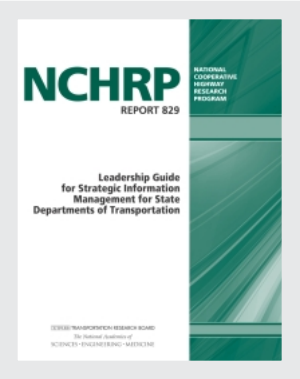

Leadership Guide for Strategic Information Management for State Departments of Transportation

DETAILS

112 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-44053-0 | DOI 10.17226/23480

AUTHORS

Harrison Frances, Michael Gordon, and Gary Allen; National Cooperative Highway Research Program; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 829

Leadership Guide for Strategic Information Management for State Departments of Transportation

Frances Harrison
Michael Gordon
Spy Pond Partners, LLC
Arlington, MA

Gary Allen
Waynesboro, VA

Subscriber Categories
Administration and Management • Data and Information Technology

Research sponsored by the American Association of State Highway and Transportation Officials
in cooperation with the Federal Highway Administration

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2016

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research is the most effective way to solve many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation results in increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

Recognizing this need, the leadership of the American Association of State Highway and Transportation Officials (AASHTO) in 1962 initiated an objective national highway research program using modern scientific techniques—the National Cooperative Highway Research Program (NCHRP). NCHRP is supported on a continuing basis by funds from participating member states of AASHTO and receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine was requested by AASHTO to administer the research program because of TRB's recognized objectivity and understanding of modern research practices. TRB is uniquely suited for this purpose for many reasons: TRB maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; TRB possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; TRB's relationship to the Academies is an insurance of objectivity; and TRB maintains a full-time staff of specialists in highway transportation matters to bring the findings of research directly to those in a position to use them.

The program is developed on the basis of research needs identified by chief administrators and other staff of the highway and transportation departments and by committees of AASHTO. Topics of the highest merit are selected by the AASHTO Standing Committee on Research (SCOR), and each year SCOR's recommendations are proposed to the AASHTO Board of Directors and the Academies. Research projects to address these topics are defined by NCHRP, and qualified research agencies are selected from submitted proposals. Administration and surveillance of research contracts are the responsibilities of the Academies and TRB.

The needs for highway research are many, and NCHRP can make significant contributions to solving highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement, rather than to substitute for or duplicate, other highway research programs.

NCHRP REPORT 829

Project 20-96
ISSN 0077-5614
ISBN 978-0-309-37550-4
Library of Congress Control Number 2016943094

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet by going to

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FOREWORD

By Andrew C. Lemer
Staff Officer
Transportation Research Board

NCHRP Report 829: Leadership Guide for Strategic Information Management for State Departments of Transportation is a guidebook for executives and managers on effectively developing and maintaining an agency's capability to provide mission-critical information when and where it is needed. The guidebook considers the importance of information to departments of transportation (DOTs) and the challenges of ensuring that good information is available for decision making, the components of an effective information governance strategy, how senior executives can assess their agency's information-governance strategy and practices, and implementation of procedures and methods for effective information management. The report will be helpful particularly to DOT senior staff responsible for ensuring an agency's access to information to support decision making.

Executives and managers in DOTs, like those in all large organizations, need relevant, accurate, and timely information about their business to make effective decisions, support their organization's operations, serve their customers, and ensure generally that their limited resources are allocated effectively to pursue the organization's mission. A sound understanding of business needs, information content, and technology is the essential foundation for ensuring that these executives and managers will have access to mission-critical information when and where they need it.

Providing access to mission-critical information is challenging for many reasons. Much of the data that a DOT collects and uses are unstructured, stored in various formats, and often available only to limited program- and organization-based user communities. The quantities of information being collected and stored are growing exponentially. The technologies for information storage, management, search, retrieval, analysis, visualization, and reporting are also advancing rapidly, while agencies face barriers in migrating away from increasingly obsolescent legacy systems. Business needs continue to evolve with shifting customer expectations, regulatory requirements, legislative programs, funding constraints, and communication methods.

Information management is a multifaceted task and increasingly complex. The objective of NCHRP Project 20-96, "Leadership Guide for Strategic Information Management for State Departments of Transportation," was to produce a guidebook, written for state DOT executives and managers, on how to effectively develop and maintain an agency's capability to provide mission-critical information when and where it is needed.

A research team led by Spy Pond Partners, LLC, undertook an extensive review of background information and relevant literature and conducted informal interviews to document approaches used by private- and public-sector entities for strategic information management. The team conducted case studies to document leading practices and extract lessons for DOTs

seeking to improve their strategic information management. The guidebook illuminates the importance of information to DOTs and the challenges of ensuring that good information is available for decision making, identifies the components of an effective information governance strategy, and suggests how senior executives can assess their agency's information-governance strategy and practices and make improvements. The guidance offered will be most usefully applied within the context of an agency's overall strategic planning and management processes.

CONTENTS

Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

SUMMARY

Leadership Guide for Strategic Information Management for State Departments of Transportation

Strategic Information Management

A Strategic Approach to Managing Information

Strategic management is the well-established practice of assessing the current and likely future environment, setting a future course, taking action, measuring progress, and adjusting as needed. *Strategic information management* can be viewed as an adjunct to a strategic management process with a focus on information. The premise of strategic information management is that information is an asset that requires deliberate management in order to maximize value. Many departments of transportation (DOTs) have established a mission, vision, and goals and perform business planning based on this strategic framework, but strategic information management is still an evolving practice at DOTs.

A strategic information management process allows an agency to

- Maximize value from available information to help meet the agency's goals and objectives;
- Maximize the efficiency of how information is collected, processed, stored, accessed, shared, and used; and
- Improve organizational readiness to take advantage of new information sources and methods for analysis and visualization.

Development of an information management strategy is not the same as developing an information technology strategy. While information technology clearly needs to play an important role, the success of strategic information management goes beyond technology deployment and depends on involvement and commitment across the entire senior leadership team of the DOT.

Because each DOT is different, there is no single one-size-fits-all way of approaching strategic information management. However, all agencies can benefit from taking a critical look at current practices and systematically considering opportunities for improvement.

Business Drivers for Improved Information Management

In an ideal world, state DOT leaders would have the ability to quickly draw upon all of the agency's data and information to understand agency performance; "steer the ship" in the right direction; and make sound, defensible decisions. Many agencies are working toward this vision, but face organizational, technological, and resource hurdles. With limited staff time and dollars for internal agency improvements and a constantly changing information and technology landscape, DOTs face difficult questions about where to focus.

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DOTs, like other organizations, are experiencing a digital information explosion. In 2013, 4.4 zetabytes of data (equivalent to over a trillion DVDs) were created or copied worldwide, and this amount is doubling every 2 years (EMC, 2014). In 2014, the average business user sent and received 122 emails per day, and this number is expected to increase as well (The Radicati Group, Inc., 2015). The shift from paper to digital formats brings many opportunities for improved efficiencies and better decision-making. Yet many DOTs find themselves in a data-rich, information-poor situation.

Availability of more information in electronic form doesn't necessarily translate into greater productivity or effectiveness. In fact, some employees find they are spending more and more of the workday searching for and piecing together information from disparate sources (IDC, 2001; McKinsey Global Institute, n.d.). Without deliberate management, disciplined processes, and investments in the right skills and technologies, DOTs miss out on improvement opportunities and face escalating costs and risks of information loss or exposure.

DOTs produce and use data and information in multiple forms—including maps, plans, web pages, social media posts, images, emails, memos, reports, presentations, database records, and increasingly, continuous real-time data streams. People both within and outside of the agency expect to be able to access this information in an integrated fashion—anytime, anywhere, and through multiple channels:

- Agency executives and managers want to see current, relevant information about agency performance.
- Agency staff members want information about their projects and activities to be available, preferably from an easily searchable, "self-service" source.
- Agency partners and stakeholders want to see information about funding programs, projects, system condition, travel options, incidents, and more.
- In addition, public disclosure and Freedom of Information Act (FOIA) requests for agency records are on the rise and can be extremely time consuming to fulfill.

Agency staff members are straining to respond to these varied and evolving demands for information. Meeting these demands in a consistent and efficient manner requires new kinds of coordination across different organizational functions responsible for different types of information and different aspects of information management—including engineering document management, records management, public affairs, intranet site management, research and library management, data management, and information technology.

Purpose of this Guide

With recent advances in information storage, integration, search, and retrieval technologies, there are many opportunities to improve the availability and delivery of information. There is no shortage of technology investment opportunities—document management systems, web content management systems, workgroup collaboration tools, data warehouses/enterprise data integration solutions, dashboard and reporting tools, as well as modernization of business systems. In addition, DOTs are considering changes to data collection processes to take advantage of new technologies as well as purchase commercial data. When implemented in a coordinated fashion, with sufficient attention to people and process, these information investments can have profound and far-reaching implications for how decisions are made, for internal agency efficiency, and for the agency's public image and relationships with partners. Yet, DOTs have limited resources to invest and can take on only so many new initiatives for change.

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In this context, DOT executives would be well served to step back and consider the following questions:

- How can we be smarter about managing and delivering information so that it adds value without weighing us down?
- How should we prioritize different data, information, and technology investments given resource limitations?
- How can we strengthen and better coordinate agency information management functions?

These are complex questions that are best answered in conjunction with an agency's strategic planning and management processes. This guide provides a framework that DOTs can use to better harness the value of information through strategic planning, information governance, process improvement, technology investments, and workforce development. This guide can be read and followed in its entirety or used as a reference for improvement ideas.

Other NCHRP Resources

This guide is part of a growing body of NCHRP work on the topic of data, information, and knowledge management at state DOTs. Related work includes the following:

- *NCHRP Report 754: Improving Management of Transportation Information* (NCHRP Project 20-90).
- *NCHRP Report 813: A Guide to Agency-Wide Knowledge Management for State Departments of Transportation* (NCHRP Project 20-98).
- *NCHRP Report 814: Data to Support Transportation Agency Business Needs: A Self-Assessment Guide* (NCHRP Project 08-92).
- NCHRP Project 20-97, "Improving Findability and Relevance of Transportation Information" (research in progress).

CHAPTER 1

Introduction

DOT Information: A Rapidly Changing Picture

The demand for information at DOTs is shifting as technologies for collecting, sharing, and delivering information are evolving. A variety of collaboration and social media platforms have emerged for sharing content of different types. Smartphones have been a disruptive technology for transportation, opening up opportunities for crowdsourcing of maintenance issues and delivery of live information about travel options. The increasing availability of "big data," including data streams from travelers and maintenance vehicles and imagery from light detection and radar (LiDAR) and other sensing technologies, provides new options for gathering information. With continued development in the connected vehicles arena, the volume and variety of available operational data will increase. The capacity of DOTs to evaluate and adopt new technologies for data collection and information management is not keeping pace with the changes that are occurring. New, more agile approaches are required.

Changes Impacting Information Management at State DOTs

- Expectations for availability of actionable information anytime, anywhere
- Emphasis on performance management and transparency of programming decisions
- Increased demand for real-time information
- Increased use of mobile devices
- Increased outsourcing of data collection
- Workflow automation–electronic forms and e-signatures
- Demand for self-service information access

Source: (AASHTO, 2015)

DOT Information: Opportunities to Create Value

DOTs are by nature information-intensive organizations and have well-established records retention, data collection, and reporting practices. However, growth in data availability and changes in technology have created new opportunities for improved management and use of information. These opportunities can be tapped to help DOTs

- Optimize use of limited funds to improve safety, operational efficiency, and accessibility.
- Identify, develop, and prioritize transportation improvements that promote economic growth and development.

- Manage system operations in real time to improve safety and minimize disruption and delay.
- Respond quickly and efficiently to winter storms and other major events.
- Provide travelers with accurate and timely information about how to get to their destinations faster and more reliably.
- Monitor program delivery and provide early warning of issues that may cause project delays and cost increases.
- Improve efficiency of internal business processes.
- Demonstrate and communicate what the agency is accomplishing.

While most DOTs are making progress in these areas, much more can be accomplished. A coordinated agency-wide strategy for managing information can enable DOTs to make faster progress than would be possible from tackling each of these opportunities separately.

DOT Information: Challenges to Improving Efficiency

Managing DOT information is an increasingly complex endeavor. The scope of information that DOTs touch is vast—covering travel patterns, freight supply chain data, multimodal transportation network characteristics, infrastructure assets, operational performance, projects and funding, detailed engineering, construction and maintenance activities, and more. The goal is to collect, manage, and deliver this information cost-effectively and efficiently. However, there are several challenges in doing this:

- **Fragmented information storage.** Most DOTs have many different systems for storing digital data and content. While some degree of compartmentalization is necessary to meet specialized requirements, there are inherent inefficiencies in maintaining a large number of information repositories. Fragmented information storage also creates challenges for both discovery and integration of information across repositories.
- **Fragmented or ambiguous information management responsibilities.** In addition to fragmented information storage, there are often multiple, disconnected, organizational functions for managing different varieties of information—such as databases, real-time traffic and incident feeds, Internet and intranet content, engineering plans and documents, and official agency records. Lack of coordination across these functions can result in duplication of effort; inconsistencies in data structures, software tools, and management practices; lack of clarity about where to store and find information; and an unsatisfactory experience for people seeking information. In some cases, there is no clear ownership for cross-cutting information management functions such as enterprise search or terminology management.
- **Lack of information governance and process standardization.** Many DOTs have not established standard information management policies and practices. As a result, there are inconsistencies across the agency in how and where different types of data and content are stored, backed up, integrated, delivered, reviewed, and purged. Lack of standard management practices can lead to wasted staff time searching for information, a buildup of redundant and out-of-date content on servers, and loss of valuable information as employees leave the agency. Lack of standard information management practices can also increase the risk that sensitive information will not be adequately protected.
- **Human factors.** An increasingly technology-savvy, born-digital workforce brings expectations that the information they need will be readily available from their desktops or mobile devices. However, the back end processes to make that happen have not kept up with these expectations. In addition, the competencies required to organize, manage, and use available information haven't been explicitly recognized or integrated into position descriptions or hiring processes.
- **Older systems.** Many agencies have older, legacy information systems serving critical business functions that would require major investments to replace. Mature tools are available for

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information management but require investments, not only in technology but in people with the skills necessary to oversee and manage them.
- **Security and privacy concerns.** There is a need to protect sensitive information and guard against cybersecurity threats. DOTs are challenged by the need to maintain security while also meeting a growing business need to share information with external partners and stakeholders. This situation can necessitate creation of duplicate information storage for external access and inefficient information-sharing practices.

Given the complexities involved, it is clearly necessary to tackle information management in smaller components in order to make progress on improvements. However, a fragmented and reactive approach to information management is all too common and can result in missed opportunities to innovate and improve delivery on the DOT's core functions.

Roadmap to Strategic Information Management

Figure 1 shows a roadmap that DOTs can use to strengthen their information management capabilities. This roadmap can be used to navigate to different sections of this guide. The roadmap is organized as follows:

- **Strategic Information Management**—introduces key elements of strategic information management (see Chapters 2 and 3).
- **Charting a Course**—covers activities for understanding the strengths and weaknesses in how an agency is currently managing information and developing a plan for improvement (see Chapter 4).
- **Equipping the Organization**—covers activities for putting in place policies and processes for information management and building the awareness and skills needed within the organization for effective information management (see Chapter 5).
- **Implementing and Sustaining Change**—covers several types of initiatives for improving information management and tracking and improving information management processes over time (see Chapter 6).

The remainder of this chapter provides a high-level summary of the nine steps included in the strategic information management roadmap.

Charting a Course

Step 1: Establish a Vision for Information Management

Description. Develop and adopt a vision for information management that communicates how the agency wants to use and manage information. Review existing models from peer agencies and develop a vision statement through a process of facilitated stakeholder input and management review.

Expected Outcomes. The process of developing a vision will build awareness of the importance of information management within the agency. Communicating the completed statement to employees will demonstrate the agency's commitment to information management improvement and will also drive the identification and evaluation of strategies for improvement.

Step 2: Assess the Current State of Information Management

Description. Conduct an assessment to understand current agency practices, assess strengths and weaknesses, and identify areas for improvement. This assessment may involve document review, focus groups, employee surveys, and interviews. Different approaches may be taken, including a "quick" assessment that can be completed in a week or less to a more compre-

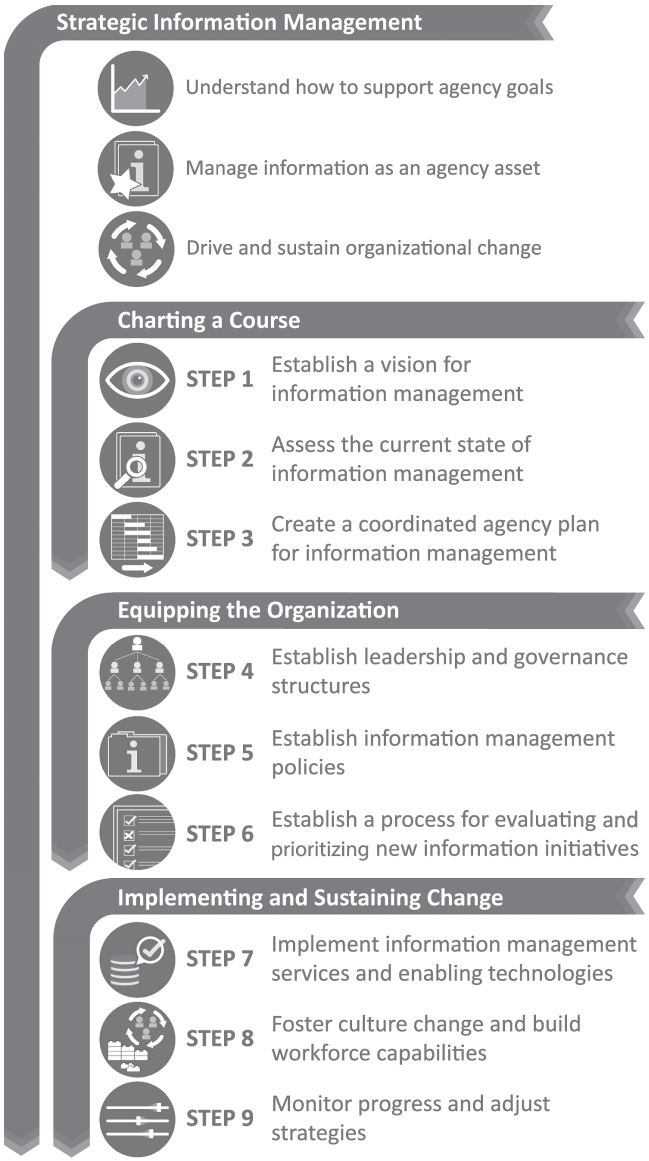

Figure 1. Roadmap for DOT strategic information management.

hensive, multi-month effort. Ideally, the assessment is something that is conducted periodically, e.g., annually or bi-annually to track progress and make course corrections.

Expected Outcomes. The assessment should produce a clear understanding of how the organization would benefit from improvements to information management practices and provide a basis for establishment of goals for information management improvement.

Step 3: Create a Coordinated Agency Plan for Information Management

Description. Create a plan for taking near-term (1 to 2 years), medium-term (3 to 5 years), and longer term (6 to 10 years) actions to improve information management in a coordinated fashion across the agency. The plan should take into consideration changes to governance, policy, processes, and responsibilities, as well as implementation of enabling technologies and support services.

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Expected Outcomes. The expected outcome is a plan and roadmap that chart a course to meet the established goals for information management improvement.

Equipping the Organization

Step 4: Establish Leadership and Governance Structures

Description. Establish or designate an information governance body that reports to executive leadership and includes management representation from both field and central office divisions responsible for core agency business functions. Establish a charter for this body that includes responsibility for setting policies and allocating resources to improve the collection, management, and utilization of data and information in support of the agency's mission.

Expected Outcomes. A governance body provides a focal point for implementation of information management improvements that benefit the agency as a whole. Establishing a governance body ensures that changes to existing responsibilities and processes in the organization have the necessary management support. An information governance body ensures that resources for information management are allocated appropriately based on benefit to the agency and that there is accountability in place to assess the effectiveness of actions taken.

Step 5: Establish Information Management Policies

Description. Review, create, and align information management policies that define how the organization will collect, classify, organize, protect, share, preserve, and archive data and information. Policies may also establish specific roles and responsibilities and accountabilities with respect to information management.

Expected Outcomes. If properly communicated, supported, and enforced, information management policies provide the foundation for achieving reliable, repeatable, and efficient processes to maximize the value of information to the organization.

Step 6: Establish a Process for Evaluating and Prioritizing New Information Initiatives

Description. Establish evaluation criteria and a review process to ensure that new initiatives related to collecting, managing, and sharing information are consistent with the agency's established goals, strategies, and priorities for information management. A standard process for evaluating new information initiatives is analogous to the construction project programming process in that it seeks to maximize agency-wide value of information investments. The focus should be on making tradeoffs and choices across alternative investments from a business perspective. This process for evaluating new information initiatives should be coordinated with existing processes that are in place to evaluate new initiatives for content management, records management, information architecture, and library collection management. The process for evaluating new information initiatives should also be coordinated or integrated with existing information technology review processes. The process for evaluating new information initiatives should be designed so that it does not impede the progress of individual business units making information improvements that do not require agency-wide review.

Expected Outcomes. Optimized use of available resources for information acquisition and management to maximize value to the agency. Coordinated investments across different information management functions. Reduced duplication, improved information integration, and efficiency gains from leveraging new technologies and commercial data sources. Maximized data value due to a disciplined approach that ensures adequate provisions to manage data over time, convert that data to information, and use the information to improve decisions or actions.

