Transportation Asset Management Case Studies

Presented by

U.S. Department of Transportation
Federal Highway Administration

DATA INTEGRATION

The Michigan Experience

Note From the Director

The Federal Highway Administration Office of Asset Management is aggressively promoting a different way for transportation agencies to distribute their resources among alternative investment options. This new way of doing business, referred to as "Asset Management," is a strategic approach to maximizing the benefits resulting from the expenditure of agency resources.

For any transportation agency, the progression toward Asset Management will involve a myriad of activities. These endeavors will differ from State to State. For example, some agencies will pursue a data integration strategy in order to ensure comparable data for the evaluation of investment alternatives across asset classes. Others will move to deploy economic analysis tools to generate fact-based information for decision makers. Still others will want to integrate new inventory assessment methods into their decision-making processes.

Much can be learned from those who are readying their organizations for Asset Management. To spark the exchange of information, we are initiating a series of case studies focused on agencies that are leading the way. In this, the inaugural year of the series, we established four tracks: data integration, economics in asset management, the Highway Economic Requirements System–State Version, and life-cycle cost analysis. In upcoming years we will add new State reports to each of the tracks and will create new tracks addressing additional facets of Asset Management such as change management and performance measurement.

On behalf of the Office of Asset Management, I am pleased to introduce this new series. We believe the case studies will help agencies meet the challenges of implementing Asset Management programs.

David R. Geiger
Director, Office of Asset Management

Note to the Reader

The Transportation Asset Management Case Study Series is the result of a partnership between State departments of transportation and the Federal Highway Administration (FHWA) Office of Asset Management. FHWA provides the forum from which to share information, and the individual States provide the details of their experiences. For each case study report, State transportation staff were interviewed by FHWA, and the resulting material was approved by the State. As such, the case study reports rely on the agencies' own assessment of their experience. Readers should note that the reported results may or may not be reproducible in other organizations. ■

Mackinac Bridge, Mackinaw City

Executive Summary

In the early 1990s the Michigan Department of Transportation (MDOT) was a highly centralized agency that had just completed its final links in the Interstate Highway System. At the same time the Department was facing the reality that much of the existing system had been in place for more than 40 years. MDOT needed to move the organization away from building to managing and operating the existing infrastructure. At the same time, the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) provided the impetus for what was to become a comprehensive redesign of MDOT's business practices within an Asset Management framework, with data management a key requirement for the decision-making process.

MDOT began its data integration effort by building a Transportation Management System, migrating key planning, programming, and project-delivery data from the mainframe to a user-friendly environment.

To support improved decision making, MDOT began its data integration effort by building the Transportation Management System (TMS). With TMS, the department migrated key planning, programming, and project delivery data from the mainframe to a more user-friendly environment. The migration resulted in the fusion of approximately 20,000 files into five major databases. To integrate the legacy databases pertaining to transportation assets, MDOT abandoned all existing linear referencing systems and adopted a single, statewide, linear referencing system. TMS now provides the platform for consistent and collaborative decision-support and resource allocation processes that support Asset Management.

The decision to invest in the development of TMS dramatically changed the way MDOT does business. Not only has the new system met the day-to-day business needs of the department's system users and many of its partners, it has also been the catalyst for changing the way MDOT is organized, how it is staffed to deliver its products, and how it relates to its various constituents.

Over the past decade, MDOT has become a leader in Transportation Asset Management. Recent legislation requiring Michigan's transportation agencies to adopt Asset Management concepts assures further business process improvements and solidifies the role of data integration and TMS in moving MDOT and its partners forward. ■

AGENCY FACTS

Managing investments to extend the life of existing facilities and improve the performance of the transportation system is essential for Michigan's citizens and economic sector to prosper.

Michigan's geography is unique among the 50 States. The Great Lakes divide the State into two large peninsulas, both located north of the major east-west transportation corridors. Michigan's economic survival depends on a sound multimodal transportation system to provide access for people and goods to the rest of the Nation.

A significant challenge facing MDOT is Michigan's unusual climate. The lakes modify the severe northern winter weather, leading to heavy lake effect snows and frequent freeze-thaw cycles. The results are rapid infrastructure deterioration, high maintenance costs, and a small window for road construction activities. Under these conditions, investments that extend the life of existing facilities and improve the performance of the transportation system are essential for Michigan's citizens and economic sector to prosper. The department's Asset Management process focuses on these objectives.

