Transportation Asset Management Case Studies

Presented by

U.S. Department of Transportation
Federal Highway Administration

DATA INTEGRATION

The Pennsylvania 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 effective Asset Management practices will involve a range 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 different asset classes. Others will move to deploy economic analysis tools to generate fact-based information for decisionmakers. Still others will want to integrate new inventory assessment methods into their decisionmaking processes.

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

On behalf of the Office of Asset Management, I am pleased to add this case study on data integration to the 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
May 2004

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 in which to share information, and the individual States provide the details of their experiences. For each case study report, FHWA interviewed State transportation staff, and the resulting material was approved by the State. As such, the 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.

SR 15, Tioga County

Executive Summary

PENNDOT's approach to data integration combines strategic business process improvements with information technology enhancements.

The Pennsylvania Department of Transportation (PENNDOT) is responsible for a large and aging transportation network. Over the past 20 years, PENNDOT made significant investments in a suite of systems designed to support the management of this network. However, these homegrown, mainframe systems could not keep up with the evolving needs of PENNDOT's decisionmakers.

In the late 1990s, the department began a concerted effort to improve the way it does business, focusing on improved efficiency, performance-based decisions, customer satisfaction, and the ability to track progress toward stated goals and objectives. These ideas were formalized through the adoption of the Baldrige quality evaluation criteria and Transportation Asset Management principles. PENNDOT's work in these areas triggered the decision to revisit its information technology (IT) resources in order to make them more consistent with each other and with improving business practices.

PENNDOT is simultaneously implementing top-down and bottom-up approaches to data integration. The central component of this process is a series of updates to three of the department's core functions and the management systems that support them. From the top, strategic guidelines drive these business process improvements and ensure that the updated management systems are all compatible with one another. At the same time, PENNDOT is working on the technical mechanisms required to integrate individual data items from the improved systems and disseminate the integrated information throughout the department.

Improved management decisions for a major transportation system such as Pennsylvania's cannot be made without a comprehensive and coordinated understanding of the infrastructure assets. If better Asset Management decisions could improve the efficiency of PENNDOT's capital program by only 1 percent (such as achieving similar benefits using less resources), the department would save over $28 million annually. Although the details of PENNDOT's enterprise data architecture are still under development, the department continues to make significant progress in several other areas required to make improved decisionmaking a reality. ■

AGENCY FACTS

PENNDOT has adopted a "Maintenance First" philosophy that focuses on preserving the functionality of its existing assets.

Pennsylvania is a large State in terms of transportation assets. PENNDOT is responsible for the fifth-largest State highway system in the United States. It owns and operates more miles of roadway than New York, New Jersey, and New England combined. PENNDOT also administers one of the largest mass transit, rail, and aviation grant programs in the country. The agency has nearly 12,000 employees and an annual budget of over $4 billion.

Pennsylvania's transportation network consists of these facilities:

- 119,000 miles of roadway (PENNDOT is responsible for 40,500 miles)
- 31,800 bridges (25,000 are owned by PENNDOT)
- Three ports—Port of Erie, Port of Pittsburgh, and Port of Philadelphia
- The Nation's 5th largest (Philadelphia) and 14th largest (Pittsburgh) transit systems
- 32 intermodal facilities
- 90 miles of rails-to-trails (most in the Nation) and more than 1,000 total miles of pedestrian trails
- 148 public access airports (one of which is State-owned)
- 5,600 miles of railroad (moving more than 190 million tons of freight annually)

Despite its size, the population of Pennsylvania is projected to be relatively stable compared to national trends. PENNDOT anticipates a 20 percent growth rate from 1999 to 2025 (compared to 29 percent nationally).

In response to this combination of a large transportation network and moderate population growth, PENNDOT has adopted a "Maintenance First" philosophy that focuses on preserving the functionality of its existing assets. Strategic expansion of the system will still occur, but growth is not the primary focus. In the near term, the department has established 80/20 as the target split between maintenance and expansion expenditures. In the long term, the agency expects to meet the vast majority of expansion needs by 2025.

Organizationally, PENNDOT has moved to a more decentralized structure, although headquarters retains an oversight function. The central office provides the districts with the flexibility and resources to develop new solutions, adopts success stories as best practices, and disseminates these experiences throughout the State.