Implementing and Sustaining Change

Step 7: Implement Information Management Services and Enabling Technologies

Description. Establish standards and processes to implement and maintain a consistent, agency-wide structure for classifying, defining, describing, integrating, and finding data and information. This structure should encompass activities related to data and information architecture that may currently be carried out by libraries, records managers, content managers, data managers, and information technology groups. Deploy tools and technologies that enable and support information management including content and records, enterprise search tools, metadata repositories, data warehouses and data integration tools, business intelligence tools, and data analytics platforms.

Expected Outcomes. Implementing information management services and enabling technologies puts an agency in a position to integrate available data and information in various forms (structured and unstructured) and make sure that they are findable and usable for different users and uses. Implementation of information management services improves efficiency of information management by reducing the effort required to update and maintain code tables that are used within multiple data sets, and it facilitates processes for identifying sensitive information and keeping it secure. Deployment of enabling technologies enables and automates processes for managing information across its life cycle. Systems and tools—when carefully selected and accompanied by appropriate configuration, governance, training, and change management processes—can serve as an important focal point for implementation of information management improvements.

Step 8: Foster Culture Change and Build Workforce Capabilities

Description. Diagnose and address barriers to information management improvements that are related to workforce capabilities or resistance to change. Recognize and strengthen specialized skills required for effective information management. Specific actions may include conducting an assessment of organizational culture; making strategic hires; clarifying or updating roles and responsibilities in descriptions of employee positions; conducting information literacy and data management training; creating guidance documents; and making modifications to performance reviews, employee recognition, and awards.

Expected Outcomes. Fostering culture change and building workforce capabilities can reduce resistance to changing entrenched ways of operating that are not in the agency's best interest, such as information hoarding, failure to provide adequate documentation or metadata, and reluctance to collaborate on data collection or reporting initiatives. The activities involved in this step can improve the workforce skills, capabilities, and motivations that are needed to operationalize and adhere to established information management policies and productively utilize available technologies.

Step 9: Monitor Progress and Adjust Strategies

Description. Institute regular tracking of progress, accomplishments and outcomes, and updates to information management strategies based on results and changing agency priorities. Draw upon techniques from available management frameworks for monitoring and improvement.

Expected Outcomes. The expected outcome of monitoring progress and adjusting strategies is making sustained progress toward established goals and objectives for information management improvement and reinforcement of desired behaviors.

CHAPTER 2

DOTs in the Information Age: Opportunities, Challenges, and Risks

Information Is a Strategic Asset

DOT executives are accountable for delivering safe, efficient, integrated, and sustainable transportation services that enhance the economic and social well-being of citizens. To carry out this mission, DOTs need to maximize use of all available assets, including infrastructure, funding, people, and information. Most DOTs have well-established strategies and programs for managing infrastructure, funding, and people. As the amount of information needed to satisfy business demands and rising expectations has increased exponentially, some DOTs have begun to view information as a strategic asset.

This guide offers a strategic information management framework that DOT senior management can use to leverage the power of information for better agency results and to ensure that each dollar invested in information is well spent.

Agencies that manage information as a strategic asset understand that good information and good decision-making go hand in hand. These agencies

- Recognize the importance of information to the agency's mission,
- Invest in agency-wide information improvements based on their expected payoff, and
- Ensure that the agency's information is effectively managed and delivers value as expected.

In contrast, agencies that do not manage information as a strategic asset may find themselves in the following situation:

- There are a lot of data but limited ability to derive actionable information—a "data-rich, information-poor" state of affairs.

Data and Information

In this report, the term "data" is generally used to refer to raw observations (e.g., traffic counts, bridge condition ratings, and photographs) whereas the term "information" is used to refer to data that have been packaged to facilitate interpretation or understanding (e.g., a planning study).

"Information management" is used as a general term that encompasses collection and processing of raw data, translation of data into information, and distribution of information so that it can be used. Information management encompasses management of tabular data as well as other types of content—documents, maps, charts, emails, etc. See the glossary at the end of this report for more definitions.

- Decisions about collecting data or improving information access are often made within individual divisions, offices, and bureaus rather than being based on a coordinated agency-wide strategy.
- Functions related to information management are dispersed throughout the agency and not coordinated, including records management, engineering document management, data management, library management, intranet and public-facing website(s) management.
- There is a seemingly endless list of requests for new data gathering and information technology investments with the promise of improving information for decision-making; however, many past information technology projects have not delivered on expectations, and prioritizing the many competing needs is challenging.

Information Helps DOTs Achieve Better Results

Several studies have documented the value of information and how effective use of information for decision-making impacts the bottom line within large organizations. For example, researchers from the Massachusetts Institute of Technology (MIT) Center for Digital Business analyzed the financial performance of 179 large publicly traded firms. The researchers found that those "firms that adopt data-driven decision-making have output and productivity that is 5–6% higher than what would be expected given their other investments and information technology usage" (Brynjolfsson, 2011).

While public-sector agencies don't generally track their output and productivity in terms of dollars, it is likely that public-sector agencies would benefit significantly and in ways similar to the ways that the businesses tracked in the MIT study benefitted. DOTs are entrusted with responsibility for making best use of sizable pools of funds for transportation improvements. Information can be used to guide a wide range of strategic and operational decisions. Without good information, agencies are "flying blind" in many respects.

A 2006 study of transportation information assets and impacts (Schofer, 2006) summarized the main categories of information that can add value. This summary includes

- Information that describes the nature and extent of problems that warrant action, such as current and projected future condition or performance;
- Information about alternative courses of action and their consequences; and
- Information about available resources and restrictions on their use.

Using Information for Better Agency Results

- **Performance Management**—using leading and lagging indicators to track agency and system performance and guide course corrections.
- **Incident and Emergency Response**—deploying the right resources armed with situational awareness.
- **System Operations**—making full use of available capacity.
- **Safety**—reducing fatalities and injuries through effective targeting of available funds.
- **Asset Management**—making the right investments that preserve asset value and manage risks.
- **Customer Service**—understanding and responding to key customer concerns, providing customers with the information they need to make good travel choices.
- **Agency Efficiency**—identifying areas for streamlining and cost reduction.
- **Construction**—speeding up project delivery, reducing costs, and ensuring quality.

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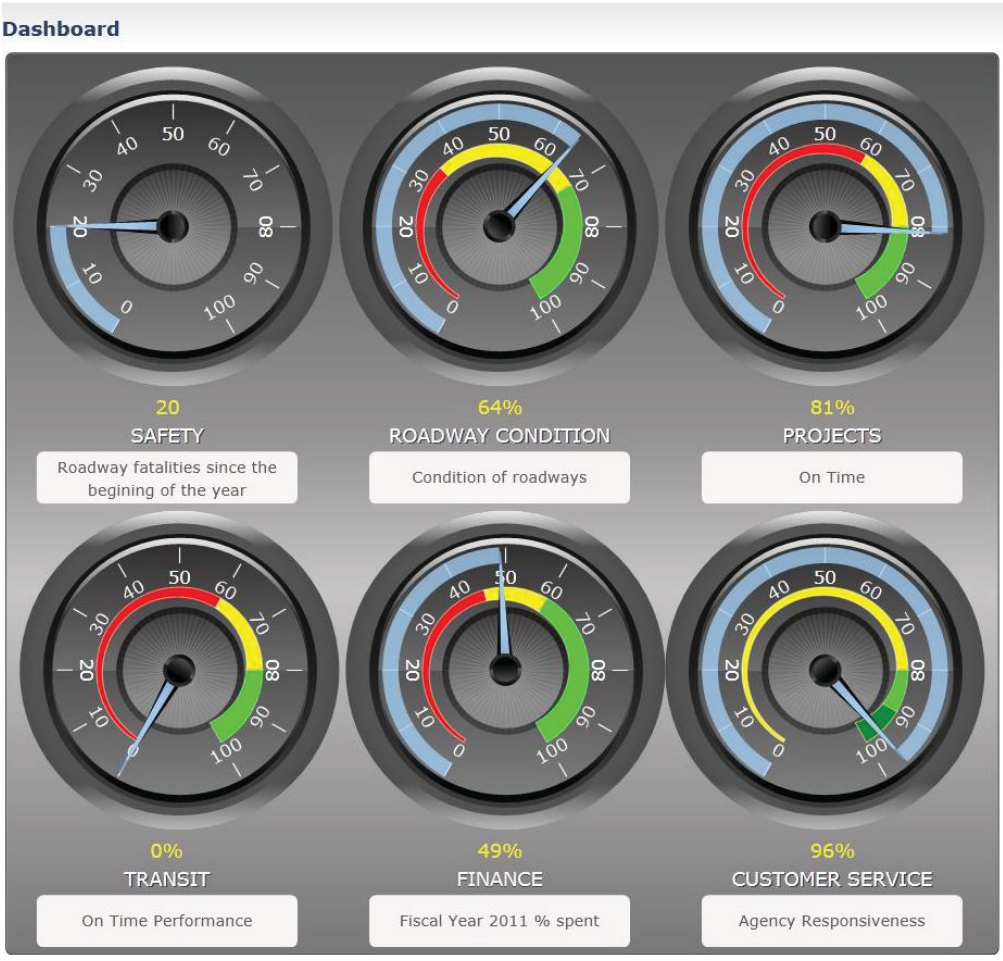
This study identified several compelling examples of how transportation decision-makers were able to leverage available information for improved decisions and outcomes:

- In Massachusetts, current and projected bridge condition data were successfully used to make the case to the state legislature for additional funding for bridges and to develop a program that balanced the replacement or rehabilitation of existing structurally deficient bridges with other preservation projects aimed at preventing additional bridges from deteriorating to a deficient condition.
- In Oklahoma, following a bridge collapse on I-40 resulting from a barge hit, commodity flow data were used to develop a plan to divert trucks to alternate corridors while the bridge was being rebuilt in order to minimize disruption of freight movement and associated economic impacts.
- In Kentucky, roadway adequacy ratings (based on safety, mobility, design, condition, and other data) were used to identify and prioritize unscheduled projects for a 6-year program.
- In Illinois, an inventory of highway-rail crossings was used to allocate resources for investment based on crash reduction potential and other factors.

Today, several DOTs use information on infrastructure condition, crash rates, and congestion patterns to allocate limited dollars to the most pressing problems and thereby demonstrate good stewardship of public funds. Some DOTs have created dashboards (see Figure 2 for an example) that provide a bird's eye view of agency effectiveness and serve as powerful tools for tracking performance and driving improvements.



Source: (District Department of Transportation, 2016. Licensed under CC BY 3.0 US.)

Figure 2. District Department of Transportation dashboard.

Need for Improved Information Management

It is a fallacy to think that once data and content are acquired, the work of producing actionable information is accomplished. In fact, when a need for information arises, many agencies have difficulty responding in an efficient manner due to a lack of proactive information management practices. Agencies may face a host of issues related to information storage, retrieval, documentation, version control, integration, and quality. These issues can severely limit the pace of progress and make efforts to produce good information cost more than anticipated.

Managers requesting information may not be fully aware of these information management issues; all they know is that it takes much more effort than expected to get answers to seemingly straightforward questions. Focused initiatives to respond to FOIA requests, produce dashboards, or develop management reports can be undertaken to work through specific issues. However, it is important to recognize that such tactical efforts won't solve the fundamental cause of information headaches: lack of a strategic, agency-wide approach to information management. For example, without an agency-wide perspective, collections of isolated information systems are created that can't talk to each other. This hampers the ability of staff to use data from business units other than their own to create innovative solutions for themselves or the agency.

Challenges to Providing Easy Access to Actionable Information

- Absence of a clear strategy, priority, and focus for improvement
- Lack of devoted staff resources supporting information management with appropriate skill sets
- Lack of information governance to ensure consistent practices
- Ad-hoc document naming conventions and storage practices
- Ad-hoc or non-existent information classification systems
- Inconsistent data structures across business applications
- Ambiguous data definitions
- Uneven data quality assurance practices
- Incomplete or absent metadata
- Varying spatial referencing, limiting map views of information
- Lack of enterprise systems for information storage and management

The Information Game Is Changing

As DOTs work to improve their information systems to meet a backlog of needs, dramatic changes are occurring in the DOT information landscape: increasing diversification of digital content types, availability of hosted and cloud information storage options, new "big" data sources, new data collection and analysis technologies, and changing expectations about sharing and using information. While there is no crystal ball available, it is clear that the information game is changing, and DOTs need to adapt.

Increasingly, DOTs are facing expectations that their data and information be available to everyone, anytime, from anywhere. These expectations come from internal agency staff and the traveling public, elected officials, and other stakeholder groups. Rapid adoption of social media, mobile communications, and cloud computing technologies have fueled and enabled these expectations. DOTs may not be organized or staffed to keep up with the increasing number and complexity of external information requests and constantly evolving expectations.

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DOTs are also experiencing an explosion in digital data. Cameras, global positioning system (GPS) receivers, and other sensing devices on infrastructure, on vehicles, and in cell phones can provide real-time data on conditions and activities.

DOTs are obtaining large amounts of operational data from private providers on weather conditions, traffic activities, and incidents. Care must be taken to ensure that externally provided data can be integrated with other DOT data and that the quality of the data is understood.

Within agencies, **modernization of information systems and increased automation** of previously paper-based transactions are creating new levels of visibility into agency operations and opportunities to analyze patterns and trends. Mainframe systems are being retired and replaced with newer database systems that make financial and other types of transactional data more easily accessible. Several state DOTs (including Missouri, Utah, Connecticut, and Oregon) are using 3D design models, creating opportunities for more dynamic and flexible management of project and infrastructure information across a project's life cycle (from design to construction to maintenance and operations). Spatial data standards and tools are being adopted that enable integration and visualization of a wide variety of agency and external data. Data warehouses and other data integration solutions are being implemented for improved agency-wide access

Changing Information Expectations

- **Open Government/Open Data**—providing open access to government content; responding to public information requests of increasing frequency and scope.
- **Real-Time Information**—using real-time operational data for active traffic management; using real-time equipment location and work zone information for maintenance management.
- **Performance Management and Accountability**—tracking delivery of projects and services, improvements in system performance, resource utilization, and efficiency; pinpointing areas for improvement.
- **Federal Reporting**—contributing to a consistent national picture of transportation needs and performance.
- **Business Operations**—providing visibility into current status and past history of budgets and individual transactions.
- **Institutional Memory**—accessing information on prior agency activities and lessons learned as career employees retire.

Changing Sources

- **Commercial Traffic Data**—real-time and archived data on travel time and speed derived from a combination of aggregated mobile phone GPS data and other sources.
- **Sensor Data**—remote sensing data from unmanned aerial vehicles, increased use of mobile and aerial LiDAR technology, 3D laser scanning, fatigue sensors on structures, and new image-processing algorithms that automate data extraction.
- **Crowdsourcing**—reported maintenance issues or asset conditions from mobile applications.
- **Connected Vehicle Data**—new data streams from connected vehicles; applications for DOTs are still emerging, but projections indicate that there may be as many as 250 million connected vehicles (globally) by 2020.
- **Text Mining**—improving ability to derive information from a variety of content types, e.g., feeds from popular social media platforms can be mined to provide awareness of incidents and traveler perceptions.

to information produced by individual business units. DOTs are also implementing electronic collaboration tools and content management systems to manage and share their growing collections of digital documents and rich media files. While not yet in common use at DOTs, advanced technologies for storing and analyzing "big data" streams have emerged that build on methods developed by Google, Yahoo, and other companies for managing information at massive scales.

This combination of changing expectations and the changing scale and diversity of available information means that a "business as usual" strategy for information management will no longer work. A reactive approach to meeting new expectations could backfire by taxing agency resources without producing an integrated solution. A more strategic approach to assessing new opportunities for building and leveraging information resources would allow DOTs to focus on high-priority areas and ensure that the right combination of skills, technologies, and business processes are in place to yield success.

Challenges for Improving Information Management

DOTs seeking to put their information to better use and adapt to a changing information landscape will face a number of technical and organizational challenges. These challenges are not insurmountable, but need to be recognized and addressed directly as part of developing an information management strategy. They include the following:

- Information silos,
- Fragmented information management responsibilities,
- Information findability,
- DOT organizational culture,
- DOT workforce challenges,
- Information security and privacy, and
- State information technology challenges.

Information Silos

Information silos naturally occur when decisions about data collection and application deployment are made in isolation by individual organizational units to meet specific business needs. Managers of individual business units legitimately think that they are in the best position to understand their unit's information needs and make decisions about technology investments that are most appropriate to meet these needs. In some cases, restrictions on how funds available for information investments can be used necessitate a silo-based approach. However, silo-based decision-making about data and associated applications can limit the value of information to the agency as a whole and impede staff from gaining a multi-disciplinary perspective on issues and solutions. Potentially negative impacts of information silos include the following:

- **Information may not be properly protected.** Valuable data may be corrupted or lost without reliable backups and access controls.
- **Information may not be findable.** One organizational unit may need information that another unit maintains but isn't aware that the information exists.
- **Information may be duplicated.** Two units may collect or acquire the same data for slightly different purposes using different methods. Duplication of data is a waste of limited resources, but beyond that, having multiple versions of the same data means that no one knows which version is the official, authoritative source. At best, data users may need to expend valuable time tracking down the official data source. An issue of greater concern is that a user could unwittingly use the "wrong" version of the data and make a bad decision based on "bad" data.
- **Information may not be documented.** An understanding of how data were collected, the meaning of particular elements, and how to produce meaningful queries or reports may exist

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only within an individual employee's brain. With employee turnover, there is a high risk that this knowledge will be lost.

- **Information may be difficult to integrate.** Opportunities for integrating data across different systems may be missed, e.g., the ability to compile a history of projects and asset inspections for a given location. Agency-wide efforts to integrate data become more complex and involve many moving parts, from both technology and business process perspectives. Changes to any individual source system may not be coordinated and may cause reports that use information from these systems to break.

In order to avoid these negative impacts, agencies can create oversight processes for data and information technology investments that are backed up by a commitment from senior managers to make sure that the processes are followed. Also, standards can be established to ensure consistency across the agency. It is important to strike the right balance and avoid creating roadblocks to progress; these can backfire and result in "rogue" efforts that circumvent the centralized process.

Fragmented Information Management Responsibilities

In addition to the information silos covered above, DOTs typically have fragmented organizational responsibilities for information management, which may make it difficult to take a coordinated, agency-wide approach. Information management silos may include library management, web content management (which may be also be split into groups with responsibility for the internal versus external web sites), records management, and data management. Data management responsibilities may also be split across different groups within information technology and business units; for example, there may be a geographic information system (GIS) group, an enterprise data warehouse team, a group that maintains databases for enterprise applications, and various groups with responsibilities for specific systems that store data or content (e.g., engineering drawings, contract documents, right-of-way plans, and crash records). Each of these units may build and maintain its own repository and employ varying approaches to information organization, formats, classification, and indexing. These variations can make it difficult for the average employee or customer to understand what information exists and how to access it. Variations in information management practices within the agency can also make it difficult to search across repositories for information relevant to a given topic area or project.

External expectations for DOTs to make their information available to the public are increasing, creating a new set of demands that require coordination across different units with information management responsibilities. DOTs are still working out standard policies and practices for determining what information can be openly shared, what type of review process is required before it is shared, what metadata and disclaimers to include, and what technical mechanisms to use for information sharing. These standards are important to ensuring the release of accurate and consistent information and minimizing potential misinterpretation or misuse of information.

One specific area where a fragmented approach to information management is creating problems for DOTs is responding to FOIA requests. The number of FOIA requests to DOTs is increasing, and fulfilling these requests can be extremely resource intensive. Locating and compiling the requested information can take weeks of staff time. Lack of strong information governance and standardized information organization practices and lack of cross-repository search tools make it difficult to efficiently respond to FOIA requests. Fragmented information management practices can also increase liability for a DOT when they contribute to an inability to locate relevant information in response to construction claims or tort claims.

With the shift from paper to digital content, the role and value of DOT libraries is being challenged. In some agencies, budgetary pressures have resulted in elimination or scaling back of library staff. However, the importance of preserving and facilitating access to agency publications has not declined just because these publications are now in digital form. Training in library and

information science is invaluable for designing and implementing effective digital information management and retrieval methods. The challenge is to leverage and integrate these skills for a broader agency-wide information management function.

Information Findability

The ability to find relevant information and understand its derivation and accuracy is an important challenge for most large organizations, DOTs included. Historically, agency print publications, records, and library management functions provided an established, orderly way to maintain centralized access to valued information assets. These types of functions have not been fully adapted to the digital age, in which policy or standards clarifications are distributed via email and individual employees collect and maintain their own collections of data and documents on shared drives. There is a need to reinvent old practices for identifying information that needs to be shared and make sure that it is stored and documented in a way that allows people to find and use it.

DOT information assets include a variety of data sets—transportation asset inventories, traffic counts, project budget and status, fund obligation and expenditure tables, and so forth. Understanding where and how to access these data sets is one aspect of information findability that can be addressed through data integration, GIS, and reporting initiatives. However, structured or tabular data represent just the tip of the information iceberg. In a typical DOT, there is a large and growing volume of digital content, e.g., emails, forms, memos, inspection reports, invoices, web pages, photos, videos, design drawings, and so forth. This content is used together with structured data and is often critical for documenting and diagnosing problems and making appropriate decisions. Some content may be stored within document or content management systems, but typically a great deal of it is unmanaged and stored on shared agency drives or local hard drives.

Content that is unmanaged is the digital equivalent of a messy desk piled with unorganized material built up over several years. This presents a problem for employees trying to find information such as the most recent set of policies and standards, background on a project they just inherited, or handouts from a meeting they missed. Poor findability of information can substantially impact employee productivity and effectiveness. It also impacts an agency's ability to respond to FOIA requests and construction claims in a timely and efficient manner. Many agencies are facing increasing numbers of public information requests, and poor information findability makes responding to these requests very labor intensive and costly.

