Taxonomy of Institutional Barriers to the Implementation of Pavement Management Systems

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The benefits of a pavement management system when fully implemented are well known, and the history of successful implementation is rich. Implementation occurs when the pavement management system is the critical component for making pavement decisions. However, there are barriers to the full implementation of pavement management systems. Institutional barriers, not technical and financial barriers, are more commonly responsible for a pavement management system's falling short of full implementation. In general, highway agencies should put more effort into overcoming these barriers. The Iowa Department of Transportation has designed an implementation process to overcome institutional obstacles and facilitate the implementation of its pavement management system.

Pavement management technology has matured in the past two decades, and excellent and inexpensive pavement management system software packages are now available. But the implementation of pavement management systems and the use of state-of-the-art pavement management techniques have been far less successful than expected, despite the beneficial experiences defined in the literature on this subject.

To understand the contention that pavement management implementation has not been as broadly successful as expected requires a common definition of implementation. Operating a pavement management system is not the same as implementing it. Smith and Hall have defined the implementation of a pavement management system as occurring "when pavement management becomes the critical component for making pavement management decisions" (*1*). Under this definition, an agency may operate a pavement management system, but if the system's results are not a critical component of decision making, the system has not been implemented. Smith and Hall's definition thus extends beyond the purchase of a pavement management system and even the development of supporting data bases and personnel.

State agencies have developed excellent pavement management systems, but they only give the system's results lip service when making actual resource allocation decisions. Other agencies restrict the use of the pavement management system's results to supporting resource allocation decisions for a limited portion of the highway network (e.g., only applying to Interstate highways) or for a specific category of activities (e.g., major restoration projects).

The likely benefits of pavement management systems have encouraged federal policy to mandate their operation. For example, in March 1989 the Federal Highway Administration established a policy requiring all state highway agencies to have an "operational" pavement management system by January 13, 1993 (*2*). The Intermodal Surface Transportation Efficiency Act of 1991 requires all federal-aid-eligible highways to be included in a pavement management system and, at the risk of federal sanctions, the pavement management must be implemented by October 1, 1997 (*3*). However, it is unlikely that federal pavement management mandates will result in complete adoption of pavement management systems as a critical element in pavement resources decision making. States may successfully develop operational pavement management systems, but actually integrating them into decision making is a separate matter.

This paper discusses the barriers to true implementation of pavement management systems. Institutional barriers, not technical or financial barriers, are more commonly responsible when a pavement management system falls short of actual implementation. The paper groups institutional issues into a general taxonomy. The final portion of the paper summarizes the implementation process of the Iowa Department of Transportation (IDOT). The Iowa approach is deliberately designed to overcome institutional issues and facilitate the complete implementation of a pavement management system.

Barriers to the Implementation of Pavement Management Systems

The three fundamental barriers to the implementation of pavement management systems are technical issues, financial and resource issues, and institutional issues.

Technical Issues

Technical issues relate to the methods necessary to conduct pavement management, to the technology and methods needed to collect data, and to available data base tools. There are three major technical barriers to viable pavement management systems:

1. Lack of a technically viable methodology to perform pavement management;
2. Lack of a knowledge base in pavement management processes and procedures; and
3. Lack of viable technology including field data collection, data base, and data processing technology.

Pavement management was first conceived in the mid-1960s (*4*). By the mid-1970s pavement management had expanded primarily for employment at the network level and involved the planning, programming, and budgeting of funds. Early network pavement management systems involved large mathematical-programming computer packages, which required massive efforts for development and were operated on expensive mainframe computers. In the 1970s and early 1980s, pavement data collection methods were still developing. Data collection strategies were often subjective, involving manual data collection methods. Both the pavement management analysis systems and the data collection methodologies in the 1960s, 1970s, and early 1980s presented significant technical barriers to the adoption of pavement management systems. By the late 1980s and early 1990s, however, pavement condition evaluation methods became more structured. Several technologies are currently available to automatically measure pavement condition. Also by the early 1990s, mainframe computer pavement management systems had been adapted to operate on inexpensive microcomputers. In fact, the currently available microcomputer versions of pavement management system software and data bases are more robust than their mainframe predecessors.

