

**TAXONOMY OF INSTITUTIONAL ISSUES THAT ACT AS
BARRIERS TO THE IMPLEMENTATION OF PAVEMENT
MANAGEMENT SYSTEMS**

**PREPARED BY
T. H. MAZE, DIRECTOR
OMAR G. SMADI, RESEARCH ASSOCIATE
IOWA TRANSPORTATION CENTER
IOWA STATE UNIVERSITY
AMES, IOWA**

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Abstract

The benefits of pavement management system when fully implemented are well known and the history of successful implementation is rich. Implementation occurs, for purposes of this paper, when the pavement management system is the critical component for making pavement decisions. This paper addresses the issues that act as barriers to full implementation of pavement management systems. Institutional barriers, not technical and financial barriers, are more commonly responsible for a pavement management systems falling short of full implementation. The paper groups these institutional issues into a general taxonomy.

In general, more effort needs to be put forth by highway agencies to overcome institutional issues. Most agencies approach pavement management as a technical process, but more commonly, institutional issues become more problematic and thus require more attention paid to institutional issues. The paper concludes by summarizing the implementation process being taken by the Iowa Department of Transportation. The process was designed to overcome institutional barriers and facilitate the complete and full implementation of their pavement management system.

INTRODUCTION

The benefits of pavement management systems are well known and the case history of successful and beneficial implementations of pavement management systems is rich. Pavement management has matured, and excellent and inexpensive pavement management system software are available. In actual experience, however, the implementation of pavement management systems and the use of state-of-art pavement management techniques is far less successful than expected given the beneficial experiences defined in the literature.

To understand our contention that pavement management implementation has not been as broadly successful as expected requires a common definition for implementation. Operating a pavement management system is not the same as implementing a pavement management system. Smith and Hall have defined implementation of a pavement management system to occur "when pavement management becomes the critical component for making pavement management decisions."⁽¹⁾ Thus 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 extends beyond the purchase of a pavement management system and even the development of supporting databases and personnel. It involves the actual use of the pavement management system's results to support decision making. State agencies have developed excellent pavement management systems but 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 made 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 promoted federal policy which mandates the operation of pavement management systems. For example, in March of 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 maybe successful in the development of an operational pavement management system. Actually implementing a pavement management system as a crucial part of the decision making process is, however, a separate matter.

This paper discusses the issues that act as barriers to true implementation of pavement management systems. Institutional barriers, not technical or financial barriers, are more commonly responsible for a pavement management system falling short of actual implementation. This paper groups institutional issues into a general taxonomy. The final portion of the paper summarizes the implementation process being taken by the Iowa Department of Transportation. The Iowa approach is deliberately designed to overcome institutional issues and facilitate the complete implementation of a pavement management system.

ISSUES THAT ACT AS BARRIERS TO THE IMPLEMENTATION OF PAVEMENT MANAGEMENT SYSTEMS

Although there are a broad variety of barriers to the implementation of pavement management systems, the three fundamental barriers 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 database tools. There are three major technical barriers to viable pavement management systems. They are;

1. Lack of a technically viable methodology to perform pavement management.
2. Lack of a knowledge base in pavement management processes and procedures.
3. Lack of viable technology including field data collection, database, 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 and 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 databases 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 to suggest that there are no additional technical issues remaining to be solved, but that the state-of-the-art of pavement management systems has matured and technical issues should not create a barrier to implementation.

Financial Issues

Financial issues are those barriers to implementation of pavement management systems that 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 are available which cost only a few thousand dollars. 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 be a barrier.

Institutional Issues

Institutional issues are barriers to implementation of pavement management systems that result from the inability of the highway agency to truly incorporate the pavement management system 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 not dependent on pavement management approaches. The inflexibility of these patterns has created institutional issues which act as primary barriers to pavement management system implementation. Institutional issues may range from fairly simplistic issues involving a lack of communication between the relevant offices within a highway agency to fairly 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.

Implementation can be problematic because individuals from all the functional areas must cooperate to generate a successful implementation. Obviously, the interdisciplinary nature of pavement management creates opportunity for a myriad of institutional issues, 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 critical part of the pavement resource allocation process (lack of a champion).
2. Lack of ample or appropriate resources provided to implement pavement management.
3. Incompatibilities or inconsistencies between groups, offices, or divisions within the organization.
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 between 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 which involves engineers, systems analysts, and technicians, implementing a pavement management system is perceived to be just another technical problem. Technical issues, however, are not the most contentious issues facing implementation. The system's functions cut across offices and disciplines and, therefore, implementing functions of the system into the decisions making framework requires collaboration.

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

Typical symptoms of the lack of top management mandate are resistance to change and resistance to incorporate new techniques into the pavement resource allocation process or resistance to techniques because a systems approach is different than traditionally accepted

methods. Agencies which lack top management direction may also suffer from balkanization of the office operating the pavement management system. For example, pavement management may be placed under the direction of one office or one individual as a means 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 substantial opportunity for other offices to participate in system design, achieving cooperation between functional disciplines is likely to be difficult.