Today MDOT is a decentralized organization with seven regional offices and fewer than 3,000 employees. Its staff is responsible for managing a $1.2 billion capital highway program and a $225 million maintenance budget.

Michigan's transportation system consists of a complex mix of facilities:

- 9,704 miles of State trunk line highways, which represent 8.5 percent of the total statewide mileage and carry 54 percent of all statewide travel
- 11,135 bridges, including Michigan's crown jewel—the Mackinaw Bridge—and various major international bridges serving Canada
- 180 miles of instrumented intelligent transportation systems (ITS) infrastructure
- 235 public use airports
- 131 intermodal passenger facilities and 568 miles of AMTRAK service
- 20 ferry services to Michigan's many inhabited islands and 40 commercial ports
- More than 4,000 miles of track for rail freight (965 miles of which are State owned)

SETTING THE STAGE

What Did MDOT Have?

In the early 1990s MDOT was a highly centralized agency with more than 4,200 employees. The completion of the 40-year-old Interstate Highway System meant it was time to begin reconstruction and modernization of those roadway segments. At that time, MDOT faced several challenges. Its organizational culture was shaped by the need to complete the construction of the interstate system rather than to preserve the system, resulting in high operating costs. In addition the department did not have enough contact with its customers, and its information system was not up to the task of supporting its changed mission.

The new mission of reconstruction and modernization called on MDOT to meet new management challenges:

- Manage existing assets
- Identify and control overhead costs
- Flatten the organization's decision-making hierarchy
- Become more agile and interdisciplinary
- Respond better to the needs of its customers

These goals required a new staffing mix for MDOT to manage its resources and operate its transportation systems more effectively.

The keys to reinventing the department were moving from a centralized to a decentralized organization and developing new relationships between strategic planning, program development, project design, and project delivery. When ISTEA was passed, MDOT saw the opportunities to re-engineer its business processes and use new computer technologies to facilitate organizational change. At the same time, MDOT was deciding whether to replace an aging mainframe system or migrate to the maturing personal computing options that were entering the market.

When the 1991 Intermodal Surface Transportation Efficiency Act of 1991 was passed, MDOT saw the opportunities to re-engineer its business processes and use new computer technologies to facilitate organizational change.

What Did MDOT Want?

MDOT began to reinvent itself by facilitating a business process re-engineering activity with its top executives and managers. Through this activity, the department recognized that data integration concepts would provide the vehicle for changing its focus and culture. A key element of the business process re-engineering effort focused on empowering MDOT's employees to make decisions in a more streamlined manner that related directly to its external customers. With this in mind, the department embraced client-server technology and relational databases as the future for its computer operations.

MDOT also envisioned an Asset Management approach to managing the transportation system, a comprehensive, long-term view that depends upon quality data on the initial condition and service levels of the system and the performance of the investments made to address system needs.

This approach required a powerful decision-support tool that would provide immediate access to data needed to support resource allocation decisions. Such a tool would help them identify asset conditions, analyze system usage patterns, and determine deficiencies in transportation infrastructure and services across modes. This tool would enable MDOT to quickly change direction if infrastructure performance resulting from investments such as pavement and bridge improvements was not meeting expectations.

HOW DID MDOT GET THERE?

Overall Approach

Integration efforts began in 1993 with a redesign of MDOT's core and support business processes. Initial efforts focused on the existing software and on processes that supported project and program development. MDOT discovered that four large data files contained essentially the same information but were stored and accessed in different ways. Reconciling these different storage methods and definitions would allow MDOT to eliminate several legacy applications and reduce multiple procedures to two major applications and one database. This integration would also significantly improve data quality.

The second step was to develop prototypes for the various internal management systems including those for bridges and pavements. The

next phase, starting in 1994, was system and database design. Final development and rollout of the systems occurred through 1996. The development process combined top-down and bottom-up approaches simultaneously to create a new business culture within MDOT. The process was designed to identify, review, and re-engineer existing business processes, establish the overall data needs of internal stakeholders, and facilitate a fully decentralized but coordinated planning and programming strategy. This new process facilitated a less complicated organizational decision-making and project delivery structure.

MDOT also identified external users of the system. By engaging its partners in the cities, counties, metropolitan planning organizations, FHWA division office, and transit properties in the prototype development, MDOT set the groundwork for extending the capabilities and benefits of the Asset Management data integration effort beyond the MDOT environment.

Immediately it became clear that establishment of an open system, client-server architecture would facilitate decision making and that this architecture would be critical to the overall success of the agency-wide restructuring.