Improving findability requires a multi-faceted approach that includes having the technology to store and manage content, implementing policies about where different types of content should be stored, instituting processes to classify and document content with metadata, and establishing governance to ensure that policies are followed in a timely manner.

DOT Organizational Culture

DOTs are typically hierarchical and somewhat bureaucratic organizations. Detailed regulations, policies, and procedures govern how work is to be accomplished and how performance is to be evaluated. Management typically follows a "command and control" structure, with clearly established rules for decision-making and approvals. Employee responsibilities are delineated within detailed position descriptions. This type of culture provides stability and repeatability, but does not necessarily support flexibility, agility, or adaptability. This means that DOTs can be slow to respond to new expectations or opportunities. For example, increased public expectations for open data require DOTs to put in place new practices for information sharing. Many DOTs still find themselves ill-equipped to implement and support these new practices.

The degree of collaboration between DOT business units and units with responsibility for information management and technology is another cultural issue that is important to examine.

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When business units independently develop concepts for new information initiatives without consulting with information specialists, this can result in sub-optimal solutions that don't consider agency-wide needs or opportunities. Separate budget development processes within different units with information management responsibilities (e.g., library management, web site management, records management, etc.) also contributes to the lack of an agency-wide approach.

Changes to processes, roles, and personnel are not easy to make. It will take special effort to reconfigure employees' responsibilities to include information management or to encourage their engagement in data-sharing efforts across business units. Such effort may include making formal changes to job descriptions and considering information management practices in performance reviews. In addition, strong leadership is essential for responding to resistance to change positively and effectively.

DOT Workforce Challenges

Many DOTs have undergone downsizing due to budget cuts and shrinking revenue sources. Trends in full-time-equivalents (FTEs) for one DOT are shown in Figure 3.

In addition, DOTs are facing a loss of experienced staff due to retirements and increased turnover due in part to a more mobile workforce and in part to competition from the private sector for certain skill sets that are in demand. From an information management perspective, the implications are the following:

- Competencies and in-house training resources in information management are thin in many agencies. Individuals trained as engineers may be asked to take on data and information man-

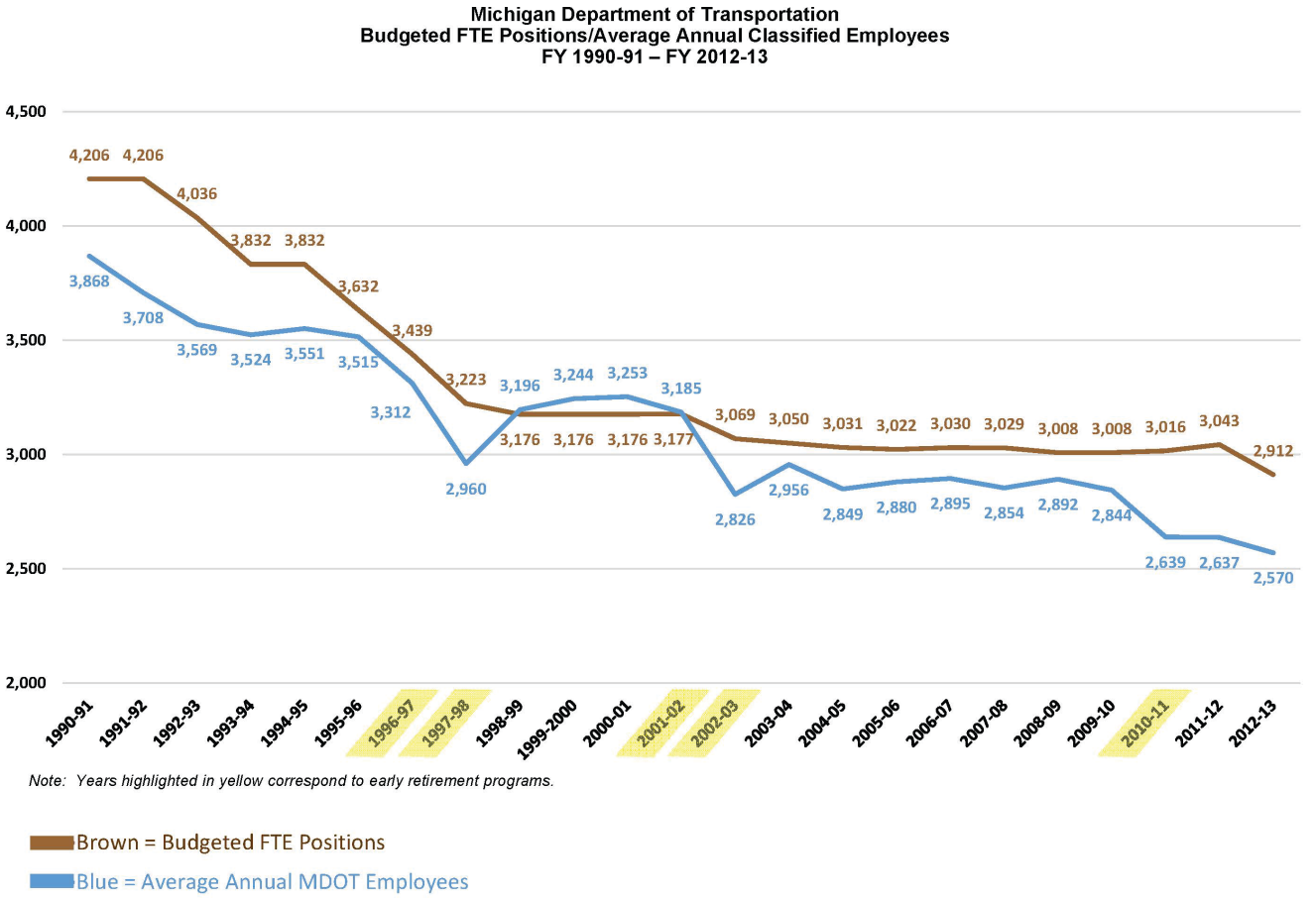

Figure 3. Workforce trends at Michigan DOT 1990–2013.

agement responsibilities without requisite knowledge or training in information architecture, library science, or data science. This situation directly impacts the ability of both information professionals and users of information resources to adopt new, improved information management practices and adjust to a rapidly changing environment.
- Because DOT salaries are generally not competitive with those of private firms, and pension benefits are being reduced, it is difficult for DOTs to retain staff once they gain valuable information management skills and experience through DOT investments in training and mentoring.
- DOTs are increasingly dependent on outsourcing for a range of services, including those related to data collection, processing, and reporting. This dependence means that DOTs will need to improve how they structure and manage outsourcing arrangements to clearly define deliverables, while providing needed flexibility to adapt and ensure strong coordination.
- DOTs are under pressure to increase efficiencies and are looking to reduce labor-intensive processes for field data collection, information summarization, and reporting.
- DOTs are at high risk of losing staff with a unique understanding of data sets—how the data were collected, what the limitations of the data are, and how the data should be interpreted. Capturing and documenting this knowledge is increasingly important.

Another dimension of workforce transition is that newer employees bring a greater comfort level with information systems and high expectations for convenient information access. This presents both opportunities and challenges for DOTs. These employees may be more accepting of automation initiatives and may require a lower level of training to ease the transition to new systems than veteran employees who are less comfortable with technology. On the other hand, increased capabilities for individuals to develop, manage, and publish content on their own can introduce risks to the organization and can work against a coordinated approach to information management.

Information Security and Privacy

Public agencies, including DOTs, are facing major challenges related to protecting sensitive information and preventing cyber-attacks on computer systems and traffic sensing and control systems. Increased system connectivity; the evolution of the "Internet of things"; and the use of technologies such as social media, mobile devices, and cloud computing are increasing the complexity of the task of maintaining information security and protecting sensitive data. DOTs must be increasingly vigilant with respect to protecting their information technology devices by following standard security protocols. DOTs that include motor vehicle registration and licensing functions including large stores of personally identifiable information are particularly vulnerable to data breaches. DOTs must balance information security concerns with the increasing demand for transparency, open data, and productive collaboration with a variety of partners. They must also navigate information security complexities in the context of public/private data-sharing arrangements. DOT staff responsible for implementing data-sharing arrangements must draw upon available cyber security expertise and build in necessary safeguards.

State Information Technology Challenges

Legacy Systems

Information technology investments to improve information management capabilities can be challenging when older, legacy systems are involved. While these systems may still adequately serve their intended purpose—such as financial management, capital program management, traffic monitoring, or highway inventory management—they may require replacement because

- They are difficult to modify to meet changing needs;
- They do not support efficient or "user friendly" methods for data updates;
- They cannot be integrated with the newer generation of agency software;
- They are no longer supported by the vendor;
- They are based on mainframe hardware that is being phased out;
- They are based on operating system versions that are being phased out;

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- They have serious data integrity issues due to a lack of edit and audit capabilities;
- Technical staff members who were responsible for system updates and maintenance have retired or moved on, and newer technical staff members are not trained to work with older technologies.

The bottom line is that legacy systems are more difficult to maintain and less flexible than their modern counterparts. The obvious solution is to replace legacy systems with more modern technology. The use of modern cloud application solutions, communication and mobile technologies, social media, and virtualization infrastructure offer quicker and more flexible solutions. However, some older systems are so large and so critical to multiple agency business processes that it can be extremely costly and risky to transition them to more modern technology. Any upgrade will require a hardware/software expense for the new technology. In addition, data must be transitioned to newer technology without loss of data integrity. Often, data transition requires a major technology project and investment, requiring careful analysis and planning to ensure that adequate resources are made available and that there is an orderly transition.

Specialized expertise for legacy modernization efforts can be tapped in order to maximize success and minimize risks. It is important to recognize that data transition or data cleanup can cost as much and take as long to complete as building a new system. Therefore, an effort to address data migration is best addressed at the beginning of any new modernization effort. The beginning of the effort is the time to eliminate data that are no longer used or needed, identify modifications that would add value, and create opportunities for reduction of ongoing maintenance and improved data integration.

Statewide Centralization of Information Technology Services

A second issue that can constrain or influence selection and prioritization of information technology investments for information management is information technology centralization. For several states—including Michigan, Virginia, Texas, and Minnesota—information technology services have been consolidated statewide. Information technology centralization is intended to reduce total costs and improve service to citizens through elimination of redundant functions and provision of shared services such as information technology project management. Information technology centralization can achieve economies of scale for purchase of hardware, software licensing, and communications and network technologies. Additionally, state information technology centralization can provide critical interoperability between agencies for effective emergency response, promoting economic development, or completing environmental impact assessments.

Because DOTs are typically one of the largest consumers of information technology services within state government and have specialized data and information technology needs to meet external reporting requirements and internal business needs, the transition to information technology centralization can be challenging for DOTs that are working to improve use of information for decision-making. A DOT operating in a centralized information technology environment may have less flexibility to modify systems and services in response to changing business needs and new external reporting requirements.

Key Points

Overcoming information challenges takes advanced planning and judicious investments in data and information systems. It also takes a well-conceived organizational strategy for how information and associated technology investment and resource allocation decisions will be made and how information will be managed. Developing a successful information management strategy involves looking ahead and anticipating changes that will impact needs, constrain future action, or present new opportunities.

CHAPTER 3

DOT Strategic Information Management

What Is Strategic Information Management?

Chapter 2 reviewed the importance of information to DOTs for getting better results, the changing nature of the information landscape, and the challenges to improving how information is managed. This chapter introduces the key elements of strategic information management that provide a way for DOTs to consider the factors reviewed in Chapter 2 and chart a clear path forward.

In this guide, the term "strategic information management" means a set of techniques for managing information to maximize improvements in organizational performance. Strategic information management is fundamentally about bringing the right information to the right people in the right form and at the right time and making wise choices about information investments that will stand the test of time.

It is important to note that information management is not the same as information technology. An information management strategy for an agency defines business needs and priorities for information and articulates how this information should be curated, organized, and delivered so that business units can access it as needed. An information technology strategy identifies how information technology—computer hardware, software, and communications links—can help to meet these needs. A DOT's information technology unit is an important enabler of information management and should participate in developing and implementing the information management strategy; however, the information management strategy should be business-driven.

Being *strategic* about information management means clarifying how information is expected to help the agency deliver on its mission and making conscious choices about investments that maximize payoff from information, including putting in place the necessary resources and competencies for sound information management practices. Of course, this is easier to talk about in the abstract than to put into practice.

Importance of Leadership

The starting point for undertaking strategic information management is to ensure that DOT leaders have information management on their agendas. Without strong leadership

- A fragmented approach will prevail making it difficult to achieve integrated information that serves the agency as a whole.
- It will be difficult to change how decisions are made about new investments in information and enabling technologies.
- It will be difficult to establish and enforce policies that will allow agencies to move forward with managing their corporate information assets, analogous to the need for a centralized approach to financial management and human resources management.

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In recent years, the topic of information and its strategic importance to DOTs has been part of the conversation at AASHTO Leadership Forums. For example, at the 2013 AASHTO CEO Leadership Forum, several current and former DOT directors spoke about data and information (University of Minnesota Center for Transportation Studies, 2013). John Njord, former director of the Utah DOT, remarked

> The idea here is that with real data, you can have a real conversation. . . .We're trying to collect all of that data we have within our department and put it into a format that our designers, customers, and anyone else who wants it has access to and can use to make better decisions . . . We had the confidence in our data that enabled us to squeeze money off higher-volume roads and put it into the lower-volume roads, which then made a very significant difference on those lower-volume roads . . . That's where data can help us do our jobs better. We make much better decisions when we have data that is consistent, repeatable, and available.

Paul Trombino, director of the Iowa DOT, said

> I don't think [construction of infrastructure] is our primary role any more. I believe we are now facilitators of information . . . To me, mobility is information . . . you can't be mobile without information.

Conversations on these topics continued at the 2014 CEO Leadership Forum. This meeting was held at the ITS World Congress meeting in Detroit, Michigan, and yielded the following summary observations (Cambridge Systematics, Inc., 2014):

> Data was presented as the currency of future transportation opportunities. The DOTs collect, analyze, and archive great volumes of data. Within each data set there are issues of accuracy, granularity, ownership, governance, and quality. Between states, there are issues of standardization. Within a DOT there are issues of changing skill sets of the DOT employee required to harness the power of the data being collected. When the private sector enters the data discussion, the DOT is the convener. The DOT data should be "machine ready" if meaningful partnerships are to be advanced. Data-sharing arrangements with third-party providers, open data, and data collection equipment and investment are key elements of implementation.

This growing awareness of the importance of data and information on the part of state DOT leadership means that now is an opportune time to define a process that DOTs can follow to define an agency-wide vision and strategy for information management.

Key Elements of Strategic Information Management

Strategic information management involves a set of coordinated activities to

- Understand how information supports agency goals,
- Manage information as an agency asset, and
- Drive and sustain organizational change.

Understand How Information Supports Agency Goals

The first key activity of strategic information management at a DOT is to establish an understanding of how information supports agency goals and priority initiatives. These may include a combination of externally focused goals (such as improving safety, reducing recurring congestion, improving incident response time, maintaining infrastructure in a state of good repair, providing responsive customer service, or speeding project delivery) and internally focused goals (such as improving budget adherence, improving utilization of fleet and equipment, or speeding orientation of new employees).

Table 1 lists examples of how information supports DOT goals.

At a high level, identifying information needs to support agency goals is relatively straightforward. Surveys and focus groups can be used to systematically assess needs and gaps. However,

Table 1. Examples of information supporting DOT goals and strategies.

Goal	Strategy	How Information Adds Value
Safety	Reduce Roadway Departures	Identify highest risk locations based on crash history and road inventory data
Mobility	Improve Incident Response	Speed up incident response and clearance based on real-time congestion data and reported events
	Facilitate Shifts in Travel Behavior	Provide travelers with information they need to avoid congestion by changing their time of travel, mode of travel, and/or route
Asset Preservation	Invest in Preventive Maintenance to Extend Asset Life	Identify assets in appropriate age or condition range for preventive maintenance to be effective
Customer Satisfaction	Proactively Address Common Concerns	Discover patterns through analysis of customer issues from call center and social media and tailor agency response and communications for maximum impact
	Integrate Available Information Needed for Customer Requests	Make available integrated information on highway geometry, maintenance resources and responsibilities, sign/signal data, right-of-way, and work zones so that call center operators can deploy the right resources in response to a call in a timely manner
Efficiency	Streamline Construction Project Delivery	Track on-time, on-budget status of projects and provide early warning to managers of missed milestones and other indicators of problems
Risk Management	Improve Management of Agency Policies and Procedures	Ensure that employees and contractors are using authoritative versions of agency policies and procedures

meeting these needs through data gathering and information system improvements is costly. If a DOT's employees and partners were asked to develop a wish list of items to meet information needs and make associated system improvements, it is likely that the resulting list would be very long, with a price tag that would well exceed what the agency could afford to spend. The real challenge is in prioritizing across competing needs and understanding interdependencies with respect to information creation and use. Meeting this challenge involves a more in-depth look at information criticality. In other words, what are the consequences of not having the right information, and what is (or could be) the true value of information improvements? To be useful, an information management strategy needs to make a compelling business case for how information investments support agency goals. The strategy needs to separate the "essential" from the "might be useful."

Manage Information as an Agency Asset

The second key element of strategic information management is to operate in a manner that recognizes information as an important agency asset, analogous to infrastructure assets and human resources. This involves

- Understanding data and information needs across the organization;
- Keeping track of what the agency's information assets are and what value they are providing;

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AASHTO SCOP Data Principles

- **Principle 1 – VALUABLE:** Data is an asset—Data is a core business asset that has value and is managed accordingly.
- **Principle 2 – AVAILABLE:** Data is open, accessible, transparent and shared—Access to data is critical to performing duties and functions, data must be open and usable for diverse applications and open to all.
- **Principle 3 – RELIABLE:** Data quality and extent is fit for a variety of applications—Data quality is acceptable and meets the needs for which it is intended.
- **Principle 4 – AUTHORIZED:** Data is secure and compliant with regulations—Data is trustworthy and is safeguarded from unauthorized access, whether malicious, fraudulent or erroneous.
- **Principle 5 – CLEAR:** There is a common vocabulary and data definition—Data dictionaries are developed and metadata established to maximize consistency and transparency of data across systems.
- **Principle 6 – EFFICIENT:** Data is not duplicated—Data is collected once and used many times for many purposes.
- **Principle 7 – ACCOUNTABLE:** Decisions maximize the benefit of data. Timely, relevant, high-quality data are essential to maximize the utility of data for decision-making.

Source: (AASHTO Subcommittee on Data, n.d.)

- Managing information throughout its life cycle to preserve its value (collection/acquisition, storage, retrieval, analysis and reporting, archiving or long-term preservation, and disposal);
- Allocating resources for information management and improvement to maximize agency-wide benefit; and
- Monitoring the value added from information assets in order to validate the business case for those assets and decide whether to abandon, maintain, or enhance them.

The AASHTO Standing Committee on Planning (SCOP) Data Subcommittee has defined a set of data principles for state DOTs that elaborate on what it means to treat data as an asset. These principles apply to information in general (not just structured data) and have themes similar to those that have been independently established by individual state DOTs in Minnesota, Alaska, and Washington.

Drive and Sustain Organizational Change

The third key element of strategic information management is to effect meaningful changes in the organization's capacity to produce, manage, and use information, including the following:

- Establishing standard operating procedures for how available information is to be used within planning, budgeting, project scoping, risk assessment, programming, monitoring, and communications functions;
- Assigning responsibility and accountability for gathering, checking, managing, and providing internal and external access to information;
- Building workforce capabilities to ensure that the agency is well-positioned to take advantage of current methods and technologies;
- Putting the right competencies in place for effective data and content management; and

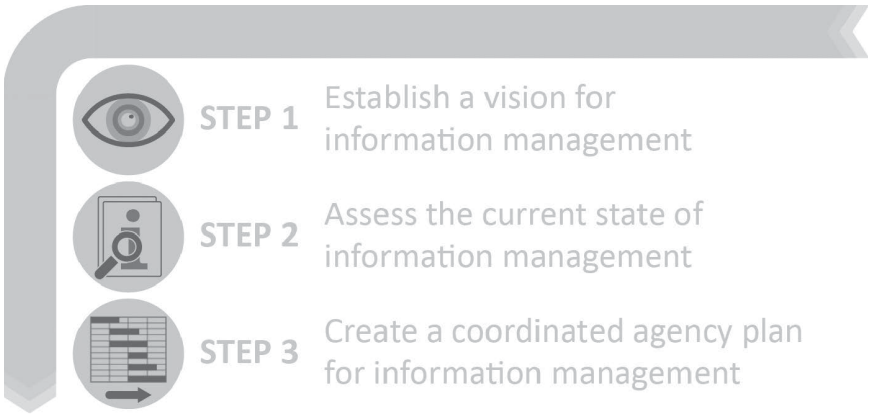
- Incentivizing good information management practices on the part of employees (e.g., checking data quality prior to distribution, storing documents in designated shared repositories, identifying sensitive information to be protected, etc.).

Without these types of changes, it will be difficult to move from fragmented decision-making about information acquisition and management to an enterprise-wide approach. In addition, it will be difficult to marshal available resources (including funding, expertise, and staff time) across the agency in order to make essential improvements in information management that make a real difference and help the agency achieve its objectives.

This element is perhaps the most challenging of the three, but it is critical. Driving and sustaining organizational change requires strong leadership to take on entrenched behaviors and long-established areas of autonomy. At the same time, strong leadership alone will not achieve organizational change. Successful and sustained change also requires agency champions "on the ground" who have credibility, believe in the proposed changes, and will work through the details of implementation. Organizational change can be addressed incrementally through a combination of strategic recruiting, education and communication, and changes to incentive and reward structures.

