Capitalizing on GIS and Asset Management

NCHRP Project 08-87
Successful Practices in GIS-Based Asset Management

Executive Guide

Do you want to…

Identify opportunities where investments can be targeted to boost economic growth?

Combine economic growth, asset condition, and funding data sets

- Overlay a heat map showing economic growth zones on top of an asset condition map in the same zones.
- Spotlight areas of economic growth and corresponding under-investment in transportation assets.
- Reveal the asset management investments needed to keep pace with economic growth.
- Show the future costs of under-investment.

Identify cost-saving opportunities in project development and maintenance practices?

Test validity of existing design standards for asset condition

- Identify existing standards that could be examined for cost saving opportunities.
  - Combine climatic and soil condition data with historic performance trends to inform pavement design.
  - Examine rutting triggers for pavement treatments — identify correlations between rut depth and safety performance.
- Use this spatial analysis to identify cost-saving opportunities.

Have information at your fingertips when meeting with an elected official?

Access geography-based information on a mobile tablet

- Have an easy-to-use application on your mobile tablet that provides access to the type of information that an elected official is interested in.
- Show historical trends in asset condition by geographic zones (e.g., elected official's district) by investments made or not made.
- Show past and future projects and the impact on transportation performance in specific geographic areas.
- Respond to questions about project status.

Is your agency maximizing the use of GIS for transportation asset management?

Most transportation agencies have already made a substantial investment in GIS tools and spatial data. But many have not fully tapped the potential of GIS for transportation asset management. Recent advances make it worthwhile for agencies to take a fresh look at how they are using these technologies.

You can use this Executive Guide to understand how your agency can:

- Develop maintenance and construction programs that consider all assets within the right of way.
- Integrate safety, mobility, and environmental considerations.
- Reduce duplicative data gathering and presentation.
- Provide a common base of information across the agency.
- Tap into available data sets to help you to understand and minimize risks.
- Gain consensus on priorities and investments.
- Efficiently manage asset inspection, maintenance, and operations activities.

What's in the guide

- A strategic overview of fundamental concepts in GIS and asset management.
- A summary of key opportunities for improving asset management through use of GIS.
- A brief checklist to help you gauge your agency's capabilities and chart a course for advancement.

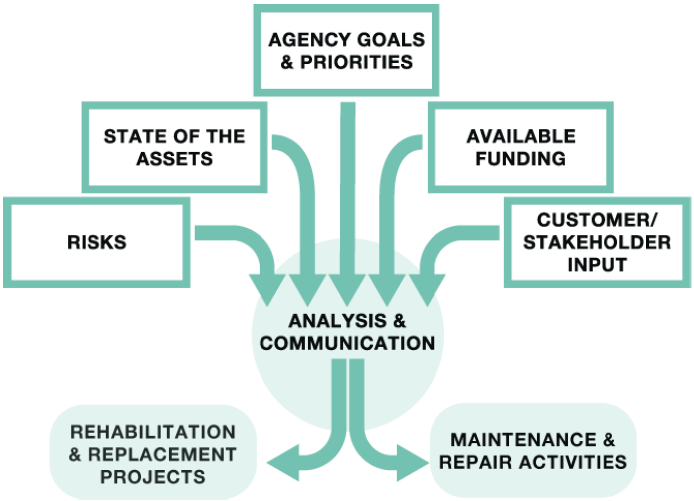
What Is Transportation Asset Management?

Transportation agencies use transportation asset management to manage infrastructure assets throughout their life cycles to meet agency objectives.

Understanding transportation asset management (TAM)

Managing physical assets—roads, bridges, signs, equipment, and more—is one of the core functions of a transportation agency. As a result, TAM is a process that covers planning, programming, design, construction, and maintenance and operations functions. Agencies use TAM to:

- Establish a data-driven, defensible, and transparent basis for allocating limited available resources to meet policy goals and priorities.
- Identify the "state of the assets"—providing a system-wide understanding of asset quantity, location, condition, and replacement value.
- Identify and mitigate risks that could cause assets to fail or cease to provide their intended function.
- Make the case for funding to sustain assets in a state of good repair.
- Do the right projects at the right time—considering condition, root causes for deterioration or failure, and impacts of delaying action.
- Coordinate work scoping and timing decisions across functional areas to maximize use of funds, improve operational efficiencies, and minimize traveler disruption.
- Plan multi-year investments that minimize life-cycle agency and user costs.



Elements of TAM

Key benefits of TAM for an agency

Performance

Improved asset conditions and reduced risks.

Efficiency

Better utilization of available resources to build, maintain, and operate assets; delivery of best possible value for tax dollars.

