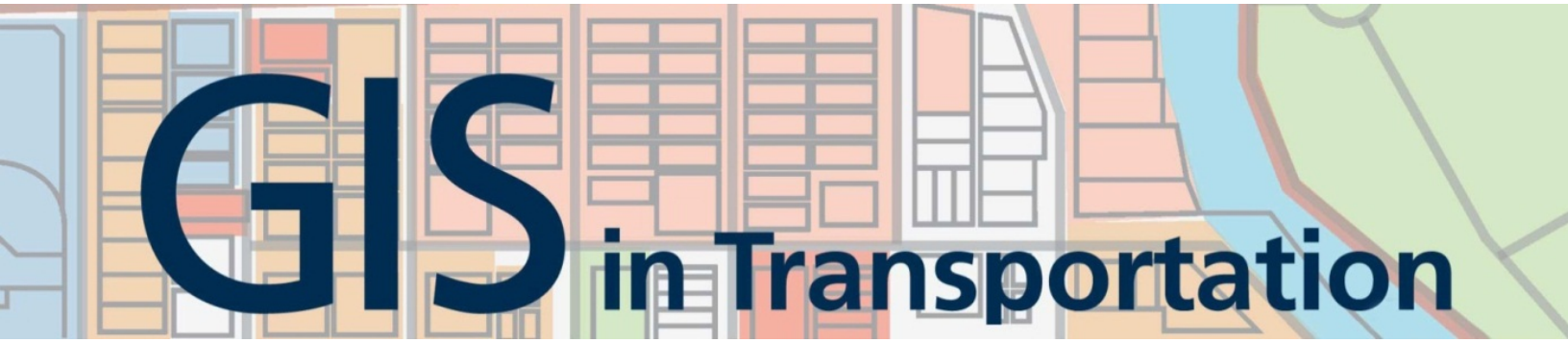

Uses of Geospatial Applications for Transportation Performance Management

Case Studies of Select Transportation Agencies

October 2016

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Office of Planning
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Andrew Reovan, Amy Sheridan, Alisa Fine	

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13. ABSTRACT (Maximum 200 words)

To explore how State DOTs are developing programs around transportation performance management (TPM), particularly as they prepare for requirements introduced by the Moving Ahead for Progress in the 21st Century (MAP-21) legislation, FHWA and the U.S. Department of Transportation (DOT) Volpe National Transportation Systems Center interviewed four State DOTs and developed a series of case studies focusing on their experiences:

- South Carolina Department of Transportation (SCDOT)
- Ohio Department of Transportation (ODOT)
- Vermont Agency of Transportation (VTrans)
- Maryland Department of Transportation, State Highway Administration (MDOT-SHA)

This case study report was developed in response to the requests of participants at an FHWA-sponsored peer exchange on the same topic, held June 30-July 2, 2015 in Spokane, WA. The report supports GIS practitioners and decision-makers by identifying examples of noteworthy practices, considering the advantages and disadvantages of different approaches in using GIS solutions for TPM and related efforts, and determining how to best use GIS to communicate the impacts of performance-based operations and planning at the State DOT level.

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Executive Summary

In recent years, transportation agencies have increasingly adopted data-driven management tools and performance management approaches to make more informed and effective investments in the transportation system. The Moving Ahead for Progress in the 21st Century Act (MAP-21) sought to formalize these processes and institute transportation performance management (TPM) as a core component of all surface transportation management, including but not limited to investment decision-making. MAP-21 outlines national performance goals relating to the National Highway Performance Program, the Highway Safety Improvement Program, the Congestion Mitigation and Air Quality Program, and freight movement. The Fixing America's Surface Transportation (FAST) Act, signed into law in December 2015, reinforces these TPM requirements and seeks to continue the efforts initiated under MAP-21. Based on the requirements introduced by MAP-21 and FAST, the Federal Highway Administration (FHWA) Office of TPM will issue final regulations on performance management for Federal-aid recipients, conduct training and education on the new regulations, and share best practices.[1]

To explore how State DOTs are developing programs around TPM, particularly as they prepare for requirements introduced by the Moving Ahead for Progress in the 21st Century (MAP-21) legislation, FHWA and the U.S. Department of Transportation (DOT) Volpe National Transportation Systems Center interviewed four State DOTs and developed a series of case studies focusing on their experiences:

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This report supports GIS practitioners and decision-makers by identifying examples of noteworthy practices, considering the advantages and disadvantages of different approaches in using GIS solutions for TPM and related efforts, and determining how to best use GIS to communicate the impacts of performance-based operations and planning at the State DOT level. Highlights of the findings presented here include:

- Most States remain in the developmental stage of implementing a TPM program, which therefore limits their ability to commit to a comprehensive GIS solution.
- Increasingly, leading States are investing in the use of GIS tools to centralize data storage and integration, enabling new insights for performance-based programming and planning, asset management, and TPM.
- Peer agencies emphasize that the largest hurdles to comprehensive TPM programs are often organizational challenges, such as lack of staff awareness around GIS, limited funding, and inconsistent practices for data management.

[1] Additional information on FHWA's Office of TPM and the MAP-21 national performance goals are available at https://www.fhwa.dot.gov/tpm/.

- To encourage organizational change and grow internal awareness, peer agencies suggest starting with a small sample of widely-used data. Over time, different divisions and groups will start to value access to data, which can open the door to discussions of broader data sharing.
- Ultimately, peers did feel that the requirements introduced under MAP-21 and continued in the FAST Act will necessitate a move toward internal culture around TPM, which will require greater collaboration across divisions and a centralized way to access data. For all of the peers in this report, GIS solutions are the preferred mechanism to achieve those goals.

1. Introduction

1.1 Purpose and Methodology

The Federal Highway Administration (FHWA) promotes geographic information systems (GIS) as a technology that can help transportation agencies save time, improve transportation decision-making, and improve outcomes related to safety, congestion, and sustainability. GIS investments can also reduce transportation project delivery timelines, leading to cost savings for transportation agencies. GIS applications help agencies monitor and address congestion, resulting in increased economic productivity for the general public.

This set of case studies and its companion peer exchange are part of FHWA's GIS in Transportation program.[2] Through technical support, resources, and capacity-building opportunities, the program aims to assist transportation agencies more effectively use GIS and geospatial applications.

Peer exchanges sponsored by the GIS in Transportation program have focused on various applications of GIS to transportation, e.g., geospatial data-sharing, uses of cloud-based GIS applications, and the business case for geospatial technologies. The companion peer exchange to this report was held on June 30-July 2, 2015 in Spokane, WA, and was hosted by the Spokane Regional Transportation Council (SRTC). Peers from State Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and local transportation agencies discussed the role of geospatial and GIS tools in developing transportation performance management (TPM) programs and initiatives. The peer exchange report, available from the FHWA GIS in Transportation website, provides key findings from roundtable discussions, as well as a list of participants.[3]

Participants at the peer exchange requested that FHWA develop further case studies to highlight how agencies are approaching the use of GIS for TPM programs and initiatives. To explore how State DOTs are harnessing GIS tools for TPM—particularly as they prepare for requirements under the Moving Ahead for Progress in the 21st Century (MAP-21) legislation—four State DOTs were interviewed by FHWA and the U.S. DOT's Volpe National Transportation Systems Center (Volpe) regarding their experiences with GIS in this context. Volpe developed the case studies below from information obtained during those interviews.

Together, the case studies and peer exchange gave participating agencies the opportunity to:

- Identify the state of the practice in how transportation agencies are using GIS tools and applications in support of their TPM goals

[2] See the FHWA GIS in Transportation website: http://gis.fhwa.dot.gov/.
[3] *Uses of Geospatial Applications for Transportation Performance Management: Peer Exchange.* https://www.gis.fhwa.dot.gov/reports.asp.

- Recognize how different agencies manage organizational change—particularly internal culture change—and improve internal capabilities, as they advance in their TPM efforts
- Share related experiences, including technical approaches and innovative examples
- Discuss benefits, challenges, success factors, and lessons learned
- Identify potential opportunities to improve the efficiency or quality of efforts around TPM

FHWA and Volpe selected agencies for case studies based on a review of their online materials and on their participation in recent discussions about TPM at industry conferences. The participating agencies were Ohio Department of Transportation (ODOT), Maryland State Highway Administration (MDOT-SHA), South Carolina Department of Transportation (SCDOT), and Vermont Department of Transportation (VTrans). Appendix A provides details on agency participants. An interview guide, included as Appendix B, provided a framework for two telephone discussions with each agency, held for 30-60 minutes each in September and November 2015. Case studies were drafted based on participant responses during the two discussions. Findings from the case studies are included in the Observations section of this report.

1.2 Transportation Performance Management (TPM)

TPM is a strategic approach that uses transportation system information to help make investment and policy decisions to achieve national performance goals. TPM is a systematic, ongoing approach to transportation decision-making that involves:

- Identifying key information about the transportation system that allows decision-makers to better understand the consequences of their investment decisions;
- Improving communications between decision-makers, stakeholders, and the traveling public; and
- Ensuring that performance targets and measures are developed in cooperative partnerships and are based on data and objective information.

In recent years, transportation agencies have increasingly adopted data-driven management tools and performance management approaches to make more informed and effective investments in the transportation system. MAP-21 legislation sought to formalize these processes and institute TPM as a core component of all surface transportation management, including but not limited to investment decision-making. MAP-21 established a number of areas in which U.S. DOT modal agencies, including FHWA, would need to establish measures to assess performance and to carry out the respective apportioned programs. The Fixing America's Surface Transportation (FAST) Act, signed into law in December 2015, reinforces these TPM requirements and seeks to continue the efforts initiated under MAP-21. Based on the requirements introduced by MAP-21 and FAST, FHWA will issue final regulations

and guidance on performance management, conduct training and education on the new regulations, share best practices, and provide technical assistance.[4]

FHWA considers TPM to be a comprehensive approach for managing the entire transportation system. However, FHWA recognizes that TPM has links to other performance management approaches such as asset management—which focuses on managing physical assets based on their useful life and replacement requirements[5]—and transportation performance-based planning and programming (PBPP). According to FHWA, PBPP shares many of TPM's core principles but focuses more on incorporating performance goals specifically into the planning and programming phases of transportation decision-making.[6] FHWA will issue final regulations for asset management and PBPP concurrent with the rollout of TPM regulations.[7]

FHWA believes that geospatial/GIS tools and applications can support a wide range of performance management goals. However, there have been few opportunities for transportation agencies to share information on how geospatial/GIS tools and applications can best support new Federal performance provisions (due, in part, to the fact that MAP-21 TPM rulemakings are still forthcoming). This case study report and the companion peer exchange report fill this gap by providing a forum for State DOTs and local transportation agencies to share noteworthy practices, success factors, and challenges encountered in using, developing, and maintaining geospatial/GIS applications and tools that support performance management approaches (e.g., asset management, PBPP, maintenance management) as well as TPM specifically.

