NCHRP Project 20-68

U. S. Domestic Scan Program: Best Practices in Transportation Asset Management

SCAN-TOUR REPORT

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This report was prepared by Cambridge Systematics, Inc., with Michael D. Meyer, Georgia Institute of Technology. Participants in the scan tour contributed to the ideas and concepts contained in the report. Any errors or omissions, however, are the fault of the authors alone. The authors gratefully acknowledge the participation of the host agencies who made the scan tour possible.

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Executive Summary

"Asset management tied to performance measures catalyzes action, helps define goals, prioritizes action and aligns efforts…we don't think about it as asset management, it simply is what you are supposed to do."

…Gordon Proctor, Director, Ohio DOT

The purpose of this scan was to identify best case examples of the application of asset management principles and practice in U.S. transportation agencies. The scan was sponsored by American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the National Cooperative Highway Research Program (NCHRP). The scan participants included FHWA officials, representatives from state transportation agencies in Michigan, North Carolina, Ohio, Oregon, and Vermont, a university professor in transportation engineering and planning, and a consultant support staff.

The scan team met with a range of organizations, including:

- State transportation agencies (Florida, Michigan, Minnesota, Ohio, Oregon, and Utah);
- A city transportation department (Portland, Oregon);
- Two metropolitan planning organizations (the Southeast Michigan Council of Governments in Detroit and the Grand Valley Metropolitan Council in Grand Rapids, Michigan);
- Two county transportation departments (Hillsborough County, FL and Kent County, Michigan);
- A tollway authority (Florida's Turnpike Enterprise); and
- Two statewide asset management associations (the Michigan Transportation Asset Management Council and the Pacific Northeast Asset Management User Group, Oregon).

Specific questions relating to different aspects of the agency's experience with asset management were sent to each agency beforehand. In most cases, the scan team received written responses to these questions, and in all cases, the scan team obtained information from interviews with key staff members at each site.

Results from Site Visits

The agencies visited exhibited various stages of evolution in their application of asset management to their transportation decision-making process. Both the Michigan and Ohio Departments of Transportation (DOT), for example, have a comprehensive and sophisticated approach to asset management that has been integrated throughout their respective organizations. Other agencies, such as the Oregon and Utah DOTs, have not yet reached the levels found in Michigan and Ohio, but have adopted innovative and successful approaches that will allow them to reach such levels in the next few years. Thus, the observations listed below should be understood in the context that not all agencies visited were at the same stage of development of their respective asset management process.

1. The agencies visited had all **adopted a 'preservation first' strategy for their investment priorities**. However, in many cases, this strategy has run up against concerns for reducing congestion on existing roads as well as dealing with the need for new road capacity to handle population and employment growth. Several examples from the scan illustrated the political pressure being brought to the 'reduce congestion' strategies.

2. In each case, **the success of the asset management process was directly linked to the actions of an asset management champion or champions** within the organization. Until asset management became institutionalized within the standard operating procedures of the agency, the role of this champion was especially critical. In some cases, this champion was the head of the agency; in others it was a key staff member who strongly believed that asset management was an important component of the agency's mandate.

3. In several cases, **the existence of an asset management process**, and more importantly, of the information that justified investment in a road system, **was instrumental in securing additional dollars from the legislature**. The use of an asset management approach in providing stewardship of a jurisdiction's resources was a very powerful tool in communicating to elected officials the needs and consequences of investing (or not investing) in highway infrastructure. As noted above, in some cases, these additional funds were dedicated to new road capacity, but the asset management process did provide the impetus for the legislature to feel comfortable that the existing road network was being handled well.

4. The most **successful asset management processes have moved away from a "worst first" investment strategy**, and **instead have adopted investment principles that are based on life-cycle costing** that result in the most cost-effective preservation and maintenance strategies. As was noted by several scan participants, this concept (e.g., repaving roads or repairing bridges that do not appear to need it when other facilities are left to deteriorate further) is often difficult to explain to elected officials and to the general public. However, the asset management examples found in this scan suggest that such an investment strategy does provide a defensible and effective approach to infrastructure stewardship.

5. **The most successful asset management processes had performance measures that guided investment decisions throughout the organization**. These performance measures have become important indicators for system monitoring and were used in one case for annual personnel evaluations. A performance-based asset management approach had become the normal way of doing business in many of the sites visited. However, in several cases, officials stated it was not clear whether the performance targets selected for the asset management process goals were the most appropriate targets. Most agencies had based their decisions on target thresholds on historical data and on some expectation of what could be achieved. In only a few cases was any effort made to obtain input from system users or customers on what performance measures and targets appeared reasonable. A few of the officials participating in this scan could answer the question of whether lowering the performance target by some small amount would still provide acceptable system performance for less cost. Several notable exceptions to this (e.g., the Michigan, Ohio and Utah DOTs) could assess with the analysis tools established in their respective asset management processes what would happen if lower system performance targets were selected.

6. **Scenario analysis showing the consequences on performance measures was one of the most effective methods of convincing decision-makers of the need for investment in the transportation system.** With the use of management systems, engineering analysis and corresponding deterioration curves, agencies are able to show the condition levels of pavements and bridges given assumed investment levels. This capability has been instrumental in political discussions on the needs for infrastructure investment.

7. **There was no one organizational model for asset management.** In some cases, agencies have identified an asset management unit or at least an agency asset management manager, while in others one cannot find asset management mentioned on an organization chart. Many different successful organizational models of asset management were found during the scan. Perhaps the most important organizational characteristic found in the cases was the use of a team approach in defining and implementing an asset management process.

8. **The "growing pains" of an asset management process in almost all cases, fostered enhanced communications among many different organizational units**. Many of the participants agreed that the need to promote cross organizational coordination in an asset management process has led to more effective planning and decision-making in the agency.

9. **One of the most important starting points for implementing an asset management process is to conduct an organizational self assessment**. The AASHTO *Asset Management Self Assessment Guide* was pointed to by most as a very useful tool for undertaking this assessment.

10. **There was very little evidence of the application of risk analysis techniques in the asset management processes observed.** The concept of risk assessment allows transportation officials to determine the economic costs associated with infrastructure failure and to incorporate these costs into the analysis process. Several other countries in the world have adopted formal procedures for doing so. It seems likely that such an approach will likely characterize U.S. asset management practice in the coming years as well.

11. Quality data and cost-effective data collection strategies served as the basis for the cases investigated. **In several cases, agencies viewed data as an asset and the data collection process as an important decision support function.** These agencies were periodically examining if the right data were being collected for the types of decisions that had to be made. In some sense, best case examples of asset management show that agencies become better consumers of data once they understand their asset management process. Effective communication tools are needed to leverage the information and value derived from data collection efforts and the strategy of "collect once, use often."

12. **A customer orientation had been adopted as part of the asset management process in several cases.** Surveys were used to determine those aspects of the infrastructure maintenance and condition that were most important to the users of the road system. Some performance measures were selected (e.g., ride quality) because of their impact on public perceptions of the agency's performance.

13. **New technologies have the potential of making data collection for asset management activities more cost-effective and efficient**. For example, portable computer lap tops combined with global positioning systems (GPS) are powerful tools that can be used to collect condition data on the road network. Michigan also is researching the possibility of using probe vehicle sensors and satellite technology to detect and report pavement conditions like potholes and other characteristics of ride quality.

14. Some of the agencies visited used private contractors for providing long-term maintenance services (and thus used the term asset maintenance practice), while others relied primarily on their own forces. Two types of contracts were noted in the scan – work accomplished and performance-based. **It is essential that an agency have its own performance measures/criteria documented whether they are performing maintenance activities in-house or through a private contract**.

Recommendations for Further Action

1. Update the AASHTO Transportation Asset Management Guide to reflect the most recent information on asset management, especially lessons and guidance that comes from this scan.

2. Develop an "ambassador" program that identifies leading state practitioners in asset management that can spend time with a DOT to discuss the steps necessary to develop an effective asset management process.

3. Disseminate the scan's results at conferences and meetings as appropriate.

4. Incorporate scan results into the ongoing efforts to create a national asset management steering group, which was one of the recommendations from the international scan.

5. Develop research statements from the research topics list resulting from this scan. Submit research statements to appropriate research organizations. Potential research topics include: How should desired performance levels be set? What is the cost of setting high levels? How were road users included when setting these levels? How does one quantify that asset management over time results in the same road condition but for less cost? How can we establish a benchmarking system that demonstrates asset management practice? How are intelligent transportation systems (ITS) assets maintained? What are the conditions of success for long-term maintenance contracts? What is the standard methodology for developing deterioration curves for assets other than pavements and bridges? Can such a methodology distinguish between regions of the country and of a state?

6. Get on the agenda and prepare materials for the FHWA Division Administrator national meeting in the spring of 2007.

7. Prepare a brochure/pamphlet on the results of the scan that could be disseminated to a wide range of transportation groups and agencies.

8. Establish a process for the case study states to report periodically on the progress they have made since the last time they reported (starting with the case study descriptions). The venue for this reporting would be the biennial national asset management conference.

9. Establish a process for state DOTs to exchange information on asset management activities during the AASHTO regional meetings or in some other agreed-upon venues, perhaps starting with the Mississippi Valley State Highway and Transportation Officials agencies. The state DOTs themselves would be the ones organizing and presenting material. These meetings might be organized around specific topics, e.g., how are states dealing with the significant increases in costs (and thus adjusting their investment programs)?

10. Establish a webinar series on "Talking Asset Management." This series would be dedicated to different themes and present states with an opportunity to describe their asset management approaches. The webinars would be held quarterly.

11. Either sponsor a web site on asset management or become part of another asset management web site (e.g., the web site supported by the TRB Committee on Asset Management).

12. Write articles on the scan results for *TR News* and the AASHTO *Journa*l.

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National Finance Technical Service Team, FHWA Georgia Office; Lacy Love, Director of Asset Management, North Carolina DOT; Leonard Evans, Transportation Administrator, Ohio DOT; Dennis Merida, Division Administrator, FHWA New Jersey Office; Robert Ritter, Planning Capacity Building Team Leader, FHWA Office of Planning; Hobart Selle, Asset Management Systems Manager, Vermont Agency of Transportation, Paul Wirfs, Engineering and Asset Management Unit Manager, Oregon DOT; Michael Meyer (subject matter expert), Professor of Civil and Environmental Engineering, Georgia Institute of Technology; and Joe Guerre (tour manager), Senior Associate, Cambridge Systematics, Inc.

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1.0 Introduction

Asset management is viewed by many in the transportation profession as one of the most effective approaches to investment decision-making in today's fiscal environment. Given constrained resources, but still facing increasing demands for improved infrastructure and services, transportation managers must determine the most cost-effective approach to using the limited amount of funding that is available to improve transportation system performance. According to the Federal Highway Administration, asset management can be viewed as a set of business principles and best practice methods for improving resource allocation and utilization decisions that consists of the following core principles:[1]

- **Policy-Driven –** Resource allocation decisions are based on a well-defined set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well.

- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management.

- **Analysis of Options and Tradeoffs –** Decisions on how to allocate funds within and across different types of investments (e.g., preventive maintenance versus rehabilitation, pavements versus bridges; capacity expansion versus operations; different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated.

- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data. Where appropriate, decision-support tools are used to provide easy access to needed information, and to assist with performance tracking and predictions.

- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feed-back on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

In order to identify best case examples of the application of asset management principles and practice in U.S. transportation agencies, American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA)

[1]Federal Highway Administration, http://www.fhwa.dot.gov/infrastructure/asstmgmt/ampp.htm#20.

through the National Cooperative Highway Research Program (NCHRP), sponsored a scan of representative agencies in the United States. This report presents the results of this scanning tour.

The scan team included FHWA officials, representatives from state transportation agencies in Michigan, North Carolina, Ohio, Oregon, and Vermont, and a university professor in transportation engineering and planning. The scan team met with a range of organizations, including state transportation agencies (Florida, Michigan, Minnesota, Ohio, Oregon, and Utah), a city transportation department (Portland, Oregon), metropolitan planning organizations (SEMCOG in Detroit and Grand Valley Metropolitan Council in Grand Rapids, Michigan), two county transportation departments (Hillsborough County, Florida and Kent County, Michigan), a tollway authority (Florida Turnpike Enterprise) and a statewide asset management association in Michigan. Specific questions relating to different aspects of the agency's experience with asset management were sent to each agency beforehand (see Appendix A). In most cases, the scan team received written responses to these questions, and in all cases, the scan team obtained information from interviews with key staff members at each site.

This report is organized in four major parts. The first section presents case studies from state transportation agencies; the second section provides similar results for metropolitan planning organization (MPO) and local agencies; the third section presents the major observations and conclusions from the scan trip; and the final section makes recommendations for future actions and research.

It should be noted that the origin for this scan came from an international scan on asset management practices that occurred in November 2005. Readers are encouraged to view this document to obtain information on asset management best practice in countries around the world.[2]

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[2] Federal Highway Administration, "Transportation Asset Management in Australia, Canada, England, and New Zealand," November 2005, www.international.fhwa.dot.gov.

2.0 State Transportation Agencies

2.1 Florida Department of Transportation

Context

Florida has been, and will continue to be in the foreseeable future, one of the fastest growing states in the country. For example, the State estimates that the population will grow to 24.4 million residents by 2025, an increase of 40 percent over 2004 levels or over 900 new residents per day. The percent of the population over 65 years old will increase by 92 percent (to 5.8 million), and the employment base will grow by 45 percent (to 11.6 million jobs). Being a major tourist destination, Florida also is expecting large increases in visitors, with over 92 million people estimated to visit the State in 2025 (a 23 percent increase over 2003 levels).

This increase in population, employment, and tourists is expected to result in significant increases in travel as well. In fact, projections suggest that the rate of growth in travel demand will exceed the rate of increase in population and employment. This increased demand will occur both in passenger travel as well as in domestic and international freight movement.

The Florida Department of Transportation (FDOT) has a strong tradition in multimodal transportation planning and decision-making. Given the extent of the State's transportation system, and a recognition on the part of the State of how important transportation is to the State's economy and quality of life, it is not surprising that FDOT has one of the largest investment programs of any state DOT in the country. For example, the FY 2005/2006 capital program budget was $7 billion; and the 5-year work program was estimated to be $31.1 billion. On average over the past five years, FDOT has let about $2.2 billion annually in transportation projects.

Although the primary focus of FDOT is on the state highway system, which consists of 41,000 lane-miles and 6,381 bridges (including the most moveable bridges in the United States), the Department also provides funding and technical support to many local agencies and operators of transportation facilities. For example, Florida has 800 aviation facilities (131 are public), 29 fixed-route transit systems, 14 seaports, and 2,707 railway miles. Many of these systems and facilities receive funding and technical support from FDOT.

"Asset management has resulted in the legislature approving our preservation and maintenance budgets without change because we were able to justify the State's needs."

…Florida DOT Official

Another important contextual factor in the Florida experience with asset management is a statewide planning philosophy that has characterized investment decision-making in the State for many years. Florida was one of the first states to pass legislation dealing with growth management and the need for infrastructure capacity to handle the extra demands caused by the tremendous increase in population. State agencies are under legislative mandate to undertake systems planning to make sure that investment policies and decisions reflect adopted statewide goals and policy directions. Historically, FDOT has been one of the lead state agencies in developing new approaches and strategies for linking infrastructure decisions with economic, environmental and transportation system performance objectives.

Decision-Making Process

FDOT is led by a Secretary who reports directly to the governor. A nine member Transportation Commission is responsible for policy oversight of the Department. The Department is largely decentralized, with seven districts and the Florida Turnpike Enterprise having important roles in prioritizing investments and implementing FDOT strategies.

The bulk of transportation funding in the State comes from 1) state sources (with the major contributor being a $0.10 per gallon motor fuel tax indexed to the consumer price index), which produces approximately 58 percent of the annual revenues; 2) Federal funds (25 percent); and 3) toll and local sources (17 percent).

Investment decision-making in FDOT is based on a strong statutory policy framework that requires a 20-year Florida Transportation Plan (FTP). The FTP provides the blueprint for investment allocations, which according to the latest plan represents over $160 billion in investment up to 2025. The most important investment principles outlined in the FTP are to invest first in projects that enhance safety and system preservation, promote economic competitiveness, and provide mobility. System preservation is considered so important by FDOT that all maintenance needs are funded first before any capacity expansion projects are programmed.

A more detailed Program and Resource Plan sets forth specific operating polices and performance measures that guide the development of each program. The Program and Resource Plan is a 10-year plan containing program funding levels and financial and production targets that are balanced against anticipated revenues. A five-year listing of projects (called the work program) is developed annually based on existing plans, district and public involvement and collaborative decision-making by a high-level executive committee in the Department.

State statute requires that 15 percent of state transportation funds go to public transportation, and at least 50 percent of discretionary funds must be directed to the Strategic Intermodal System (SIS), although the Department has adopted a policy that 75 percent of these funds will go to the SIS. Twenty-five percent of these funds are distributed to FDOT districts by formula based on a weighting of 50 percent for the motor fuel receipts produced in each district and a 50 percent population weight. The SIS is an important concept developed by FDOT to focus its resources on the most important transportation facilities in the State. The designation of the SIS is intended to enhance Florida's economic competitiveness by focusing resources on priority elements of the transportation system. Table 2.1 shows the components of Florida's SIS. Emerging SIS facilities currently do not meet adopted SIS criteria, but are experiencing growing levels of activity and provide connectivity to fast-growing economic regions and rural areas.

The state legislature in 1987 adopted specific performance targets for the state highway system that were based on the then FDOT standards for road condition. According to state law, FDOT's investment should:

- Ensure that 80 percent of the pavement on the state highway system meets department standards;
- Ensure that 90 percent of the Department-maintained bridges meet Department standards; and
- Ensure that the Department achieves 100 percent of the acceptable maintenance standard on the state highway system.

Table 2.1 Florida's Strategic Intermodal System

Facility Type	SIS	Emerging SIS
Commercial Service Airports	7	9
• Percent of all Florida enplanements	93%	6%
• Percent of all Florida air cargo tonnage	98%	1%
Spaceports	1	0
• Percent of all launch activity	100%	0%
Deepwater Seaports	7	3
• Percent of all waterborne freight tonnage	98%	2%
• Percent of all home-port cruise passengers	>99%	<1%
Rail Freight Terminals	5	2
• Percent of all intermodal rail freight tonnage	85%	15%
Interregional Passenger Terminals	25	7
• Percent of all interregional passengers	70%	6%
Rail Corridors	1,700 miles	400 miles
• Percent of all interregional rail passengers	100%	0%
• Percent of all freight rail tonnage	>90%	<10%

Table 2.1 Florida's Strategic Intermodal System (continued)

Facility Type	SIS	Emerging SIS
Waterways	1,100 miles	300 miles
• Percent of all waterborne freight on costal and international shipping routes	100%	0%
• Percent of all waterborne freight on inland interregional waterways	0%	100%
Highways	3,500 miles	760 miles
• Percent of all traffic on SHS	51%	2%
• Percent of all truck traffic on SHS	64%	3%
Intermodal Connectors	76	27

FDOT is developing a performance measurement system that monitors key indicators of transportation system and FDOT performance. The system allows FDOT officials to "drill down" in the database to identify contributing factors to the performance levels associated with the five major performance categories of transportation system safety, customer and market conditions, production performance (such as number of contracts let), transportation system performance, and organizational performance (such employee survey results). Thus, for example, the statewide measure for transportation system performance might have "below" it measures associated with highway condition, highway performance and multimodal performance. The next level in the hierarchy might include performance measures relating to bridge, pavement, and maintenance conditions that feed into the highway condition performance category. Asset management factors are included in two of the five primary performance categories-system performance and in customer and market conditions (a user survey asks for perceptions on road condition and maintenance).

As can be seen from above, FDOT has a very systematic approach toward investment decision-making as it relates to asset preservation. Many of the funds are distributed by formula, performance targets have been established, and investment priorities are given to those projects that best allow FDOT to meet the performance targets.

Asset Management Approach

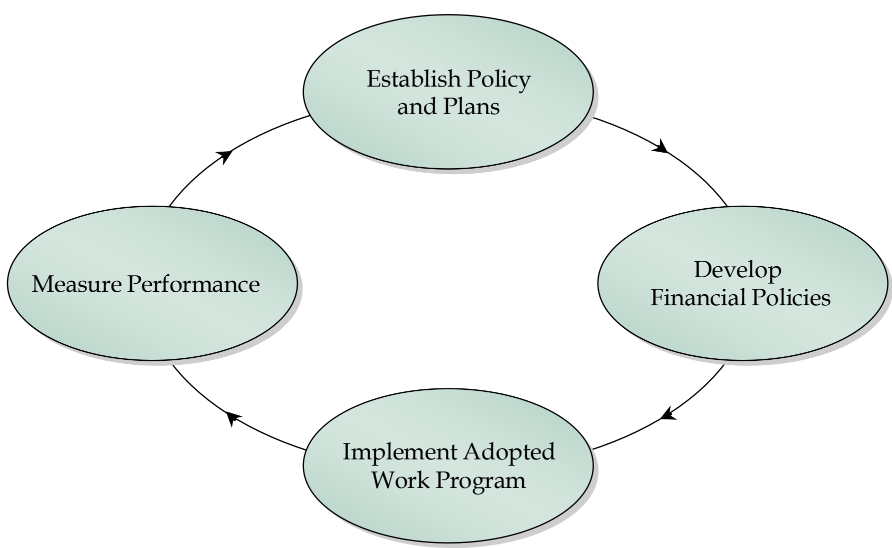
FDOT does not identify a separate asset management program or organizational unit within the Department. Asset management is simply considered to be the entire process of planning, programming, and system monitoring as they relate to preserving the State's transportation system (see Figure 2.1). As noted in FDOT's description of asset management efforts within the Department,

> *"Asset management concepts of data-supported decision-making, management systems, strong relationships between condition and performance, and an emphasis on tradeoff and investment analysis are integral components of daily business that support the Department's mission to provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity and preserves the quality of our environment and communities. The concepts are part of the culture and are strongly supported by upper management."*

FDOT divides system preservation into three categories: pavement, bridge, and routine maintenance. As noted earlier, funding for maintenance is "taken off the top." Each of these has an extensive inventory-driven, performance-based management system that supports investment decisions in each area.

FDOT's asset management approach also is very much based on adopted operational policies that guide organizational decision-making. For example, FDOT's resurfacing operating policy has stated for years that on average 5.9 percent of the state highway system's pavement will be resurfaced each year. FDOT has adopted a new operating policy that specifies 5.6 percent of the state highway system will be resurfaced to ensure that 80 percent of the paved surfaces meet department standards. Changing this policy was motivated partly by the need to free up additional dollars for other transportation investment needs. Similarly, FDOT's operating policy for bridge management is that, once declared deficient, bridges will be replaced within nine years. For routine maintenance, the operating policy is to provide full funding to achieve a maintenance rating of 80 or above (to be discussed below). Thus, asset management in FDOT is directed by policies that are very targeted on specific performance outcomes.

Figure 2.1 Florida DOT's Concept of the Asset Management Process



Another important characteristic of FDOT's asset management approach is the use of private contractors in providing many core maintenance functions. Called asset maintenance contracting, FDOT was one of the first states to use such an approach in a significant way to satisfy its maintenance function. FDOT defines asset maintenance contracting as an "innovative, long-term, performance-based contract encompassing all (or most) maintenance functions required to serve the public and maintain the roadways within specific roadway corridors or entire geographic areas." Typical asset maintenance contracts include: routine and non-routine maintenance activities, environmental regulation compliance, lighting and call box maintenance, customer service complaint resolution, formal inspection of bridges and appurtenances, motorist and service patrols, roadway characteristics inventory data collection, with options for rest area/weigh station/welcome center maintenance, and payment of utilities for rest areas/weigh stations/welcome centers. Contracts can cover different geographic areas such as corridors versus districts, can be focused on facility type such as welcome centers and rest areas, or can provide responsibility for a specific asset type such as bridges. FDOT's biggest contract under this concept was for $100 million and lasted seven years. At the request of the district offices, future contracts are to be five-year contracts with five one-year renewals. FDOT resurfacing contracts also carry a three-year warranty based on ride, rut and cracking conditions.

The asset maintenance contract program has grown from $484 million and 17 contracts in 2004 (annual cost of $64 million) to a projected $900 million and 28 contracts in 2008 (annual cost of $118 million). Sixty percent of the maintenance budget in 1994 supported in-house maintenance activities with the remaining 40 percent undertaken through traditional (non-performance-based) contracts. In 2008, 40 percent of FDOT's maintenance budget will go to asset maintenance contracts, 40 percent will be used to fund traditional maintenance contracts, and the remaining 20 percent will support in-house staff.

Management and Data Systems

A roadway characteristics inventory (RCI) is one of the most important asset databases in the Department. The RCI is a computerized database of physical and administrative data related to the roadway networks that are maintained by or are of special interest to the Department. FDOT's offices of planning, maintenance, and traffic operations (only for traffic signal data) maintain the database, with planning considered the primary "owner" of the RCI. In addition to data required by the Department, the RCI contains other data as required for special Federal and state reporting obligations. The RCI is maintained by district and central office personnel. While there are many other important databases maintained by the Department, the RCI is the largest with over one million records.

A very important use of the RCI involves obtaining and disbursing transportation funds. For example, the Office of Maintenance's budget, and that of the district maintenance programs, are directly related to the inventory that is found in the RCI. Twenty-nine features (found within a road's right-of-way) are included in the RCI, with 118 characteristics possible for each feature. A "guard rail" would be an example of a road's feature, and possible characteristics might include "barrier wall," "double face guard rail," "miscellaneous guard rail," and "standard guard rail." FDOT conducts training every two years on what goes into the RCI and how the RCI data are used in decision-making. Every one of the 36 maintenance yards has either two to three people devoted to maintaining the RCI database for their maintenance area.

"The best step in making asset management an effective decision-making support tool is to institutionalize it into the organization."

…Florida DOT Official

The planning office is responsible for adding new roads to the RCI database. When a new road is considered "active," the FDOT budget development process includes the new assets as part of the calculation of a district's maintenance budget. Statewide average unit costs are used to estimate a budget, although FDOT is heading in the direction of differentiating maintenance costs by district. A re-inventory is conducted every five years. For major new construction or reconstruction, the inventory data must be included in the RCI within 90 days.

Mileposts are used as the major referencing system in the RCI. However, the Miami district office is converting its RCI referencing system to a GIS-based approach with GPS coordinates and visual images attached to each location on the road system.

FDOT relies on four major management systems for providing information to support investment decision-making: a pavement management system (PMS), a bridge management system (BMS), a maintenance management system (MMS) and a maintenance rating program (MRP).

Pavement Management System – An annual pavement condition survey is conducted to evaluate ride quality, crack severity, and average depth of wheel-path ruts. A rating of six or less on a 10 point scale in any of these areas causes a pavement segment to be declared eligible for treatment. The pavement condition objective is that at least 80 percent of the state highway system lane-miles are of sufficient quality to meet department standards. Currently, 82 percent of the lane-miles meet the standards. Interstate pavement priorities are determined in the central office; arterial road pavement priorities are determined in the district offices. The central office has five staff dedicated to pavement management, and four teams are used statewide in collecting the data that goes into the pavement management system database. The annual resurfacing budget for FDOT is approximately $600 million, so the level of investment that is supported by the PMS is substantial.

Bridge Management System – Each of the 6,200 state-owned bridges as well as an additional 4,000 local bridges is inspected every two years to identify preventative maintenance, minor or major repair work, or replacement priorities. A bridge that meets department standards is defined as not showing evidence of structural deterioration, not being limited by weight restrictions or not needing preventative maintenance. Ninety percent of department-maintained bridges are to be kept at a level that meets these standards and currently 93 percent of FDOT's bridges meet the standards. FDOT uses Pontis as the basis for its bridge management program, with access to the database provided to many groups (e.g., MPOs, consultants, other state agencies) in addition to internal FDOT offices.

Bridge needs are classified as routine maintenance, periodic maintenance and repair, and replacement. Routine maintenance needs result in the writing of a work order that is uploaded to the maintenance management system, which is then forwarded to a maintenance yard. Organizational performance measures have been established to monitor the effectiveness of this process. “No delinquent priority 1 or 2 work order priorities” (within 60 and 180 days response) and “95 percent of work orders completed on time” are examples of such measures. For more critical bridge needs, a deficient bridge list is created that includes all bridges needing repair or replacement due to structural reasons. Moveable bridges, of which there are 98 in the State, create special challenges with respect to bridge deficiencies, and FDOT has adopted a policy of rehabilitating such bridges every 30 years.

The FDOT executive board has adopted several policies aimed at bolstering the State’s bridge program. Structurally deficient or posted bridges will be replaced or repaired within six years after the bridge is so listed. Bridges that are more economical to replace than repair will be replaced within nine years. The result of these policies is a very impressive bridge condition performance record. As of 2006, only six bridges owned by the State were weight posted, and less than 50 bridges owned by the State were listed as structurally deficient. Given the bridge needs on non-state bridges, a substantial level of funding is targeted at “off system” bridges. By 2012, for example, FDOT estimates that 20 percent of Federal bridge dollars will go to off state system bridges.

The information found in Pontis is used by other information systems in the Department. Load rating information is used to support the routing of overweight trucks. The Department’s financial management system extracts information for budgetary purposes, and a project-level analysis tool (PLAT) that is used to assess the characteristics of individual projects.

Maintenance Management System – FDOT’s maintenance management system (MMS) is a database that includes production, personnel, equipment, and materials data. Specific maintenance activities, of which there are 127 different types, are defined considering personnel and equipment requirements. The MMS assigns a site number to a particular job, and when the work is completed, the job production parameters are entered back into the MMS. At a minimum, every two weeks the information in the MMS is exported to a mainframe database that is accessible to other management systems for use in budget preparation and performance monitoring. The MMS is linked to another database application that collects data on the estimating, bidding, letting, awarding, and management of maintenance contracts. For asset maintenance contracts, where a contractor receives a set budget no matter what work is done, the contractor simply reports what number of units were completed for each maintenance activity.

Maintenance Rating Program – State highway maintenance condition is based on a sampling process that rates five primary categories of the highway environment three times a year. The items rated are roadway (potholes, etc.), roadside (shoulders), vegetation and aesthetics (mowing, litter removal), traffic services (signs, lighting), and drainage (ditches). This maintenance rating program (MRP) is used to “provide information to schedule and prioritize routine maintenance activities, and to provide uniform maintenance conditions that meet established departmental objectives.”

Each MRP element consists of individual characteristics, where each characteristic is assigned a factor between six and 10 as it relates to the importance to the safety and preservation of the roadway system. Thus, for example, guard rails are assigned a factor of eight. The characteristics for each element include:

- Roadway Characteristics:
  - Flexible pavement pothole;
  - Flexible pavement edge raveling;
  - Flexible pavement shoving;
  - Flexible pavement depression/bump;
  - Flexible pavement paved shoulder/turnout;
  - Rigid pavement pothole;
  - Rigid pavement depression/bump;
  - Rigid pavement cracking; and
  - Rigid pavement paved shoulder/turnout.
- Roadside Characteristics:
  - Unpaved shoulder;
  - Front slope;
  - Slope pavement;
  - Sidewalk; and
  - Fence.
- Traffic Services Characteristics:
  - Raised pavement markers;
  - Striping;
  - Pavement symbols;
  - Guardrail;
  - Attenuators;
  - Signs less than 30 square feet;
  - Signs greater than 30 square feet;
  - Object markers; and
  - Highway lighting.

- Drainage Characteristics:
  - Side and cross drains;
  - Roadside and median ditches;
  - Outfall ditches;
  - Inlets;
  - Miscellaneous drainage structures; and
  - Roadway sweeping.
- Vegetation Aesthetics Characteristics:
  - Roadside mowing;
  - Slope moving;
  - Landscaping;
  - Tree trimming;
  - Curb and sidewalk edging;
  - Litter removal; and
  - Turf condition.

All characteristics are evaluated against established standards, and an overall maintenance condition is calculated. A maintenance rating of 80 is considered acceptable. The Department's objective is to ensure that 100 percent of the state highway system meets the maintenance standard and currently, this standard is being met.

The method of calculating the score is based on random sampling. Each maintenance area has 30 random sample segments identified each for rural limited access roads, urban limited access roads, rural arterial roads, and for urban arterials. Each segment is 0.1 mile in length. The scores are then averaged across all facility types to come up with a total score for each maintenance area, and for the State. Each district is responsible for implementing and maintaining the MRP, with each district having at least two staff members that conduct the data surveys. The surveys are conducted for each characteristic within the sample segment by entering a "yes" or "no" into the rating form on whether the characteristic meets the MRP standards. Each district office is required to perform at least one quality control check on each team, and FDOT's Office of Maintenance conducts an annual quality assurance review of each MRP team as well.

A statewide MRP standard of 80 has been established by state statute. The MRP 80 standard was considered a reasonable target given the challenges facing road maintenance, and as well corresponds to surveys of public expectations as to road maintenance. FDOT did conduct an economic analysis to determine whether an MRP standard of 90 was economically feasible, and determined that it was not.

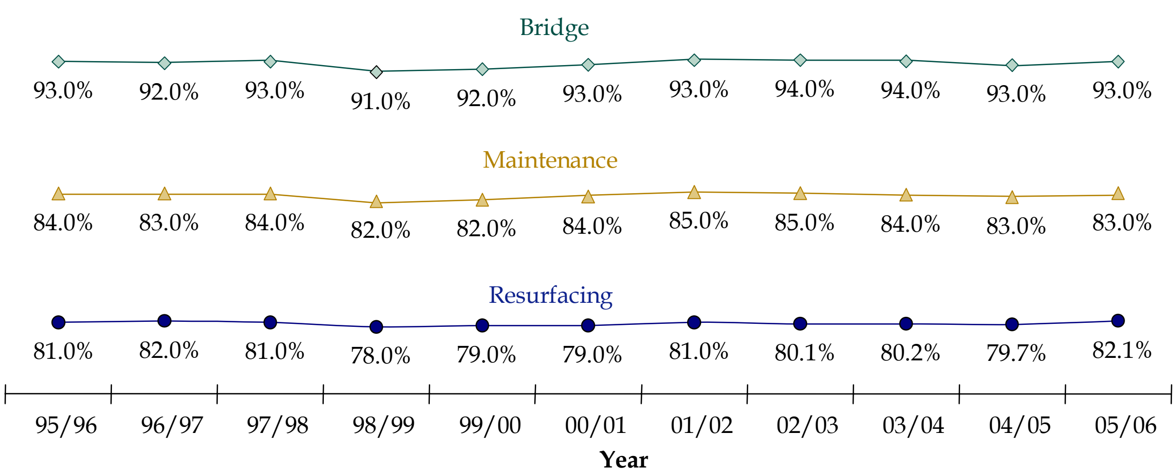
Results of the System Preservation Strategy

As has been described above, FDOT's system preservation strategy has been very successful in achieving the targets that have been established by the state legislature and through policy direction from FDOT management. The very impressive record on deficient bridges, in particular, indicates the importance of an asset management perspective in guiding departmental investments.

The maintenance rating program also has shown value in terms of obtaining additional dollars from the state legislature to support the transportation program. FDOT officials pointed to their ability to quantify the level of effort the Department has put into preservation and maintenance and the linkage of this effort to system performance metrics as a critical factor in the Department's success in receiving additional funds from the legislature.

Figure 2.2 shows the performance of the state road network in Florida given FDOT's focus on asset management. As can be seen, the percent of road segments meeting departmental standards for pavements and bridges has been exceeded in the last 10 years; maintenance does not yet meet the target.

Figure 2.2 Percent of Florida Road Networking Meeting FDOT Standards



Standards: Minimum 80% of road network should meet pavement resurfacing standard.
Minimum 90% of road network should meet bridge condition standard.
100% should meet maintenance standard.

Lessons Learned

The FDOT experience with asset management can be characterized in the following way.

1. FDOT management has made a strong commitment to system preservation and maintenance, and has been actively involved in establishing policies that target such investments.

2. The asset management process is mission driven, that is, it is clear that the asset management ethic is incorporated into the mission statement, goals, and operating policies of the Department.

3. Asset management is customer focused in that surveys are used to determine public expectations on road conditions and maintenance levels. In addition, in a broader sense, legislative adoption of performance targets is an indication of the direct link to political expectations of system performance as well.

4. The asset management process is based on a strong linkage among planning, programming, budgeting, and work scheduling. The prioritization process is largely needs-based, and budgets are linked to asset inventories.

5. FDOT has invested heavily in the development of database support and management systems that support asset management decisions. Detailed inventory and condition data provide a defensible approach to justifying such decisions.

The scan team also observed that FDOT has integrated asset management into departmental activities at all levels – there was no one unit responsible for asset management. In addition, the asset maintenance contracting approach to achieving maintenance goals is an interesting strategy that merits continued assessment.

Perhaps the best description of FDOT's asset management process was provided by FDOT officials when they stated that their asset management process is "simply good quality management."

For further information, see: http://www.dot.state.fl.us/planning/statistics/assetmgt/default.htm.

2.2 Florida Turnpike Enterprise

Context

The Florida State Turnpike Authority, the predecessor to the Florida Turnpike Enterprise, was created in 1953. In 1969, the Authority was incorporated into the new Florida Department of Transportation (FDOT). In 1993, the Turnpike became one of eight FDOT districts. In 2002, it became Florida's Turnpike Enterprise (FTE). A governmental enterprise is defined by the State of Florida as an organization that uses best practice private sector management approaches while serving the public interest. In this case, the FTE is a separate business unit of the Florida DOT and has its own bonding authority.

In 1988, when the finance bonds for the original turnpike roads were nearly paid off, the Florida Transportation Commission (FTC), an oversight group of the FDOT, approved a financing scheme to use the bonding capacity of the FTE to finance new Florida intrastate highway system projects. As of May 2006, FDOT, using toll revenue and Florida's Turnpike bonding capability, has added 143 miles of new roads to Florida's intrastate highway system. The collected toll revenue also has funded the construction of 15 new interchanges and additional lanes on the Turnpike's mainline.

The FTE is responsible for toll collection operations on every FDOT-owned and operated toll road and bridge in the State, and also is contracted to collect tolls on the Garcon Point and Mid-Bay bridges in the Panhandle, as well as the Leroy Selman-Crosstown Expressway in the Tampa Bay area, representing almost 600 miles of roadway (80 percent of all toll facilities in the State). The Turnpike's current bonding capacity is $4.5 billion.

Investment Decision-Making Process

The Florida Turnpike Enterprise has a 10-year finance plan of $11.1 billion that is distributed in the following way: 59 percent for new projects, 25 percent on debt service, and 16 percent on operations and maintenance. A draft five-year work program of $4.69 billion reserves $525 million for routine and periodic maintenance activities, $585 for system expansion, and $966 million for road widenings.

The decision on where to build new interchanges or highways follows the formal decision-making process within FDOT, which is governed by Florida statute, and also must satisfy bond covenants. The FTE is recognized by Moody's Investors Service as the highest rated turnpike in the United States. One of the reasons for this rating was the fact that FTE was operated in a business-like manner, and was able to manage its capital assets in a way that assured their continued viability.

Transportation need for a project is evaluated by determining how much traffic a future project would serve and what type of relief it may provide for other transportation facilities. Economic feasibility tests are conducted for new roadway projects. To pass these tests, a new roadway must pay 50 percent of its own bond indebtedness by the 12th year of opening to traffic and all of its own bond indebtedness by the 22nd year of operation. Projects that pass these tests are considered viable and must compete statewide with other possible projects.

"The only way to fix bad roads is to maintain good roads."

…Florida Turnpike Enterprise Official

In 1996, the Florida Transportation Commission requested that a thorough review be conducted of the Turnpike's program after the year 2000. The resulting "futures report" identified numerous projects throughout the State that had the potential for FTE investment over the next 20 years. Part of this effort also was estimating the amount of support that would be necessary for periodic system renewal and replacement. Prior to this, the FTE only developed 10-year financial plans, but now there was a need for a 20-year plan and a corresponding 20-year needs projection for renewal and maintenance. At the time, the methods used for determining these needs projections included rules of thumb, historic projections, and adopting only a short time horizon for costs that were known. After this "futures" exercise, it was very clear to FTE officials that a better, more systematic process should be used to develop such estimates, and thus FTE turned to asset management.

Asset Management Approach

According to FTE officials, the reasons for adopting an asset management approach within the agency included:

1. Enhance fiscal responsibility:
   - Adopt a "fix it before it is broke" principle;
   - Maintain facilities at a higher level of service; and
   - Lower the cost to maintain over time.
2. Maintain FTE's bond rating;
3. Obtain higher customer service ratings; and
4. Meet adopted goals and performance measures.

The information support for asset management now used by FTE is called the Turnpike Enterprise Asset Management System (TEAMS). Developed through consultant support, TEAMS is a desktop application that allows FTE to show an accurate inventory of infrastructure assets, provide the current condition of these assets, and forecast and prioritize capital expenditures needed to renew this asset base. The assets managed in TEAMS include pavements, roadways, facilities (FTE has around 500 buildings), bridges, drainage systems, and safety conditions. As part of the TEAMS development process (in the late 1990s), focus groups and surveys of Turnpike district and program staff were used to determine the information needs for system preservation decisions. An assessment of FTE's then existing database support systems showed that a wide range of tools were being used, ranging from simple spreadsheets to Federally required databases on bridge conditions. FTE officials reviewed off-the-shelf asset management software packages and decided that the most appropriate approach for their agency was to develop their own customized system.

The project team developing the new asset management framework reported to the financial manager in FTE. Thus, the general "tone" of the asset management system shows a decision support perspective for investment decision-making. The application goals for the TEAMS tool were that it should be graphically driven, fully integrated with existing databases, have the ability to use pull down menus and maps, be accessible via the FTE Intranet and be web-enabled. A pilot project was undertaken to show the feasibility of different data collection strategies, including the use of photogrammetry, mobile van data collection, and global positioning system (GPS) field data units. A VISAT (Video, Inertial, and Satellite) van was used to obtain a geo-referenced digital image of every Turnpike road. The van travels up to 45 miles per hour, and takes 360^{o} images. The position and geodetic orientation of the camera's focal point are recorded along with the image. For pavement conditions, an Automated Road Analyzer (ARAN) van was used to obtain condition information.

Management and Database Systems

The TEAMS approach toward asset management provides an overall framework for the FTE's asset management program. Within this framework, FTE uses typical management systems for key assets. Thus, for example, Pontis is used to estimate bridge investment needs, and a pavement management system (PMS) is used to predict pavement deterioration (the pavement degradation models in the PMS were not different from one part of the State to another). TEAMS allows users to choose an asset type or geographic area, and then provides a range of information, including database tables, spreadsheets, aerial photos, digital images, photographs, and scanned documents and plans.

With respect to data collection, the entire road network is inspected each year (requirement by the bond covenants) with a 1 to 10 rating given to pavement condition. Condition data are assigned to milepost reference points. FTE also surveys maintained features using the same maintenance rating program (MRP) as FDOT. However, FTE has set a higher rating standard.

Currently, FTE is developing the functionality requirements for field teams to collect data on the turnpike system. The vision is to have automatic location and real-time data updates from all field collection sites. To date, FTE has collected over 300,000 data elements from photogrammetry, 500,000 data elements from the VISAT van, 600,000 data elements from manual inspections, and 600,000 data elements from the ARAN van. When combined with the one million data elements already existing in FTE databases, over three million data elements have been collected, quality controlled, and compiled in the TEAMS database. In addition, inspecting the entire road network annually enhances FTE's opportunity to calibrate its deterioration curves for its assets.

The database also has been helpful to the public information office in that calls concerning signs on Turnpike roads can be answered very quickly by accessing the inventory database.

Lessons Learned

The Florida Turnpike Enterprise provides a very interesting example of a targeted asset management system based on enterprise decision-making principles. The requirements of the financial bond institutions have a strong motivation for the FTE to adopt effective system renewal and preservation strategies, as well as a comprehensive and extensive decision support tool (TEAMS). Although the extent of the FTE's road network is much less than a typical state DOT's, the FTE experience does show several elements of best practice for asset management.

1. FTE developed its asset management program in collaboration with all of the internal groups that would have some role in its implementation, e.g., finance, planning, maintenance, and administration. Focus groups and surveys were used to determine the types of information that should be produced by TEAMS. This organization-wide effort built confidence in the approach that FTE was adopting for its asset management program.

2. FTE based much of its asset management program on existing procedures and databases as was possible. By so doing, greater acceptance of the new system was obtained from FTE staff.

3. TEAMS is an excellent example of a fully integrated asset management system for all assets owned by a transportation agency. It is easy to use and provides photographic, documentary, and data information for any asset that might be of interest to a TEAMS user. For example, all road and bridge plans are digitally available in TEAMS for the road network.

4. Florida DOT's performance measure framework has provided an overarching reference for the desired condition and mobility measures that FTE is striving for. Asset management is thus one way of achieving the policy and planning objectives for the State's transportation system.

5. FTE's asset management program was strongly influenced by the requirements of the financial bond institutions. Showing an ability to preserve and maintain existing assets is an important consideration in the bond rating received by the FTE. As more public/private financing proposals are being considered around the country, the asset management strategy adopted by FTE might be a very good model for state DOTs to examine as part of partnership agreements with private consortia.

2.3 Michigan Department of Transportation

Context

The Michigan Department of Transportation (MDOT) is recognized nationally as one of the leading state transportation agencies in the practice of asset management. Not only is MDOT an important case study for the lessons learned with MDOT's experience with asset management, but department officials are pushing the boundaries of what future asset management applications should look like through the use of new technologies and by creating new institutional structures for fostering an asset management ethic within the agency.

The MDOT case also is one of the few examples in this scan of where a transportation agency has adopted an asset management strategy for a wide range of transportation assets. For example, MDOT is responsible for:

- Over 9,700 miles of road (9 percent of the State's road network), 27,000 lane-miles) and 5,600 bridges;
- 215 park-and-ride lots;
- 2,400 trucks, maintenance vehicles, vans and cars;
- 450,000 signs; 4,025 traffic lights, 8 million linear feet of guardrails;
- 83 rest areas and 13 travel information centers;
- 85 roadside parks and 27 scenic turnouts; 41 picnic sites and 2,400 picnic tables;
- 163 pump houses; 188 water wells; 54 sewage disposal facilities and 64,000 catch basins;
- Nearly 2,000 miles of nonmotorized facilities; 4,500 miles of fences;
- 7 regional offices, 26 Transportation Service Centers and over 40,000 acres of land;
- Over 600 miles of rail lines; 107 railroad bridges; 736 railroad crossings;
- 140 permanent traffic recorders and 40 weigh-in-motion sites; and
- 4 airports and a number of planes.

For most of these assets, MDOT has implemented some form of asset management program to monitor asset condition and to develop budgets that promote asset preservation.

As is the case in most state transportation agencies, MDOT officials identified the need to obtain sufficient funding to meet the needs of the State's transportation system as one of the critical transportation issues facing the State (bridge and road funding can only be used for these purposes as per the state constitution). Other critical issues that relate to asset management included: 1) maintaining a balance between investments to preserve the existing system and investments to meet growing congestion problems; 2) continually developing a trained work force (nearly one-quarter of the current employees will be eligible for retirement in the next five years; 40 percent in the next 10 years); and 3) working within the current rules for obligating Federal funds, which makes it difficult to implement some of MDOT's investment strategies and to achieve stated goals.

Decision-Making Process

Revenues for transportation projects come from a variety of sources. Federal road, aviation, and transit aid accounts for 37 percent of the annual transportation revenues received by MDOT, 31 percent come from state motor-fuel taxes (gasoline and diesel), 27 percent from state vehicle-registration taxes, and the rest from a variety of state and local taxes and fees. State law governs the distribution of this revenue. Ten percent of these funds is reserved for the comprehensive transportation fund (e.g., public transit funding). Of the remaining funds, MDOT receives approximately 39 percent for the state trunk road system, 39 percent goes to the state county road commissions, and 22 percent goes to the State's cities and villages. State law establishes a number of priorities on how the monies may be spent, including a provision that requires 90 percent of the funds to be spent on the "preservation of highways, roads, streets, and bridges and for the payment of debt service on bonds, notes, or other obligations." The law also requires that an average of 25 percent of the Federal reimbursement funds be shared between MDOT and local road agencies.

"Asset management is not a buzzword…it is a core value."

…Michigan DOT Official

State law also states: "(1) The Department shall develop and implement a life-cycle cost analysis for each project for which total pavement costs exceed $1,000,000 funded in whole, or in part, with state funds. The Department shall design and award paving projects utilizing material having the lowest life-cycle cost. All pavement design life shall ensure that state funds are utilized as efficiently as possible. (2) As used in this section, "life-cycle cost" means the total of the cost of the initial project plus all anticipated costs for subsequent maintenance, repair, or resurfacing over the life of the pavement. Life-cycle cost also shall compare equivalent designs and shall be based upon Michigan's actual historic project maintenance, repair, and resurfacing schedules and costs as recorded by the pavement management system, and shall include estimates of user costs throughout the entire pavement life."[3]

MDOT's budget in 2006 is $3.5 billion. The process for choosing projects that are funded in this budget involves many different players and units within MDOT. MDOT regional offices propose projects within a centrally determined program investment template. Most state highway preservation, maintenance, and operations functions are now decentralized into the seven regional offices, 26 transportation service centers, and numerous field offices and garages. Planning, project-development, and traffic-and-safety functions are divided between regional offices and the central office in Lansing.