Customer experience

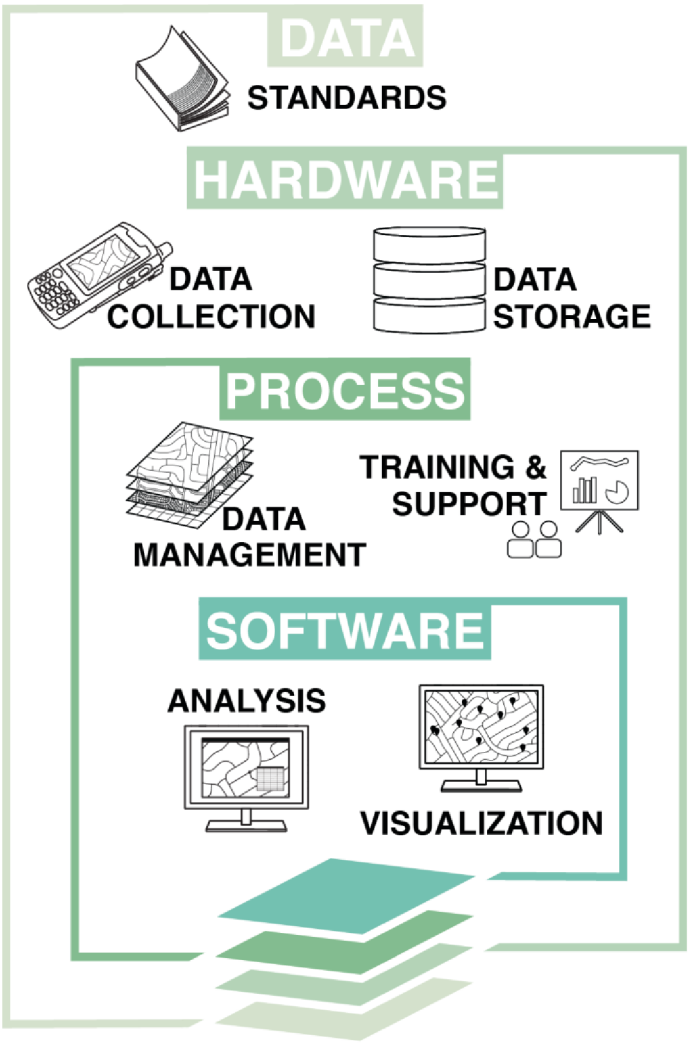
Improved levels of service experienced by the traveling public.

Credibility and accountability

Improved agency perception by political leaders and the public, leading to greater willingness to invest in maintaining and upgrading assets.

What Is a Geographic Information System?

A geographic information system (GIS) enables the management, analysis, and display of geographically referenced information using integrated hardware, software, and data.



Elements of GIS

Key benefits of GIS for an agency

- **Decision making.** GIS can provide a common base of information to multiple stakeholders, facilitating a shared understanding of problems and solutions.
- **Analysis.** GIS can help reveal trends and relationships that would be difficult to uncover without a spatial view.
- **Efficiency.** GIS provides the ability to leverage existing data from internal and external sources, increasing the value obtained from an agency's investments in data.
- **Consistency.** GIS can provide a centralized resource that reduces the need for duplicative efforts across districts or divisions.
- **Communication.** Static and interactive maps can communicate information about performance, risks, and needs within the agency and to external stakeholders.
- **Learning.** GIS provides a powerful tool to help employees and agency partners to rapidly understand the organization's available body of information.

Why Use GIS for Transportation Asset Management?

GIS provides a technology platform for integration, visualization, analysis, and communication—strengthening and streamlining the asset management process. GIS can be a formidable weapon for tackling common obstacles to effective asset management—such as siloed, uncoordinated decision making, expensive and duplicative data collection efforts, and lack of transparency and accountability for investment decisions.

Saving time and money using GIS for TAM

- **Increasing Efficiency of Data Collection.** Time-consuming inventory and inspection processes involving clipboards and manual data entry can be replaced by newer methods including video and sensing technologies for inventory capture, and use of GPS mobile devices. Some agencies are even using location-aware smartphones for crowd-sourcing data from travelers.
- **Automating Data Compilation for Analysis.** With consistent standards for measuring and referencing locations, GIS tools can be used to integrate data for analysis—avoiding the need for staff to download and manipulate data sets in spreadsheets or write custom code for data compilation.
- **Automating Mapping.** In many agencies, creating specialized maps to show asset conditions and planned project locations requires considerable staff effort. With automated, web-based mapping tools and a standard process for geospatially-enabling common data sets, staff can spend less time responding to data requests and more time analyzing and understanding conditions and trends.
- **Work Scheduling.** GIS tools can help staff to package work within geographic areas or corridors in order to deploy crews in an efficient manner and minimize traffic disruption due to work zones.