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[4] Additional information on FHWA's Office of TPM and the MAP-21 national performance goals are available at https://www.fhwa.dot.gov/tpm/.

[5] See FHWA's discussion of the difference between TPM and asset management approaches at https://www.fhwa.dot.gov/tpm/about/difference.cfm.

[6] Additional information on FHWA's PBPP framework is available at http://www.fhwa.dot.gov/planning/performance_based_planning/pbpp_guidebook/.

[7] FHWA's 2012 report on "Best Practices in GIS-Based Transportation Asset Management" provides additional information on using GIS tools to support asset management goals –see https://www.gis.fhwa.dot.gov/documents/GIS_AssetMgmt.htm. Some of the examples included in the 2012 document are also referenced in this peer exchange report.

2. Observations

Approaches to TPM vary widely among the four peer agencies interviewed. They have all focused on the use of geospatial/GIS tools and applications to support a limited range of performance management approaches, in particular asset management, performance-based planning and programming (PBPP), and maintenance activities. However, of the four agencies, only MDOT-SHA has begun to monitor performance of the roadway system in terms of mobility, freight movement, or similar measures. Given that final rules for system performance TPM have not yet been published, most agencies reported hesitancy in developing—or considering how to develop—geospatial/GIS tools that support these goals prior to seeing clear guidance from FHWA. However, the agencies expected to build upon existing initiatives and efforts to refine, tailor, or adopt current GIS tools for TPM-related goals over the next few years.

Table 1 provides an overview and summary points about each of the case study examples. The examples are sorted by their self-assessed level of preparedness to implement TPM practices in their agency. The three levels of readiness from the case study participants were: early stage, moderately prepared, or well prepared.

Table 1. Summary of Case Study Agencies' TPM and TAM Efforts using GIS

Agency	GIS or Geospatial Solution(s)	TAM Efforts	TPM Efforts	TPM Readiness
SCDOT	• Integrated Transportation Management System (ITMS) • Project Programming System (P2S)	Developing initial Asset Management Plan (TAMP), based on MAP-21 requirements (not integrated with GIS tools)	Reviewing viability of existing geospatial tools for TPM reporting; awaiting FHWA rulemakings	Early stage
ODOT	Transportation Information Mapping System (TIMS)	Developing automated asset reporting capabilities using TIMS	Using TIMS to communicate PBPP efforts; evaluating appropriate internal performance measures	Moderately prepared

Agency	GIS or Geospatial Solution(s)	TAM Efforts	TPM Efforts	TPM Readiness
VTrans	VTransparency	VTransparency maps data on pavement, bridges, projects, and maintenance. VTrans is currently developing an automated report using this data to meet MAP-21 TAMP requirements.	Testing initial dashboards for individual departments (project delivery time, adherence to engineer's budget estimate)	Moderately prepared
MDOT-SHA	• Enterprise GIS (eGIS) • SHA Data Hub	Piloting an internal asset management dashboard, currently in use with multiple teams.	Developing a MAP-21 dashboard as well as dashboards for freight and mobility. SHA anticipates that existing data within the eGIS will support reporting for MAP-21, with small changes.	Well prepared

2.1 Motivations for Pursuing Transportation Performance Management

Case study participants were all focused on pursuing TPM not only because of the requirements introduced by MAP-21, but also as part of a broader effort to move their agencies toward a more performance-driven decision-making approach. Within that overarching goal, the agencies were motivated to pursue TPM for one or more of these reasons:

- **Improve data integration and reduce redundancies**. All of the agencies mentioned the value of sharing data among divisions, disciplines, offices, and stakeholders—even if that data only represents a small portion of the system. In particular, Ohio DOT, VTrans, and MDOT-SHA all emphasized the value that a system-wide view can provide, especially for asset management projects. Likewise, displaying project information and asset condition in an easy-to-access, online map helps ensure that projects and investments in the same or nearby locations do not interfere with each other or result in unnecessary work.
- **Visualize problems in the system and in operations, in turn informing more strategic investments.** On a related point, visualizing the system in an easy-to-access map enables agencies to better decide where to invest their limited resources. For example, ODOT

emphasizes that its TIMS system has already improved decision-making about asset management and improvements—allowing the agency to reference safety data as an indicator of poor pavement condition and invest in new pavement for problem areas.

- **More clearly communicate transportation investments and outcomes to the travelling public and officials.** VTrans—which aligns its TPM efforts with its broader data openness and transparency initiative, VTransparency—has improved operational efficiency thanks to its investment in an online, GIS-based database and dashboard system. For many of the case study agencies, the ability to reference publicly-available information and to share asset information and investments with stakeholders and the public improves communication and reduces the time burden on staff when responding to information requests.
- **Inform discussions about future investment priorities.** In line with improving information-sharing and open communication with stakeholders, the four agencies all emphasized the value that GIS provides in informing discussions with leadership and legislators about investment priorities. SCDOT reflected the belief of all four in hoping that current efforts to develop and implement a data-driven approach would provide greater visibility into the needs of the State's transportation assets for leadership and lawmakers. In the same vein, MDOT-SHA expressed the hope that more of its investment decisions will be data-driven, weighing performance aspects like safety, mobility, and freight movement with the potential benefits of a project.

2.2 Benefits

Transportation agencies reported a number of benefits related to using GIS systems and databases as part of a TPM and PBPP program, especially as they prepare for the TPM requirements of MAP-21. Agencies highlighted the following benefits in the discussions:

- **A visual, system-wide view of investments and projects.** All four agencies anticipate that GIS will play an integral role in performance management efforts. Because GIS offers the ability to layer different types of information, it will provide agencies with a more cohesive, system-wide view of how all projects interact with other projects, natural features, land uses, and other elements of the built and natural environment. In turn, this will support each agency in making more strategic, effective decisions that can improve an overall corridor or system.
- **Improved asset management practices.** Integrated, visual asset data helps identify and prioritize areas of most need. It leads to better decisions about where to spend the budget and where an investment could have the greatest impact. In the area of safety, for example, most agencies use data on accident incidences to identify areas that may have poor pavement condition or require improved roadway design.
- **Improved communication and understanding.** The visual data presentation helps inform and convince stakeholders. The data supports performance plans, helps raise public support for spending decisions, and provides supporting data when conclusions are questioned.
- **More data-driven internal culture**. The overall ease and usefulness of a GIS system supports continuing internal culture change in favor of collecting and maintaining good data. When

agencies rely on data that is collectively sourced and managed from among multiple divisions and offices, staff begin to focus on better accuracy in data collection and management.

- **Performance-based decision-making.** Performance reports, such as those required under MAP-21 and the FAST Act, are after-the-fact. In contrast, integrated GIS data can be used to detect problems ahead of the report schedule, so they can be addressed before they reach a low performance threshold or create larger problems.

2.3 Challenges

Agencies noted several challenges associated with developing business cases:

- **Collecting and properly managing data are expensive.** Many State DOTs have experienced reductions in staff size, which limits their ability to send multiple staff out in the field to collect data. Additionally, finding skilled staff to work through tool and database development to build the systems to support sustainable data collection, management and integration can be an even bigger challenge than collection itself. If organizations treated data as an asset rather than a cost, they might realize significant savings from proactive data management.
- **Internal culture is resistant to prioritizing data quality.** Cultural barriers can likewise be significant, as both legacy internal cultures and leadership in many agencies do not support a shift to GIS-based data storage. The need for standardization and for data to be useful outside their own department is not familiar or, sometimes, welcome. Agencies should plan and allow extra time to make the internal case for the use of GIS for TPM and PBPP efforts.
- **MAP-21 and FAST reporting requirements may not align with an agency's existing performance measures.** While all of the agencies were uncertain of what FHWA's TPM rulemakings will require, they all believed that these requirements likely would not be fully aligned with their own needs and priorities. Furthermore, they are concerned that FHWA will require data for the same asset or performance measures to be aggregated in ways that are not easily aligned with the State's own priorities for reporting performance goals. States worry that it will be a challenge for to manage understanding of different performance measures and reporting structures among users when the performance measures are publicly available.
- **Leadership and staff transitions.** While it is essential to have a champion leading the GIS effort, senior leadership can change in response to changes in administrations. Additionally, retirement and downsizing have resulted in loss of institutional knowledge, particularly about legacy IT systems. At the same time, behavior change tends require more bottom-up support, and inconsistent direction from leadership can stand in the way of that support.
- **Finding adequate staff resources is difficult.** SCDOT noted that identifying staff resources may be challenging. The agency estimated that it would need to hire additional staff or reallocate current staff to focus their time specifically on performance management activities.

2.4 Lessons Learned

The case study agencies offered the following lessons learned based on their experiences:

- **Encourage an organizational culture of performance management.** Agencies noted that it is essential to adopt strategies to help foster an agency-wide culture of performance management to help create an environment conducive to implementing new approaches in the future.
- **Dedicate appropriate resources to training and staff development.** In the early stages of tool development, agencies should identify opportunities to train and subtly encourage staff awareness of the value of data sharing in GIS. Likewise, after data owners and key users become aware of the benefits of an enterprise GIS offering, additional staff may express interest in accessing the data, compounding the benefits of an easy-to-access system.
- **Ensure high-quality data before relying on it for performance measurement.** It will save time in the long run if an agency takes the time to understand existing data—its actual quality as well as the framework for collecting, analyzing, and presenting it. Some agencies, including VTrans, have found that releasing some rough or questionable data to the public can increase the perceived value of the data to the data stewards who, in turn, take steps to ensure credible, reliable and accurate information. Agencies do caution against making performance decisions based on inaccurate data: it is critical to have a data management plan in place and working before using data to answer specific questions.
- **Bring business units together to hear what other units need and want for data.** Agencies recommend putting management of GIS and its data in the hands of the business units, instead of an IT department, which may have other priorities like security and storage efficiency. There is a need to help GIS and data management staff understand how to use an enterprise system. Likewise, agencies may need to evaluate opportunities to work with other agencies and partners (MPOs, county engineers, and private organizations) to enhance data collection and coverage.
- **Treat your performance data (and all data) as an asset.** If data is valued and is maintained at a high quality, the applications become easier to use and performance management becomes more automatic within the agency. Agencies should have clear strategic goals and objectives for data management and use, ensuring that decisions align with the achievement of those goals.[8] Agencies should also put a succession plan in place, particularly to ensure smooth transitions in data governance and maintenance in the midst of potential staff turnover and retirements.