The State Long-Range Plan (SLRP) provides the framework for investment in Michigan's transportation system. The goals identified in the current SLRP provide direction for MDOT's transportation programs, as well as has led to specific investment strategies. Three strategies, in particular, were identified for attaining the long-range goals for the state system of freeways, highways, and bridges-asset management, corridors of highest significance, and congestion management.

In addition, the Department recently updated its "Strategic Plan 2006." Two of the Department's strategic objectives are directly related to its asset management strategy.

1. Provide training to improve employee understanding of asset management principles and their application to integrated transportation solutions; and
2. Continue to use asset management and other innovative methods to improve performance outcomes, cost-efficiencies, and implement pilot initiatives.

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[3] Act 51 of the State of Michigan Public Acts of 1951, revised July 25, 1997.

The planning process leads to the development of a rolling Five-Year Transportation Program and a three-year State Transportation Improvement Program (STIP).

Four analysis tools are used to develop the investment program:

1. Cash Flow Model (identifies when funds will be expended and estimates cash balance);
2. Road Quality Forecasting System (RQFS);
3. Bridge Condition Forecasting System (BCFS); and
4. Integrated Call for Projects.

The Road Quality Forecasting System (RQFS), along with extensive pavement management data, is used to predict future system condition based on various investment strategies. Analysis is done to determine which strategy results in the best progress towards meeting the condition goals. Data also are used to support project-specific decisions that are not necessarily reflected in the strategy, such as dealing with rutting, ride quality, faulting and specific pavement surface distress types.

The Bridge Condition Forecasting System (BCFS), along with extensive bridge inspection data, is used to predict future system condition based on various investment strategies. Regional allocations are made based on strategies that work towards meeting statewide condition goals of 95 percent of the freeway bridges and 85 percent of the non-freeway bridges being in good/fair condition by the year 2007.

According to MDOT officials, the Integrated Call for Projects is the “heart” of the asset management process. This is an annual activity that starts with a confirmation of the asset condition goals and is completed when a new fifth year is added to the Five-Year Transportation Program.

The Statewide Planning Division, in cooperation with the Chief Operations Office, issues an annual Integrated Call for Projects letter. In the letter, key emphasis areas and strategic objectives are outlined and specific technical instructions are detailed for the regional system managers. These managers use these instructions to update their regional strategies in the RQFS and BCFS. During the annual Integrated Call for Projects process, a Project Screening Committee and the Bridge Operations Section review the condition of bridges on a statewide and regional basis. The Bridge Operations Section also monitors the benefit of preventive maintenance on system condition and determines how it can be most effectively used in strategy development.

The Safety Program uses the “time of return” method in selection of projects. Project costs are estimated using recent actual bidding information. User costs are determined by running project-level data such as traffic volumes and construction traffic plans through a software program called Construction Congestion Cost (CO3).

Based on information from all of the above sources, candidate projects are identified for more detailed scoping. Road and bridge candidates are identified in concert, so that no one aspect of the system drives the other. Final project selection occurs in such a way that a "mix of fixes" program results. This may also entail adjustments to intervening year programs, not just the new fifth year. An example of the template that is used to determine the different types of investment strategies that could be considered for this mix in the case of bridges is shown in Table 2.2.

Table 2.2 Possible Bridge Strategies to be Considered for Bridge Investment, Michigan DOT

Condition State					**Potential Result to NBI**		
Deck Surface NBI	**Deck Surface Deficiencies Percent**	**Deck NBI**	**Deck Underside Deficiencies Percent**	**Repair Options**	**Deck Surface Rating**	**Deck Rating**	**Next Anticipated Evaluation**
N/A	N/A	N/A	N/A	CSM Activities	No Change	No Change	1 to 8 years
NBI = 5, 6, 7	2% to 5%	NBI > 5	N/A	Deck Patch/ Seal Cracks	Up to 1 point	No Change	3 to 10 years
				Epoxy Overlay	NBI now 8, 9	No Change	10 to 15 years
		NBI > 5	N/A	Deck Patch	Up to 1 point	No Change	3 to 10 years
				Hold	No change	No Change	1 to 8 years
NBI = 5	5% to 15%	N/A		Hold	No change	No Change	1 to 8 years
				Deck Patch	Up to 1 point	No Change	3 to 10 years
NBI = 4 or 5	15% to 30%	NBI =5, 6	<10%	Deep Concrete Overlay	NBI now 8, 9	Up by 1 or 2 points	25 to 30 years
		NBI = 3 or 4	10% to 30%	Shallow Concrete Overlay	NBI now 8, 9	Up by 1 point	10 to 15 years
		NBI = 2 or 3	>30%	HMA Overlay with waterproofing membrane	NBI now 8, 9	No change	8 to 10 years
NBI = ≤ 4	>30 %	NBI > 5	<5%	Deep Concrete Overlay	NBI now 8, 9	Up by 1 or 2 points	20 to 25 years
		NBI = 3, 4, or 5	5% to 30%	Shallow Concrete Overlay	NBI now 8, 9	Up by 1 point	10 years
				HMA Overlay with waterproofing membrane	NBI now 8, 9	No change	5 to 7 years
		NBI = 2 or 3	>30%	Replace Deck	NBI now 9	NBI now 9	40+ years
				HMA Cap	NBI now 8, 9	No change	1 to 3 years

NBI = National Bridge Inventory.

Development of an investment strategy is a cooperative process between the finance, planning, and program coordinators in the Department. All available revenue is identified, including Federal obligation authority, state revenue, and bonding capacity.

MDOT works with other state agencies to identify near-term revenue estimates and then uses a revenue forecasting model and cash flow model to identify long-term revenues.

One of the most effective tools for linking goals to program outcomes is the Department's investment template, which identifies the investment level for each program category over a multiyear and annual timeframe. The statewide template represents the overall investment plan in that it links funding levels to program categories consistent with policy direction or program emphasis. The investment template is approved annually by the Director and State Transportation Commission. Investments are focused where they will be most beneficial with the directions established in the SLRP. Dollars are assigned to program categories, such as road and bridge preservation, safety, and capacity improvements. The investment template is used to communicate MDOT's investment strategy to the governor, legislature, and Department of Management and Budget.

MDOT's current investment template is made up of over 20 program categories. Specific performance standards or goals have been established for the majority of these categories. The investment strategy is communicated to the organization during the annual Integrated Call for Projects (CFP) process. Strategic direction and funding targets provided in the Call letter form the basis for project selection and prioritization. Since funding is allocated to achieve specific performance outcomes and projects are selected consistent with the funding targets and strategic directions, a direct link is established with the Department's goals and policies.

An example of an investment template comes from the safety program, which has an annual budget of $63 million. The State's safety goal is to achieve one fatality per 100 million VMT by 2008. This can be done in many different ways, but effective traffic signals, signs and pavement markings are an important element in achieving this goal. Thus, the investment template for safety includes the following guidelines:

- **Signal Goal –** Modernize signal network every 10 years;
- **Sign Replacement Goal –** Replace every 15 years; and
- **Pavement Marking Goal –** Re-stripe 85 percent of network annually.

All relevant project and program documentation is prepared, assembled, entered into a statewide database, and submitted to the Statewide Planning Division. The statewide program and resultant strategies are analyzed for consistency with instructions and statewide forecasting. The results are reviewed with each region in a Project Screening Committee meeting and with department leadership. Finally, the project selections are assembled into the new Five-Year Transportation Program for presentation to the State Transportation Commission for approval.

Asset Management Approach

MDOT's move toward asset management began in the early 1990s. At that time, the Department was a highly centralized agency with more than 4,200 employees. In addition, the culture of the organization was shaped by the need to complete the construction of the

Interstate system, rather than preserve existing assets. With the completion of the Interstate system in Michigan, the Department found new challenges, including: managing existing assets more effectively, identifying and controlling overheard costs, flattening the organization's decision-making hierarchy, becoming more agile and interdisciplinary, and responding better to the needs of the customers. Around the same time, the newest Federal transportation legislation, the Intermodal Surface Transportation Efficiency Act (ISTEA), required the development of six management systems. MDOT management saw this as an opportunity to restructure the Department's core business processes, and proceeded to invest heavily in the development of these management systems.

The legislature also passed a law establishing a statewide Asset Management Council (MDOT is a member). This law defined asset management as: "an ongoing process of maintaining, upgrading, and operating physical assets cost-effectively, based on a continuous physical inventory and condition assessment." MDOT is required to provide administrative support to the Council.

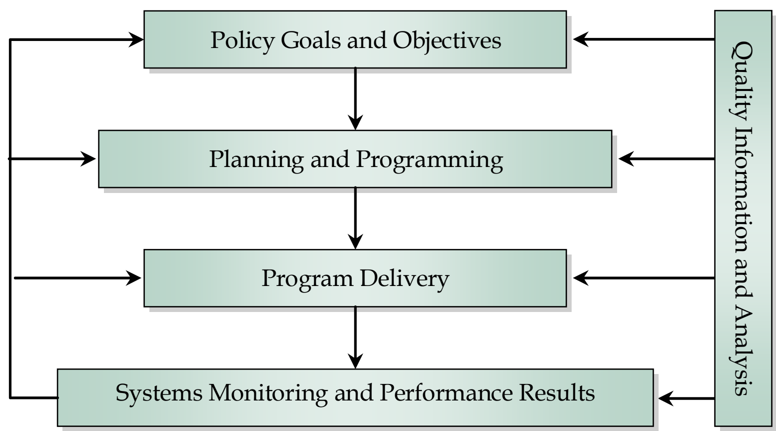
Another motivating factor for implementing asset management came from the Deputy Director of the Bureau of Transportation Planning's membership on AASHTO's Task Force on Asset Management. Given his experience with this task force, MDOT began to look into reorganizing the Bureau and developing a plan to implement the principles of asset management that had been identified by the task force.

Through the strong support of upper management, asset management principles have begun to permeate the major activities of the Department. As noted by an MDOT official, "the aim of our process is to maintain the initial investment in an asset by setting performance standards, monitoring facility condition and performance, and applying specific treatments at critical points to sustain or extend the facility's useful life." Although MDOT has a section and a division named "Asset Management," the asset management function is shared and integrated across many areas within the Department. Every business area within the Department (central, regionally and local) has resources that support the asset management function. Centrally, the Asset Management Division is dedicated to coordinating asset management efforts within the Department. An asset management administrator is responsible for coordinating activities statewide and monitoring best practices from around the country and world, as well as coordinating the Department's administrative activities for the Transportation Asset Management Council (TAMC – see separate case study in this report). The administrator also interacts with other agencies to assist in their asset management functions. In addition to this position, MDOT has defined a manager of the Asset Management Section who is primarily responsible for coordinating the Department's asset management activities internally. Both of these positions are located within the Bureau of Transportation Planning and report to the administrator of the Bureau. On a regional and local level, MDOT's Transportation Service Centers (TSC) coordinate with local agencies within their jurisdiction in the planning and scheduling of projects.

Officially there are 20 full-time equivalent employees and four part-time students assigned to the Asset Management Division and Asset Management Section. Unofficially, resources throughout the Department are involved in all of the various aspects of the asset management process.

Figure 2.3 illustrates MDOT's asset management process. As reported on the Department's web page, asset management is a process to strategically manage the transportation system in a cost-effective and efficient manner. It consists of five major elements: 1) developing policy goals and objectives; 2) data collection; 3) planning and programming; 4) program delivery; and 5) monitoring and reporting results.

Figure 2.3 MDOT's Asset Management Process



A number of asset management teams within the Department help implement this process. These include the Project Screening Committee, the Pavement Management Advisory Committee, an MDOT Architecture Project (MAP) Data Team, and a Traffic Signal and Sign Team. The Project Screening Committee is a team whose primary role is to coordinate and review the Integrated Call for Projects. Candidate projects for the highway program are reviewed for consistency with regional and statewide goals identified in the Call instructions to ensure that all relevant elements are accounted for, that the proposed fixes are realistic, and that the budget estimates are aligned with anticipated revenue. The committee ensures that progress toward department goals is being made and makes funding adjustment recommendations to the MDOT director, if deemed necessary. The committee is comprised of individuals with expertise in the various areas of program development.

The Statewide Pavement Management Advisory Committee was formed in 2005 to develop a comprehensive outline to identify how MDOT currently manages pavement, and to implement changes and/or make recommendations to management about resource adjustments, changes to organization/function, goals, performance measurements, and policies/guidelines. There are 14 committee members; seven from regional offices and seven from the central office.

A MAP Data Team oversees the MAP database and its related business processes. The MAP database is the repository for the Department's project and phase information for local improvements receiving Federal-aid and for the state trunk line capital improvement program. It is the mission of the MAP Data Team to ensure the integrity of the data and of the database structure.

The Traffic Signal and Sign Team is comprised of members responsible for the signals and signs, computer software support staff, and selected users. Their responsibility is to identify issues related to the system and make corrections and improvements accordingly. The team also determines levels of security for the different database users.

Designated asset management teams are not in place for multimodal assets, however, this function is generally handled through the modal program areas. For example, for rail assets, the property management/capital development program area monitors the condition of the overall railroad infrastructure, including track, bridges, and culverts. The rail regulatory area monitors the condition of crossing surfaces and warning devices at public grade crossings.

Another benchmark in MDOT's asset management efforts occurred with the requirement for asset valuation in the Governmental Accounting Standards Board (GASB) 34 guidelines. MDOT's asset valuation method is conducted as part of its GASB 34 requirements. For the purposes of GASB 34, the "modified approach" is used rather than depreciation for estimating asset value. As of September 30, 2005, the Department's assets were valued at over $15.2 billion out of a total State of Michigan governmental asset value of $19 billion. The Established Condition Level for pavements is: "No more than 30 percent of the pavements shall be rated as "poor" or "very poor."" For bridges the Established Condition Level is: "No more than 35 percent of the bridges shall be rated as "structurally deficient." According to the 2004-2005 Comprehensive Annual Financial Report, 19 percent of the State's roads were rated as "poor" or "very poor" and 15.8 percent of the bridges were rated as "structurally deficient."

MDOT has a very active training program in asset management, with much of this training being carried out through the Asset Management Council. MDOT staff can take two very specific courses directly related to asset management. The first is a modified version of the National Highway Institute (NHI) Asset Management Course that is specific to Michigan. It covers the workings of the Council and the five major components of an asset management process. Second, the Council has partnered with the National Center of Pavement Preservation to conduct a two-day advanced course on applied asset management, pavement preservation, and roadway deterioration.

Management and Data Systems

MDOT was one of the first states to develop the six management systems required by ISTEA (pavement, bridge, congestion, intermodal, public transit facilities and equipment, and safety management systems). These management systems are still in place today. Numerous physical assets are monitored on a regular basis. The major asset classes, such as pavements and bridges, are actively monitored and are the major determinants of the investment templates described earlier. Other program areas, such as safety feature improvements, are coordinated with the pavement and bridge program to leverage project implementation costs (such as environmental clearance, traffic maintenance, etc.).

In addition, MDOT monitors assets, including vehicles, equipment, and computer hardware and software. For rail assets, MDOT's contract operators and in-house personnel monitor major components within the railroad right-of-way, including: rail, ties, ballast, switches, culverts, bridges and buildings. Railroad crossing surface conditions and warning devices at public grade crossings also are monitored.

Bridge, safety, intermodal, congestion, and public transportation management systems store their data in a single common Oracle database. Data in this database are designed and implemented with common referencing, a uniform set of technical standards and definitions, and are managed as a single database. Data are reused in several of these systems, especially those that describe system components, their location, and attributes. Detailed pavement data are maintained in a separate Oracle database, but the analysis results of this data are stored in the common management system database for distribution and use by other management systems.

Other MDOT divisions maintain inventories (bridges/culverts greater than 10 feet in diameter, signals, and signs), which are referenced by the regions to complete their physical feature inventory. Physical feature inventory details, excluding lane-miles, are kept in spreadsheet format and are not linked to any other data system. As new systems are developed or existing ones updated, information housed in other databases is utilized by access to those other systems.

The MAP database is a result of implementing the original ISTEA requirements. The database combined several mainframe files, eliminated over 27 competing versions of the program management file, and created tightly controlled data standards, definitions, and procedures. The result is a data environment that allows management to capture project commitments, approve funding, schedules, and basically ensure that the program will be executed as promised. From a data quality perspective, the data is defined and stored in a widely acceptable spot so no one has to recreate the data. The data edits are tightly linked to the process to make sure it works across the process and the organization.

Pavement condition data are collected in a number of ways by different areas of the Department, and used for different purposes. Data collected includes high-speed, vehicle-based measurement of longitudinal and transverse profiles (laser), friction, and downward/forward digital images (from which surface cracking is observed). Road friction data is collected by MDOT personnel; other data are collected by a contractor. The data are used to arrive at measures such as a surface distress identification (type, severity, and extent), distress index, remaining service life (RSL), rutting, faulting, ride quality index, international roughness index, and friction number.

RSL is defined as the "estimated number of years until Capital Preventive Maintenance (CPM) is generally no longer a cost-effective way to preserve pavement condition." Remaining service life (RSL) is calculated for each uniform section. An RSL rating of "0" corresponds to a Distress Index of "50." RSL accounts for project history and condition over time, as opposed to other condition measures that reflect a "snapshot" at a specific point in time.

The summary of the pavement surface distress is reported as "distress index" or DI. DI is a measure of the surface distress for each 1/10th-mile segment of roadway. DI has a range from zero (distress free pavement) to over 100. When a segment of roadway has a DI of 50 it has reached a condition threshold at which it is no longer feasible to do capital preventive maintenance.

MDOT is just beginning to use results from automated calculations. This involves the processing of historical distress data, project type history, and utilization of distress growth curves. A logic diagram is being developed to document the decisions made to assign RSL. MDOT starts the distress growth curves at Distress Index (DI) equal zero at time zero, and DI increases with age. If insufficient DI data are available to lead to realistic RSL assignments, assumptions based on historical performance data of similar pavements and engineering judgment must be utilized. Pavements are grouped into RSL categories to assess the overall condition of the system (see Table 2.3). MDOT is beginning to use the Pontis software to estimate the time to "next condition state" for bridges. The next condition state for bridges is analogous to RSL for roads.

Table 2.3 Michigan DOT's Pavement Remaining Service Life Category Ratings

Remaining Service Life Categories		
Category	**RSL Range**	**Condition**
I	0-2 years	Poor
II	3-7 years	Good
III	8-12 years	Good
IV	13-17 years	Good
V	18-22 years	Good
VI	23-25 years	Good

For pavements, life-cycle cost analysis is not formally used until the decision between repair/replace/build has been made. It is then used to choose between comparable alternatives (concrete pavement or hot mix asphalt pavement). Pavement historical condition and project data are used to establish the information utilized in the analysis. The decisions of whether to repair/replace/build are based more on pavement strategies to achieve long-term goals and other constraints than on life-cycle costs. The same holds true for bridges. Once the decision is made to replace a structure, life-cycle cost is used to determine the type of structure that is most cost-effective.

Point values are assigned to a specific distress type/extent/severity combination in terms of how much of that distress type could accumulate in a 1/10th-mile segment before the condition threshold is reached. DI is calculated by summing all distress points along a defined roadway segment. This figure is then used to calculate remaining service life.

A sufficiency rating is a windshield survey conducted annually by a pavement management engineer that rates pavements from 1 to 5. MDOT has been conducting sufficiency ratings on the entire state trunk line system since 1961. This is a systematic evaluation of the condition and relative performance of any segment of the highway. The sufficiency rating includes capacity, base, surface, and crash measures. The maximum point value assigned to each rating category represents its relative contribution to the total rating. The rating provides a general systems-level overview of the relative condition of the state highway condition and is used for the Department's GASB 34 reporting.

Bridge data are collected during the biannual bridge inspection process. Inspections are done by qualified, trained personnel as required by the National Bridge Inspection Standards. Bridge inspections are primarily a visual rating of the separate elements such as the deck, superstructure, and substructure. MDOT uses this referencing system to define bridges in good, fair, and poor condition. MDOT also does underwater, fracture critical, fatigue sensitive, and other special inspections as needed. Nondestructive testing is often used to augment the visual inspection. Examples of this include chain dragging a bridge deck, taking ultrasonic measurements to measure beam thickness, or dye penetrant or magnetic particle testing to locate flaws in the steel. MDOT also monitors functionally obsolete bridges and collects AASHTO Commonly Recognized (CoRe) elements. This is a rating system that further divides a bridge into specific element types having quantities that can be used in more detail when doing more advanced assessment of bridge conditions.

Systemwide measures of condition influence the distribution of funding (within specific categories) to the different regions within the State. Pavement condition goals are in place based on Remaining Service Life (RSL). MDOT officials set strategies and projects to continually work toward meeting and sustaining the goals. The targets serve to both support and drive pavement-related decision-making, but not to the exclusion of other asset needs.

MDOT has been working to identify/develop a pavement condition customer descriptor (measure) that reflects Michigan's citizens' and travelers' perception of the trunk line pavement condition. This measure would be used to report pavement condition to the public, legislators, and stakeholders in the Five-Year Program and other department communications. Small scale studies to get motorist input regarding relevant measures have occurred over the past two years.

For traffic signals and signs, the life expectancy of the device is used in replacement decisions. The life expectancy for traffic signals and signs is incorporated into the asset management analysis. For traffic signals, level of performance is more related to features of the equipment used. Newer equipment will, in most cases, provide more options, thus, giving the ability to improve signal system performance. The life expectancy of signs is directly related to level of service. Sign performance measures are established from national research on sign retro reflectivity. However, if a new product is being evaluated, the device's replacement cycle can be used to determine a replacement strategy.

With regard to maintenance, MDOT privatizes a number of maintenance activities such as roadside mowing, catch basin cleaning, and janitorial services for roadside parks and rest areas. In addition, MDOT contracts with local agencies for the majority of highway maintenance on much of the state trunk line system. Currently, there are 66 counties and 161 municipalities providing maintenance on 23,512 lane-miles of state trunk line. Maintenance budgets and tasks are defined as part of an annual work plan that is compatible with department goals and the Five-Year Transportation Program. Decisions to contract specific tasks, such as culvert replacements, slope restoration, shoulder rehabilitation, etc. are based on costs and the ability to deliver. A Maintenance Activity Reporting System (MARS) is used to plan maintenance activities based on the actual cost estimates of doing the work (labor, equipment, and materials). Budgets for the local agencies are based in part on the number of lane-miles maintained by that entity. MARS includes all road and bridge physical feature inventories and is the key link to integrating all maintenance components. For maintenance reporting purposes, an annual physical features inventory is conducted for use in a MARS planning tool. GPS location is collected for guardrail and culverts.

Three databases are used to maintain the Department's equipment assets: a fleet management program for inventory and repair costs, a Data Collection and Distribution System for usage reporting, and the Michigan Administrative Information Network for payments to vendors. Excel spreadsheets are used by each region and support area to track and report on the current status of the information technology equipment. These systems are not integrated with one another, but reports can be created with reporting programs by pulling information from separate databases.

"The power of asset management is that it is a way
of bringing the Department together."

…Michigan DOT Official

MDOT's linear referencing system is used for storing transportation data (other state and local agencies use this system as well). All of the major data bases are integrated through the use of a physical reference number, a unique number assigned to each segment of road. The linear reference system is tied to latitude/longitude and is designed to accommodate geographic information system information. As long as an asset can be related to a geographic point, it can be linked with all other assets.

Road configuration data (location, intersections, and lengths) are kept and maintained by the Center for Geographic Information (CGI). This agency (part of the Department of Information Technology) annually produces the State's GIS base map, which includes all public roads and the linear referencing system. This base map, commonly referred to as the "Framework," is the underpinning of the State's road referencing system. It also contains other features such as governmental boundaries, lakes, rivers and other water courses.

MDOT has taken the approach of storing data such that segmentation is determined by the values of the asset's attributes. Thus, there is segmentation appropriate for traffic volumes, another for number of lanes, yet another for pavement type, and so on. These segmentations are stored individually, and then combined when a user or application needs to answer a particular question. At that time the data is merged and the segmentation appropriate for the user's application is generated. Some applications need their data segmented by intersection, others by jurisdiction, yet others by land use, national functional classification, etc. These segmentations are produced to accommodate these applications when they are needed. This minimizes data storage and management issues, while providing the data in the form needed to the users.

Although the base data are stored in a single database and can be accessed through a single integrated set of management systems, some of the performance analyses are maintained as separate applications. For example, Pontis data are contained in a Transportation Management System (TMS) database, but the actual functionality of Pontis is executed through the Pontis application. The results are then stored in the TMS database. The Congestion Management System is more of a repository of analyses performed outside of TMS than an analytical tool. Results from scenarios developed in a demand/systems modeling tool are stored in the TMS for use by other management systems. Extensive safety analyses are contained in the Safety Management System component of the TMS.

Similarly, the pavement management data are stored in the TMS database, but the forecasting and strategy analysis function is housed in the legacy Road Quality Forecasting System (RQFS). Remaining Service Life distributions can be predicted by knowing the deterioration rates of pavements along with proposed project types. Proposed projects are entered into RQFS by indicating the percent of lane-miles that are expected to move from one category to another for the coming years. Investment strategies are made by "moving" pavements from one category to another by using a "mix of fixes" strategy.

Traffic data (commercial, truck weight, total volume) are collected according to the Traffic Monitoring Guide to determine vehicle composition and characteristics. MDOT uses 140 permanent traffic recorders and 40 weigh-in-motion locations in this effort. The information is used for capacity planning, as well as in the pavement design process. Congestion data are a product of the traffic volume/characteristic data, in conjunction with the configuration of the road system and many of its attributes. Crash data are collected by the Michigan State Police in cooperation with local police agencies.

Data collection cycles vary depending on the asset. Most data are collected on pavements and bridges over a two-year period. Pavement friction data collection is done for about one-third of network each year, with one dedicated MDOT person performing the measurement. Pavement data collection is accomplished by a consultant at a cost estimated at $750,000 annually. In addition, a dedicated staff of five MDOT personnel manages the data.

Sufficiency data are collected every year by a two-person team at the cost of about $75,000 per year. Bridge inspections are performed by MDOT personnel at an estimated cost of $1 million per year. Local agencies are responsible for performing their own pavement and bridge data collection; costs are unknown. Changes in lane-miles and/or physical features are collected by the regions and reported to Lansing Central Maintenance on an annual basis. Every fifth year, each region compiles a new inventory (lane-miles and physical features). There is no dedicated staff used to do this inventory. Costs are absorbed by the region/TSC based on salaries and wages appropriated.

Crash data are collected as an ongoing practice by police agencies. This is a statutorily assigned activity for local agencies. Traffic volumes are collected at least every three years, as required by the Traffic Monitoring Guide, or in response to identified business needs.

Intermodal asset condition data are collected by MDOT staff on a periodic basis. Some of this data collection is used to assess condition, which is then reported on MDOT's web site. Public transit information includes condition, budgets, ridership, and applications for capital and operating funds. These are performed on a quarterly basis. (This software has recently been migrated from a client-server application to a web-based tool).

Table 2.4 summarizes the different data collected by MDOT for its asset management system and the corresponding characteristics.

Each of the data collection areas has quality control procedures established. These are performed within the respective areas, and are part of the data collection process. MDOT is developing quality control/quality assurance procedures for bridge inspections performed by local agencies.

Table 2.4 Pavement Data Collection Efforts
Michigan DOT

Data Item	Survey Type	Collected By	Extent of System	Cycle	Uses	Notes
PASER Rating	Windshield	Asset Mgt Council	System minus ramps	Annual	AM Council	AM Council and as QC for other data
Surface Condition	Windshield	Planning	System minus ramps	Annual	GASB	Secondary measure for pavement condition
Shoulder Condition	Windshield	Sufficiency	System minus ramps	Annual	Inventory	1-excellent; 5-very poor, TMS
Subbase Condition	Windshield	Sufficiency	System minus ramps	Annual	Inventory	1-excellent; 5-very poor, TMS
Drainage Condition	Windshield	Sufficiency	System minus ramps	Annual	Inventory	1-excellent; 5-very poor, TMS
Ride Quality	Windshield	Sufficiency	System minus ramps	Annual	Inventory	1-excellent; 5-very poor, TMS
Remaining Service Life (RSL)	Data not collected but calculated	N/A	System minus ramps	Annual	Project selection, RQFS, Network Planning Fix determination R&R and CPM programs. Preserve priority model.	Estimated from historical distress observations. Reported in pavement condition file and TMS

Table 2.4 Pavement Data Collection Efforts (continued)
Michigan DOT

Data Item	Survey Type	Collected By	Extent of System	Cycle	Uses	Notes
Distress/ Distress Index	Crack count	Pavement unit	Half of system, except ramps	Annual	Use to calculate RSL	Reported in TMS
International Roughness Index	Crack count	Pavement unit	System minus ramps	Annual	HPMS, calculation of RQI	Measures roughness, not condition, TMS
Road Quality Index	Crack count	Pavement unit	Half of system, except ramps	Annual	Preserve model	Generated from IRI data
Pavement Type	Windshield	Planning	System minus ramps	Annual	Distress and RSL	Not detailed enough for analysis
Rut	Crack count	Pavement unit	Half of system, except ramps	Annual	ID locations with problems	Reported in pavement conditions, TMS
Friction	Machine measured	Special crew	Projects	3-year cycle	Project selection	

Note: Pavement Surface Evaluation and Rating (PASER) ratings are based on laser sensing equipment obtained from riding over the surface. The data are related to a condition number that correlates to criterion for that particular number rating on a PASER chart. Roadways are rated on a scale from 1 to 10, with 10 being the best or new construction, and one representing a condition needing total replacement.

Results of the System Preservation Strategy

In 1996, MDOT successfully used the Road Quality Forecasting System to determine the level of funding needed to bring 90 percent of the roads and bridges into good condition by 2007. This information was used by the governor and legislature in developing the Build Michigan II program, which was passed in 1997. Build Michigan II raised the gasoline tax from $0.15/gallon to $0.19/gallon, generating an additional $200 million per year.

Figures 2.4 and 2.5 show the results of MDOT's system preservation efforts since 1996. As can be seen in both figures, pavement and bridge conditions have improved significantly over the past 10 years. Interestingly, Figure 2.4 also shows a projection to 2012 of what might happen to pavement condition if additional investments over and above what is available are not made in the road system.

Figure 2.4 Pavement Condition, Michigan
1996-2012

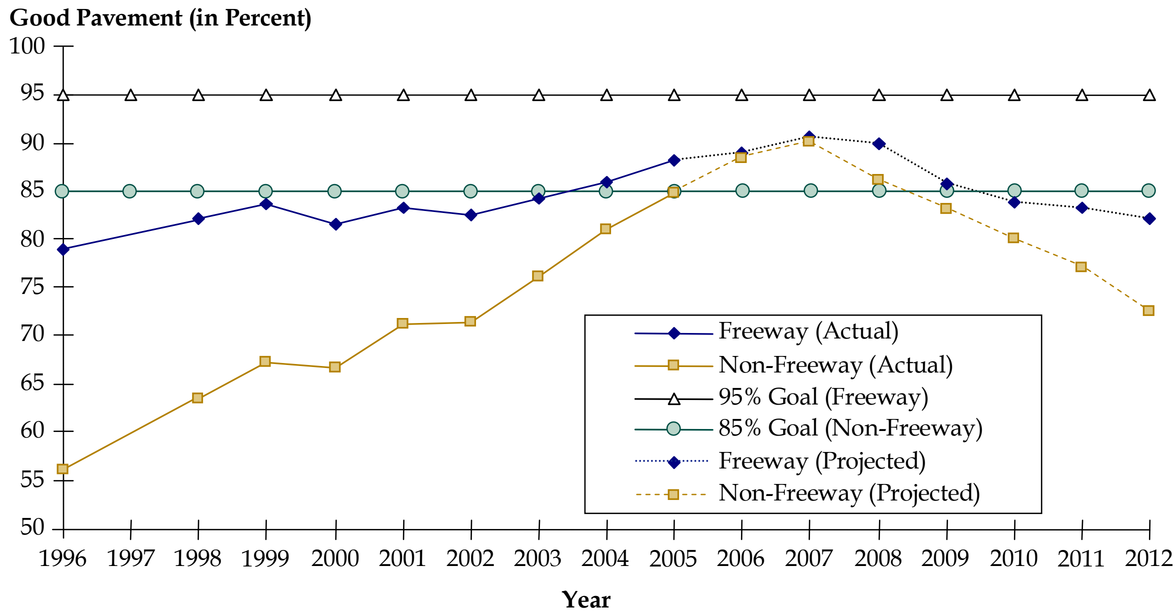
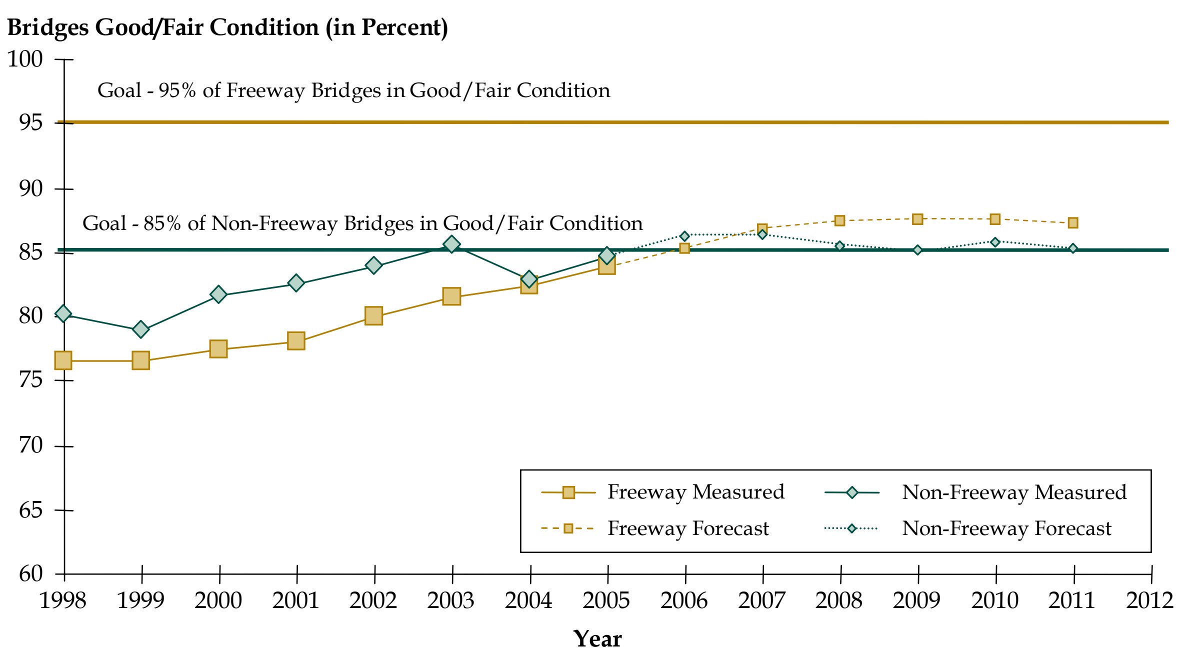


Figure 2.5 Bridge Conditions, Michigan
1996-2012



One of the asset management areas that Michigan has been investigating with some interest is intelligent transportation system (ITS) technologies. The Detroit and Grand Rapids metropolitan areas use ITS technologies to monitor traffic on a "real-time" basis along the major freeways. A combination of cameras and large changeable message signs are used to convey system information to many different users, including local law enforcement agencies, emergency responders, and the motorists themselves. The Michigan Intelligent Transportation System (MITS) Center in Detroit is one of the largest Advanced Traffic Management Systems (ATMS) deployments in the nation.

MDOT has been looking at different ways of incorporating asset management requirements into the contracts of those providing the ITS services. For example, ITS maintenance contracts are based on the amount of time a device is operational. If a device is not operational, the contractor is not paid. Desired response times are built into the contract by device type. The results of this contract approach have been as follows: digital message signs have been operational on average 90-95 percent of the time, CCTV cameras 90-95 percent operational, and detector stations 75-80 percent operational.

In addition, MDOT is looking at using satellite imagery to identify asset existence/location/condition for several asset types. MDOT's "Transportation Application of Restricted Use Technology Study (TARUT)" is an 18-month study to explore the possibility of using high-resolution remote sensing systems and other assets with advanced geospatial analysis techniques to examine transportation issues. It is a collaborative effort among more than 80 state and local transportation stakeholders and technology experts. The group initially decided to look closer at eight potential areas of emphasis, including: asset management, HAZMAT shipping, ITS and operations, border crossing operations, traffic safety and congestion forecasting, environmental assessment, multimodal issues, and homeland security. Based on the input from the participants, these eight were revised into four suggested pilots:

1. Characterization of roadways and transportation corridors using remote sensing. This would include elements of asset management, thorough inventories, and security concerns.

2. Assessment of environmental context in transportation corridors and sensitive watersheds.

3. Analysis of traffic queues and delay.

4. Estimation of AADT with remote sensing.

MDOT is now moving to the third phase of the study, which will address whether the technology is feasible in meeting the specific business needs as identified in each of the four pilot studies.

"Asset management provides a forum for a common vision and language.
It has given the Michigan DOT a sense of purpose."

…Michigan DOT Official

MDOT also is looking closely at Vehicle Infrastructure Initiative (VII) strategies as possible opportunities for asset management applications. VII is the integration of surface transportation vehicles and the infrastructure those vehicles use. Such capability is not possible without the ability for vehicles to exchange data with the roadside infrastructure, and for communications potentially to transmit this vast amount of data to control centers or other central locations. Once data is communicated to the infrastructure, the data can be shared, fused, packaged, and disseminated from a wide range of providers to a wide range of users.

Three key subsystems being evaluated as part of this program are:

1. **On-board Equipment (OBE) –** Components installed in vehicles which may or may not include integration with the various vehicle systems. This equipment includes the wireless communication in the vehicle, including the components necessary for vehicle to vehicle communications.

2. **Roadside Equipment (RSE) –** The components installed along the roadside, specifically the wireless communications necessary for vehicle to infrastructure.

3. **Network Subsystem –** The backhaul or network necessary to connect roadside devices to one another and to connect roadside devices to the various central processing locations.

Deploying infrastructure is only one part of the equation. How the data are used is a key to improving the safety of the road network and reducing congestion. As a result, MDOT has initiated the VII Data Use Analysis and Processing (DUAP) Project. The goal is to identify how VII data will change the way a DOT operates. The DUAP project takes the data from vehicles and incorporates it into information that can be used to manage traffic flow. This includes the ability to know which routes are congested and the ability to detect incidents more rapidly. This also includes the ability to detect changing weather and road conditions allowing MDOT to better deploy snow plows in a more timely and location-specific manner than any previous sensing mechanism.

Lessons Learned

MDOT officials identified several elements of the Department's asset management program that they felt were important steps for a successful effort.

- Enlist the support of upper management and designate a contact person/section within the organization.

- Set goals, develop multiyear plans, set performance measures based upon the goals.

- Provide adequate IT staff to build sound relational databases.

- Develop an accurate system inventory and analyze condition data.

- Provide adequate resources for data interpretation, as well as for data collection. Asset management data is only good if it is used.
- Explore increased investment in preventive maintenance and, by applying asset management, optimize the use of funds to get the maximum system benefit.
- Initially, start simple and focus at the lower levels of the organization. If additional information is necessary, build from the base. Simplicity helps create buy-in, and facilitates early, measurable success. Information should be adequately detailed, but manageable in such a way to accommodate easy retrieval, review, use, and maintenance.
- Establish department-wide performance measures, goals, and objectives.
- Develop investment strategies to achieve goals and objectives. Utilize condition forecasting tools.
- Monitor results of implemented strategies.
- Seek and pursue opportunities for continuous improvement.
- Work together department-wide to reach common understanding and decisions on strategy-related issues.
- Provide ready access to data across the Department.
- Inventory and map all infrastructures that must be maintained or monitored. Condition inventories ensure improvements have been prioritized in an efficient and organized manner. Maps are utilized for project coordination; for example, snowmobile crossings and truck safety turnouts are coordinated with future road projects. This allows facility improvements to occur at the appropriate time, saving time and money – "the right fix at the right time." Maps also make interagency coordination easy and clear. For example, information that is readily available and easy to share could quickly identify a Michigan Department of Natural Resources snowmobile crossing within MDOT right-of-way, located in the middle of a wetland.

In addition to these "steps for success," the Michigan case also highlights several additional aspects of the Michigan experience that are important to note. First, the existence of state legislation requiring asset management has been a strong catalyst for both MDOT and other governmental agencies to adopt an asset management perspective. Second, MDOT maximizes the use of its funding resources. However, each of these resources has a set of legal restrictions that limit the degree to which funds can be shifted from asset class to asset class, and sometimes between uses within an asset class. In addition, from a multimodal perspective, constitutional and legislative requirements do not permit the transferability of funds to any degree among modal assets that would make a multimodal analysis worthwhile. Each of the various modes is responsible for establishing priorities within their respective areas, but because of the legal restrictions there is no attempt to establish priorities among the modes.

Third, because of MDOT's early commitment to the ISTEA management systems and need to develop an efficient and effective database, all of its asset management systems are integrated from the standpoint that they use the same set of conventions, standard data collection methods, mapping and referencing systems, technical platforms, etc. This provides an important capability that many transportation agencies lack. However, one of the most important challenges facing MDOT in its asset management program is the timely and accurate updating of the databases, especially with new project and heavy maintenance information. Several new IT projects are being developed to facilitate this effort.

Fourth, MDOT's use of asset management has provided a methodology to show the benefit of developing bridge and pavement strategies comprised of a mix of fixes (preventive maintenance, rehabilitation, and replacement/reconstruction). It has prompted tremendous discussion, debate, and research into what is the most effective and realistic system preservation strategy. It has shifted paradigms and transitioned the organization into one mindful of the value of long-range strategic planning, investing in infrastructure, and the benefits of doing preventive maintenance.

Fifth, MDOT's senior management is well-versed in the principles of asset management. MDOT has been fortunate to have upper managers who have "championed" asset management as a business process. Those directly involved in the Integrated Call for Projects also are well-versed in the program and its results. Other areas of the Department also understand asset management principles. In addition, elected officials such as the governor and key legislators are familiar with asset management and the Department's process. In fact, it was a state law requiring an asset management perspective in transportation investment that was part of the motivation for MDOT to pursue this direction. This understanding by elected officials contributed to the political support that produced an increase in the gas tax for additional transportation investment.

Sixth, MDOT's regional offices and transportation service centers (TSC) are intimately involved with implementing the asset management program. Data from the pavement management and bridge management systems are shared with the regional system managers, who use this data to analyze various strategies and select projects for the Five-Year Transportation Program. The regions and TSCs meet with local agencies within their area to share the strategies and discuss local needs and plans and coordinate programs. The result of this effort is ultimately shared with the State Transportation Commission, legislators, local agencies and others. There is a great deal of vertical integration within MDOT as it relates to asset management.

Finally, MDOT is very much committed to training and educating its own staff and other transportation professionals on the different aspects of asset management. One of the key strategic objectives of MDOT's strategic plan is to "provide training to improve employee understanding of asset management principles and their application to integrated transportation solutions."

With respect to future, MDOT officials identified the following needs:

- Different levels of training on asset management, ranging from short sessions (possibly on the Internet) for people who need a general overview, to more detailed training for those who need or want it.

- Information about any unique, best practices being successfully utilized by other agencies.
- An information technology management tool/system (ITMT) for the development, delivery, and financial monitoring of IT/ITS, and a centralized IT hardware and software inventory system for the forecasting, tracking, monitoring, and analyzing of IT hardware and software items. Both would provide management with the information needed to make quality business decisions, and ultimately, the ability to optimally manage MDOT's IT investment.
- A tool or software that would link the Maintenance Activity Reporting System directly to the other management systems, capture any maintenance activities on our assets, and immediately update the condition of those assets. The use of GPS coordinates or some other numbering system should make capturing that information relatively easy.
- Further research into transition probabilities, including how they are affected when the strategy is modified. For example, when a state implements a significant increase in preventive maintenance on its bridges, how are transition probabilities affected?
- Further research into cost for different types of bridge projects as it relates to improvements made to element-level condition state information, rule making, and discount rate.

For further information, see: http://www.michigan.gov/mdot/0,1607,7-151-9621_15757--,00.html.

2.4 Minnesota Department of Transportation

Context

Minnesota DOT (Mn/DOT) is known nationally for its early commitment to, and continuing efforts at, performance-based planning and programming processes. Such processes focus on agency actions that will achieve specified transportation system performance levels, including meeting asset condition targets. One of the major reasons why Mn/DOT was chosen for this scan was its integration of asset management into this broader performance-based decision-making process. Mn/DOT does not have a separate asset management process or organizational structure dedicated for this purpose.

There are 135,350 miles of public roads in Minnesota. Of this total, Mn/DOT is responsible for 11,869 centerline–miles (about 62 percent is bituminous pavements, 22 percent is bituminous over concrete, and 16 percent concrete pavements). With cold temperatures in the winter, Mn/DOT not only faces significant challenges maintaining good pavement ride quality (due to freeze-thaw cycles), but the public perception of the agency is often directly related to how it performs in removing snow and ice from the road network. Given this important public imperative, and limited funding to add new roads to the State's highway network, Mn/DOT has adopted an operations perspective for enhancing network performance. It is not surprising therefore that Mn/DOT is known as one of the nation's innovators in the application of intelligent transportation systems (ITS) technologies, road pricing, travel demand management strategies, and traffic operations.

Mn/DOT officials identified several important transportation issues facing the State. These included: an aging infrastructure, a continuing debate about truck size and weight allowances, increasing project costs with revenues that do not keep pace with inflation, significant funding constraints, and an increasing tension between preserving the existing system versus expanding network capacity. This latter issue is particularly important to Minnesota given that it is experiencing population growth. To a large extent, very little capacity has been added to the state trunk highway system over the past decade; the growth in road mileage is occurring primarily on the local road network. In addition, an important policy context for transportation investment has been a "no tax increase" policy adopted by the governor's office.

The most recent capital budget for Mn/DOT was $1.625 billion, with Federal monies accounting for approximately 23 percent of this budget.

Investment Decision-Making Process

Mn/DOT's investment decision-making process is driven by performance-based plans and programs. While policy and performance measures and targets are established at the Department level, the investment decision process is largely decentralized, with the eight Mn/DOT regional offices playing a very important role in selecting transportation projects that meet their own regional-level performance targets. The State also has created area transportation partnerships (ATP) consisting of district managers, local government officials, representatives from the business and local communities, and other interested parties. The ATPs play an important role in establishing guidelines and priorities in each area for transportation investment.

Mn/DOT officials have selected system preservation as its most important strategic direction, in their terms, "safeguarding what exists." According to Mn/DOT's most recent strategic plan, this direction means:

- Maintaining the State's physical transportation assets – highways, bridges, airports, water ports, bikeways and freight, bus, rail and intermodal facilities – in sound and safe condition;
- Protecting system performance through effective design, access management, financial support and coordination with local transportation partners;
- Minimizing system downtime due to incidents, construction activities and other disruptions; and
- Safeguarding the security of Minnesota's transportation infrastructure.

The Mn/DOT planning and programming process includes a variety of steps and documents. As noted above, the Department's strategic plan outlines the overall directions for transportation investment. The statewide transportation plan provides more specific directions on how the Department's strategic directions are to be implemented. Thus, for example, under "Safeguard What Exists," the statewide plan identifies three major policies:

1. Preserve essential elements of existing transportation systems;

2. Support land use decisions that preserve mobility and enhance the safety of transportation systems (most measures and targets under this policy are not yet operational; will be revised in future); and

3. Effectively manage the operation of existing transportation systems to provide maximum service to customers.

Each policy has a set of measures and targets that allow Mn/DOT officials to monitor progress over time, and that can be used by the district offices in establishing their policy directions. For the first policy above, for example, a typical measure would be "percent bridge area with structural condition rating of good or better." A corresponding performance target would be, "55 percent of the bridges should be rated good or better by 2023." Mn/DOT also keeps track of performance measures for other modal assets even though they are not responsible of their upkeep. For example, a transit-related performance measure monitored by Mn/DOT is the percent of the transit fleet whose remaining life is within the minimum normal service life (the target is 80 percent). For aviation, the Department monitors the percent of airport runways that meet good and poor pavement condition targets (the current [2006] targets are at least 82.25 percent in good pavement condition and 5.75 percent or less in poor condition).

It was interesting to note that the performance measures were subject to public input in terms of what the public thought was important and what level of performance the public found satisfactory. Field trials, simulations, and videos of roadway conditions and corresponding measures have been used with random samples of Mn/DOT customers to obtain feedback on what was considered most desirable. In fact, Mn/DOT's Office of Investment has two market research experts on staff who provide additional input into Mn/DOT's performance-oriented investment program. In addition, Mn/DOT officials noted that the target values were set with some sense of reasonable expectations reflecting the level of funding that was potentially available. For example, the bridge condition target of 55 percent rated "good or better" was originally 60 percent, but was lowered because Mn/DOT did not feel the level of expected funding was sufficient to reach a 60 percent target value.