PENNDOT has also shifted recently toward greater participation by local and regional parties in transportation planning and management activities. For example, through its Agility Program, PENNDOT shares maintenance and operations resources with over 1,500 local partners through simple agreements that trade services of similar value.

SETTING THE STAGE

What Did PENNDOT Have?

Over the past 20 years, PENNDOT has made significant investments in a suite of management systems designed to support its business operations, as follows:

- Roadway Management System (RMS)
- Bridge Management System (BMS)
- Maintenance Operations Reporting Information System (MORIS)
- Engineering Construction Management System (ECMS)
- Multimodal Project Management System (MPMS)
- Automated Permit Routing/Analysis System (APRAS)
- Electronic Document Management System (EDMS)
- Financial Management Information System (FMIS)

These systems are homegrown, mainframe applications that have evolved over time in reaction to the changing needs of PENNDOT staff. The systems provide a wealth of standardized inventory and condition data from the last 15–20 years. However, because of their origins, many of the systems are based on outdated technology and do not meet the expanding needs of the modern user community. Specifically, modern users need improved functions for needs predictions, cost tracking, and the integration of data and results across asset categories. Due largely to the size and complexity of the organization, and the rapid pace of technological advances, PENNDOT's previous information technology (IT) efforts have been uncoordinated and often performed without adequate consideration for other systems or the needs of staff outside traditional user groups.

What Did PENNDOT Want?

In the late 1990s, PENNDOT adopted the Malcolm Baldrige excellence criteria as the basis for an intensive evaluation of its business operations. Through this initiative, PENNDOT continues to review and improve five critical business areas:

- Integrated strategic business planning
- Information system integration
- External customer satisfaction management
- Internal customer satisfaction management
- Benchmarking

In support of this effort, PENNDOT conducts a formal business planning process annually. Department and district level business plans identify activities that support PENNDOT's strategic agenda, define performance measures, and set targets. Progress toward these targets is tracked throughout the year with a performance scorecard.

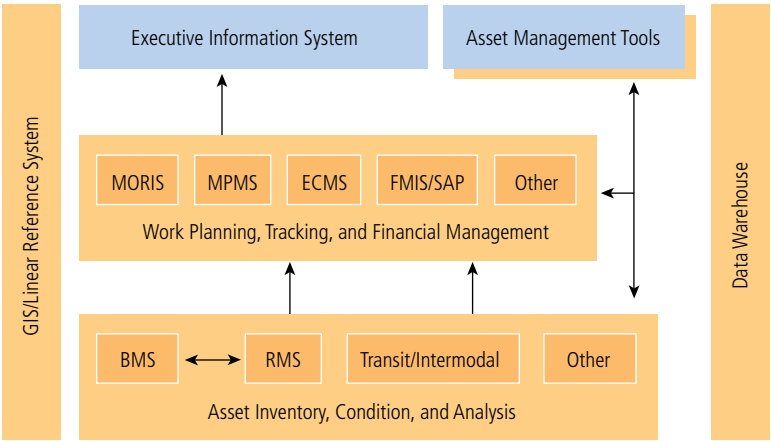
At the same time, PENNDOT was also moving toward a more strategic approach to resource allocation and utilization. The adoption of Asset Management principles reinforced the need for performance measurement, better coordination of decisions horizontally and vertically across the department, timely and accurate data, and an improved suite of decision-support tools.

The adoption of the Baldrige criteria and Transportation Asset Management principles became the catalyst for PENNDOT to revisit its legacy tools, with an eye toward making them more consistent with each other and with improving business practices.

PENNDOT revisited its legacy systems to support a broad movement toward a more performance-based and customer-oriented approach to doing business.

In response to these corporate goals, PENNDOT is working to clearly articulate its business needs, incorporate them into a systematic IT planning process, define an overall architecture for how different systems and databases could work together to address these requirements, and incorporate all of these components into updated versions of their legacy management systems. This overall architecture would provide access to strategic performance and cost data by an executive information system, regardless of where the data reside. As a starting point for the integration effort, PENNDOT's Asset Management Concept Plan proposed the high-level system architecture concept illustrated below.

High-Level System Architecture Concept



HOW DID PENNDOT GET THERE?