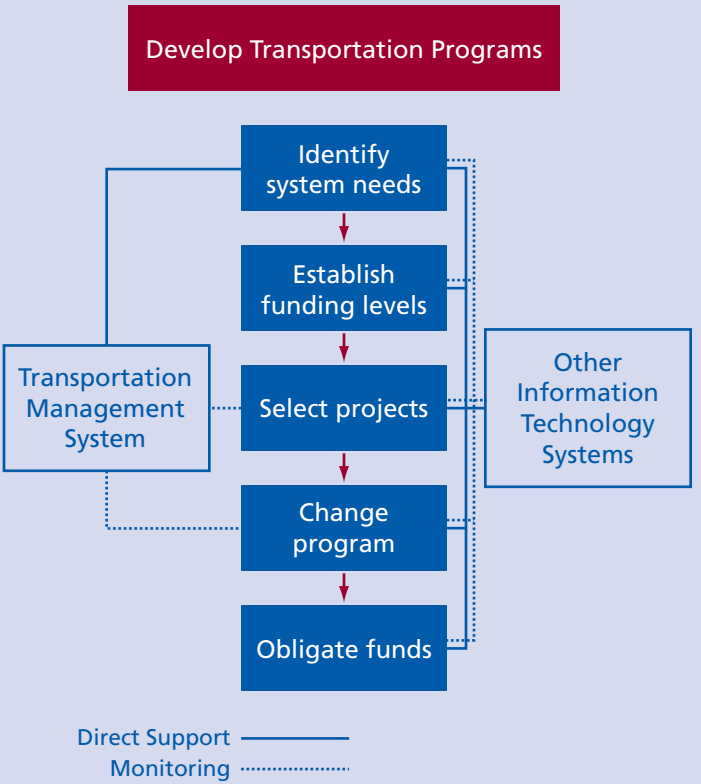
MDOT's first business plan, completed in 1997, formalized the need to develop the Transportation Management System (TMS) and tied the system directly to the agency's business processes and other information technology systems, as shown in the diagram on page 8. The TMS was designed as one integrated application with one integrated database. This design reflected MDOT's view that the organization would now function as a single entity with common requirements for data and analysis, rather than as many competing components with independent missions, needs, products, and constituencies.

The development process was a joint effort between the consultant community and various business and process owners at MDOT. Over the life of the project, and especially during the prototyping phase, more than 500 department employees became part of the empowerment process.

Technical Approach

For data to be a "corporate asset" instead of a source of conflict and misinformation, it must be managed systematically. In addition, standards for data timeliness, quality, and collection must be agreed to by the business

Michigan's Process for Developing Transportation Programs



process owners. All data integration efforts at MDOT were driven by business needs, not the other way around. A key to making this happen was the Michigan Architecture Project (MAP). This effort did not address process relationships, but examined the data needed for day-to-day operations. The MAP study found that 75 to 80 percent of MDOT data were duplicated across four application areas.

In moving toward its integrated Asset Management process, MDOT adopted four of the guiding principles identified by the National

Performance Review[1] for gathering data. The four principles are that data gathering must be focused, flexible, meaningful, and consistent.

The standard established was to collect data once, store it once, and use it many times. The most critical and difficult activity of the data integration process was identifying and defining which data should continue to be collected, which should be dropped, and what new data might be important. The guideline for this process was that every piece of data must have some owner who could not possibly function without it.

MDOT used four methods to establish its corporate data standards:

- Limiting original data collection
- Adopting sampling and quality standards
- Agreeing on common data and attribute definitions
- Eliminating duplicate storage

The combination of TMS and MAP efforts resulted in the reduction of approximately 20,000 files into five major databases to be maintained and populated by MDOT. The MAP activity resulted in an enterprise data model, naming standards, quality assurance techniques, and a set of functional requirements necessary to ensure that decision makers had access to current and accurate data. MDOT decided to develop a new application in-house after it determined that no existing nonproprietary product could satisfy these requirements.

The Michigan DOT data integration effort was guided by the best-practice principle of collecting data once, storing it once, and using it many times.

Linear Referencing System

MDOT's ability to integrate the various asset databases was facilitated by the decision to abandon all existing linear referencing systems and adopt a single, statewide system. The single referencing system allowed consistency among many key data components and enabled sharing both within the agency and among county and city road agencies and the State Police.

[1] *Serving The American Public: Best Practices In Performance Measurement,* National Performance Review (June 1997), http://govinfo.library.unt.edu/npr/library/papers/benchmrk/nprbook.html.