CHAPTER 4

Charting a Course



Step 1. Establish a Vision for Information Management

Purpose of an Information Management Vision

A vision for information management is a statement that communicates how the agency wants to be using and managing information in order to meet its strategic objectives. The vision statement defines the desired future state and provides a clear focus and inspiration for activities. Ideally, the vision will encompass data and information in all of their forms—structured data, documents, email, web content, and so on. A unified vision for information management will help to build bridges across different areas of responsibility, improving users' ability to locate authoritative information, reducing duplication of effort, and maximizing use of available agency skill sets.

To be useful, the vision must be realistic and in alignment with the broader agency strategic vision. A vision can be brief, but should include sufficient content to provide a framework for developing strategies and evaluating progress.

In the U.S. Forest Service's "Information Management Vision," (see text box) agency adoption of information management practices is emphasized.

A complementary approach to vision development is illustrated in Figure 4. The Utah DOT has integrated consideration of data and information into its overall vision for asset management. This approach establishes a clear perspective on what information is needed and how improvements to information will move the agency toward improved decision-making (ability to select the right project at the right place at the right time) and sustained results (longer lasting pavements).

United States Forest Service—Information Management Vision

Our Information Management Vision pictures a desired future condition in which the Forest Service:

- Recognizes information as a resource critical to our success.
- Shares and manages information in ways that support the mission and business of the organization.
- Strives, as a commonly understood, accepted, and supported goal, to bring quality information, in the right form, to the right people at the right time to support sound and deliberate decisions and to generate ideas.
- When we achieve this state:
  - Employees at all levels will better understand the Information Management methodology as it relates to the business of the Forest Service, the importance and role of information as a resource in support of that business, and the need for clearly identified, essential standards for data and information elements.
  - Management will be visibly involved in development and committed to implementation of national information management investments, policies, and procedures.
  - The information management environment will generate quality information that can be used by all levels of the organization and by external partners in accomplishing the business of the Forest Service.
  - Management will recognize the investments, and will commit the resources to implement information management decisions.
  - Information policies and technologies will anticipate future needs and new developments, reflecting internal and external considerations.

Source: (USDA Forest Service Strategic IM Team, 1992)

Source: (Braceras, 2014)

Figure 4. Utah DOT's vision for data-driven pavement management.

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Developing the Vision

The process of setting a vision provides agency leaders with the opportunity to discuss how they would like information to better serve the agency's mission. This *process* can be just as important as the end product. Ideally, the vision will be developed with the involvement of important stakeholders for information, including

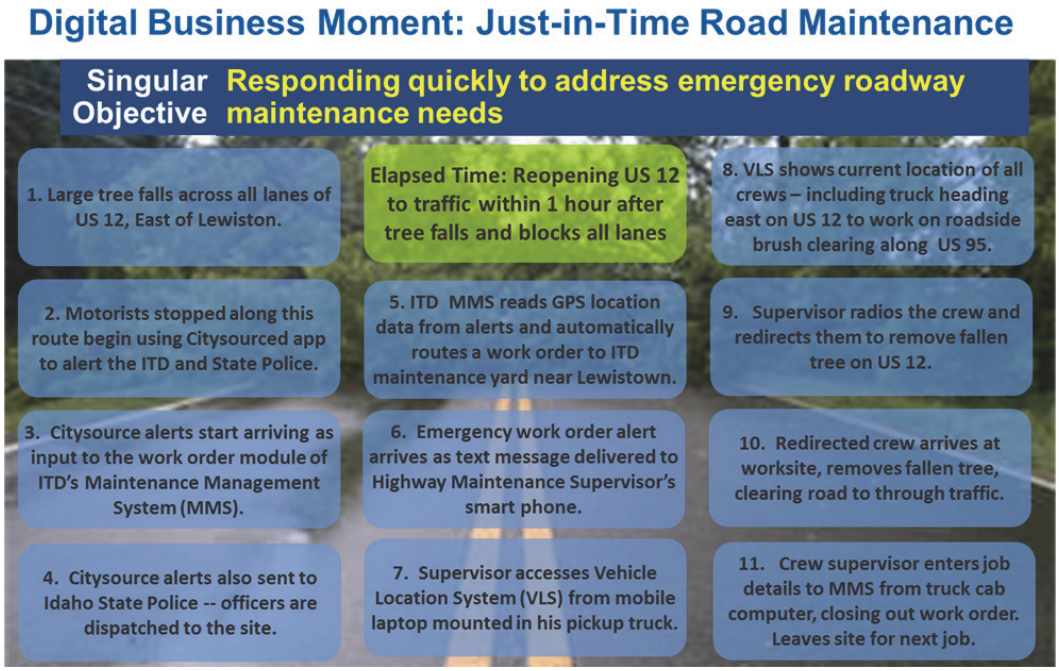
- Leadership team;
- Representatives of major departments or functions (e.g., planning, design, construction, maintenance, and operations);
- Representatives of information management and technology functions (e.g., data warehouse/reporting, GIS, internal and external web sites, social media, library management, and records management); and
- Representatives of major data programs (e.g., traffic, safety, road inventory, and asset management).

The content of the vision should focus on desired outcomes for information management, not so much how to get there, but what results the agency wants to achieve.

Visioning for information management should be integrated and aligned with the agency's overall strategic planning process. Scenario planning approaches [as illustrated, for example, in the *NCHRP Foresight* Series (Burns & McDonnell Engineering Company, Inc., and High Street Consulting Group, 2014)] can be applied to examine alternative futures—including variations in the types, sources, and uses of information that should be anticipated, and signposts that indicate the need to begin responding to emerging changes.

In Appendix A of this guide, Table A-1 presents possible elements of a DOT information management vision that can be used as a starting point for developing an information management vision.

One visioning technique is to develop specific examples of how information would add value. Figure 5 provides an example of a "digital business moment" developed by the Idaho Transportation



Source: (Gartner, 2014)

Figure 5. ITD "Digital Business Moment."

Department (ITD) that provides a concrete illustration of how information would be used in an emergency maintenance situation.

This example can then drive the coordinated deployment of information systems and technologies (e.g., maintenance management system, mobile devices, and vehicle location systems) and information management strategies (e.g., standardized location referencing, compilation and integration of incident response data for performance reporting, archiving of historical work order data in an appropriate form for future analysis, etc.).

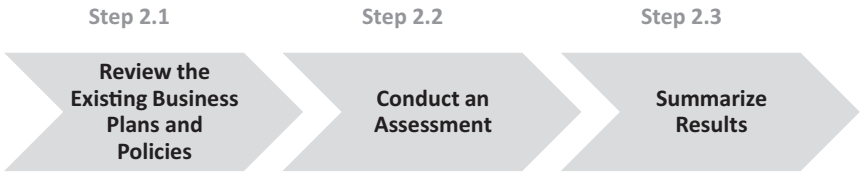
Key Points

The exercise of developing a vision for information management establishes the link between what the agency is trying to achieve and how improved information management can help it get there. It is important to get the right people at the table for this discussion in order to reflect the variety of perspectives that may exist and to ensure that a firm foundation is established to guide subsequent steps. Techniques for visioning include the following:

- Facilitated discussion using a template (provided in Table A-1);
- Scenario planning to look at alternative futures and their implications for information needs in the agency; and
- Business process walk-throughs to envision new ways of utilizing information.

Step 2. Assess the Current State of Information Management

An assessment of the current state of information management can provide the foundation for identifying what types of improvements are needed and which are most important. This assessment can identify current areas of strength and weakness and identify risks and opportunities for improvement. It can answer the question: "What problems are we trying to solve?"



Step 2.1: Review Existing Business Plans and Policies

In preparation for the assessment, it is worthwhile to begin by taking stock of relevant plans, policies, and procedures, including the following:

- Agency strategic plan,
- Agency business plan,
- Unit/division business plans,
- Information technology strategic plan,

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- Information management strategic plan,
- Data business plans,
- GIS strategic plan,
- Data policies and guidelines,
- Library policies and collection management plans,
- Web site/intranet policies and guidelines,
- Records management/retention schedules and policies,
- Engineering/computer-aided design (CAD) file management policies,
- Data and information security and privacy policies, and
- Risk management policies.

Key questions to consider in reviewing these existing documents are the following:

- Are information-management and technology-focused strategic plans (where they exist) linked to or in alignment with the agency's strategic plan?
- Do agency and unit/division business plans include discussion of information improvements needed to meet business objectives?
- Do any plans or policy documents define roles, responsibilities, and processes for prioritizing agency investments to improve information availability, quality, and usability?
- Are there areas of ambiguity or conflict in how the different policies describe information management roles and responsibilities?
- Do data, library, records management, web site/intranet, and CAD file management policies clearly lay out expectations for what types of information are to be stored in different repositories? Are these policies being adequately supported and enforced?
- Are methods for classifying or categorizing different types of information consistent?
- Are there gaps in policies that put critical information resources at risk or increase tendencies toward duplication of information across different business units?
- Have data security/privacy and risk management policies been reviewed to ensure that they cover current known requirements and threats? Are they adequately supported and enforced?

This exercise will likely uncover gaps and inconsistencies in the agency's plans and documented policies. The next step is to convene a group to do a more complete assessment of actual agency practice.

Step 2.2: Conduct an Assessment

Agencies can choose to do a quick assessment involving a few meetings with senior managers to get a high-level read on the situation. Alternatively, a more comprehensive assessment can be undertaken involving a broader cross section of department staff and external stakeholders.

The assessment should address the following three questions:

1. How is our information working for us now to support the agency's mission and priorities?
   a. In what ways are we being held back by poor quality or inadequate information?
   b. What important questions are difficult to answer?
   c. Are there areas where missing or inaccessible information creates inefficiencies or impacts customer service?
2. How can the agency manage its information more efficiently?
   a. Is there information being collected but not used or needed?
   b. Are there duplicative information collection and management efforts?

   c. Where does a lack of data integration make it difficult and time consuming for staff to assemble and analyze available information?
3. What are the most important risks to be mitigated?

Sample assessment tools are included in Appendix A to provide a structure for addressing these questions. These tools can be used as is or adapted to focus on issues of specific concern. Since there are likely to be varying viewpoints on information needs and risks, several different individuals across the organization can be asked to complete the assessment individually and then come together in a session to discuss responses and arrive at a consensus view.

Each of the tools in Appendix A is structured to facilitate linking assessment results to three typical high-level goals for information management: (A) improving information for better internal agency decisions, (B) meeting external information requests and reporting requirements, and (C) improving information usability and reliability.

Assessment Tool 1 (shown in Table A-2) identifies potential information needs for a DOT and asks respondents to provide their perspective on the priority of taking action to address these needs.

Assessment Tool 2 (shown in Table A-3) focuses on risk and asks respondents to rate both the likelihood and consequences of potential risks associated with continuing the status quo situation, that is, not improving information or information management practices. This tool can help the agency to prioritize actions that would mitigate risks with both medium to high likelihood and medium to high consequences. The overall risk score—calculated as the product of likelihood and consequences/impacts (ranging from 1 for the lowest risks to 9 for the highest risks)—can be used to guide identification of priority areas to be addressed.

Assessment Tool 3 (shown in Table A-4) lists several fundamental management practices to ensure efficient use of information and asks respondents to assess the extent to which the agency is carrying out these practices.

Another useful assessment method, which can build on results from the three assessment tools included in Appendix A, is to identify Strengths, Weaknesses, Opportunities and Threats (known as a SWOT analysis). Strengths and weaknesses are characteristics of the agency that either support or challenge its ability to gather, manage, and use information in an effective manner. Opportunities and threats are external factors that may positively or negatively impact the agency's information management capabilities. These may include regulatory changes, changes in leadership or organizational structure, changes in funding availability or flexibility, changes in technology, and changes in information sources.

Example strengths, weaknesses, opportunities, and threats related to information management are shown in Table A-5 in Appendix A. The examples shown in Table A-5 can be used as a starting point for agencies to discuss and identify more specific items.

Step 2.3: Summarize Results

The assessment summary should provide a good picture of needs and priorities for shoring up agency information. It should inform the development of a coordinated agency plan for information management. The summary can include the following:

- A list of urgent and high-priority needs for improving available information in support of agency goals (from Assessment Tool 1—Table A-2);
- A list of high-priority risks to be mitigated (from Assessment Tool 2—Table A-3);
- A list of information management practices that need to be strengthened (from Assessment Tool 3—Table A-4); and
- Results of the SWOT analysis (illustrated in Table A-5)—strengths that the agency can build on, opportunities to leverage, and weaknesses and threats to be addressed.

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Key Points

An assessment of current practice provides valuable information to guide development of focus areas and strategies for improvement. It provides a common understanding of gaps and risks to be addressed. Several tools are available in Appendix A of this guide that can lead to a summary of agency strengths, weaknesses, opportunities, and threats.

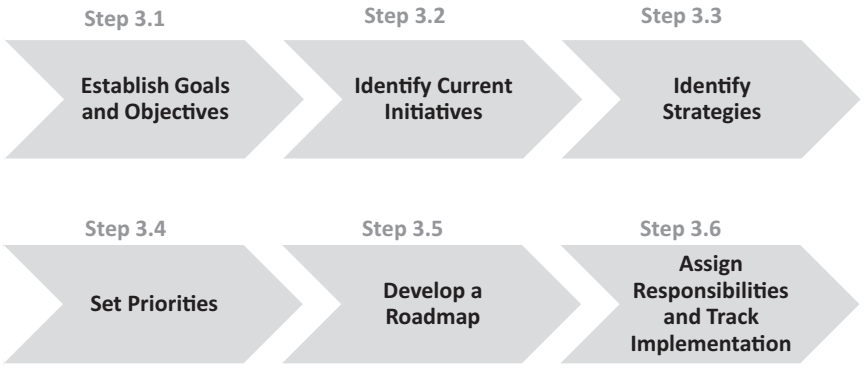
Step 3. Create a Coordinated Agency Plan for Information Management

Purpose of a Coordinated Plan

An information management strategic plan connects the agency's goals and vision for strategic information management to a set of practical, implementable actions that move the agency forward. The plan should include near-term (1 to 2 years), medium-term (3 to 5 years), and longer term (6 to 10 years) actions. Longer term actions can be specified at a more general level of detail than near- and medium-term actions. The plan should provide metrics or milestones that can be used to track progress. It should also acknowledge and incorporate the existing initiatives already underway that may have been identified in the visioning process. Note that this doesn't need to be a stand-alone plan; it can be integrated into the agency's strategic or business plan or serve as a business-focused component of the information technology strategic plan.

Developing the Plan

The following process can be used to develop the plan.



Step 3.1: Establish Goals and Objectives

Building on the vision and the assessment results, identify key goals for information management and measurable objectives to achieve each of these goals.

Step 3.2: Identify Current Initiatives

Identify initiatives that are currently underway to improve information availability, quality, access, and value for decision-making. These initiatives might include things like open data initiatives, technology upgrades, process automation efforts, data warehouse development or

expansion, and content management implementation. Each agency initiative can be mapped to one or more of the goals identified in Step 3.1.

Step 3.3: Identify Strategies

Strategies can be identified for each of the objectives using the results of the current state of information management (from Step 2). Strategy development can draw upon the material in this guide and should include a balance of the following:

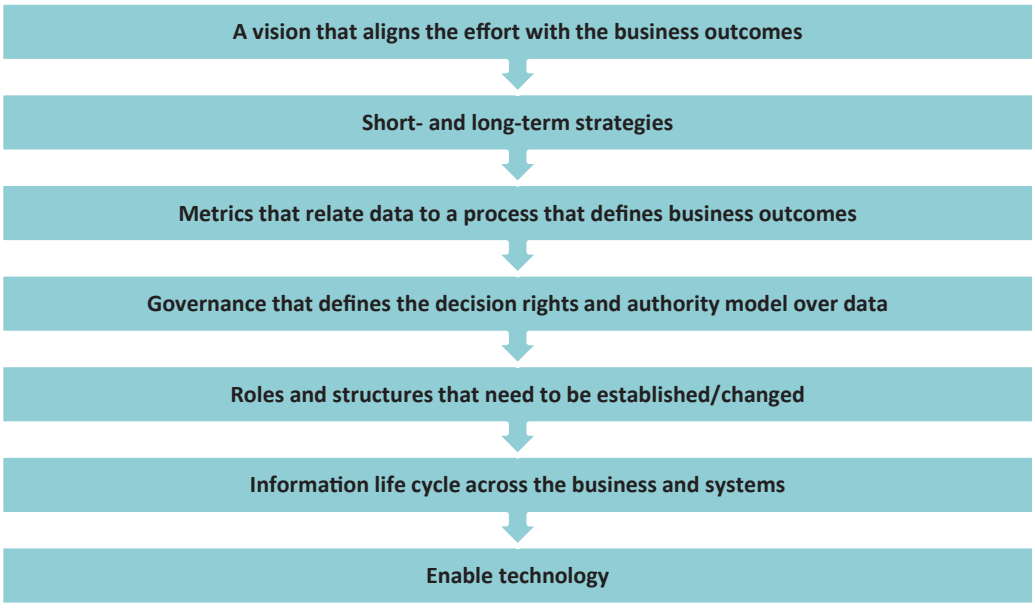
- Changes to decision-making structures and information governance policies to provide better *alignment* between information investments and agency priorities (see Steps 4 through 6);
- Development of agency-wide *information management capabilities* to enhance consistency, integration, and findability of information (see Step 7);
- Investments in *enabling technologies* to meet common needs for information storage, search, analysis, and reporting through centralized solutions (see Step 7); and
- Building *workforce awareness, skills, and capabilities* in areas related to information management (see Step 8).

The plan should also define an ongoing process for monitoring progress and making adjustments as needed (see Step 9.)

The flow chart shown in Figure 6 illustrates the ITD's planned approach to developing information strategies based on a vision. This approach emphasizes the importance of ensuring that each strategy is designed to achieve desired business outcomes. The approach also highlights the fact that changes to governance, roles, and organization structures are important components of effective information management.

Step 3.4: Set Priorities

Once strategies are identified, the stakeholder group should identify priority initiatives to move forward. These priorities can consider urgency, or risk, and ease of implementation given existing resources.



Source: (Idaho Transportation Department, n.d.)

Figure 6. ITD building blocks for an enterprise information strategy.

Step 3.5: Develop a Roadmap

Step 3.5 is to develop a roadmap that shows the sequence of activities that the agency plans to complete within the plan's timeframe. This roadmap should include both the existing initiatives and the new strategies that have been identified. Roadmap development should consider dependencies across strategies; for example, getting people with the right skills in place might be required prior to embarking on an information architecture effort. Pilot or small-scale initiatives can be planned early on, with tentative full-scale implementation in later years.

The roadmap can be updated periodically to indicate which activities have been completed and to adjust planned activities and their schedules.

Step 3.6: Assign Responsibilities and Track Implementation

Each activity on the roadmap should have an owner, who is responsible for working out implementation details and periodically reporting on progress. The overall plan and roadmap should also have an owner who is responsible for updating it periodically (e.g., quarterly or annually) as inevitable changes occur in resource availability and as new needs or priorities arise.

Key Points

The coordinated plan for information management lays out what the agency is going to do to move toward the vision it has established in Step 1 and addresses the areas of need or weakness it has uncovered in Step 2. The plan clearly establishes goals, objectives, strategies, and actions, and assigns responsibilities. Producing the plan and assigning responsibility for its implementation and tracking means that the agency intends to move forward. The plan sets the stage for the remaining six steps of the strategic information management process.

CHAPTER 5

Equipping the Organization

Step 4. Establish Leadership and Governance Structures

Information governance is the mechanism by which an agency is able to improve information integration, quality, and usability, and adapt to new requirements in a coordinated and efficient manner. It is the opposite of a decentralized, "laissez-faire" approach in which individual business units create their own methods for information collection and management, and nobody is specifically held accountable for how the agency manages its information. This decentralized approach is sub-optimal from many perspectives. The following results are all too familiar to many organizations:

- Uneven information support for different business needs across the agency;
- Disk space on shared drives clogged with growing collections of old, inactive content;
- Data and content that are undocumented and of undetermined quality;
- Data sets in a variety of formats that overlap and can't be integrated;
- Lack of ability to find or access information produced within the agency;
- Many potential sources of risk that are difficult to identify, let alone manage; and
- Difficulty mounting coordinated responses to new information needs.

On the other hand, a highly structured approach to information governance—with multiple levels of approvals and complex decision-making criteria—can pose barriers to progress and consume valuable senior staff time. Standardizing how information is managed requires changes in well-established behaviors, which are always difficult to achieve. Therefore, to be effective, agencies need a balanced approach of "just enough" governance to achieve economies of scale

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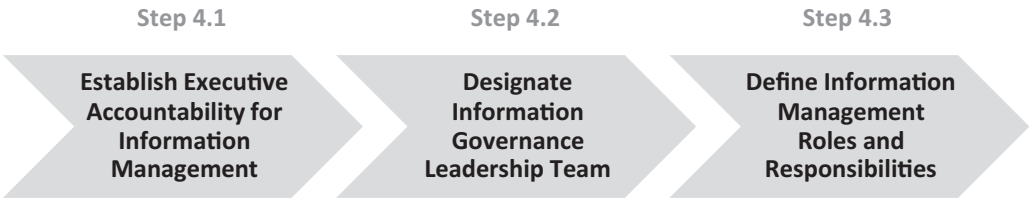
for information investments, integrated data of acceptable quality, and organizational capability for change to meet new demands and a tolerable level of risk.

Identifying roles and responsibilities for individuals and groups within the agency with respect to information governance establishes the accountability that is needed to ensure progress. Without this accountability, it is unlikely that agency information governance and management will change from the status quo. Designating a group responsible for developing and ensuring implementation of agency information management policies is one way to provide this accountability. This group could identify how the agency will make decisions about what information to collect and how to manage it across its life cycle for maximum value. Identifying roles and responsibilities also provides two additional benefits: it can increase organizational ability to coordinate across silos and adapt to new requirements, and it can identify willing champions with time and resources to follow through on the leadership and governance direction.