Overall Approach

PENNDOT is simultaneously implementing top-down and bottom-up approaches to data integration. The central component of this process is a series of projects to update the department's highway, bridge, and maintenance management practices, and the legacy systems that support them. From the top, strategic guidelines drive these business process improvements. This approach will help ensure that the ensuing management sys-

tems are all compatible with one another from a business process point of view. At the same time, PENNDOT is working on the technical mechanisms required to integrate individual data items from the improved systems. This work will help ensure that PENNDOT is able to combine data and analytical results from the updated management systems and provide the integrated information to decisionmakers across the department.

Strategic Integration. PENNDOT has developed an IT Strategic Plan, a Geographic Information System (GIS) Strategic Plan, and an Asset Management Concept Plan. With each of these plans, PENNDOT has established an organizational framework for improvements, reviewed current practices, identified gaps, and provided strategic guidelines to fill the gaps. These plans provide the organizing principles for the legacy system rewrites.

Legacy System Rewrites. PENNDOT is rewriting three core legacy systems: MORIS, RMS, and BMS. The rewrite process consists of reengineering the business functions that each system supports and then developing a new system to meet the updated business needs. The final functionality of each new system is based on an analysis of the expected rate of return on investment—there is a clear tradeoff between technological wish lists and the resources required to implement them. Consideration of principles documented in the Asset Management Concept Plan during the reengineering process and adherence to IT standards during the design ensure that the new systems will be fully compatible even though they are being developed separately.

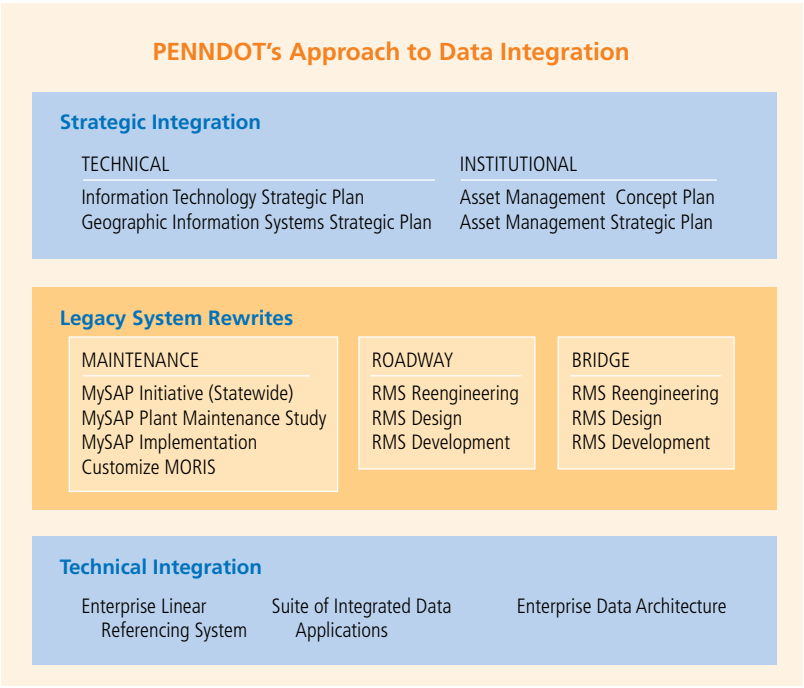
In addition to rewriting the systems, PENNDOT is implementing a new fiscal management system (mySAP) to replace its 1980s vintage system, FMIS. This work is being performed in conjunction with a Commonwealth-wide initiative. It is anticipated that the new system will better support Asset Management because the current system is oriented toward a contract or project cost methodology that does not lend itself to tracking expenditures by asset.

Technical Integration. PENNDOT has made significant progress on the technology of integration. For example, the department has developed an enterprise linear referencing system for referencing data stored in the legacy mainframe systems and implemented a suite of GIS applications that provide access to integrated data to consumers throughout the

department. Through its Systems Enhancement and Integration Initiative, PENNDOT is also working to develop guidelines for a comprehensive data architecture required to fully integrate the updated management systems.

> Adherence to strategic and technical guidelines will enable thorough integration of PENNDOT's updated management systems.

PENNDOT's integration activities reach across and up and down the entire organization. Representatives from across the organization have participated in the strategic planning projects, individual functional groups (e.g., Bridge Quality Assurance Division) are taking the lead on the system rewrite efforts, and the Geographic Information Division of the Bureau of Planning and Research is responsible for the enterprise LRS and GIS applications.