To implement this new referencing system, MDOT worked with the Michigan Center for Geographic Information to fund the development of a statewide geographic information system (GIS) capability. This relationship leveraged the latest GIS and global positioning system (GPS) technology to develop a statewide, GIS basemap for use by all State agencies. The collaboration also produced a complete referencing system to which all transportation features could be tagged. On a statewide basis, this multi-agency partnership eliminated many of the processing steps that occur between data capture, integration into appropriate shared databases, and final dissemination across State government.

Integrated Data Architecture

The scope of MDOT's data integration efforts involved the migration of all key planning and programming data from the mainframe to a client-server/open-system environment. The efforts also established direct support and linkage to MDOT's Financial Obligation System and Project Information System. These two packages support the planning, monitoring, scheduling, and funding of projects through construction contract lettings.

TMS operates in a client-server environment using UNIX servers and Oracle databases. The system was programmed using the PowerBuilder development software. Each of the component databases is supported by ad hoc queries using the Sybase InfoMaker tool, although any tool supporting open database connectivity connections could have been used. The Maptitude software supports GIS queries. Other software is used in

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Roadway in the Keweenaw

business areas to support lower level data preparation tasks. For example, FoxPro is used to prepare data for exchange between the traffic data information system and TMS.

The TMS was intended to be a single integrated application. The final product requires MDOT staff and remote users to access TMS to run all asset management or analysis programs available. This has created a strong awareness among various business areas of the information available to all users and has facilitated an integrated data analysis process across the following management systems:

- Pavement
- Bridge
- Congestion
- Safety
- Public transit
- Intermodal facilities

TMS data and analysis results can be displayed using the statewide GIS basemap, which allows the following additional functions:

- Leveraging many other opportunities for integrated transportation decision making
- Identifying responsibility for long-term maintenance and updating of the map and data sets
- Embedding MDOT's common roadway referencing system as the standard for all transportation providers and planning agencies in Michigan

WAS IT WORTH IT?

The decision to invest in the development of TMS has dramatically changed the face and internal operation of MDOT. Not only has the new system met the day-to-day business needs of the department and many of its partners, but it has also been the catalyst for changing the way MDOT is organized, how it is staffed to deliver its products, and how it relates to its various constituents. TMS has established the baseline for data quality and timeliness and for asset condition and service levels to use in program and project decision making and strategic asset investment targets. Many specific benefits flow from these capabilities:

Better Data Management and Utilization

- Substantial elimination of the duplication of data collection activities.
- Improved understanding of the criticality of quality data in the program and project decision-making and priority determination processes.
- Substantial agreement among the users on a single definition of key data elements.
- Extensive sharing of data and analysis tools among all internal and external users.
- Agreement on a common referencing system to locate transportation elements and facilitate GIS/GPS compatibility with the statewide effort.

A New Approach to Systems Management

- TMS enables MDOT to establish long-range condition targets for freeway and nonfreeway pavements and bridges.
- The condition of the total system has gone from 64 percent "good" to 75 percent "good" since 1996, and the remaining service life of the pavements has increased by 21 percent over the same time.
- Feedback from system condition information has allowed strategies to be adjusted based on actual extension of pavement life and project costs, resulting in a "mix of fixes."

- Using the integrated TMS and the Asset Management philosophy, MDOT has developed a corridor programming approach that emphasizes coordinated pavement and bridge activities.
- MDOT's Capital Preventive Maintenance Program has reduced routine maintenance costs and stretched reconstruction dollars by extending pavement life.

Stabilized Program Development and Project Delivery

- Road condition forecasts helped support the 1997 user fee increase, which generated over $200 million in new State money for road work.
- The availability of consistent and timely condition information provided by TMS ensures consistent involvement of the regions in recommending projects for the Five Year Plan.
- TMS is used to produce more predictable construction plans, with beneficial results:
  - MDOT can analyze annually how its pavement strategies are meeting system condition goals.
  - Contractors and suppliers can plan with greater certainty for each construction season.
  - MDOT's designers can deliver plans in a way that allows over 90 percent of all contracts to be let by March, which enables those contracts to be completed in one construction season.

WHAT HAS MDOT LEARNED?