[8] As an example of how to identify strategic goals, VTrans referenced the so-called Data, Information, Knowledge, Wisdom (DIKW) Pyramid, which helps conceptualize how raw data can lead to deeper understanding of the processes at work. The concept of the DIKW Pyramid is most frequently attributed to Russell Ackoff, see: Ackoff, Russell (1989). "From Data to Wisdom." Journal of Applied Systems Analysis 16: 3–9.

3. Case Studies

This section presents in-depth case studies on the transportation agencies that participated in the report interviews. Each case study starts with a high-level summary of the efforts underway. The background section provides a more in-depth review of these efforts, specifically: 1) the GIS or geospatial tool each State DOT is using; 2) how this contributes to the State DOT's transportation asset management (TAM) efforts; 3) how it contributes to the State DOT's TPM; and 4) any related efforts (if applicable). Following the background section, each case study concludes with a summary of the benefits of the State's chosen solution, any challenges to implementing the solution, and a review of lessons learned and next steps (as applicable).

3.1 South Carolina Department of Transportation (SCDOT)

Summary

SCDOT believes that that it is still in the early stages of applying geospatial/GIS tools or resources to support a performance management approach, but SCDOT anticipates that forthcoming MAP-21 TPM rulemakings will inform its future efforts in this area.

SCDOT is exploring how to refine or adapt current GIS tools for performance management and is assessing what resources (e.g., data, staff) might be required. SCDOT has completed the development process for two valuable GIS-based tools, which are already showing benefits for the agency. The tools are the Integrated Transportation Management System (ITMS), which provides an enterprise-level asset management and inventory for the agency, and the Project Programming System (P2S), which provides project management support in a geospatial database. SCDOT hopes to build on the early successes of these two systems to move toward an integrated system for managing TPM reporting, PBPP, and other efforts and, hopefully, moving the agency toward a culture of performance-based decision-making.

Background

In the past, SCDOT has used a number of different geospatial/GIS tools and resources to support asset management and project management efforts. While SCDOT is still exploring how best to use GIS resources for TPM-specific goals, the agency anticipates drawing on past and current efforts as foundations for any future work in this area. These past and current efforts are described below.

Geospatial or GIS Solution: Integrated Transportation Management System (ITMS)

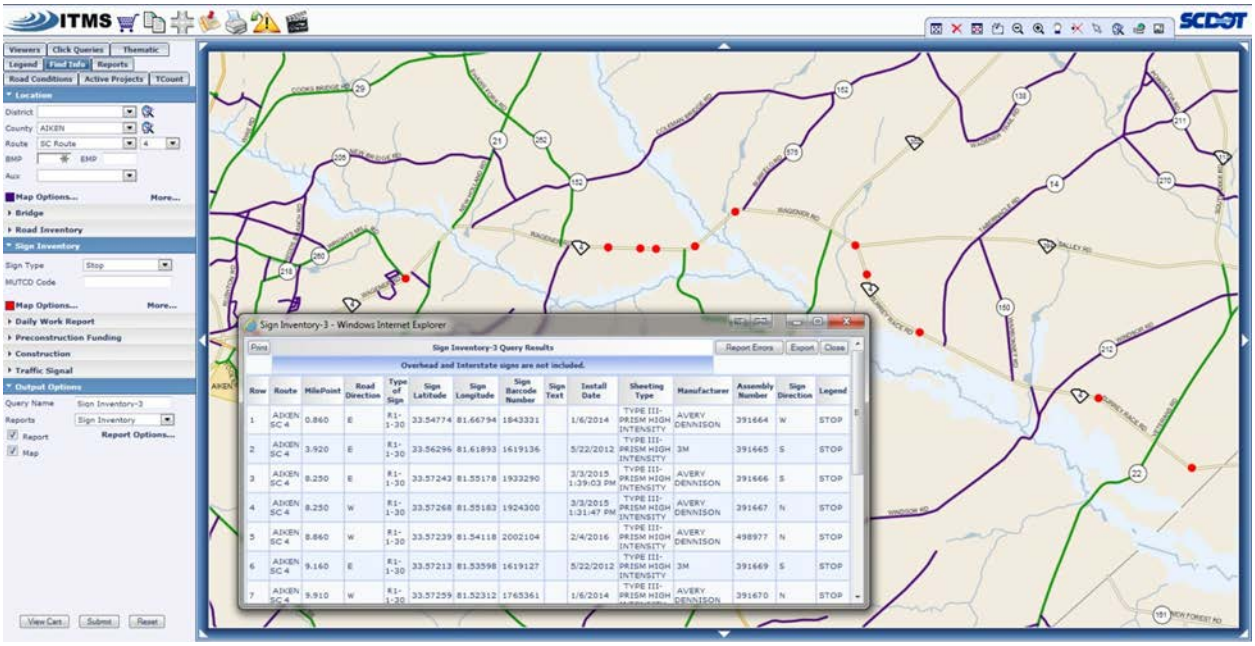

Figure 1. SCDOT's ITMS Solution.

In anticipation of Federally-mandated performance management requirements, SCDOT has focused foremost on implementing a centralized data management solution, known as the Integrated Transportation Management System (ITMS). ITMS is a web-based, geospatial tool that integrates with different SCDOT systems including roadway inventory, construction management, maintenance management, safety, bridge, pavement, traffic, and financial systems. Essentially, ITMS provides an enterprise-level view of a range of SCDOT data, helping staff in SCDOT's headquarters and district offices to visualize, assess, and manage transportation projects. For example, ITMS helps SCDOT identify which roadways require pavement resurfacing, thus helping the agency as a whole better plan resource allocations.

ITMS offers staff the ability to see the same set of data, supporting overall communication and coordination. ITMS also offers reporting capabilities for SCDOT users to easily package information and communicate it to internal or external stakeholders, including the public. In particular, SCDOT noted that ITMS' visualization capabilities are particularly helpful when developing reports, maps, or materials that respond to legislative requests. SCDOT mentioned that "showing visuals helps make our case more effectively than showing spreadsheets."

SCDOT continues to work on improving ITMS functionality and including additional capabilities to ensure that it is an effective resource for overall agency project management. For example, SCDOT has added a videolog that permits virtual "drive-bys" along roadways, eliminating or reducing the time that field personnel or other staff need to spend in the field to evaluate asset conditions or evaluate proposed projects. It has also added asset inventories for culverts, signs, and signals. Pavement and bridge

dashboards are being developed to help staff see, at a glance, a range of performance information for these assets.

Project Programming System (P2S)

In addition to focusing on ITMS, SCDOT is considering whether the Project Programming System (P2S), a tool developed to manage and track project spending and progress, could be adapted or refined to support broader asset management efforts. P2S currently provides geospatial database support only to project management tasks. For example, P2S helps staff identify overlap of planned transportation projects. P2S was developed over the course of several years, beginning with initial planning in 2009 by a committee tasked with documenting project management needs. The committee suggested that a system to prevent project overlap was most critical, since projects often originated from different areas of SCDOT without overall coordination. Ultimately the P2S became the solution, using location referencing via a linear referencing system (LRS) and visualization as a primary means of documenting project overlap. P2S was launched internally in 2013.

P2S is a web-based tool accessible to internal SCDOT users, although access for editing information is limited to staff with direct project management responsibilities. P2S uses a variety of SCDOT roadway data to show information about projects across SCDOT. For asset management efforts, SCDOT is looking at P2S data—especially road resurfacing information—to identify where such information could help feed into the pavement management system for life cycle analysis.

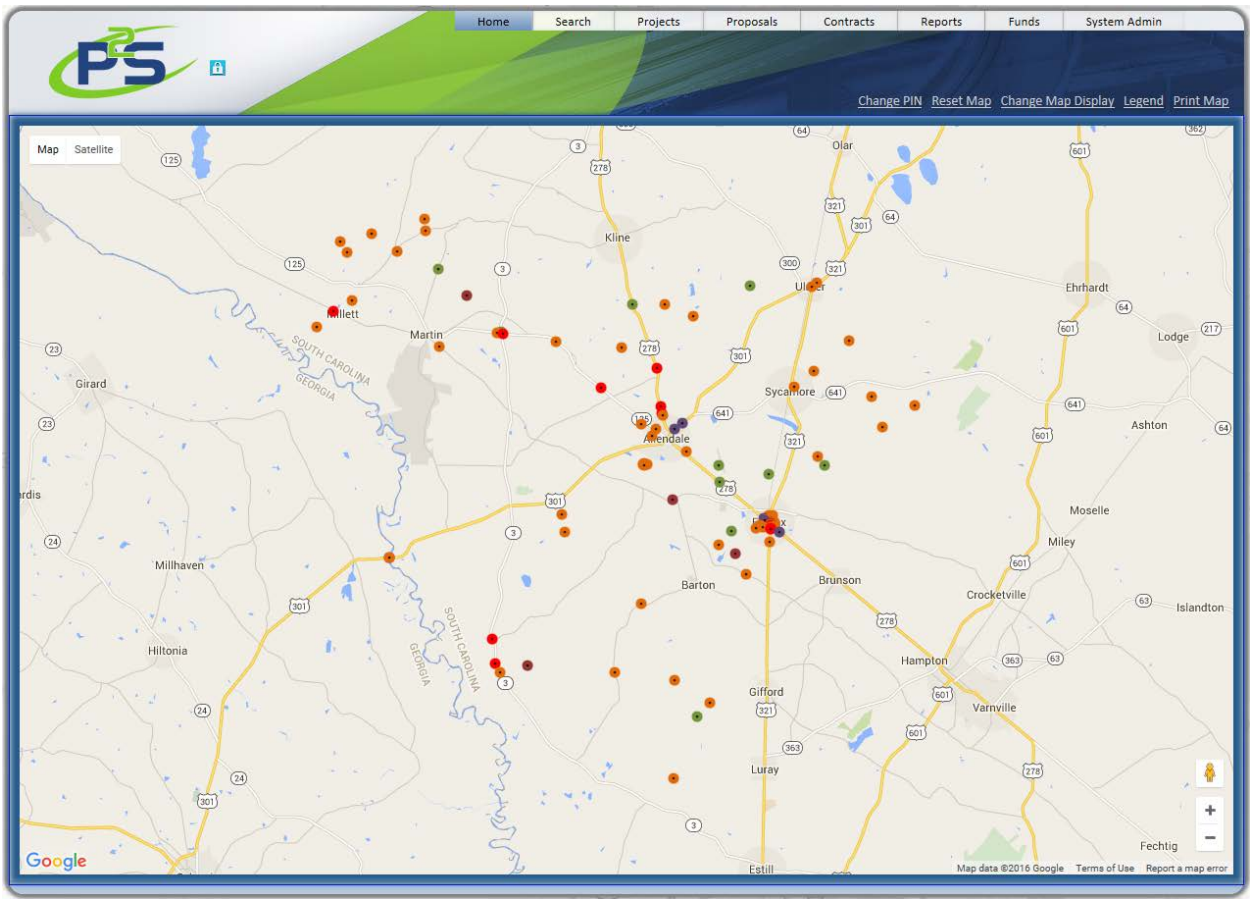

Figure 2. Screenshot of P2S.