GIS has the biggest payoff when it is implemented with an agency-wide perspective. A common, GIS-centric approach to data collection and analysis can save time and result in more holistic decision making compared to when pavement, bridge, safety, design, and planning units are individually compiling and analyzing their own data.

GIS for TAM: Return on Investment (ROI)

Improving GIS capabilities requires investments in software, data, and staff time, as well as changes to current work processes and roles. The largest cost elements are typically the acquisition of the base map and roadway data, establishment of the foundational location referencing system that links data together, and assignment of standard location referencing to existing data. It is important to keep in mind, however, that benefits from these initial major investments will continue to accrue over an extended time period. Many agencies already have these investments behind them, and are ready to leverage them to provide business value.

Technology advances over the past few years have lowered the costs of obtaining location-referenced asset data and deploying GIS applications. Agencies making judicious investments in high-value GIS improvements can recoup the costs of these investments through gains in efficiency and decision-making capabilities.

ROI Studies

Several studies have documented staff time savings from GIS implementation and compared these with the costs for hardware, software, and application development to calculate ROI. These studies did not factor in the important yet difficult to measure benefits to decision making from integrating and visualizing information.

Florida DOT

A study of Florida DOT's GIS implementation[1] found a positive net benefit after three years.

Benefits

- Estimated net benefits of between $950,000 and $2.8 million over five years from 1996–2001.
- Cost savings in data collection, storage, analysis, and output due to increased productivity, data integration, and reduction of redundancy.

King County DOT

A 2012 King County DOT study[2] quantified ROI for GIS, based on cost savings and productivity gains.

Benefits

- An estimated $775M in net benefits to all county agencies from 1992 to 2010.
- The DOT saw $18.8M in annual benefits for 2010, including $7.3M in cost savings and $11.5M in enhanced productivity.

Iowa DOT and Caltrans

A 2011 study[3] quantified benefit/cost of statewide multi-level linear referencing systems in the Iowa DOT and Caltrans.

Benefits

- A five year breakeven point with an overall benefit/cost ratio of 21.4 to 1.
- Total potential savings were valued at $12.6 million for a state with a 25,000 mile road network.
- Cost savings were achieved through reductions in staff hours and improved efficiencies in data management and decision making.

[1] Flintsch, G. W. "Spatial Analysis Applications for Pavement Management." In *6th International Conference on Managing Pavements: The Lessons, The Challenges, The Way Ahead*. 2004.

[2] Babinski, Gregory, Dani Fumia, Travis Reynolds, Pradeep Singh, Tyler Scott, and Richard Zerbe. "An Analysis of Benefits from Use of Geographic Information Systems by King County, Washington." Richard Zerbe and Associates, 2012.[3] Hoekstra, Renee L., CVS, RH & Associates. "Multi-Level Linear Referencing System (MLLRS) Cost/Benefit Value Analysis Study," requested by the American Association of State Highway and Transportation Officials, Standing Committee on Highways, 2011.