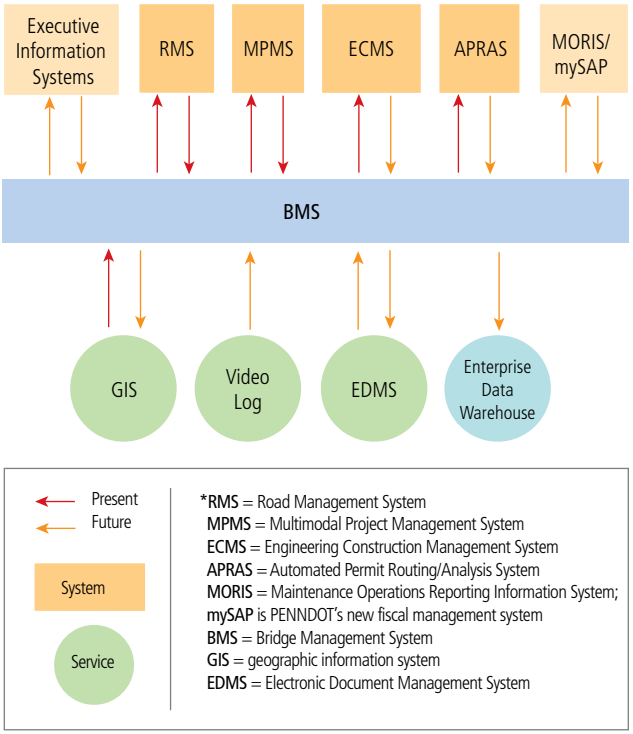


Technical Approach

The details of PENNDOT's enterprise data architecture have not yet been finalized. One option being considered is to maintain all corporate databases in a relational mainframe database management system. Various management systems could then perform direct, real-time queries of the integrated data as needed.

While these details are being worked out, the development of an enterprise linear reference system, the interim integration of data from the legacy mainframe systems through a GIS, and the legacy system rewrites are moving forward. For example, it is anticipated that PENNDOT's updated BMS will eventually interface with six different systems. Details of how best to implement these connections will be addressed in the next phase of the design process.

BMS Interfaces With Other Management Systems*



Enterprise Linear Referencing System

Pennsylvania's transportation assets are geographically coded using a variety of linear referencing systems. For example, State roads are referenced with a county-route segment-offset address; turnpikes are referenced by administrative code, route, and milepoint; and local road segments are referenced by a municipality code and local street name.

PENNDOT's Geographic Information Division has developed an enterprise linear referencing system in order to integrate data referenced with these systems and link them to PENNDOT's centerline base maps. The referencing system consists of a network linear feature identifier (nlf_id) and end points. PENNDOT has developed a series of cross-reference tables that can assign an nlf_id and distance to any referenced segments or records. Once translated to the enterprise system, data can be integrated into PENNDOT's GIS.

Integrated GIS Architecture

PENNDOT is a nationally recognized leader in GIS development and implementation. The department's current GIS integrates data from several internal and external sources, including the RMS, BMS, and MORIS on the agency's mainframe. Data are extracted from these systems using a series of custom-developed data extraction and update routines. The data are normalized to reduce redundancy and are stored in an Oracle database. Users access, query, and analyze the integrated data through a series of client-server applications and thin client Web applications, like the following:

- A GIS Interactive Web Query Application that enables users to map selected data sets
- An Interactive Straight Line Environment that displays multiple roadway attributes simultaneously for a segment of roadway
- A VideoLog Application that enables users to "drive" along a roadway and view the latest images of the road surface and roadside (see picture, page 12)
- A Data Dictionary Application that helps users understand what data are available

PENNDOT's VideoLog Application

WAS IT WORTH IT?

Improved management decisions for a major transportation system such as Pennsylvania's cannot be made without a comprehensive and coordinated understanding of the infrastructure assets. Several factors make a department-wide approach to Asset Management and data integration attractive to PENNDOT:

- In Pennsylvania, aging infrastructure assets and growing transportation needs place ever-increasing demands on the limited resources available to maintain an efficient and safe network.
- The ability to predict asset needs and asset condition for various funding levels and program policies (i.e., improvement versus preservation versus maintenance) will be essential for strategic and tactical decisions.
- Competing needs across asset categories and among customers complicate decisionmaking beyond the point where the simplistic analysis approach of just a few years ago can still ensure good investment strategies for the future.