Transportation Asset Management (TAM)

SCDOT is in the early stages of creating a risk-based Transportation Asset Management Plan (TAMP), as required under MAP-21 legislation. Under the FHWA's proposed asset management rulemaking, this TAMP will need to include several elements, including: asset inventories; bridge and highway condition data; lifecycle cost analysis; performance gap analysis; and a financial plan that evaluates various investment options. To meet these requirements, SCDOT has identified several types of data it will need to acquire, including Inventory and condition data on pavement, bridges, and other assets. SCDOT is looking at examples from peer States to identify how best to collect, compile, and analyze inventory and condition information to support development of the TAMP. The agency anticipates using data from ITMS for this purpose.

The agency is assessing its current state of practice in terms of what asset data is available, where data gaps exist, and how these gaps can be addressed. SCDOT is also exploring the possibility of acquiring new geospatial software to support asset management efforts. Currently it is evaluating internal

requirements to assess the need for such a system, which would complement the data contained in ITMS.

Transportation Performance Management (TPM)

SCDOT believes that its past and current efforts, such as developing ITMS and P2S, have established a good foundation with regard to performance management, particularly asset management. In the future, the agency anticipates placing more of a focus on prioritizing transportation projects based on a corridor-level approach. This type of approach would allow SCDOT to plan for and implement projects more strategically and efficiently. GIS will be an integral component of adopting such an approach, since it provides the ability to visualize an array of information and see interactions between individual projects. For example, instead of replacing only one bridge on an interstate that carries significant amount of freight within and through South Carolina, SCDOT could analyze the pavement, bridge, and safety needs of the entire corridor to allow freight to move more reliably and efficiently. The ability to make more strategic decisions aligns closely with the overall goals of performance management approaches, including (but not limited to) TPM.

SCDOT's planning office is actively discussing the forthcoming MAP-21 TPM rulemakings to better anticipate and plan for an agency-wide response. However, the agency has not yet established formal performance management measures in areas where FHWA rulemakings have not been finalized, as it feels that the final rulemakings are necessary to help guide efforts in this area.

Benefits

SCDOT lists the following benefits from its use of ITMS and P2S:

- **Cohesive, system-wide performance monitoring.** SCDOT anticipates that GIS will play an integral role in its performance management efforts. Because GIS offers the ability to layer different types of information, it will help SCDOT take a more cohesive, system-wide view of how all projects interact with other projects, natural features, land uses, and other elements of the built and natural environment. In turn, this will support the agency in making more strategic decisions that will improve its corridors efficiently and effectively.

- **Improved efficiency.** SCDOT anticipates that being able to view together an assortment of projects which may have been planned over a span of time and from different funding sources, will help the agency to be more efficient.

- **Improved communication and outreach.** SCDOT has already recognized that P2S has simplified the communications process for project reporting and monitoring, as well as communications with stakeholders and the public. The visual display enables SCDOT to simply and easily communicate where project investments are occurring and to see where project managers might benefit from collaboration on projects within a single corridor or region.

Challenges

SCDOT faced the following challenges in its TPM project and efforts:

- **Staff transitions create delays.** Like many State DOTs, SCDOT has struggled to maintain momentum on strategic initiatives (including GIS tool development) in light of changing leadership and staff transitions.

- **Finding adequate staff resources is difficult.** The agency estimated that it would need to hire additional staff—or, at a minimum, refocus time for current staff—to allow for additional time focused specifically on performance management activities.

Recommendations and Lessons Learned

- **Encourage an organizational culture of performance management.** SCDOT noted that implementing a performance management approach would require buy-in from across the agency. It might be important to adopt strategies that help foster an agency-wide culture of performance management, creating an environment conducive to implementing new approaches in the future.

- **Dedicate appropriate resources to training and staff development.** SCDOT feels that it still has a need for additional internal training. In this early stage of tool development, SCDOT anticipates increased staff interest, as they become more aware of the value of sharing data.

Next Steps

Moving forward, the biggest hurdle for SCDOT is creating and maintaining open communication throughout the organization. However, as the agency looks toward the TPM reporting requirements, it hopes to use ITMS, P2S or an enhanced system to improve its reporting capabilities. Specifically, SCDOT hopes to:

- Be able to show changes to the system over a given time period using GIS based tools.
- Pull performance information through automated, web-based reporting.
- Quickly generate reports for senior leadership, outside stakeholders, and the public.

3.2 Ohio Department of Transportation (ODOT)

Summary

ODOT has been using a centralized GIS-based data management application to support decision-making and performance plans for five years. The capability of GIS to show interconnections between data sets has helped transform the internal culture of ODOT from data and asset silos to one of engagement with all available information.

Background

In 2010, the Office of Technical Services (OTS), within ODOT's Office of Planning, was interested in centralizing data from disparate systems, hoping to use GIS to bring information from these disparate systems together. OTS recommended a plan that included data collection, data distribution, and data consumption. They developed a work plan, gained support of executive management, and stayed with their plan. They developed data standards and recognized that the single biggest challenge was changing the culture so that departmental silos saw the benefit in having access to each other's data. The result was ODOT's centralized information application, TIMS—the Transportation Mapping Information System.

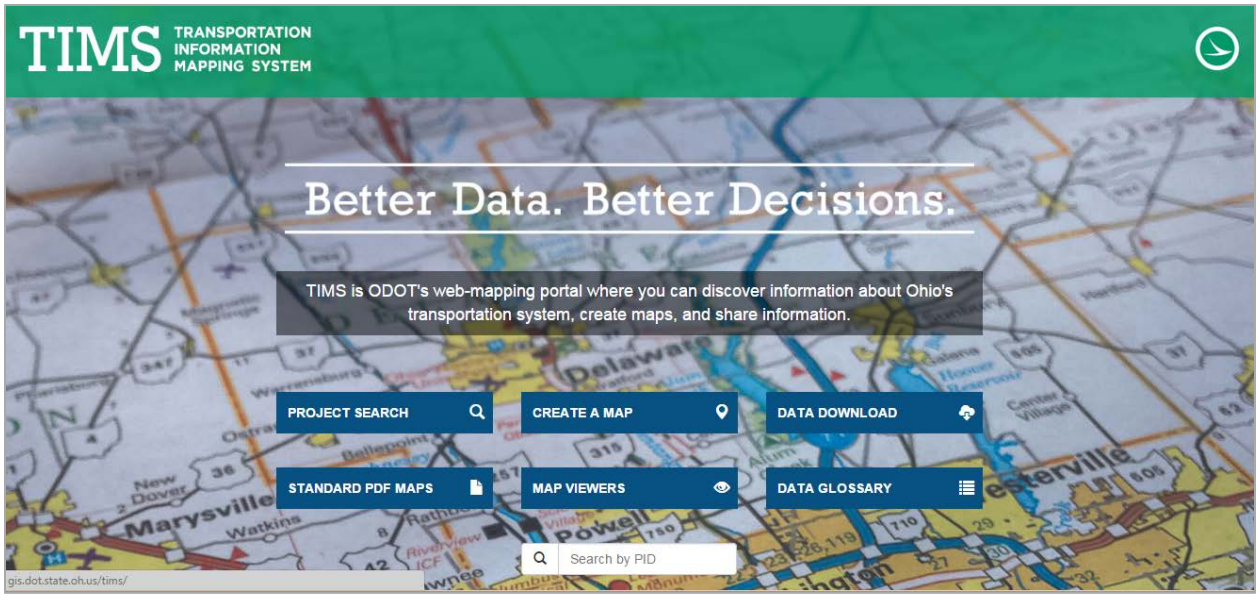

Figure 3. Landing page for ODOT's Transportation Information Mapping System (TIMS).

Geospatial or GIS Solution: Transportation Information Mapping System (TIMS)

TIMS is a cloud-based, collaborative, public-facing tool used by local transportation departments, MPOs, and State agencies. ODOT maintains the road inventory file as a base for other network data. TIMS

integrates data from all divisions' records, providing an enterprise-level view both inside and outside the agency. TIMS is also able to receive data from outside organizations, primarily MPOs.

OTS provides, maintains, and upgrades TIMS on behalf of all of ODOT units. Developed over the last five years from several separate applications, TIMS has recently been made accessible to anyone via laptop[9] or smartphone, using the ArcGIS Collector application. ODOT has developed a series of lively YouTube videos[10] explaining in detail what TIMS can be used for and how to use it.

TIMS development has been a long process of building internal support, demonstrating results, and slowly changing the culture around data management. Previously, data was collected and maintained in divisional silos. The movement to unify ODOT's data began with asset management. A GIS platform was recognized as the ideal means for aggregating and unifying data. Executive management was recruited and approved a series of projects to move forward. Early success helped division staff to recognize the power of combined data and to buy in to the system.

Transportation Asset Management (TAM)

OTS plans to streamline ODOT's TAM capabilities and reporting processes by enabling TIMS to render the results of asset queries and analysis. For example, OTS hopes to show all locations in the State with pavement cracking at a certain level and then turn on the capital improvement plan to see if it matches the need. They would also like managers to be able to use TIMS to show how close conditions are to target index levels, e.g., set a goal of no more than 10 percent of the pavement having a score below 85 and show how close (or far) conditions are from that goal and where the problem spots are.