Clearly, barriers due to a lack of pavement management system methodologies, lack of a pavement management knowledge base, and lack of adequate technology have been overcome. This does not mean that no additional technical issues remain to be solved, but that pavement management systems have matured and technical issues should no longer create a barrier to implementation.

Financial Issues

Financial issues relate to the cost of implementing the system. For example, the original mainframe network pavement management systems cost several hundred thousand dollars to develop and install. Currently, more robust microcomputer pavement management software systems that cost only a few thousand dollars are available. As a result, the cost to operate and install pavement management system software has diminished considerably. Although the costs of implementing a pavement management system may have acted as a barrier to implementation in the past, system costs should not currently present an obstacle.

Institutional Issues

Institutional issues that impeded the implementation of pavement management systems result from the inability of highway agencies to truly incorporate pavement management systems into resource allocation decisions. Highway agencies have operated without fully effective pavement management systems for most of their existence. As a result, these agencies have well-established decision-making patterns that are independent of pavement management approaches. The inflexibility of these patterns prevents effective pavement management. Institutional issues may range from simple issues involving a lack of communication between the relevant offices within a highway agency to troublesome issues involving independence of decision making between the central office and field offices (turf battles).

The institutional issues that bar implementation of pavement management systems are particularly problematic because pavement management cuts across the boundaries of several functional disciplines within a highway agency. Pavement management should involve the functional areas of materials and material testing, construction, highway design, maintenance, highway program

planning, highway improvement planning, research, and others. Individuals from all the functional areas must cooperate for implementation to succeed. Obviously, the interdisciplinary nature of pavement management creates opportunity for many institutional problems to arise, and the specifics of each are unique to the organization. However, these institutional issues can be grouped into four broad categories:

1. Lack of an agency mandate or directive to implement pavement management and to use the pavement management system as a critical part of the pavement resource allocation process (lack of a champion);
2. Lack of ample or appropriate resources to implement pavement management;
3. Incompatibilities or inconsistencies between groups, offices, or divisions within the organization; and
4. Laws, administrative rules, organizational charter, or codes that preclude the implementation of pavement management.

Lack of an Agency Mandate

Because pavement management systems require cooperation among several functional areas within a highway agency, successful implementation calls for a top manager to serve as a pavement management champion to promote collaboration among the various functional areas (e.g., between maintenance and design). Particularly in state highway agencies, pavement management is commonly promoted by one office, often the office involved in materials and material testing or the research office. A single-office initiative is an outcrop of the traditional view that pavement management implementation is a technical issue. Because the development of a pavement management system appears to be an issue of system design and development involving engineers, systems analysts, and technicians, implementing a pavement management system is perceived to be just another technical problem.

Top management may mistakenly believe that implementation of a pavement management system is a technical issue and does not need top management's support and attention. However, incorporating the system into the decision-making process requires the resolve and focused support of top management, who must champion and promote the acceptance of the pavement management process by all participating offices.

Typical symptoms of the lack of a top management mandate are resistance to change and resistance to incorporating new techniques into the pavement resource allocation process because an approach is different from traditionally accepted methods. Agencies without top management direction may also suffer from balkanization. For example, pavement management may be placed under the direction of one office or one individual to expedite development without considering its links with other offices or individuals important to implementing the pavement management system recommendations. Without top management's promotion of collaboration between offices and the substantial opportunity for other offices to participate in system design, achieving cooperation among functional disciplines is likely to be difficult.

Lack of Ample or Appropriate Resources

The availability of ample or appropriate resources relates to the ability of highway agencies to provide the personnel, intellectual skills, and material resources necessary to implement pavement management systems. As previously stated, pavement management system costs have declined considerably, and highway agencies typically have the financial resources to implement such systems. However, institutional issues may preclude an agency from bringing to bear the appropriate intellectual resources or budgeting ample resources to completely implement pavement management.

The appropriate use of pavement management systems requires knowledge of systems approaches, pavement design, pavement maintenance, automated testing equipment, and computer systems. Traditionally, highway agencies are very knowledgeable about pavement design and management. Although a highly specialized knowledge of systems approaches is not a requirement for operating a pavement management system, a good working knowledge of systems concepts and engineering economy is needed. On the other hand, development of a customized pavement management system requires specialized knowledge of systems approaches, computer software, and data base development tools. To develop a customized system or operate a commercially available package may require particular intellectual resources that are unavailable within a highway agency. Even large agencies may have difficulty in attracting specialized individuals to develop and implement the pavement management process.