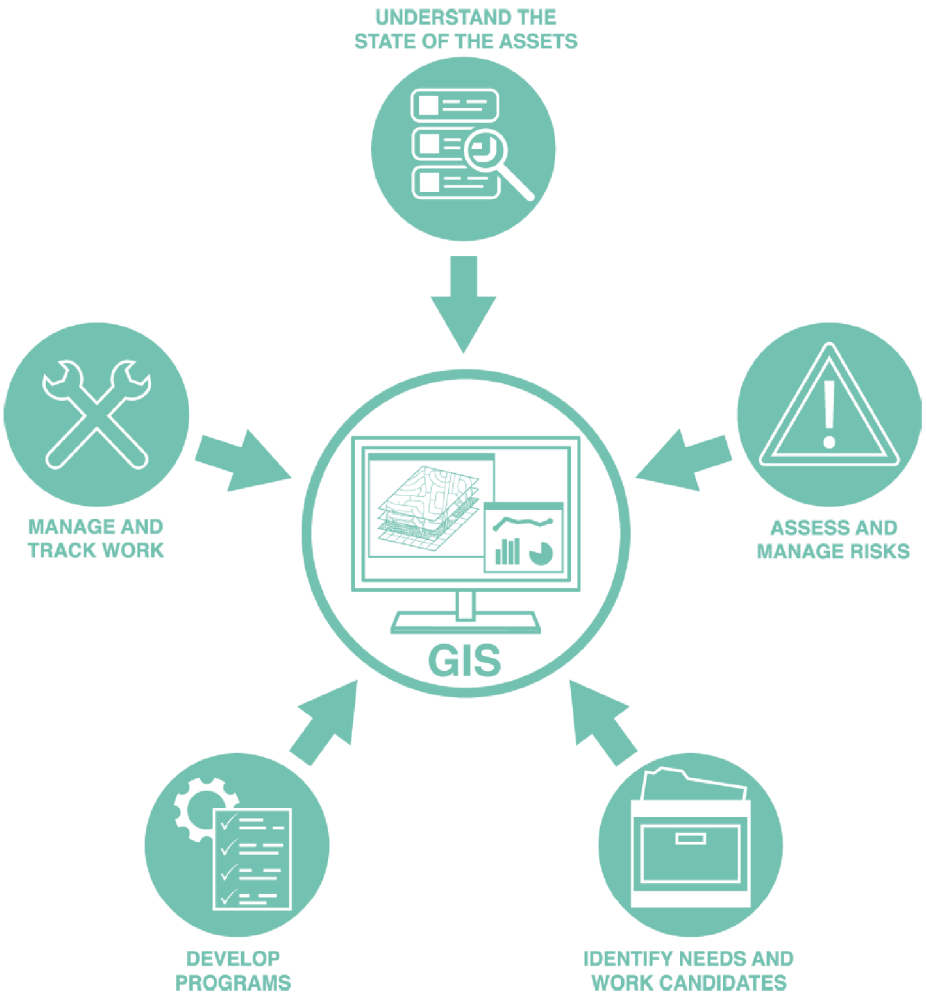
[3] Hoekstra,Renee L., CVS, RH & Associates. "Multi-Level LinearReferencing System (MLLRS) Cost/Benefit Value Analysis Study," requested by the American Association of State Highway and Transportation Officials,Standing Committee on Highways, 2011.

Opportunities to Leverage GIS for More Effective Asset Management

The following pages highlight opportunities for enhancing asset management using GIS, with examples from transportation and other industries. Opportunities are organized according to the five core TAM business processes shown below.

GIS technology can lead to better decisions and more effective use of available funds by:

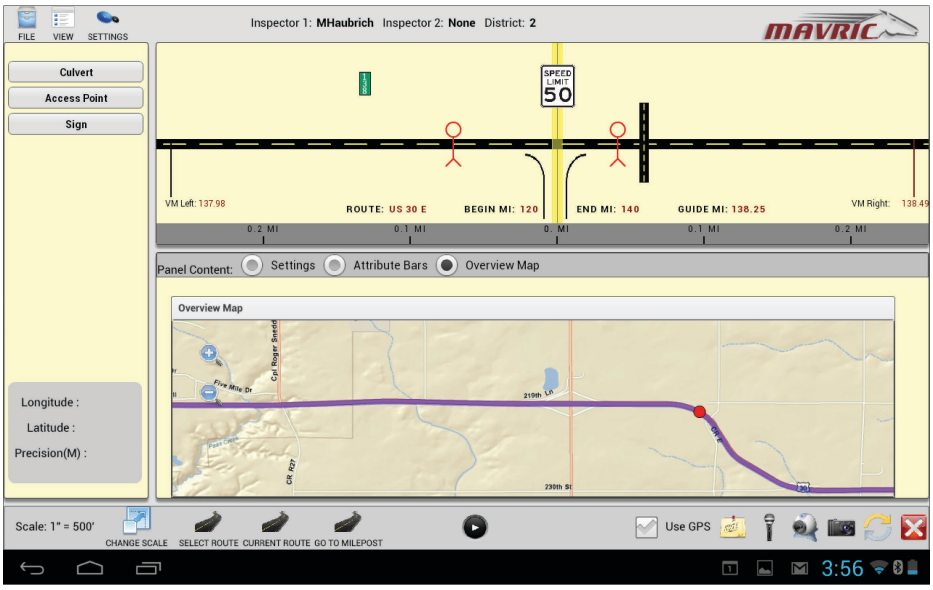
- **Providing a common understanding of asset conditions, deterioration patterns, and risks.**
- **Understanding factors contributing to asset performance.**
- **Proactively identifying assets in need of repair.**
- **Prioritizing assets for rehabilitation based on key economic and environmental factors.**



Core TAM Business Processes

Understanding the State of the Assets

Use GIS to inventory and inspect assets and to display asset location and condition.



GIS Capabilities

- Optimize asset inspection routing and track inspection completion.
- Use spatially-enabled devices to collect inventory and condition data in the field.
- Use tools for automated and semi-automated extraction of asset features from digital images or LiDAR data.
- Update information for existing assets in the field by retrieving available data based on location.
- Use a map to review inventory and condition data.
- Geo-tag photos of asset condition before and after work completion.
- Use a map to access digital images and photographs taken in the field.