Lack of Ample or Appropriate Resources

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, therefore highway agencies typically have the financial resources to implement pavement management. 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 of pavement design and pavement maintenance. Although 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 are needed. On the other hand, development of a customized pavement management systems requires specialized knowledge of systems

approaches and computer software and database development tools. To develop a customized system or to 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 manage the pavement management process.

Further, in an era of down-sizing (sometimes euphemistically referred to as right-sizing), 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 be made in a more open and systematic environment, and the system provides an overarching conduit for decision making between offices and divisions. In the past, decisions may have been more subjectively structured and made 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 needs 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 be contentious and 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/administrative issues include those barriers presented by laws, administrative rules, organizational charter, or codes that as barriers to the implementation of pavement management. However, for an agency facing these issues they may be very difficult to overcome. For example, locally legislated policies identifying specific street maintenance policy or a legislated organizational structure which places maintenance and construction of highways under the domain of separate political jurisdictions (ie. townships and counties). An administrative or legislated decision may require each subdivision (a ward of a city or district of a state) of the entire jurisdiction receive equal proportions of maintenance and/or capital thus overriding resource allocations decisions based on pavement management criteria.

IMPLICATIONS OF INSTITUTIONAL ISSUES

For some highway agencies, internal institutional issues have resulted in those agencies lacking the ability to even begin the implementation process or to start development of a pavement management system only to later retrench and abandon pavement management. Other agencies have developed pavement management systems but have not incorporated the system into the pavement management decision process or have limited use of the system to specific

programs. At the very least, the contentiousness of pavement management system implementation has resulted in a conservative mood towards pavement management systems among highway officials and a lack of willingness to take the risks inherent in adopting new and innovative pavement management processes.

Probably the best example of how reluctance to risk taking has stymied the state-of-the-art of pavement management is the current state-of-the-practice of pavement management analysis tools used by state highway agencies. Even though in the last ten 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. They began collecting pavement condition data in the 1950s and since have maintained the information in various uncoordinated forms.(6) In the late 1970s, the Iowa Department of Transportation (IDOT) began developing an information system—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, the IDOT developed a scheme to prioritize restoration and reconstruction projects. The prioritization scheme used a composite of several pavement condition measures to provide a ranking of projects. Ultimately the ranking developed was sent

to field office for review but was poorly accepted. The prioritization scheme was eventually dropped.

During the mid-1980s and early 1990s, IDOT improved their location referencing system, refined their 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 devoted to improving the IPMIS, data management, and information support, and they have moved the information system forward to the point of becoming a highly useful tool to support development of program plans.

In 1992, IDOT moved forward and initiated a multi-year project to develop automated decision support capabilities in the pavement management process. At the same time, the agency began implementing 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 non-technical actions have been taken, including the development of specific statements of purpose, use of a multi-disciplinary team to steer the project, and provision of both broad agency-wide educational and informational programs and focused, small core group training programs. All non-technical 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 which include:

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

- Identify the purpose of the pavement management decision support program.
- Determine the decision support tools available and their assumptions.
- Gather information on pavement management decision support tools used by highway agencies in the U.S. and internationally.
- Present a workshop on the findings of the first phase for all staff that are likely to be involved in pavement management decision making.
- Through the workshop, develop criteria for the selection of decision support tools.

Phase II - Selection of a decision support methodology and/or tool, which consists of the following activities:

- Conduct site visits which allow the entire committee to visit other agencies which have operational pavement management decision support systems.
- Review of decision support software options including commercially available packages, computer programs in the public domain, and customized development of software.
- Bench test the most desirable software options using an IDOT data set.
- Through the committee, develop system selection recommendation.
- Present a workshop covering model selection steps, the bench test, and the selection recommendations.

Phase III - Development of an implementation plan, which includes;

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

Phase IV - System development, which includes calibrating the models within the analysis package, populating the database, and training IDOT employees in the program's operation.

Phase V - 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 50-60 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 their own institutional issues acting as barriers to complete implementation. Seeing these barriers firsthand provided the committee with an understanding of the importance of overcoming institutional issues.

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

Currently, the project is starting Phase IV. After two years of work, the project team and steering committee expect 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 a sufficient level of 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

A highway agency having an operable pavement management system is not the same as implementing a pavement management system. To implement a system requires an operating system but it also requires that the pavement management system become a critical part of the resource allocation process. However, there are a number of issues that can act as barriers to implementation of a pavement management system. These include technical issues, financial issues, and institutional issues. Of these, technical and financial issues do not commonly act as barriers to full pavement management system implementation. Instead, institutional issues have been the most contentious issues faced and have resulted in several agencies failing to reach complete system implementation.

These institutional issues can be quite varied. To aid in recognizing and addressing these issues, this paper categorizes pavement management institutional issues into four broad categories. Recognizing that institutional issues may become barriers to implementation, agencies should work in advance to develop strategies to overcome institutional issues. Such an approach, taken by the 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, it is very important that highway agencies recognize the need to deal with institutional issues as part of the implementation strategy for a pavement management system.

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