As a next step, OTS is working on capabilities to automatically generate a report on asset return on investment (ROI), based on existing asset condition and project funding data in the TIMS system.

Transportation Performance Management (TPM)

ODOT's use of performance management is primarily focused around asset condition at this time. Currently, asset performance plans are built into the asset management system. TIMS is used to define the performance plan, identify what metrics are useful, aggregate information needed for investment decisions, and ultimately to inform stakeholders.

TIMS has enabled ODOT to better pinpoint problem areas and to target investment and improvements in a more strategic and less piecemeal manner. For example, comparing pavement condition (using the International Roughness Index, IRI) to other mapped attributes via TIMS allowed ODOT to ultimately identify certain sources of aggregate as a possible cause of poor pavement performance.

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[9] https://www.dot.state.oh.us/Divisions/Planning/TechServ/Pages/tims.aspx.
[10] https://www.youtube.com/watch?v=Pn52BLU0668&index=2&list=PLxpoBQq_MZGuLfxXuuO8tZSciP30kj-RF.

TIMS also helps reveal and target key areas where improvements will have the greatest impact, helping to prioritize investments and funding requests. For example, overlaying crash locations with traffic volumes can help identify the most important locations for mitigating safety risks—in essence, identifying the intersections and roadways with the greatest problems. Likewise, TIMS enables the organization to analyze the types of location, asset, and design element that contribute to accident occurrence, improving roadway safety practices and operations overall.

Finally, ODOT uses TIMS to communicate performance-based planning initiatives to and from localities, which are responsible for maintaining their own mileage (due to the decentralized nature of ODOT operations). TPM is a new idea for many localities, and MPOs often serve as intermediaries between ODOT and the localities. As MPOs and local agencies begin to use TIMS as a data source for performance and asset management, ODOT hopes that it can serve as a vital communications tool to engage stakeholders and customers in efforts to improve transportation system performance.

Related Efforts

Data Governance Initiative

Now that TIMS is accessible to the public, MPOs, and other agencies, ODOT is promoting a formal data governance system, to increase successful integration with additional datasets. OTS would like to expand TIMS to include additional enterprise data sets, including the TAM audit. The initial step in this process is educating users about how existing data sets will be cleaned, stored, and managed, ultimately enhancing the use of other business owners data sets.

Benefits

ODOT cited the following benefits that it has obtained to date, thanks to its investment in TIMS as a centralized data system for managing performance management and asset management efforts:

- **Improved investment decision-making and project prioritization**. The accessibility and availability of TIMS leads to better decisions about where to spend the budget—across multiple teams and divisions. For example, when pavement was not performing well in certain areas, ODOT used GIS to identify the aggregate sources in those areas and found that a certain type of gravel was adversely affecting the aggregate.

- **Increased stakeholder engagement.** Visual data presentation in TIMS helps inform and convince stakeholders better than traditional reports or other data presentations. For example, TIMS data supports performance plans, has helped raise public support for spending decisions, and provides supporting data for presentations to management and legislators.

- **Expanded internal collaboration and data stewardship.** The overall ease and usefulness of the system has supported continuing internal culture change, in favor of collecting and maintaining

good data. The data is essentially supported and maintained by crowdsourcing, as staff need for accurate data leads to better and more accurate data collection and management.

- **Preparation for performance reporting.** An integrated data set such as TIMS supports more effective performance reporting. Performance reports are after-the-fact, but GIS data can be used to detect problems ahead of the report schedule, so they can be addressed before they go into "red" (i.e., not yellow or green) territory.

Challenges

In spite of the substantial benefits, ODOT has faced a few challenges to a smooth TIMS implementation and to using the database for TPM efforts. A few examples are:

- **Data quality is a low priority for many staff.** With individual databases, staff did not need to consider standardization, and errors may be harder to discern in data presented in tables (instead of maps). The new message—*data needs to be standardized so it can be leveraged outside your area of responsibility*—has not been easy to embed.

- **Supportive leadership is vulnerable to the election cycle.** While it is essential to have champions within the agency, leadership may change. Behavior and thinking changes must be bottom-up and ingrained in the culture in order to survive administration changes.

- **Staff turnover and low staff levels limit the ability to collect and update data.** Staff size has decreased, so ODOT is no longer able to send multiple people out in the field to collect data. Business units must be creative in finding data without spending staff hours. Likewise, retirement and downsizing have resulted in loss of institutional knowledge, particularly in IT, where new staff typically have limited experience in the transportation field.

- **FHWA requirements for TPM reporting may require new data collection practices.** ODOT believes that it measures performance, but not by using the same measures proposed under MAP-21 and the FAST Act. ODOT believes that much of its data can be converted to meet Federal reporting requirements, but it will likely use a more fine-grained reporting structure for its internal and State reports.

Recommendations/Lessons Learned

ODOT shares the following lessons learned and recommendations based on its experiences implementing TIMS:

- **Focus on existing good datasets and heavy users, instead of on specific applications or theories about what data is important**. The heavy users have insight into what data is really

important and how they need to use it. Most agencies also have a lot of legacy data that is never used and can be eliminated (instead of imported).

- **Bring business units together to hear what other units need and want for data.** Cross-disciplinary meetings can trigger new or original thinking, about users' own data and also about what data might be desirable. Likewise, it encourages data owners to open up and share the data, including data they might not have realized was quite valuable to others.

- **Treat your data as an asset.** If data is valued and is maintained at high quality, the applications will become easier to use. ODOT recommends putting a succession plan in place, particularly to ensure smooth transitions in data governance and maintenance in the midst of staff turnover and retirements.

- **Put control of GIS data in the hands of the business units.** Often the priorities of specific business units are vastly different from those of IT, which tends to prioritize security and data reliability. Educate staff on the importance of an enterprise system and encourage them to provide data and contribute to its maintenance. In particular, sharing data with stakeholders—MPOs, county engineers, and the public—substantially enhances data quality.

Next Steps

Ohio DOT lists the following as next steps in its TPM and asset management efforts:

- **Developing TAM Plans and Reports**. OTS is working to enable queries and analysis on asset management within TIMS and to render results in the GIS environment. For example, they will be able to show all places in the State with cracking at a certain level and then turn on the capital improvement plan to see if it matches the needs.

- **Establishing initial performance measures and targets**. ODOT anticipates looking at index levels for various assets. For example, there may be a goal of no more than 10 percent of the pavement below an IRI score of 85.

- **Improving and expanding network distribution and data collection.** ODOT has been working with districts and MPOs throughout the State to identify opportunities to improve and expand data collection. It has identified multiple ESRI products that can be used to validate the data, which it is considering licensing for use by its districts and by MPO partners.

3.3 Vermont Agency of Transportation (VTrans)

Summary

VTrans is in the middle stages of developing a software solution to support its TPM goals and objectives, using a GIS database to support a web-based platform. It released the current form of its public-facing, web-based GIS tool called VTransparency in 2014, with a focus on keeping information simple and clear for public users who spend very little time on the site. VTransparency provides simple visual data on pavement, bridges, projects, and maintenance efforts, as well as links to data sources. VTrans is now working on an internal version of VTransparency that will provide more detailed data and connect to other tools used by the agency, in support of its asset management and performance management efforts.

Background

The concept for VTransparency was derived from an internal customer survey (of VTrans employees) by the Office of Planning, which sought to identify the types and frequency of questions that different offices receive related to data needs. The actual tool was initiated by the collaboration of multiple divisions pulling together data and developing tools to ensure highly accessible and consumable data.

Recognizing that there was significant overlap in data coverage and, in some cases, different ways of representing similar data, data owners from multiple divisions proposed a web-based, geospatial tool to improve consistency of data presentation and ease of use for the data tool. Based on initial discussions at a meeting with multiple functional divisions, VTrans' Office of Planning worked with support from IT and senior leadership to streamline data and develop an initial, public-facing tool.

Geospatial or GIS Solution: VTransparency

VTransparency packages and rebrands some of the agency's available data for public consumption. The team has made a concerted effort to discover what the public wants to know and to display the data in a way that answers their questions simply and directly. It allows the agency to provide quick answers to specific customer questions, but it also allows agency staff to point customers toward self-service locations for project schedules and asset conditions.

Once the tool was released the public, offices across VTrans became increasingly interested in sharing their data via VTransparency and in ensuring high-quality data made it into the system. In addition, centralized project staff now use VTransparency to share project and asset related data with regional Maintenance and Operations staff. As a result, regional offices have started training employees and seeking to hire new employees with GIS skills, to support the communication of data.

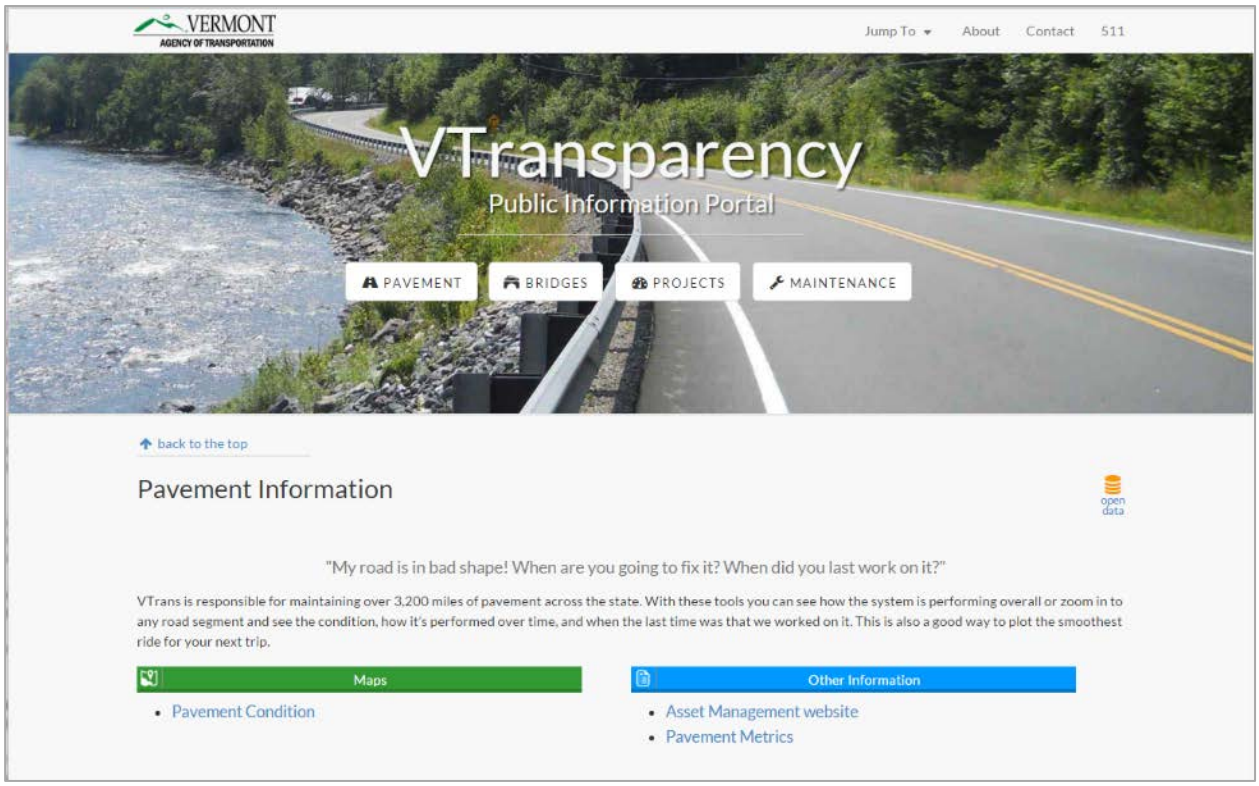

Figure 4. Landing page for VTransparency.