Given the important role Mn/DOT's districts have in defining investment programs, Mn/DOT requires that each district prepare a project-specific district plan that shows how its program meets statewide policy directions. The district plan's scope includes discussion of the following: how does the proposed investment program relate to system preservation; transit and freight mobility; interregional mobility; trade center mobility; and safety? The plan covers three time periods: 2008 to 2014, 2015 to 2023, and 2024 to 2030; and investigates two investment scenarios, a level of funding to meet performance targets, and a list of investment priorities for estimated available funding. Mn/DOT allocates Federal funding on the basis of a district's estimated needs to meet system performance targets. Safety funds are allocated based on a measure representing need and safety conditions on the road network. Pavement and bridge preservation needs are fully funded first. Priorities among other performance categories and community improvement projects are determined by the district with input from the area transportation partnerships. If it is on track to meet priority performance targets, up to 10 percent of the district funding can be used for any purpose the district wants to invest in.

"It is far better to be approximately correct, than absolutely wrong."

…Mn/DOT Official

Mn/DOT believes it has one of the most decentralized decision-making structures in the country among state DOTs. A formula distributes Federal funds among the district/area transportation partnership regions. Such an approach has been used since the development of the 1994-1996 state transportation improvement program (STIP), with the formula revised in 2006 to make it more consistent with overall state policies. The formula weights preservation, safety, and mobility as 60/10/30, respectively. The individual factors include: average bridge needs (20 percent), heavy commercial vehicle miles traveled (5 percent), average pavement needs (35 percent), fatal/A-injury crashes (10 percent), congested vehicle miles traveled (15 percent), transit use (5 percent), and future vehicle miles traveled (10 percent). A total of $392 million in Federal funds will be distributed by formula in 2009, of which $47 million is allocated to address inflation in system preservation costs between 2005 when then formula was devised and 2009 when it will be implemented. In addition about $80 million in Federal funds are held back for projects of statewide significance such as statewide corridor projects.

The Mn/DOT central office provides information to the districts in areas that provide some sense of future needs. For example, the Materials Office uses a statewide model to determine the annual investment levels necessary in each planning period to meet ride quality index (RQI) targets by 2014. The Bridge Office has developed an investment tree analysis that shows the annual investment levels needed for each planning period to meet bridge condition targets by 2023.

Once the districts have prepared their four-year area transportation improvement programs, they are reviewed by the central office and adjustments are made by the districts to fit the level of funding available in the STIP. As noted by Mn/DOT officials, a primary result of this process is that district and locally defined priorities for Federal funds go to safety and mobility projects, whereas Mn/DOT's funding contribution goes almost entirely to system preservation. A meeting is held with the district engineers to go over the propose budgets and the likely achievement of performance targets.

Mn/DOT's Office of Investment estimates that $38.1 billion will be needed in the period 2008 to 2030 to meet principal performance targets in the statewide plan for highway infrastructure and Greater Minnesota transit. Approximately 23 percent of this investment would go toward meeting the system preservation strategic policy direction. However, the level of estimated funding available during this period is only $14.2 billion, of which 60.8 percent is allocated for system preservation. In some districts, up to 80 percent of the estimated available funding will go to system preservation. The biggest gap in investment is in road capacity enhancement in the Twin Cities metropolitan area.

One of the more recent applications of the performance-based approach to decision-making has been the development of a highway system operations plan (HSOP), which focuses on maintenance and operations needs. The HSOP provides a consistent approach to defining such needs statewide, and was designed to articulate the needs in face of historical-level funding levels. Table 2.5 shows the linkage between HSOP performance measures and statewide plan policy directions for the preservation category. Service levels are established for each performance category and gaps in performance monitored. Mn/DOT district and functional offices then identify the resources needed to achieve service targets by the 2006-2009 investment period. In order to help meet these targets, Mn/DOT has shifted $13.5 million from state road construction to the HSOP implementation. In addition, Mn/DOT officials pointed to the transfer of $5 million of transportation dollars to enforcement and education strategies (part of the Strategic Highway Safety Plan (SHSP) process) as an example of how flexible the operations planning process can be in the Department.

Table 2.5 Minnesota DOT's Highway System Operations Plan Linkage to Statewide Plan Strategic Directions

Strategic Direction 1 "Safeguarding What Exists"	
Statewide Plan Policies	**HSOP Performance Categories and Measures**
Preservation Preserve Essential Elements of Existing Transportation Systems	Infrastructure Maintenance and Preservation: 1. Bridge preventive maintenance; 2. Pavement preventive maintenance; 3. Pavement patching; and 4. Signal and lighting maintenance. Supporting Infrastructure Management: 1. Building functional adequacy; 2. Fleet management life-cycle utilization; 3. Building maintenance; 4. Electronic communication coverage; 5. Electronic communications management; and 6. IT infrastructure preservation.

Mn/DOT is including public opinion in developing the HSOP performance measures. An omnibus survey that Mn/DOT conducts annually includes questions relating to maintenance services and asset condition. Public perception of ride quality was the one major measure that was below the target level. Mn/DOT currently has a study underway to better define public tradeoffs among different asset condition measures.

Mn/DOT estimates that the benefit-to-cost ratio for HSOP investments will be quite high. Highway infrastructure maintenance (not only bridges) is an area that has been consistently highlighted by public opinion as being one of the most important priorities for investment. The overall bridge preventive maintenance benefit/cost ratio is estimated to be 4.0 to 1. Similar ratios for preventive maintenance strategies include:

- **Crack Sealing –** 7.9 to 1
- **Poured Joint Repair –** 3.8 to 1
- **Strip Seal Repair –** 2.8 to 1
- **Flushing –** Extends life 10 to 15 years
- **Deck Sealing –** 1.3 to 1
- **Rail Sealing –** 2.9 to 1
- **Partial Painting –** 2.2 to 1

These prospective ratios helped "sell" the HSOP to both the legislature and internally to the Department. Preventive maintenance measures, baseline status, and targets have been defined as follows:

	Percent Good Condition	**Target**
• Strip seal repairs	91%	96%
• Poured joint repairs	74%	88%
• Crack sealing	49%	80%
	Frequency	
• Deck sealing	10 years	90%
• Rail sealing	10 years	90%
• Flushing	1 year	100%

The planning period for the HSOP plan is four years, but districts only receive two biennial years' budget. As noted by Mn/DOT officials, they are in a "learning mode" with respect to using the HSOP process for improving asset preservation – and one of the most important needs is to develop better ways of determining the benefits from HSOP investment. An annual report on HSOP achievement with these targets is presented to Mn/DOT management.

Asset Management Approach

Minnesota does not have any legislative mandate to use asset management principles as part of the planning or programming processes. However, Mn/DOT officials did consider asset management as best practice with respect to agency decision-making, and in the early 1990s undertook a systematic effort to examine how asset management could be integrated into the agency's decision-making framework.

"Asset management needs to be data-driven, but not data dependent."

…Mn/DOT Official

Mn/DOT officials based their early asset management efforts on the AASHTO *Asset Management Self Assessment Guide,* which allowed them to identify the components of the agency's planning and decision-making processes that needed to evolve to reflect an asset management perspective. To a large extent, these early efforts focused on incorporating asset management-focused performance measures into the ongoing performance-based decision-making process in Mn/DOT.

The performance-based approach adopted by Mn/DOT has provided a very important platform for Mn/DOT officials to foster greater attention to the State's transportation asset management needs. Such capability has provided the legislature with clear and consistent definitions of "need" and of the Department's priorities. The approach has provided a strong justification for adopting system preservation as the top priority for investment, and has helped focus limited resources on key performance issues. As noted by Mn/DOT officials, performance-based planning shifted the debate in the legislature away from what the Department was going to build to how the State was going to pay for it. In the absence of performance measures, the decisions tended to be based on design considerations. The asset management process was viewed as an important means of articulating revenue needs to the legislature, as well as providing DOT management with a tool for better managing the limited amount of funding available for system investment.

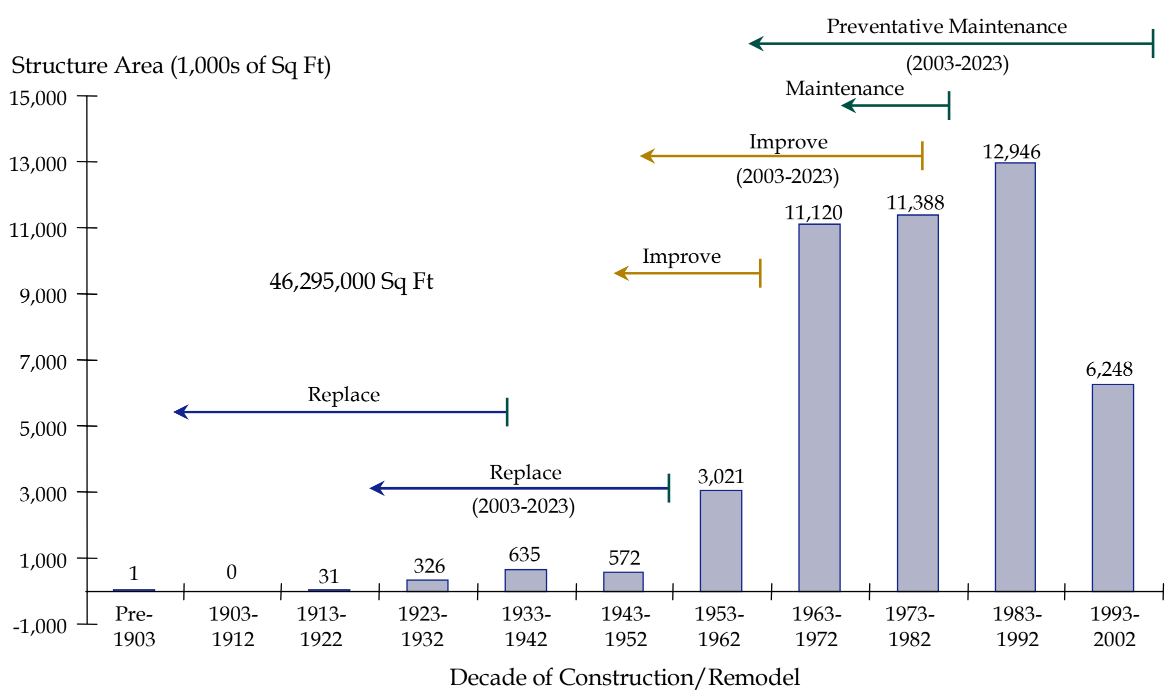
Asset preservation measures are reported on Mn/DOT's department scorecard, which provides top management and key stakeholders with some indication of the progress being made in meeting overall performance targets. Table 2.6 shows the performance targets for pavement condition ratings and remaining service life. As seen in this table, the asset management approach adopted by Mn/DOT is to establish targets at both the high end (the good or very good categories) and at the low end (the poor or very poor categories). Mn/DOT also has a good sense of the challenges that the agency faces (or will soon face) due to historical investment and maintenance decisions. For example, the age distribution of Minnesota's bridges represents a particularly important challenge (see Figure 2.6). Bridges are being replaced today that were built before 1940.

Table 2.6 Pavement Performance Targets, Minnesota
Ride Quality Index[a]

Functional Group	RQI (Ride Quality Index) Categories: Good/Very Good	RQI (Ride Quality Index) Categories: Poor/Very Poor
Principal Arterial	70% or More	2% or Less
Non-Principal Arterial	65% or More	3% or Less
Functional Group	**Remaining Service Life: RSL of 12 years or more**	**Remaining Service Life: RSL of 3 years or less**
Principal Arterial	50% or More	10% or Less
Non-Principal Arterial	40% or More	25% or Less

[a] Mn/DOT's name for PSR (Present Serviceability Rating.)

Figure 2.6 Age Distribution of Bridges, Minnesota



Improvement projects are being scheduled for those built in the 1950s and 1960s. And because very little preventive maintenance was done prior to 2005, bridges were not really maintained until they were about 25 years old, thus creating even more of a challenge for bridges built in the 1970s and 1980s.

Looking ahead 20 years, there will clearly be an increase in bridge replacement needs, and a greater need for bridge improvement projects. In order to reduce the impact of this big jump in bridge investment, Mn/DOT has begun a preventive maintenance program that begins at the time of construction and continues until major improvements need to be scheduled.

Mn/DOT also obtains information on the condition of other multimodal assets in the State, for example, through its performance-based freight and aviation plans.

This information is primarily considered as part of the general knowledge base for transportation in Minnesota, and also is used to support decision-making within the agency. Examples include pass-through and grant funds for transit buses, airport improvement grants, railroad crossing improvements.

"You need quality data to support decision-making,
and if you need this data, you have to invest in it."

…Mn/DOT Official

Management and Data Systems

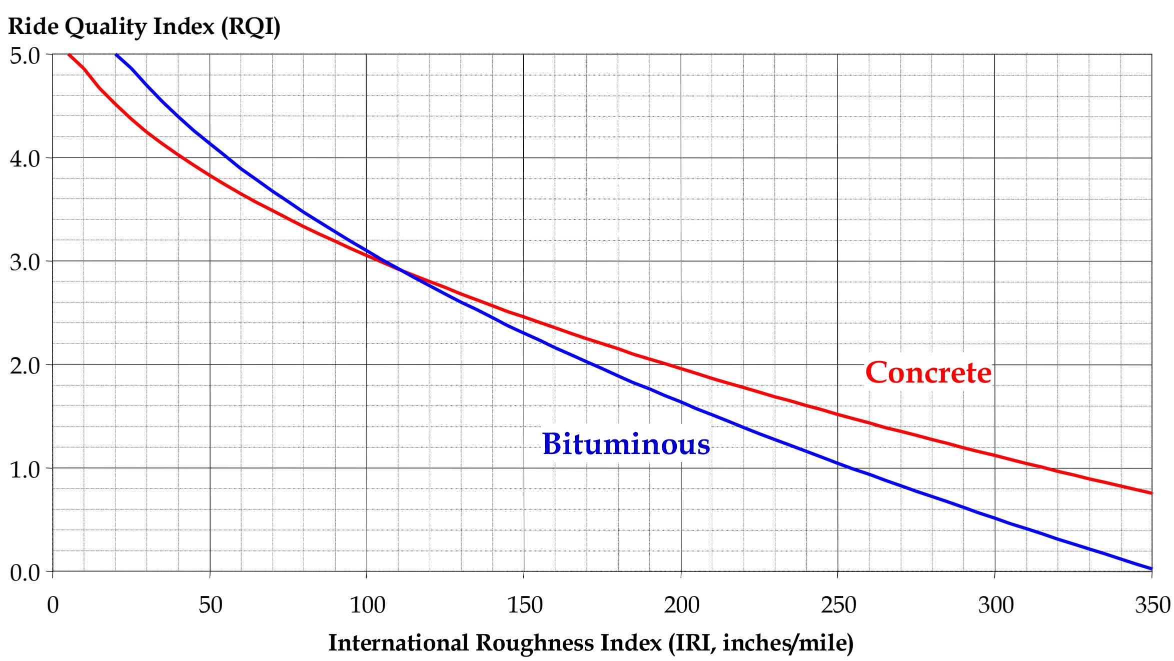
Mn/DOT's transportation information system (TIS) is the central repository for data on the public road network in the State (just over 112,000 routes). The data are updated via construction plans and from annual input from Mn/DOT data collection activities and those of its local partners. The TIS consists of subsystems that relate to different elements of the road network and that feed into the TIS when information is sought. The subsystems include data on bridge conditions, pavement management, roadway history, traffic, crashes, intersections, and rail grade-crossings. TIS data are used by Mn/DOT asset management systems, such as the pavement management system, and contribute to Federal and internal reports. With respect to pavement management, the following data and data collection strategies are used to keep this TIS subsystem current.

- Roughness and Rutting:
  - Collected annually on all trunk highways;
  - Collected annually on one-quarter of the county state aid system;
  - Roads are driven in both directions;
  - Data stored on a mile-by-mile basis; and
  - Outer lane is measured, left and right wheel path.

- Cracking and Faulting:
  - About 60 percent of the system is rated annually;
  - One-fourth of the county state aid highway (CSAH) system rated annually;
  - First 500 feet of each mile is surveyed (10 percent); and
  - Only one direction is surveyed on two-lane roads.
- Digital Images (right-of-way and pavement):
  - Collected annually on all trunk highways and one-quarter of CSAHs.

Mn/DOT uses several performance measures in its pavement management system. A ride quality index (RQI) is a measure of pavement smoothness as perceived by the users of the road system. A ranking from 0 to 5 is assigned to a road segment based on a curve that relates the RQI to the International Roughness Index (IRI) (see Figure 2.7). Mn/DOT also collects data on pavement cracking and rates each segment with a surface rating (SR) as determined via video images (75 million images were collected in 2005). The surface rating ranges from 0 (many defects) to 4 (no defects). Two Mn/DOT employees rate the entire state road system each year.

Figure 2.7 Converting IRI to RQI, Minnesota



From these two data items, a pavement quality index (PQI) is calculated as the square root of the product of the RQI and SR. Given the range associated with the RQI and SR measures, the PQI can range from 0 to 4.47.

$$PQI = \sqrt{(RQI)(SR)}$$

These three indices are used to identify prospective pavement projects.

Mn/DOT's pavement management software extracts data from the TIS and relates future pavement condition to three pavement performance measures: the RQI; remaining service life (RSL), defined as the estimated time in years until the RQI reaches a value of 2.5, which is considered by Mn/DOT to be the end of a pavement's useful life; and preventive maintenance needs.

The bridge data management system used prior to 2002 was a Mn/DOT-developed program that was used to determine bridge investment strategies. In 2001, Mn/DOT switched to Pontis, which is used primarily for inventory and inspection data. Pontis is used to estimate bridge conditions three to four years in the future based on the bridge projects that are listed in the state transportation improvement program (STIP). Mn/DOT expects to have the Pontis planning module fully operational by 2007. Mn/DOT measures the condition of culverts 20 feet or longer, which are considered bridges, but not for those less than 20 feet in length. For a National Bridge Inventory condition rating of 4.0 or less for deck, superstructure, substructure or culvert items, inspections are conducted annually; otherwise, bridges are inspected every two years. Approximately 20 percent of bridge inspections are audited annually.

"If you don't have a plan, someone will give you one."

…Mn/DOT Official

Mn/DOT has extensive data on traffic operations conditions – incident clearance, travel time, ramp meter wait times, percent system coverage, and many other elements. Mn/DOT also tracks the age, location, and repair history of all fixed and mobile communications assets. Mn/DOT tracks the condition of its fleet and reports quarterly to districts and senior staff on progress toward four fleet condition and maintenance targets. Mn/DOT produces an annual report on the condition of all of its physical facilities (buildings) and uses this information as the basis for investment decisions and proposals to the legislature. Mn/DOT is in the process of implementing asset condition monitoring system for IT assets – computers, network servers, etc.

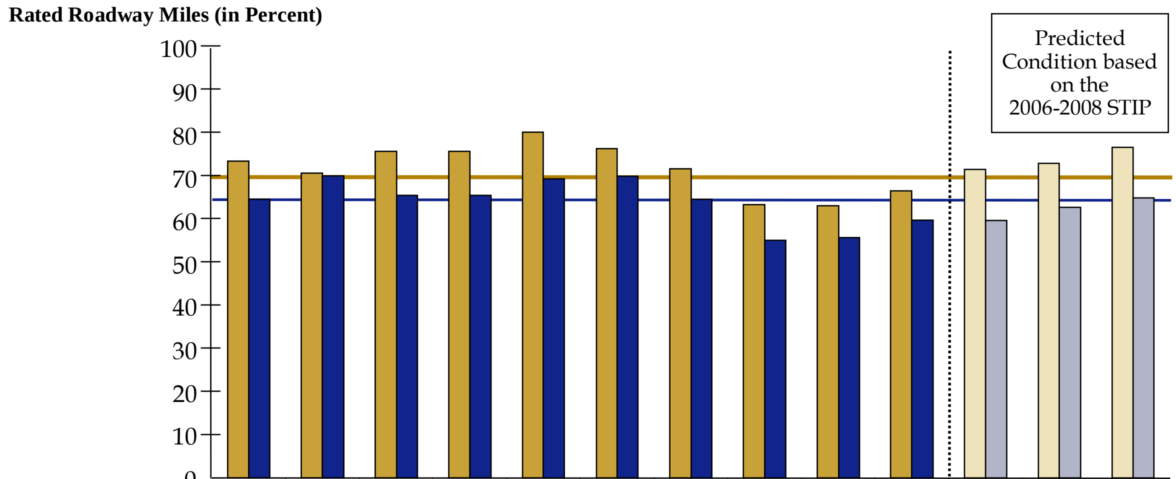
Mn/DOT officials noted two important characteristics of the agency's data collection and data base management strategy. First, local partner agencies have access to the database. The Mn/DOT State Aid Division led an effort to purchase a pavement data collection van for use in monitoring county roads; Mn/DOT's Materials Office is using it to collect and process pavement data for the State's 87 counties. The State Aid Division also pays the operating cost for monitoring county state aid roads on a four-year cycle. Second, because of the importance of performance measures in agency decision-making, these same performance measures have caused Mn/DOT to be more strategic about the data being collected for agency decision-making.

Results of the System Preservation Strategy

Mn/DOT is nearing its performance targets for bridges, but has been losing ground for pavements (more specifically, it is having difficulty stemming the increases in "poor" pavement). Figures 2.8 and 2.9 show the values for the RQI and RSL over the last 10 years, as well as the projected values over the next three-year STIP time horizon. The level of "good" or above ride quality has increased slightly since 2003 when new bond revenues were available to invest in the State's road system. However, the level of "poor" or worse has steadily increased for non-principal arterial roads and remained stable for arterial roads. The extent of "poor or worse" roads is expected to increase over the next three years (with the explanation from Mn/DOT that this expected trend is a result of investment not concentrating on roads with really bad pavement conditions). Similarly, the decline in the number of good bridges was reversed about three years ago with additional bond funding provided by the legislature for expansion projects that resulted in the replacement of aging trunk highway bridges. These bond funds were a factor in reversing this trend, but not the sole factor for bridge and pavement improvements. Another factor was a one-time infusion of state general fund revenues for projects let from about 2000 to 2002 and completed by 2003.

Figure 2.8 Monitoring of Pavement Ride Quality, Minnesota

"Good" Ride Quality Index (Miles with a RQI greater than 3.0) Statewide Data

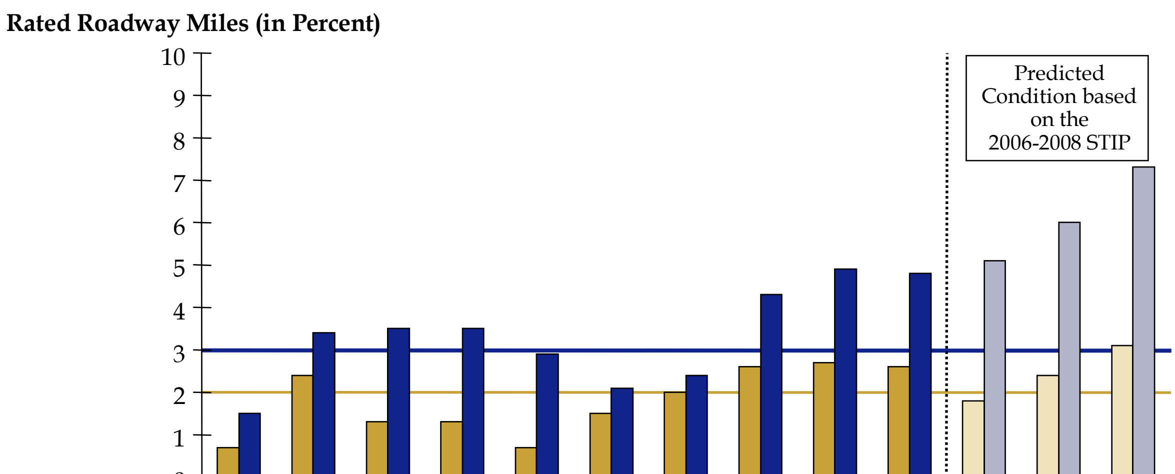


	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Principal Art.	73.8%	71.0%	76.1%	76.1%	80.5%	76.7%	72.0%	63.6%	63.4%	66.8%	71.8%	73.2%	77.0%
Non-Principal Art.	64.9%	70.4%	65.8%	65.8%	69.7%	70.3%	64.8%	55.3%	55.9%	60.1%	60.0%	63.0%	65.2%

Year

Principal Arterial Target = 70 percent or more
Non-Principal Arterial Target = 65 percent or more

"Poor" Ride Quality Index (Miles with a RQI 2.0 or less) Statewide Data



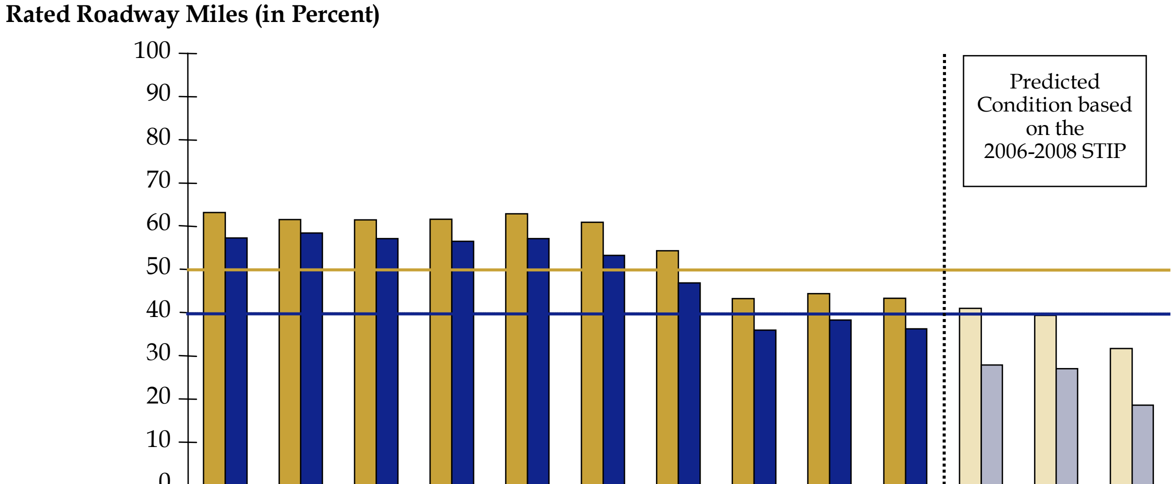
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Principal Art.	0.7%	2.4%	1.3%	1.3%	0.7%	1.5%	2.0%	2.6%	2.7%	2.6%	1.8%	2.4%	3.1%
Non-Principal Art.	1.5%	3.4%	3.5%	3.5%	2.9%	2.1%	2.4%	4.3%	4.9%	4.8%	5.1%	6.0%	7.3%

Year

Principal Arterial Target = 2 percent or less
Non-Principal Arterial Target = 3 percent or less

Figure 2.9 Monitoring of Pavement Remaining Service Life, Minnesota

Statewide "High" Remaining Service Life (Remaining Service Life of 12 Years or More) 1996-2005

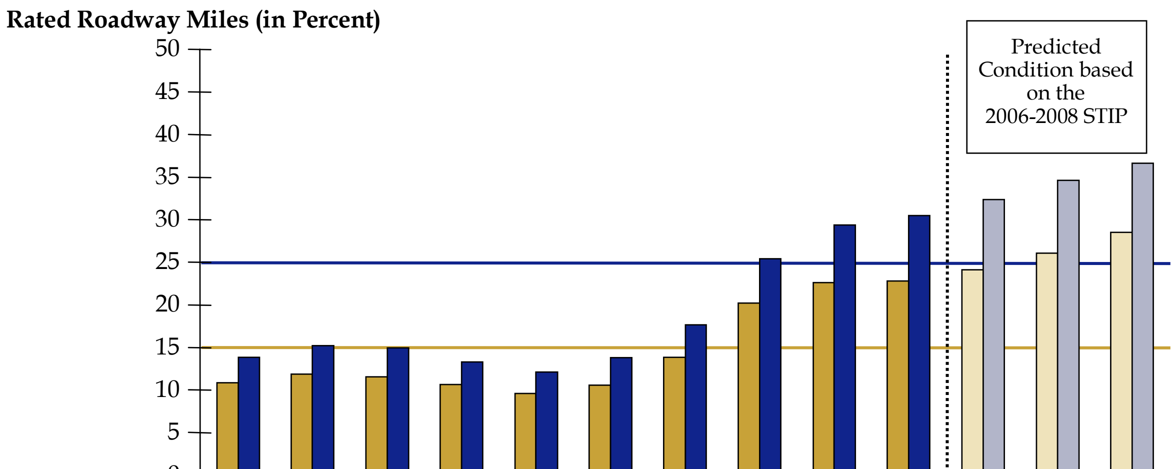


	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Principal Art.	63.1%	61.6%	61.5%	61.6%	62.9%	60.9%	54.3%	43.2%	44.4%	43.3%	41.0%	39.3%	31.7%
Non-Principal Art.	57.2%	58.4%	57.1%	56.5%	57.1%	53.2%	46.8%	36.0%	38.2%	36.1%	27.8%	26.9%	18.5%

Year

Principal Arterial Target = 50 percent or more
Non-Principal Arterial Target = 40 percent or more

Statewide "Low" Remaining Service Life (Remaining Serivce Life of 3 Years or Less) 1996-2005



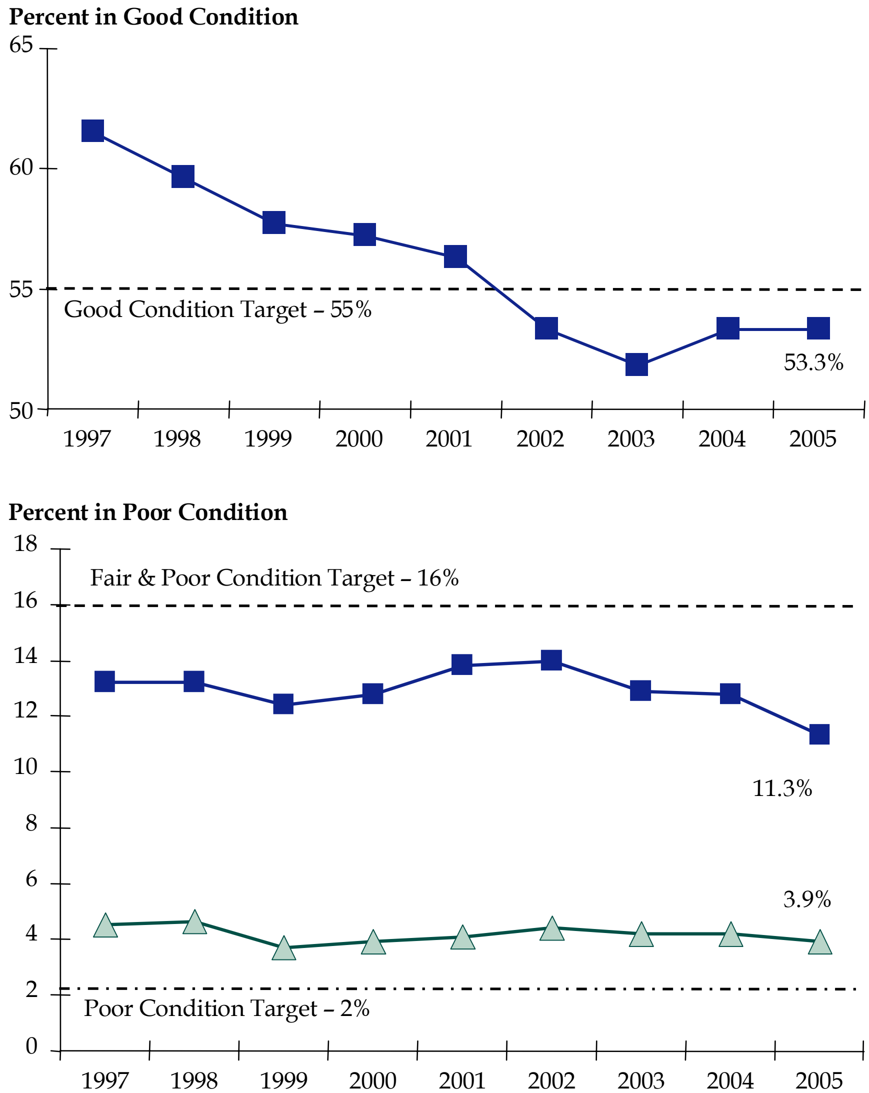
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Principal Art.	10.9%	11.9%	11.5%	10.6%	9.6%	10.6%	13.8%	20.2%	22.6%	22.8%	24.1%	26.0%	28.5%
Non-Principal Art.	13.8%	15.2%	14.9%	13.2%	12.1%	13.8%	17.6%	25.4%	29.4%	30.5%	32.4%	34.6%	36.6%

Year

Principal Arterial Target = 15 percent or less
Non-Principal Arterial Target = 25 percent or less

The number of "poor" bridges continues to hold its own at about four percent and the number of "fair" and "poor" bridges has fluctuated, but has been going down for the last couple of years, again due to the increased highway spending available in these years (see Figure 2.10).

Figure 2.10 Monitoring of Bridge Condition, Minnesota



Reporting Trends: Bridge Condition

Trunk Highway Principal Arterial Bridges (20 and Over).

Structural Condition Performance Target (Percentage by Area).

Principal Arterial = 85% of TH Bridge Area January 2006.

Mn/DOT also has used its management systems to conduct scenario analyses, with the two major scenarios being, 1) given a budget, what pavement conditions can be expected? and 2) how much funding is required to achieve a desired pavement condition level? This scenario analysis exercise estimated that $286 million was needed annually for pavement needs if the pavement performance targets were to be met by 2014.

For bridges, the bridge office prepared a template that identified typical replacement/ rehabilitation strategies based on when a bridge was built, current bridge condition, the average daily traffic using the bridge and the types of treatments the bridge has received since 1980. This template was used to determine the expected bridge investment needs for the 2007 to 2030 timeframe. This analysis resulted in the following projected budget needs compared to the historical funding levels over the past 15 years.

Projected	Compared to the Past 15 Years
Bridge Replacements – $53 million/year	158%
Bridge Decks – $14.8 million/year	190%
Bridge Painting – $9 million/year	260%
Total Estimate – $77+ million/year	173%

During the last couple of years, Mn/DOT has analyzed the gap in spending between the actual amount of bridge preservation projects programmed and the needs identified in the district plans. A similar exercise was done to estimate the cost of a statewide preventive maintenance program. This latter effort resulted in an estimated $1 million that was needed each year to repair bridge joints, about $2.4 million to seal bridge cracks and decks, and about $1.4 million needed to annually flush bridge decks, joints and drains. This totaled approximately $4.7 million per year (funds were shifted from the capital investment program to provide $3.6 million of this estimated need).

Lessons Learned

Mn/DOT officials felt very strongly that the use of a performance management approach to investment decision-making and its linkage to an asset management process shifted the focus of debate on transportation resources both inside the agency and among key stakeholders. The debate no longer was one of which particular projects should be part of the State's investment program, but rather how will the performance targets be reached? As noted by a Mn/DOT official, when performance targets are set, funding can usually be justified.

Mn/DOT officials also noted that asset management 1) allows better decisions to be made because it conveys the consequences of making these decisions (or not), 2) establishes as policy framework for decisions, 3) answers the question of "how do we know what will likely happen?” 4) improves internal decision-making by providing clear priorities, and 5) helps with external communications by showing what you can “buy” for additional funding.

Other observations of note from the Minnesota case:

1. Asset management is part of a broader comprehensive performance planning and investment management system. Accordingly, the success of this broader decision-making system has led directly to a successful asset management process. The approach has enhanced the understanding of system performance trends, and provided input into issues identified by the legislature, transportation partners, and the general public. The performance-based approach has enhanced Mn/DOT’s internal capacity to analyze and understand tradeoffs for decision-making, and has increased the transparency of investment decisions and the sense of fairness associated with investment decisions.

2. Mn/DOT’s district offices play a very important role in establishing investment priorities for the State’s road network. Mn/DOT’s headquarters office establishes the performance targets for the districts and allows them to determine the best way of meeting these targets. Mn/DOT officials felt that decentralizing the performance-based investment process to the districts has helped institutionalize the process within the Department. Providing incentives to the districts to meet their performance goals has turned out to be an important way of motivating desired investments (in Minnesota, districts that achieve their targets have access to a statewide funding pool for corridor projects). Mn/DOT also has found that peer pressure among the district directors is another motivating factor.

3. A consensus among top managers on the appropriate performance targets and on which measures are more important than others is critical to the overall success of the decision-making approach. This is especially true when a change in administration occurs. When such a change occurred in Minnesota, Mn/DOT officials met with the new administration early on and explained the concept of performance-based management. The new administration adopted approximately 95 percent of the plan.

4. Some performance measures drive investment decisions, while others are reported on, but really have no influence on how the agency spends its dollars. The most important measures and targets have to line up with the priorities of the agency – this leads to action. Some of these actions might not be investment-oriented. For example, Mn/DOT officials noted that one of the strategies that is receiving more attention by the Department is access management, which is viewed as an important opportunity to preserve a road’s capacity to handle traffic. Another interesting aspect of the use of performance measures in Mn/DOT is its focus at both the high end targets (e.g., some percent should be “good” or better) and at the low end (e.g., the percent roads in “poor” or worse condition should not be greater than some threshold).

5. The Highway Systems Operations Plan (HSOP) is an interesting application of a systems approach to better managing system operations. In many ways, the HSOP is a model of how such a plan can be used to provide the most cost-effective strategies for

operating a State's road system. The integration of preventive maintenance strategies in this plan illustrates how asset management should be included as part of an operations strategy.

6. Finally, Mn/DOT officials emphasized the need to have a broader definition of an agency asset. For example, as mentioned earlier, data were viewed as an asset and the resources dedicated to data collection and data base management were viewed as an investment in this asset. In addition, Mn/DOT is facing a serious loss of senior managers through retirements. As noted by a high-ranking Mn/DOT official, perhaps the ultimate asset in an agency like Mn/DOT is the human resource.

Mn/DOT officials identified several future needs for asset management that relate to possible research or to governmental action. First, it is important that forecasting capability be available for all performance areas, not just pavement and bridge conditions. This would include ITS, traffic signals, culverts, and the many other assets that are the responsibility of a state DOT. Second, better measures and approaches are needed to compare the relative advantages between capital and operating investments. Third, risk-based estimating and the identification of a range of costs associated with failure is needed in U.S. practice. Finally, Mn/DOT officials felt that the U.S. DOT could provide stronger support for the use of a systemwide performance management approach in state DOT investment decision-making.

For further information, see: http://www.oim.dot.state.mn.us/StatePlan/index.html.

2.5 Ohio Department of Transportation

Context

The Ohio DOT (ODOT) has one of the most integrated approaches to asset management of any state DOT in the United States. Indeed, as noted by the ODOT officials participating in the panel visit, one will not find an asset management handbook, nor an asset management unit or manager in the Department. Asset management is considered a core value and function of the organization.

The state highway network is divided into three policy systems: priority (interstate and four-lane divided highways), urban (state highways within municipalities), and general (primarily two-lane highways across the State). At 12,417 lane-miles, the priority system accounts for 26 percent of the State's lane mileage, handles 57 percent of the State's total vehicle traffic and 75 percent of the total truck traffic. The urban systems consist of 5,964 lane-miles of state highway in urban areas, and the general system consists of 30,256 lane-miles of two-lane highways. Ohio has the fourth largest interstate road mileage, the second largest number of bridges, and the fifth largest road volume of all the states. ODOT owns 15,098 bridges, slightly more than one-third of Ohio's 43,898 bridges. These bridges tend to be the larger and more expensive bridges in the State, accounting for more than 72 percent of the total bridge deck area in the State.

To be effective, asset management should be:

- *Linked to budgeting;*
- *Linked to employee assessments;*
- *Linked to project selection;*
- *Implemented within a guiding policy framework; and*
- *Linked to performance measures that are used actively.*

…Ohio DOT

ODOT has divided the State into 12 districts each having from seven to eight county maintenance yards. Maintenance on the State's road network is provided by ODOT forces.

Although the current condition of Ohio's priority road network is in very good condition, this was not always the case. In the 1980s, the State had a significant number of deficient bridges, which resulted in a legislative program to repair and replace bridges According to the *ODOT Business Plan*, *2006* and *2007*, as recently as 1997, 20 percent of the State's freeways had a pavement condition rating of less than 65 out of 100. Beginning in the late 1990s, ODOT began the process of turning around this alarming condition of the priority road network through an integrated and comprehensive implementation of asset management principles.

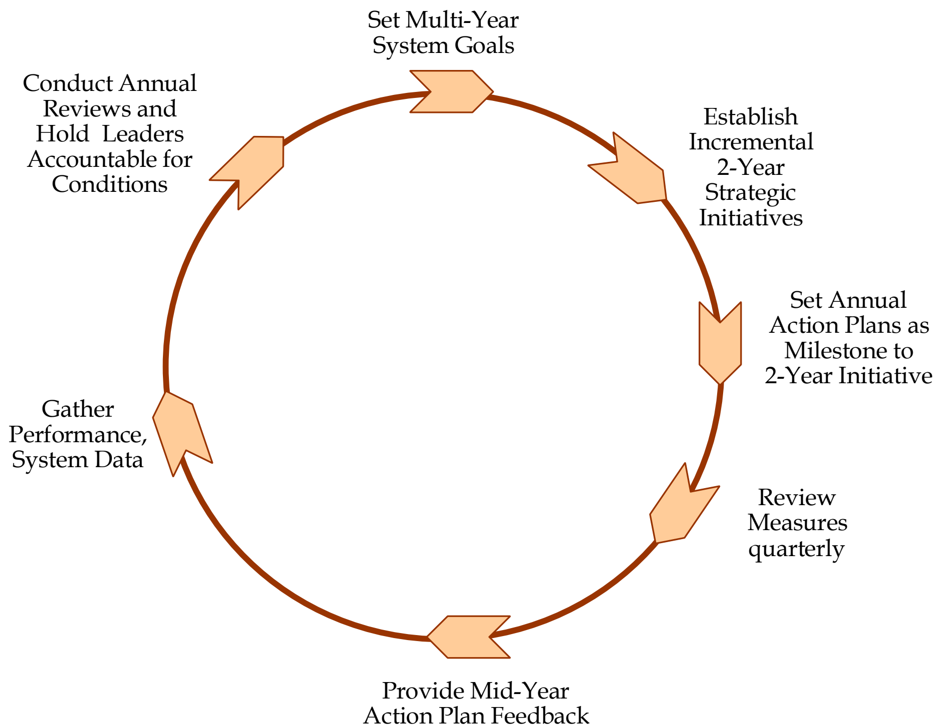
Investment Decision-Making Process

ODOT decisions are guided by a set of principles and strategic goals that link to performance measures that are found at all levels of organizational decision-making. At the strategic decision-making level, ODOT has adopted goals in five strategic areas: transportation safety, economic development and quality of life; efficient and reliable traffic flow; system preservation; and resource management.

The system preservation goal is defined as achieving a steady state condition for pavement and bridges, that is, "a state of relatively low and stable level of deficiencies, small enough that a predictable rate of preventive maintenance and regular repairs can sustain that level of acceptable conditions." ODOT spends approximately $750 million per year on system preservation activities.

Figure 2.11 shows the general flow of planning and decision-making in ODOT as it relates to the system preservation goal. Every 2 years, ODOT management updates the system goals and develops a new 10-year system preservation plan. Two-year strategic initiatives are established that outlines what activities in the short term are needed to achieve the 10-year goals. Annual action plans for all ODOT units, headquarters and districts, are produced that specify expectations in terms of performance achievement. Quarterly and midyear meetings are held to provide feedback on how well ODOT units are doing in achieving their action plan. System condition data are collected to assess the change in road and bridge condition as compared to the previous year's assessment. The degree to which managers and other employees have achieved their performance targets is strongly considered in the employees' annual evaluations. No raises have been given in cases where performance measures were not met.

Figure 2.11 Asset Management Decision-Making, Ohio DOT



The districts' budgets are driven by the condition of the assets for which they are responsible. Annual monitoring of the road and bridge condition (from the central office) assures that the reported condition information reflects actual conditions. Bridges that score a "4" or less on the bridge rating scheme are reinspected by the central office to confirm that they are indeed in such poor condition.

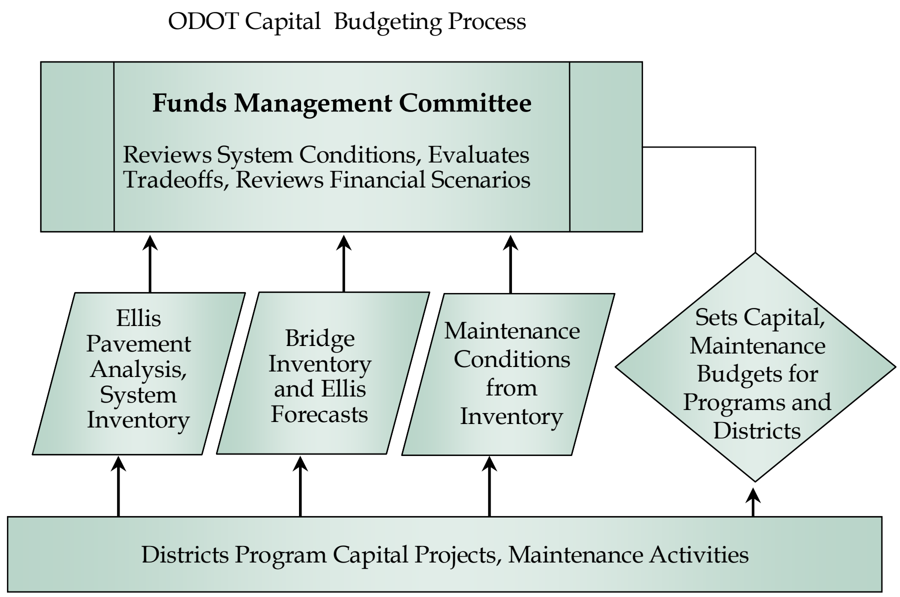
"Asset management tied to performance measures catalyzes action, helps define goals, prioritizes action, and aligns efforts."

…Gordon Proctor, Director, Ohio DOT

A funds management committee decides the relative distribution of budget to the districts (see Figure 2.12). Expected trends of pavement condition in each of the districts provide the basis for changes in district preservation budgets. Districts are given lump sums and four years to produce changes in condition measures.

With respect to capacity projects, a nine-member council called the Transportation Review Advisory Council (TRAC), established at the request of ODOT in 1997, sets policies and criteria for choosing such projects. Numerical ratings are assigned to proposed projects, with 70 percent of the base score going to transportation efficiency and effectiveness factors, and 30 percent going to economic development factors. MPOs have their own prioritization approach toward dollars in their regions, although state project ratings do reflect whether the project is in an MPO's plan.

Figure 2.12 Funds Management Committee Process in Ohio DOT



The investment program for ODOT does not assume more money from the legislature. In fact, capacity dollars are often reduced to put more money into preservation. However, due to a good understanding of the network's current and future condition that has been provided by ODOT, and of the money needed to keep this condition at a certain level, the legislature has provided additional dollars for capacity projects. The latest capital investment program is the Jobs and Progress Plan, which has provided $5 billion over 10 years for new road projects.

Asset Management Approach

Condition and performance measures are integrated within all departmental functions, and are not really identified as asset management measures as such. The pavement on the priority road network is evaluated annually using a 100-point Pavement Condition Rating (PCR). Priority system pavements are deficient when the PCR is below 65 points. Urban and general system pavements are deficient when the PCR is less than 55 points. The Office of Pavements in ODOT's Planning Office is responsible for collecting the data on pavement condition.

"You first have to master system conditions before you can develop a sustained capital budget."

…Ohio DOT Manager

Annual bridge inspections also are conducted on the basis of four categories:

1. **General Appraisal –** A composite measure of the major structural items of a bridge, such as piers and abutments. Bridges are considered deficient when this rating drops to 4 or below on a scale of 0 to 9 (the higher the number the better).

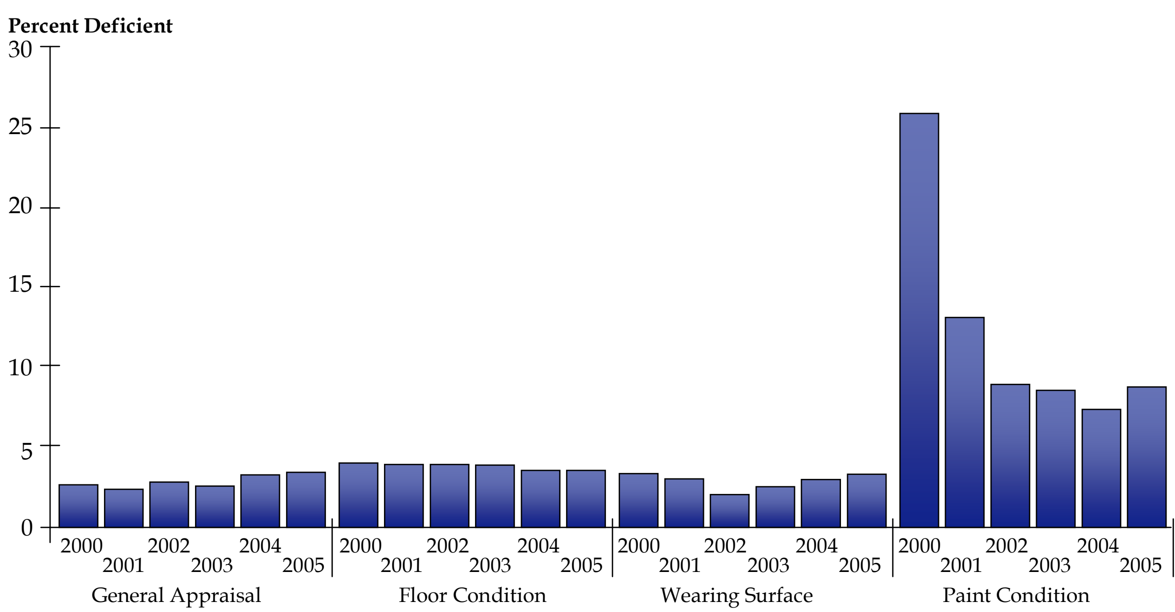
2. **Deck Conditions –** Ratings measure the major horizontal structural element which carries the riding surface. Bridges are deemed deficient when the deck rating is 3 or 4 on a scale of 1 to 4 (the lower the number the better).