The following process (Steps 4.1 through 4.3) can be used to establish information governance and management roles and responsibilities.



Step 4.1: Establish Executive Accountability for Information Management

The first step is to identify a member of the agency leadership team who will be accountable for improving information management at the agency. Executives must understand the value of information management in order to provide the desired resources to support it. Without executive support, information management might take a low priority compared to other issues and projects, and lack the interest or resources within the agency required for successful implementation.

While some agencies may have a chief information officer or a chief technology officer, these roles are often primarily focused on information technology. An executive responsible for information management would work in partnership with the agency's technology lead to implement a business-driven approach to organizing, analyzing, delivering, and sharing information. As a National Association of State Chief Information Officers (NASCIO) issue brief discussed, executive roles in implementing information governance and management can include sponsorship, strategic direction, funding, advocacy, and oversight. (NASCIO, 2008)

One approach being taken by both private- and public-sector organizations (including U.S. DOT) is to designate a chief data officer (CDO). A CDO role can be defined to include not only structured data (big or traditional) but also unstructured data such as documents, engineering plans, and multimedia files. This individual can be located within the information technology group or work directly for the agency's chief executive. A 2014 MIT study on the role of chief data officers provides a useful summary of the need that a CDO fills (Lee, Madnick, Wang, Wang, & Zhang, 2014):

> Some might argue that traditional data-related managers and data governance mechanisms can deliver the same results as a CDO. However, there are critical differences between the efforts of low-level data managers and those of executive-rank CDOs. The key contrast lies in organizationally sanctioned leadership and accountability appropriated to the executive level CDOs . . . unlike data managers, the CDO can

> lead the effort to build an organizational capability that can energize and sustain the entire organization and extended enterprise. . . .the CDO can be held accountable for a failure of leadership in resolving data problems.

This study goes on to define the different types of roles that a CDO can play, classified based on three dimensions: (1) data space (big data versus traditional data), (2) collaboration direction (inward versus outward), and (3) value impact (strategy versus service). Table B-1 in Appendix B summarizes these roles and can provide a useful reference for DOTs considering establishing a CDO position (or other positions with similar functions).

Step 4.2: Designate Information Governance Leadership Team

Below the executive level, an information governance leadership team can serve as an oversight body responsible for developing and ensuring implementation of agency information management policies. This is not the same as an information technology governance body, though there could be some areas of overlap to be coordinated.

There is no single recommended approach to setting up an information governance structure in a DOT. (See text box titled "Washington State DOT—Enterprise Information Governance Group [EIGG]" for one example). Some agencies may have existing groups that can take on

U.S. DOT, CDO

The U.S. DOT added a CDO position in 2014, to report to the chief technical officer (who reports to the chief information officer). The U.S. DOT CDO role includes the following responsibilities:

- Envisioning DOT data and data management (e.g., interviewing stakeholders to inform data needs)
- Building department data policies
- Improving data quality
- Increasing data sharing—including data awareness, use, and collaboration—for DOT employees and for the public
- Developing new data products and data analysis tools
- Tracking agency-wide data collection and data linkages

Sources: (Moore, 2015; U.S. Department of Transportation—Office of the Secretary of Transportation, Job Listing for Chief Data Officer: IT Specialist, Job Announcement Number OST.CIO-2014-0011, 2014)

Financial Services Company, CDO

The CDO of a major financial services company oversaw a "Data Transformation Program" in which the objectives included the following:

- Formalizing data governance, including not only the process, but also the roles for employees involved in data governance, such as business data owners and business data stewards
- Measuring and improving data management maturity
- Enabling business initiatives by coordinating with key programs and better leveraging the data for projects
- Optimizing the data infrastructure through consolidation, integration, modernization, and automation

The intent was to increase business value by enhancing business strategy, analysis, and decision-making, and to increase infrastructure and operations value through more modern, consolidated systems.

Source: (Gerber, n.d.)

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Washington State DOT—Enterprise Information Governance Group (EIGG)

Washington State DOT's EIGG includes director-level representation from each major division of the department. The EIGG has been designated as the policy-setting body for all Washington State DOT data- and information-management-related issues. The EIGG has the following responsibilities:

- Review existing agency policies and executive orders related to data and information management and periodically prepare a report that summarizes the effectiveness of current practices; develop and implement a work plan to remedy policy gaps, inconsistencies, and any conflicting or unclear direction within existing policies related to the assignment of roles and responsibilities including policy enforcement, accountability, and authority.
- Develop policies that are directed toward efficient and strategic use of resources associated with data and information assets including the collection, storage, management, findability, and access to data and information.
- Identify roles and responsibilities related to enforcement, accountability, and authority in an effort to allow conformation to the data and information principles.
- Provide to executives by the end of each fiscal year a summary of all policies established by the EIGG, improvements resulting from the policy change, and policy issues under consideration.

Source: (Washington State Department of Transportation, 2015)

information governance functions. To be effective, the governance group should include representation from

- Core central office business units (planning and programming, design, project delivery, maintenance, and operations);
- Field offices;
- Information technology, data management, and applications development; and
- Information management units including records management, web content management, engineering document management, and library management.

A core function of a governance group is to establish policy and guidance. A second important related function is to provide an escalation path for issues or problems related to information management. These issues or problems might include an inability to get agreement on standards or priorities across business units, a lack of resources or priorities for improving data quality, an inability to get staff to store their files in designated locations, or a resistance to data sharing across business units or with the public. Table B-2 in Appendix B presents sample information governance group objectives and functions. Although information governance objectives and functions are likely to change based on an agency's focus and the existing state of information management, these sample objectives and functions can provide a starting point.

In order to facilitate the work of the governance team, it is important to designate a lead manager (who may be the chair of the team) who has the time to understand issues, lead development of recommendations, and spend time working across agency silos to negotiate strategies. This lead can serve as an evangelist for an agency-wide information management

approach and advocate for improvements leading to more consistent and coordinated practices. Additional staff support is also helpful for activities including meeting logistics, background research, benchmarking with other agencies, technical review, and agency outreach/communications.

Many agencies have existing business leadership and information technology governance teams. The information governance group's function should be clearly delineated to distinguish it from the roles of these other teams. As part of this process, formal reporting relationships and points of coordination can be defined as appropriate.

Step 4.3: Define Information Management Roles and Responsibilities

In order for the information governance team to implement effective policies and management techniques, other individuals within the agency will need to assume various information management roles and responsibilities. This will typically involve identifying business owners for different types of data (points of accountability) and additional responsibilities (e.g., for quality assurance, documentation, and change management). It may also involve establishing metrics to track progress and regular monitoring. Table B-3 in Appendix B provides a sample list of information governance roles to consider.

Key Points

Step 4 of the strategic information management process establishes ongoing decision-making authorities and processes and clarifies roles and responsibilities for information management. This is a key element of "equipping the organization"; it is difficult to make substantive progress without it. Each agency will need to determine the information governance approach that fits best with its culture, leadership structure, and decision-making processes. DOTs can look to other agencies for models and lessons learned.

Step 5. Establish Information Management Policies

The information governance group will set information management policies in order to achieve the objectives outlined in Step 4. Information management policies can define agency expectations for how employees will manage and use information. Policies can cover a range of topics about information, including categorization, storage, life cycle management, standardization, and integration. Each of these topics is discussed further below.

Creating policies and expectations serves an important function of governance groups; however, the groups must ensure that the agency is ready to implement and enforce the policies that they create. This can include a number of factors, such as the following:

- Defining roles for individuals upon policy implementation,
- Affirming executive support of major policies,
- Communicating new policies to the affected employees,
- Ensuring that necessary resources are available to enact the policies, and
- Determining how the policies will be monitored and how results will be measured.

If the agency is not prepared to implement and enforce the policies and expectations that are created, then setting the policies and expectations can lead to negative consequences, such as the following:

- Reducing agency performance in other areas by requiring the transfer of limited resources (e.g., employee time and financial resources) toward implementing the new policies and/or meeting new expectations.
- Decreasing agency interest in implementing and enforcing the policies and expectations at a later date when the agency would be prepared to do so, as the initial failure could lead to the policies and expectations going stale.
- Weakening the information governance group's credibility going forward, both with the executive leadership empowering the group and with the employees adhering to the group's policies and expectations.

An incremental approach can be taken by developing and rolling out guidance and training on recommended practices prior to establishing formal policies. This gives the agency a chance to test different approaches and adjust them as needed.

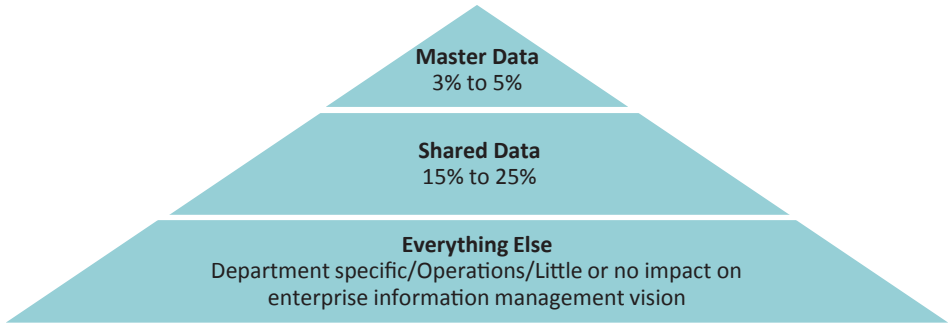
The following process (Steps 5.1 through 5.4) can be used to establish information management guidance and policies.

Step 5.1: Define Information Categories

Defining consistent ways of categorizing information is a fundamental activity that provides the building blocks for other information management activities. Defining information categories agency-wide allows for consistent handling of different information types (data sets, web content, and policy documents) and lays the foundation for searching across different repositories. Several different types of classifications are useful: scope or agency value (agency-wide, department-wide, work unit, personal); subject (environmental, construction, financial, etc.); and degree of sensitivity. Each of these methods is discussed briefly below.

Classification by Scope or Agency Value

Information classification based on scope or value to the agency is a logical first step for an information governance program because it allows the agency to decide what information requires different levels of governance. For example, as illustrated in Figure 7, at the Michigan DOT, 3% to 5%



Source: (Michigan Department of Transportation, n.d.)

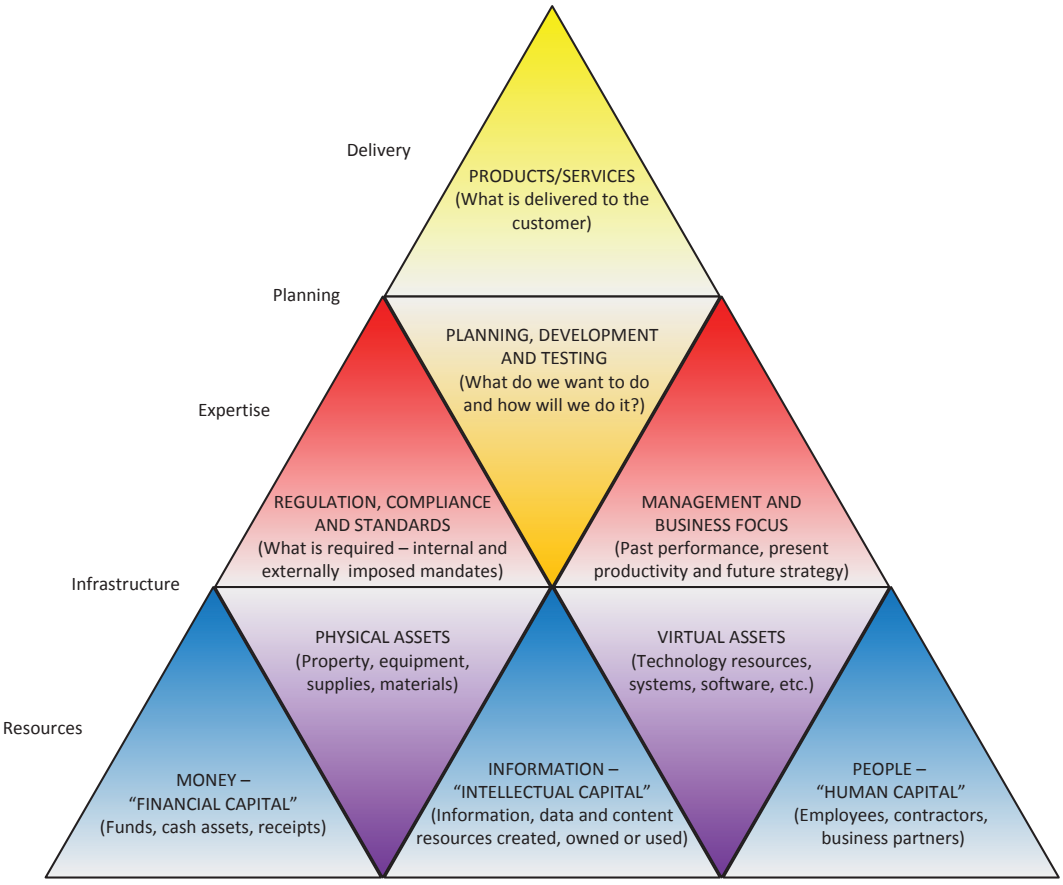
Figure 7. Michigan DOT agency-department data categorization.

of data are master data for the agency, 15% to 25% are shared, and the remainder (at least 70%) of the data are department specific, operational, or with limited impact on the enterprise information management vision. Michigan focused on structured data, but this type of classification method is applicable to documents and other types of content.

Through this classification, information that is of agency-wide significance can be classified and managed as a corporate asset. This is different from information that is only of interest within individual business units and specific project teams or for particular individuals. Governance teams are responsible for understanding and communicating this difference to individuals in the agency. For example, an agency may choose to share information that could be used across multiple business areas by multiple individuals, but does not need to share each individual's version of that data. The governance team can develop classifications that request sharing the former but not the latter and implement policies for individuals and groups to adhere to those classifications.

Classification by Subject Area

Information can be categorized by high-level subjects (e.g., spatial data and infrastructure data). These subject categories can then drive the structure of information repositories. They can also help organize subject area stewardship, assigning individual data stewards to account for data within each subject area. The high-level subjects can link to core business categories of the agency. Figure 8 shows a taxonomy structure developed by a state DOT librarian, intended to be applicable to any type of business, nonprofit, or government agency. Each triangle represents a high-level facet that could be used to classify different types of information. For example, the compliance facet would be used for documents and data related to compliance with internal or external policies, rules, standards, laws, regulations, specifications, or other governance or



Source: (Smith, 2016)

Figure 8. Sample information taxonomy.

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Minnesota DOT: Data Domain Classification by Subject Area

The Minnesota DOT has created a set of nine data domains (see table) reflecting high-level subject areas in the DOT. Each data domain has a steward, an individual assuming responsibility for the data and serving as a point of contact. The list of domains, the types of data contained in the domain, and the domain steward are available to ease data sharing and improve cross-subject data availability across the agency. An agency list is published and updated, providing data users with a clear point of contact for questions about specific data types or data within a specific domain.

Domain	Example Data Types
Human Resources	Employee data; Training and certification data; Applicant data
Financial	Procurement data; Budget data; Grant data; Transaction data
Planning, Programing, and Projects	Project scheduling data; Environmental process data
Infrastructure	Bridge data; Airport data; Rail crossing data; Safety feature data
Spatial	Boundary data; Coordinate-based data; Linear referencing data
Regulatory	Internal audit data; Prevailing wage data; Enforcement data
Recorded Events	Crash and accident data; Maintenance activity data
Supporting Assets	Equipment data; Fuel data; Building and facility data; Tower data
Business Stakeholder/ Customer	Customer market research data; City and county partner data

Source: (Minnesota Department of Transportation, 2014)

mandates. The money and funding facet would be used for content related to management of financial resources and transactions, including funding and programming.

The Minnesota DOT defined nine different subject area domains as part of its data business planning efforts (see text box titled "Minnesota DOT: Data Domain Classification by Subject Area"). These domains provide the structure for Minnesota DOT's data governance activities. A domain steward is assigned to each area to serve as the point person for data related to that subject.

A third example of a high-level subject classification method is illustrated in the text box titled "Hawley Committee Information Categories." This method was developed from research conducted in the United Kingdom in the mid-1990s that looked at 40 different private companies. The example in the text box shows the generic categories from the Hawley Committee along with DOT-specific applications to illustrate how these categories might be applied within a DOT setting.

Classification by Sensitivity

At state DOTs, it is common for some information to be highly sensitive and therefore necessary to protect at a higher level than other information. For example, a state DOT may have personally identifying information that is highly sensitive and culvert location information that is not highly

Hawley Committee Information Categories

The Hawley Committee was set up in the United Kingdom and consisted of 15 business executives from private- and public-sector organizations. Their charge was to develop a model for encouraging boards of directors to recognize and treat information as an asset. The Committee researched information assets and associated risks and opportunities at 40 organizations. The Committee recommended that all significant information assets in an organization be identified and that the board of directors for an organization should provide direction to management on actions to be taken with respect to the assets. The research identified eight types of information; these types can provide a starting point for identification of strategic information assets in any organization. The eight types of information are listed in the table, along with examples of the NCHRP Project 20-96 research team's interpretation of how DOT information types that would fit within each category.

Hawley Committee Information Category	Example DOT Application
Market and Customer	Freight and passenger demand, system utilization, demographics
Product	Capacity, travel time, transit routes, construction project scope
Specialist Knowledge	Pavement design, maintenance practices, traffic engineering
Business Process	Standard operating procedures, business process maps, manuals
Management	Performance measures and trends, funding/expenditure trends
Human Resources	Employee skills and certifications, years of service and experience
Supplier	Vendor and contractor information (offerings, prices, etc.)
Accountable (Legal/Regulatory)	Federal financial reporting, MAP-21 performance reports

Source: (Oppenheim, Stenson, & Wilson, 2001)

sensitive. Information management can differ based on information sensitivity, and this is important to consider when creating policies and expectations and communicating those policies and expectations to employees.

Figure 9 provides an example of information classification categories from Oregon.

Step 5.2: Establish Information Storage Policies

Step 5.2 is to define information storage policies. Information storage policies define where to store different kinds of information and how long different types of information should be kept.

Policies for Where Information Should Be Stored

The text boxes that follow provide two examples of information storage policies. The text box titled "Kraft Foods Information Storage Guidebook" lists the different storage options that are

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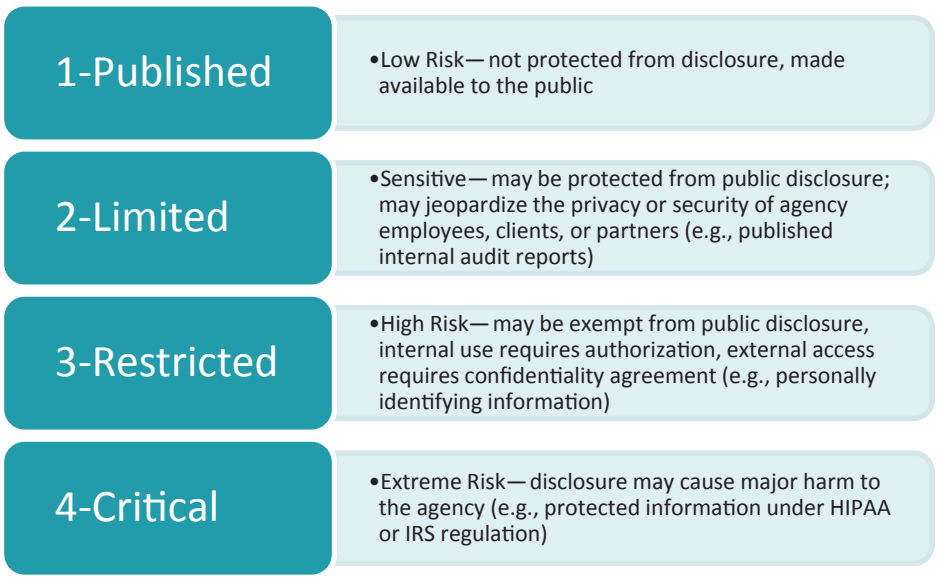
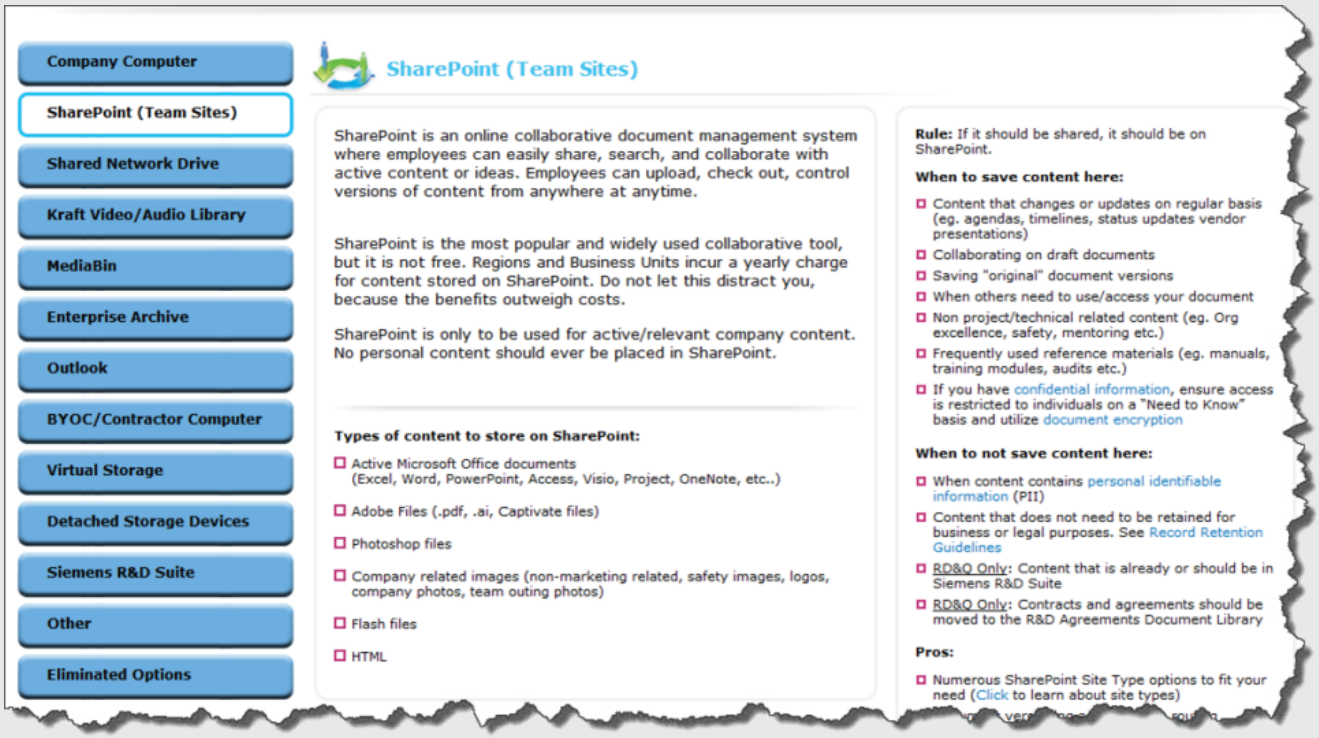


Source: Based on *Information Asset Classification* (State of Oregon Department of Administrative Services, 2015)

Figure 9. Risk-based information asset classification.