Value Added

- Richer and more accurate data source for decision support – integrating imagery, location, and classification/attribution.
- More efficient maintenance and timely updating of asset inventory and condition data.
- Improved ability to leverage asset data by linking field systems with existing inventories.
- Reduced field time for data. collection resulting in lower costs and reduced risk of injury.
- Reduced staff time in preparing annual federal reports.
- Reduced staff time responding to information requests.

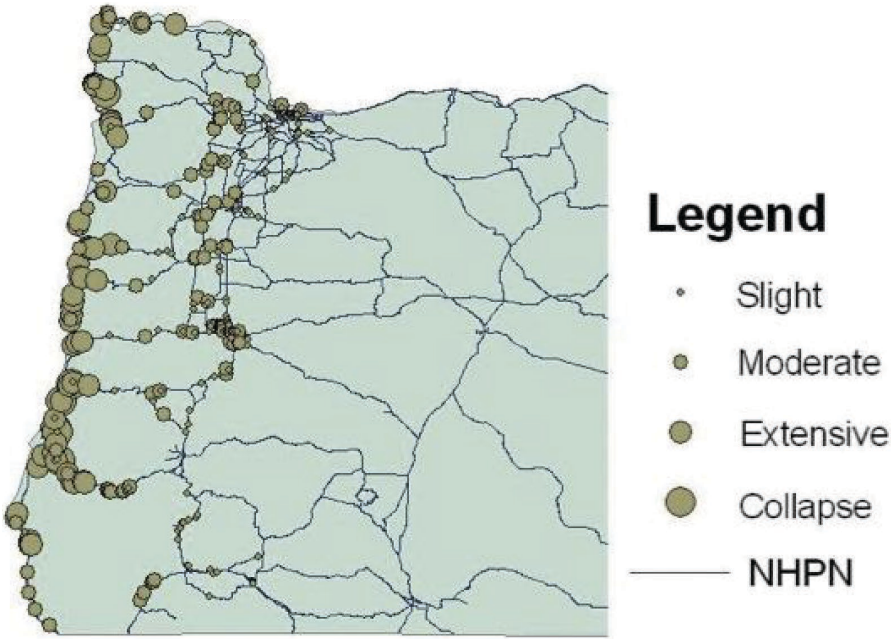
Example

Iowa DOT Asset Field Data Collection Project

The Iowa DOT has completed two phases of a pilot project to prove the feasibility of using tablet-based tools for collecting assets in the field. The first phase assessed hardware options and developed a module for collecting culvert inventory and inspection records. The application uses drop-down lists that are continually filtered based on user inputs to simplify data collection. The application also has the ability to collect and link video, photographs, audio clips, or notes to inventory or inspection records. The second phase of the project added the capability to collect sign data. The Iowa DOT plans to add modules to collect data for other asset types.

Identifying and Managing Risks

Use GIS to understand asset vulnerabilities and manage real-time response to extreme weather events and other emergencies.



NHPN = National Highway Planning Network.

GIS Capabilities

- Use GIS to overlay information such as floodplains, fault zones, detour routes, and historical weather information on top of asset location data to assess risks, estimate potential damage, and determine recovery costs.
- Use GIS location analytics to model asset failure risk as a function of historic rainfall, population, traffic, and other factors.
- Use GIS to track current road conditions and locations of maintenance vehicles in real time during snow or other extreme weather events.

Value Added

- Provide information needed to better assess and manage risks.
- Lower failure risks through development of mitigation strategies.
- Lower insurance costs through demonstrating use of preventive maintenance to lower failure risks for critical infrastructure.
- Provide situational awareness—allowing more effective and timely responses to weather events.