3. **Wearing Surface –** Ratings measure the driving surface of a bridge. Bridges are considered deficient when the wearing surface is evaluated at 3 or 4 on a scale of 1 to 4 (the lower the number the better).

4. **Paint Conditions –** Ratings measure the corrosion protection applied to the structural steel. Bridges are deemed deficient when they are evaluated at 3 or 4 on a scale of 1 to 4 (the lower the number the better).

The state and district data are shared among the district directors so that they can see how the districts compare to one another. Previously, districts did not have a good sense of how they compared to other districts and, in some cases, the data showed wide ranges in pavement and bridge conditions, even for adjacent districts. The overall policy framework makes sure that everyone is shooting for the same quality levels. Figure 2.13 is an example of the type of bridge condition data that are monitored by district.

Figure 2.13 Example Bridge Condition Data Collected for Ohio DOT Districts



Overall condition targets have been established for the different road systems. Table 2.7 shows the District pavement and bridge condition target values for the current year as well for FY 2008. The urban system pavement condition rating has fluctuated between 94 percent and 97 percent acceptable from 1997 to today, with the current rating at 96 percent acceptable. From 1998 to 2002, the priority system conditions rose steadily, reaching a high of 97 percent acceptable in FY 2002. The priority system currently stands at 95 percent acceptable, well above the FY 2006 goal of 90.5 percent acceptable.

Table 2.7 Ohio DOT District Pavement and Bridge Condition Goals

	District Pavement Goals	
System	**FY 2006**	**FY 2008**
Priority ≥ 65 PCR	90.5%	90%
General ≥ 55 PCR	91.5%	90%
Urban ≥ 55 PCR	92.0%	90%
	District Bridge Goals	
General Appraisal	95.5%	96.0%
Floor Condition	94.5%	95.0%
Wearing Surface	96.5%	96.0%
Paint Condition	88.0%	89.0%

ODOT uses a "mix of fixes" to provide as close to a steady state in condition as possible. The type of analysis that follows this approach examines such questions as, "How much investment is necessary to keep performance of two-lane roads at a specific level of performance?" With respect to pavement condition, the overall condition target is 90 percent of the system at a specified performance level or better. The setting of this target value was fairly arbitrary, but it did relate to a sense of what a satisfactory ride quality might be and what the ODOT could afford.

ODOT officials stated that they are not going to develop deterioration models of appurtenances such as guard rails because the condition of such assets is too unreliable in terms of day-to-day operations. For example, crashes into guard rails are unpredictable, but could have an important impact on a condition rating.

With respect to road maintenance, ODOT collects inspection data on eight characteristics of the condition of road maintenance and summarize the data at the system and district levels. These eight characteristics include:

1. **Drainage Obstruction –** Deficiencies are recorded for any ditch where 50 percent of the cross section is obstructed and includes damaged or obstructed pipes that cause water pooling on the pavement.

2. **Guardrail –** Deficiencies are recorded for damaged or deteriorated guardrail, anchor assembly, bridge anchor assembly, or impact attenuator, which does not properly function as a safety barrier.

3. **Litter –** Deficiencies are recorded for any 1/10th of a mile segment where litter exceeds 10 items.

4. **Pavement Marking –** Deficiencies are recorded for missing or faded pavement striping, lane-dividing lines, no passing areas, pavement edge lines, crosswalks, turn lanes and school zones

5. **Pavement Deficiency –** Deficiencies are recorded for the deterioration (ruts and pot-holes), obstruction bleeding of pavement and excessive crack sealing that is dangerous to motorists.

6. **Pavement Drop-Off –** Deficiencies are recorded for drop offs between the pavement and shoulder exceeding two-inches deep and six-feet long.

7. **Sign Deficiencies –** Are recorded for deteriorated signs. This includes loss of message, damaged or twisted posts or supports, loss of reflectivity preventing clear visual comprehension, missing delineators and unnecessary or obsolete signs that confuse motorists.

8. **Vegetation Obstruction –** Deficiencies are recorded for vegetation obscuring signage, sight distance, and guardrail.

Table 2.8 shows a summary of how the maintenance deficiency data are presented to ODOT management. Note that goals are established for each of the eight maintenance deficiency factors by both ODOT's priority road system and the general road system.

The maintenance deficiency data are collected via a 100 percent road inspection with the data collection crew inputting the visual inspection data using a laptop computer. Figure 2.14 shows the typical touch screen that is used to input data as the inspection crew travels the road network. The location of the assets monitored by the touch screen is tied to GPS to ensure accurate location of identified deficiencies. Similar in the use of pavement and bridge condition data, additional funds are added to district budgets to reduce maintenance deficiencies. These additional funds then translate into a work plan for the county maintenance yards.

Table 2.9 shows a typical maintenance yard work program that identifies the current scores for each maintenance deficiency, the number of deficiencies in that maintenance yard's service area, the overall goal for the service area, and the difference that currently exists in the maintenance yard meeting the goal. For example, Table 2.9 shows that this maintenance yard can have 126 guardrail segments in deficient condition and still meet its goal. The different time periods in the table are simply measuring deficiencies every quarter.

Table 2.8 Summary of Maintenance Deficiencies on Ohio's Roads

OPI Measures	FY 2001	FY 2002	FY 2003	FY 2004	FY 2006-2007 Goal	FY 2005 to Date[a]	FY 2005 Goal to Date[a]
Priority System Deficiencies							
Drainage Obstruction	226	245	377	45	645	42	461
Guardrail	4,372	1,797	1,250	614	2,226	250	1,605
Litter	55,245	26,131	20,149	19,432	50,870	9,259	36,666
Pavement Marking	4,238	995	863	607	2,623	435	1,890
Pavement Deficiency	14,800	4,306	3,682	1,562	7,110	163	5,125
Pavement Drop-Off	1,464	4,000	3,034	601	2,296	102	1,656
Sign Deficiency	1,429	983	760	505	1,090	304	785
Vegetation Obstruction	363	135	202	53	552	14	396
General System Deficiencies							
Drainage Obstruction	1,186	1,099	1,267	792	1,673	296	1,286
Guardrail	5,579	3,358	3,569	2,365	5,856	829	4,498
Litter	32,550	32,365	25,107	21,990	29,793	11,226	22,892
Pavement Marking	11,495	8,149	7,360	5,567	6,678	2,045	5,129
Pavement Deficiency	16,131	9,698	7,527	3,285	10,854	189	8,340
Pavement Drop-Off	3,878	10,416	7,507	1,196	5,856	506	4,498
Sign Deficiency	4,251	3,512	2,585	1,230	2,791	905	2,146
Vegetation Obstruction	552	1,068	959	285	1,393	168	1,071
Statewide Totals	**157,724**	**108,257**	**86,198**	**60,129**	**132,306**	**26,733**	**98,444**

Deficiency Table Legend: Goal | Does Not Meet Goal | Meets Goal

a Through third quarter.

Figure 2.14 Laptop Screen for ODOT Maintenance Quality Survey

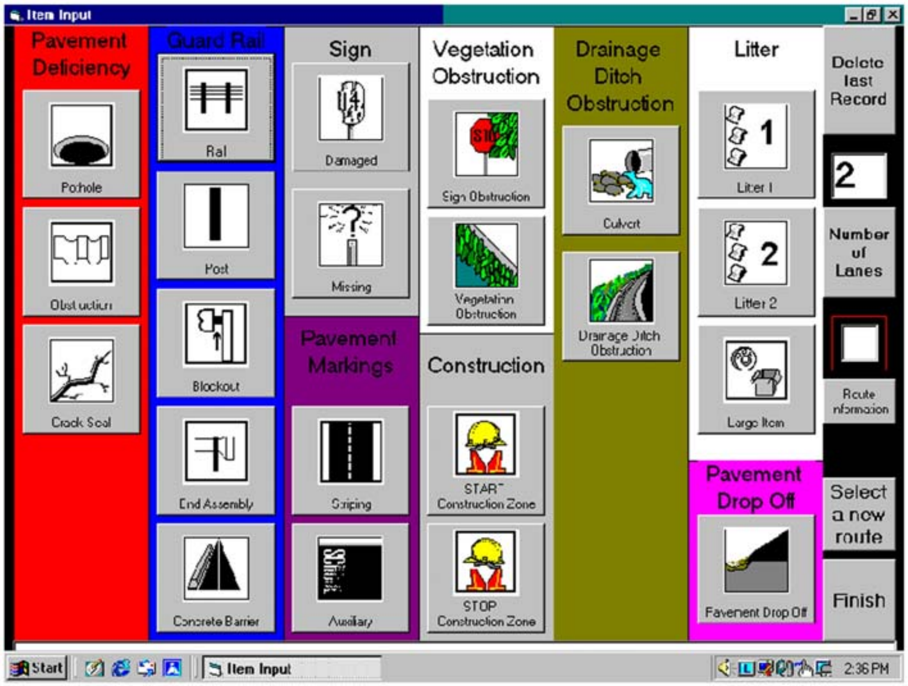


Table 2.9 Typical County Maintenance Yard Work Program

	Priority System					
	OPI Scores		Deficiencies		Goal	Status
Maintenance OPI Category	**04/01/06**	**06/30/06**	**04/01/06**	**06/30/06**	**03/31/07**	**06/30/06**
Guardrail	6	6	3	1	127	-126
Pavement Deficiency	6	6	2	1	392	-391
Pavement Drop Off	6	6	13	10	127	-117
Vegetation Obstruction	6	6	2	0	30	-30
Litter	5	5	1,125	1,084	2,807	-1,723
Drainage Ditch Obstruction	6	6	0	0	36	-36
Sign Deterioration	5	5	30	20	60	-40
Pavement Marking	5	5	50	69	145	-76
Snow and Ice						
Total			**1,225**	**1,185**	**3,724**	**-2,539**

Note: OPI is organizational performance indicator.

It is important to note that the State of Ohio conducts a citizen poll every two years in which ODOT adds questions that relate to the condition of the road system. Between 75 percent and 80 percent of the respondents rate ODOT's performance at least as "good.'' Given that some of these questions relate to the condition and maintenance characteristics of the road network, ODOT officials believe that the results of the citizens' survey verifies the general effectiveness of its pavement and bridge preservation program as well as its maintenance activities.

Management and Data Systems

ODOT has developed a project management system called "Ellis," which tracks all capital project scopes, schedules and budgets. Complex projects are further tracked in detail for 26 items for schedule adherence and 186 items on changes in project scope to determine the risk of cost overruns. Projects are reviewed for schedule and scope creep, and budgets are adjusted accordingly.

ODOT's integrated management systems links project and program investment decisions to the pavement and bridge inventory databases through its pavement and bridge management systems. Thus, ODOT is able to conduct analyses on whether project investments are contributing to achieve targeted performance goals.

"We want the owner of the task to own the data."

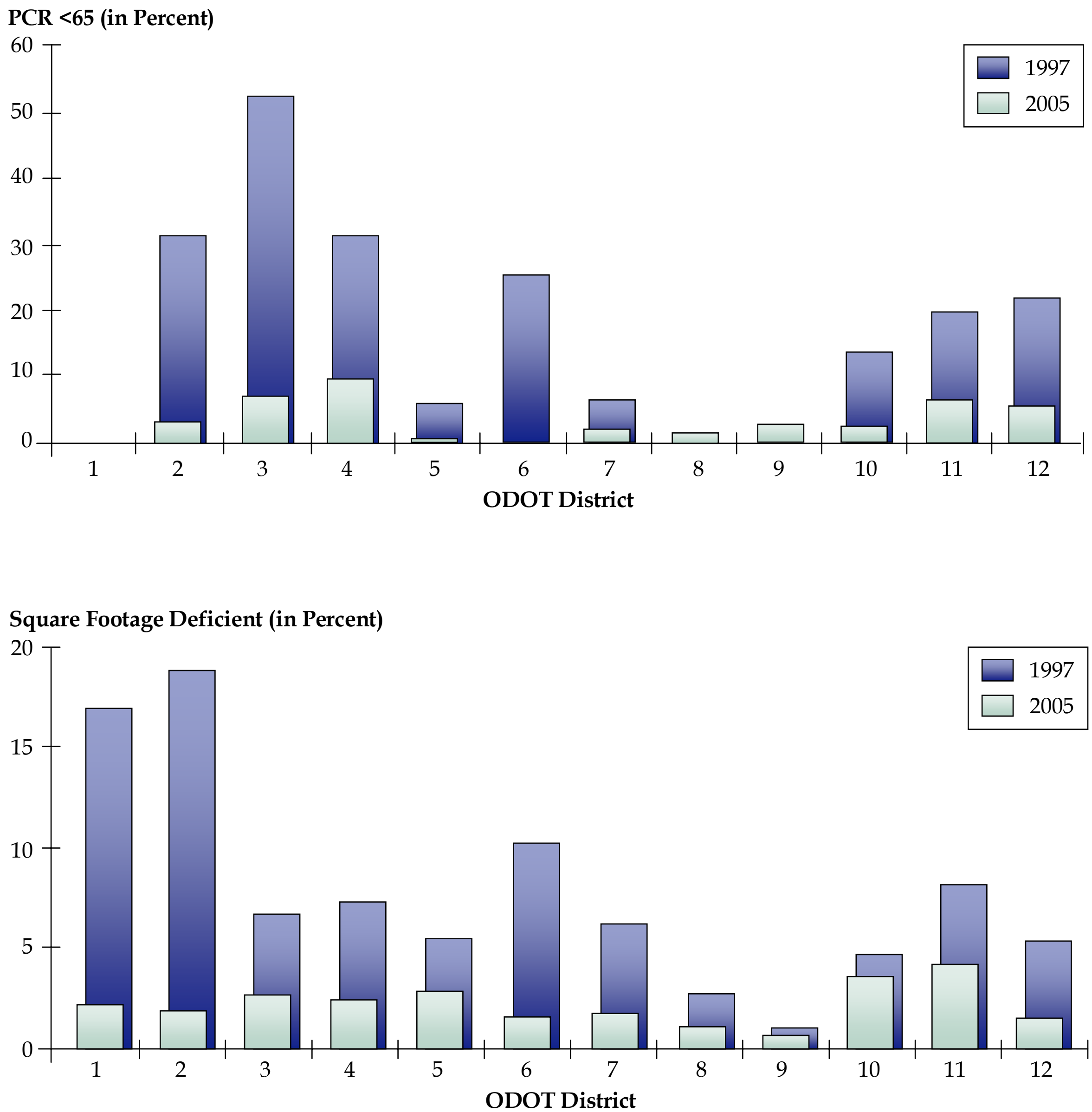
…Ohio DOT Manager

Using a data warehousing process, Ohio's 19,000 centerline mile road network is divided into 0.01-mile segments (1.9 million segments) to permit data integration among legacy mainframe systems, GPS and new web applications. The condition data collected during the annual inspections are assigned to the respective segments. Fifteen years of pavement condition data (or estimated future condition data based on deterioration curves) are used to determine the level of investment and the types of preservation strategies that are necessary to meet the condition target values. If, after the annual pavement condition inspections, there is a deterioration record that is other than what was assumed in the pavement management model, the model "rules" are changed to reflect the real historical record of pavement condition. Thus, actual values are put in the historical trend record, along with projected conditions given different investment strategies.

Results of the System Preservation Strategy

After following its system preservation strategy for several years, ODOT has seen a marked improvement in system condition. Figure 2.15 shows how pavement and bridge conditions changed between 1997 and 2005. Statewide system condition deficiencies have been reduced by 66 percent (road) and 80 percent (bridges) since 1997.

Figure 2.15 Effect of Asset Management Strategy
Road and Bridge Condition, FY 1997 and FY 2005



Lessons Learned

The ODOT case illustrates an agency where asset management principles have been totally integrated into every level of organizational activities. As noted by ODOT officials, asset management should be considered just part of good management, and the ODOT experience has shown that such an approach can produce impressive results. The strategy of trying to get a good "age mix" of pavement conditions over time allows ODOT to achieve a sustained performance regime given known funding levels.

Not only has a system preservation ethic provided a consistent institutional mission for the organization, but it has helped promote coordination among the different units responsible for the road network in the State. Given the annual monitoring of conditions and its relationship to system performance measures, employees at all levels of the organization understand how their activities contribute to ODOT's mission.

Tying unit budgets to condition measures has been very effective in focusing organizational resources on the priorities established by ODOT management. The agency maintains a 10-year fiscal forecast which is tied to system conditions and is reviewed biennially in sync with the state budgeting process. However, given recent rise in construction costs and thus less dollars available for projects, ODOT has evaluated the sensitivity of program funding levels to different and lower goal thresholds. This analysis of bridge and pavement preservation programs showed (over a four-year period) a sensitivity in the range of a $738 million deficit, to a $243 million surplus, depending on the goal level and strategy for distribution to district offices. The sensitivity analysis informed program/budget decision-making that eventually increased these programs by $455 million over a four-year period. Further refinement of fund allocation saw some districts receive only an increase to cover inflation, while other districts' allocations were further increased over inflation to meet their pavement and bridge goals.

Public acceptance of ODOT's competence is a result of the good stewardship record established over the past 10 years. The predictability of future system conditions has had a supportive effect in securing legislative support for ODOT's budget. For example, ODOT management has defined a progression of system management efforts that illustrate the causal linkage between system stewardship and resources being made available. This progression included:

- "Through resource management efforts, ODOT constrained internal operating cost and improved project delivery;
- Through system preservation goals, ODOT set and attained a steady, predictable state of system conditions;
- Achieving this steady state allowed for a long-range fiscal forecast and financial plan, demonstrating that existing program/funds management budgets (with rational revenue growth forecast) could sustain good system conditions;
- Success in these areas bolstered public trust in the Department, leading to the Governor's Jobs and Progress Plan and related finance proposal; and
- The Ohio General Assembly embraced the Jobs and Progress Plan by passing a historic transportation finance package; that package, coupled with pending Congressional action, allows ODOT to advance its other goals of transportation safety, economic development and quality of life, and efficient, reliable traffic flow."

Telling the asset management "story" through effective data collection, analysis and database management has helped set the public agenda for transportation investment in Ohio.

For further information see: http://www.dot.state.oh.us/policy.htm.

2.6 Oregon Department of Transportation

Context

The Oregon Department of Transportation (ODOT) is in the early stages of implementing a comprehensive asset management system. Thus, this case study is not offered as an example of a fully operational asset management process. However, ODOT has taken important initial steps in implementing such a process, and the experience ODOT officials have had with these early efforts offer important lessons to others interested in adopting asset management principles in their own organizations.

ODOT is responsible for 8,067 miles of state highway, several airports, and two short-line railroads. Although state highways constitute less than 10 percent of the total road and street miles in the State, they carry 60 percent of the traffic – more than 57 million vehicle miles per day. Despite a 23 percent increase in miles traveled over the past decade, Oregon's road mileage has grown by only 3.7 percent. Annually, trucks travel more than two billion miles and move an estimated 250 to 300 million tons of goods on Oregon highways. In funding the state highway system, Oregon provides 84 percent of the funding, only 16 percent comes from the Federal government.

According to ODOT officials, some of the asset management challenges facing the State include:

- Oregon's highway infrastructure, including pavements, bridges, and traffic control systems, continues to age, and therefore requires more maintenance and a growing share of ODOT's revenue. As the infrastructure ages it becomes increasingly difficult to keep pace with growing costs through efficiency gains.

- Oregon is expected to grow by 1.2 million people by 2020. Seventy-two percent of this growth will occur in the Willamette Valley, from Portland to Eugene. Growth places additional stress on already crowded highways and bridges. Increased vehicle travel also causes safety concerns for drivers, as well as for highway employees and contractors in work zones.

- Strategies must be found to help Oregon meet long-term highway revenue needs. State highway fund sources (gas tax, weight-mile taxes, and vehicle registration fees) have not, with the exception of a special investment program for bridges and other targeted projects, increased in more than a decade. State and Federal revenues supporting highway programs have failed to keep pace with needs.

ODOT management also has identified numerous areas of departmental operations that will receive greater emphasis over the next several years, including asset management, information management and information accessibility, culverts, environmental stewardship, contract services and management of consultants, operations, and linking transportation investment decisions to economic development.

Investment Decision-Making Process

The Oregon Transportation Commission (OTC) provides ODOT with overall policy guidance on transportation priorities. Although the OTC can establish new directions for transportation investment in the State, Oregon has a very strong statewide planning tradition with a long history of state-level planning rules guiding individual agency actions. For example, in 1989, the State published *Oregon Shines* as a statewide vision for all of Oregon (updates occurred in 1997 and will again in 2007). Benchmarks have been established for state agencies to measure progress in their own actions to meet the vision of *Oregon Shines*. Benchmarks are organized into seven categories: economy, education, civic engagement, social support, public safety, community development, and environment. In total there are 90 benchmarks for all state agencies. Of these, ODOT has identified 11 that the agency directly or indirectly impacts, and has further identified 19 performance measures relating to these benchmarks.

While *Oregon Shines* and *Oregon Benchmarks* identify specific benchmarks for the agency, statewide transportation planning takes a broader look at transportation decisions across Oregon. The Oregon Transportation Plan (OTP), adopted in September 2006, includes goals, and strategies that are to guide statewide decision-making. The OTP is the overarching policy document among a series of plans that together form the state transportation system plan. The plan guides statewide multimodal and modal plans and regional and local transportation system plans. While there are numerous strategies in the plan, some of the key strategies that will be supported by the outputs of asset management include:

- Managing the existing transportation system effectively;
- Improving the efficiency and operational capacity of existing transportation infrastructure and facilities by making minor improvements to the existing system;
- Adding capacity to the existing transportation system; and
- Adding new facilities to the transportation.

Additionally, ODOT created a policy on how to triage in the event of insufficient revenue. It is the policy of the State of Oregon to resolve revenue shortfalls by means that maximize public acceptance and that minimize undesirable long-term consequences to the overall transportation system in urban and rural areas.

Although the OTP does not identify specific projects for development, it provides a framework for prioritizing transportation improvements and developing funding as well as the establishment of priorities. This is followed up by individual modal plans. For example, the 1999 *Oregon Highway Plan* established the following policy concerning the priorities for investment in the state highway system.

"Use the following priorities for developing corridor plans, transportation system plans, the Statewide Transportation Improvement Program, and project plans to respond to highway needs. Implement higher priority measures first unless a lower priority measure is clearly more cost-effective or unless it clearly better supports safety, growth management, or other livability and economic viability considerations. Plans must document the findings which support using lower priority measures before higher priority measures.

1. **Protect the Existing System –** The highest priority is to preserve the functionality of the existing highway system by means such as access management, local comprehensive plans, transportation demand management, improved traffic operations, and alternative modes of transportation.

2. **Improve Efficiency and Capacity of Existing Highway Facilities –** The second priority is to make minor improvements to existing highway facilities such as widening highway shoulders or adding auxiliary lanes, providing better access for alternative modes (e.g., bike lanes, sidewalks, bus shelters), extending or connecting local streets, and making other off-system improvements.

3. **Add Capacity to the Existing System –** The third priority is to make major roadway improvements to existing highway facilities such as adding general purpose lanes and making alignment corrections to accommodate legal size vehicles.

4. **Add New Facilities to the System –** The lowest priority is to add new transportation facilities such as a new highway or bypass."

Once the overall policies have been identified, funding allocations are established for the next six years based on financial forecasts, new capital project requests, current performance and condition data, and directives from other offices. The Oregon Transportation Commission has established Area Commissions on Transportation (ACTs), which act as advisory bodies to ODOT. Membership consists primarily of community decision-makers such as local elected officials, business, industry, and public advocates. ACTs address all aspects of transportation (surface, marine and air and transportation safety) with a primary focus on the state transportation system. ACTs also consider regional and local transportation issues if they affect the state system.

ACTs play a key advisory role in the development of the Statewide Transportation Improvement Program (STIP), which schedules funded transportation projects over the following six-year period. They establish a public process for area project selection priorities for the STIP. Through such a process they prioritize transportation problems and solutions and recommend projects in their area to be included in the STIP. There are 10 ACTs throughout Oregon.

Another key stakeholder is the legislatively designated Oregon Freight Advisory Committee members. The Oregon Freight Advisory Committee (OFAC) was created in the late 1990s to provide a statewide forum for freight issues to be addressed and inputs made to the Oregon Transportation Commission (OTC) and the Oregon Department of Transportation (ODOT).

According to ODOT officials, once the asset management system becomes more robust, its data and information will be key in framing legislative dialogues regarding the nature and extent of transportation issues and challenges. It also will provide clearer depictions for the public as to what transportation conditions they can expect at various levels of investment. As it stands currently, the existing decision-making structure in ODOT is largely integrated vertically and horizontally. All program areas are included and represented in executive, steering, and tactical committees. The overall process for agencywide priority setting, funding allocations (including but not limited to the STIP), performance measures, legislative budgeting and operational planning and budgeting identifies asset management as one of the key inputs, both at the statewide policy level and at the operational level. ODOT also is in the process of formalizing its data governance to ensure that all levels of the organization and its partners and stakeholders understand and can rely on the data, its management, and the information provided from it.

Asset Management Approach

As noted earlier, ODOT is in the early stages of implementing a comprehensive asset management process, although some elements of such a process have been available over the past 15 years. As part of an organizational assessment of its business practices, ODOT identified several gaps in its data management processes that lessened the impact of information support for key investment decisions in the Department. These gaps included:

- Absence of recognized, widely used or agreed upon organizational data standards and definitions for some categories of ODOT assets;
- Absence of coordinated organizational data collection efforts;
- Absence of readily available linear asset information to be used in making scoping decisions for highway construction projects;
- Incomplete, not readily accessible, inadequate or nonexistent location and/or condition data for all asset categories;
- Absence of analysis tools to manage all ODOT's assets result in the inability or difficulty to perform basic systemwide management functions such as generating reports by asset or cross-asset category, condition, functional adequacy, cost, etc.;

- Inconsistent tracking of information about physical roadway components that leads to differing levels of management, maintenance and understanding of current conditions; and

- Inconsistent corporate asset data in terms of collection interval, scale, or level of detail.

Based on this assessment of then current business practices, and utilizing the different asset management capabilities that existed in ODOT (such as a pavement management and bridge management system), ODOT officials established an asset management vision, mission and organizational structure to "move, over time, to a fully integrated asset management system."

The adopted vision for such a fully integrated asset management system was defined as:

ODOT's assets are managed strategically by utilizing integrated and systematic data collection, storage, analysis, and reporting standards on a broad range of transportation system assets, optimizing funding and life-cycle decisions for operations, maintenance and construction business functions.

The corresponding mission for asset management was identified as:

> "Recognizing that Asset Management is a process or methodology that ODOT can use to cost-effectively deliver an efficient, effective, reliable and safe transportation service, the mission of ODOT Asset Management is to:
>
> – Put in place the plans, people, processes and products that enable ODOT to implement accepted Asset Management practices in a timely and cost-effective manner; and
>
> – Continually monitor and improve Asset Management implementation over time.
>
> We do this so that benefits to ODOT in the areas of Accountability, Communication, Risk Management, and Financial Efficiency can be realized."

Specific goals, objectives, and strategies have been identified in an asset management strategic plan. Figure 2.16 shows the overall vision for a fully integrated asset management program in ODOT. Figure 2.17 shows how the management systems and department's databases will support the types of decisions that will be faced by ODOT officials. As shown, through a strategically managed and integrated asset management system, ODOT will have information and processes in place to analyze and make funding allocation, operational, maintenance and asset replacement decisions on a systemwide and cross-asset basis.

Figure 2.16 Oregon DOT's Vision of a Fully Integrated Asset Management System

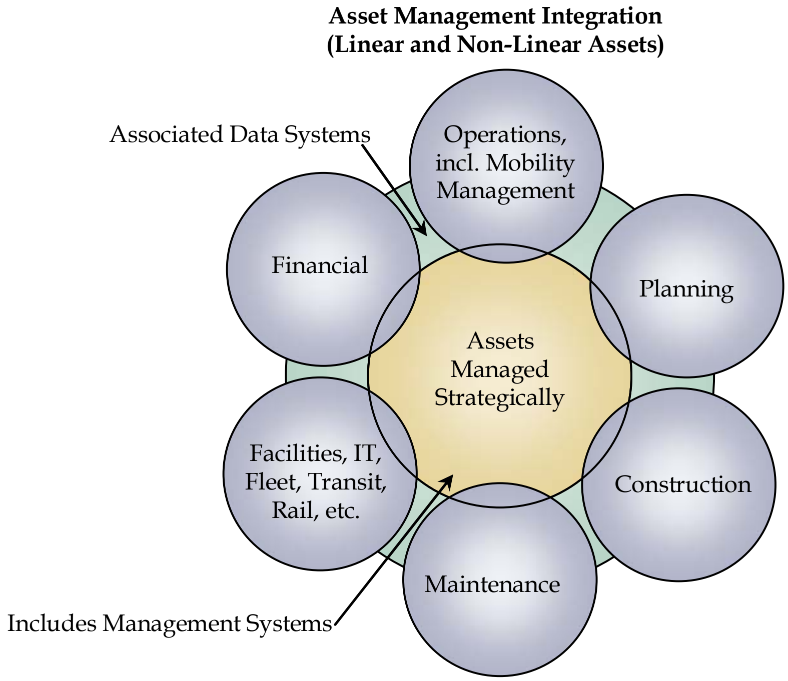
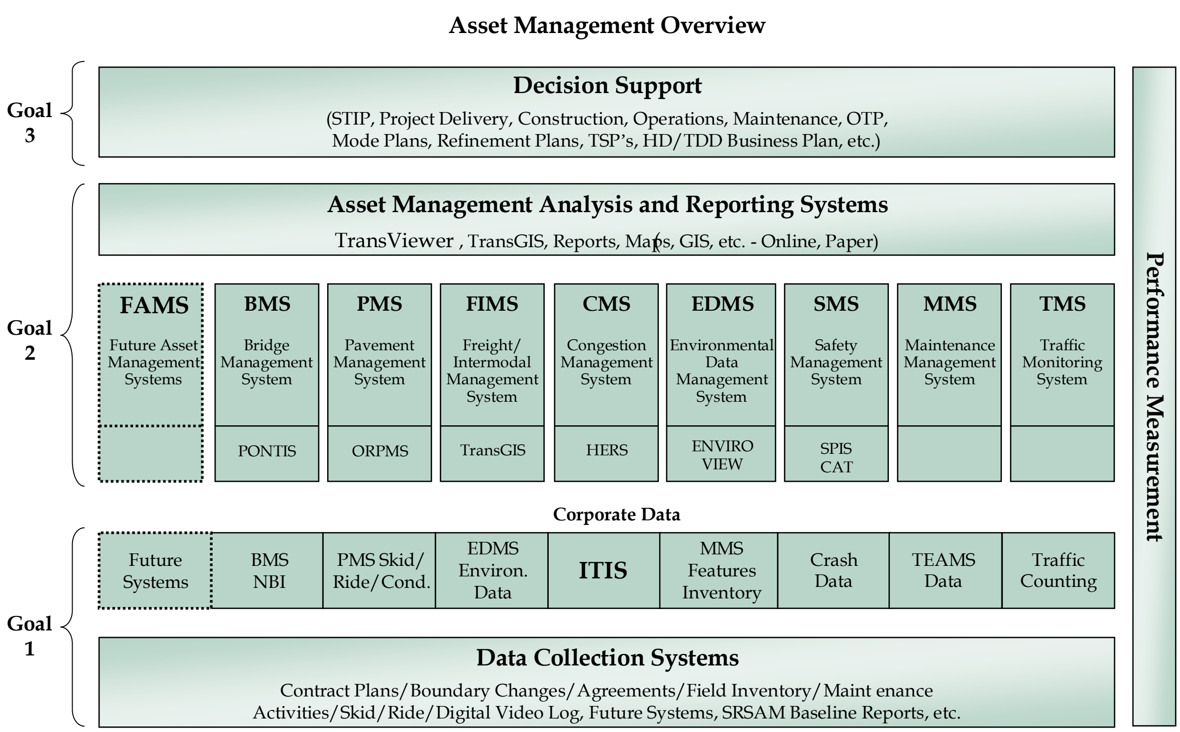


Figure 2.17 ODOT's Vision for Asset Management Reporting Systems



Given that ODOT is still in the implementation phase of a fully integrated asset management system, ODOT officials realized that it was important to lay out upfront the core principles that are to provide a focus for implementation activities. These core principles, that have been incorporated into the asset management implementation plan, include:

- Asset management will add value;
- Asset management will be done well;
- Asset management will build upon ODOT's good management system work;
- Current efforts underway to gather or improve ODOT data will be supported;
- Asset management will be part of ODOT's daily work function;
- Asset management will use trusted and reliable data;
- Asset management processes will be regularly monitored;
- Asset management will support broad-based funding allocation decisions;
- Asset management processes will allow readily available asset reports; and
- Asset management will foster cross-asset communication.

There are no legislative mandates for conducting asset management, however, there are legislatively required performance measures that address assets and while these performance measures do not provide complete asset information, it does give an indication as to asset condition and risk areas. In addition, over the past several years, ODOT has been concerned about some high-risk assets such as bridges and culverts. This has increased general recognition of the importance of asset management.

ODOT's emphasis on asset management also is found in the Oregon Transportation Plan (OTP). The OTP provides ongoing support for asset management via many of its goals, policies, and strategies. One example is a stated policy that "the State of Oregon will manage transportation assets to extend their life and reduce maintenance costs." This is supported by a specific strategy to "develop, enhance, and implement management systems for transportation assets, including roadway pavement, bridges, right-of-way, public transportation facilities and equipment, safety features, congestion and other infrastructure. Promote new technologies and strategies to improve the way assets are maintained."

ODOT has realized that an organization-wide implementation of an integrated asset management system requires changes in organizational procedures and, in some cases, organizational structure. The overall executive owner of the asset management initiative is the Transportation Development Division (TDD) Administrator. Key leadership for linear assets resides jointly with the TDD Data Section and the Technical Services Branch. Key leadership for nonlinear assets resides within the Central Services Division.

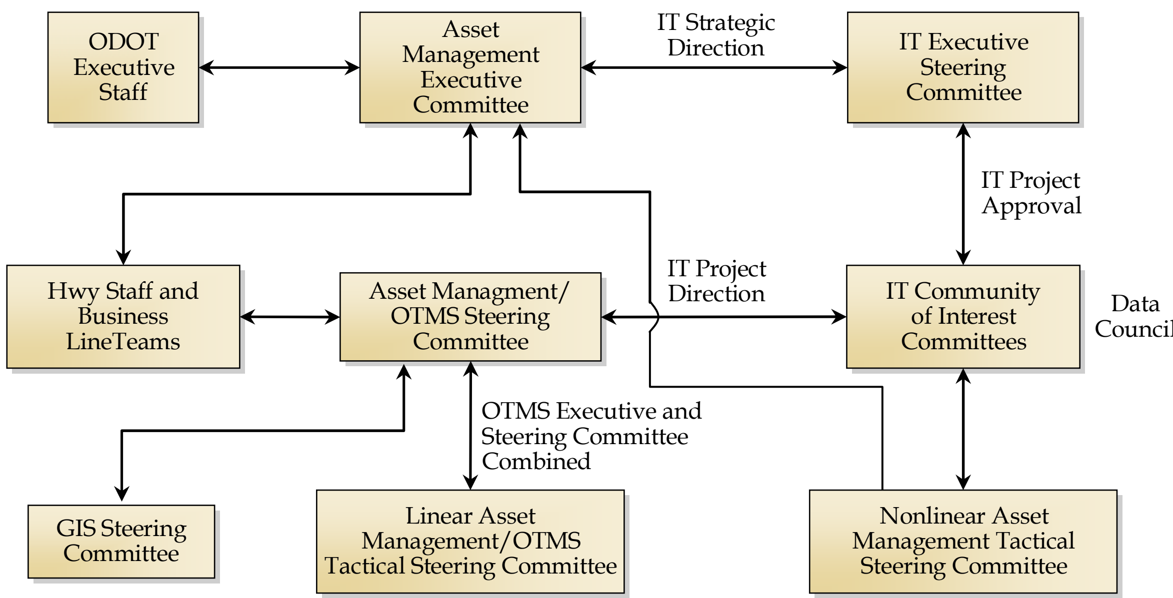
Several asset management teams have been created, covering numerous organizational hierarchies and technical disciplines, including: (See Figure 2.18.)

- Asset Management Executive Steering Committee;
- Asset Management Steering Committee;

- Asset Management Tactical Committee;
- Asset Management Region 2 Pilot Team; and
- ODOT GIS Steering Committee.

The purpose of these teams is to provide executive oversight and direction; manage the system's strategic, operational, and tactical directions and recommendations; establish priorities and charters; and determine data standards.

Figure 2.18 ODOT's Asset Management Decision Structure



Additionally, asset managers and corresponding teams exist within various technical disciplines, such as bridge, pavement, geo/hydro/environmental, operations, information systems, etc. These asset managers are responsible for managing, monitoring, and reporting on asset condition and needs for decisions impacting operations, maintenance, and construction by:

- Performing field data collection and condition rating, updating restrictions, and training for data collection processes;
- Performing needs analysis for project selection and development;
- Working together with other asset owners, between systems to integrate asset data annually and on an as-needed basis; and
- Performing quality assurance/quality control on annual asset data.

ODOT also has requested additional resources from the legislature to advance asset management work. This package proposes utilization of consultant services that will support many key program functions identified in ODOT's "Linear Asset Management Strategic Plan" and "Linear Asset Management Implementation Plan." These services include:

- Completion and enhancement of asset features inventories;
- Design and implementation of cross-database validation procedures to insure data consistency;
- Development of innovative tools for managing assets and reporting asset needs; and
- Implementation of an Executive Asset Management Reporting System, which will provide the organization the ability to perform efficient asset life-cycle and cross-asset investment tradeoff analysis.

One of the interesting initiatives that ODOT has undertaken to understand better the level of effort needed to develop a fully integrated asset management system is a pilot study in one of ODOT's regional offices (Region 2). An agreement to develop a multi-phased asset management pilot study was signed in November 2005, with the focus of the pilot being the development of an asset database in four highway corridors that will allow regional officials to assess project priorities. ODOT hopes to learn several lessons from this experience, including:

- What are the best asset features to document for a first level effort?
- Where are there gaps in data availability?
- What level of effort is necessary to integrate existing data?
- What is the magnitude of the issues surrounding data quality?
- How much effort is necessary to gather additional data?
- How should ODOT stage implementation steps for broader application?
- How should asset condition be assessed?
- What are the best methods to report information for decisions?

Knowledge gained in answering these questions will provide important insight for rolling out an effective asset management effort statewide.

ODOT officials also have realized that to be effective organization-wide as well as with a much broader audience, the agency's asset management system must be understood and be viewed as a credible basis for investment decisions. Thus, ODOT has developed a specific asset management communication plan that is focused on increasing the awareness of the need for asset management, and more specifically enhance the understanding of ODOT's approach. A brochure and web site have been developed, and an asset management users group has been supported.

Management and Data Systems

ODOT is one of the states that implemented all of the Intermodal Surface Transportation Efficiency Act (ISTEA)-required management systems following the law in 1991 and decided to keep all of the systems in place when all but two were required after 1995. According to the ODOT statewide transportation plan, the decision to keep all of the management systems reflected a belief that the systems were considered "critical to facilitate sound decision-making and cost-effective investments."

ODOT estimates that data is being collected and analyzed in 60 and 70 databases and programs agencywide. The major management systems currently in place in ODOT include:

- Pontis – Bridge Management System;
- Bridge document system – Scans of as-built project documents, foundation; sheets, boring logs, and calculation books;
- PMS – Pavement Management System;
- R2SIGN – Sign inventory database;
- ITIS – Integrated Transportation Information System (ITIS);
- MMS – Maintenance Management System;
- TMS – Traffic Monitoring System;
- TransGIS – Web-based GIS tool (includes Freight and Intermodal Management Systems);
- HERS – Highway Economic Requirements System;
- EDMS – Environmental Data Management System;
- RAIN – Right-of-Way Automated Information Network;
- TMOC – Transportation Management Operations Center;
- TEAMS – Transportation Environment Accounting and Management System (financial services); and
- CDS – Crash Data System.

Some of the more unique information systems include an Aggregate Source Information System (ASIS), which allows ODOT officials to manage the aggregate pits owned by the State (the first one was purchased in 1922). These aggregate pits are considered a valuable resource to ODOT in that they keep aggregate costs down. ODOT also has developed an unstable slope management process, which rates potential landslide locations on the basis of risks (numeric scores). From 1993 to 2003, 382 crashes have occurred on state roads due to landslides or rockfalls, 154 injuries and 23 deaths. ODOT's is using a drainage facility management database that provides condition assessments, hydraulic characteristics, environmental conditions and maintenance schedules for the estimated 30,000 culverts statewide. The Right-of-Way Data Management System (RWDMS) was developed at the request of the legislature and the Transportation Commission to provide accurate and real property asset information. Right-of-way and other property plans have been scanned into this database, and the overall system has greatly improved the effectiveness of utilizing this data in project costing and property valuation.

One of the challenges ODOT faces with all of its systems is that they are not linked. Current systems often utilize data extracts, report views or Excel, Access or SQL file downloads from other programs to produce annual reports and perform analyses. For example, the Integrated Transportation Information Systems (IT IS) provides data extracts to the PMS, TransGIS, Pontis, TMS, CDS, and a Project Delivery Work Planning (PDWP) systems using its report tables to create views. TransGIS is a web-based spatial data tool that allows many of the asset systems to provide/share annual updates of their inventories and other information. The MMS provides data directly to TEAMS to assist in tracking project schedules and costs.

ODOT's strategy for evolving to a fully integrated asset management system includes:

- Developing organizational data standards and definitions for ODOT's assets;
- Establishing suitable standards for asset data in terms of field data collection intervals, level of detail and scale needed to support strategic decision-making;
- Developing coordinated organizational data collection efforts, and linear referencing system;
- Collecting and determining location and/or condition data for all asset categories;
- Developing new or improved analysis tools to manage all ODOT assets;
- Analyzing and reporting on a project-specific or a broad range of transportation system assets to optimize funding and life-cycle decisions;
- Developing performance measures to identify if the asset is being managed efficiently and effectively; and
- Prioritizing asset system automation projects, identifying integration needs and opportunities.

ODOT has identified a long list of linear and nonlinear assets that eventually will be incorporated into the fully integrated asset management system. However, so far, ODOT has focused management system development and data collection on just a few of these assets, which reflect the collective sense of ODOT officials of where the greatest concerns and risks are. In addition, some of the priority assets have been chosen because of political interest in the issues surrounding that particular asset. The priority linear assets include: culverts, tide gates, right-of-way, traffic barriers, pavements, bridges, and retaining walls. Nonlinear asset priorities include: computer software, data, equipment, and vehicles; facilities; special management areas and archaeological areas as well as TMOCs – Transportation Management Operation Centers.

One of the best examples of how management systems have been used effectively in securing new transportation resources for the State is the use of bridge management data in showing the economic costs to the State of allowing bridges to deteriorate. In 2003, the legislature approved a 10-year $2.5 billion program called the Oregon Transportation Investment Act III (OTIA III) to fund $1.3 billion for state bridges, $300 million for local bridges, $361 million for local maintenance and preservation, and $500 million for infrastructure modernization. ODOT used an existing bridge management system and Pontis to directly quantify the economic cost (dollars and jobs) of restricting truck movements due to posted bridges. The study identified which regions and industries would be affected and by how much. Thus, the study was more than just a technical study of deficient bridges; it also showed the impact of such bridges on the economy and quality of life to affected communities. According to ODOT officials, this approach presented "thoughtful, proactive options rather than a "crisis" approach to the legislature." It also represented a shift from a "worst-first strategy to a corridor-by-corridor or bridge repair prioritization scheme." The analysis allowed ODOT to develop a staging plan that included identifying the least costly interstate detour routes as bridges were being repaired or replaced.

This type of economic analysis is not uncommon to ODOT. The bridge analysis was conducted using the Oregon integrated economic-land use-transport model. This model is one of the most advanced models of its kind in the United States, integrating economic, land use and transportation elements across the entire State. It was developed as an analytical tool to assist policy-makers in making informed decisions. Another analytical tool used by Oregon is the Highway Economic Requirements System (HERS) model. HERS is a Federal software package that predicts the investment required to achieve certain highway system performance levels. Alternatively, the software can be used to estimate the highway system performance that would result given various investment levels. HERS considers capital improvement projects directed at correcting pavement and/or capacity deficiencies. Modeling tools have been key to making informed policy choices in Oregon.

Given all of the different management systems and data analysis processes found in ODOT, it is not surprising that substantial amounts of data are collected each year. ODOT uses a variety of data collection and management technologies, including: digital video log (DVL) for the inventory of the state highway systems; linear field data collection utilizing GPS; laser sensors for pavement roughness and bridge/structure clearance data; remote cameras for bridge inspection; web-based bridge inspection reporting applications; GIS-mapped projects integrated with other management systems and data; and a TransGIS web-based mapping tool with documents and image links.

ODOT has recently implemented a web-based data collection registry to assist in coordinating and tracking asset inventory efforts throughout the organization. Included in the web site are links to data standard references and contacts that will improve organization-wide communication of collection activities as well as the approved collection methodologies and techniques. ODOT has not conducted a benefit/cost analysis of its data collection efforts. However, ODOT is performing a pilot project within one of its regional offices to identify gaps in the data available. The intent is to discover what data are within existing databases, conduct a comparison to field collection results, identify efforts required and develop 'lessons learned' that will assist in determining the most cost-effective approach to data collection.

"An asset owner needs to be responsible for the data that provides an ongoing assessment of the condition of that asset."

ODOT official

ODOT has been examining ways of making the data collection efforts in the Department more cost-effective. For example, the bridge program has a remote monitoring system for its bridge inspection program. ODOT's Intelligent Transportation System (ITS) Program has 178 cameras accessible via the Internet showing current operations on the Interstate system. Data from 119 ramp meters in the Portland metropolitan area allow remote monitoring of traffic flows. ODOT has installed 78 road and weather information systems that gather weather and road surface information. This number includes several weather warning systems that gather information about a specific hazard (e.g., high water, high winds, low visibility, or ice) and automatically activate signs and perform notifications. Maintenance is piloting a new asset and time recording system related to traffic signal maintenance. Central traffic signal control systems (under local responsibility) are in place in Portland, Salem, Eugene, and Medford that provide remote monitoring of signal operations.

Results of the System Preservation Strategy

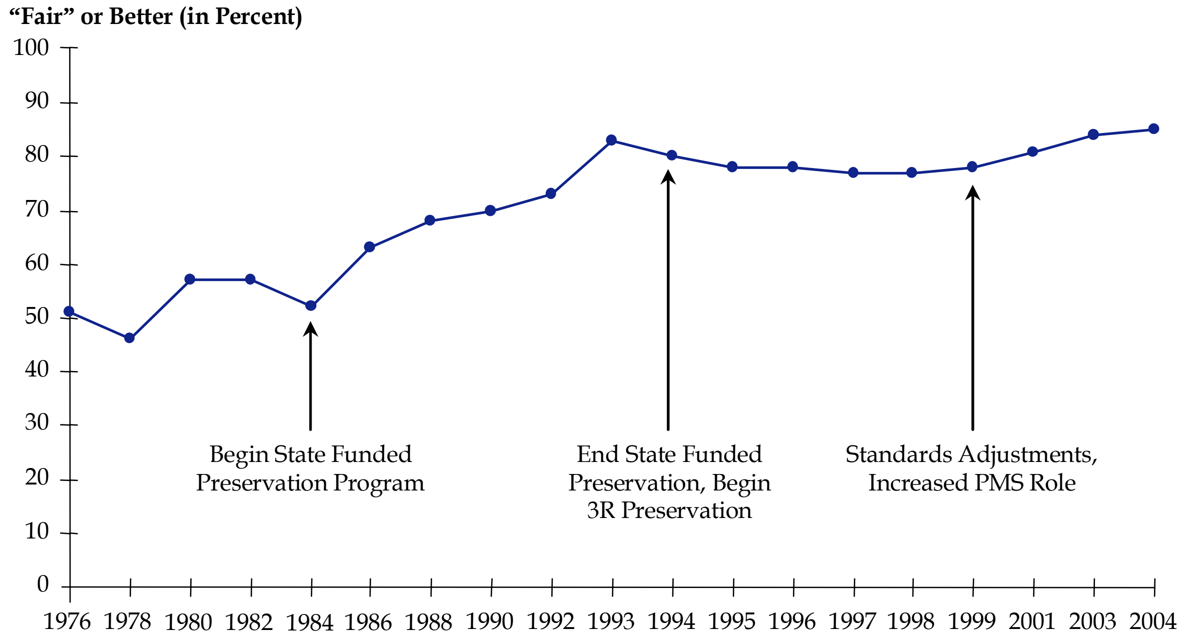
As noted at the outset, ODOT is in the early stages of its implementation of its Asset Management Strategic Plan. However, the monitoring of ODOT asset condition has provided important information to both the legislature and ODOT officials on the trends associated with components of the State's transportation system. Some of this monitoring is shown below.