Kraft Foods Information Storage Guidebook

Kraft Foods developed a guidebook documenting where to store various classes of information. The guidebook included a description of each of the storage locations, a list of the types of content to store at each location, a simple rule describing when to store information at each location, and more detailed descriptions of when to save or not save content at each location.

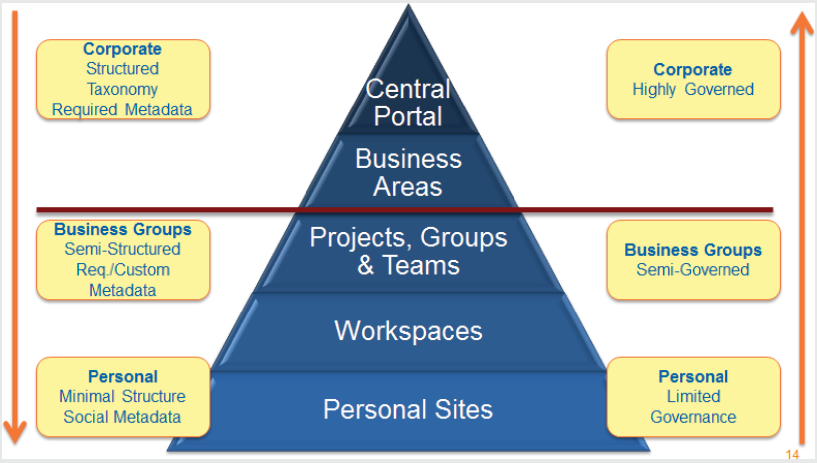


Source: (Arora and Associates, P.C., 2014)

Virginia DOT Governance of Corporate Documents in Transition to SharePoint 2010

The Virginia DOT created a stakeholder survey in 2010 to analyze its usage of internal information-sharing systems. The results of the survey reported that the sharing systems were minimally used, lacked compliant metadata that would enable wider searchability and accessibility, contained duplicate information, and contained a number of unused or obsolete team sites.

To address these issues, the Virginia DOT recognized that it needed to focus its governance efforts on a smaller portion of information. The Virginia DOT created a governance structure that acknowledged that different levels of governance are required for different agency classifications; for example, data in the central portal would be highly governed and widely applicable across the agency, while team and personal information would have more limited structure and lower levels of governance. In particular, the Virginia DOT has prioritized the centralization and storage of about 1,400 corporate documents, documents essential to the Virginia DOT's functions. These documents have the highest level of governance and are classified into highly structured areas. The Virginia DOT Knowledge Management Office is in the process of completing metadata for all corporate documents and is also working to improve the searchability of the documents.



Source: (Hammer, 2010)

available and describes the intended uses for each one. The text box titled "Virginia DOT Governance of Corporate Documents in Transition to SharePoint 2010" illustrates how information classification (in Step 5.1) can provide the basis for an information storage (and governance) policy within an agency's intranet site.

Policies for How Long Information Should Be Kept

Records management functions at statewide and agency levels will typically define different classes of public records and specify how long each type is to be retained and those types that are to be archived permanently. However, these records management functions may not apply to all types of DOT information and may not necessarily be reviewed to ensure that they match with business needs. One of the challenges for DOTs (and other organizations) is alignment

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between records management functions that are compliance-oriented and other functions that emphasize information delivery.

The easiest course of action from the perspective of an individual information user is to keep everything indefinitely "just in case." However, retaining all information results in higher storage fees and can increase agency risk exposure. In addition, keeping redundant and outdated content together with current content makes it more difficult for people to find what they are looking for.

One increasingly common technical approach to information storage is to use cloud computing or hosted storage. Cloud storage can be a relatively inexpensive approach to information storage while providing opportunities for easy scalability. In July 2014, for example, California and IBM announced the creation of CalCloud, which government agencies and municipalities could subscribe to, with the intention of allowing for improved cross-agency and cross-municipality coordination (Business Cloud News, 2014).

One study found that cloud services may provide additional functionality, but are unlikely to result in significant cost savings (Miller, 2015). Transportation agencies using the cloud for geospatial uses have found that the cloud can increase usage and impact, increase collaboration, and improve public interaction; however, the cloud also raises security concerns and has unfamiliar cost structures (Federal Highway Administration—Office of Planning, 2013). Specific issues to think about when considering a shift to cloud usage include cost, vendor, procurement, and security. Security is of particular concern to an agency, but could be addressed through a private cloud solution, such as that used by the Michigan DOT (Overman & Louch, 2013).

Step 5.3: Establish Information Life Cycle Management Activities

Agencies may wish to define policies that encourage a life cycle view of information management. These policies reinforce the idea that information is an asset that needs to be managed from creation to long-term preservation or deletion. These policies also recognize that information may be used by a variety of people for different purposes. Establishing agency-wide policies for life cycle information management can create a greater level of consistency in practice, reduce the risk of information loss, and ensure that information will be maintained and shared to address the multiple users and uses that exist.

A standard information life cycle is illustrated in Figure 10. While this model will not work for all classes of information, it can provide a foundation to help build tailored life cycles.

- **Plan.** This phase includes activities to prepare for the collection of new data or the initiation of a new project or process that will generate new content. Preparatory activities may include establishing a business case, assigning an owner, determining applicable policies for storage and retention, determining applicable standards to ensure that new information can be integrated with existing agency information and properly classified and documented, and defining milestones or events that will trigger information storage or transfer.
- **Collect/capture/prepare.** This phase calls for determining the method for information collection or capture and preparing the information for use. Once the information is acquired in the Plan Phase, it should be processed and stored in preparation for use. This could include cleaning and standardizing the information, documenting the information (e.g., recording metadata where appropriate), and loading the information into the proper storage repository. In the case of structured data, there may be additional transformation and integration processes and creation of additional information products including standard reports and GIS data layers.
- **Manage.** After information has been collected and stored, it is managed to ensure appropriate controls and auditing of access and updates. Metadata quality assurance checks are performed. Backups are made and tested.

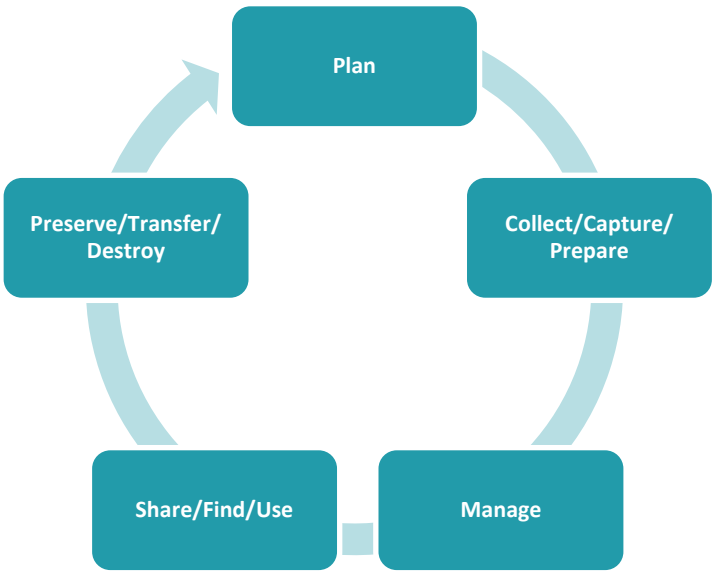

Figure 10. Standard information life cycle.

- **Share/find/use.** Information is shared, published, or disseminated via appropriate channels. It is discovered by users, who may use available tools for review and analysis.
- **Preserve/transfer/destroy.** Retention policies are applied and appropriate actions are taken to review, delete, or transfer information for long-term preservation or archiving.

A sample checklist is included in Table A-6 in Appendix A to provide a structure for following the information life cycle. This checklist could be adapted to address specific focus areas or could be used as is. The checklist includes several fundamental components of the information life cycle in order to address different aspects of each life cycle phase. An agency could use this life cycle checklist for both tabular data and content.

Different classes of information call for different approaches to the standard life cycle. For example, the information life cycle for engineering design plans might differ significantly from the life cycle for human resources information. In mapping out the information life cycle, it is important to consider all potential users and uses of the information, not just the users and uses associated with the business unit taking the lead. This broad consideration of data users and uses will impact the development of requirements, documentation, and provisions for information access.

Information life cycle development should ideally be coordinated with business process planning and mapping activities for a holistic approach that looks across different repositories and information management functions. For example, at each stage of a construction project development cycle, information of various types (design plans, photographs, calculation spreadsheets, standard forms, contract documents, etc.) is produced and stored in various agency repositories (databases, content management systems, internal and external web pages, library shelves, library digital repositories, and shared drives). Email files may also include important project records. An information life cycle plan can be developed to align with the project life cycle. This would involve defining standard practices for what types of project information should be stored in each repository and how the information should be packaged, annotated, transferred, updated, preserved, archived, or deleted at each stage of the project (e.g., design initiation, advertisement, notice to proceed, work completion, and project close-out). The information life cycle plan would be informed by a variety of perspectives: library collection policies, records retention schedules, public information officers and project staff with experience responding to public

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records requests, legal staff who handle project-related litigation, as well as field and central office staff who need to retrieve project-related information in different forms for different purposes.

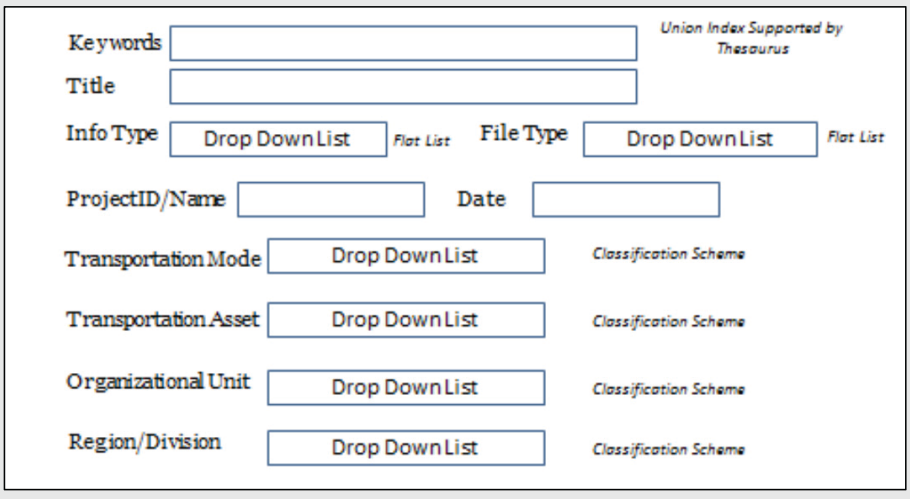
Step 5.4: Establish Information Standardization and Integration Policies

Step 5.4 establishes policy concerning standardization and integration. This kind of policy includes

- Identifying authoritative source systems for different types of data and content.
- Standardizing and controlling updates to "master data," which in a DOT includes identification, naming, and classification of core entities like routes, bridges, projects, funding sources, work categories, financial accounts, organizational units, employees, and vendors.
- Standardizing spatial and temporal referencing so that different data sets and content types can be integrated based on location and time frame.
- Standardizing metadata elements across different information repositories, some of which may use authoritative sources of master data (e.g., so that any document or data record about a construction project would be tagged with a common project identifier) as well as spatial and temporal referencing.

Standard Metadata Elements

A recent project for Washington State DOT was undertaken to "identify the components of an enterprise information taxonomy that could enhance the Washington State Department of Transportation Public Disclosure Request (PDR) team's ability to find materials which are eligible for disposition/destruction." The project identified a standard set of metadata elements to be used to tag various types of information that might be included in a PDR. The picture below shows a design of an enterprise search screen that would leverage the standard metadata elements. Organizational unit and region/division are examples of metadata elements with controlled lists of values that would be centrally managed as master agency data.



Source: (Lee, 2014). Image courtesy of Washington State Department of Transportation. Used with permission.

Geospatial Data Management Policies

Multiple state DOTs have enacted policies specific to geospatial data management. Two examples are provided below.

North Carolina DOT developed guidelines intended to maximize the value of spatial data through standardization and data sharing. These guidelines outline roles, data validation and correction processes, data storage requirements, spatial data access philosophies, and documentation. North Carolina DOT also outlines geospatial data and metadata standards that are consistent with other state geospatial standards (allowing for easier multi-agency coordination). Other topics (such as publication standards) are covered in additional documents. Examples of North Carolina DOT geospatial standards include the following:

- Standard spatial reference (North American Datum of 1983).
- Standard measurement units (United States Survey Foot).
- Linear reference standard (referenced to road network).
- Standard methods for referencing characteristics along the road network (route milepost, intersection offset, percent along a road segment, distance along a road segment, and coordinate).
- Data quality descriptions (e.g., positional accuracy).

Oregon DOT created standards to allow transportation data applications to acquire, use, and display geospatial data from a variety of sources. One example, the Oregon Road Centerline Data Standard, defined standards for items such as

- Reference systems (Oregon Lambert Conformal Conic Projection and North American Datum of 1983 Data).
- GPS (road centerline data collection standards for tools and data collectors).
- Accuracy (minimum accuracy within 40 feet for 95% of well-known features).
- Specific attributes (a data dictionary is included that provides detailed information on attributes, e.g., "UNIQUE-ID" corresponds to a segment identifier and is a concatenation of the agency identifier, line identifier, and road ID number).

Sources: (North Carolina Department of Transportation, 2012; Oregon Department of Transportation, 2014)

Several DOTs have developed geospatial data management policies to address geospatial standardization. Given the importance and value of integrating DOT information spatially, this is a logical starting point for standardization efforts. Many DOTs have also used data warehouse and agency-wide performance reporting initiatives as an opportunity to improve standardization and implement master data management practices.

To be effective, standardization policies should be based on an understanding of the current state of information in the agency and the reasons why standardization has not yet occurred. Typically, there are historical as well as technical reasons that need to be addressed as part of policy implementation. Once desired standards are identified, it may take time to change both information systems and business practices to conform to the new standard.

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Key Points

Most DOTs have policies and procedures that establish common practices and ensure consistency. Step 5 outlines a range of policies that can be put in place to ensure consistency and coordination across different information management functions in the agency. These policies cover classification of information based on scope of use and sensitivity, practices for managing information across its life cycle, and standardizing data and metadata to facilitate integration and discovery across the agency.

Step 6. Establish a Process for Evaluating and Prioritizing New Information Initiatives

Step 3 discussed developing a coordinated agency plan for information management, which includes identifying and prioritizing initiatives to move the agency toward its vision. Once the roadmap has been completed, it will be necessary to put an ongoing evaluation and prioritization process in place to update the roadmap and allocate resources for its initiatives via the agency's budgeting process.

The first question to be considered is which types of "information initiatives" should go through an agency-wide prioritization and budgeting process and which should be selected and funded at the discretion of individual business units. A variety of candidate projects or efforts—such as those regarding new data or content collection, information integration, information system acquisition or upgrade, workflow automation, and so on—may be initiated from different business units in the agency to meet emerging needs and improve efficiencies. Agencies need to strike a balance between an overly centralized approach that can impede the agility of business units and an overly decentralized approach that makes it more difficult to move toward established agency goals for information management. Prioritizing information management projects with agency-wide impacts in the context of agency strategic objectives can yield better business outcomes for the agency as a whole.

One approach is to establish clear criteria for which types of efforts need to go through an agency-wide evaluation process. Criteria may be based on size, scope of use/impact within the agency, or use of information technology resources. Many agencies already have an established information technology project prioritization process which could be adapted to include additional types of initiatives (such as new data collection or metadata and taxonomy improvement projects). Another approach is to establish an annual agency-wide budget for different categories of information management improvements and accept project nominations from different parts of the agency that are selected on a competitive basis.

Information management projects can be evaluated and prioritized using a process that is analogous to how agency capital improvements are prioritized. Information management project prioritization would involve identifying how each project within each department is aligned with the goals, objectives, and strategies identified as part of the information management plan developed in Step 3.

A sample information management project prioritization approach is presented in Figure 11.

The evaluation and prioritization process can include qualitative and quantitative components and should address a variety of topics. A sample form with criteria to include in an evaluation is presented in Table A-7 in Appendix A. This form could be used as part of the sample approach shown in Figure 11, as a way to establish criteria for determining project impact.

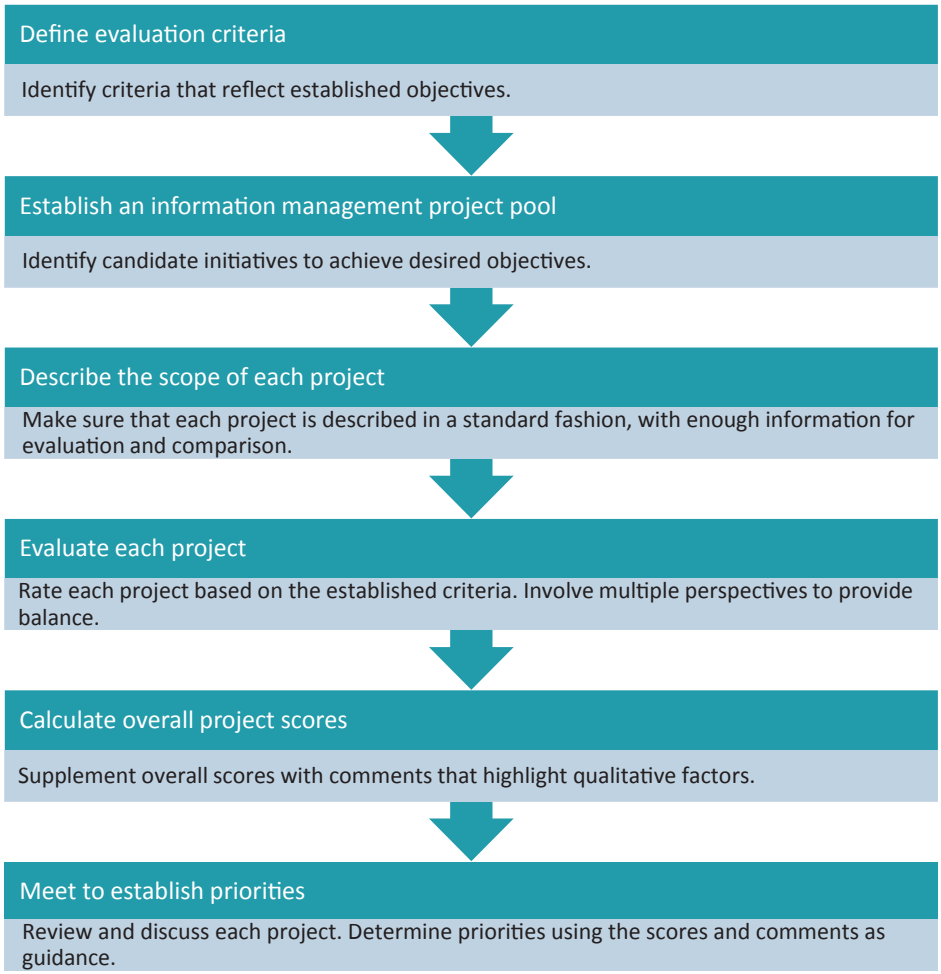

Figure 11. Sample project prioritization approach.

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Utah DOT Information Technology Project Evaluation and Prioritization

Utah DOT piloted an information technology project prioritization framework modeled after the approach the agency uses to prioritize capital transportation projects. While the agency is continuing to refine this framework, it provides a useful example of how to structure an approach for prioritizing investments to improve information management and access. This structured approach demonstrates one example methodology for evaluating and prioritizing information management projects.

In the process, projects are nominated and rated based on several factors including

- Organizational impacts (e.g., preserve infrastructure, optimize mobility, number of users).
- System condition (e.g., meets current business requirements, meets security requirements).
- Project value and funding source.
- Project risks (e.g., level of impact on business processes, anticipated user/customer acceptance).
- Non-tangible benefits (e.g., improve data input/quality, improve state/federal compliance).
- Benefit ratio (estimated tangible savings and cost avoidance/total estimated project costs).