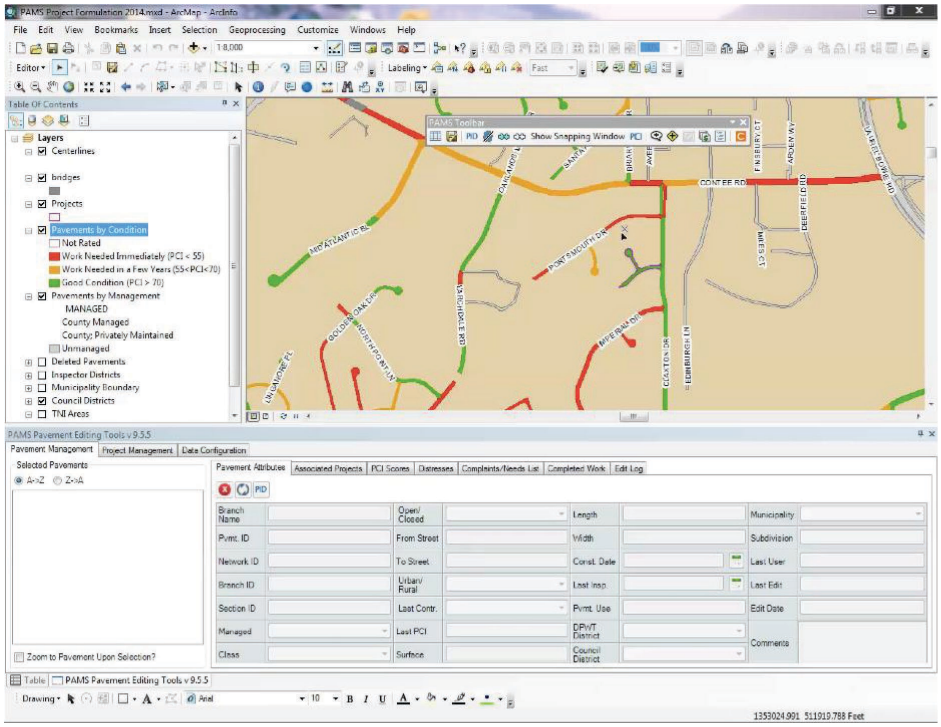
Example

Oregon Department of Transportation (ODOT) Risk Assessment

To estimate the effects of earthquakes on the Oregon roadway system, ODOT employed the GIS-based Risks from Earthquake Damage to Roadway Systems (REDARS2) tool. The application integrates seismic data and assesses potential economic losses of seismic events based on impacts on lifeline routes. ODOT used REDARS2 to identify the highest priority bridges for retrofit based on seismic hazards and their consequences, including repair cost and closure times.

Identifying Needs and Work Candidates

Use GIS to integrate data necessary to provide a holistic view of asset maintenance and rehabilitation needs.



GIS Capabilities

- Integrate a wide variety of data for assessment of needs.
- Review and assign appropriate treatment/fix based on asset condition, environment, soils, traffic, safety, and other data.
- Review geospatial patterns of asset failure/deterioration.

Value Added

- Identify root causes for poor performance.
- Incorporate other factors beyond asset condition in determining asset maintenance and rehabilitation needs.

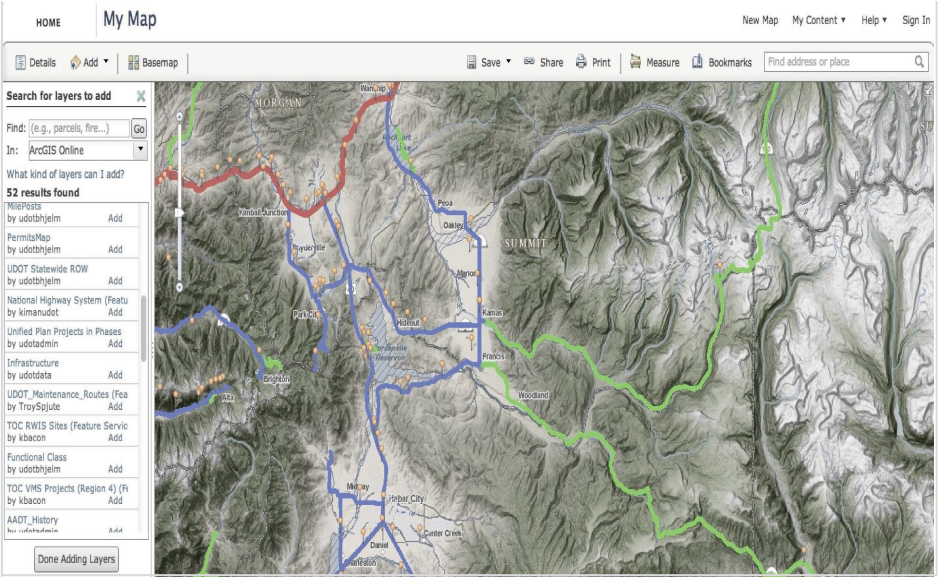
Example

Maryland Department of Public Works and Transportation (DPW&T) Pavement Asset Management System (PAMS)

In Prince George's County, DPW&T developed a PAMS solution to support a cost-effective maintenance program. Semi-automatic pavement condition data is collected on a five-year cycle and analyzed using MicroPAVER. Data are available to DPW&T employees through a custom ArcGIS/SilverLight application programming interface (API) solution that stores deterioration curves, condition index scores, and digital photos. DPW&T also maintains an ArcGIS Desktop solution that identifies candidates for roadway projects using condition ratings from MicroPAVER, citizen complaints, and planned and completed work.

