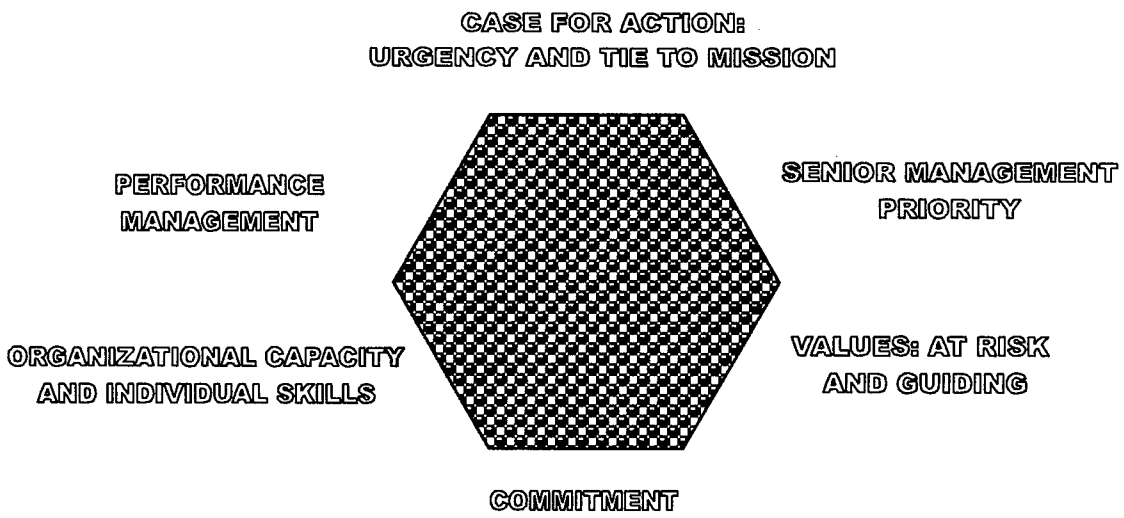


FIGURE B-2 Critical success factors for managing change *(13).*

address successful implementation, they do so by focusing on the cultural side of the organization and, therefore, relate to issues of cultural readiness. If these factors are managed well, the likelihood of successful implementation improves. These factors were developed after 8 years of change management experience in the Oregon DOT. The factors are portrayed as six sides of a hexagon to emphasize that all six combine to form organizational capacity (represented by the area of the hexagon) to implement change. As an organization improves its capability in a particular area, the length of that line increases. As the length of the line increases, so does the area of the hexagon and the organizational capacity for change.

1. ***Case for Action: Urgency and Tie to Mission***—The efficient installation of an information system or process reengineering depends on how rapidly employees embrace a new way of doing business. This efficiency is directly tied to the urgency employees feel to change the business. The strength of this factor therefore is determined by the answers to two questions:

   √ To what extent does the proposed initiative advance the primary mission of the organization?

   √ Are employees clear on the mission or purpose of the initiative itself?

The success of a change initiative depends on employees understanding that the initiative is critical to the delivery of the organization's mission. In addition, they must understand and feel that the initiative must be undertaken immediately.

2. ***Values: Guiding and At-Risk***—By its very nature, when substantial change is introduced into an organization it alters existing relationships, responsibilities, and workflow. To that extent, the question of fairness is woven throughout the initiative. The organization's readiness to manage this factor is determined by answering two questions:

   √ What are the guiding values that must operate during the reengineering transition?

   √ What values will employees perceive to be violated during implementation (and what can be done to minimize or eliminate the violation)?

Establishing a set of guiding values or principles at the outset assists with a smoother transition to the new order. What is more difficult to anticipate, but more likely to cause disruption in the change process when violated, is the existing set of organizational values and norms that guide behavior on a daily basis. The reason these norms are difficult to anticipate is that they are often unstated. If these values and norms can be identified and sufficiently addressed during the design of the implementation process, people are more likely to embrace rather than resist the change initiative.

3. ***Priority***—Is this reengineering effort truly among the top three organizational priorities, or is it just one of many similar priorities? Employees in most organizations do an excellent job of concentrating on what is important and ignoring the unimportant. Likewise, most of them feel that they are already working at capacity. If a proposed initiative appears as "the idea of the month" and an impediment to accomplishing work, employees will ignore it and hope that it will soon "go away." On the other hand, if senior management portrays the change as among the top priorities for the agency and essential to the agency's continued success,

employees are far more likely to treat the initiative with the seriousness needed.

4. ***Commitment***—Despite the rather obvious inclusion of "commitment" within the list of critical success factors, the nature of commitment to successfully implement a reengineering/system installation effort is less obvious. First, there are various forms of commitment. The lowest form is "active sabotage." Active sabotage can be a legitimate form of commitment (as in the case of opposing governmental tyranny), but it is not a form of commitment that will enhance successful implementation. Depending on the specific organization and intended change, there are probably a number of employees who are prepared to actively sabotage the effort. Anticipating, understanding, and addressing the concerns of these employees is important. A somewhat more positive form of commitment is "go along to get along." Although this is a frequently held form of commitment in the early stages of a change effort, it does not help advance the effort. Only the upper levels of commitment such as "I will do whatever is legal/ethically within my power to help this succeed" will be sufficient to implement the change. The challenge is to attract and involve a sufficient number of employees with this level of commitment. Without it, the change effort will die.