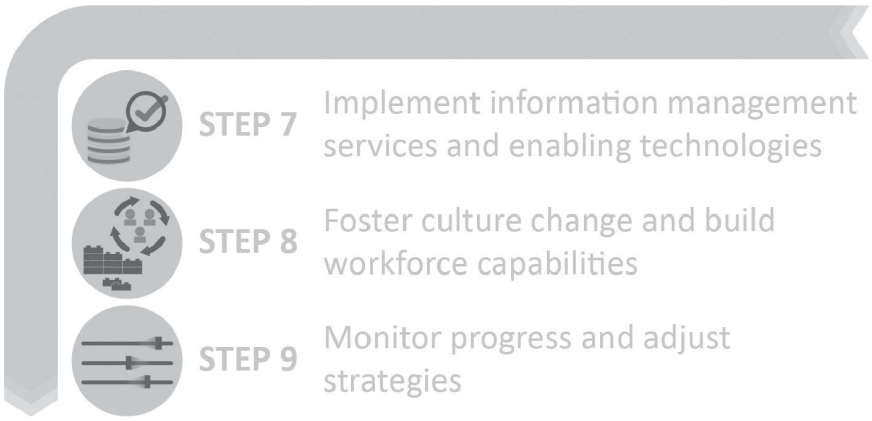
A prioritization committee uses ratings in each category to determine an overall project score. The committee then ranks the projects based on this overall score. The prioritization committee then uses these rankings to make a recommendation to the Portfolio Management Team, which is chaired by the Utah DOT Deputy Director and includes Utah DOT executive staff. The Portfolio Management Team then provides a final list to the Director, who has veto power on the projects.

Key Points

An agency-wide process for evaluating and prioritizing potential initiatives for improving information management can be implemented to ensure that scarce agency resources (staff time as well as available funds for consultants and new technology) are used wisely. This process can build on existing agency capital project or information technology project selection processes. The focus should be on projects of agency-wide significance that will require significant investments, rather than on creation of a process that introduces unnecessary bottlenecks for division or department-level efforts.

CHAPTER 6

Implementing and Sustaining Change



Step 7. Implement Information Management Services and Enabling Technologies

Step 7 involves establishing standards and processes to implement and maintain a consistent agency-wide structure for classifying, defining, describing, integrating, and finding data and information. This step encompasses coordination of data and information architecture-related activities that may currently be carried out by libraries, records managers, content managers, data offices, and information technology groups. It also includes deployment of enabling tools and technologies that support information management including content management systems, terminology and metadata management tools, data warehouses, data integration tools, data catalogs, business intelligence tools, and data-cleansing tools.

Key information management services can be grouped into six categories:

- Architecture and standards;
- Records and content management;
- Library services and information provisioning;
- Metadata and terminology management;
- Enterprise search; and
- Data integration, reporting, and analytics.

Each of these services and their enabling technologies are summarized in Table 2.

A comprehensive DOT information management strategy will consider how each of these functions is currently being performed and will define priority improvements needed to deliver business value. The strategy will identify ways to achieve synergies across these different functions.

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Table 2. Information services and enabling technologies.

Service	Description	Enabling Technologies
Architecture and Standards	Developing and implementing standards for where information is to be stored and how it is to be integrated and delivered.	Enterprise Architecture tools, information modeling tools
Records and Content Management	Capturing, organizing, indexing, storing, and delivering different types of information objects including documents, images, and email. Web content management is a subset of this involving creating, organizing, and updating content for internal and external agency websites.	Content management systems, records management systems, email archiving systems, web content management systems
Library Services and Information Provisioning	Curating, collecting, cataloging, and organizing publications and other information resources to meet agency needs. Responding to information requests through clarification of information needs, directing users to available resources, compiling summaries of available resources, or providing requested information.	Library management systems, search engines, document and content management systems, knowledge management solutions
Metadata and Terminology Management	Establishing metadata standards for different content types; developing and maintaining business glossaries, controlled vocabularies, and taxonomies to facilitate search and discovery.	Taxonomy/thesaurus management tools, text analytics tools, enterprise metadata repositories
Enterprise Search	Deploying and refining search capabilities within and across different agency information repositories.	Search engines, enterprise search software (including text, image, and audio analytics), search monitoring tools
Data Integration, Reporting, and Analytics	Deploying and refining capabilities for analysis and visualization of integrated, authoritative information.	Data warehouses, data integration tools, business intelligence and reporting platforms, big data search and analytics platforms

A full technical discussion of these services is beyond the scope of this guide. However, key selected practices are highlighted below.

Architecture and Standards

Architecture and standardization are critical activities that provide a common "map of the territory" when it comes to information management. If done well, architecture efforts can help everyone in the organization understand what information exists and where to find it. Analogous to designing a house renovation, architecture projects produce an "as is" view of information as well as a "to be" view. The "to be" view may involve consolidation of different information repositories and show how information is to be linked across repositories through use of consis-

tent standards and integration methods. The scope of architecture efforts can vary from a single system effort to an organization-wide one. Architecture can be all-encompassing, covering all aspects of the organization's functions, processes, information, and technology, or it can focus on one of these.

A good DOT information architecture should recognize and balance different stakeholder concerns, including the following:

- Agency staff seeking access to authoritative agency information,
- Agency staff seeking secure and convenient storage for their working documents,
- External partners who need to collaborate and share documents with DOT staff,
- Agency staff responsible for developing and updating content on the agency's external facing website,
- Agency staff responsible for developing and updating content on the agency's intranet,
- Library staff and archivists responsible for developing and maintaining collections of agency publications,
- Agency staff who must respond to information requests from auditors,
- Public information officers who must respond to information requests,
- Legal staff who perform e-discovery tasks in response to litigation,
- Records managers charged with responsibility for development of and compliance with retention policies,
- Research and library staff charged with responsibility for providing access to both internal and external information resources to meet business needs and helping agency staff to find relevant information,
- Information security officers charged with protecting sensitive information, and
- Information technology managers seeking to contain cost increases for data storage.

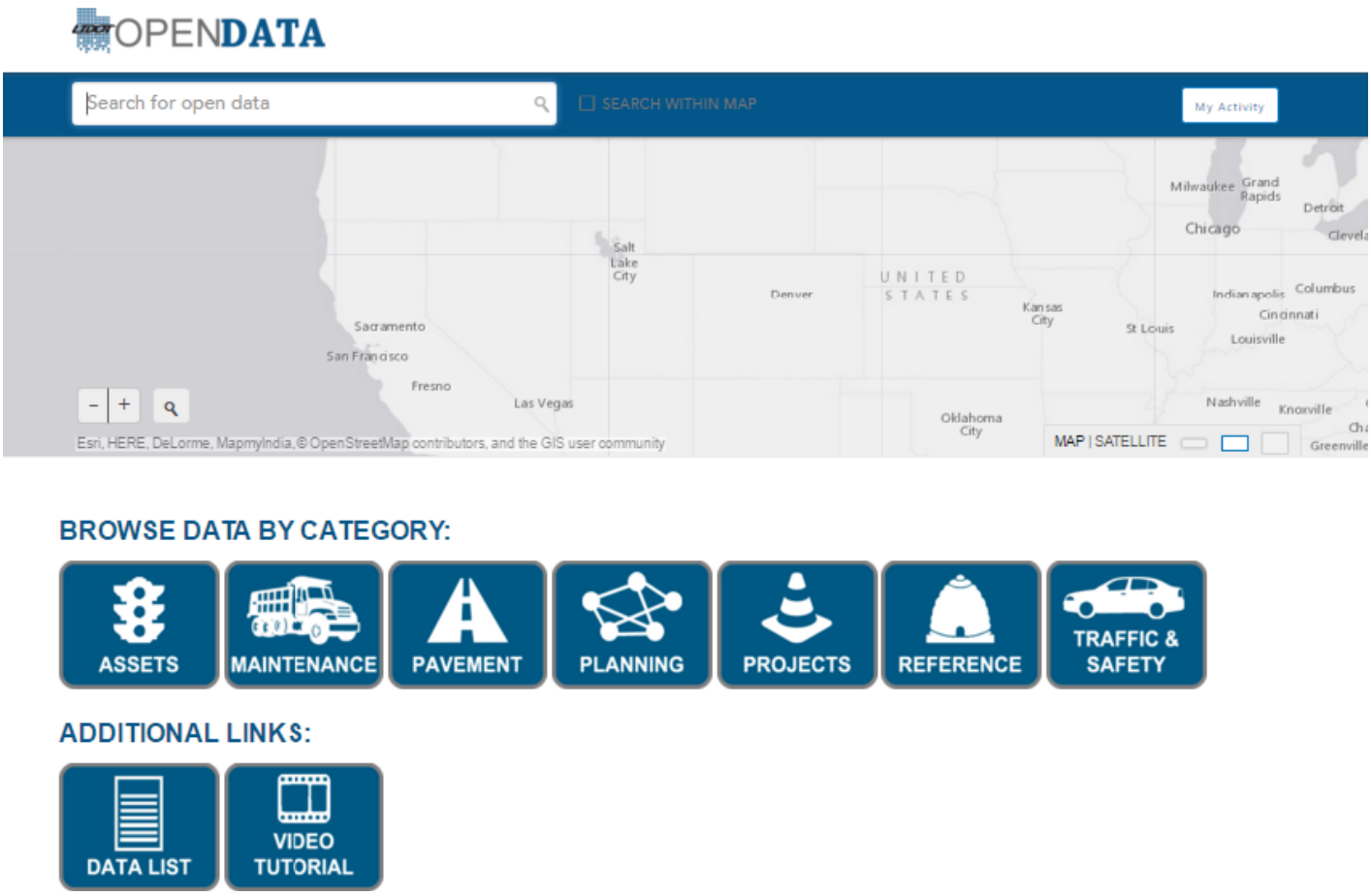
By looking at the different information needs that exist and the different places where data and content are stored, architecture efforts can seek to reduce duplication, increase consistency, facilitate integration, reduce risk, and improve information access. It is important to recognize that changing existing patterns of behavior around information storage and access is not easy. Thus, an architecture project is not a purely technical exercise; it requires extensive stakeholder involvement and considerable attention to how changes will be phased and managed.

Information Architecture

Information architecture is an evolving discipline that has been defined as "art and science of shaping information products and experiences to support usability and findability." Information architecture brings together an understanding of content, business context, and user information needs to "help people find what they need and understand what they find" (Morville, 2012; Rosenfeld, Morville, & Arango, 2015). In practice, it involves extensive work with users to understand how they interact with information. Information architecture efforts commonly focus on design of web sites, but information architecture principles and practices can be applied more widely to look at information organization and access.

Information organization in the digital world involves deciding where different types of information will be stored and how they will be categorized and ordered to facilitate future retrieval for different purposes. For example, as illustrated in Figure 12, a web site providing access to different data sets in a DOT can allow the user to browse data by category.

Classifications can be based on multiple criteria such as content type, geographic area, mode, and business function. In addition, standard keywords or tags can be assigned to help users find information on a particular topic. Adopting processes to classify and organize information can increase efficiency, decrease data duplication, and improve information accessibility.



Source: (Utah Department of Transportation, 2015)

Figure 12. Utah DOT open data categories.

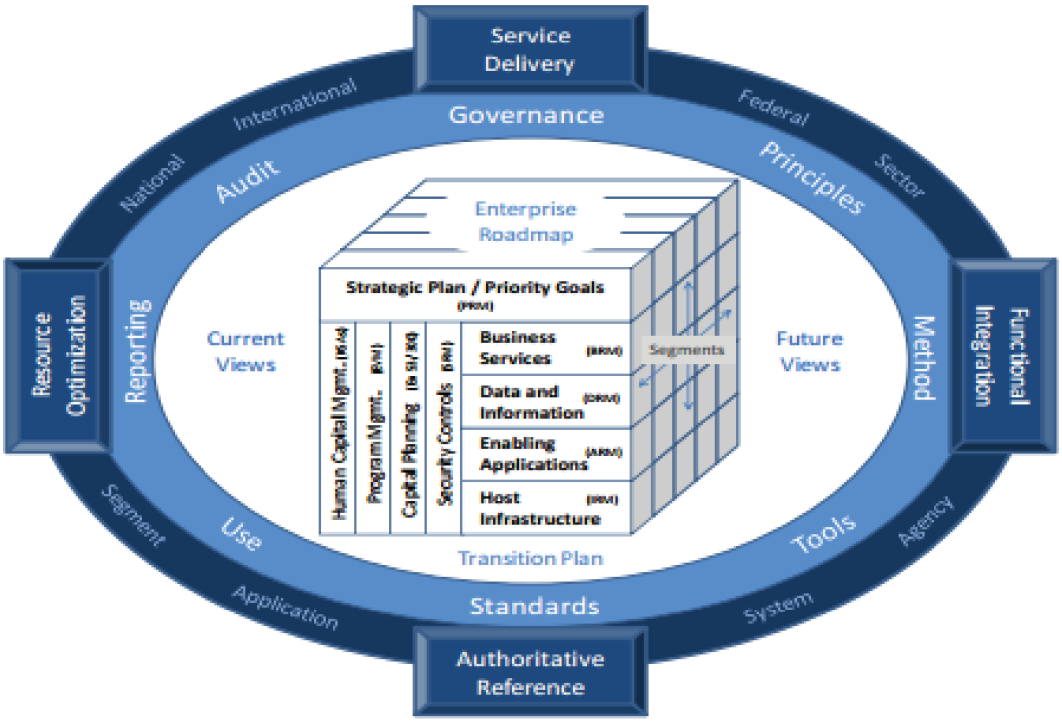
An understanding of user information needs and patterns of information seeking is integral to effective information architecture.

Enterprise Architecture

Enterprise architecture is broader than information architecture. Enterprise architecture creates a blueprint for how an agency will meet its future information needs and transition from the current state ("as is") to a desired future state ("to be"). It includes looking at business processes, data/information, applications, and technology infrastructure.

There are several available enterprise architecture frameworks (both commercial and open source), including the Federal Enterprise Architecture Framework (FEAF) illustrated in Figure 13.

From a DOT strategic information management perspective, the business process and data/information components of enterprise architecture can be very useful for systematically documenting information assets and their relationship to different business functions. Kansas DOT conducted an extensive architecture project (Kansas Department of Transportation, 2003) in the mid-2000s involving diagramming of data flows across business units and external entities (e.g., FHWA) for major business processes (e.g., program management, preconstruction, and project initiation). Ohio DOT completed an enterprise architecture design study in early 2014 that included a data architecture to "establish data standards for all of Ohio DOT's systems



Source: (Executive Office of the President of the United States—Office of Management and Budget, 2013)

Figure 13. Federal enterprise architecture framework.

to support integration and information sharing between these systems" (Cooney, Clement, & Shah, 2014).

Architectures are rarely static; they require ongoing efforts to refine and update. An enterprise architect role is essential for developing and maintaining the architecture and ensuring that standards are applied appropriately.

Records and Content Management

Records and content management practices as well as enabling technologies provide an important mechanism for ensuring that a DOT's important documents and files are preserved, well-documented, and available when needed. Records management functions are typically focused on compliance and have historically emphasized physical records. Content management functions (which include document management) are focused on digital information and are implemented to improve active information access and efficiency. However, given the proliferation of records in digital form, records management and content management functions are less distinct and therefore require more coordination than in the past.

Records Management

All state agencies are subject to public records requirements (Reporters Committee for Freedom of the Press, 2011) and must identify records; establish records retention schedules; track, manage, preserve, and dispose of records per retention schedules; and organize records so that they can be made available on request. DOTs depend on sound records management processes and systems in order to efficiently respond to public records requests, meet U.S. DOT record-keeping requirements, and handle information requests related to audits and litigation. Public records are typically broadly defined (see text box titled "Ohio DOT Public Records Function").

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Ohio DOT Public Records Function

Definition: "Any document, device, or item, regardless of physical form or characteristic, including an electronic record, created or received by or coming under the jurisdiction of any public office of the state, which serves to document the organization, functions, policies, decisions, procedures, operations, and other activities of ODOT [Ohio DOT]."

Exemptions (examples): Cost estimates of projects prior to all bids being received, sealed bids for construction projects, employee medical records, social security numbers, home addresses and telephone numbers of state employees, infrastructure records that disclose the configuration of the DOT's critical systems.

Procedures: Each office has copy of current retention schedule; requests can be verbal or in writing; requests are acknowledged; request may be clarified if ambiguous; the Ohio DOT fulfills request, redacting exempt portions, or denies request and cites legal authority for denial; copying fee is collected if hard copies are requested.

Source: (Ohio Department of Transportation, n.d.)

DOTs are subject to policies and processes established at the statewide level, including retention schedules for general categories of administrative documents (e.g., financial, personnel, facilities, and equipment, etc.). Agency-specific retention schedules are developed to reflect the unique categories of records at the DOT (e.g., annual reports, performance reports, plans, and surveys).

Content Management

There are different types of content management systems with overlapping functions. In DOTs, there might be a system for engineering drawings, one for web content management, a third for official records management, and a fourth focusing on workgroup collaboration. Having different types of systems is not necessarily problematic as long as there is a clear strategy for avoiding ambiguity and duplication of effort and ensuring that compliance obligations are met.

Web content management systems offer features for authoring content, storing multimedia components, and publishing to multiple locations. They may also include a built-in workflow to manage content intake, metadata assignment, and publication.

Content management systems typically include the following capabilities:

- **Capture/create**—import/upload multiple content types, use integrated scanning/imaging to convert paper documents, integrate with email and other business applications.
- **Manage**—catalog; author/assign metadata; control access; manage workflow including intake, check-out/check-in, versioning, auditing, archiving, and deletion.
- **Store/preserve**—provide both active and archive storage, de-duplication.
- **Deliver**—search/access from multiple locations, print, publish to the web, share with other applications.

Important considerations in implementing content and document management systems include the following:

- Clarity on what the goals of the system are and how to measure success.
- Governance, i.e., who will be tasked with establishing parameters for system utilization and handling issues as they arise.

- Types of content/documents to be managed and potential overlaps with other systems.
- Consistency in information organization, metadata, and terminology with other agency systems to enable searches across systems and to foster a familiar method of information retrieval.
- Clear expectations for who will be adding content, providing metadata, and cleaning up content that is no longer needed.
- Initial and ongoing support for the system.

Lessons Learned from Electronic Document and Records Management System (EDRMS) Implementation (from National Archives of Australia)

Implementation Should Be Business-Driven. The implementation of an EDRMS project was more than technology. The project was about improving digital information management and the way people work with digital information. Successful implementations that met business needs and were accepted by users had strong information technology support and involvement, but were not information-technology-driven initiatives.

Change Management Is Required. Agencies felt that the implementation of an EDRMS should be treated as a change management project. Staff members were aware that new ways of working may be better for the agency as a whole but did not necessarily see any benefits to them and their work.

Leadership Support Is a Critical Success Factor. With senior management championing the project, all agencies acknowledged that implementation of an EDRMS had a better chance for success. Chief executive officers and branch heads using the EDRMS actually encouraged take-up throughout the agency.

A Range of Skills and Experience Were Needed. Significant input was required from professionals with skills and experience in records and information management, information technology, business analysis, project management, and change management.

Support Transition in Staff Responsibilities. End users were sometimes required to assume more responsibility for managing their own records (for example, creating and naming electronic files). Some agencies acknowledged that they did not invest enough time in developing business rules and training staff in basic records management responsibilities. If business records had been kept in unstructured storage areas such as shared folders, email folders, and personal drives, the migration of these records to the EDRMS was a trigger for staff to use the new system. Some agencies held special events such as "records week" prior to the migration of documents stored on unstructured drives to the EDRMS.

Source: adapted from "Implementing an EDRMS—Lessons from Agencies" (National Archives of Australia, 2011)

Library Services and Information Provisioning

As of 2009, 34 state DOTs had a transportation library (U.S. Department of Transportation, 2014). State DOT library collections generally include agency-specific information resources (e.g., agency research reports, plans, manuals, maps, photographs, and state transportation legislation) as well as national transportation information resources (e.g., engineering standards and

U.S. DOT, TRB, and AASHTO reports and journals). Some libraries provide access to subscription databases and curated web resources. Most libraries maintain a mix of print and digital collections, but have placed greater emphasis on digital collections in recent years.

Transportation librarians bring formal training in library science and have expertise in the collection, organization, preservation, and dissemination of information resources. They also bring detailed knowledge of available transportation-related information sources. Many participate in transportation knowledge networks (U.S. Department of Transportation, 2015) that provide a valuable channel for sharing of policies and practices across peer agencies. Some DOTs are taking advantage of these unique capabilities and using their librarians to assist with developing web content, developing and managing controlled vocabularies (for broader application beyond indexing of library collections), creating metadata for data sets, performing literature reviews to support agency research, and providing reference and advisory services.

Wisconsin DOT Transportation Library Web Site

A unique aspect of the Wisconsin DOT library web site is the philosophy of partnership with different areas and personnel within the DOT. Currently, more than a dozen staff members have web author rights to maintain separate areas of the library site by contributing their subject expertise to the design and content of the original site. The Office of General Counsel, Office of Public Affairs, Division of Motor Vehicles, Division of State Patrol, Bureau of Highway Operations (Research Section), to name a few, all have rights and separate areas within the library site that they maintain. The result is that the library is a central conduit and repository for others within the DOT.