MDOT's experience in developing and implementing the TMS has identified several strategies that are critical to successful Asset Management data integration:

Establish cooperation between information technology (IT) staff and business process owners. The TMS integration effort, combined with the move to the client-server, open system computing environment, provided a solid basis for meeting various objectives across the agency:

- Reevaluate business process relationships
- Identify and define key data needs

- Break down the stovepipes that exist in all organizations
- Empower individual employees

Critical to the success of this approach was having the IT staff responsible for maintaining and enhancing the software work side-by-side with the business process owners and users.

Maintain buy-in using a business plan that supports technical efforts. The enthusiasm, focus, and buy-in that were established among the users during the early project conception process were difficult to sustain throughout the lengthy development process. Much of the initiative taken and progress created by the business process owners through the prototyping activity was lost and, in most cases, had to be re-established at the rollout, often with new staff.

Commit to a statewide referencing system. MDOT had envisioned an embedded GIS functionality for TMS that the marketplace had not yet produced. This resulted in higher development costs and delays. MDOT's involvement in the statewide referencing system helped offset these problems and led to the ultimate inclusion of GPS capabilities in the TMS.

Decide whether to build or buy. At the time the TMS was developed, MDOT had to break new ground—no suitable off-the-shelf solutions were available. Today there are many more mature products suitable to facilitate the integration and analysis requirements for Asset Management activities. MDOT would likely not attempt to develop its own system if it were starting out today.

Ensure effective project management. Two critical questions were not well addressed in the management of the TMS process: What are necessary "scope adjustments"? What are deadly "scope creep" issues? After the completion of the TMS contract, MDOT instituted new project management tools and internal controls to keep IT projects on schedule and within budget.

Today there are more mature products available to facilitate data integration and analysis for Transportation Asset Management. If MDOT were starting today, it would likely not attempt to develop its own system.

It is much easier and cheaper to stay current than it is to catch up. An important lesson MDOT learned is that it is one thing to develop an integrated system of databases and applications, and quite another to maintain that environment so it can

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continue to meet evolving business and technology needs. This is both a business and a technical challenge. Agencies cannot assume a system is "done" and neglect it. Similarly, the agency needs to ensure that the technical side of the operation stays current with existing and emerging technologies. Two other ingredients are critical: a methodology to design databases and applications that are flexible enough to accommodate the user's changing data requirements; and sufficient training for users to understand how to use the tools that are provided.

Satisfy system users. Keeping the system users' needs satisfied is the only way to sustain the shared data concept in any agency. This will prevent users from going "outside" the system because they do not understand or cannot use the data. A combination of education and facilitation to make systems and databases user friendly must be embedded in the maintenance process.

WHAT'S NEXT?

In 2002, the State of Michigan passed Act 499, which requires Michigan's transportation agencies to adopt Asset Management concepts and to meet these requirements:

- Report to the legislature the condition and service levels of all Federal-aid-eligible roads and bridges
- Report the 3-year road and bridge program of projects for all State, county, and city agencies

- Develop performance-based investment strategies for condition and service targets

Meeting these guidelines will require the integrated database and single basemap activities initiated at MDOT to be maintained and extended to allow city and county providers to use them.

Additional data integration issues that MDOT will be focusing on as it continues to implement Asset Management concepts include:

- Definition of data elements and collection techniques necessary to determine the life cycle cost of various capital and maintenance treatments
- Integration between financial databases and Asset Management systems to fully analyze the relationship between fiscal constraints and condition targets
- Integration of ITS activities and real-time data collection capabilities in the planning and programming process

MDOT is also in the process of implementing Web-based front ends to selected applications. For example, the Public Transportation Management System and the bridge inspection component of the Pontis bridge management system are currently being migrated to the Web.

S.S. Badger, Ludington

Closing Thoughts

MDOT has changed the way it does its business. This change has happened in no small part because of its investments in technology. The use of technology, driven by business needs and dedication to shared and integrated "corporate data," has enabled MDOT to adopt an Asset Management approach to meeting its customers' most important needs.

Further Information

MDOT Asset Management Web Site
www.mdot.state.mi.us/assetmgt

Asset Management Process
Rick Lilly
517-335-2606
lillyr@michigan.gov

Transportation Management System
Ron Vibbert
517-373-9561
vibbertr@michigan.gov

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U.S. Department
of Transportation
**Federal Highway
Administration**

Office of Asset Management
Federal Highway Administration
U.S. Department of Transportation
400 Seventh Street, SW, HIAM-30
Washington, DC 20590

Telephone: 202-366-9242
Fax: 202-366-9981
www.fhwa.dot.gov/infrastructure/asstmgmt/diindex.htm

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