Developing Programs

Use GIS to develop resource-constrained programs and communicate program information to agency stakeholders.



GIS Capabilities

Developing Programs

- View integrated information about multiple asset classes including condition, needs, and pipeline projects.

Communicating Programs

- Provide public-facing web applications showing asset conditions and planned projects.
- Display completed and planned projects and performance results on mobile GIS apps—for executive "road shows."

Value Added

- Better informed decisions on infrastructure improvements.
- Better coordination of work activities by location.
- Improved public confidence in agency decisions.
- Improved ability to communicate agency plans to customers and elected officials.

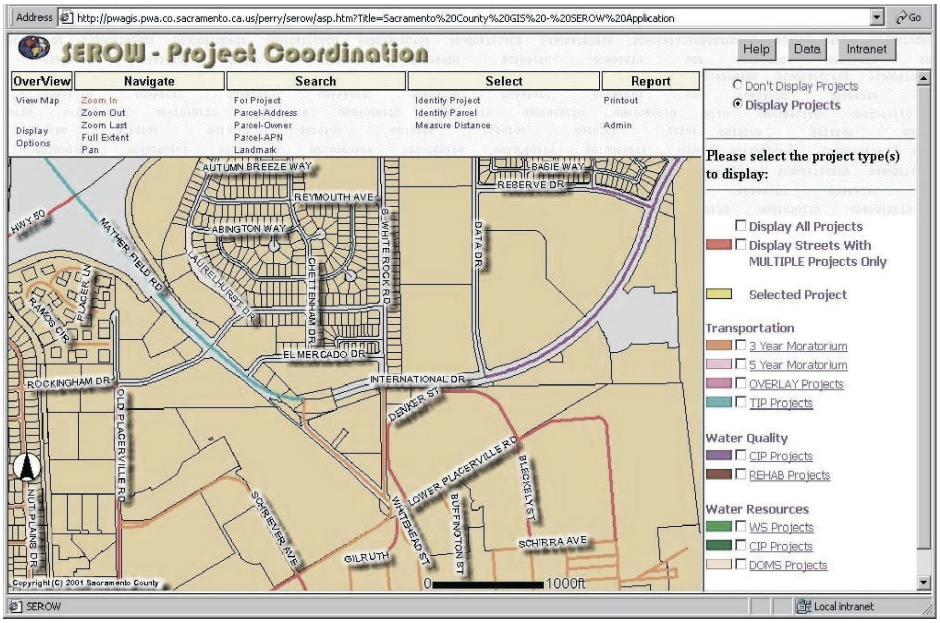
Example

Utah Department of Transportation (UDOT) uPlan

UDOT created a web-based interactive GIS planning and analysis tool, called uPlan, to improve data accessibility and comprehension. The program integrates information from multiple sources and is heavily used by decision makers who are able to easily query and analyze the available data. uPlan also has a public component which is made available on the UDOT website. The tool can be used to view projects and project information from the Unified Transportation Plan. A variety of additional data layers are available and can be used to create customized maps.

Managing and Tracking Work

Use GIS to coordinate construction and maintenance work on different assets within a corridor.



GIS Capabilities

- Review planned work by location to consolidate contracts.
- Review scheduled work to avoid conflicts with external activities. (e.g., utility work) and avoid adverse customer impacts (e.g., from closing lanes on two parallel routes).

Value Added

- Minimize customer impacts from scheduled work through coordination of lane closures.
- Gain efficiencies through work packaging—particularly where traffic control is required.
- Coordinate maintenance work on different assets to avoid duplication and conflicts.

Example

Sacramento County, CA, Excavation in Right-of-Way Application

Sacramento County's Street Excavation in Right-of-Way (SEROW) application is a web-based system that provides the ability to map current and planned future projects requiring excavation. Reports can easily be run that identify potential conflicts between projects, or the potential for unnecessary or duplicate work. Moreover, the system can be configured to automatically generate email alerts when conflicts are created by new projects entering the system or modifications to existing project data.

Sizing up Your Agency's Capabilities

A GIS and Asset Management Checklist

Most transportation agencies have strong GIS programs and have begun to use elements of GIS for asset management. However, while it is relatively straightforward to develop a single GIS-enabled application with a limited data set, using GIS to its full potential as an integrating force across divisions for asset management requires leadership, careful planning and orchestration.

Here are a few questions to ask about your agency's GIS capabilities for asset management.

Understanding the State of Your Assets

Which of your agency's assets can you see on a map?