Transportation Asset Management (TAM)

The current asset management effort at VTrans began in earnest in 2002. An initial policy at that time, called "Road to Affordability," focused attention on maintaining existing infrastructure, rather than building new infrastructure, to reign in transportation spending and move toward sustainability for the State's transportation system. In 2014, VTrans re-situated the asset management program within a newly-created Asset Management and Performance Bureau inside the Highway Division, which gave it a bigger visibility across the agency.

The asset management bureau has performance management, data, and budget software which can be connected together and can also connect to the strategic plan and goals. They see asset management as the tactical piece to support strategic goals and objectives. They have a huge need to ensure that asset condition and performance levels are tied to financial data. Their process is to identify asset condition levels, develop TAM programs for specific assets, consider funding needed to sustain performance of the assets in the out years, and, finally, look at how it all ties in to transportation values such as safety, mobility, and accountability.

VTrans hopes to connect asset management and investment level data with VTransparency, as they add more asset types (e.g., culverts and rock falls), and to expand the breadth of content to better reflect the conversation about asset lifecycle and sustainable funding. The primary focus of VTransparency, in

line with the emphasis on transparency, is really on serving customers, and for that they need a solid understanding of issues in the field. That said, the initial online tools have already assisted with asset management, particularly by increasing visibility over asset condition and work-in-progress for budgeting purposes. For example, the integration of culvert asset data and upcoming capital project data led to the request to designers to evaluate over 200 culverts for inclusion into the scope of work for existing projects.

In preparation for the MAP-21 requirements, VTrans is developing a more comprehensive asset management plan (TAMP) to address what they can afford and sustain, as well as the return period for a given asset. One challenge in developing a new TAMP is that the existing roster of projects—those already underway and funded—includes projects that have been underway for up to 15 years. It will therefore be difficult to re-prioritize projects based on the expected return or other performance metrics until the existing projects are complete and funding for new projects is available.

Transportation Performance Management (TPM)

TPM efforts are currently overseen by the Asset Management and Performance Bureau, the same bureau that oversees asset management efforts. The bureau intends to support each unit within VTrans as they develop their own performance metrics and goals, since those goals ultimately inform the agency's overall strategic plan and performance measures. Because VTrans links TPM to customer service and public awareness as well, VTransparency is a useful mechanism for displaying data that the public can consume.

VTrans is currently monitoring performance for specific areas, such as project delivery time and adherence to engineer's budget estimate, which will inform internal dashboards currently in development. The next step is to produce an internal version of VTransparency that provides more engineering data and connects to other tools used by the business units.

Performance is currently managed separately by each division.[11] The Finance & Administration division has a Performance, Innovation and Excellence section; the Aviation division has performance measures incorporated in its Airport System Plan. It is VTrans' intent to continue to support the maturation of performance management culture.

Benefits

Since implementing VTransparency and other GIS-based tools and applications for performance and asset management, VTrans has recognized the following preliminary benefits:

- **Improved customer responsiveness.** The centralized GIS database makes it easy for staff to answer individual questions from customers, without the need to contact other divisions or

[11] http://vtrans.vermont.gov/about-us/divisions.

departments. Likewise, customers can be directed to VTransparency to get the answers themselves. In that way, it frees up staff for other tasks and improves operational efficiency.

- **Improved stakeholder and public engagement.** The more VTrans data that is public in VTransparency, the better the agency's perceived credibility with the public. For example, many Regional Planning Commissions are among the primary users of VTransparency, which they use for the communication of asset conditions and project schedules or scopes. Previously, this information was mostly communicated through e-mails or meetings, but it can now be shared directly with VTransparency web maps. Ultimately, VTransparency provides a transparent view of key assets and helps improve the agency's accountability.
- **Greater efficiency in the planning process**. Viewing assets through GIS-based tools and applications provides site visit efficiencies, as mobilization can be coordinated across a variety of assets at a given site. This helps ensure asset condition and performance levels are tied to financial data, i.e., decisions about new priorities must be supported by budget but also by asset and performance levels.

Challenges

VTrans noted that its implementation of VTransparency faced several hurdles:

- **Internal culture has been slow to adjust to an emphasis on quality data**. Getting staff to recognize the value of high quality, shared data is a difficult culture change, not only in headquarters but in the maintenance districts.
- **Project backlogs slow the transition to data-driven decision-making**. There is a long backlog of committed projects that were not selected on the basis of performance and asset management. Those projects must be completed before performance-based decisions can be implemented.

Recommendations/Lessons Learned

VTrans recommends agencies consider the following practices when looking to use a GIS database for TPM and PBPP efforts:

- **If possible, consider dedicating staff time for the development of GIS solutions**. VTrans' offsite development session was useful in freeing staff from daily operational needs and tasks and allowing them to focus on the new tool. Because of the lack of adequate staffing for asset management activities, agencies often focus on operational tasks to keep the systems and data running. However, dedicating staff to developing sustainable systems is critical to future success. As an example process, VTrans has documented its "rapid application development" process online.[12]

[12] For an overview of the project development process, see: http://vtrans.github.io/vtp3-roadmap/.

- **Culture change is more valuable than short-term financial savings**. A return on investment is important, but the key to success is changing the culture to recognize the time efficiencies of sharing a single source of data. An agency needs leadership champions using the right words and the right concepts to continually reinforce the shift to a single data source.
- **Ensure high-quality data before using it for performance measurement**. It will save time in the long run if an agency takes the time to understand existing data—its actual quality as well as the framework for collecting, analyzing, and presenting it. VTrans has found that releasing some rough or questionable data to the public can increase the perceived value of the data to the data stewards who, in turn, take steps to ensure credible, reliable and accurate information. VTrans cautions against making performance decisions based on inaccurate data: it is critical to have a data management plan in place before using data to answer specific questions.
- **Be wary of information overload**. Too much information on the public tool can be distracting to the average user, who may only spends two minutes on the page. A better approach may be to direct users who would like more detail to additional data sets or other locations to download data.

Next Steps

VTrans lists the following as next steps as it seeks to improve the capabilities of VTransparency and use the GIS database for its TPM, asset management, and PBPP reporting:

- **Develop asset performance dashboards**. Within the next two years, VTrans would like to have three to four performance dashboards that would provide a quick look at a specific type of asset, e.g., bridges.

- **Improved functionality for user feedback and input**. VTrans would like to get more feedback from the public, perhaps via a slider-type tool the public could use to look at the cost of desired improvements. For example, a viewer might click on an asset type and record an answer to "How much are you willing to spend on this asset?"

- **Enhanced ease of use for common users.** VTrans is evaluating the addition of more detailed information and the expansion of new content areas to the VTransparency site. The development team is trying to balance the need to share more information while maintaining the streamlined functionality and focus of the tool on the most frequently requested information. With the average user spending less than two minutes per site visit, clear navigation and data retrieval is a priority.

- **Improved accessibility for heavy users and richer data sets.** Though it was developed for public use of stakeholders, the tool has been widely adopted by internal business units. As the needs and demands of these units quickly exceed the capabilities of the external facing tools, VTrans is starting to recognize that a separate but similar tool is needed. This tool could be used internally to cater to more detailed data needs, e.g. asset management and related work activities.

3.4 Maryland DOT State Highway Administration (MDOT-SHA)

Summary

Maryland State Highway Administration (SHA), a dedicated business unit within Maryland Department of Transportation (MDOT), is working to advance performance-based decision-making within the agency by increasing access to the data held by different groups. SHA's Office of Planning and Preliminary Engineering (OPPE) has worked to establish data standards and a GIS-based, centralized data repository (the SHA Data Hub) for use in sharing data collected by different offices and groups. With only preliminary work complete, interest in sharing data among different offices has already grown, and the agency is working to develop a series of dashboards in support of its performance management efforts. SHA attributes the success of its data efforts foremost to the internal work done to communicate the role that data and data linkages can play to reduce work effort and increase efficiency throughout the agency.

Background

Geospatial or GIS Solutions: Enterprise GIS

Since 2011, OPPE has led efforts to integrate an Enterprise GIS (eGIS) system as the primary data management system for planning. Over time, a number of additional tools and data sources have been integrated with the eGIS system—such as asset management, mobility, environmental, and freight data—spurring further efforts to develop performance-based programming efforts.

The eGIS has largely been an internal system, for use in sharing limited datasets with an internal audience (for example, providing access to the common linear referencing system, or LRS). More recently, the agency has worked to develop outward-facing dashboards that use JavaScript to connect to the eGIS, providing summary information and easy access to data on particular topics. The dashboards are currently in development but will focus on four key areas: mobility, freight, asset management, and MAP-21 system performance.