5. ***Organizational Capacity and Individual Skills***—Do employees and managers have the skills to operate in the new environment? Do they also have sufficient skills to manage the transition to the new environment? If the answer to either question is no, training is necessary for the effort to be successful. There are two pitfalls typically associated with training. The first pitfall is that the organization does not budget an adequate amount of staff time and funding to sufficiently train staff to successfully use a new system. The second pitfall is ignoring the training needs of the staff members who are charged with designing and installing a new system or process. Having key staff trained in the basics of reengineering and change management can greatly reduce the time and enhance the efficiency of changing.

6. ***Performance Management***—The final critical factor in successful change management is performance management; that is, developing, monitoring, and managing by a set of key measures to ensure that the new system meets its operational objectives. Having a clear set of measures provides a number of benefits. First, it sets clear expectations for those charged with developing and implementing the system. Second, senior management is better able to monitor and guide the development of the new system. Finally, measures give management a means of communicating with external audiences such as legislative committees that the agency is taking appropriate action to ensure that the investment is protected.

REFERENCES

1. Kilmann, R.H., *Beyond the Quick Fix,* Jossey–Bass, San Francisco, Calif., 1984.
2. Katzenbach, J.R. and D.K. Smith, *The Wisdom of Teams,* Harper Collins, New York, N.Y., 1993.
3. *Improving Mission Performance Through Strategic Information Management and Technology,* GAO/AIMD-94-115, U.S. General Accounting Office, Washington, D.C., May 1994.
4. Adizes, I., *Corporate Lifecycles,* Prentice Hall, Englewood Cliffs, N.J., 1988.
5. Gouillart, F.J. and J.N. Kelly, *Transforming the Organization,* McGraw–Hill, New York, N.Y., 1995.
6. Tenner, A.R. and I.J. DeToro, *Process Redesign—The Implementation Guide for Managers,* Addison–Wesley, Reading, Mass., 1997.
7. "Selecting the Right Team for Your Project," BPR OnLine Learning Center, ProSci, Quality Leadership Center, Inc., Loveland, Colo., 1998, <http://www.prosci.com>.
8. Shabana, A.A., "The Effect of Outside Consultants Involvement Over the Success of BPR Projects," Texas A&M University, College Station, Tex., 1998.
9. Markus, M.L., *Systems in Organizations: Bugs and Features,* Pitman, Boston, Mass., 1984.
10. "The Role of Consultants in BPR Projects," BPR OnLine Learning Center, ProSci, Quality Leadership Center, Inc., Loveland, Colo., 1998, <http://www.prosci.com>.
11. Hammer, M. and Stanton, S.A., *The Reengineering Revolution,* Harper Collins, New York, N.Y., 1995.
12. Bashein, B.J., L. Markus, and P. Riley, "Business Process Reengineering: Preconditions for Success and How to Prevent Failure," *Information Systems Management,* Spring, 1994.
13. Forbes, D.E., "Lessons Learned About Successfully Managing Change," Presented at the Minnesota Department of Transportation 1996 Spring Conference, Minneapolis, Minn., March 1996.

APPENDIX C

Summaries of Responses and Remarks

TABLE C-1

SUMMARY OF RESPONSES TO "SYSTEM DEVELOPMENT AND IMPLEMENTATION"

DOT	Approach to Development and Implementation							Remarks
	External IS/IT Consultant	Partnered with another DOT	"Off-the Shelf"	Internal Team	Acquired from another Agency	Not Sure	Other	
Arkansas			X					Off-the-shelf systems required interfaces to link to existing systems.
Colorado				X				Internal team included ROW managers, environmental manager, staff design engineer, design engineers, and human resource staff.
Illinois							X	The DOT used a combination of external consultants and internal staff.
Kansas	X		X	X				The internal team included the Assistant Design Engineer, Traffic Engineer, Construction Engineer, Engineer of local/urban projects, Chief of Federal Aid, and Chief of Program Management.
Louisiana				X				Internal team of programmers, engineering supervisors and managers, and engineering technicians.
Maine				X				The team included one planning and research assistant and one programmer.
Manitoba			X	X			X	Artemis software was integrated with existing in-house software by a consultant/internal team (Senior Systems Analyst, Programmer/Analyst, Information Analyst).
Maryland (highway development)			X	X				Microsoft Project 4.0 coupled with Microsoft Access 2.0.
Maryland (planning)			X					Microsoft Project 4.0.
Massachusetts (not finished)				X		X		The internal team includes two systems analysts and a business analyst.
Minnesota			X					The off-the-shelf system was modified by internal staff with assistance from a consultant.
Missouri	X	X	X	X				Internal team included Transportation Program Director and a Senior Transportation Planner.
Montana					X			Acquired from New Mexico in the 80's and has been highly modified.
Nebraska	X		X	X				Software is IBM Application System (AS) developed and customized for Nebraska.
New Hampshire (not finished)	X			X				The internal team included various programmers and analysts familiar with the mainframe and PC applications.
New York	X		X					Internal team and consultants are building custom modules for PC LAN system.
North Carolina				X				The team included preconstruction branch managers and unit heads.
North Dakota				X				The internal system includes only construction records.
Oregon			X					System modified to fit DOT's processes.