Pavement Condition

Definition – Percent of pavement lane-miles rated fair or better out of total lane-miles on the state highway system (see Figure 2.19).

The percent of pavement in good condition is a measure of the level of service experienced by customers and an indicator of the ability of the agency to maintain the network. Using this measure at a disaggregate level (e.g., specific areas, corridors, roadways) can help ODOT identify particularly troublesome locations. Each ODOT region has a specific mileage target for improving "poor" condition roads.

Figure 2.19 Oregon DOT Pavement Condition Monitoring
1976 to Present



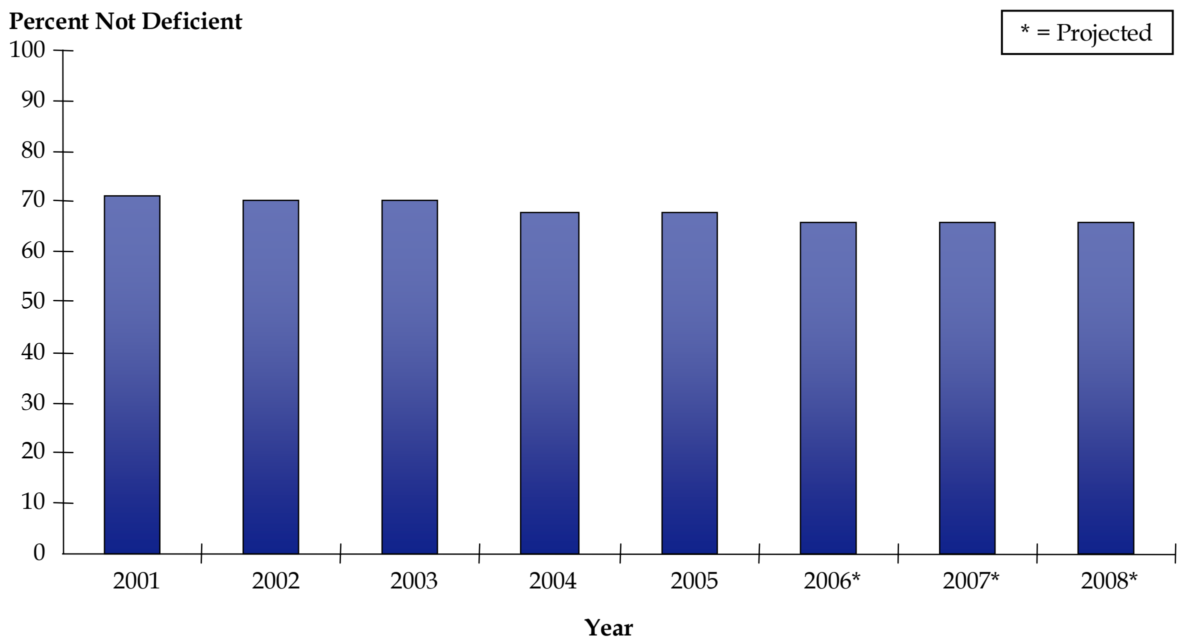
Note: Pavement Condition ratings are now conducted in a biennial basis (even years starting in 2004).

Bridge Condition

Definition – Percent of state highway bridges that are not deficient (see Figure 2.20).

The percent of state highway bridges that are not deficient is calculated based on a methodology used nationally, the National Bridge Inventory. "Not deficient" bridges are those that are not structurally deficient or functionally obsolete. Using this measure at a disaggregate level (e.g., specific bridges) can help identify particularly troublesome locations. This measure also captures potential freight movement issues by identifying deficiencies on identified freight routes.

Figure 2.20 Oregon DOT Bridge Condition Monitoring
2001 to Present

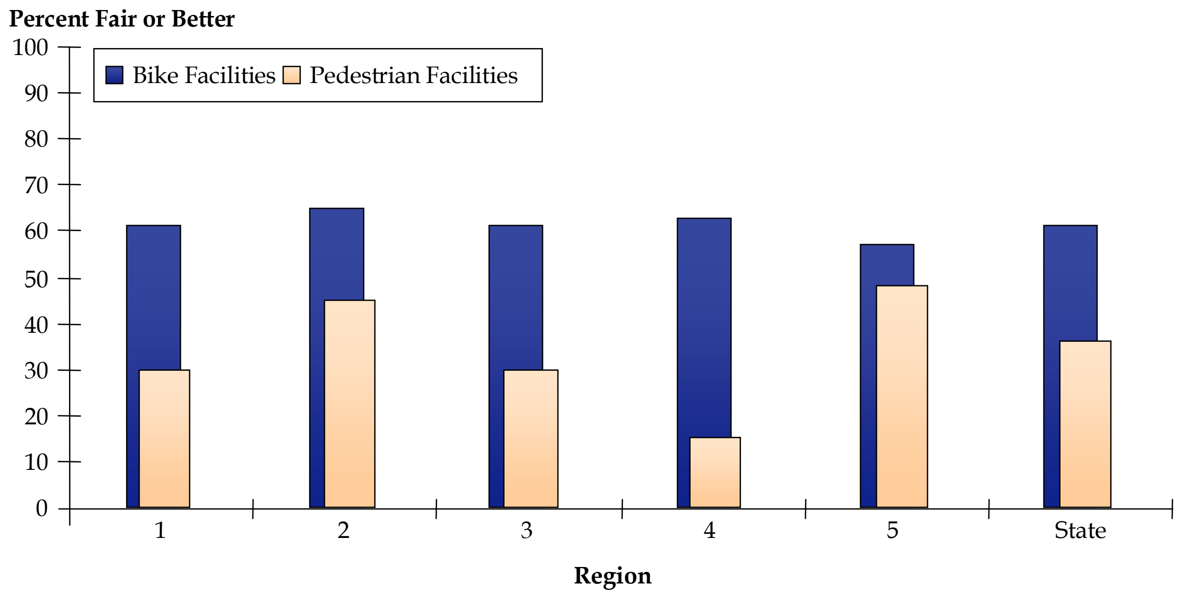


Bike Lanes and Sidewalks

Definition – Percent of urban state highway miles with bike lanes and pedestrian facilities in fair or better condition (see Figure 2.21).

The percent of urbanized highway miles with sidewalks and bike facilities in good condition provides a complimentary measure to the pavement and bridge measures above. It captures the ability of cyclists and pedestrians to use the appropriate parts of the state highway system for trips of all types (commute, recreation, etc.) Using this measure at a disaggregate level (e.g., specific highways or towns) can help ODOT identify particularly troublesome locations.

Figure 2.21 Oregon DOT Bike/Pedestrian Facilities Condition Monitoring



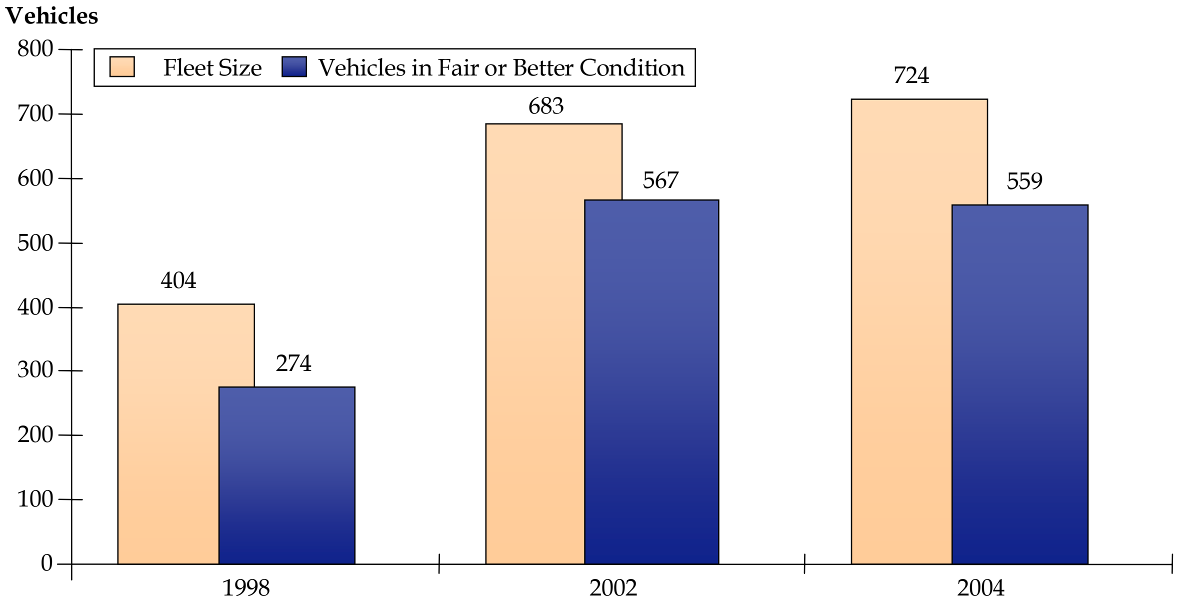
Vehicle Condition

Definition: Percent of vehicle fleet in fair or better condition (see Figure 2.22).

An important program goal is to provide a fleet of safe and accessible vehicles large enough to meet the transportation needs of seniors and people with disabilities. ODOT's Public Transit Division goal is to maintain 80 percent or more of this fleet in fair or better condition as defined by Federal useful life standards. These standards are based on age and mileage for type of vehicle. The rural and special needs fleet currently is at 77 percent fair or better condition.

Although the evolution toward a fully integrated asset management system is still in the early stages of implementation, ODOT already has had some success in using asset management information in securing additional resources for the transportation program. As was noted earlier, the $2.5 billion bond program primarily for bridges was justified on the economic analysis that came from ODOT's bridge management system and related programs. Although the culvert information in the asset management system is not yet complete, it was sufficient to illuminate the high risks associated with it. This resulted in $17 million being reallocated from the Interstate Maintenance Program specifically to culverts in the current biennium. The data and information provided by the pavement management system has consistently provided the Oregon Transportation Commission with investment tradeoff information for varying levels of funding for the STIP preservation and maintenance programs.

Figure 2.22 Condition of Oregon DOT-Funded Bus Fleet



As noted by ODOT officials, "the interest of agency management and the OTC in having comprehensive and integrated information in support of improved decision-making capabilities has been one of the major drivers supporting asset management. With complex decisions becoming even more so, requiring consideration of mobility management (goods and people), fuel costs, and supplies and the related potential impacts, etc., the need for enhanced decision-making tools is clear."

Lessons Learned

The Oregon Department of Transportation is in the early stages of developing a comprehensive asset management process. However, the initial steps taken by ODOT have positioned the Department well for future success in using asset management to support investment decisions. ODOT already has had some success in obtaining additional funds from the state legislature due to its ability to present a convincing case on the serious condition of the State's bridges. As noted by ODOT officials, they believe that the information provided from a comprehensive asset management process (such as life-cycle, maintenance, operations and replacement costs) along with the ability to conduct tradeoff analyses will "increase ODOT effectiveness in providing a compelling reason for additional transportation resources."

ODOT officials offered the following advice for those desiring to implement an asset management process in their agency:

- Link asset management to the vision or mission as well as the strategies and goals of the agency;
- Secure sustained political commitment and leadership from executive staff;
- Set up an asset management committee decision structure to resolve issues and provide agencywide direction;
- Build on your existing management system foundation, but be ready to modify it as needed;
- Allow existing data collection processes and information systems to serve new applications;
- Create a focused implementation plan;
- Communicate early and often;
- Create and participate in partnership opportunities with other entities;
- Focus on transforming data into useful information for decision-makers;
- Use relational databases (e.g., geographic referencing applications like Geographic Information Systems – GIS) to link individual knowledge centers;
- Create tools that are simple, flexible and capable of providing needed information to users;
- Ensure data quality by developing standard definitions and clearly communicating them to all users;
- Develop and continually improve coordinating mechanisms between various asset classes of the organization;
- Provide agency staff responsible for various aspects of asset management appropriate education and training to fulfill their roles;
- Maintain a customer focus; and
- Include asset management as a priority in business/operational plans.

The ODOT case has illustrated best practice in creating a strategic vision for what asset management can do for an organization, and for creating a multiyear strategic plan for implementing this vision. The concept of asset management has clearly taken hold in ODOT, and with the strong foundation already established in the legacy management systems from ISTEA, and the specialty systems developed for specific topics, it seems likely that ODOT will be quite successful in creating an effective information base for the types of decisions it will face in coming years. The economic analysis that justified the

$2.5 billion bridge program is an example of how an economic analysis process combined with effective management systems can produce very worthwhile and influential information. This one example perhaps, more than anything else, illustrates the potential of a comprehensive asset management system.

For further information, see: http://www.oregon.gov/ODOT/TD/asset_mgmt/WhatIsAssetMananagement.shtml.

2.7 Utah Department of Transportation

Context

The Utah Department of Transportation (UDOT) is responsible for about 5,900 miles of highways – 14 percent of the State's total highway road system of 42,704 miles. As the fifth fastest growing State in the United States, Utah is facing many growth-related pressures on this system. Due in large part to this growth, the state legislature has been forthcoming with additional monies for the State's highways, resulting in only 14 percent of the transportation capital budget coming from Federal sources. However, the vast majority of this additional funding has been for capital improvements, not for system preservation. That being said, the additional capital improvement projects have benefited the UDOT network as a whole and has led to significant improvement in the system condition.

The history of asset management in UDOT really begins in 1978 when a report entitled *Good Roads Cost Less* was published. In many ways, UDOT was way ahead of other state DOTs in recognizing the importance of asset management for providing the most cost-effective investment strategy for a State's road network. However, this early recognition of asset management faltered due to little understanding at the time of how to implement a comprehensive asset management program. It did, however, firmly establish the ideals of pavement management within UDOT which led to the creation of the Roadway Management Team within UDOT in the late 1980s and the adoption of the Deighton Pavement Management System (dTIMS) in the early 1990s.

Today, UDOT has embraced the concept of asset management as an organizational philosophy, one that is integrated throughout the agency at the central office and at the regional level. According to UDOT officials, the reasons why asset management was pursued more actively around 2001 were:

- It was the "right thing to do and we were ready."
- Asset management provided greater credibility with elected officials and stakeholders. It could help answer such questions as, what would be the effect on asset condition of a 15 percent increase or decrease in funding? What would be the effect on asset condition of trading off maintenance and preservation dollars with congestion mitigation dollars?

- Based on the earlier recognition of asset management in the *Good Roads Cost Less* publication in 1978, UDOT already believed in a "preservation first" investment strategy. The practice of asset management and enabling technology in terms of data collection, database management, and analysis tools had finally caught up to UDOT's desire to implement an analysis-driven systematic preservation program.

- The Utah Transportation Commission (UTC), the board that chooses the State's investment policies for transportation, was asking for a more optimal and equitable way of allocating transportation resources, where these decisions would be based on sound engineering judgment and economic analysis.

- Asset management allowed UDOT management to align investment funding with the agency's strategic goals, and the strategic goals with agency performance plans.

- UDOT already was utilizing a proprietary asset management software program within the pavement management unit.

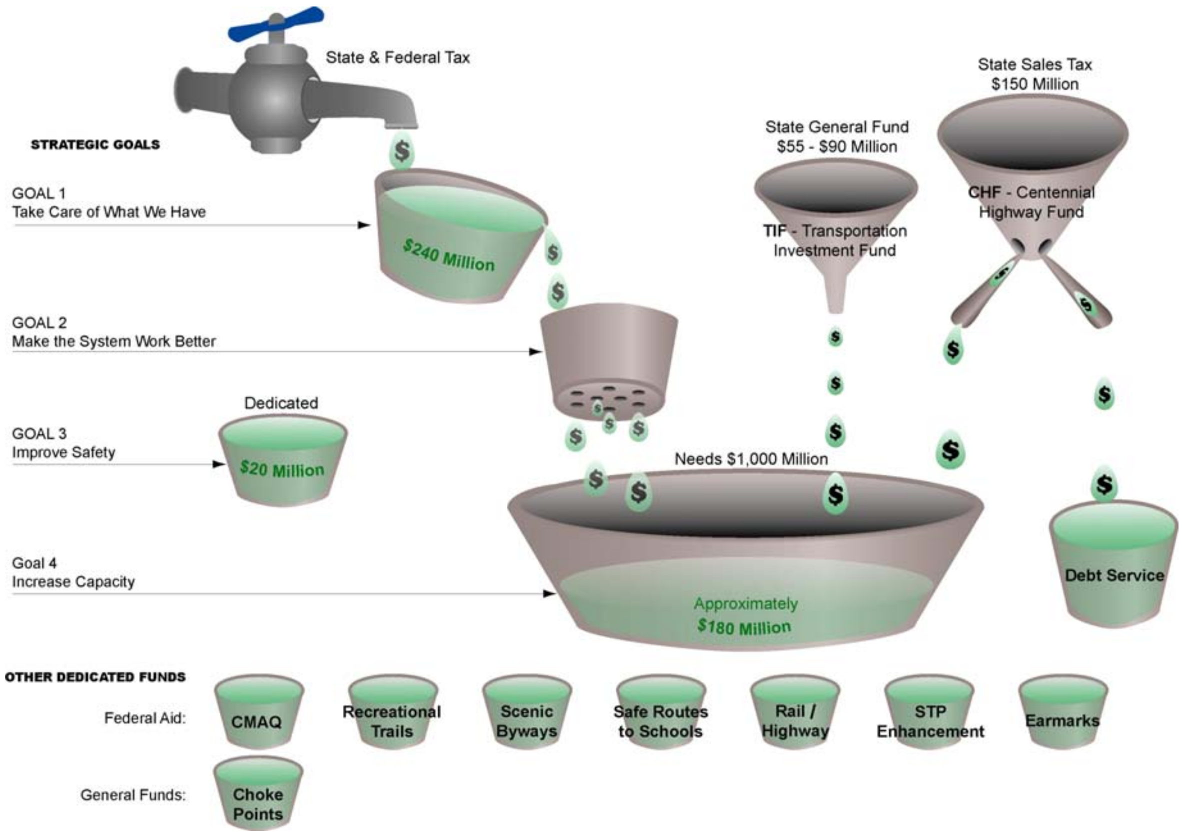
Although the legislature has not mandated an asset management requirement for UDOT, the legislature did provide a major boost for a state asset management strategy when I-15 in Salt Lake City was being reconstructed through a design/build contract (the project was being expedited for the 2002 Olympic Games). This $1.6 billion, 17-mile project was the most complex project undertaken in UDOT's history, with 130 structures, three major junctions with other freeways and seven major urban interchanges. With the successful completion of the project, the legislature challenged UDOT to decide between continuing to use its own forces to maintain the facility or to instead use a private maintenance contract (PMC). UDOT chose to continue to use its own forces and to do so within the context of a new statewide program of asset management.

Investment Decision-Making Process

Investment decisions within UDOT relate directly to the agency's strategic goals, especially those labeled "The Final Four:" 1) take care of what we have; 2) make the system work better; 3) improve safety; and 4) increase capacity. Funds are first allocated to system preservation, second to improving system performance, and third enhancing system capacity. Dedicated funding is provided to the safety program. Figure 2.23 shows how the different flows of dollars in Utah reflect these priorities.

UDOT also has adopted specific performance measures that relate to these four goals. For example, the latest performance measure report identifies the following performance measures for each of the goals.

Figure 2.23 Flow of Transportation Investment in Utah



Taking care of what we have:

- Maintain 90 percent of freeway pavements, 70 percent of arterial pavements, and 50 percent of collector pavements in fair or better condition.
- Maintain no less than 65 percent of bridges in very good condition, 25 percent of bridges in good condition, and no more than 10 percent of bridges in fair condition.
- Maintain a grade of "B+" for snow and ice removal based on conditions reported one hour after a storm. (The Maintenance Management Quality Assurance (MMQA) system assigns a grade for snow and ice removal, with "A" for "clear, dry conditions" and "B" for "occasional snow or ice buildup").
- Maintain a grade of "A" for signing and striping. (The MMQA system assigns a grade for signing and striping, with "A" for "excellent daytime and nighttime visibility" and "B" for "good daytime visibility and fair nighttime visibility").

Make the system work better:

- Increase annual usage of 511 (phone) and CommuterLink (web) traveler information sources by 10 percent;
- Increase the percentage of motorists who change travel patterns because of information received through 511 or CommuterLink (UDOT will soon begin polling motorists to determine this result); and
- Clear non- or minor-injury crashes in 30 minutes or less on average, serious-injury crashes in 60 minutes or less on average, and fatal accidents in 120 minutes or less.

Improve safety:

- Reduce the number of traffic-related fatalities by two percent each year.
- Reduce the number of pedestrian fatalities by two percent each year.

Increase capacity:

- UDOT is measuring baseline travel times between various intersections along the Wasatch Front (Interstates 15 and 80 in the Salt Lake City area). Once a baseline has been determined, UDOT will establish objectives relative to travel times.

The impacts and results of the asset management system (AMS) analysis are reported in terms of these performance measures where possible for the asset groups included in the asset management system.

The "preservation first" strategy has been adopted by the Utah Transportation Commission (UTC) in its Policy 07-10. Another provision of this policy is that project selection in UDOT should be a transparent process. As noted in Policy 07-10, "It is UTC policy to have a fair, open, and equitable selection process based on criteria that determine which projects contribute most to state, regional, and local transportation, and economic development goals. Further, the UTC process intends to use decision support systems based on criteria (data) to help maximize and prioritize resources using quantifiable measures." Although this policy is intended primarily for capital construction projects, the philosophy of having in place a defensible and understandable project selection process is a basic principle found in UDOT's asset management program as well.

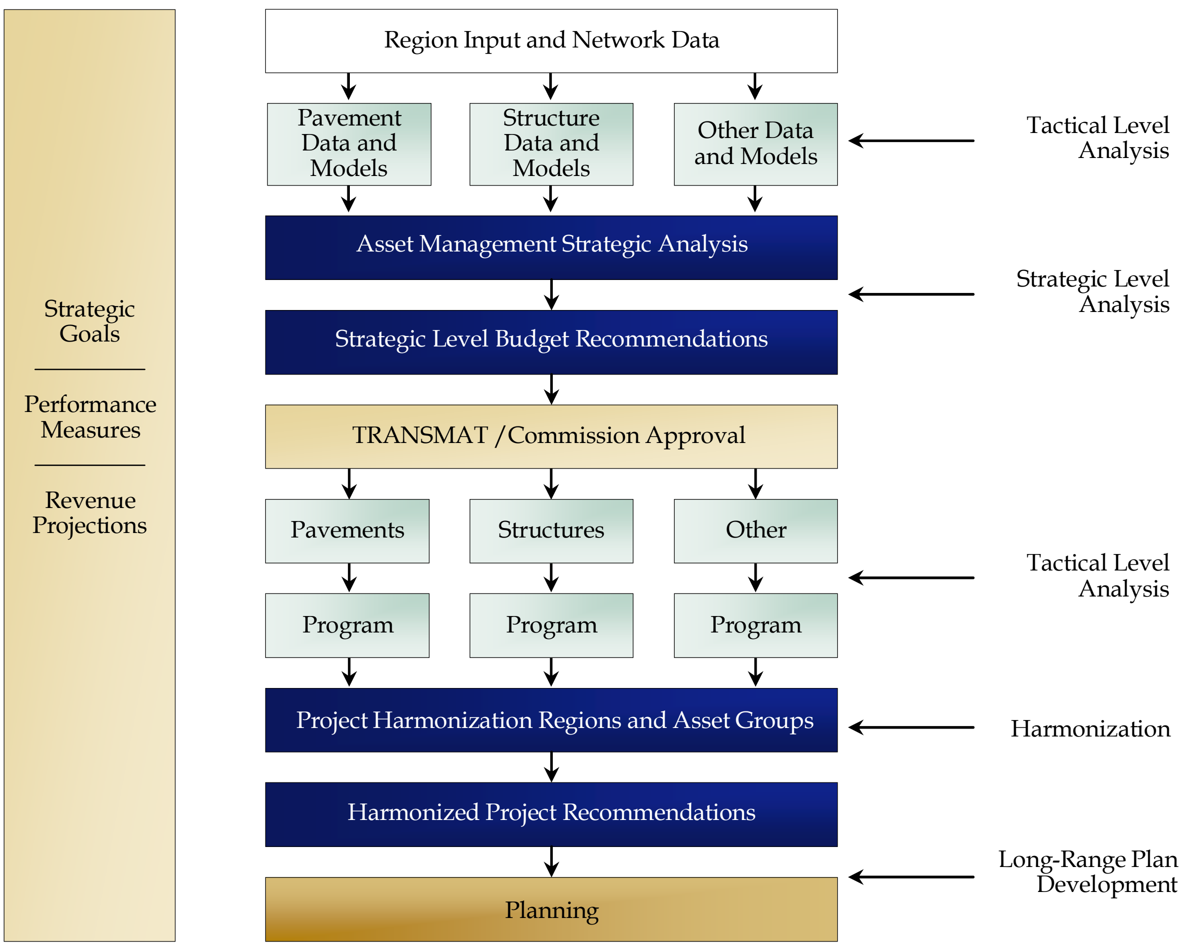
The UDOT Planning process displayed in Figure 2.24 outlines the planning cycle in UDOT. Asset management at the strategic level is used to set budgets and performance targets for each of the asset groups. The budget levels and performance targets are then approved by the executive committee known as Transportation Systems Management Team (TRANSMAT) and the Utah Transportation Commission and distributed to the asset groups at the tactical level. The asset groups at the tactical level then use their respective management systems to put together a 10-year plan. Each 10-year plan is then forwarded to the Asset Management Team (AMT) to "harmonize" into the 10-year System Preservation Plan. This plan is then distributed to the Central office and to the Regional offices for project selection and prioritization. UDOT has a formal policy requirement that the regions use the 10-year System Preservation Plan when selecting and putting projects together for the STIP. The following illustrates how a regional office may prioritize road segments for preservation strategies following the strategic level and tactical-level asset management analysis completed at the central office:

- Step 1 – Identify Candidates:
  - Start with 312 roadway segments (this particular region);
  - Remove all segments with committed STIP projects:
    - Centennial Highway Fund (CHF) list projects;
    - High-priority projects;
    - Special case projects; and
    - Pavement projects.
  - Use remaining segments in Step 2.
- Step 2 – Segment Evaluation:
  - Identify segment condition using common pavement management measures;
  - Semiannual maintenance inspections;
  - Visual distress surveys (cracking); and
  - System distress surveys (ride, rut, strength, skid (used to improve safety)).
- Step 3 – Identify Treatment Candidates:
  - Identify minor rehab candidates (20 to 25);
  - Identify major rehab candidates (10 to 15);
  - Identify capacity candidates (5 to 10);
  - Identify no-action candidates (remaining for surface seal program); and
  - 35 to 50 total candidates for prioritization.
- Step 4 – Prioritize Individual Programs:
  - Utilize asset management system to help identify and prioritize projects;
  - Use volume to capacity ratio for capacity projects;
  - Use structure rating for structures projects; and
  - Adjust according to roadway characteristics (volume/AADT, function, adjacent sections/related projects, safety concerns, maintenance costs).
- Step 5 – Site Review:
  - Region pavement management team;
  - One-day review for condition verification;

- Verify project limits;
- Identify special concepts; and
- Determine relative priority with individual program by team consensus.

- Step 6 – Prioritize Overall Region List:
  - Preservation strategy (surface seals and minor rehabs are first priority);
  - Pavement type (do work on all four classifications);
  - Structures coordination;
  - Small program coordination; and
  - Safety concerns.

Figure 2.24 Planning and Asset Management in Utah DOT



Asset Management Approach

Following the publication of the report *Good Roads Cost Less* in 1978, UDOT began developing the data analysis infrastructure for an asset management program by creating a pavement management unit. Senior management in the agency was committed to pavement management as a decision support tool, but there was no stable funding source at the time dedicated to asset preservation. Although a department-wide pavement management training program had been proposed, it was not implemented.

In the 1990s, UDOT officials and key legislators were facing the question of how much funding support would be necessary to keep the road network in its then condition. The answer to this question was, "all of the funds that were available to UDOT." The concern that arose from this exercise, along with the challenge associated with the I-15 project described earlier, led UDOT to develop a more comprehensive asset management system.

When UDOT officials began the process of developing a comprehensive asset management program they began with the self-assessment survey that was part of the NCHRP 20-24 efforts on asset management. The survey was significantly modified by the Asset Management Team (UDOT and its consultant) to address specific shortfalls and concerns known to the AMT. The survey results were reviewed and presented to top management, an asset management strategy was developed, and an asset management implementation plan published. UDOT devoted considerable resources to thinking seriously about how to structure an assess management program for the challenges it was facing. As noted by several during the visit, "the pain of planning caused everyone to understand what was needed and perhaps more importantly why it was needed."

It is important to note here that UDOT's asset management strategy and asset management implementation plan was not directly targeted to implementing an asset management decision support tool, but rather towards implementing asset management best practice throughout the entire UDOT organization. Asset management involves initiatives throughout the Department of Transportation from design and construction to finance, operations and maintenance and not just the implementation of an asset management decision support tool (AMS). There must be a separate and distinct understanding of asset management and an asset management system as they are not one and the same. During the multiphase implementation of asset management within UDOT, the consultant referred to this as the Asset Management Paradox that states:

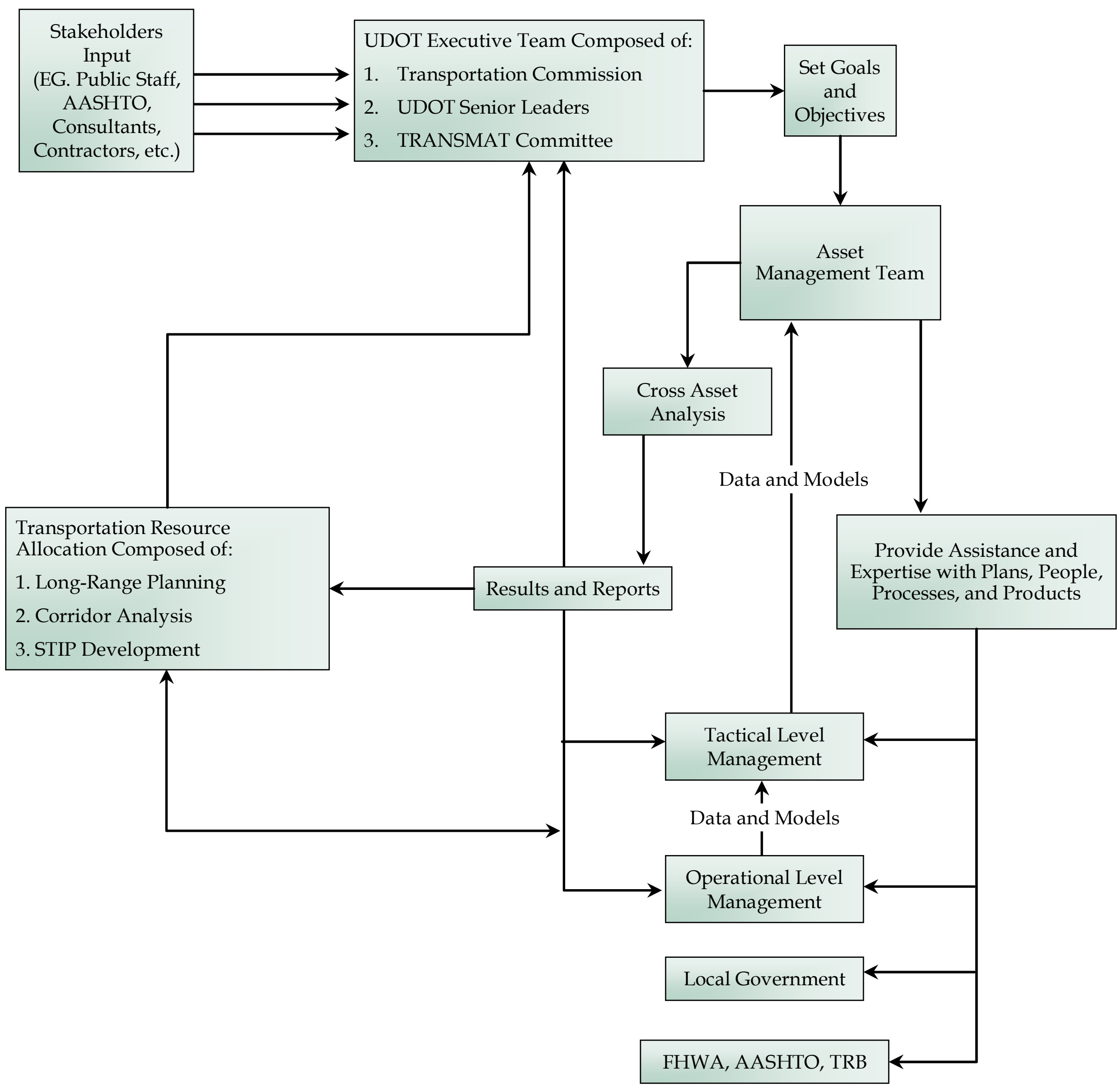
"*An asset management system cannot be implemented in any agency unless that agency first adopts best practice asset management.*"

"*An asset management system is not necessarily in itself good asset management*"

Figure 2.25 shows UDOT's approach toward asset management. Top officials are involved in establishing goals and targets for the asset management program. The Transportation Advisory Group, called TRANSMAT, consists of the UDOT assistant director, the planning and programming director, other division directors, regional office directors, the asset management team, asset group leaders, public involvement director, the comptroller, and a representative from the Federal Highway Administration. The

Asset Management Team consists of the asset management director, the asset management engineer, consultant support and the asset management systems administrator. An Asset Management Committee consists of the asset management engineer, and representatives from the pavement, safety, structures and maintenance units. Currently, the asset management team answers to the planning and programming director because UDOT management views asset management as a planning function that leads to a 10-year System Preservation Plan that is aligned with the Department's strategic goals.

Figure 2.25 Asset Management Approach in the Utah Department of Transportation



From a decision support system viewpoint, UDOT has identified the following roles for its asset management system.

Strategic – Asset management at the strategic level is used to make funding allocation decisions across asset groups. The asset management system (AMS) has been implemented within a commercially available off-the-shelf software package called dTIMS CT developed by Deighton Associates Limited. The AMS allows for a "stovepipe" type analysis for any asset (pavement, bridge, safety, maintenance, mobility, etc.) and allows for a "cross-asset analysis and optimization."

At present, UDOT utilizes the cross asset analysis and optimization functionality of the dTIMS CT asset management system using condition performance measures and Remaining Service Life (RSL). Other performance measures such as risk, asset value, written down replacement cost, delay costs, user costs, environmental impacts, societal impacts, and economic impacts have not been factored into the cross asset analysis and optimization at the present time (see below). In the future UDOT will increasingly rely on this technology once the additional cross asset analysis and optimization performance measures have been developed and approved by TRANSMAT. This strategic-level analysis uses an incremental benefit/cost optimization approach to determine strategic funding levels among asset groups. Data and model results from each of the lower-level asset-specific management systems are fed into the strategic-level asset management system for analysis.

UDOT Asset Management – Cross Asset Analysis and Asset Group Analysis
Benefit Weighting Multipliers

Performance Measure	1	5	10
Asset Value	Low Replacement Value	Moderate Replacement Value	High Replacement Value
Risk – Criticality	Low Risk Upon Failure	Moderate Risk Upon Failure	High Risk Upon Failure
Risk – Vulnerability	Low Vulnerability	Moderate Vulnerability	High Vulnerability
Risk – Safety Liability	Low Risk of Liability	Moderate Risk of Liability	High Risk of Liability
Risk – Environmental Impact	Low Impact	Moderate Impact	High Impact
Risk – Economic Impact	Low Impact	Moderate Impact	High Impact
Risk – Societal Impact	Low Impact	Moderate Impact	High Impact
Mobility	Low Impact	Moderate Impact	High Impact

The AMS is capable of utilizing asset value or any other performance measure with the analysis and the optimization, but UDOT has not yet implemented any asset valuation models within the AMS. UDOT has considered "Written Down Replacement Cost" as one method, but has formed no conclusions on its application within the AMS.

UDOT currently is investigating a benefit model that allows UDOT to weigh the importance for each asset of the following criteria and may approve this weighting system that currently is implemented within the AMS but not yet approved for use in the cross asset analysis and optimization.

UDOT leadership and asset group managers as of yet have not evaluated the network assets and ranked them according to the benefit weighting modifiers but will complete the exercise in the future if the weighting methodology is approved.

UDOT's asset groups have used condition and performance monitoring and design standards to determine the life cycle of assets that are included within the respective management systems. For example, asphalt pavements are assumed to have a design life of 30 years and concrete pavements a design life of 40 years

Tactical – Asset management at the tactical level involves separate management systems designed and implemented for each specific asset. Funding allocation decisions and project recommendations from the strategic level are passed down to the tactical-level management systems to form the basis for more asset-specific analyses. Within each asset group, the performance measures of each asset are used to determine the effective mix of preservation and rehabilitation funding. These performance measures at the tactical level may be different than those at the strategic level as the asset management system matures over time. The asset groups use their respective management systems (Pontis and dTIMS CT for structures, dTIMS CT for pavements, etc.) to determine recommended projects for each individual asset. During this tactical analysis, incremental benefit/cost optimization is used to determine recommended projects and to compare preservation strategies, repair strategies, rehabilitation strategies, and replacement/reconstruction against one another to come up with the optimum strategy of one or more treatments for an asset within the analysis timeframe. Life-cycle costs are used to determine effective funding needs for each asset group.

Operational – Asset management at the operational level involves decision support tools that outline the recommendations from the strategic and tactical levels and allow for routine maintenance decisions to be captured and maintained on a per maintenance section basis. This tool, called the "Plan for Every Section," is a database that contains the semiannual inspection information for each maintenance section, the recommendations from the tactical and strategic-level asset management systems and the routine maintenance schedule based on condition and treatment life data in the Plan for Every Section database.

UDOT has relied on consultant support to develop and implement its Strategic Highway Transportation Asset Management System. The contract was defined with the following tasks: 1) develop and document a framework establishing an autonomous process allowing UDOT to practice asset management immediately and grow the framework into a fully implemented Strategic Highway Transportation Asset Management System; 2) integrate data, models, stakeholder input and the best practices for asset management within the existing UDOT environment; 3) demonstrate this framework is capable of performing cross asset group analysis in support of UDOT's strategic decision-making process; 4) demonstrate the framework is capable of supporting operational-level management systems planning and programming operations; and 5) implement the best practices in asset management from worldwide experience within the existing UDOT organization.

An important component of UDOT's asset management system is in the way costs, and more interestingly, cost uncertainties are incorporated into the analysis. At the strategic level, cost uncertainties are accounted for by using weighting factors on costs appropriate for each asset type. For example, bridge projects have a large cost variability and therefore a higher estimated cost to deal with the uncertainty in costs from the time the project is conceived to the time the project is completed. For bridges, the costs are increased by 50 percent of the total estimated cost for the project, which includes PE, CE, mobilization, traffic control, roadway costs, and contingency funding. For pavements, costs (which include actual pavement costs plus mobilization, public information services, traffic control and striping) are increased by 15 percent; unit costs are not increased for maintenance and safety projects. UDOT currently is looking at developing one method that will account for cost variability for all project types.

UDOT has just begun to look at user costs on a network-wide basis as a result of the *Good Roads Cost Less Study* update undertaken in the past year. User costs are calculated for each pavement section in the network and reported in the study. At present, the user costs currently are not factored into the incremental benefit/cost optimization neither at the strategic level nor at the tactical-level asset group analysis. They might be used in the future if the UDOT management determines that user costs are an effective measure for determining funding allocations and project priorities.

The AMS implemented in dTIMS CT provides the capability to conduct scenario analysis to determine the effects of different funding levels on system performance. For example, UDOT can adjust the budgets for each budget category (e.g., $140 million for rehabilitation and $40 million for pavement preservation), or UDOT can supply one overall budget $180 million for pavements and let dTIMS CT determine the optimum distribution between preservation and rehabilitation needs. UDOT can change the objective function for any scenario, which allows UDOT to determine optimal investment programs based on achieving performance as defined by a cost index, remaining service life (RSL), savings in maintenance costs, savings in user costs, increase in asset value or any other objective function (determined by the agency).

UDOT also can change deterioration rates, treatment triggering mechanisms, traffic growth rates and any other parameters for any of the asset groups included within the AMS to see the results on the network performance for any of the performance measures and objective functions implemented within the AMS. As an example, if UDOT changed the minimum time between successive overlays from 8 years to 10 years, what is the impact on pavement performance and what is the impact on RSL over the analysis period? UDOT can investigate the impacts of this change on each performance measure for the asset, the budget distributions, and the preferred treatments across the network and many other measures that are available within the AMS.

When UDOT updated the *Good Roads Cost Less Study*, UDOT configured the UDOT PMS in dTIMS CT to conduct over 23 different separate and distinct analyses with varying parameters to determine the impacts on 11 different performance measures, including user costs, RSL, crash costs, treatment costs, overall condition indexes, and several other performance measures.

As can be seen from this discussion, UDOT has implemented a comprehensive structure of data-driven and analysis-based decision support tools that help agency officials identify the best mix of investments for the State's road network. The approach is very robust in providing a range of analysis capabilities, and is based as much as possible on accepted project evaluation methods, such as benefit/cost analysis.

Asset management at the local level within Utah is relatively independent from influence by UDOT. If communities want help in developing their asset management program, they utilize the Utah Local Technical Assistance Program (LTAP) Center. The Center will work with communities desiring asset management to collect data on the configuration, condition, and performance of locally owned roadway infrastructure and then help the locality develop its own reinvestment programs using LTAP's decision support software.

With respect to future activities, UDOT's vision for its asset management system in three to five-year's time is that it will be:

- Integrated, where funding allocation decisions are broad-based across various asset categories;
- Automated, so that funding allocation decisions are generated in a more systematic, repeatable and objective manner;
- Expanded, to include other network assets other than just pavements and bridges; and
- Accessible, to all UDOT stakeholders through the Internet or other communication media.

Management and Data Systems

As noted above, there is a strong relationship between the strategic-level decision-making support system and the more tactical-level, asset-specific management systems. Data and analysis results are exported out of the respective asset group systems and loaded into the strategic-level asset management system. Integration of data and analysis is completed at the strategic level and UDOT management has the ability to perform scenario analysis in the AMS where results can be viewed on the screen, printed, exported, or viewed in the UDOT GIS.

At the tactical level, each asset group has its own unique management system individually suited for the particular asset being maintained.

- **Pavement Management System (PMS) –** The PMS has been implemented in dTIMS CT, the same commercially available software package that has been used to implement the AMS. Thus, the transfer of data and model runs between the PMS and the AMS is easy and seamless. UDOT uses its own crew and equipment to collect pavement data, an effort that covers approximately 5,900 state highway miles (about $400,000 annual work program budget). UDOT uses a high-speed profiler, lock wheel skid tester for collecting the data.
- **Bridge Management System –** UDOT uses Pontis to store, enter, and maintain the state bridge database within Oracle. This data is exported from Pontis to dTIMS CT

for analysis at the network level. The results from the network-level analysis, project-level Pontis analyses and manual methods are used to determine the recommended bridge preservation and rehabilitation/replacement program. Bridge data are exported from Pontis based on route and mile point and imported into the AMS for analysis.

- **Maintenance Management –** The maintenance unit utilizes three management systems: a Maintenance Management System (MMS), a Maintenance Features Inventory (MFI) system, and a Maintenance Management Quality Assurance (MMQA) system. The MMS is used to plan activities and track the use of labor, equipment, and materials for those activities. MFI and MMQA (developed in-house) store the features inventory data and provide for quality assessments of different maintenance groups and activities. Within MMQA, users can determine what performance was achieved in the previous year and the estimated funding needed to meet a given performance goal. All three of these systems will be incorporated into a single Operations Management System (OMS), currently under development using commercial off-the-shelf software. Integration of the OMS data with the AMS will be a goal for both the OMS and AMS systems.

- **Accidents and Safety –** The raw crash data records are exported from the Central Accidents Record System (CARS) database into the AMS for analysis. The AMS calculates a safety index for each one-mile section of pavement within the network and recommends safety spot improvements based on strategic-level funding allocations. The recommendations from this analysis are used by the Traffic and Safety Division to prioritize safety projects throughout the State.

Integration of data takes place within UDOT's asset management system (AMS) by importing and exporting data from each separate management system. In the future, the completed development of a corporate data warehouse by UDOT and the development of the location referencing system engine will facilitate easier data integration within UDOT. The AMS will pull the most recent data out of the data warehouse for analysis as opposed to each individual management system.

The types of data collected by UDOT for input into its management systems include the following:

- **International Roughness Index (IRI) –** The IRI is used by UDOT's regional offices as a tool to prioritize projects, and is UDOT's primary condition measure. Data on state highways are collected per year. The IRI is measured directly in inches of vertical roughness per mile of pavement. Vehicle-mounted accelerometers over each wheel path are used to measure the roughness over the full length of the section. The values reported are the "Half Car Simulation" IRI, which factors both left and right wheel path IRI values, indicating the overall ride quality felt by vehicle occupants, not the roughness of individual wheel paths. IRI data quality checks occur during collection by using the running average of the last 100 inches/mile readings. A running average that falls outside +/-1.0 standard deviation (Std) will require data collection to stop and be evaluated.

- **Rutting –** Rutting data are used by the regional offices as a tool to prioritize projects and also is used in system-level evaluation. Rut measurement is the average of the rut depths in both wheel paths, assuming the road is otherwise flat. The data collection cycle is the same as for the IRI with a similar quality control strategy. A running average that falls outside +/-1.0 Std will require data collection to stop and be evaluated.

- **Faulting –** The fault measurement is the total number of faults in the right wheel path with a magnitude of 0.1 inch or greater in width, and at least 0.1 inch in depth. The fault index is calculated by summing the magnitudes that are greater than 0.1 inch, and dividing by the total number of faults in one section, a section usually being represented in one-mile increments. In other words, the fault index is the average fault height for all faults over 0.1 inches for each section. The fault data are used by the regional offices as a tool to prioritize projects, as well as being reported for system-level evaluation of pavements. The data collection schedule is the same as the previous two data items, as all three are collected simultaneously by the same equipment. A running average falling outside +/-1.0 Std's will require data collection to stop and be evaluated.

- **Skid –** Skid numbers for pavement sections range between 0 and 100. UDOT considers values above 45 to be standard, 35 to 45 approaching an evaluation level, and those below 35 to be considered for further evaluation. The skid values reported have been normalized to 40. Each regional office receives a listing of pavement surfaces falling below standard and this information is then used as a tool to prioritize projects. Data are collected on one-half of the state road system each year (more than 3,390 miles). A running average of the last 100 readings that falls outside +/-1.5 Std will require data collection to stop and be evaluated.

- **Falling Weight Deflectometer (FWD) –** FWD readings (corrected for temperature and normalized to 9,000-pound load), are collected at each milepost. These data are used by the regional offices in pavement design calculations, and they also are reported at the system level for overall structural condition evaluation. The FWD also is being used to collect load transfer information on PCCP. Data are collected on approximately more than 1,800 miles per year of the state highway network, including the load transfer testing on the PCCP. FWD data quality checks occur during collection. Any sensor's running average over the last 100 readings falling outside +/-1.0 Std's, requires data collection to stop and be evaluated.

For bridges, bridge location is defined in many different ways ranging from State Route and milepost to GPS coordinates, county, maintenance shed number, etc. UDOT collects its bridge data in the field using laptop computers, handheld devices, and desktop computers. In addition, UDOT is in the process of linking its photographs, correspondence, and bridge plans to the inspection data using web links and document management systems. These data are being used in a variety of ways not only for asset management, but also for permit routing and emergency management.

The QC/QA process for bridges involves such strategies as rotating the individuals doing inspections, quality control reviews, and independent quality assurance reviews.

With respect to maintenance, a maintenance management system includes data on the following assets and activities: delineators, signs, pavement striping and marking, guardrail and barrier, shoulder work, erosion repair, fence, inlets, ditches, curb and gutter and islands, litter pickup, weed control, vegetation obstruction, mowing and sweeping. These data are placed in a database called Maintenance Management Quality Assurance (MMQA).

Transportation technicians in each of the maintenance sheds collect MMQA data for their shed. Where feasible, data collection is piggybacked onto other work. Costs for data collection are generally not broken out from other station costs. Although an activity code was created at the beginning of FY 2006 to try to capture those costs, the code was not generally used. Also, much of the data collection effort is done during the course of other work. No benefit/cost analysis has been done to determine how beneficial the data collection effort has been.