At the same time, the GIS services team has sought to make a business case to each SHA office for a central data repository, emphasizing the importance of data sharing. They have encouraged data owners to move their databases to a location accessible by the eGIS system, rather than asking for control of the data. At the leadership level, the team has held meetings with managers of key departments—IT security, operations, maintenance, other business units etc—to convey the benefits of sharing data throughout the organization. Overall, SHA's internal staff and leadership have been highly supportive of the GIS initiative and have been more than willing to contribute data. Examples of internal successes supported by the eGIS are:

- **Maryland Coordinated Highways Action Response Team (CHART)**. CHART is a real-time traffic management center (TMC) that is a joint effort of Maryland DOT the Maryland Transportation Authority, and Maryland State Police. CHART aims to improve real-time operations of Maryland's highway system and to provide real-time travel information for travelers using multiple modes. CHART has been a long-time supporter of SHA's GIS initiatives. SHA has a longstanding data-exchange partnership with the University of Maryland Center for Advanced Transportation Technology Laboratory (UMD CATT), and UMD researchers are able to access Maryland's central data hub. Using this data, researchers are investigating improved ways to visualize and to model traffic movement, mobility, safety performance, and other indicators on the State's highway network. These datasets are used in various SHA eGIS initiatives and provides important information on crash incidents, lane closures, route restrictions, speed sensor data, and other information via a feed directly into the eGIS (it also has public RSS and XML feeds).

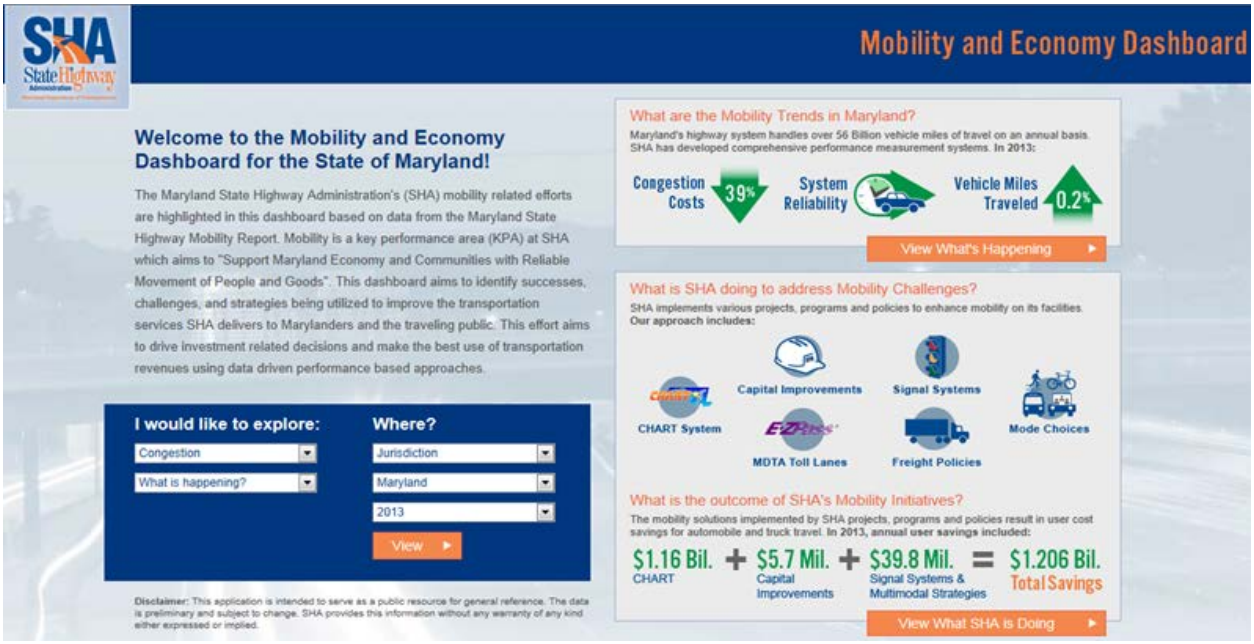

Figure 5. SHA Mobility Dashboard.

- **SHA Mobility Report and Dashboard.** Since 2012, SHA has been publishing an external-facing report on mobility within the State for the prior year (the first report covers performance in 2011).[13] Using indicators such as travel time index (TTI) at off-peak and peak travel times and annual vehicle miles traveled (VMT) throughout the State, the mobility report tracks year-over-year performance on highways managed by SHA (which handle over 85% of the State's traffic).

[13] For historical SHA Mobility Reports from 2012, 2013, and 2014, see the following: http://www.roads.maryland.gov/Index.aspx?PageId=711.

This report is currently based on TTI data from INRIX; and other SHA datasets. Based on past mobility performance, SHA has also identified key bottlenecks within the State and is using data from multiple divisions and offices to study different corridor strategies to improve mobility.[14] SHA has also developed a Mobility Dashboard that is updated regularly with more current data than the report. The Mobility Dashboard, currently used internally only, is built around the same themes of the Mobility Report: it identifies congestion trends and discusses SHA's mobility policies, programs and projects and the outcomes to the traveling public.

- **Maryland Statewide ITS Architecture**. The 2009 update of the Maryland Statewide ITS Architecture identifies existing and planned ITS projects across the State and the architecture "elements" associated with those projects. It defines the relationships among the elements and describes the flow of information between elements. The document also presents an ITS "operational concept" and identifies key ITS stakeholders and agreements.

Transportation Asset Management (TAM)

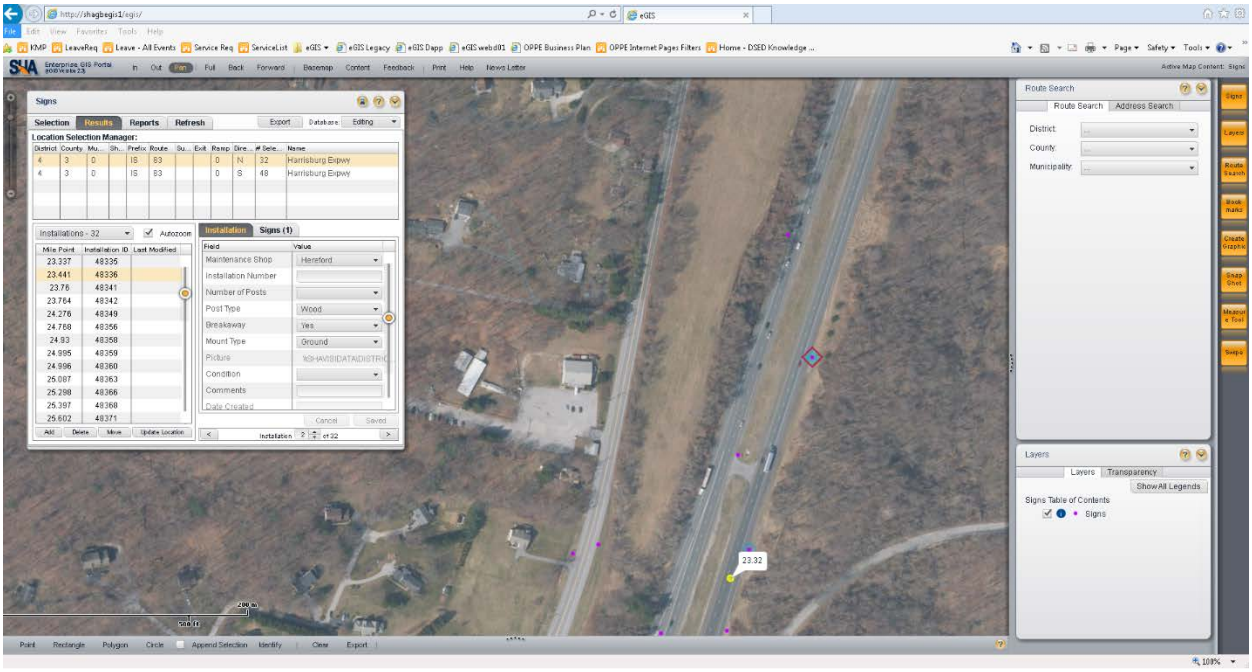

Figure 6. SHA's Asset Data Management Warehouse.

SHA is working to develop an asset management dashboard that will serve internal groups seeking information on projects and asset condition, as well as inform the traveling public of planned projects and improvements. SHA has already rolled out the asset management dashboard for use with select internal teams and has found significant success. SHA reported that some of the tools have saved users as much as two weeks in project preparation time. For example, the dashboard can be used to automate

[14] Ibid.

project status reports (assuming on-the-ground reporting is consistent), to put placeholders on project site locations and avoid overlap (or coordinate on project schedules), and to project lifecycles and monitor asset performance. The asset management data warehouse has data on eight types of SHA assets, which has helped the asset management team, the OPPE, and other offices with decision-making when planning for future investments and projects. Beyond the eight assets in the data warehouse, other assets are maintained in separate databases that still integrate with eGIS for analysis and display. SHA is working towards having all assets in the asset management data warehouse, but it anticipates that will take several years as it will require significant migration from older, legacy systems.

Transportation Performance Management (TPM)

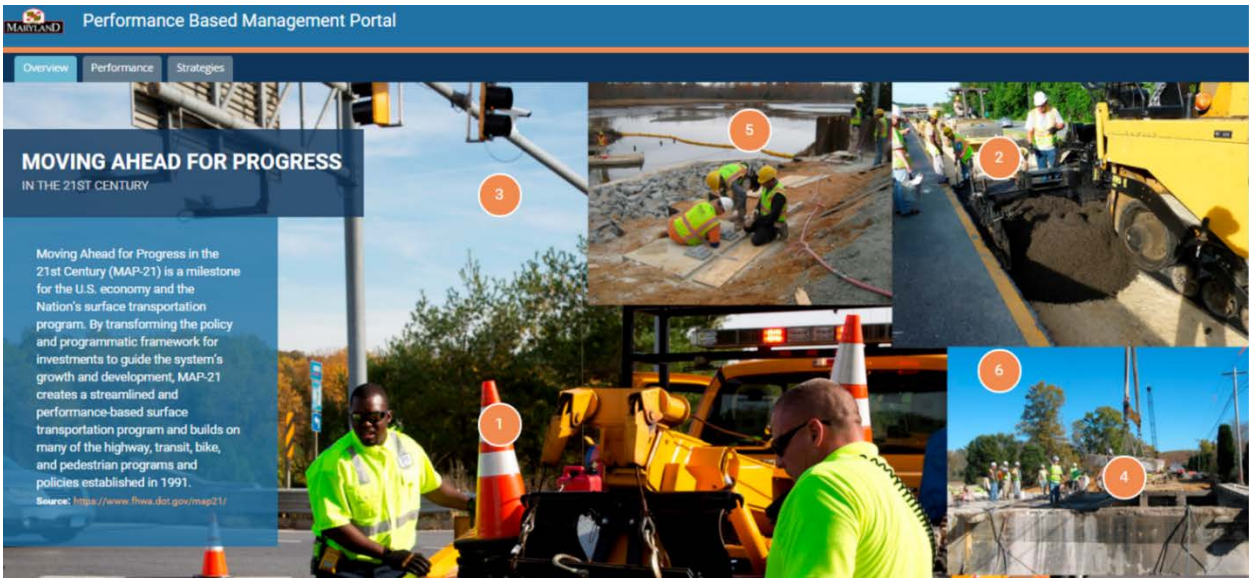

Figure 7. Landing Page for SHA's MAP-21 Dashboard.