TABLE C-1 *(Continued)*

DOT	Approach to Development and Implementation: External IS/IT Consultant	Partnered with another DOT	"Off-the Shelf"	Internal Team	Acquired from another Agency	Not Sure	Other	Remarks
Pennsylvania	X		X					Consultant is developing and installing Welcom Open Plan (Professional and Desktop).
South Carolina							X	External consultant with internal design team.
Texas	X	X						"Site Manager" software is being developed with other DOTs.
Utah	X			X	X			Multiple Project Scheduling module from South Carolina is being combined with custom built software developed by a consultant and internal team.
Vermont					X			The software was acquired from South Carolina.
Washington								No overall system is in place.
Wisconsin			X	X				The DOT purchased 130 copies of Microsoft Project. District offices store projects and reports on their LANs. The software was modified to collect, update, edit, and post reports to a DB2 database. The DOT also provides management reporting capabilities.

TABLE C-2

SUMMARY OF REMARKS TO "SURVEY OF AUTOMATED SYSTEMS AND SOFTWARE"

DOT	System Attributes: Mainframe	LAN/WAN	Desktop Computers	Notebook Computers	Other (specify)	Software Profile: Commercially Developed	Modified (yes)? (see remarks)	Internally Developed	Acquired from another agency	Remarks
Arkansas	X		X			X	X			The software package is "Fieldbook," 1.1B. Internal staff developed an interface with CAS on the mainframe.
Georgia		X						X		Project files are on VAX cluster and can be accessed over LAN/WAN with PCs and terminals.
Hawaii										No system.
Illinois	X		X	X				X		Data resides on the mainframe with access through desktops and laptops.
Kansas	X					X	X			The software is IBM's AS 4.1 with DB2 that has been modified to enhance project management. It has been expanded to do program, production, and fund management.

TABLE C-2 *(Continued)*

DOT	System Attributes					Software Profile				Remarks
	Mainframe	LAN/WAN	Desktop Computers	Notebook Computers	Other (specify)	Commercially Developed	Modified (yes)? (see remarks)	Internally Developed	Acquired from another agency	
Manitoba	X					X	X	X		Artemis Project View was modified to integrate with in-house developed software.
Maryland (highway development)		X	X			X				Microsoft Project 4.0 coupled with Microsoft Access 2.0.
Maryland (planning)		X	X			X				Microsoft Project 4.0.
Minnesota	X		X			X	X			Artemis 9000 for the mainframe and Artemis 2000 for PC use. Added features include a funding application, a bridge subsystem, and State-Aid subsystem, and a District subsystem.
Missouri		X				X	X			The software is Project View 4.0 with Lotus Notes databases. The software has been modified to show project tracking information.
Montana	X						X			Data are created on the mainframe and project files are then downloaded to an Oracle environment.
Nebraska	X					X	X	X		IBM (AS 4.2) has been modified by internal staff.
New Hampshire (not finished)	X	X	X	X				X		Projects are not linked through LAN/WAN.
New York	X	X	X			X	X			In the process of migrating from a mainframe to a PC LAN based system. Software is Artemis 9000/EX (version 3.1), Artemis Planning 9000 (version 3.1—modified to simplify the input screens), and Artemis Project View (version 3.3).
North Dakota			X	X				X		There is no overall system, only tracking for construction pay items, change orders, etc.

TABLE C-2 *(Continued)*

DOT	System Attributes					Software Profile				Remarks
	Mainframe	LAN/WAN	Desktop Computers	Notebook Computers	Other (specify)	Commercially Developed	Modified (yes)? (see remarks)	Internally Developed	Acquired from another agency	
Oregon	X		X			X	X			Artemis 9000EX and Schedule Publisher-PC.
Pennsylvania		X	X	X		X	X			Software is Welcom Open Plan 2.0B. Modifications to interface with business needs, the mainframe, and other databases.
Tennessee	X	X							X	Project files are shared on the LAN/WAN. The software was acquired from Florida.
Texas	X	X	X	X		X	X			Software packages are CIS (modified to meet business changes) and Site Manager (beta version).
Utah	X	X			X			X	X	In the process of converting from a 3090XA mainframe to a client-server system using LAN/WAN. Software (Multiple Project Scheduling Module) from South Carolina is being combined with custom designed software.
Vermont	X								X	Software was acquired from South Carolina.
Wisconsin	X	X	X			X				Microsoft Project 4.1a modified with macros and menu options, views, tables.
Wyoming		X	X			X				The software is Primavera.