The "Plan for Every Section" database tracks both planned and completed pavement preventive maintenance activities. Emergency maintenance on pavements is tracked inside the maintenance management system, identified by milepoint. Planned or emergency maintenance on roadside features is identified as well by location, not by individual asset.

The UDOT quality assurance plan for MMQA consists of teams from the central office making an independent survey on a single stretch of road in each maintenance station on a two-year cycle. The station is asked to perform its own survey on the same stretch the day before the QA team arrives to do its survey. When the QA team completes its survey, they meet with the shed personnel to compare results, highlight areas where there were differences, and conduct training in standard procedures.

In the future, the Maintenance Features Inventory (MFI), Maintenance Management Quality Assurance (MMQA), and the Maintenance Management System (MMS) are expected to be integral parts of a new Operations Management System. Field technology will operate using a mobile data collection module using either PDAs or Tablet PCs or similar devices. These will be integrated to a GIS map base, and will use GPS to identify and record locations of features, events, and activities. The system will include a highly developed work management system, which will update the feature (asset) inventory as work orders are completed and recorded using either the mobile technology or the desktop application itself. The OMS will be detailed enough to target culverts and roadside hardware.

The different asset management systems, when integrated together under the asset management system (AMS) framework, provide UDOT with the capability to produce a program of investment that best utilizes the limited resources available for system preservation. Figure 2.26 shows the optimization procedure that is integral to the AMS. The analysis variables for pavements include a concrete index, faulting index, joint spalling index, cracking index, ride index, and a wheel path cracking index. The analysis variables for structures include a culvert index, deck index and deck remaining service life (RSL), superstructure index and superstructure RSL, substructure index and substructure RSL, sufficiency rating, overall condition index and overall RSL. Benefits currently are calculated based on an overall condition index, but UDOT is investigating alternative benefit models such as RSL, asset value, user costs and total transport costs.

Figures 2.27, 2.28, and 2.29 illustrate the types of analyses that can be conducted within the AMS framework at UDOT.

Figure 2.26 Optimization Approach in UDOT's Asset Management System

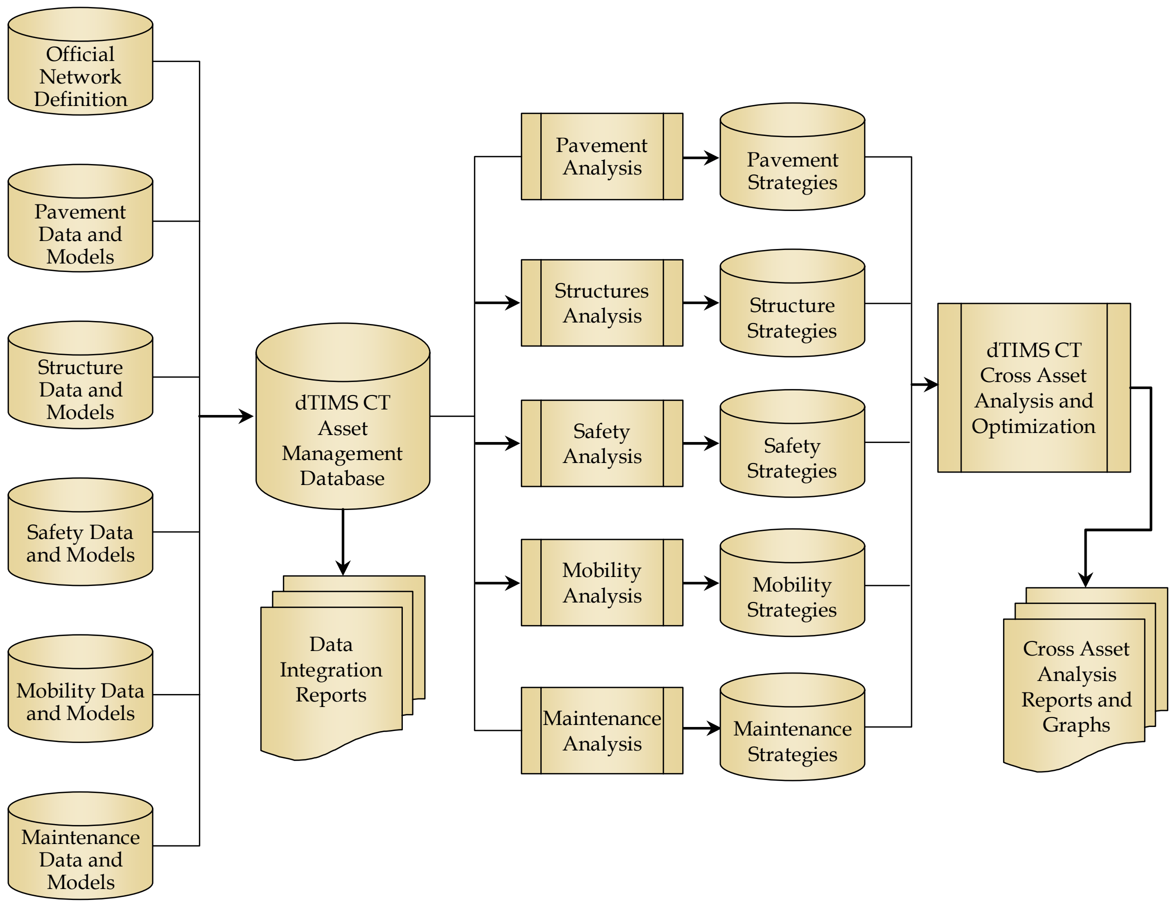


Figure 2.27 Remaining Service Life for Structures, UDOT

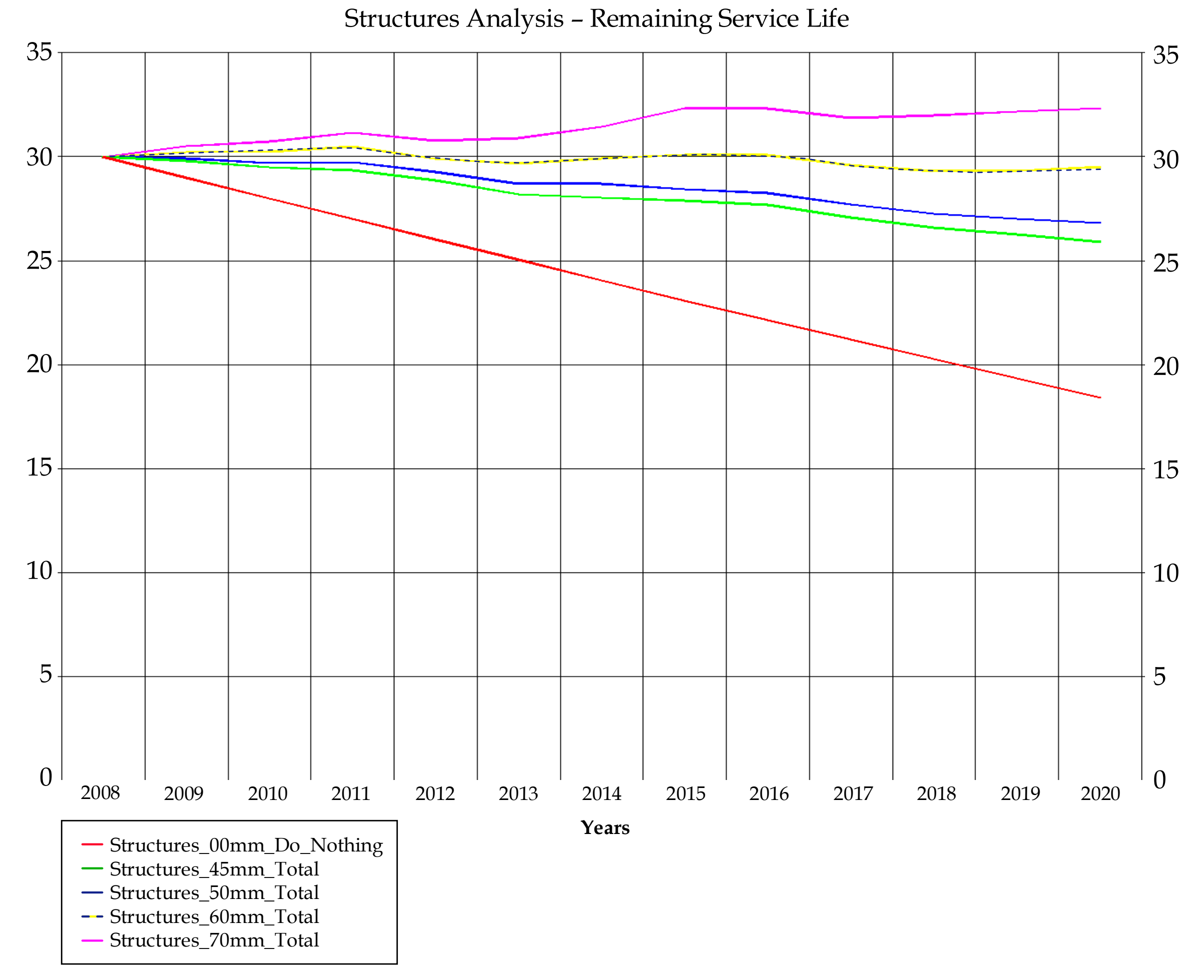
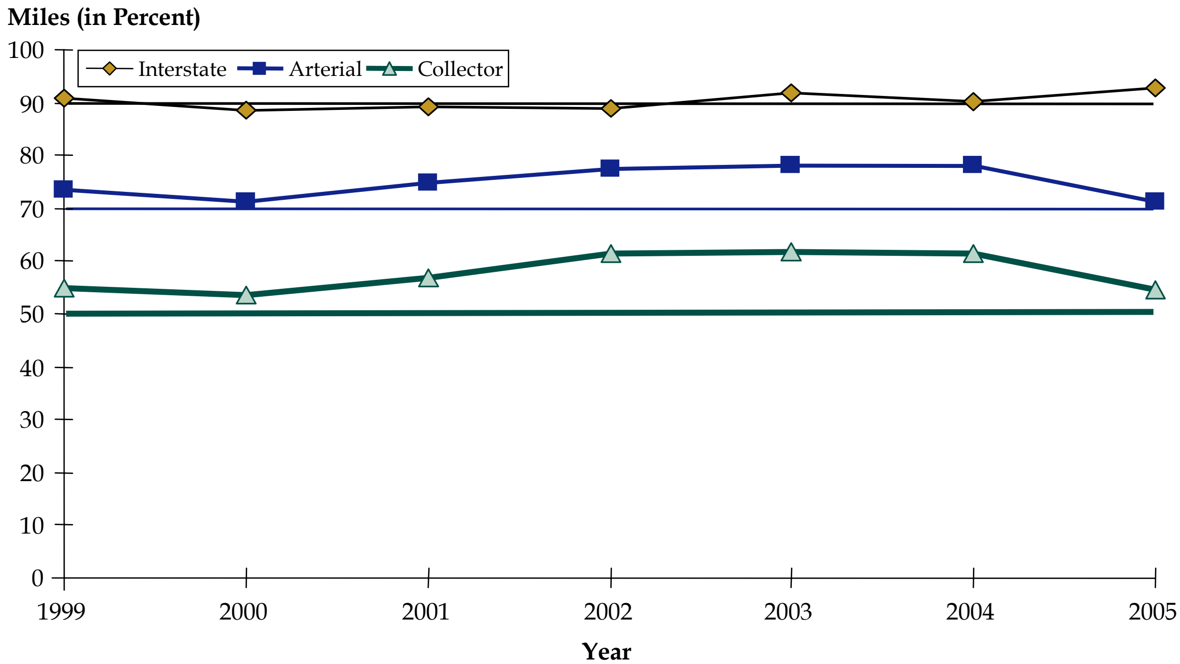
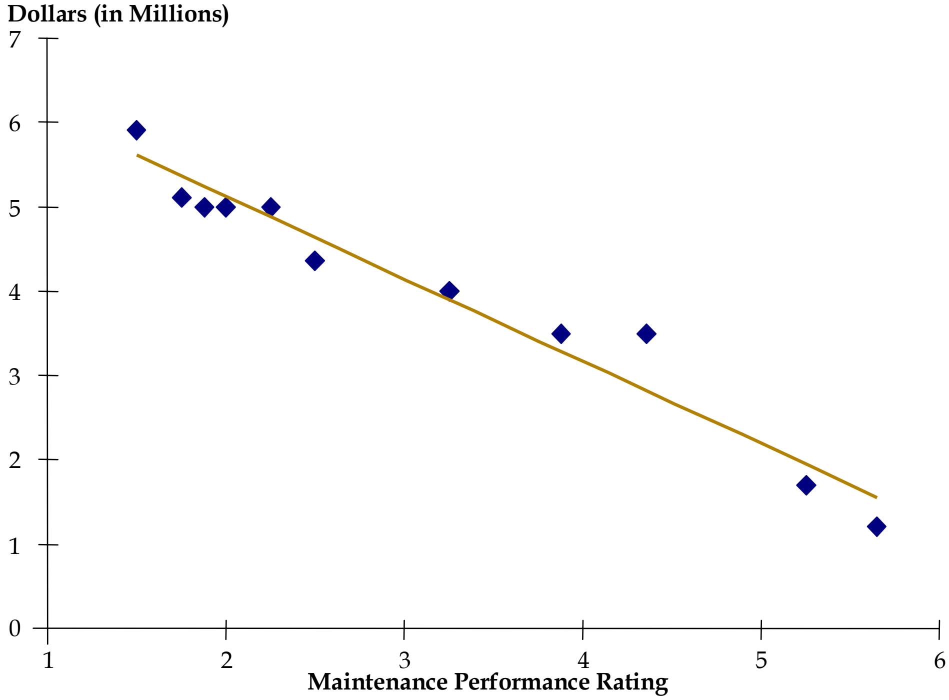


Figure 2.28 UDOT's Pavement System Monitoring



Note: Based on half car IRI and RI Index.

Figure 2.29 Relationship Between Maintenance Performance and Funds Expended
UDOT



One of the interesting aspects of the project selection process at UDOT is called the "harmonization" process. This final step in selecting a program of investment consists of a manual process of examining all of the projects that have been selected for investment over the programming timeframe to determine if there are some projects that can be combined or perhaps maintenance deferred (if a capital project is soon to occur at that site). This effort is intended to apply engineering judgment to selecting the best (or in the terms of UDOT, optimal) package of investments. As noted by UDOT officials, the benefits of the harmonization process included:

- Taxpayers and the traveling public see everything being done at once (less inconvenience);
- Reduced costs due to sharing of traffic control expenses;
- Pavements, bridges, safety are considered equally;
- Provides an approach for better future planning; and
- Based on engineering and economics (it is a fundable and viable construction program).

Results of the System Preservation Strategy

In many ways, the UDOT system preservation program is still in an evolutionary stage. According to UDOT officials, the major benefits so far of its asset management approach are that it has:

- Established a hierarchy for funding allocation among the four strategic goals;
- Optimized a preservation program aimed at achieving stated goals or performance measures;
- Developed an investment program that harmonized all four strategic goals; and
- Established credibility and trust in UDOT program decisions.

The state legislature has provided additional funds to UDOT for investment in the State's road system; however, all of these funds were dedicated to capacity expansion. UDOT officials believe that their asset management program provided a level of assurance to state legislators that the existing state roads are being systematically monitored and that the most cost-effective investments are being made to preserve the system. This has provided a high level of confidence in UDOT's ability to produce with the funds it is given.

UDOT officials also view another major accomplishment being the understanding that UDOT officials themselves have of asset management and the importance of preserving the current system as much as possible.

Lessons Learned

UDOT officials identified several lessons they have learned over the course of implementing their asset management program. These included:

- The self-assessment survey is only a "menu" of best practice components. What is best for your own organization can only be determined by the individuals within the organization itself, along with key stakeholders outside the agency.
- Survey respondents will take an active role in implementing the selected best practice components. The self-assessment survey catalyzed several officials within UDOT to become champions for asset management. When survey respondents see the results of the survey being implemented, many will understand the reasons for the efforts being undertaken.
- An asset management system is just one part of asset management. A computer-based data management system augmented with analysis capability is a very important enabling tool for an agency's asset management program. However, truly effective asset management requires organizational structures, operating procedures, human resources (and training), and clear authority be in place to serve as the foundation upon which an asset management program can be built.

- An asset management strategy and plan will cover many years; adoption will not happen overnight. In UDOT's case, they have been developing their most recent advancements in asset management over the past five years, and have several more years to go.
- It is important to communicate clearly to decision-makers so that they understand the urgency of system preservation. If presented effectively, the logic and facts of system preservation speak for themselves.
- UDOT has established an understanding with the legislature that pavement and bridge preservation projects will not compete against one another from the perspective of regions or legislative districts. Threshold target values for asset condition determine whether a project will be built.
- The characteristics of an effective asset management plan include keeping it:
  - Simple;
  - Understandable;
  - Easy to follow;
  - Flexible;
  - Close to the end user;
  - Goal driven; and
  - Reporting on progress.
- The champions for asset management should be:
  - A communicator;
  - Respected;
  - A believer in process;
  - Willing to take chances;
  - Able to give credit to others; and
  - Continually teaching others.
- There is no "silver bullet" solution.

The UDOT case provides a very good example of a state DOT that has made a commitment to start on the asset management path, and has made very impressive progress. The evolution of its asset management system, and the abilities of this system to provide useful information to agency decision-makers, is an important element of UDOT's success to date. UDOT is one of the few transportation agencies in the United States that has incorporated a cross asset optimization step in its planning process using condition performance measures. The simple fact that UDOT officials are thinking along these lines puts UDOT in a good position to surpass other states in their asset management practices when this step is fully implemented using various additional performance measures.

As with other cases, the existence of strong top management support for asset management and the understanding of its purpose and contribution by key decision-makers both within the agency and in the state legislature provide has been instrumental in UDOT's success.

For further information, see: http://www.udot.utah.gov/index.php/m=c/tid=982.

3.0 Local Agencies

3.1 Hillsborough County, Florida

Context

Hillsborough County, the location of Tampa, Florida, has approximately 1 million people in an area of 1,100 square miles. As one of the fastest growing counties in the country, Hillsborough County has been experiencing tremendous demands on all of the infrastructure for which it is responsible (an estimated asset value of $5.8 billion), including 3,000 center line miles of paved roadway (288 miles of principal arterial roads). The county's growth is best seen in the fact that the road network grows by about 120 lane-miles and 30,000 people each year. In addition to the roads, the County is responsible for 1,880 miles of sidewalks, 246 bridges, 14,155 intersections, 86,574 signs, and 63,123 storm mains and culverts. In recognition of the need to provide a coordinated approach to managing the county's infrastructure, the Hillsborough County Public Works Department was created in 1996. One of the first things the new Public Works Director did was examine ways of implementing an asset management program for the county that could support the investment decision-making process in the county.

Investment Decision-Making Process

The 2006-2011 public works capital improvement budget is $158.4 million, with 90 percent going to transportation projects and 10 percent going to storm water facilities. The annual operating budget for Public Works is approximately $70 million per year. The County Board has adopted a policy that infrastructure preservation should receive first priority when funds are allocated to the transportation and storm water systems. Even with this, the county is facing tremendous pressure on its infrastructure given the substantial growth it is facing in population growth. Thus, although county officials have adopted a system preservation first policy, they often find themselves defending it when faced with requests for new roads or drainage systems. One of the ways of providing service to new residents has been to add requirements to development approvals that give the responsibility to developers and/or owners to preserve the assets that are in their subdivision.

The county's asset management process supports many different types of infrastructure investment decisions that are made by county officials. For example, Table 3.1 summarizes the types of county investment programs that use information from the asset management system.

Table 3.1 Hillsborough County Investment Programs

Transportation	Storm water
• Road widening	• Storm water atlas
• Bridge	• NPDES permit program
• Intersection improvements	• Storm water master plan
• Sidewalks	• Storm water modeling
• ADA ramps	• Storm water improvement program
• Road resurfacing	• Enhanced storm water maintenance
• Traffic operations	
• Safety improvements	
• Bicycle lanes/shoulders	
• Major street lighting	
• Enhanced roadway maintenance	

County officials have incorporated economic analysis tools into investment decision-making as much as possible. Life-cycle costs are used in decisions relating to pavements, bridges, and storm water assets, and benefit/cost analyses have been incorporated into the planning and evaluation of individual projects.

One of the points emphasized by county officials was the difficulty evolving from a "worst first" investment philosophy to one based on asset management. This was a difficult concept to convey to public officials and local residents who often could not understand why one road was receiving treatment when another road that was in worse condition was not.

"Divorcing yourself from the 'worst first' investment strategy is hard for local officials to understand, but in the long run is the most cost-effective use of the public's dollars."

…Hillsborough County Official

In addition, county officials pointed to showing compliance with Government Accounting Standards Board statement number 34 (GASB 34) as another benefit of having an asset management system in place. In fact, it was the need to show compliance with GASB-34 that caused the county to think differently about its approach toward asset management. The condition and system preservation standards that were adopted as part of the asset management response to GASB 34 were officially adopted by the County Board.

Although the Public Works Department is the primary developer and user of the asset management system, one of the biggest supporters of the system has been the County Budget Office because they view this program as having an influence on the county's bond rating.

Asset Management Approach

Hillsborough County started in the late 1990s to develop a comprehensive asset management program. This was partly in response to the then state of decision support for public works decisions. The Department had a geographic information system (GIS) system, but it did not include a complete inventory of assets, their location, or their condition. The different asset categories had different types of analysis tools, most very simple, that did not allow county officials to estimate future budgetary needs for county infrastructure.

The process of developing a more comprehensive and systematic asset management program was very much based on the concept of decision support. Management teams were created to assess the then current status of information support and infrastructure decision-making. The types of information used at that time to determine an investment strategy largely included historic line item budgets, citizen complaints, and requests from political leaders.

The asset management program that surfaced from this assessment is known as the Hillsborough County Asset Management System (HAMS). HAMS is a management information system that includes an inventory of all infrastructure assets and their current condition, and allows county officials to estimate needed investments for system preservation. Three asset categories were defined early on in the development process: roadway (e.g., traffic devices, pavements, markings, lighting, bridges and intersections, signals); roadedge (e.g., sidewalks, shoulders, curbs and gutters, inlets, and driveways); and road side (e.g., storm water pipes, ditches, and other right-of-way features). In order to implement HAMS, the county relied on consultants to both develop the overall management information system and to collect inventory and condition data. From 1999 to 2000, more than 20,000 miles of linear assets and 500,000 point assets were incorporated into HAMS.

The basic inventory created in 2000 still serves as the foundation of HAMS today. New inventory data are included when new roads or road-related appurtenances are added to the asset base. The public works department has two inspection teams in the field at all times updating condition data of the county's infrastructure assets. The Department has four maintenance units located in the county, and each unit has an asset coordinator who is responsible for knowing the condition of the assets in that unit's service area.

Management and Data Systems

HAMS integrates information obtained from several different sources. Thus, for example, bridge inspections are conducted every two years and reported to the Florida DOT (FDOT). HAMS is linked to the FDOT bridge database and relevant data for Hillsborough County bridges are imported into HAMS. The county is developing a Hillsborough County Appraisal Rating (HCAR) scheme that assigns weights to four different characteristics of the county's bridges – structural capacity, FDOT sufficiency ratings, the "essentiality" of the bridge with respect to the road network, and safety. This system is intended to provide more detailed information that will assist in assigning priorities to bridge improvements.

A pavement management system is used to identify the most cost-effective treatments for the county roads. The GIS-based program provides a candidate list of road segments where some form of treatment is necessary. This list is based on assumed deterioration of pavement surfaces whose original condition was part of the initial HAMS road inventory. Candidate road segments are field verified by department technicians. A Road Condition Index (RCI), which rates pavements on the basis of 1 to 10, is used to develop the condition information.

Intersection improvements are prioritized through the use of benefit/cost ratios. In this case, the benefits are defined as the change in the number of crashes and the reduction in vehicle delay (and the corresponding monetary value of both).

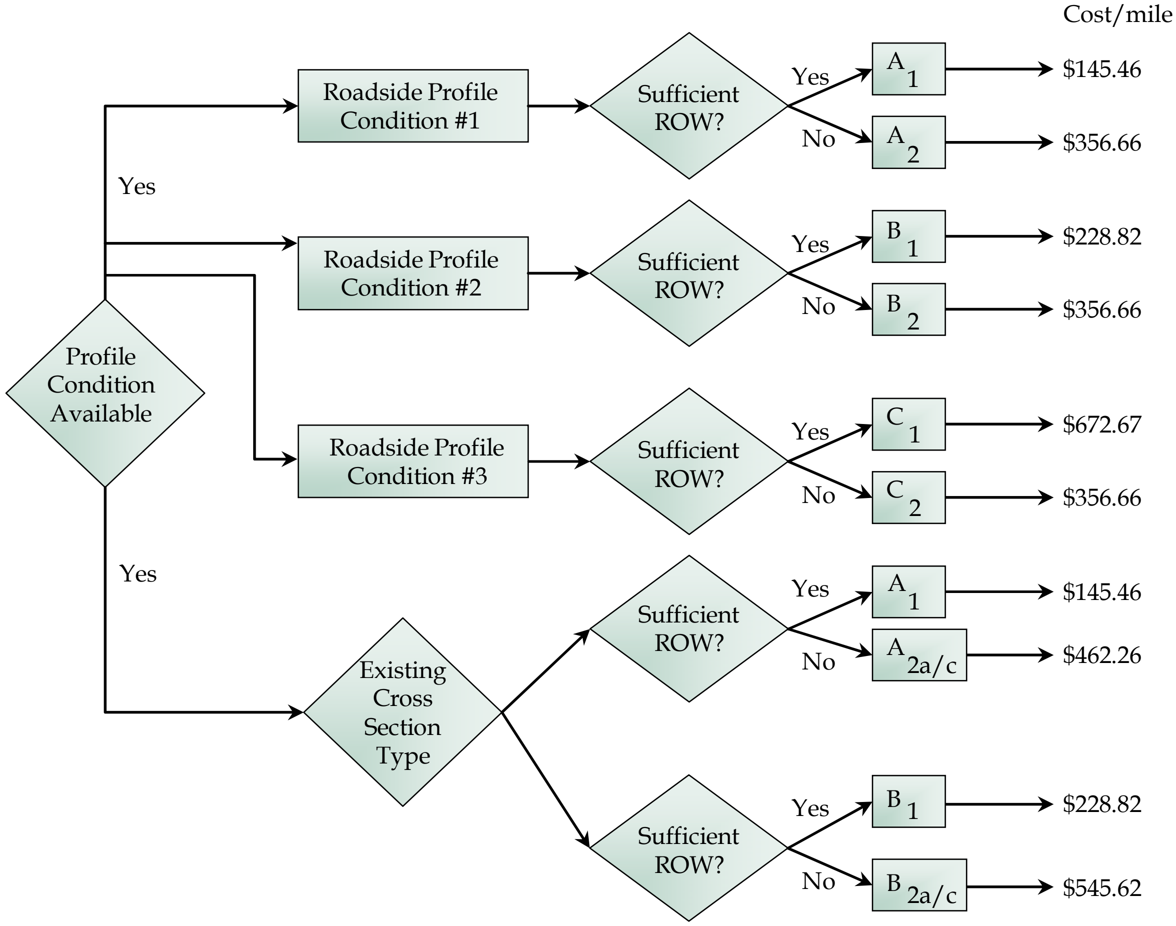
For sidewalks, the Department had been using a benefit/cost analysis to determine the most cost-effective investment strategy, but is now adopting a scoring tool, which assigns weights and scores to such things as proximity to transit services, distance to schools and sidewalk condition. There are 12,000 sidewalk segments in HAMS, and the county has allocated $3.3 million for sidewalk expansion and preservation. The new "safe-routes-to-school" program has been one reason for an increased interest in sidewalk investment in the county. Sidewalks undergo a visual inspection and are rated as good, fair or poor. Figure 3.1 shows a cost decision tree that is used to determine the most appropriate strategy for sidewalk investment decisions. The rectangles on the far right of the figure represent potential work activities.

The county has a traffic sign database that includes condition data (e.g., retro-reflectivity measures) and will soon have a database for traffic signals.

Visual inspections are conducted of storm water structures and roadside ditches. The inspection assesses each on the degree of blockage, structural deficiencies, and overall condition taking note of cracks, missing covers, etc. on the basis of 1 to 5. Any structure receiving a combined score of less than 8 receives a more detailed investigation.

It is interesting to note that in all of the asset management areas except for bridges, the deterioration of the asset is based on very simple curves associated with expected lives of the asset; no degradation models have been incorporated into the analysis.

Figure 3.1 Cost Decision Tree for Sidewalk Investment
Hillsborough County, Florida



Results of the System Preservation Strategy

Public works officials identified several benefits of the asset management program. First, they have concluded that HAMS has been a very effective tool in developing an investment portfolio that is defensible and convincing to local decision-makers. This credibility in the program has resulted in additional dollars being allocated to system preservation and to the transportation system by the County Board.

Second, the credibility of the Public Works Department has been enhanced in the eyes of the general public because it can show in understandable ways what the proposed investment is going to produce. Thus, Public Works officials feel that HAMS has had a very positive impact on communication with the general public.

Third, HAMS provided Hillsborough County with a rapid capability to respond to the GASB 34 requirements, and in fact, was singled out by GASB for its rapid response.

Fourth, Hillsborough County officials believe that the existence of a comprehensive asset management program has had an important influence on the county's bond ratings. Similar to the case with the Florida Turnpike Enterprise, bond rating agencies look for good management practices in preserving existing infrastructure and HAMS provides such a capability.

Fifth, Hillsborough County is prone to hurricane damage, and HAMS provides county officials with a strong capability to determine potential locations of flooding and the characteristics of the assets (e.g., signs) that were destroyed in the storm. County officials believe that in storm water areas, in particular, the existence of HAMS lowers the risk associated with catastrophic failures, and thus results in lower insurance rates (such as in the flood ratings from the Federal Emergency Management Agency).

Lessons Learned

Hillsborough County illustrates several interesting characteristics of a local government's asset management strategy. Most importantly, the county has adopted a multimodal perspective for its asset management program, that is, the transportation assets covered by HAMS include roads, bike paths/shoulders, sidewalks, and bridges (it is not responsible for transit services). In addition, HAMS includes drainage structures that can be used in combination with the transportation assets to undertake analyses of where the transportation system might experience problems with a large storm. The comprehensive nature of the asset management program also fits in nicely with the adopted county policy of preservation first, even though the county also has had to address the need for additional infrastructure associated with new developments (such as developer agreements for maintaining assets on their property).

The Hillsborough County experience also shows how a local government can overcome a "worst first" philosophy on where county dollars should be spent by educating local officials on why an asset management program is a more cost-effective strategy. As was pointed out by county officials, this is not an easy thing to do. By largely staying with the asset management program, the county has developed a level of public credibility in its investment decisions that did not exist many years ago. In addition, the existence of HAMS and the policies that serve at its foundation have had a positive financial impact on the county through the bond ratings that it has been able to secure for its borrowing.

Finally, although the county collects condition data on a periodic basis for all of its transportation assets, it has been able to base its asset management efforts on the original inventory collected in the late 1990s. This suggests that very useful information can be obtained from comprehensive asset management programs that are established with a base inventory, and then updated periodically or as the need arises.

3.2 Kent County Road Commission, Michigan

Context

Many local jurisdictions in Michigan have initiated asset management programs, partly in response to a state-level effort to promote more effective strategies for preserving the State's road system. The Kent County Road Commission (KCRC) in Grand Rapids, Michigan, is one of the most advanced agencies in considering asset management as part of its road investment strategies.

In 1909, the Michigan legislature created road commissions in every county in the State to be responsible for all county roads. These commissions are not part of the county government, and thus do not report to county officials (and are therefore theoretically not beholden to local politics). County road commissions maintain all aspects of construction and maintenance for 72 percent of Michigan's roads (approximately 90,000 miles), and 65 commissions maintain state highways under contract with the Michigan DOT.

The Kent County Road Commission is responsible for maintaining all county primary and local roads, and by contract, the state highways in Kent County. The primary source of funding for the Road Commission's road program is the state gas and weight tax receipts that are distributed to the Michigan DOT, road commissions, cities and villages with a formula based on highway mileage, population, and vehicle registration.

Given that the activities of the Road Commission occur within much broader governmental relationships (such as with the MPO), the approach adopted for determining investment priorities must occur in a coordinated and collaborative manner. Thus, in urban areas such as Kent County (Grand Rapids is a designated transportation management area under Federal law and thus the MPO has planning requirements that must be fulfilled), a road commission will often have some relationship with the local metropolitan planning organization to establish programming priorities for major projects and for projects funded with Federal dollars. In high-growth areas such as Kent County, a key challenge for a road commission is providing sufficient funding to preserve the road system while still handling the infrastructure needs of a fast growing county. In Kent County, for example, the population is expected to grow by 21 percent by 2025 (to a population just over 700,000) with a resulting 32 percent increase in vehicle miles traveled.

Investment Decision-Making Process

The Kent County Road Commission has established three priority management areas for the primary road system: safety, system preservation and corridor reconstruction and expansion. A 10-year strategic investment plan targets future system condition (as determined through a pavement management system), identifies specific reconstruction and expansion projects, and establishes investment levels for preservation, expansion, reconstruction, safety and bridges. As noted in the Commission's Long-Range Vision statement, the goal for the preservation program is to "achieve 70 percent of the road system (being) in "good condition" by 2016 through preservation and reconstruction activities." With respect to bridges, this same statement identifies the Commission's goal as being, "maintain good bridge conditions through annual inspections and timely investment in repairs." This strategic investment plan is developed with substantial interaction with many other stakeholders in the county, including the MPO technical committees, township officials, the county board of commissioners, the chamber of commerce, as well as being presented on local television.

A five-year primary road improvement program is updated annually with schedules of major reconstruction and capacity expansion projects, lists of significant resurfacing projects, and estimated investment levels for preservation, intersection safety and bridges.

An annual budget provides a comprehensive list of planned revenues and expenditures for all Road Commission activities, and identifies specific road improvement projects that will be undertaken during that year.

Where capital funds are being expended on major projects or for which Federal matching funds are being used, the projects must be included in the MPO transportation improvement program (TIP).

Asset Management Approach

The Road Commission's asset management focus is on the county's primary road network (approximately 670 miles), on which priority is given to improve and sustain the network's pavement condition. For local roads, the Commission is responsible for routine maintenance and townships contribute financially to reconstruction and resurfacing (approximately 1,323 miles, of which 969 miles are paved and 354 miles are gravel). A long-range (10-year) plan and a 5-year program are developed that outlines the projects that will be undertaken over the life of the program. Pavement condition data are collected and used to determine priorities in the annual updates of the five-year program and budget.

"With good tools comes good decision-making."

…Kent County Road Commission Official

In 1996, the Road Commission along with the Grand Valley Metro Council (GVMC), the metropolitan planning organization for Grand Rapids, MI, launched an initiative to assess the condition of the region's pavements. The impetus for this effort came from the transportation professionals in both organizations, partly to counter balance growing public demands for more road construction to meet the growth in population (perhaps at the expense of maintaining the existing road network). This initial asset management effort provided important justification for the need to preserve the existing road network. The resulting information presented local officials with the opportunity to determine what it was they wanted out of their road network, and to identify the tradeoffs associated with different strategies.

A six-step planning process is followed by the Road Commission in determining its preservation investment program.

1. Survey conditions;

2. Document current needs;

3. Select and package improvements;

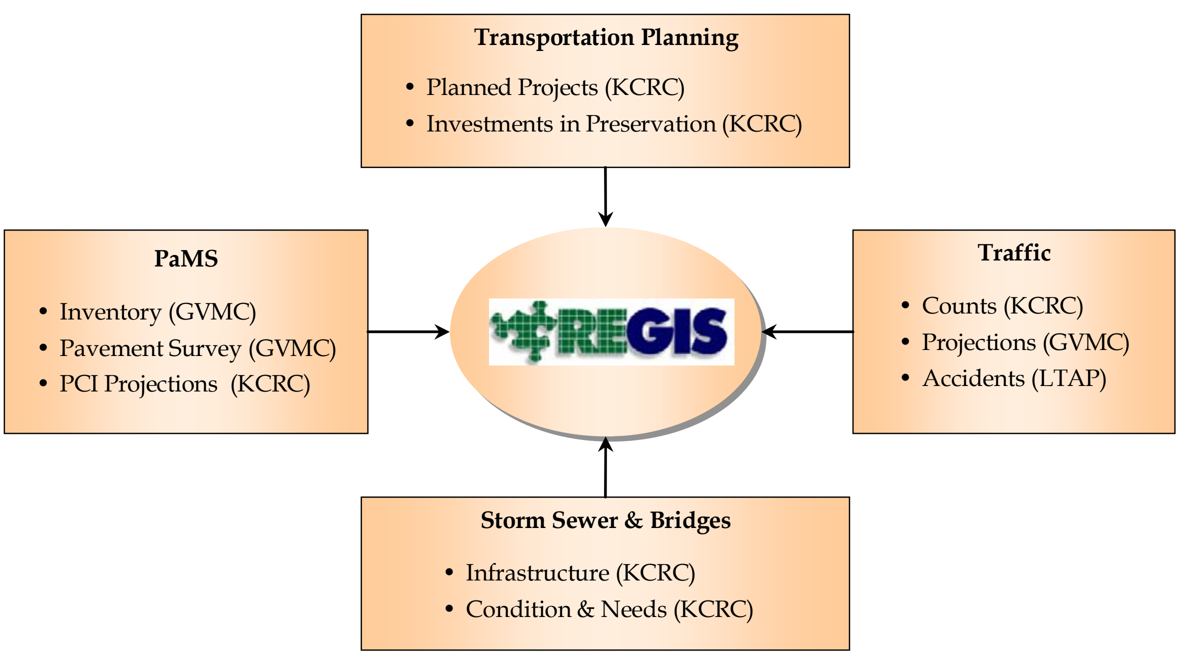
4. Analyze future conditions;

5. Update five-year improvement program; and

6. Monitor performance indicators.

Figure 3.2 shows the sources of data that feed into the asset management program. REGIS is a regional geographic information system that allows the Road Commission to combine all of the data on one reference base. A pavement survey is conducted with a laser/camera-equipped van by the Grand Valley Metro Council, with the entire Federal-aid system now being collected annually (1,500 miles) and one-third of the local road network (900 miles). Prior to acquiring the van, data were collected on a smaller sample of the Federal-aid system and no data were collected on the local road network. The data collection effort results in the production of pavement condition indices (PCI) using MicroPAVER which was adopted in 1995 as the pavement management system of choice.

Figure 3.2 Data Input Into the Asset Management Program
Kent County Road Commission



The Road Commission uses the pavement condition data in MicroPAVER to project future deterioration based on the historical records of previous pavement treatments.

Management and Data Systems

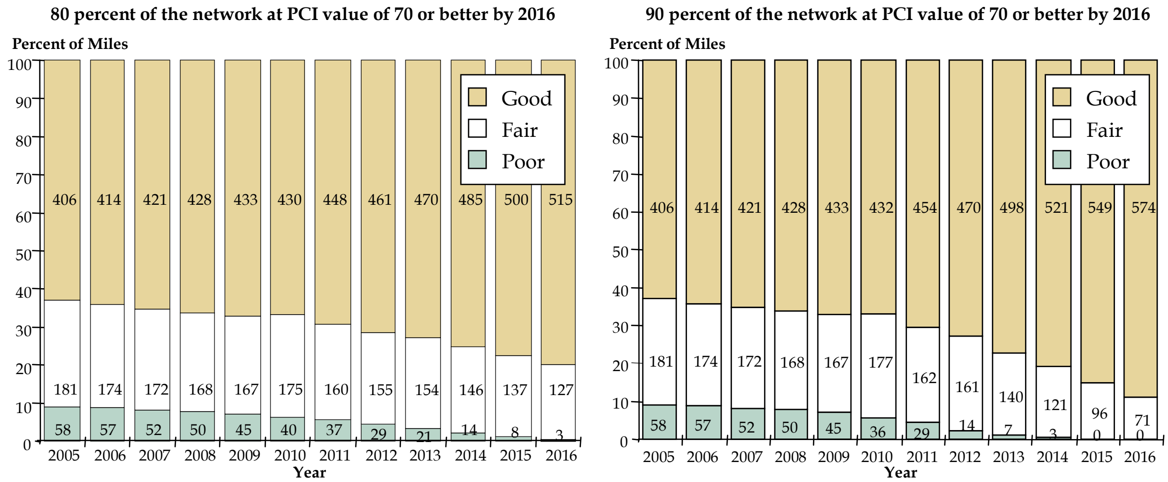
The Road Commission's pavement management system is very straightforward. The roadway inventory is segmented on the road network by a unique identification tag. Each segment has the typical characteristics of pavement surface type, functional class, traffic counts, length/width/area, number of lanes, etc. PCI values for each segment also are included in the database. Future PCI values are determined through the application of deterioration curves that reflect the type of pavement that is being used for a particular segment.

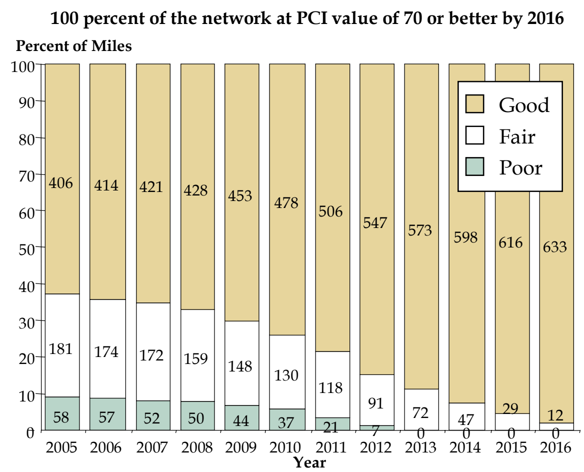
One of the uses of this approach is to conduct scenario analyses on the amount of investment necessary to meet different levels of road network condition. For example, the Road Commission has conducted scenario analysis on the level of investment in pavement overlays and surface treatments for network conditions that show 70 percent of the network at a PCI value of 70 or better by 2016, as well as 80, 90 and 100 percent. Figure 3.3 shows the results of the scenario analysis in terms of the distribution of network pavement condition as well as the level of funding that would be necessary to achieve each target. The upper portion of each column in the pavement condition figure represents the percent miles that need routine maintenance; the middle portion of the column represents the percent miles that require preservation; and the bottom portion represents the percent miles that need reconstruction.

"Asset management allows officials to provide the most cost-effective mix of projects…and possibly add funds back into the investment strategy in future years because of better short-term preservation decisions."

…Kent County Road Commission Official

Figure 3.3 Example of Scenario Analysis
Kent County Road Commission





Investment Strategies Percent of System Condition PCI > 70					
	Surface Treatments		Overlays		Total
	Miles	Dollars	Miles	Dollars	Dollars
70%	475	$42.0	183	$26.2	$68.2
80%	565	$50.5	215	$30.7	$81.2
90%	650	$58.0	245	$35.1	$93.1
100%	735	$65.4	275	$39.4	$104.8

Results of the System Preservation Strategy

The long-range asset management plan projects pavement conditions over the 10-year strategic plan time horizon. Figure 3.4 shows the current projection to the year 2017 to reach the target of 70 percent of the pavement condition being at a rating of 70 or better. As before, the top portion of the column in the figure is the percent miles that need to be maintained, the middle portion is the percent miles that need to be preserved, and the bottom portion of the column is the percent miles that need to be reconstructed. As can be seen in the figure, the goal of having 70 percent of the road mileage in the “maintain” category has pretty much been reached in the proposed investment strategy. Reconstruction needs are expected to be less than five percent of the annual investment in 2017.

Figure 3.4 Historical and Projected Road System Condition
Kent County Road Commission, 1996-2017

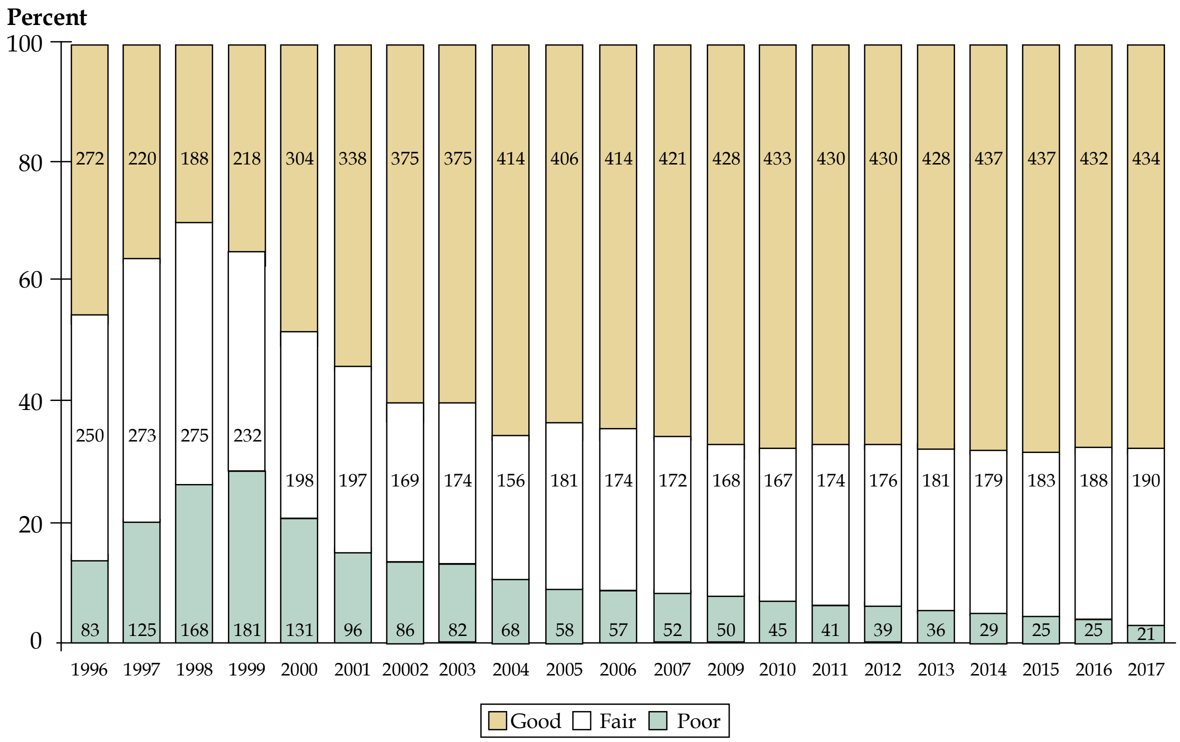
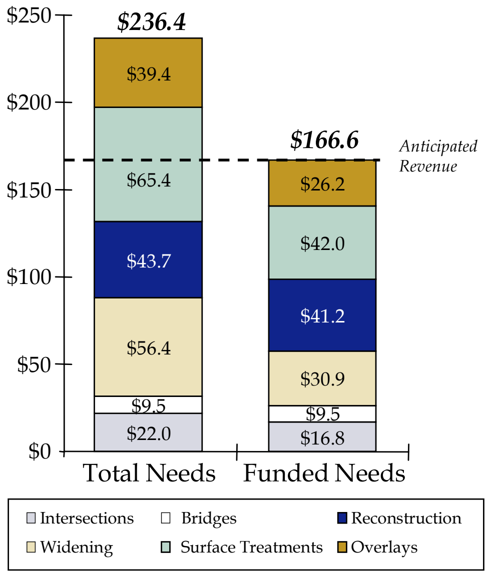


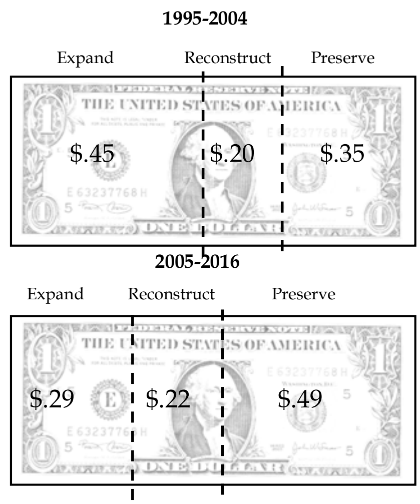
Figure 3.5 shows the breakdown of the planned investment by type of project. As can be seen, the average annual investment in preservation has increased substantially in the 2005-2017 period as compared to the 1995-2004.

Figure 3.5 Distribution of Planned Expenditures
Kent County Road Commission, 2005-2016

Long-Range Needs versus Planned Expenditures (Dollars in Millions)



Average Annual Investment in Primary Roads by Category



Lessons Learned

According to Kent County Road Commission officials, the application of an asset management approach to investment decision-making has resulted in several benefits to the county and to the decision-making process.

Asset management has allowed Commission officials to:

- Establish a logical and repeatable process to define a future vision and an investment strategy to achieve that vision;
- Create a framework to analyze the consequences of investment choices;
- Provide a forum for Division Directors and staff to achieve common understanding and provide input to the organization's vision and strategy;
- Establish a basis for Board members, elected officials, business community, and public to have greater confidence in how assets are being managed; and
- Identify unmet needs and to demonstrate how additional resources can be used most effectively.