As mentioned above, one of the new dashboards under development at SHA will focus on performance management in accordance with MAP-21, likely to be developed using the Story Map functionality from ArcGIS Online. SHA anticipates that the data structure built for the central data repository will serve well for MAP-21 reporting requirements, as it is already able to toggle data between different levels (i.e., statewide, MPO, municipal, and local).The GIS team has worked to integrate mobility performance metrics with their travel modeling and travel analysis models; thus, as new measures and reporting requirements roll out, SHA will be ready to compile that data for performance management.

According to SHA, "MAP-21 reporting is just one aspect for us. Now that our dashboards and databases are pretty stable, we have much more detailed programs we use for our own operations, strategizing, and planning. We use GIS to port data we already have, to meet the requirements at both local and State levels. For example, our MPO performance metrics would be the same as SHA's reporting metrics."

In general, SHA is advancing a performance-driven approach to operations and planning within the organization. This approach includes monitoring mobility performance, identifying freight performance metrics, and monitoring assets within its central eGIS. The challenge for SHA is not about getting the data to report on performance management, but on identifying which metrics and measures matter most to its overall perception of performance—both internally and for the public and State officials.

Benefits

SHA identified a number of benefits to its use of GIS solutions, particularly its Enterprise GIS, as part of its efforts in TPM and asset management:

- **Enhanced reliability and quality of data**. Improved GIS capability has definitely improved efficiency for data owners. It has cut down on redundancies and inconsistencies, thus improving data quality, which adds significant value.
- **Substantial time savings.** MDOT-SHA notes they used to spend something like 80% of time developing data and 20% analyzing it; now it's more like 50/50. They can concentrate on mitigation strategies rather than on trying to line up data and check for inconsistencies. Some of the tools they've built have saved users as much as two weeks of preparation time.
- **Collaboration between divisions and teams.** The efforts to develop the eGIS system and its various applications have not only increased visibility over different data, but have increased opportunities and willingness to collaborate between offices. eGIS has had over 2,000 unique users since inception in 2011, from SHA and the MDOT Transportation Secretary Office (TSO). The process of getting teams to provide data took a good deal of effort, but now that data is available, the teams are beginning to rely on the eGIS as the main place to store data.
- **Advanced readiness for TPM reporting.** Thanks to the process of developing dashboards as well as the flexible data structure that MDOT-SHA has selected, the agency anticipates it will be readily able to report its performance measures and metrics once FHWA issues rules about TPM. Much of its performance data can scale from the highly-local to the Statewide and regional scales, which makes performance reporting straightforward.

Challenges

SHA lists two key challenges to its overall development of an eGIS system and the dashboards:

- **Planning efforts continue to operate in silos**. As with many DOTs across the nation, SHA's planning and project scheduling remains a rather siloed process, with decisions made by different offices about asset improvements and project funding. SHA hopes its asset management and planning dashboards will move the conversation about transparency to the next level, so a person looking at a project can see how that would affect the entire traffic system and can see opportunities to tie into other proposed projects. The dashboards have enabled preliminary conversations about synergies of various programs, which SHA hopes will increase collaboration and alignment in data standards.

- **Different divisions and offices have different levels of readiness for the solution**. After multiple years of moving this effort forward, OPPE has recognized that different offices will be at different levels when it comes to using an enterprise data system. The first step for all offices has been educating leadership and key data management staff. Over time, field and operational staff have recognized the benefits of open data, which leads to further improvement.

Recommendations and Lessons Learned

MDOT-SHA shares the following recommendations and lessons learned for other agencies pursuing enterprise GIS systems for performance management:

- **Maintain strong relationships with the leaders of key divisions and teams**. In changing the culture, it was key to have face time with leaders of all the teams, e.g., IT security and maintenance managers. SHA emphasizes keeping the lines of communication with teams and leadership open, involving them in decisions and in setting strategy for the program, and ensuring that they see the vision.
- **Establish a multidisciplinary core team to manage day-to-day decision-making**. SHA created technical team meetings that address where the app will go in the future and what new datasets are needed. The core team sends out a newsletter and has created central and offsite user support groups. Additionally, the team established a beginner course called Introduction to eGIS and established advanced level trainings as needed. To date, over 200 users have been trained in the introduction course, and over 150 users have completed advanced or subject specific training.
- **Allocate resources and time for staff education and awareness building**. SHA has learned that education has to start with the data owner. The core team's general practice is to first educate data owners, then work with staff on creating data dictionaries—what's needed to map data to the existing LRS and database. The team also supports data owners on how to massage their data to fit with other datasets and improve data integration. For broader internal staff awareness, SHA holds an annual GIS day, which the team uses to communicate the strategic plan and its successes.
- **Ensure partners and contractors are also aware of the importance of data governance**. SHA has also worked to educate contractors, trying to be proactive when new projects start. The team worked closely with IT to develop an IT standards document, listing data collection standards for master contractors. This document adheres to AASHTO's seven principles of good data.

Next Steps

SHA has listed a few next steps for these efforts as they eye a more integrated performance management process:

- **Develop annual performance management report.** The agency will be moving forward with an annual performance management report that integrates data from the various dashboards and from other reports for a comprehensive picture of performance management. Some programs are further along than others, because some have data that are not as available to the public, due to privacy and other reasons. So a major challenge will be ensuring that all data meets a common standard of reliability and quality.

- **Advance the use of key data in decision-making around funding.** For example, SHA used GIS interfaces to find congestion hot spots, then looked at data behind the hotspots to see what was happening, and then worked on solutions. Then the agency looked at what the solutions meant in terms of life cycles and funding cycles. Finally, SHA took its findings to the office and division managers, telling the story in terms of benefits and costs. GIS was not the only driver, but it was involved in identifying the problem, developing solutions, and telling the story.

- **Create integrated O&M system.** For maintenance and operations, the agency would like daily activities to be logged into some integrated system, seamlessly connecting product life cycles with performance metrics, incidents, and increased safety of the system. Ideally, this would enable agency staff to evaluate a safety project compared to another project and weigh the costs and benefits. Within 10 years' time, SHA believes that it will be able to reliably allocate funds to the best outcomes for safety, mobility and reliability, provided a general state of good repair.

- **Establish a data business and governance plan**. The core focus for SHA from the above steps is to have a Data Business and Data Governance Plan. MDOT-SHA is participating in a FHWA-sponsored pilot study to develop a data business plan for planning and operations data. The outcome of this pilot will enable the agency to further streamline the data driven performance based decisions. The eGIS initiatives should be a great enabler for the agency in this regard.

Appendix A: List of Case Study Participants

Agency	Name	Title	Work Phone	Email
South Carolina Department of Transportation	*Lynsee Gibson*	Director of Program Controls	803-737-1170	GibsonLR@scdot.org
	Kevin Gantt	Asset Management Engineer	803-737-5808	GanttKL@scdot.org
	Todd Anderson	Road Data Services Engineer	803-737-1468	AndersonRT@scdot.org
Ohio Department of Transportation	*David Blackstone*	GIS Manager, Office of Technical Services	614-466-2594	Dave.Blackstone@dot.ohio.gov
	Andrew Williams	Administrator	614-752-4059	Andrew.Williams@dot.ohio.gov
Vermont Department of Transportation	*Kevin Viani*	Data Management Supervisor	802-279-4883	Kevin.Viani@vermont.gov
	Chad Allen	Director, Asset Management and Performance Bureau	802-828-0768	Chad.Allen@vermont.gov
Maryland State Highway Administration	*Laurie Goudy*	eGIS Program Manager Assistant Division Chief, OPPE	410-545-5681	LGoudy@sha.state.md.us
	Subrat Mahapatra	Transportation Manager	410-545-5649	SMahapatra@sha.state.md.us
U.S. DOT FHWA Headquarters	*Mark Sarmiento*	GIS Planning Specialist	202-366-4828	Mark.Sarmiento@dot.gov
	Chris Allen	Chief, Division of Highway System Performance	202-366-4104	Chris.Allen@dot.gov
	Ronald Vaughn	Senior Transportation Specialist	202-366-9248	Ronald.Vaughn@dot.gov
	Chris Chang	Senior Transportation Specialist	202-366-4657	Christopher.Chang@dot.gov
	Michael Nesbitt	Senior Transportation Specialist	202-366-1179	Michael.Nesbitt@dot.gov
U.S. DOT Volpe Center	*Andrew Reovan*	Community Planner	617-494-3843	Andrew.Reovan@dot.gov
	Alisa Fine	Community Planner	617-494-2310	Alisa.Fine@dot.gov
	Amy Sheridan	Senior Analyst	617-494-3563	Amy.Sheridan.CTR@dot.gov
	Anthony Thomas	Policy Analyst	617-494-2689	Anthony.Thomas2@dot.gov

Appendix B: Interview Guide

Volpe used the following questionnaire to guide discussions with interviewees during a 60-90 minute discussion, held in August and September 2015.

1. How do GIS/geospatial tools support your agency's performance management efforts? For example, do you use GIS to:
    - Develop performance plans?
    - Inform investment decisions?
    - Share condition and performance information among stakeholders?

    Can you provide any specific examples of these tools? Who can use/access these tools?

    If your agency has not yet started using any geospatial tools for transportation performance management – when do you anticipate doing so? What are some factors or issues that your agency will consider in developing these tools?

2. Are you working across disciplines (e.g., with safety, operations, etc.) within your agency on this initiative/initiatives? If so, can you provide more details?

3. How are you managing performance management data using these tools?

4. Does your Agency use Federal Funds to support any of its GIS activities. If so, what types of funds?

5. Has your agency tried to calculate the return on investment of its GIS performance management tools?

6. What are your future plans for your GIS for performance management efforts?

7. What have been the biggest successes or challenges relating to efforts to develop GIS-TPM tools or share/collect/maintain GIS-TPM data? Are there any general lessons learned resulting from these efforts that you may want to share with others?