- ☐ Pavements
- ☐ Structures (bridges, culverts, tunnels)
- ☐ Traffic and safety (signals, signs, barriers, lighting, rumble strips)
- ☐ Drainage and Stormwater Facilities
- ☐ Intelligent Transportation Systems (sensors, cameras, message signs, ramp meters)

Anticipating and Managing Risks

- ☐ Can you pull up a map showing a history of asset failures due to deterioration and extreme weather/seismic events?
- ☐ Can you produce a map today showing seismic, environmental, and weather data that may impact future asset condition? If not, how long would it take your staff to produce it?
- ☐ Is your pavement staff currently able to use GIS to understand reasons for higher than typical deterioration in condition—e.g., by looking at soil characteristics, paving contractors, mix types, historical weather patterns, drainage, etc.?
- ☐ Can your safety staff produce a map integrating external data (e.g., state police records, weather records) with agency data (e.g., crashes, structure locations)?

Scoping and Prioritizing Work

- ☐ Can you produce a map today showing current asset deficiencies and candidate projects under consideration but not yet programmed? If not, how long would it take your staff to produce it?

Coordinating Project Timing and Managing Work

- ☐ Does your agency currently have a process to review planned and proposed work by location in order to coordinate scheduling or contracting for this work?
- ☐ Does your agency track snow plow and other maintenance vehicle location in real time?

Communicating with Stakeholders

- ☐ Can you pull up a map at your desk showing programmed projects (for all asset types) and their current status? Can you access this information from your mobile device?
- ☐ Can your agency staff easily produce a set of maps that would make a persuasive case for your proposed transportation improvement program? How long would it take to produce?
- ☐ Can your agency staff easily fulfill a request from a local agency for geospatial information on asset condition and proposed projects? How long would it take?

Making It Happen

Integrating GIS capabilities with TAM requires strong leadership. The agency may have one or more "silos of excellence" that have implemented some of the capabilities described earlier in this guide. However, a unified agency-wide approach is needed to have maximum impact and benefit. Leadership is the ingredient that ensures that everyone is moving in the same direction, in a manner that allows the agency to provide the best possible value.

What does it take?

Vision

The key to success is starting with a clear vision of how GIS will be used—for collecting and analyzing data, for scoping and prioritizing projects, for developing programs, and for communicating with stakeholders.

Communication

Once a vision is developed, make sure it is documented, communicated, and understood across the agency.

Business-Driven Priorities

Identify a manageable set of initiatives that move you towards realization of the vision. Ensure that each initiative will add value and show an ROI. Make sure business champions are in place and accountable for showing results.

Challenge Staff to Deliver

Challenge staff to push the envelope of what they think is possible—this is how innovation occurs.

Monitoring and Collaboration

Follow up often to track progress. Add GIS topics to the agenda of leadership team meetings to check status of initiatives and remove roadblocks.

Where do I start?

Locate assets, projects, and maintenance activities

Make sure that your important assets—and associated maintenance, rehabilitation, and replacement actions—can be located on a map. Use standard methods for location referencing so that asset-related data can be integrated. Location-aware (GPS) field data collection technologies are available to facilitate this process.

Integrate asset management systems with GIS

If your asset management systems are built on a GIS platform, make sure that they can talk to each other. Even if they are not, you will still need to ensure that location referencing standards are in place to allow management system data to be mapped and analyzed using GIS tools.

Assemble other geospatial data

Pull in other spatial data sets needed to assess risks, opportunities, and constraints (seismic zones, rainfall history, freight routes, equipment sheds, etc.). Many such data sets are available from local, state, and federal sources.

For more information, see the companion Implementation Guide, available as part of *NCHRP Report 800* and online.

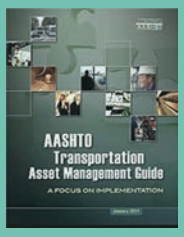
Further Reading

Best Practices in Geographic Information Systems-Based Transportation Asset Management

http://gis.fhwa.dot.gov/documents/GIS-AssetMgmt.pdf

Multi-Level Linear Referencing System (MLLRS) Cost/Benefit Value Analysis Study

http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(302)_FR.pdf



AASHTO Transportation Asset Management Guide: A Focus on Implementation

https://bookstore.transportation.org/collection_detail.aspx?ID=100 (Executive Summary: http://www.fhwa.dot.gov/asset/pubs/hif13047.pdf)

Analysis of Benefits from Use of Geographic Systems by King County, Washington

http://gis.fhwa.dot.gov/documents/GIS-AssetMgmt.pdf

GIS in Transportation Website

http://www.gis.fhwa.dot.gov

TRB Peer Exchange: Geospatial Information Technologies for Asset Management

http://onlinepubs.trb.org/onlinepubs/circulars/ec108.pdf

GIS-T: AASHTO GIS for Transportation Symposium Website

http://www.gis-t.org/index.php