- Development of shorter term plans to accomplish in-place, long-range strategies will help PENNDOT avoid the inefficiencies of a reactive, management–by-crisis approach.
- The credibility gained by consistent planning can improve customer and partner buy-in for longer term goals.

If better Asset Management decisions can produce a marginal improvement of only 1 percent in the efficiency of PENNDOT's capital spending (such as achieving similar benefits using less resources), the agency could save more than $28 million annually. More importantly, making poor decisions could have disastrous results in terms of asset performance or in the budgets needed to maintain minimum performance goals.

WHAT HAS PENNDOT LEARNED?

Asset Management Implementation

- When managing a transportation network as large as PENNDOT's, there are several opportunities to improve efficiency by applying the principles of Asset Management.
- Agencies should not wait until their entire wish list of rigorous and sophisticated analysis tools are in place before implementing Asset Management.
- The ability to track some measure of customer satisfaction can be helpful in a variety of decisionmaking contexts.
- For a large agency such as PENNDOT, a department–wide champion for Asset Management may be advisable to provide vision and day-to-day encouragement for timely implementation of Asset Management.

Data and IT Resources

- It is very easy for an agency to become "data rich and information poor." DOTs should strive to use existing tools to do the most rigorous analysis possible with current data resources. In addition to a better understanding of asset conditions, early analysis, even with less sophisticated tools, may help DOTs determine if they are collecting the "right" data.

DOTs should strive to use existing tools to do the most rigorous analysis possible given current data resources.

- The selection and use of good performance measures help in establishing goals and budgets, while providing the means to monitor the effectiveness of management decisions. DOTs should minimize the collection of data that do not support management decisions. They should also be prepared to modify their set of performance measures as circumstances dictate.
- Apply basic Asset Management principles now with the information currently available. Even the use of simple trend lines can provide an improved perspective of historical and future directions.
- Implement Asset Management tools using an incremental approach. It may be difficult to simultaneously bring all current management systems to the same level of development to allow for a comprehensive conversion. It is better to implement systems or subsystems "as you go" to take advantage of systems that are ahead of the curve.

GIS Implementation

- PENNDOT's GIS work has spanned several years and addressed a wide range of issues. Staff have identified the critical success factors for this effort:
  - Adherence to and periodic review of a GIS strategic plan
  - Development of a GIS plan that focuses on the problems but does not constrain the solutions
  - Utilization of strong project management methods
  - Development of contractor relationships that promoted training and technology transfer
  - Emphasis on outreach and public relations efforts
  - Project objectives that included keeping up with latest technology advancements as they became available
  - Documentation of the data structure and available applications in order to facilitate use and understanding of the system by data customers
  - A balance between strategic planning, practical applications, and future maintenance and operations requirements

IT Benefits of Reengineering Business Practices

- PENNDOT began the rewrite of its BMS after reengineering key components of its bridge management practice. The rewrite is currently in progress, so it is too early to fully evaluate this approach to system enhancement. However, several benefits of this approach have already been identified:
  - The effort helped PENNDOT identify new opportunities for rapid implementation (e.g., the development of a network planning tool based on existing tools).
  - It helped limit the scope of the software development process.
  - It established a common vision for the new BMS across the agency.
  - It enabled creative technological solutions because the process concentrated initially on bridge management practices rather than on potential IT tools.

WHAT'S NEXT?

The next steps on PENNDOT's journey toward agency-wide improvement include a mixture of business process and technical activities:

- Establishing an Asset Management Steering Committee to oversee the full development and implementation of Asset Management principles and procedures.
- Developing a Transportation Asset Management Strategic Plan. This plan will build on the existing Asset Management Concept Plan and develop a detailed strategy, including a timeline for full implementation (it is anticipated that this strategic plan will be complete by June 2005).
- Completing the legacy system rewrites for BMS, RMS, and MORIS.
- Completing the conversion of FMIS to the mySAP financial management system.
- Developing a location referencing system.
- Integrating data from additional sources into the GIS database.
- Developing an enterprise data model and incorporate it into a comprehensive data management strategic plan.

Closing Thoughts

Over the past five years, PENNDOT has made significant progress toward improving both its business practices and the IT resources required to support them. Further work in these areas is vital for PENNDOT to continue to address the growing needs of an aging infrastructure system in an era of intensifying competition for limited resources.

Further Information

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