Further, in an era of downsizing (sometimes euphemistically referred to as rightsizing), it may be difficult for agencies to devote the personnel resources necessary to fully implement a pavement management system. Although pavement management systems may ultimately save an organization financial resources through better pavement resource allocation decisions, public agencies are seldom given the opportunity to transfer savings from expenditures on physical assets to increased expenditures for management personnel, data processing resources, and pavement testing equipment. Even though a pavement management system may ultimately provide significant savings, finding appropriate and adequate resources for implementation may be a significant institutional barrier.

Organizational Incompatibility or Inconsistency

Pavement management systems require resource allocation decisions to be made in a more open and systematic environment, and the system provides an overarching conduit for decision making among offices and divisions. In the past, decisions may have been made more subjectively and in relative isolation. Replacing old approaches with open and systematic approaches often results in turf battles over decision-making authority and conflicts between parts of the organization with inconsistent objectives. Inconsistency in the definition of objectives may result from an agency attempting to develop centralized control over pavement management decisions and reducing the autonomy of field offices. Inconsistency in objectives may also result from a data processing office's need to justify its investment in expensive mainframe computers and skilled data-processing staff while pavement managers may want to operate in a more robust microcomputer environment requiring little data-processing support. Inconsistency in objectives between offices and within organizations can become the most significant barrier to the implementation of pavement management.

Incompatible Laws, Rules, Charters, or Codes

The least common of the institutional issues, legal and administrative issues, include those barriers presented by laws, administrative rules, organizational charter, or codes. However, an agency facing such barriers may find them difficult to overcome. For example, local legislation identifying specific street maintenance policy may conflict with a pavement management system, or a legislated organizational structure may place maintenance and construction of highways under the domain of separate political jurisdictions (i.e., townships and counties), complicating the highway agency's task. An administrative or legislated decision may require each subdivision (a ward of a city or district of a state) of the entire jurisdiction to receive equal proportions of maintenance or capital investment, thus overriding resource allocation decisions based on pavement management criteria.

Implications of Institutional Issues

Internal institutional issues have left some highway agencies incapable of even beginning the implementation process, or have caused them to start developing a pavement management system only to later retrench and abandon it. Other agencies have developed pavement management systems but have not incorporated them into the pavement management decision process, or have limited their use to specific programs. At the very least, the contentiousness of pavement management system implementation has resulted in a conservative approach to pavement management systems among highway officials and a lack of willingness to adopt innovative pavement management processes.

Probably the best example of how reluctance to take risks has stymied up-to-date pavement management is the current state-of-the-practice of pavement management analysis tools used by state highway agencies. Even though in the last 10 years the state of the art of pavement management analysis tools has progressed tremendously through the use of different mathematical programming tools, use of knowledge-based systems, and applications of artificial intelligence, all decision support models currently in use by state highway agencies are based on formulations developed in the late 1970s and early 1980s (*5*). The predominant improvement in the state-of-the-practice has been the refinement and miniaturization of decision support models for operation on microcomputers.

Iowa Implementation Case Study

The Iowa Highway Commission began very early to develop tools to support pavement management. The commission began collecting pavement condition data in the 1950s and since then has maintained the information in various uncoordinated forms (*6*). In the late 1970s, IDOT began developing the Iowa Pavement Management Information System (IPMIS), which integrated its pavement condition measurement surveys and automated its condition data processing.

At roughly the same time, IDOT developed a scheme to rank restoration and reconstruction projects using a composite of several pavement condition measures. The ranking was sent to field office for review but was poorly accepted and was eventually dropped.

During the mid-1980s and early 1990s, IDOT improved its location referencing system, refined its pavement condition measures and performance models, improved pavement condition testing and data-collection equipment and methods, and further developed the IPMIS. Two full-time systems analysts were assigned to improving the IPMIS, data management, and information support, and they have made the information system into a highly useful tool to support development of program plans.