The Kent County Road Commission's asset management experience demonstrates the level of accomplishment that can occur when local officials adopt an asset management approach for their road network. Commission officials did not wait for state legislation to begin their asset management effort. They went from a "worst first" investment strategy and switched to a more comprehensive approach toward maximizing investment resources over a longer timeframe. Scenario analysis was used effectively to show the level of investment that would be necessary to achieve different levels of system pavement condition.

The Road Commission has done an excellent job establishing institutional relationships with the local MPO as well as with other groups in the county to use all possible funding sources for road improvement. The existence of a strong analysis basis for needed investment levels has established strong credibility in the Commission's investment program.

3.3 City of Portland Office of Transportation

Context

The City of Portland has a national reputation for being at the forefront of transportation policy and system management. Thus, it is not surprising that Portland was one of the first cities in the United States to adopt a comprehensive approach to asset management, and has been a national leader in evolving this approach to one that is directly tied to investment decision-making.

With a population of approximately 550,000, out of 1.9 million in the metropolitan area, Portland is the largest city in Oregon and one of the largest on the west coast. Portland has the only elected regional government in the United States with responsibility for regional planning, regional growth, and infrastructure development. It also is the only large U.S. city having a commission form of government, meaning that one of the elected commissioners holds the transportation portfolio (and is known as the 'transportation commissioner').

The Portland Office of Transportation (PDOT) is the agency most responsible for transportation assets in the city. PDOT includes: 1) the Bureau of Maintenance, which is responsible for the maintenance of the city's street system, sewer and storm water collection system, traffic signals and control devices, street lights, bridges, sidewalks and curbs and parking meters; 2) the Bureau of Transportation System Management, which is responsible for traffic signals, parking, street lighting systems, transportation demand management and traffic safety; 3) the Bureau of Transportation Engineering and Development, which is the capital investment and development arm for PDOT; and 4) the Office of the Director, which provides overall administrative, financial and planning guidance. The primary sources of transportation funding (39 percent of the total) come from state highway trust funds, the city's share of Multnomah County's tax revenues and city parking revenues. In addition, the city uses revenues from the general fund (5 percent), contract revenues (20 percent), interagency transfers (20 percent), program revenues (8 percent), and grants (8 percent) to support the transportation program.

According to PDOT officials, the critical transportation issues facing Portland include:

- None of PDOT's primary sources of discretionary operating revenues (Highway Trust Fund – gas tax, vehicle registration fees and title fees) are indexed to inflation; these are projected to be relatively flat in coming years.

- Infrastructure maintenance and renewal costs are increasing due to age, complexity and increase in the extent of the city's transportation assets. As documented in PDOT's asset management plans, an additional $19 to $26 million per year is required to halt the decline in system condition, while an additional $28 to $36 million would be required annually to reach a sustainable level of service.

- New and ongoing commitments create demands on resources. These include compliance with the Americans with Disabilities Act (ADA); operations and maintenance impacts of new developments; rising costs of energy and health benefits; environmental protection requirements; rate of growth in retiring bond debt; reduced transfers from the City's General Fund to the transportation program; the costs associated with rebuilding a transit mall; and projected operation and maintenance costs for a new aerial tram that will begin service in 2007.

- Funding shortages have resulted in Portland investing far below a sustaining level in infrastructure maintenance. Funding reductions have occurred in road reconstruction, street preservation, new street lights, sign maintenance, street light maintenance, signal maintenance, and street area landscaping. Curb repair has been eliminated.

- Portland has been unable to adequately fund budget reserves, currently, 11 percent of the target level.

- Freight weight tonnage in the Portland metropolitan area is projected to double by 2030, with the truck share increasing from 63 percent to 73 percent over the same time period.

Investment Decision-Making Process

The institutional characteristics of Portland's governance structure greatly influence the decision-making process for infrastructure investment. As noted earlier, the commission form of government is unique among large cities and means that the commissioner with responsibility for transportation carries a great deal of influence on investment priorities. The current commissioner has been very supportive of transportation and of making investment decisions based on a defensible and transparent analysis process. He has adopted the following vision for Portland's transportation system:

Vision:
Portland's transportation system should be an accessible, safe, well-maintained transportation system, which provides travel options and supports a family-friendly city as well as being integral to economic development.

The commissioner holds weekly meetings with PDOT staff to review the progress made on key program initiatives. At these meetings, progress is measured against the commissioner's "strategic change measures," which he believes provide an important framework for PDOT decisions. These strategic change measures are:

- Repair and replace infrastructure on the most cost-effective schedule;
- Accurately price transportation trips and services;
- Reduce the number of single occupancy vehicle trips where realistic transportation alternatives exist;
- Reduce the number and duration of unexpected, non-repeating transportation delays; and
- Prevent crashes, especially at intersections, focusing on the 20 most dangerous intersections in the city.

Note that repair and replacement are listed as the top change measure.

Another influential characteristic of infrastructure decision-making in Portland is that state law (as implemented through a Transportation Planning Rule) requires local transportation plans to be consistent with state growth management goals. In particular, the Rule requires that performance measures be used to monitor progress, for example, are vehicle miles traveled being reduced? These performance measures are reviewed during the five-year updates of the city's transportation system plan (TSP). As noted in the plan, these performance measures were intended to provide a dynamic link between TSP policies and plan implementation by providing periodic feedback and updates to the decision-making process to ensure that the TSP satisfies transportation and land use goals; satisfies mandated benchmarks specified by the TPR; and provides criteria for advancing major capital improvements from the TSP into the capital improvement plan (CIP).

"Asset management has been the best translator between various public groups and the transportation department."

…Commissioner, City of Portland

Efforts to adopt PDOT strategic performance measures tied to asset and operational performance occurred in 2004 as part of the PDOT strategic planning process. The strategic plan adopted as one of its five strategies, "Build and Operate the System to Last," a recognition of the need to match capital investment with long-term asset management. Specific objectives were to:

- Budget the resources necessary to eliminate the growth in the maintenance backlog.
- Design and adopt practical life-cycle costing methods. In order to be "practical," methods will have to support the Office of Transportation's long-term zero-growth goal for maintenance backlog without unduly inhibiting its ability to respond flexibly to new resource demands.

- Adopt capital project development strategies that enhance and optimize long-term maintenance capacity. This pertains not only to transportation-funded projects, but also those projects that are either privately funded or paid for by partnering agencies.

- Develop a greater understanding within the organization of the long-term implications for increasing the inventory of transportation assets, especially when making decisions that involve building or installing new assets.

In 2005, key performance targets were established, and a Life-Cycle Management Committee adopted a generic life-cycle cost model to estimate costs. The key performance targets included:

- Keep paving backlog at or below 586 miles;

- Keep paving ratings at or above 55 percent good and 22 percent fair each year (FY 2004-2005 levels);

- Keep signal hardware condition rating at or above 29 percent good and 35 percent fair (FY 2004-2005 levels); and

- Keep citizens' overall perception of street condition remains at or above 55 percent good and 22 percent fair.

During the FY 2006-2007 budget process, the City's Office of Management and Finance recommended PDOT also report on the International City/County Managers Association (ICMA) performance measures:

- Street Maintenance:
  - Street rehabilitation expenditures per paved lane-mile and per capita;
  - Paved lane-miles assessed in satisfactory or better condition as percentage of total paved lane-miles; and
  - Citizen ratings of street condition.

- Street Sweeping:
  - Expenditures per linear mile swept and per capita.

- Citizen Ratings of Cleanliness.

Figure 3.6 shows how performance measures, in this case for street preservation, provides vertical integration of decision-making within PDOT.

Figure 3.6 Use of Performance Measures for Vertically Integrated Decision-Making
Portland DOT

Outcomes/Strategic Vision

Smooth, safe, and affordable street network

'Build and Operate the System to Last'

Service Level Targets

- Street Smoothness 55% good (KPM)
- Citizen rating
  - Neighborhood street smoothness
  - 55% good Overall street maintenance: 40% good
- Maintain backlog at 2004 level (586 miles)

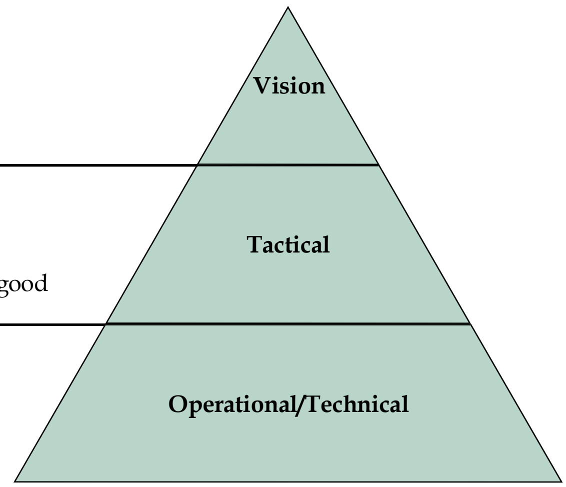
Service Level Indicators

- Street condition
- Perceived overall street maintenance
- Perceived neighborhood street smoothness
- Backlog

Service Response Standard

Response time to fill potholes

- 2 hours emergency
- 48 hours routine



A good example of the use of asset management in establishing budget priorities, in this case when the budget has to be cut, was the FY 2006/2007 budget process. Significant budget reductions had been requested for all city bureaus, including budgets for system maintenance and preservation. To inform decision-makers of where to cut back, PDOT adopted a process of rating and ranking different level of service options for asset conditions and service provision using asset-related considerations. A scale of 1 to 4 was applied to the following risk categories:

- Linkage to Council goals;
- Effects on customers;
- Effects on asset life;
- Effects on level of service;
- Risks of service failure;
- Effects on revenues;
- Effects on other divisions; and
- Impacts on staff.

Within a category, scores were normalized to mitigate the impact of higher scores resulting from more elements being rated for some risk categories. PDOT directors then assigned 100 points among different weight factors. The weights included impact to customers (22 percent), asset condition (20 percent), asset life (20 percent), impact of legal risk (10 percent), geographic area equity (10 percent), other customer/stakeholders (5 percent), internal customer/stakeholders (5 percent), city goals (5 percent), council focus areas (2.5 percent), and strategic goals (0 percent – strategic goals were under revision). Normalized scores were then multiplied by the weighted criteria to arrive at an overall ranking.

Performance measures also are reported as a part of the City's move to implement performance-based budgeting. The City Auditor has published a *Service, Efforts, and Accomplishments (SEA)* report annually for 15 years. These reports track 10-year cost and performance trends for City services to better inform decision-makers and the community on cost and performance.

The Transportation System Plan identifies preservation as a category for funding capital projects. However, this plan does not state or explicitly rank investments based on the relative importance of funding across life-cycle categories (operations, maintenance, preservation, and expansion). The *Transportation Management and Planning System Final Report* (1989) identified this lack of "clarity of existing policies" as a major deficiency in the process. Efforts throughout the 1990s to address this have been unsuccessful. In large part there is a belief that embracing a multimodal transportation strategy will both, 1) reduce capacity expansion needs of the street network, and 2) in the process of building new transit facilities, replace aging infrastructure.

Although tradeoffs are not made among life-cycle categories, the City's adopted debt policy and the City's *Capital Planning and Budgeting Guidelines* require asset management and replacement plans be developed to estimate the annual funding needed for a sustainable level of maintenance and where the funding will come from. In addition, replacement capital projects also are to be described. If a bureau does not have such plans, a statement concerning what is being done to develop schedules and estimate when they will be available is to be prepared.

The TSP also does not conduct cross-modal ranking. In other words, the City does not assess in its planning process whether a dollar invested in a road is better or less beneficial than a dollar invested in transit. While some citizens wanted PDOT to establish a "green hierarchy" of modes that would give preference to pedestrian, bikes, transit, cars (in that order), the TSP instead adopted themes of providing the citizens of Portland with "choice" and a "modal balance."

One of the interesting aspects of asset management-related decision-making in Portland is the consideration of risk. As part of the budget reduction process, each asset manager and asset team explicitly evaluated risks associated with under funding subassets within an asset class. The objective was to minimize impacts on transportation assets and services while achieving a significant budget reduction. For example, the relative risks of funding arterial asphalt streets compared to local concrete streets included the following:

- Rate of deterioration;
- Energy pricing sensitivity;

- Primary safety route;
- Opportunity for funding;
- Replacement value;
- Inconvenience to public;
- Initial investment;
- Political mandate;
- Future cost avoidance;
- Age of asset;
- Legal mandate; and
- Functional classification as proxy for demand, e.g., arterial versus local streets for pavements, or pedestrian walkways for sidewalk system.

These efforts explicitly stated the level of confidence in the information presented, and described near- and longer-term asset and service risks. The City Council liked the risk management approach used in this effort and adopted an explicit confidence-level rating matrix for new capital and major maintenance projects (see Table 3.2 and Figure 3.7). The purpose of such an approach was to better inform decision-makers prior to investing public monies of the confidence associated with the information that is justifying the investment. The high level of confidence shown for pavements was due to the long history of frequent inspections of the street inventory in PDOT's Pavement Management System.

"Asset management let's show people that we are making the right investment in the right place at the right time."

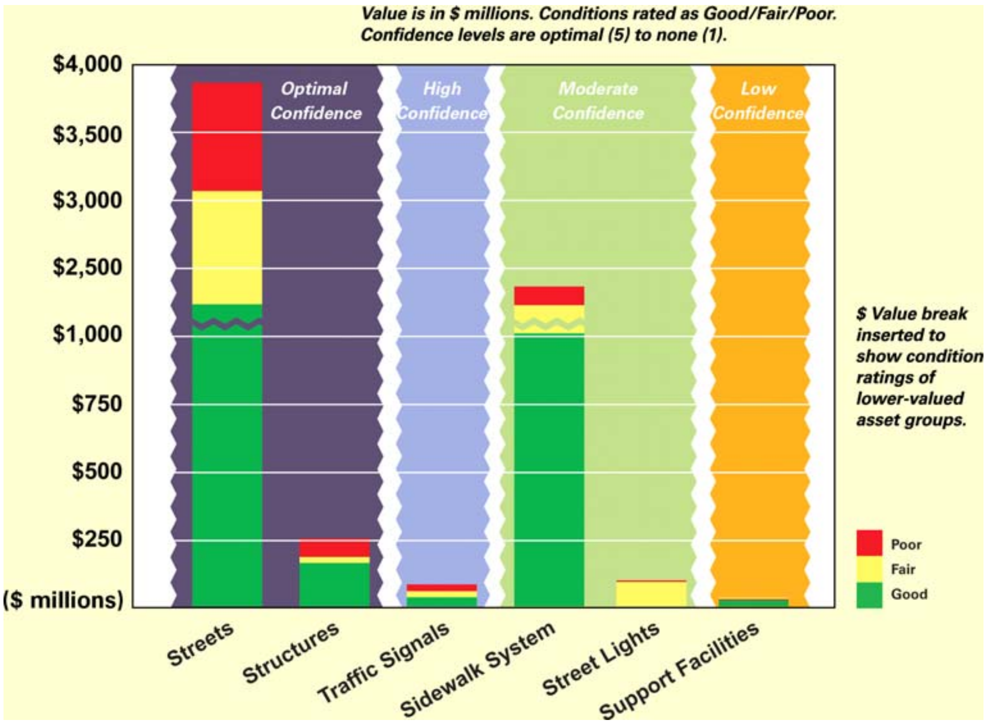
…Portland DOT Official

With respect to including life-cycle costs into capital decision-making, as a consequence of the 2004 strategic planning process, which identified the need to lower life-cycle costs and reduce the number of assets being created, maintenance managers have become involved in major capital projects (e.g., rebuilding a transit mall). Life-cycle costing does not always drive decisions, but the involvement of asset managers in these discussions is helping add life-cycle cost implications to decision-making.

Table 3.2 Confidence Levels Used to Assess Forecast Reliability *Portland DOT*

	Project Estimate Confidence Level Rating Index Defined
Complete	• Final payment made. • Post project assessment completed comparing project estimate, amount of contract award and total amount of change orders issued during project. • Total project costs reported.
Optimal	• Project scope and specifications clearly understood and well defined. • Clear understanding of materials, size, and quantities needed to execute job. • Schedule and special site conditions understood. • Project estimate unlikely to change (generally at 90% or greater design and engineering phase). • Total project contingencies (including project management, design, engineering, plus construction) range between 10% to 15%.
High	• Project scope and specifications nearly complete but still subject to change (70% to 90% design and engineering phase). • Materials, size, and quantities needed to execute job have been defined but subject to minor changes. • Schedule understood. • Total project contingencies (including project management, design, engineering, plus construction) may range between 20% to 30%.
Moderate	• Project scope defined but lacks details. • Project specifications incomplete (60% to 70% design and engineering phase). • Total Project contingencies (including project management, design, engineering, plus construction) may range between 30% to 40%.
Low	• Project scope is a conceptual "vision" with limited detail. • Project cost is an educated guesstimate. Limited technical information available and/or limited analysis performed. • Specifications still in infancy stage. (Less than 50% design and engineering phase). • Total Project contingencies (including project management, design, engineering, plus construction) may range up to or exceed 50%.

Figure 3.7 PDOT's Asset Condition Measures With Confidence Levels



Asset Management Approach

The City of Portland describes its asset management process as a "whole-of-government" approach. This means that all of the city's assets – transportation, waste water, water supply, civic buildings, and parks – are part of the asset preservation decision-making process. The City has defined asset management in the following way:

> *"Asset management is the continuous cycle of asset inventory, condition, and performance assessment that has as its goal the cost-effective provision of a desired level of service for physical assets. Investment decisions consider planning, design, construction, maintenance, operation, rehabilitation, and replacing assets on a sustainable basis that considers social, economic, and environmental impacts."*

PDOT's Asset Management Steering Committee adopted an asset management goal in 2005 that was more inclusive of operations and non-asset services:

> *"Asset management is a strategic approach to preserving, maintaining, and operating the transportation system cost-effectively. Fact-based tools track physical assets (e.g., streets, bridges, traffic signals) as well as nonphysical assets (people, data, and work processes) so that decision-makers can effectively analyze performance, communicate needs and target resources. Plans reflect long-term, sustainable strategies for improved infrastructure performance at the best available cost with the least environmental impact."*

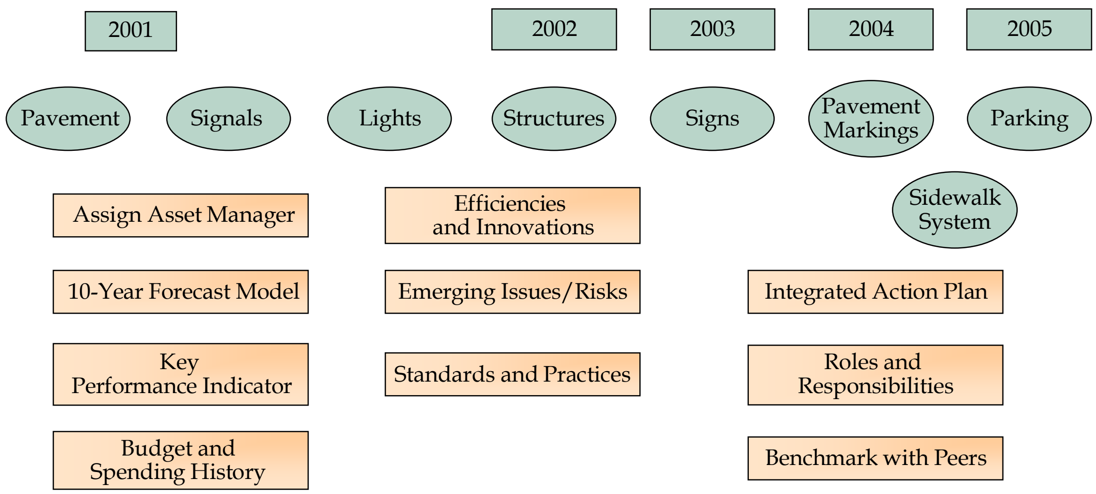
There are no legislative mandates requiring the use of an asset management process. However, there are several policies and program requirements that have strongly influenced the City's adoption of such a process. GASB 34, which Portland adopted very quickly, required the reporting of physical assets. The City itself requires that the capital plan be consistent with its comprehensive plan. The transportation element of the comprehensive plan has adopted a goal that the City "Protect the public interest and investment in the public ROW and transportation system by: …maintaining the infrastructure in good condition." The City's debt policy states that "consistent with its philosophy of keeping its capital facilities and infrastructure systems in good repair and to maximize the capital stock's useful life, the City should set aside sufficient current revenues to finance ongoing maintenance needs and to provide reserves for periodic replacement and renewal." This policy, updated and adopted by City Council in October 1995, includes more restrictive limits on the issuance of city debt than required by state law. And in some special cases, that is, where a significant addition is being added to an existing infrastructure system, a targeted asset management plan might be required. For example, a July 2006 ordinance adopted by the City Council which expands the street car network to the eastside of Portland requires development of an asset management plan for this expansion.

The reasons for PDOT embracing asset management so comprehensively were described by PDOT officials as an "evolving asset management story." (See Figure 3.8.) In 1985, City officials believed that the condition of the transportation system was declining and that the gap between revenues and transportation maintenance needs was widening. Data to support this belief came from: 1) a pavement management system in PDOT that had been used in the Maintenance Bureau to support pavement management since the mid-1970s; 2) a maintenance management system with established planning standards for over 200 maintenance activities; and 3) Federally mandated bridge inspections. The inability to describe these needs in a consistent and transparent way to the state legislature and City Council led PDOT's then Deputy Director to assign staff to develop a report on the status and condition of the transportation system. This was the first step in many that has embedded asset management into PDOT. The timeline of significant activities includes:

- Leadership by the PDOT Deputy Director led to the initial staff assignment (1985) to develop improved, timely, and accurate information on the inventory, condition, replacement value, and unmet needs of the transportation system. The first *Status & Condition Report* (January 1986) engaged all bureaus as ad hoc datasets were analyzed and an annual reporting process established for production of this report. The most current report is July 2005.

- The desire to develop a street user fee led to "flexible cost allocation and a user fee model that distributes transportation costs among some or all transportation customers based on the cost of services." (1987)

Figure 3.8 Evolution of Asset Management in Portland DOT



- An agencywide strategic planning process, known as the *Transportation Management and Planning System (TMAPS)* (1989) called for an inventory of Federal, state, regional and local policies, a needs assessment process, a map of existing and future capital needs, a five-year financial plan, and a manual of operating policies and procedures. An inter-bureau committee ranked policy issues gleaned from the review of policies and over 70 interviews within PDOT, other city bureaus and other jurisdictions and agencies. This process brought an awareness and subsequent ongoing contact with 10 U.S. cities that received assistance from the Urban Land Institute to develop integrated data to support decision-making. The inter-bureau committee ranked "implementing TMAPS" as the highest priority. (Note: TMAPS later became known as Infrastructure Management System (IMS), now called Transportation Asset Management.)

- Work performed across PDOT was categorized into operations, maintenance, repair and preservation and capital and expansion categories with indirect costs allocated among these. This cost of service model (1990) was based on a "primary level of service provided by a transportation bureau. An activity represented an end product or service." This was in anticipation of billing for street lighting, street cleaning, operations, maintenance, or capital services. One of the TMAPS ranked priorities was to develop a long-range maintenance plan whose intent was to "develop a policy that governs the establishment of a long-range maintenance plan. This should include policy direction for the establishment of a Maintenance Tracking System for all transportation facilities so that adequate information exists to assess deferred maintenance and make least cost maintenance decisions. This should include an explicit statement of the underlying policy of the Pavement Management System." (1990)

- A *Financial Forecast Model* was built on the cost of service model so that various scenarios could be analyzed linking levels of service with available revenue. (1993)

- The *Infrastructure Management System (IMS) Master Plan (*1993) recommended a strategy to merge ad hoc databases in a relational database and link inventories to mapping (GIS) and a work management system. Portland's regional street centerline system, which involved the Port of Portland, Tri-Met, county and city representatives, was a product of this early work.

- A data warehouse was developed in 2000. Mapped data (GIS), city financial and asset inventories were included in a work management system, which allowed managers and employees to query daily cost reports and accomplishments. Data maintenance was assigned as a duty of PDOT asset managers.

- PDOT-wide workshops during the data integration effort (2000) and leadership by the IT Director and Bureau of Maintenance Director led to a shift in the organizational perspective on the value of data in support of decision-making.

- GASB 34 (adopted 1993, implemented in 1999) required that bureaus report the adequacy of investment in existing assets. This increased the focus of financial officials on the issue of asset condition, and caused PDOT's financial managers to embrace asset reporting. The City chose to implement the depreciation method in defining replacement value. However, PDOT's ongoing annual reporting of maintenance and renewal needs for key transportation asset classes was much closer to the modified method of GASB 34 reporting.

- Awareness of international best asset management practice from Australia (1995) and New Zealand (2000) assisted in structuring PDOT's transportation asset management approach, and asset management plan structure (2001-2006).

- Three levels of service for major asset classes – pavement, bridges, traffic signal, and street lights – were reported annually in the *Financial Forecast* (2003). One of these is defined as a target, or the sustainable, level of service. The performance target varies for each asset class.

- A PDOT *Strategic Plan* (2004) adopted as one of its five strategies "build and operate the transportation system to last." A Benchmark Committee adopted key performance measures for this strategic objective (2005).

- Leadership by the Maintenance Bureau Director (2000) in requesting an analysis of 20 years in asset condition trends led to the development of eight asset management plans (2001-2006). A strategic objective reflecting concern for adequate investment in transportation infrastructure was adopted in the PDOT *Strategic Plan* (2005).

- A Life-Cycle Cost Committee (2005) adopted a generic life-cycle model based on the FHWA primer and example life-cycle costs for traffic signals and street lights. A more robust model for pavements also was developed. Capital project managers used these rough estimates for signal, light and pavement costs to assist discussions with Oregon DOT to select the lowest life-cycle design for a major intersection (Eastside Connector) (2005).

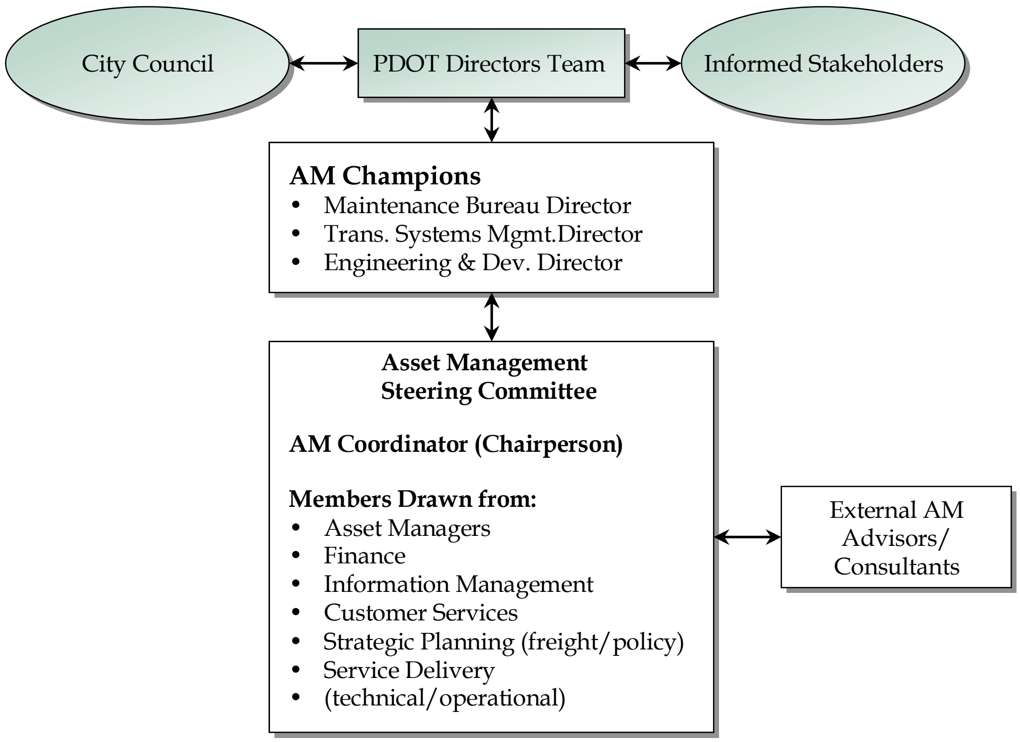
- Asset teams identified and ranked subasset risks for each major asset class in preparation for FY 2006-2007 budget cutbacks (fall 2005).

Organizationally, a decision was made in the early 1990s to embed asset management within PDOT, rather than having it be seen as a separate program or a single effort imposed by the Office of the Director. An organizational structure of asset management champions, an asset management coordinator, asset managers and an asset management steering committee reflecting this cross-agency commitment was formally adopted by PDOT's leadership in 2005 (see Figure 3.9). The role of asset management coordinator has evolved from strategic project manager in the late 1980s to Infrastructure Management System program manager in the 1990s to PDOT asset management coordinator since 2000. Between 1986 and 1999, this position administratively reported to either PDOT's Deputy Director or since 2000 to the Bureau of Maintenance Director. This position has consistently been a PDOT-wide resource.

Since 2000, seven managers within PDOT have been assigned the role and duties of being an asset manager. This position is responsible for maintaining the database for the asset categories that are the responsibility of the asset manager. Each asset manager has budget authority in PDOT; job descriptions range from principal engineer/division manager (pavement, signals/lights, structures), public works supervisor (sidewalks), senior engineer (signs, markings) and program manager (parking). The asset manager is the primary advocate for keeping the related assets in a high level of condition and performance. This is accomplished within the context of a team of engineering, technical, finance, and management staff. The asset team's goal is to ensure that PDOT makes the right actions on the right asset at the right time. The asset manager and the respective teams make management aware of risks and costs associated with current, higher, and lower levels of service.

As noted by PDOT officials, this organizational structure for asset management is intended to make PDOT a knowledgeable asset owner. At its most basic level, this means keeping the physical inventory current, an up-to-date condition assessment and a having recent replacement value for the city's assets. This has been and remains the core tenet of PDOT's asset management efforts.

Figure 3.9 Asset Management Roles and Responsibilities in PDOT



Management and Data Systems

The data set for each of 31 defined asset classes is large and unique, with different data systems used for inventory and asset condition monitoring. For the most part, these systems are linked rather than fully integrated. The information systems that collectively comprise PDOT's asset management system include:

- Maximo (asset inventory, equipment inventory, work management, purchasing, labor, resources, location model, location relationships, condition monitoring);
- Physical assets maintained in ArcGIS Desktop and ArcGIS SDE Server (asset attribution not stored in Maximo, asset and location feature management, asset location assignment);
- A report server (reporting functions for multiple systems and databases) supported by a Transportation Enterprise Data Warehouse that combines assets and locations with financial information;
- Custom desktop data maintenance applications (asset inventory maintenance tools, sign library, street light outage reporting);

- Off-the-shelf applications for asset management, which are customized for PDOT (pavement management system, includes condition monitoring);

- ArcGIS data layers (capital improvement plan, transportation system plan, crash history, traffic data) maintained either with custom applications or standard ArcGIS tools;

- Computer-aided design (CAD) design files for as-built projects; and

- Custom desktop applications to manage financial or project information.

Other than simple summary statistics, data must be exported and analyzed outside of Maximo or ArcMap. From there, individual managers use a variety of tools to perform analysis, typically spreadsheet applications.

All asset classes include a relative location reference point (distance/direction/other descriptor) as well as a set of physical attributes. Every transportation asset is assigned to one or more physical locations referenced to Portland's street system. Currently, there are 219,000 such locations, each with its own unique identifier (ID) and description. Most components of the location model are classified as street segments, intersections, blockfaces, or nodelegs. Their attributes and geometry are primarily derived from the city's street centerline file. These locations are arranged in a hierarchy and stored within the Maximo database.

This hierarchical structure is useful for finding locations in a tabular data environment by drilling down from a generalized location to a detailed location, for example, from an entire street to the segments on the street to the blockfaces along the street. It also can be used to aggregate sets of locations, and the data associated with them.

The geometry of most transportation assets does not extend beyond the location with which they are associated. Pavement sections do not extend through intersections. Sidewalks do not extend beyond intersection corners. Therefore, a one-to-one relationship can be maintained between assets and locations as required by Maximo.

A supplementary relationship table allowing for many-to-many relationships is maintained for GIS features whose geometry does not coincide with location geometry. The relationships between assets and locations are automatically maintained by the asset data maintenance tools. For non-assets, the relationships are automatically maintained via ArcGIS class extensions operating in the background.

Asset location and other asset attributions necessary to write maintenance work orders are input into Maximo/ArcMap. Planned assets (attributes and location) are created during development of the transportation system plan. Capital improvement project assets are designed using the city's computer-aided design system and the projects are mapped in the GIS system.

Condition data are collected by different means and different schedules, depending on the class of asset. For example, fairly rigorous inspections are performed for structures such as bridges, retaining walls, and stairways. The Pavement Management System (PMS) maintains a regular, ongoing inspection program. Critical types of signs, such as stop signs, are inspected more frequently than other types of signs. Sidewalks in the downtown core are inspected every 5 years and all other sidewalks on a 20-year cycle. The transit mall is inspected annually. Condition inspection data, where available, is typically housed in a separate database. A pending upgrade of the work management system will more readily accept condition data for each asset.

With respect to pavements, the PMS identifies the best intervention strategy based on the current composition and condition of a street segment. The PMS attempts to manage streets at the optimum or lowest life-cycle cost. The rating of deficient pavements and the overall investment strategy have come under scrutiny by an internal audit. Replacing the legacy PMS is a priority to PDOT officials, especially adopting a new approach that utilizes remaining service life methods for projecting level of service impacts.

PDOT takes a multiyear view in developing the paving list. A 10-year pavement prediction model, spreadsheet-based and to be replaced in 2008, uses historic deterioration rates and available funding as a basis for predicting future conditions. It forecasts pavement conditions for local and arterial streets based on work program investments. The criteria for the replacement model include the ability to both manage annual work programs and forecast scenarios based on a more refined set of demand characteristics. A pavement life-cycle cost model also was developed for PDOT in 2005.

The PMS incorporates street classification as a proxy measure for demand. Street preservation and other capital improvement plan and utility relocation work are coordinated as yearly programs are developed. The time horizon for this effort is 5 to 7 years, thus the investment in street treatments is preserved and pavement disruption activities are minimized within the first five years after a treatment is put in place.

For signs, each sign and sign mount has an ID assigned to it. The sign database includes information on the sign and mount code, location reference (distance/direction/reference point), type of sheeting, ownership and maintenance responsibility, date of installation, and authorizing work order. The sign code describes the sign type, legend, color, etc. The mount code describes the mount type and material. There currently is no ongoing condition monitoring for signs and sign mounts. Limited condition data that were previously collected visually rated the sign as in very poor, poor, fair, good, or very good condition. The database also includes a provision for problem/action/cause fields that coincide with each sign and sign mount asset as part of a limited condition assessment process.

For pavement markings, the database includes color, line type and line pattern, material type, installation date and authorizing work order. Location data are captured in the database when the lines/markings are placed (drawn) into the city's mapping system. Periodic inspections by field staff make note of lines needing replacement. New and/or replaced lines and markings following construction or overlays are updated through the Maximo/ArcMap system.

Two full-time engineering technicians are responsible for both work orders and inventory management as well as several other related and unrelated tasks in parking signs and pavement markings. Additionally, temporary or reassigned staff manages work order data entry or data collection in signs and pavement markings. GIS staff enters as-built data from development projects. Wholesale replacement of assets (replacing space parking meters with pay stations) requires specific data collection efforts. The street light inventory is not maintained by PDOT, but is calculated via energy billings.

New field data collection technologies were identified as a core deliverable in the initial Infrastructure Management System project scope in 2000. However, due to project cost constraints, this deliverable has been delayed. A pilot study of field data collection is anticipated in 2007 for signs and parking asset classes.

There is no PDOT-wide policy on quality assurance/quality control (QA/QC) concerning data collection. However, several QA/QC steps do occur:

- Batch processes are used to validate linkages between data systems, refresh distributed data sets, and identify missing, duplicate, or invalid GIS information;
- Data warehouse creation includes a validation of data sets; and
- Tools have been developed to manage location hierarchy relationships, validate and repair location definitions, and update locations based on retirements.

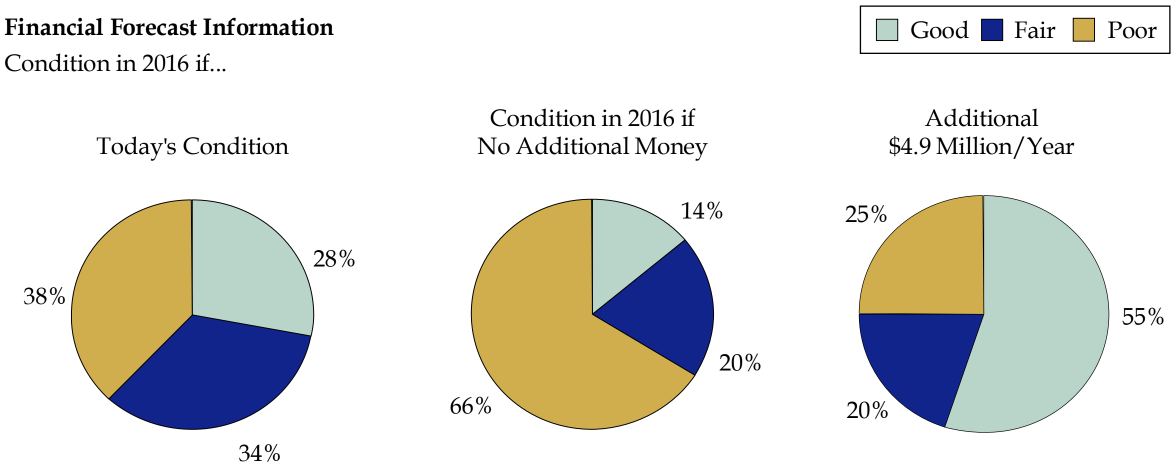
Relying on part-time staff for data collection on signs and pavement markings makes the quality of data an ongoing concern. Due to rules limiting temporary staff to 860 work hours, the amount of time for productive quality work is very limited after accounting for training time and time to acquire a certain dependable skill level. Usually, poor or erroneous data is discovered on a case-by-case basis when field verification occurs. For signs and markings, an error with one asset on a blockface will trigger an investigation of all the sign assets on that blockface. Therefore, QA/QC for sign assets occurs on an as-needed or as-discovered basis.

The cost associated with these specific data collection tasks has not been computed across PDOT. However, the need to define these costs has been identified. The adequacy of data management efforts is to be addressed in an overarching assessment of PDOT's asset management process, scheduled for completion in 2007.

Levels of service have been defined for major asset classes – pavement, bridges, traffic signals, street lights, and the sidewalk system. A target service level also has been defined. Target or sustainable levels of service and how these are defined vary by major asset class. Pavement condition comes from the PMS; bridge condition from bridge inspections; and traffic signal and street light condition is based on the age of assets. Curb condition also is estimated through visual inspections. The number of ADA accessible corners determines the target service level and need for this asset.

Figure 3.10 shows a typical scenario analysis that can occur by using desirable levels of service and estimating the level of funding that would be necessary to achieve them. This type of financial analysis is found for the five major asset classes that make up 99 percent of the transportation system replacement value (pavements, bridges, traffic signals, sidewalk system, and street lights).

Figure 3.10 Scenario Analysis for Asset Condition
PDOT



Source: City of Portland, Oregon, September 12, 2006.

Replacement value assumes replacing an asset class to today's standards. By using an average unit cost for each asset, PDOT uses a simple approach in calculating the replacement value for its assets. The replacement value includes labor (removal and installation), materials, and overhead. Depending on the assets, the source documents can come from work order reports, bid items, or contracts. PDOT's Business and Support Services Division contacts asset managers and capital project cost estimators to update inventory, work order and contract cost information. PDOT officials place greater reliance on work order reports because they are based on actual costs, whereas contracts could be outdated and it might be difficult to find a contract that represents "typical" work. Costs are updated annually and replacement value for each asset class reported in the *Status & Condition Report*, *Financial Forecast* and other briefing documents.

With respect to community input on the asset management process, for 15 years, the City Auditor has asked the community to rate street smoothness, satisfaction with congestion, street cleanliness, on street parking, street lighting, pedestrian safety, bike safety, traffic speed, street maintenance services, and traffic management services relative to safety. The citizens' perceptions of service outcomes are incorporated into PDOT's asset management plans.

For atypical decisions, such as the development of the FY 2006-2007 budget that required significant reductions in budgets, targeted public outreach occurs. For example, in this instance, over 1,000 responses to a survey on transportation priorities were received from the general public. Information also was obtained from a 27-person stakeholders task force, a community meeting, a meeting with a business association, an Internet blog, and input from PDOT employees and managers. Service priorities identified through this process were used to inform decisions on budget reductions.

Results of the System Preservation Strategy

According to PDOT officials, the transportation asset management (TAM) process has continuously improved information on the city's asset base, provided for greater availability of this information throughout PDOT, and has resulted in more transparency and accuracy in estimating future needs. The goal was to improve the explicit link between transportation policy, strategies that implement policy, information on physical and nonphysical asset services or programs, and performance (both quantitative and qualitative) measures. PDOT's TAM efforts were based on the premise that relevant, reliable, and timely information about asset resources was needed to inform decisions and create political, managerial, and operational accountability. This approach required the commitment of managers throughout the agency to fund initiatives and assign staff that would represent various professional disciplines as data, decisions and performance were linked. PDOT officials believe these desirable outcomes of the PDOT asset management process have been achieved.

The condition of major transportation assets – pavement, traffic signals, bridges, street lights, and sidewalk system – has been used to brief the City Council and state legislature since 1986. The paving backlog has become the most recognized indicator of the decline in the transportation system condition and maintenance and renewal needs. Twenty-year trends in each major asset class condition (pavement, bridges, signals, lights) also have been used to indicate transportation renewal and maintenance needs.

Sustainable levels of service have targeted conditions within the pavement, bridge, traffic signal, and street light asset classes since 2002. The sidewalk system (curbs, corners, and sidewalks) also identified a sustainable level of service in 2004. These have been a part of PDOT's *Financial Forecast* since 2003 and remain unfunded.

Figure 3.11 shows the trend in condition for several asset categories, and Figure 3.12 shows the same information for traffic signals. As can be seen in both figures, the condition trends have shown a steady decline over the past 20 years. It appears that although the asset management process has been successful at systematically defining the condition of the city's asset base, it has not been successful at securing significant dollars to reverse the trends. According to PDOT officials, however, shifts in resources are occasionally made based on performance indicators. For example, $1.5 million was moved to address street preservation needs in FY 1998-1999 based on the growing backlog. This increase was continued in the following two years, but then remained unfunded for the next three years. The FY 2005-2006 budget included a decision to redirect $1.2 million from other services to this program to alleviate annual increases in the maintenance backlog. The decline of the condition of the traffic signal system led the City Council to allocate one-time monies for signal system renewal over several years in FY 2006-2007. Approximately $250,000 was allocated in 2006 to install tactile warning devices on new accessible intersection corners. This amount was based on the sidewalk asset manager's ability to quantify the need that indicated the City's risk for noncompliance with an adopted ADA transition plan, a risk recognized by the asset team in the *Sidewalk Asset Management Plan*.

Figure 3.11 Trends in Asset Condition
Portland DOT

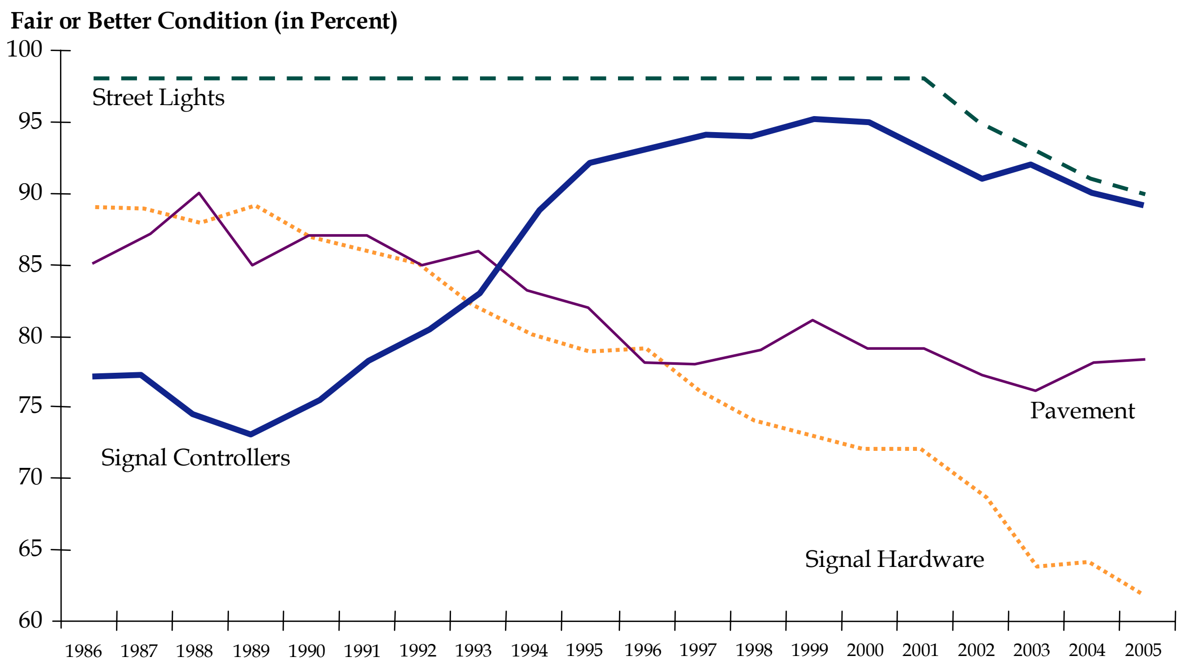
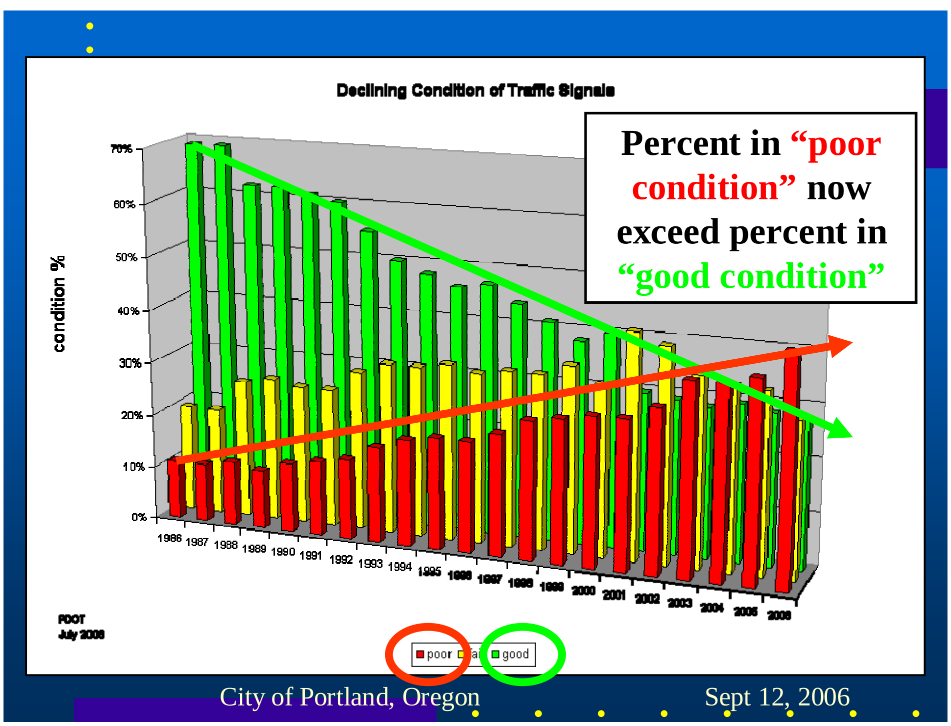


Figure 3.12 Trends in Traffic Signal Condition
Portland DOT



The City's pavement marking strategy was shifted from painted lines to thermoplastic pavement markings based on a life-cycle analysis comparison of both approaches. The return on this investment, including labor, materials, and equipment was included in that analysis.

The asset management process has been helpful in efforts to identify and justify new funding sources for the city's assets. A street light levy, street user fee, street maintenance and improvement fee as well as other single service efforts to have users pay for services (leaf removal districts, parking, permits, systems development charges) have either been developed or put in place. An effort to generate new revenues, called the street maintenance and improvement fee (SMIF), included preservation and capacity expansion. The SMIF was passed by City Council in 2002, but was rescinded before it took effect when it appeared that the business community opposed the fee.

In 2002, Council briefings on the state of the city's deteriorating infrastructure caused the Council to rank this as one of its four strategic issues. The FY 2006-2007 budget process involved five budget hearings that focused on infrastructure bureau needs, including a presentation of the first *City Asset Status and Condition Report.* Replacement value, condition, and unmet maintenance and renewal needs were described. Rate increases were agreed to (Water and Environmental Services), and one-time monies allocated to meet infrastructure needs (buildings, parks and transportation).

Perhaps the best example of the importance of the asset management process occurred during the recent budget process where priorities had to be established with respect to budget cutbacks. The 1,000 survey respondents placed maintenance and safety in the first tier of priorities as budgets were cut. Clear descriptions of service outcomes and costs were used to describe why timing investments made a difference in long-term costs and system performance.