In 1992, IDOT initiated a multiyear project to develop automated decision support capabilities in the pavement management process. At the same time, the agency began integrating total quality management (TQM) philosophies into departmental actions. Accordingly, the pavement management system implementation project is being conducted in a manner compatible with TQM concepts. Several nontechnical actions have been taken, including the development of specific statements of purpose, use of a

multidisciplinary team to steer the project, and provision of both agencywide educational and informational programs and focused, small, core group training programs. All nontechnical actions are intended to assist in avoiding institutional issues and barriers.

The project is being directed by a committee designed to bring together the functional disciplines required for successful implementation of an IDOT pavement management system. Accordingly, the committee consists of individuals from the offices responsible for data processing, pavement design, materials, research, and planning. The project is divided into five phases.

Phase I is objective-setting, which consists of the following activities:

- Identifying the purpose of the pavement management decision support program,
- Determining the decision support tools available and their assumptions,
- Gathering information on pavement management decision support tools used by highway agencies in the United States and internationally,
- Presenting a workshop on the findings of the first phase for all staff likely to be involved in pavement management decision making, and
- Developing criteria through the workshop for the selection of decision support tools.

Phase II is the selection of a decision support methodology or tool, which consists of the following activities:

- Allowing the entire committee to visit other agencies with operational pavement management decision support systems;
- Reviewing decision support software options, including commercially available packages, computer programs in the public domain, and customized development of software;
- Bench-testing the most desirable software options using an IDOT data set;
- Developing a system selection recommendation through the committee; and
- Presenting a workshop covering model selection steps, the bench test, and the selection recommendations.

Phase III is the development of an implementation plan, which includes the following activities:

- Developing a physical and logical structure for the pavement management process before and after the implementation of the pavement management decisions support system,
- Developing a description of the physical architecture of the future computer pavement management system,
- Identifying likely personnel and equipment resource requirements and functional changes as a result of the implementation of the pavement management system, and
- Identifying the software that needs to be developed or purchased.

Phase IV is system development, which includes calibrating the models within the analysis package, populating the data base, and training IDOT employees in the program's operation.

Phase V is system operation, training, and maintenance, which includes the routine and continuous improvement of the system.

To date, Phases I through III of the project have been completed. Many significant milestones were reached in carrying out these activities. During Phase I, the pavement management workshop was attended by 50 to 60 staff members from offices throughout the IDOT. Follow-up presentations were made at formal and informal meetings by members of the steering committee. Steering committee members also made presentations at all the district field offices, explaining the status of the project and demonstrating the use of the IPMIS.

As part of Phase II, visits to other agencies provided the members of the committee with tremendous insight into institutional issues. To varying degrees, each agency visited had its own institutional barriers to complete implementation. Seeing these barriers first-hand provided the committee with an understanding of the importance of overcoming institutional issues.

During Phase III activities to identify resource requirements, all the relevant office directors were asked to identify specific numbers of full-time equivalent personnel who will be committed to pavement management. The commitment of personnel was seen as a critical step toward implementation.

At this writing, the project is starting Phase IV. After 2 years of work, the project team and steering committee expect that the project will continue for at least an additional year before reaching Phase V. The slow pace of the project is a result of the effort necessary to promote staff participation, carry on continuous communication, and develop open statements of purpose and objectives. The project has been endorsed by top IDOT management, and sufficient personnel and financial resources have been allocated to the project. In all, a very deliberate attempt is being made to avoid serious institutional issues.

Conclusions

Having an operable pavement management system is not the same as implementing a pavement management system. To implement a system requires that the pavement management system become a critical part of the resource

allocation process. As described in this paper, technical and financial issues are usually not barriers to system implementation. However, institutional issues continue to be the most contentious obstacles and have resulted in several agencies failing to reach complete system implementation.

Recognizing that institutional issues may become barriers to implementation, agencies should develop strategies to overcome institutional issues. Such an approach, taken by IDOT, is outlined in this paper. Other agencies wishing to implement pavement management may need to find their own unique strategies to diminish the impact of institutional issues. Whatever the approach taken, highway agencies must recognize the need to deal with institutional issues as part of the implementation strategy for a pavement management system.

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