Lessons Learned

The evolution of PDOT's transportation asset management process relied on the distributed assignment of roles and responsibilities in management and staff for developing information, tools, policies, and performance. This created an organization-wide expectation of using this information for legislative sessions, annual budget development, and City Council hearings. The success of documenting and trending the needs of the transportation system in "what-if" scenarios, long-term staff assignments to various asset management-related roles, success in obtaining staff and consulting resources as required to further develop decision processes and effective information technology tools are all key elements in enhancing the use and understanding of asset management in PDOT.

PDOT officials identified the following benefits of its asset management process.

- Portland transportation asset management practice relies on known asset inventory, condition, and maintenance and renewal needs of the transportation system. Key system performance measures provided accountability. New management and elected officials can use information shared across the organization for many years with transportation stakeholders to understand the community's priorities and target available resources in a manner that mitigates long-term service and asset impact.

- An existing asset management culture in PDOT is the foundation for a credible, risk-based budget prioritization process for new management, elected officials and the public.

- PDOT's experience and ability to report asset inventory, value, condition, and unmet need is influencing other bureaus' efforts to launch similar asset management efforts. Portland elected officials and managers view the ability to communicate infrastructure challenges a "win."

- There is a structure and information to support joint decision-making. System performance is documented and accountability is made possible. Targeting and obtaining resources is a work in progress – both for accurately timing investments in the lowest cost manner, as well as engaging the community in choosing affordable and desired levels and types of transportation service.

PDOT officials identified the following challenges to their implementation of an effective asset management process:

- A lack of sufficient resources to meet asset maintenance and renewal needs.

- A lack of adequate staff to meet the data maintenance needs, especially since 2000.

- Although important to organizational acceptance, the distributed model of developing and evolving asset management practice has slowed its implementation. This consensus and collaborative approach to implementation takes longer than top down directives. However, because of the distributed model, a long-term understanding of asset management's purpose is embedded in many middle and top managers who have participated in developing PDOT's efforts.

- Changes in elected and management positions have required continuous proactive briefings and education.

- Inadequate ongoing training, lack of data maintenance standardization and inadequate funding of data maintenance positions are threats to the long-term success of the accuracy of asset data, the core tenet of being a "knowledgeable owner." This is the cornerstone of PDOT success and especially its financial planning.

PDOT officials identified the following recommendations that they would give to other jurisdictions interested in implementing a transportation asset management process.

- **Engage leadership at the top –** PDOT's TAM efforts began with strong leadership and has benefited generally with management interest ever since. Ironically, tougher financial times have elevated the importance of having a robust TAM approach to decision-makers in city government.

- **Involve cross-functional teams.** At a minimum, these teams should involve engineers, operations and maintenance managers, finance, information management, and communications. Each perspective is needed to refine the "so what" question to data gathering, risk identification and decision-making. Get people involved; silence is not consensus.

- **Make sure your assets' physical inventory is maintained first –** Do not collect asset inventory data unless you know you have the resources to maintain the information. Define your business decisions before collecting the data to support these decisions. The sequence should be: define the business purpose and process, define key information that supports decisions, collect inventory and attributes, and maintain the information base.

- **Build condition monitoring into the inventory management process –** Do not wait to add the monitoring function (and the associated costs) later in the development process. This needs to be strategically assessed at the very beginning.

- **Do not get caught up on technology –** Asset management is a way of thinking, doing, and making decisions. The technology provides a means of getting there. Decide what your decision-making process looks like and get buy-in on this first. Then, go after the tools and resources to make it happen. Starting with spreadsheets and standalone systems is fine. A strategy to integrate key data takes time and is key to creating one "view" of information, which can drive down the day-to-day and long-term costs of service delivery.

- **Treat the data as an asset –** Have a plan for what the database is going to look like, how it will be managed, manipulated, and updated. While individual persons or parts of the organization are responsible for a particular data set, it is "owned" by the organization. Eliminate turf wars at all costs, and cost out data collection, maintenance, and management. This too needs to be funded adequately and not seen as overhead or secondary to the core services provided in an agency.

- **Identify costs –** Knowing the cost per level of activity or service helps clarify what communities are willing to pay for, which may differ from what they desire. The major weakness in PDOT's consultation process was that services were not tied to costs. Without this information, stakeholders tend to support a wide range of services, including expressing a desire for more services at higher service levels.

- **Develop a transparent process for decision-making –** Transparent decision-making garners public support. Decision-makers and the community are willing to make decisions based on the available information when the validity of the data is explicitly described and when it is known that future efforts will continue to improve the data and decision-making process. Establishing explicit confidence levels in reporting asset information was key to garnering City Council support for asset management.

In the context of the other case studies examined in this scan, the Portland case provides some interesting characteristics of an effective asset management process. First, and perhaps most noteworthy, is Portland's "whole-of-government" approach toward asset management. Most examples of asset management found in the transportation literature focus on transportation assets, when in reality many governments, especially local governments, are responsible for many other assets as well. Portland has gone a long way toward systematically developing an asset management approach to decision-making that encompasses all of the major assets that the city government is responsible for. Within transportation, the development of targeted asset management plans for each of the important asset categories provides a sound institutional basis for making decisions on where the most cost-effective investment should occur.

Second, even with a limited success in convincing the City Council to provide additional dollars for preserving certain transportation assets, the overall picture of expected asset condition over the next few years in Portland is not good. With tremendous pressures on local government to provide a wide range of public services, it is not surprising that city officials have a difficult time finding the funds to reverse the trends. However, what is interesting about the Portland case is that the asset management process was credited with providing a defensible and credible basis for deciding where funds should be cut. It is almost as if asset management worked best when facing budget cutbacks.

Third, the Portland case was one of the few examples where public input was considered a normal part of the asset management process. Public surveys over many years have monitored the public perception of the importance of asset preservation. When facing cutbacks, PDOT used a public participation process to determine the priorities of where to focus the budget cuts. This outreach to the public is credited by PDOT officials as raising PDOT's credibility both with the general public and with elected officials.

Finally, PDOT has undergone a many-years evolution in incorporating asset management principles into the organizational culture. Portland, of all the sites visited, provided the best example of how an organization can change over longer periods of time if asset management becomes a driving factor in agency standard procedures. As noted by PDOT officials, "asset management has been embedded within the organization, and it is now part of the value system of PDOT employees."

For further information, see: http://www.portlandonline.com/transportation/index.cfm?a=gfbde&c=dehfd.

4.0 Metropolitan Planning Organizations

4.1 Grand Valley Metropolitan Council (GVMC), Grand Rapids, Michigan

Context

The Grand Valley Metropolitan Council is the metropolitan planning organization (MPO) for the Grand Rapids, MI metropolitan area. The 2005 estimated population of the metropolitan area was 771,000. The MPO boundaries encompass all of Kent County (and thus the jurisdiction of the Kent County Road Commission, see page 2.7), and portions of neighboring Ottawa County. The Grand Rapids metropolitan area is one of the fastest growing regions in Michigan, and thus has faced pressures not only on preserving the condition of the existing road infrastructure, but also to add capacity to this network to satisfy new travel demand.

Investment Decision-Making Process

The GVMC policy committee consists of 32 voting members, primarily representing local agencies, but also including the Michigan DOT. As the MPO, the GVMC is responsible of developing and maintaining a long-range plan and the region's transportation improvement program (TIP). The latest version of the long-range plan has numerous goals and objectives listed for guiding the investment decision-making process of the policy committee. The goal and associated objectives that relate most to asset management is Goal 4, which considers economic and financial considerations.

Goal Four:

The transportation plan should reflect the ability to finance such a system, to best allocate resources, and to remain an economic asset to the region.

- **Objective 4a –** Transportation improvements should be cost-effective and should maximize the long-term cost/benefits by considering the overall life-cycle costs.

- **Objective 4b –** Transportation improvements, for all modes, should minimize capital and operating costs.

- **Objective 4c –** The scale and character of transportation improvements should be consistent with the ability to finance such improvements.

- **Objective 4d –** Transportation system investments should be maximized from all available sources, including the private sector.

- **Objective 4e –** The transportation system should support the economic viability of West Michigan.

- **Objective 4f –** Transportation Management Systems developed in cooperation with state and local agencies should be employed to identify and assess the transportation system.

- **Objective 4g –** The existing transportation infrastructure system should be preserved and protected wherever feasible.

The commitment of GVMC to asset management can be seen in the use of Surface Transportation Program (STP) funds for reconstruction and resurfacing projects in the region, and the use of PL funds to support asset management data collection and analysis capability.

Asset Management Approach

GVMC has been very strategic in the evolution of its approach toward asset management. In 2006, the asset management efforts of GVMC took an important step with the purchase of an instrumented van that collects pavement condition data on much of the road network in its study area. The GVMC uses the pavement condition index (PCI), a numeric rating of pavement condition from 0 to 100, where a value of 100 is assigned to new construction and 10 and below is considered failed pavement. Historically, this value has been derived from visual measurements of existing pavement distress using a sampling method.

MicroPaver, a proprietary pavement management software package, has been adopted by local jurisdictions, including the most important road agency, the Kent County Road Commission. MicroPaver includes 38 different types of pavement distress for concrete and asphalt pavements, with deterioration curves associated with different types of pavements given observed distress. GVMC provides the deterioration curves to local jurisdictions and the Road Commission, although only nine of the pavement distress types are used by GVMC.

Up to 2006, only one-third of the Federal-aid road system in the region (approximately 350 miles per year) was inspected for pavement condition, at an estimated cost of about $250 per mile. GVMC did not collect pavement condition data on local roads. Federal PL funds were used to support the data collection effort. The resulting data were provided to MPO members for their own use (such as the Kent County Road Commission) and also were used in the prioritization of road investments. The data collection effort was undertaken primarily through consultants.

A new approach toward data collection, and thus the extent of the asset management effort in the region, was adopted this year. A semi-automated, advanced sensor technology data collection system housed in a van is now used to collect data annually for the Federal aid road system (with a reclassification of the region's road network, this now represents 1,350 miles) and on up to 3,000 miles of the local road network. The data collection and analysis effort is operated in-house. The estimated cost of the data collection activity is less than $100 per mile (see section below for more details on this data collection approach).

As noted above, GVMC uses the collected data as input to programming transportation investments in the region's TIP. Figure 4.1 shows the criteria that are used by GVMC to determine the different types of project eligibility when the TIP is developed. Currently, the expected deterioration of pavements given today's condition is the value shown in Figure 4.1. However, the GVMC is intending to use its travel demand model to estimate future volumes on the network, with individual link volumes then used to determine on a year-by-year basis what the PCI value is likely to be. As is today, this information would be considered when priorities are established for regional and local transportation investments. As noted by the GVMC transportation planning director, this approach helps meet GASB-34 requirements, allows local governments to develop their own pavement management strategies, and meets Michigan's Asset Management Council requirements for PASER ratings (see Asset Management Council case study).

Figure 4.1 Relationship Between PCI and Programming Eligibility
Grand Valley Metropolitan Council

	CONDITION	PCI		GVMC PROJECT ELIGIBILITY	PCI
	EXCELLENT	100			100
		86		ROUTINE	
	VERY GOOD	85		MAINTENANCE	
		71			71
	GOOD	70			70
		56		OVERLAY	
	FAIR	55			46
		41			45
	POOR	40			
		26			
	SERIOUS	25		RECONSTRUCT	
		11			
	FAILED	10			
		0			0

Management and Data Systems

The GVMC's web site description of the MPO's asset management program states, "Grand Valley Metro Council's Pavement Management System (PaMS) is a tool that enables local and state transportation officials to make better, more efficient use of resources, save time and make more informed decisions about which repairs to use on our region's roads and bridges and when to use them." As noted above, the data collection effort to support this program now relies on a van equipped with state-of-the-art electronic pavement scanners, high-resolution still cameras, global positioning system (GPS) components and computers (see Figure 4.2). Digital downward linescan images reveal distresses of up to 1.0 mm. Digital photos with straight forward and side right-of-way views are taken every 25 feet. Thus, the van has the ability to inventory other roadside assets (signs, guardrail, utilities, geometric configuration, etc.) at submeter accuracy. All of this data can be collected while traveling up to 65 mph. The software can generate both PCI and PAVER ratings. The fully equipped van cost approximately $400,000, which was funded with STP dollars.

Figure 4.2 Instrumented Van to Collect Pavement Condition Data
Grand Valley Metropolitan Council

The GVMC identified the following benefits associated with the decision to purchase this new data collection capability. It was considered to be:

- More cost-effective in the long term;
- Safer than current data collection method;
- More flexible, consistent and accurate in handling data;
- Able to collect data for MPO members at low or no cost;

- Consistent with current approaches to pavement management in the region;
- More efficient in collecting large amounts of data in a short period of time, as well as processing that data in-house more efficiently; and
- Able to collect data on the entire Federal-aid system annually.

GVMC is the first region in Michigan to use a mobile, semi-automated, advanced technology system to gather and analyze road condition data.

GVMC also is responsible for a comprehensive traffic counting program that feeds into the asset management database. The approach adopted by GVMC in this program is to subsidize local governments to collect this data, with 80 percent of the cost reimbursed (Federal aid) to the local government if it has covered the 20 percent local share.

Another important tool that is used by GVMC and its local jurisdictions is REGIS, the regional geographic information system that has been adopted by 20 cities, townships, and regional planning agencies in western Michigan. REGIS provides a common database and a series of interfaces that allows spatial data management by member agencies (See Kent County Road Commission case study). The REGIS system has been used very effectively by GVMC and local agencies to manage the region's asset management database.

Results of the System Preservation Strategy

Given that the implementation of the region's asset management program rests with the county and local transportation agencies, the results of GVMC's asset management efforts really depend on how successful they are in supporting the local efforts. From information gathered during this scan, it seems that the MPO has played a critical role in data collection and resource allocation in supporting such efforts. In addition, GVMC has invested in an enhanced pavement condition data collection capability that sets it apart from most MPOs in the country.

With respect to regional transportation investment, 62 percent of the road investment has been targeted to system preservation. Another 26 percent has been allocated to bridge rehabilitation. As noted earlier, Federal STP funds have been used for reconstruction and resurfacing projects in Kent County.

Lessons Learned

The GVMC case study illustrates an important role that a metropolitan planning organization can play in a regional asset management program. It was evident in the discussion with both GVMC and Kent Road Commission officials that a level of trust has been developed between the MPO and local agencies that has served the region's asset management program well. In particular, the use of Federal STP funds to purchase the instrumented van for a more comprehensive data collection effort is unique for an MPO, and yet critical for the ongoing evolution of the region's asset management effort. The consideration of using traffic projections from the regional travel demand model to determine long-range pavement deterioration is something that could be quite interesting and relevant to other MPOs in the country.

Although the institutional relationships established in the GVMC region seem conducive to effective decision-making on investment priorities for road preservation, it is not clear how this arrangement might work in other metropolitan areas where a potential exists for disagreements on project priorities among the planning and implementing agencies. It seems likely that, just as in the GVMC case, some level of accommodation and agreement on roles and responsibilities would have to be agreed to early on. However, as was shown in this case, the MPO can play an important role in educating and influencing local decision-making with respect to transportation investments. It also can provide a data collection and database management capability that promotes a stable and consistent approach to data utilization and producing the information needed by decision-makers for both regional and local priorities.

4.2 Southeast Michigan Council of Governments (SEMCOG), Detroit, Michigan

Context

The Southeast Michigan Council of Governments (SEMCOG) is the regional planning agency in southeast Michigan. The SEMCOG region encompasses seven counties and over 200 local governments. The region has an estimated current population of 4.9 million. As the metropolitan planning organization for the Detroit urbanized area, SEMCOG plays a critical role in defining future transportation policies and investment strategies for the region.

According to SEMCOG officials, there are several critical transportation issues facing the region. These include: the need to rehabilitate a significant portion of the roads and bridges in the region; congestion levels are increasing; coordinating all of the road construction that is ongoing to make it as tolerable as possible to motorists and businesses; insufficient funding; and inadequate transit services. The region's transportation policy places a higher value on maintenance and rehabilitation over providing additional capacity. Developing an asset management program is one of the stated policies in the adopted 2030 Regional Transportation Plan.

The creation of the State Transportation Asset Management Council (see related case study) was a major reason for SEMCOG becoming involved in asset management. The Asset Management Council was appointed by the State Transportation Commission in September 2002. SEMCOG became involved shortly thereafter.

Investment Decision-Making Process

Given that it is the MPO for the Detroit urbanized area, SEMCOG is organized for decision-making similar to other large MPOs. An executive committee, consisting of 51 members, provides policy guidance on overall transportation investment directions in the region. A total of 143 dues-paying jurisdictions belong to the SEMCOG General Assembly, which must approve the transportation plan and transportation improvement program (TIP). A transportation advisory committee, consisting of between 70 and 90 people, provides technical input into the transportation planning process.

The 2030 Regional Transportation Plan identified $70 billion in needs for the region, but found only $40 billion in likely revenues. A result of this gap between need and available resources was an increased interest on the part of local officials in maximizing the use of the existing transportation system. One of the ways of doing this was to encourage an asset management effort as part of the regional transportation planning process. For example, an action strategy in the 2030 plan was to "support the efforts of the Transportation Asset Management Council to collect, evaluate and report on the regional pavement and bridge conditions…and to use the resulting data to formulate regional transportation funding decisions that are cost-effective."

Asset Management Approach

SEMCOG is in the early stages of developing a structured asset management approach in its planning program. It is now moving from an organizing phase to the point where it is both beginning to educate local agencies on the benefits of asset management as well as assessing the pavement and bridge data collected over the last three years.

The SEMCOG asset management functions are assigned primarily to the transportation and environmental program areas. SEMCOG has one staff person working primarily on asset management-related activities, with several additional staff participating in the transportation data collection effort. However, data collection on the entire road network is dependent on the willingness of local agencies to collect data for their road networks. SEMCOG officials stated that the largest challenge to date has been the development of a schedule to collect pavement condition data since the visual inspection approach requires at least three individuals – one from the county, the Michigan DOT and SEMCOG – to be in the car when inspections occur.

The overall approach that SEMCOG is envisioning for its asset management activity follows closely the traditional asset management steps.

- Conduct annual system condition inventories;
- Identify needs by forecasting system conditions based upon reliable rates of deterioration;
- Establishing strategic goals and objectives (and performance measures);

- Evaluate investment scenarios based upon forecasted conditions and achievement of goals and objectives;
- Develop and implement a multiyear investment program; and
- Routinely monitor the performance of system improvements.

SEMCOG has so far focused on road and bridge conditions. There are several transit properties in the Detroit metropolitan area, each having their own asset management program. SEMCOG does not collect this data, but does expect that when transit properties request investments in the TIP process, justification is provided on why new vehicles or equipment are necessary.

Management and Data Systems

SEMCOG has a number of data bases, including: three years of pavement condition ratings, three years of National Bridge Inventory information, five years of past expenditures, and a data base that contains physical attributes of the system. All of the databases are integrated through the use of a unique reference number assigned to each segment of a road.

Road condition data are collected on an annual basis using the Pavement Surface Evaluation and Rating System (PASER). PASER is a visual survey that rates the condition of various types of pavement distress on a scale of 1 to 10. The ratings are then combined into three categories based upon the type of work that is required for each rating: routine maintenance (ratings 8 to 10), capital preventive maintenance (ratings 5 to 7), and structural improvement (ratings 1 to 4). A minimum of a three-person team drives the entire Federal-aid eligible roads in the region collecting road condition data, surface type, and number of lanes. National Bridge Inventory data, collected by certified inspectors, are submitted to the Michigan DOT by local agencies on a two-year cycle. Investment data are submitted to SEMCOG by individual road agencies. Michigan's Local Transportation Assistance Program (LTAP) provides training for the individuals tasked with collecting this data.

Estimating the level of funding associated with this data collection effort is difficult because of the way agencies account for work activity funding. However, SEMCOG estimates that the regional costs are in the neighborhood of $130,000, including the costs for collecting both PASER and the investment data.

With respect to quality control, a pavement engineer from the Michigan DOT drives a one percent sample of the roads in each county. The ratings by the teams are then compared to the quality control ratings.

The RoadSoft pavement management model, developed by the Michigan Local Technical Assistance Program, is used to determine expected deterioration of existing pavement surfaces. PASER data is collected using a laptop that is outfitted with a specialized screen tied into the RoadSoft pavement management system. A GPS receiver is used to locate coordinates of each segment. The base map is the standard State of Michigan GIS base map, which includes all public roads. In addition, the State's Center for Geographic Information (CGI) has developed an Internet-based asset management investment tool that is used to collect information on past and future projects of the various road agencies.

Michigan law requires life-cycle cost analysis for any project where the "pavement" costs exceed $1 million, but it only applies to the Michigan DOT, not local agencies. However, pavement remaining service life (RSL) is calculated as part of the RoadSoft analysis, and thus life-cycle costing is available for those using this pavement management system. Each segment of a road is related to one of five deterioration curves, thus each segment has a corresponding RSL value. The deterioration curves are based on Wisconsin data (which is where PASER originated). The intent is to replace these curves with Michigan-specific curves once sufficient data are collected.

Both RoadSoft and the Internet-reporting tool used to report condition data to the State's Asset Management Council are designed so that a local road agency can use them in the prioritization of local projects. RoadSoft is continually being modified at the request of the users to include more and more assets. For example, a culvert module is expected to be added in 2006.

Results of the System Preservation Strategy

The SEMCOG asset management initiative is in the early stages of development. However, SEMCOG has recognized the need for preservation for many years and has monitored the level of funding that has gone into system preservation. For example, of 168 projects in the 2005 TIP, two-thirds of the total project costs ($545.4 million) were dedicated for pavement preservation or bridge projects. From 2002 to 2005, 574 center lane-miles (2,000 lane-miles) were repaved, 447 bridges received some preservation treatment, in comparison to 80 miles of road widening. Monitoring of the change in pavement condition between 2004 and 2005 showed that 33 percent of the road mileage saw improved pavement condition, 42 percent stayed same, and 25 percent deteriorated. From 2000 to 2005, the number of deficient bridges in the region declined from 1,251 to 1,164. Almost 50 percent of the transit fleet consists of new vehicles. Such numbers indicate the level of commitment of the region to system preservation.

SEMCOG officials noted that the major benefit to date has been the change in attitude among various transportation agencies. Today there is less contention and competition and more a spirit of partnership in managing the region's transportation system. Promoting asset management is another service that SEMCOG believes it can provide to member governments.

As noted earlier, one of the major activities SEMCOG has undertaken with regard to asset management has been educating local officials on the benefits of such an approach to system management. Many elected officials are now well aware of the benefits of an asset management approach and how it can help them especially when facing budgetary problems. Interestingly, SEMCOG officials note that in presentations at public meetings, the public has been surprised that this type of analysis is only now being conducted.

SEMCOG has provided training on data collection for asset management and provides the forum for the State Transportation Asset Management Council's various training classes that are open to any agency.

Interestingly, perhaps one of the major results of the asset management efforts to date is the agreement among MPO members that the planning process needs to be changed to include asset management in a more systematic way. This includes applying performance measures, collecting data on 8,000 miles of the regional road network, and conducting investment analyses that indicate the most cost-effective long-range investment strategy for the region.

Lessons Learned

SEMCOG officials noted that an agency could face several challenges in implementing an asset management program. There are no "ribbon cuttings" associated with system preservation; and this often requires extra effort in outlining the benefits of asset management to local officials. Staffing, especially in a regional planning agency, can be a significant problem, primarily in finding someone with the appropriate skills. As seen in this and other cases, asset management tends to be data analysis-driven, and yet, data collection is often the first activity that is cut when an agency faces a budget problem.

SEMCOG officials also identified several benefits to an asset management program. Importantly, a comprehensive asset management program provides institutional knowledge about what has happened to the road network and how conditions have changed over time, an important consideration for agencies facing retirements of its most knowledgeable professionals. The uniform approach toward rating condition promotes understanding and equitable distribution of funds around the region. Decision-makers are clearly able to see what will happen to pavement and bridge condition if investment in preservation does not continue. This understanding also transfers to the general public where it is manifested in enhanced public confidence in the ability of transportation agencies to manage their assets. Both decision-maker and public confidence could result in additional funds being provided to transportation agencies. Or if nothing else, asset management could "stretch" the investment dollars expected over the lifetime of an investment plan. Another benefit in Michigan is that state law allows for additional flexibility in the use of state funds if a community has an asset management program in place.

5.0 Associations

5.1 Transportation Asset Management Council (Michigan)

Context

In 1999, the Michigan legislature established a bipartisan committee to study the need to change the funding formula for the distribution of Michigan's transportation funds. As a result of committee deliberations, the legislature amended Act 51 in 2002, that established an asset management approach for local jurisdictions and state road agencies. The legislation also created a Transportation Asset Management Council (TAMC). The TAMC was appointed by the Michigan Transportation Commission in September 2002. Since 2002, the Council has moved from an organizational phase to a point where it is now beginning to educate local agencies on the benefits of asset management and assess the data that has been collected over the last three years. There are 617 agencies in Michigan that are subject to the Act 51 provisions.

Decision-Making Process

Given that the Council does not own assets, it does not have an "investment decision-making process" per se. The Council is comprised of 11 members, 10 of which are voting members. There are two members each from the Michigan Municipal League, County Road Association of Michigan, Michigan Department of Transportation, and one from the Michigan Transportation Planners Association (metropolitan planning organizations), Michigan Association of Regions, Michigan Association of Counties, and the Michigan Townships Association. The nonvoting member is from the Center for Geographic Information, which serves as the central repository for all of the data collected by the TAMC. These agencies represent the owners of the assets and those that are in some manner responsible for project selection or funding. Members serve three-year terms and are eligible to be reappointed.

MDOT is responsible for all administrative functions of the TAMC, with the functions of the Council assigned primarily to the Asset Management Division/Bureau of Transportation Planning in MDOT. The metropolitan planning and regional planning organizations are required to provide "technical" assistance to the Council.

The legislature appropriates funds for the TAMC on an annual basis, with the appropriation being just over $1.6 million. The Council must submit an annual report to the legislature that describes the condition of the State's roads and bridges, and outlines the level of investment in roads and bridges during the prior year. Approximately 50 percent to 60 percent of the 617 Act 51 agencies have submitted financial data for the system in their jurisdiction.

Asset Management Approach

The mission statement of the Council is taken directly from the law that created it. It states: "In order to provide a coordinated, unified effort by the various roadway agencies within the State, the transportation asset management council is hereby created within the state transportation commission and is charged with advising the commission on a statewide asset management strategy and the processes and necessary tools needed to implement such a strategy…in a cost-effective and efficient manner."

In addition the Council has adopted the following goal statement and associated objectives. The "Transportation Asset Management Council will expand the practice of asset management statewide to enhance the productivity of investing in Michigan's roads and bridges through coordination and collaboration among state and local transportation agencies by:

- Surveying and reporting the condition of roads and bridges by functional classification categories for the State and Regional Planning areas;
- Assessing completed and planned investments in roads and bridges by the various transportation agencies of the State;
- Supporting the development of appropriate asset management tools and procedures; and
- Providing education and training on the benefits of developing road improvement programs through the use of asset management principles and procedures.

Our expected outcome is an asset management process that is easily used and communicated and leads to a road network that is managed by function."

The Council relies on local jurisdictions and the Michigan DOT to collect the relevant road and bridge condition data. Road condition data is collected using the Pavement Surface Evaluation and Rating System (PASER). PASER is a visual survey that rates the condition of various types of pavement distress on a scale of 1 to 10. The Council then groups these ratings into three categories based upon the type of work that is required for each rating. These categories are routine maintenance (ratings 8 to10), capital preventive maintenance (ratings 5 to 7), and structural improvement (ratings 1 to 4). National Bridge Inventory data is submitted to MDOT by local agencies on a two-year cycle. Certified inspectors collect the data. Investment data is submitted by individual road agencies.

Members of the various road agencies collect PASER data through a cooperative arrangement. Teams consisting of a representative of MDOT, the regional planning organization and the respective county road commission or city, drive all the Federal-aid eligible roads within a given county. There are over 100 teams involved in this effort, rating over 43,000 miles annually. The Council estimates that the annual cost of collecting road condition data is approximately $865,000. This would include costs for both PASER and the investment data. The TAMC is not directly involved in the collection of bridge data.

Management and Data Systems

The Council has a number of data bases, including: three year's of PASER condition ratings, three year's of National Bridge Inventory information, one year (2005) of past expenditures. All of the databases are integrated through the use of a physical reference number, which is a unique number assigned to each segment of road. The enabling legislation for TAMC required that data be stored in an "unbiased" repository and thus the State's Center for Geographic Information has worked with the Council to use the State's geographic information reference system for the Council's activities.

The Council has recently chosen to use the RoadSoft pavement management model for roads. This model has available a series of five default deterioration curves, and thus each road segment (0.1 mile) is related to one of the five curves. Remaining Service Life is calculated from the segment-specific curve. The Council also has decided to use MDOT's Bridge Condition Forecasting System for determining the future condition of the State's bridge assets.

PASER data is collected using a laptop that is outfitted with a specialized screen tied into the RoadSoft system. A GPS receiver is used to establish reference locations along the road network. In terms of quality control, a pavement engineer from MDOT drives a sample of one percent of the roads in each county, and compares his/her ratings to those collected by the Council teams. A recent comparison showed that nearly 70 percent of the team's ratings were within one PASER rating of the pavement engineer's rating; over 91 percent were within two rating points. TAMC does not believe this is good enough and may be establishing a certification process for pavement raters that should result in better quality data in the future.

Results of the System Preservation Strategy

Given that the TAMC does not directly make investment decisions regarding road preservation, and since they have been in existence only since 2002, it is too early to say whether its efforts are making a difference with respect to road condition. However, as noted by a TAMC representative, the most important issue that the Council had to overcome was a decade of suspicion and mistrust among the various agencies. Attitudes of individual members have seemingly changed and the members appear willing to set aside differences in order for the Council's effort to succeed. The Council fulfills the role of the "honest broker" when it comes to providing data and information to the legislature.

Another barrier has been getting buy-in from local road agencies. The Council recently published a user's guide for local agencies and has increased its commitment to training and educational seminars. The first annual asset management conference was held in spring 2006 that was attended by over 200 state and local officials.

"Asset management is as much about pulling all the players together for a common purpose as it is about its technical aspects."

…Michigan Asset Management Council Official

With regard to member agencies, the Council usually makes presentations at their respective annual meetings. In addition, the agencies receive quarterly and annual reports from the Council. Key legislative staff members receive quarterly reports and members of the legislature receive the annual report. Also, the Council sponsors a number of training programs through the Michigan Local Technical Assistance Program, and the National Center for Pavement Preservation. An introductory one-day class covers the basics of asset management and pavement preservation. A second, two-day advanced course is jointly offered with the National Center of Pavement Preservation on pavement preservation and roadway deterioration. Finally, the TAMC staff teaches a one-day overview course on asset management.

Lessons Learned

According to TAMC officials, the key factors in any successful asset management program seem to be: 1) some type of legal mandate; 2) the assembling of a team to promote asset management; and 3) development of a number of educational and outreach materials that local agencies can use to adopt asset management principles. As noted by these same officials, one of the most compelling points raised at a recent conference by representatives from New Zealand was that until they began to publish their educational materials and began teaching their regions how to do asset management, they were just "spinning their wheels." Ultimately, in Michigan, asset management will be a success when local road agencies believe that it will benefit them and they adopt asset management principles as the basis for investment decision-making. This will take a strong educational effort.

A very important issue faced by the TAMC has been the amount of data that is required to run a standard strategic analysis model. Data such as date of last reconstruction, average costs per work type, and the number of deterioration curves needed to accurately assess future condition, have been difficult to come by. Many agencies have not traditionally collected this information so it takes a long time to populate the model to accurately reflect what is happening in Michigan.

The Transportation Asset Management Council case study is a good example of how a statewide effort in asset management can be successful. The Council has raised asset management awareness among state and local officials through communication and education efforts, and by collaboratively establishing asset management activities with key stakeholders in the State. The use of an "outside" data repository, that is, the Center for Geographic Information, is an interesting strategy for overcoming a possible trust issue of who controls the data, but also assures that everyone has access to the data.

6.0 Observations and Conclusions

The agencies visited exhibited various stages of evolution in their application of asset management to their transportation decision-making process. Both the Michigan and Ohio DOTs, for example, have a comprehensive and sophisticated approach to asset management that has been integrated throughout their respective organizations. Other agencies, such as the Oregon and Utah DOTs, have not yet reached the levels found in Michigan and Ohio, but have adopted innovative and successful approaches that will allow them to reach such levels in the next few years. Thus, the observations listed below should be understood in the context that not all agencies visited were at the same stage of development of their respective asset management process.

- The agencies visited had all **adopted a 'preservation first' strategy for their investment priorities**. However, in many cases, this strategy has run up against concerns for reducing congestion on existing roads as well as dealing with the need for new road capacity to handle population and employment growth. Several examples from the scan illustrated the political pressure being brought to the 'reduce congestion' strategies.

- In each case, **the success of the asset management process was directly linked to the actions of an asset management champion or champions** within the organization. Until asset management became institutionalized within the standard operating procedures of the agency, the role of this champion was especially critical. In some cases, this champion was the head of the agency; in others it was a key staff member who strongly believed that asset management was an important component of the agency's mandate.

- In several cases, **the existence of an asset management process**, and more importantly, of the information that justified investment in a road system, **was instrumental in securing additional dollars from the legislature**. The use of an asset management approach in providing stewardship of a jurisdiction's resources was a very powerful tool in communicating to elected officials the needs and consequences of investing (or not investing) in highway infrastructure. As noted above, in some cases, these additional funds were dedicated to new road capacity, but the asset management process did provide the impetus for the legislature to feel comfortable that the existing road network was being handled well.

- The most **successful asset management processes have moved away from a "worst first" investment strategy**, and **instead have adopted investment principles that are based on life-cycle costing** that result in the most cost-effective preservation and maintenance strategies. As was noted by several scan participants, this concept (e.g., repaving roads or repairing bridges that do not appear to need it when other facilities are left to deteriorate further) is often difficult to explain to elected officials and to the general public. However, the asset management examples found in this scan suggest that such an investment strategy does provide a defensible and effective approach to infrastructure stewardship.

- **The most successful asset management processes had performance measures that guided investment decisions throughout the organization**. These performance measures have become important indicators for system monitoring and were used in one case for annual personnel evaluations. A performance-based asset management approach had become the normal way of doing business in many of the sites visited. However, in several cases, officials stated it was not clear whether the performance targets selected for the asset management process goals were the most appropriate targets. Most agencies had based their decisions on target thresholds on historical data and on some expectation of what could be achieved. In only a few cases was any effort made to obtain input from system users or customers on what performance measures and targets appeared reasonable. A few of the officials participating in this scan could answer the question of whether lowering the performance target by some small amount would still provide acceptable system performance for less cost. Several notable exceptions to this (e.g., the Michigan, Ohio and Utah DOTs) could assess with the analysis tools established in their respective asset management processes what would happen if lower system performance targets were selected.

- **Scenario analysis showing the consequences on performance measures was one of the most effective methods of convincing decision-makers of the need for investment in the transportation system.** With the use of management systems, engineering analysis and corresponding deterioration curves, agencies are able to show the condition levels of pavements and bridges given assumed investment levels. This capability has been instrumental in political discussions on the needs for infrastructure investment.

- **There was no one organizational model for asset management.** In some cases, agencies have identified an asset management unit or at least an agency asset management manager, while in others one cannot find asset management mentioned on an organization chart. Many different successful organizational models of asset management were found during the scan. Perhaps the most important organizational characteristic found in the cases was the use of a team approach in defining and implementing an asset management process.

- **The "growing pains" of an asset management process in almost all cases, fostered enhanced communications among many different organizational units**. Many of the participants agreed that the need to promote cross organizational coordination in an asset management process has led to more effective planning and decision-making in the agency.

- **One of the most important starting points for implementing an asset management process is to conduct an organizational self assessment**. The AASHTO *Asset*

Management Self Assessment Guide was pointed to by most as a very useful tool for undertaking this assessment.

- **There was very little evidence of the application of risk analysis techniques in the asset management processes observed.** The concept of risk assessment allows transportation officials to determine the economic costs associated with infrastructure failure and to incorporate these costs into the analysis process. Several other countries in the world have adopted formal procedures for doing so. It seems likely that such an approach will likely characterize U.S. asset management practice in the coming years as well.

- Quality data and cost-effective data collection strategies served as the basis for the cases investigated. **In several cases, agencies viewed data as an asset and the data collection process as an important decision support function.** These agencies were periodically examining if the right data were being collected for the types of decisions that had to be made. In some sense, best case examples of asset management sow that agencies become better consumers of data once they understand their asset management process. Effective communication tools are needed to leverage the information and value derived from data collection efforts and the strategy of "collect once, use often."

- **A customer orientation had been adopted as part of the asset management process in several cases.** Surveys were used to determine those aspects of the infrastructure maintenance and condition that were most important to the users of the road system. Some performance measures were selected (e.g., ride quality) because of their impact on public perceptions of the agency's performance.

- **New technologies have the potential of making data collection for asset management activities more cost-effective and efficient**. For example, portable computer lap tops combined with global positioning systems (GPS) are powerful tools that can be used to collect condition data on the road network. Michigan also is researching the possibility of using probe vehicle sensors and satellite technology to detect and report pavement conditions like potholes and other characteristics of ride quality.

- Some of the agencies visited used private contractors for providing long-term maintenance services (and thus used the term asset maintenance practice), while others relied primarily on their own forces. Two types of contracts were noted in the scan – work accomplished and performance-based. **It is essential that an agency have its own performance measures/criteria documented whether they are performing maintenance activities in-house or through a private contract**.

6.1 Recommendations for Further Action

The scan team identified several actions that should be taken to further transportation asset management principles in the United States. In addition, the case studies identified several possible research projects that would add to the knowledge base of current asset management practice. The action items included:

- Update the AASHTO Transportation Asset Management Guide to reflect the most recent information on asset management, especially lessons and guidance that comes from this scan.

- Develop an "ambassador" program that identifies leading state practitioners in asset management that can spend time with a DOT to discuss the steps necessary to develop an effective asset management process.

- Disseminate the scan's results at conferences and meetings as appropriate.

- Incorporate scan results into the ongoing efforts to create a national asset management steering group, which was one of the recommendations from the international scan.

- Develop research statements from the research topics list resulting from this scan. Submit research statements to appropriate research organizations. Potential research topics include: How should desired performance levels be set? What is the cost of setting high levels? How were road users included when setting these levels? How does one quantify that asset management over time results in the same road condition but for less cost? How can we establish a benchmarking system that demonstrates asset management practice? How are intelligent transportation systems (ITS) assets maintained? What are the conditions of success for long-term maintenance contracts? What is the standard methodology for developing deterioration curves for assets other than pavements and bridges? Can such a methodology distinguish between regions of the country and of a state?

- Get on the agenda and prepare materials for the FHWA Division Administrator national meeting in the spring of 2007.

- Prepare a brochure/pamphlet on the results of the scan that could be disseminated to a wide range of transportation groups and agencies.

- Establish a process for the case study states to report periodically on the progress they have made since the last time they reported (starting with the case study descriptions). The venue for this reporting would be the biennial national asset management conference.

- Establish a process for state DOTs to exchange information on asset management activities during the AASHTO regional meetings or in some other agreed-upon venues, perhaps starting with the Mississippi Valley State Highway and Transportation Officials agencies. The state DOTs themselves would be the ones organizing and presenting material. These meetings might be organized around specific topics, e.g., how are states dealing with the significant increases in costs (and thus adjusting their investment programs)?

- Establish a webinar series on "Talking Asset Management." This series would be dedicated to different themes and present states with an opportunity to describe their asset management approaches. The webinars would be held quarterly.

- Either sponsor a web site on asset management or become part of another asset management web site (e.g., the web site supported by the TRB Committee on Asset Management).

- Write articles on the scan results for *TR News* and the AASHTO *Journa*l.

6.2 Potential Research

Many of those who participated in the case study visits identified different research topics that they felt would further the state of practice of asset management. One of the proposed next steps is to develop research statements from the list resulting from this scan. Potential research questions include:

- How should desired performance levels be set? What is the cost of setting high levels? How were road users included when setting these levels? How should they be included?

- How does one quantify that asset management over time results in the same road condition, but for less cost? This, in essence, is providing a stronger economic basis for justifying the adoption of asset management principles and processes.

- How can we establish a benchmarking system that demonstrates asset management practice? Is there a way of comparing different asset management processes that provides a fair assessment of the relative strengths and weaknesses?

- How are intelligent transportation systems (ITS) assets maintained? How should ITS assets be incorporated into an asset management process?

- What are the conditions for success of long-term maintenance contracts? How have these contracts been used to provide asset management capabilities in state DOTs and other transportation agencies?

- What is the standard methodology for developing deterioration curves for assets other than pavements and bridges? What are the best transition probabilities associated with moving from one condition level to another? Can such a methodology distinguish between regions of the country and of a state?

- How are asset management processes incorporated into the different functional areas of a typical transportation agency, such as planning, maintenance, operations, program development? In particular, what is the evolving linkage between operations and asset management?

- What new technologies can be used to better monitor system condition? What are their strengths and weaknesses? What are the relative costs compared to the value of the information provided?

Appendix A

Amplifying Questions

Amplifying Questions

The following questions were distributed to the participating agencies to help them in preparing their presentations.

Overview of Transportation Asset Management

- Please provide a brief overview of how your agency is organized. What are the major funding sources for your transportation program? What are the critical transportation issues/challenges facing your agency?

- Is the asset management function primarily assigned to one office, or is it integrated throughout the organization? What staff resources are dedicated to this function? Has this organizational responsibility stayed the same over time, or has it changed? If it has changed, why was the change made?

- What were the major reasons your agency adopted an asset management philosophy for organizational decision-making and management? When did your agency first begin to use transportation asset management? How has it evolved since this initial use? What barriers or challenges have you faced in implementing your asset management program in your agency? How were these barriers/challenges overcome?

- What have been the major "drivers" of transportation asset management in your agency? Are there legislative mandates for conducting asset management?

- Do you have a stated goal or mission for your asset management program? How important is asset management as stated in this goal or mission in influencing decisions in comparison to other factors, such as politics; emphasis on large-scale, capital projects; regional equity in investment, etc.?

- Have you defined a position in your agency of "asset manager?" If so, what are the duties of this position? Where does the role of asset manager report within your operations and management organization with respect to budget allocation and work assignments?

- Do you have asset management teams in your agency? If so, what is their role, responsibilities? and composition?

- How have state and local asset management efforts been coordinated?

- We are interested in comprehensive/integrated/organization-wide transportation asset management programs. By this we mean, an asset management program that considers assets across modes, organizational functions, and asset groups; and that integrates asset management information vertically and horizontally within the agency decision-making structure. Would you describe your asset management program as being "comprehensive" and/or "integrated"? What aspects of your program make it so?

Relationship Between Asset Management and Decision-Making

- Please describe the investment decision-making processes in your agency. How is the information produced from your asset management system used in your agency decision-making, ranging from strategic planning to long-range planning to operations decisions? Please provide specific examples of this linkage between asset management information and decision-making.

- Have you used the results of your asset management effort to make the case to elected officials for either additional funds or for shifting funds between priorities (e.g., moving from expansion to preservation)? Have your efforts influenced the overall level of funding provided to your agency?

- Does your agency have a policy that establishes the relative importance of infrastructure maintenance and preservation versus capacity expansion versus operational improvements? How is a balance in investment made among the different types of projects in your agency's portfolio (e.g., balanced investment among bridge, pavement, operations, preservation, etc. projects)?

- If investment tradeoffs are made among such things as safety, environmental quality, sustainability, congestion relief, capacity expansion, infrastructure preservation, etc., how are these tradeoffs made? If your agency is responsible for more than one mode of transportation, how are investment tradeoffs made and priorities established among different modal programs?

- Does your asset management process occur within a much larger transportation system performance measurement or key performance indicator process? If so, what are the key performance/condition measures that are used in the asset management process?

- If system performance measurement is used in your agency or jurisdiction, how is decision-making influenced by performance indicators? If benchmarks or targets are used as part of the performance measurement program, do these benchmarks/targets support decision-making or do they "drive" it?

- Do you use return on investment or benefit/cost analyses to establish project priorities? How do you deal with uncertainty in cost estimates? How do you account for user costs?

- Do you use life-cycle costs in repair/replace/build decisions? Is asset data used to establish life-cycle costs information? If so, how does life-cycle cost information affect decisions relating to budgets for capital investment and for maintenance?

- For unique projects where special materials are used in project design (e.g., downtown transit or pedestrian malls, main streets, etc.), do you assess the life-cycle costs of such special treatments when making a project decision?

- If you outsource or privatize maintenance/operations activities in your organization, how is your asset management program used in establishing the budgets, priorities, and/or task allocations in such efforts?

■ Technical Aspects of Transportation Asset Management

- What are the major components/tasks of your transportation asset management system? What physical assets are monitored?

- What are the different data base systems that are part of your asset management program (e.g., pavement, bridge, sign/signal/pavement markings, intelligent transportation system, equipment inventory, etc.)? How are these systems linked or integrated with one another?

- If you have an integrated or linked set of systems, can managers use them to conduct scenario analyses to investigate the implications on transportation system performance and condition of different levels of investment?

- For the different assets monitored as part of your asset management program, describe the types of data that are collected and the data collection strategies used. In particular, how does condition inspection occur for the different types of assets in your agency's portfolio?

- What is the schedule for collecting data on different assets in your inventory? How is this data collection effort staffed (data collection, data entry, data maintenance, process, etc.)? Is data collection a distinct role/task assigned to dedicated forces or is it piggybacked onto other work? What are the costs associated with the data collection effort? Have you conducted a benefit/cost analysis of the data collection effort associated with your asset management effort?

- What quality assurance/quality control policies and/or methods do you employ to assure the integrity and value of the data collected?

- Do you track planned and emergency maintenance on individual assets? If so, how is this done within the context of your asset management program?

- What types of information and location technology systems are used as part of the asset management program (field technology, mapping applications, work management systems, global positioning systems, geographic information systems, etc.)? How are they integrated with each other? What, if any, problems have you had with any of these systems?

- How do you segment linear systems (roads, trails, sidewalks, etc.) into assets?

- Can mapped data be used to plan and design projects? For example, is the database detailed enough to be able to target sign replacement by sign legend?

- Do you use remote electronic devices for either maintaining asset inventories or for tracking asset condition? Do you have, or do you envision, using "smart" materials or sensors for monitoring the condition of infrastructure?

- Are benchmarks or target values of asset condition and maintenance incorporated into the asset management analysis? Is the level of service or other measures of operating performance used in the asset management analysis? How are these measures established? Has any effort been made to get input from the public or from other groups on what these measures should be?

- In the context of maintaining infrastructure integrity, how does your agency or jurisdiction establish and enforce restrictions on damage-causing activities such as overweight vehicles? Have the results of your asset management program been used to help define what these activities might be?

- What technical models/approaches are used as part of your asset management program, in particular to assess the value of assets? What types of asset valuation methods have been used in your asset management program, and have any of these methods been more effective than others?

- How have you defined "life-cycle" or "useful life" timeframes for infrastructure management and operations? Do you calculate "remaining service life" as part of this assessment?

- Are you aware of protocols or requirements that mandate life-cycle costing in different jurisdictions in your state/province?

- For those projects with multiple assets (e.g., pavement, lights, signals, signs, etc.), how have life-cycle costs of **alternative project designs** been calculated and used in decision-making for large, long-term expenditures?

Information Understanding and Dissemination

- To what extent are asset management and the results of your asset management program understood by senior managers, mid-level managers, and other employees in your agency? By key elected officials? By the general public? Did you make any special effort to educate these groups on what asset management means to your jurisdiction?

- How are the results of your asset management effort conveyed to agency and government decision-makers, as well as to the public? What lessons have you learned in this effort on how to communicate such information in the most effective way?

- How is asset management data/information shared with other units in your organization? Does your agency have compatible data sharing systems in place that allow other organizational units to tap into the data base for their own purposes?

- If other jurisdictions (e.g., cities) want data on your agency's transportation infrastructure for their own planning purposes, is there a database they have access to? Is this database provided in print and digital form? Is it accessible via the Internet?

- Does your agency provide training on asset management to your staff and/or to others? If so, what are the topics included in this training?

- What type of research have you conducted to advance the state of practice of asset management?

- What type of guidance, training, research, or tools would be most beneficial to your agency?

Benefits/Impacts of Transportation Asset Management

- Do you use any measure or indicator of performance of your asset management function (in this case, we are interested in performance of the asset management program, not of the transportation system)? Are resources allocated within your agency based on achieving performance indicators?

- Have you evaluated the effectiveness of your asset management program? If so, what measures of effectiveness have you used? What do you think have been the major benefits of asset management as used in your agency, whether they can be measured or not?

- How effective has the asset management staff function competed for agency resources? Through the use of asset management, how effective has your agency been in competing for resources?

- Do you benchmark your asset management effort with other agencies and/or jurisdictions? If so, what benchmark measures are used?

- Based on your experience with asset management, what best practices would you recommend to other agencies?