Source: (Wisconsin Department of Transportation, 2009)

Metadata and Terminology Management

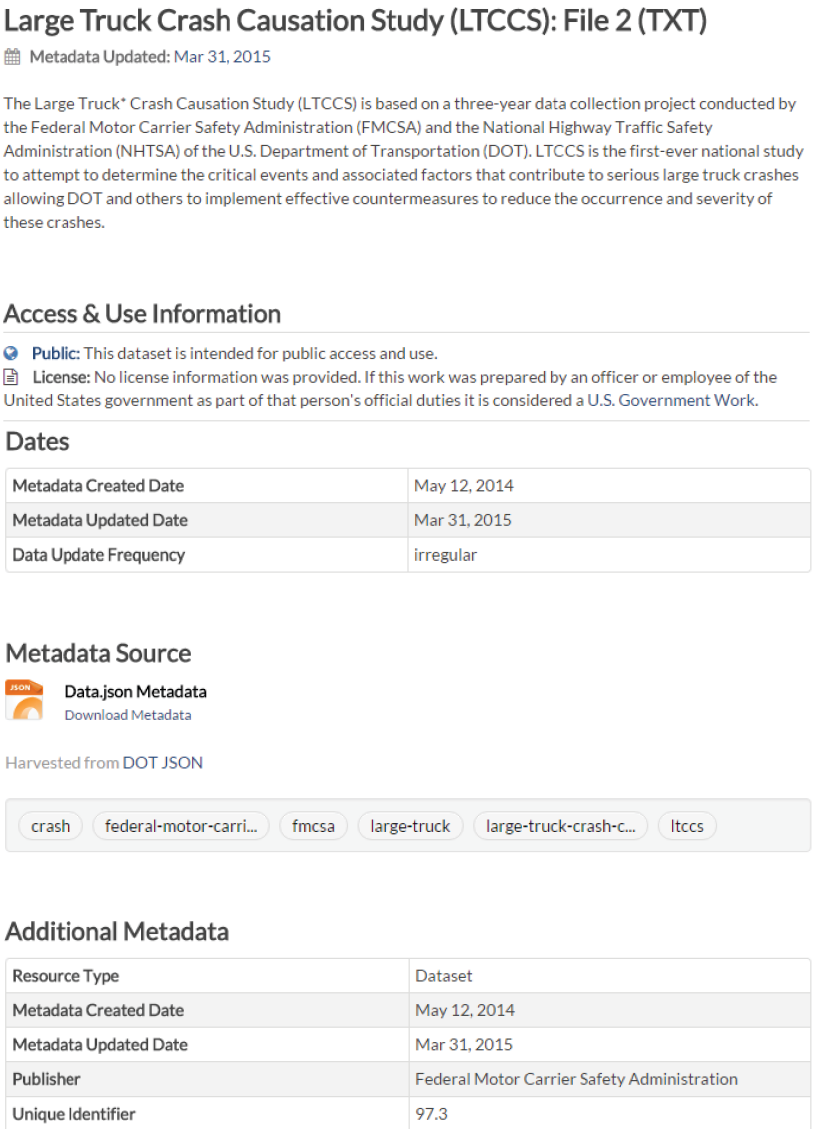
Metadata Management

Metadata is "structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource" (National Information Standards Organization, 2004). Metadata comes in multiple forms, such as the following:

- A data dictionary describing what each data element means,
- A set of "tags" identifying the subject of a photograph,
- A card catalog entry for a book, and
- A detailed description of a data set.

Creating and maintaining metadata is essential to effective information management. However, maintaining metadata requires time and effort, and many organizations find it difficult to sustain metadata management without dedicated resources. Therefore, it is important to be judicious about defining minimum metadata requirements and then to make a commitment to ensure that they are followed. An agency's library staff can be an important resource for metadata creation, providing rich expertise in information organization and classification.

Defining consistent metadata elements across different agency information sources is a strategy that takes time and effort, but it can be a way to provide centralized access to information without actually having all of the content in one place. For example, some agencies have implemented metadata repositories that provide a single location to see information about all of an agency's



Large Truck Crash Causation Study (LTCCS): File 2 (TXT)

Metadata Updated: Mar 31, 2015

The Large Truck* Crash Causation Study (LTCCS) is based on a three-year data collection project conducted by the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation (DOT). LTCCS is the first-ever national study to attempt to determine the critical events and associated factors that contribute to serious large truck crashes allowing DOT and others to implement effective countermeasures to reduce the occurrence and severity of these crashes.

Access & Use Information

Public: This dataset is intended for public access and use.
License: No license information was provided. If this work was prepared by an officer or employee of the United States government as part of that person's official duties it is considered a U.S. Government Work.

Dates

Metadata Created Date	May 12, 2014
Metadata Updated Date	Mar 31, 2015
Data Update Frequency	irregular

Metadata Source

Data.json Metadata
Download Metadata

Harvested from DOT JSON

crash | federal-motor-carri... | fmcsa | large-truck | large-truck-crash-c... | ltccs

Additional Metadata

Resource Type	Dataset
Metadata Created Date	May 12, 2014
Metadata Updated Date	Mar 31, 2015
Publisher	Federal Motor Carrier Safety Administration
Unique Identifier	97.3

Source: (U.S. General Services Administration, 2015)

Figure 14. Metadata from Data.gov.

centrally managed databases, data tables, and data elements. With the growing emphasis on open data, the value of metadata is becoming more obvious, and practices for creating metadata are maturing (See Figure 14).

Terminology Management

Many DOTs have developed glossaries of terms in order to get new employees and partners up to speed and provide a precise common language. Glossaries can help to answer basic questions such as "What is a project?" or "What is the definition of a divided highway?" Other terminology management tools such as taxonomies and thesauri can be used to further define how different terms are related to one another (e.g., a crash is a synonym for a collision; coal is a type of commodity, etc.). TRB and U.S. DOT have worked for many years to create and maintain a set of standard terms for indexing transportation research products (the Transportation Research Thesaurus; Transportation Research Board, n.d.). Taxonomies can be integrated with content management systems to improve search capabilities (Will, 2013). For example, through taxonomy management, users can find more specific, more inclusive, or related topics (Walli, 2014).

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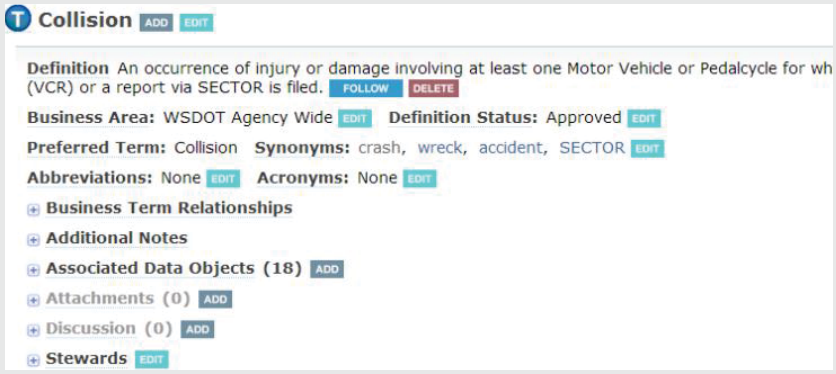
Washington State DOT: Data or Term Search (DOTS) Metadata Repository and Taxonomy Management System

Washington State DOT has implemented the DOTS metadata repository. DOTS contains data definitions and provides the business stewards of business terms and data objects so that users know who to go to for more information. DOTS also includes a search capability to provide users with access to more relevant information.



As part of DOTS, a thesaurus management tool defines broader "parent" terms, narrower "child" terms, and related terms, which allows users to more easily find the appropriate terminology. This taxonomy management tool is integrated into the metadata repository, built around a hierarchical relationship between terms defined through the metadata. This enables users to access any available metadata for linked terms that are listed in the thesaurus.

Source: (Everett, 2014). Images courtesy of Washington State Department of Transportation. Used with permission.

Software is available to support management of terminology, including taxonomy creation and implementation. This software may allow users to import existing taxonomies, automatically generate a new taxonomy, and automatically classify text into an existing taxonomy; it may also maintain taxonomies by updating related fields, which is important given the relational nature of taxonomy management (Walli, 2014).

Enterprise Search

Enterprise search capabilities allow users to search for content within and across different types of repositories in an organization. Enterprise search is generally much less effective than Internet search, since Internet search algorithms rely on the presence of millions of links across web pages

(White, 2015). A poor search function for an agency intranet site or content management system can result in a lack of user confidence and ultimately lack of use.

While enterprise search technology is constantly improving, it requires skillful configuration and ongoing maintenance in order to maximize search results. Configuration and maintenance involve monitoring of search terms that are used and deployment of strategies, including use of hand-picked "best bets" for the most frequent searches, weighting of results ranking based on preferred sources, and use of taxonomies to match search terms with synonyms or related terms. Development of "advanced search" and faceted search capabilities with appropriate facets is another activity that can dramatically improve the user search experience.

There are a growing number of commercial search solution offerings that include capabilities for searches across different information repositories. Deployment of these solutions requires careful planning and design to navigate different access protocols and translate across different metadata elements. Information architecture activities (discussed above) can include work to harmonize metadata in order to reduce some of the challenges to configuration of cross-repository searches.

Data Integration, Reporting, and Analytics

Data Warehouses

Data warehouses are a common approach to integrating data from multiple source systems to enable consistent reporting from a single, consolidated database. Whereas source systems (sometimes called "transactional systems") are designed to efficiently add and update individual data records, a data warehouse is structured specifically to support reporting and analysis. Data warehouses can be used to provide trend data as well as support drill down capabilities that are useful for data exploration. Creating a data warehouse involves understanding the organization's reporting and analysis requirements and then developing processes to "extract, transform, and load" data from various sources into the warehouse. Data warehouses take time, skill, and effort to design, build, and manage. Incremental implementation, prioritization of data and features based on value added, clear policies about what the data warehouse will and will not take on, sufficient ongoing staff resources, and expectation management are all important to success.

Utah DOT: Data Warehouse Development

The Utah DOT created UGATE, a data warehouse that provides access to a variety of agency data. UGATE initially focused on geospatial data, providing the internal data storage and organization to support UDOT's UPLAN data portal. The Utah DOT is working to extend UGATE to include additional data on construction projects and related financial and asset data.

Geographic Information Systems

Most DOTs use GIS to integrate a variety of data based on location. Methods for creating, managing, and delivering spatial data are critical elements of a DOTs information management strategy. As GIS technologies have matured, spatial data are more integrated with conventional (non-spatial) database systems, and there are now end-user tools for creating and updating spatial data, creating maps, and performing spatial analysis. This shift allows DOTs to rethink how they manage and support spatial data. The shift also allows for increased emphasis on value-added analysis. For example, integrating GIS with asset management practices can help agencies understand asset condition, assess and manage risks, identify needs and work candidates, develop

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programs, and manage and track work (Spy Pond Partners, LLC; Transcend Spatial Solutions, LLC; James P. Hall, 2015).

Other Data Integration Methods

While they are not used as commonly as GIS, middleware technologies are used by some organizations to enable live integration of data from their source systems without physically moving data to a consolidated warehouse.

Increasingly, service-oriented approaches are being implemented to provide access to data from different sources. For example, an agency building an application for displaying spatial data can access a variety of data sources that have been published as services. Agencies can also use data services as a way to provide authoritative versions of master codes (e.g., list of districts) used in multiple applications.

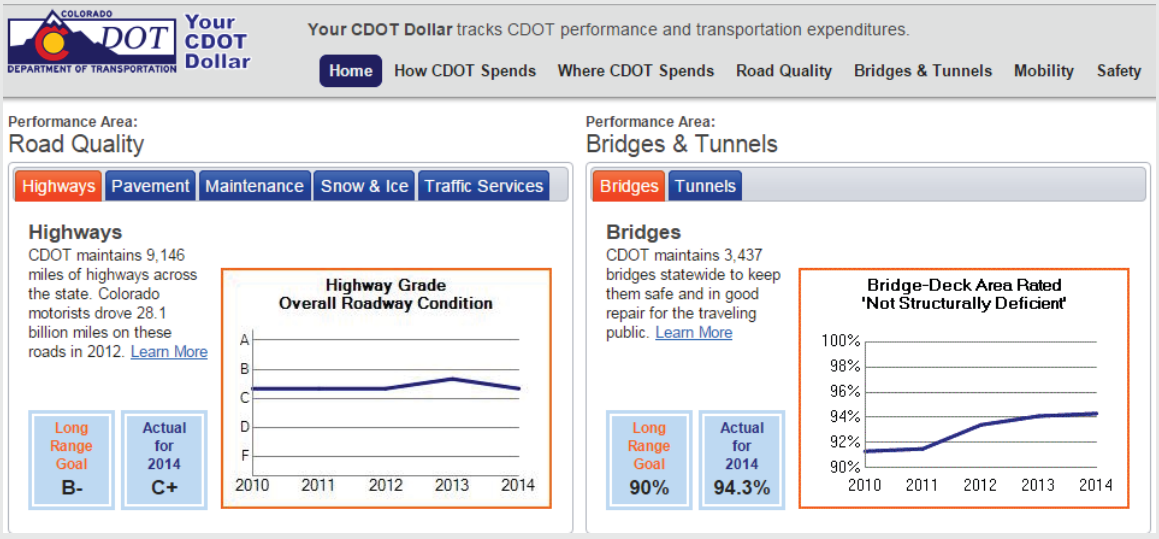
In order to address integration of "big data"—encompassing continuous data streams, very large data sets, and varied formats—some vendors have been promoting the concept of a "data lakes." Data lakes collect a variety of data sources in a single location. However, in contrast to a data warehouse, all data are stored in their native format. Specialized tools can then be used to explore and analyze the data to meet specific needs as they arise. There is some debate about the value of data lakes, and while some applications exist, the practice is still maturing (Stein & Morrison, 2014; Gartner, Inc., 2014).

Reporting, Mapping, Business Intelligence, and Dashboards

Reports, maps, dashboards, charts, and other interactive data and content exploration tools are the visible products of an organization's information management initiatives. Without

Colorado DOT: Your CDOT Dollar

The Colorado DOT developed a dashboard for performance reporting (Your CDOT Dollar), which is also made publicly available online. This dashboard compares agency performance to the Colorado DOT long-range goal across different areas. It also displays a graph of recent historical performance, allowing the user to identify the performance trend. Users can further drill down into each of the categories to compare historical performance against historical targets, and view the annual performance together with the annual budget.



Source: (Colorado Department of Transportation, n.d.)

centralized planning and control, agencies may find a proliferation of tools and approaches created by users to meet specific needs, resulting in duplicated effort, confusion caused by inconsistently defined reports, and multiple uncoordinated efforts to resolve data issues. On the other hand, a completely centralized approach can create bottlenecks, stifle creativity, and leave a large gap between what users need and what is available. A middle ground approach is to identify the types of reporting needs that exist and identify some standard ways to meet these needs. For example, an agency can provide a combination of self-service tools for simple reporting from standard agency data sources and define a process for requesting information technology services for development of more complex reports.

A proactive approach to meeting agency information access needs can reduce overall costs and provide higher quality solutions than would be found otherwise. However, strong leadership and governance is required to gain agreement on needs and to balance competing priorities.

Big Data Analytics

Big data sources—which include real-time data streams and unstructured or semi-structured data types (e.g., imagery or social media posts)—pose data management and analysis challenges. Big data cannot easily be stored in available agency databases or queried and summarized using existing tools. Big data analytics provide methods for transforming large volumes of data into information that agency staff and/or customers can use for decision-making purposes. Advanced statistical methods and artificial intelligence techniques are being applied to identify patterns and relationships and provide predictive capabilities. Data visualization techniques are an important adjunct to analytics, enabling analysts to derive information from data, for example:

- Variations in congestion (including bottlenecks, delay, travel time variability) by location, time of day, day of week, and month of the year, as well as long-term trends.
- Accident/incident heat maps showing spatial and temporal distribution by category/cause.
- Comparison of automobile versus bicycle and transit mode share across geographic areas.
- Patterns of weigh station violations by time of day and day of week.

Through visualization and big data analytics, agencies can improve information management and make better use of available data. One compelling example of this is from United Parcel Service (UPS) and is shown in the text box titled "UPS On-Road Integrated Optimization and Navigation ('ORION')."

UPS On-Road Integrated Optimization and Navigation ("ORION")

UPS had a wealth of data from vehicle sensors capturing engine performance, idling, and vehicle location and driver handhelds capturing delivery information. UPS was able to combine these sources, along with various UPS business rules, into the foundation of a system to optimize vehicle routing. By using the historical data processed from the vehicle sensors and driver handhelds, ORION was able to analyze approximately 200,000 route possibilities for a driver's stops each day (an average of 120 stops per driver). Among other things, the optimization ultimately led UPS to minimize left turns when possible, as these led to wasted time and fuel due to idling.

As of 2013, UPS had used ORION on 10,000 of its routes, saving fuel, decreasing fuel costs, and lowering emissions. The company expects full implementation on its routes by the end of 2016, with an expected annual savings of over $300 million and annual reductions of 100 million miles driven, 10 million gallons of fuel, and 100,000 metric tons of CO_2 emissions.

Sources: (Levis, 2014; UPS, 2015; BusinessIntelligence.com Staff, 2015)

Key Points

A wide variety of mature, well-proven information management services and enabling technologies are available to help agencies move toward their strategic information management vision. Agencies can develop specific initiatives for each of the six categories of services discussed in Step 7 based on identified needs and priorities. One approach to this is to identify a point person for each category to look at current agency practice and benchmark it against peer agencies and other organizations.

Step 8. Foster Culture Change and Build Workforce Capabilities

All successful information management improvements require attention to the human side of the equation, which involves assessing workforce capabilities and managing organizational change. There are two basic questions to ask:

- Do we have people with the technical skills and experience needed to implement and support what the agency is trying to do?
- How can we best support the kinds of organizational and behavioral changes that will be needed?

Workforce Capabilities

Implementing the information management services discussed in Step 7 requires a number of specialized skills. To maximize success, it is important to get the right people with the right competencies involved. Unfortunately, these skills may be in short supply at a DOT. In some cases, they do exist, but their presence may not be widely known. As a result, staff with engineering or general administrative skills may be asked to take on information management responsibilities as part of their jobs without the necessary background in information organization and categorization, information preservation, metadata management, etc., and without sufficient time to build their knowledge base. Vendors and consultants can help to fill the gaps for new initiatives, but once they complete their assignment, there is still a need for skilled management, guidance, upkeep, and support of systems and processes.

An assessment of required (and available) capabilities should be part of every information management initiative. See Table B-4 in Appendix B for a list of sample areas of expertise for selected types of information management functions. In addition to building information management capabilities into position descriptions, DOTs can consider ways to better leverage and coordinate resources that may already exist. For example, many DOTs employ professional librarians, who bring education and experience in information management. There may be staff within information technology units, records management functions, or other functional areas, with training in information needs assessment, business analysis, and information architecture. Once staff with relevant skills are identified, an information management community of practice could be established to offer support to staff who are less experienced and to enhance collaboration and coordination across different functions with information management responsibilities.

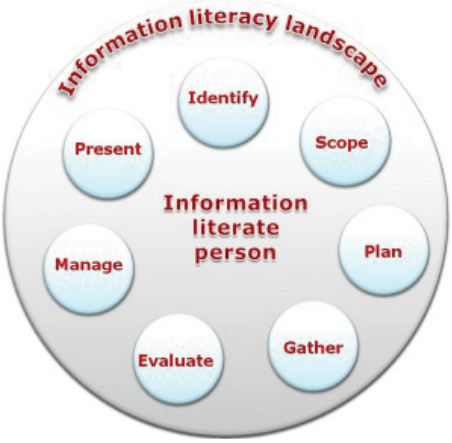
Beyond ensuring that specialized information management capabilities are in place, DOTs can also consider initiatives to strengthen general information literacy among all employees. As illustrated in Figure 15, information literacy covers a wide range of skills for finding, gathering, using, managing, and presenting information.

Colorado DOT: Bridging the Organizational Gap Between Business and Technology

Whether in small private businesses or large government enterprises, communicating information business needs often must flow through information technology staff who speak their own technology lingo. In state transportation agencies, the responsibility of translating technology and information needs can often fall to professionals without strong technical experience.

During SAP enterprise resource planning implementation in 2006, the Colorado DOT recognized the gap in understanding between its technology professionals—both staff and consultants—and the many users of the vast array of transportation information that would be managed in its new system. The Colorado DOT established the Business Process Expert position, creating about one dozen liaisons between database builders or code writers and the business side of the organization.

The Business Process Experts combine a strong understanding of business processes with SAP insight and experience. They understand the business needs and pain points for both the Colorado DOT and their parts of the organization. The Business Process Experts work together to develop common approaches, solutions, and priorities for their departments and for the Colorado DOT.



Source: (SCONUL Working Group on Information Literacy, 2011)

Figure 15. The Society of College, National and University Libraries (SCONUL) information literacy landscape.

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The concept of building information literacy within business environments has been addressed in multiple studies (Williams, 2014). This body of material can provide a foundation for DOT information literacy training, potentially touching on the following topics:

- The value of information for the employee's job and to the agency as a whole.
- The importance of sharing information and understanding of how to store and organize shared information.
- Strategies for coping with information overload.
- Methods for evaluating information needs.
- Approaches to identifying available information sources, including online sources, physical sources, and people.
- Strategies for leveraging available information services (e.g., reference desk and literature reviews).
- Awareness of available search tools and efficient search techniques.
- Critical interpretation and evaluation of information authenticity and applicability.
- Information packaging and presentation.
- Understanding of information sensitivity, privacy, and security.
- Appropriate use of copyrighted material.
- Version control.
- File management (cleanup and backups).

Managing Change

Anyone who has been through implementation of a new information system, business process, or organizational structure understands that change management can mean the difference between success and failure. There are multiple dimensions to consider:

- Do people understand why an initiative is being undertaken, and are they convinced that it is a good idea?
- Are people motivated enough to change current ways of doing things?
- Are there incentives (or disincentives) to the kind of collaboration and coordination needed for success?
- Is there sufficient training in place to make sure people understand how to use new capabilities?

For example, implementing a document management system will require people to start storing their documents in the system and to create consistent metadata for each document. Even though this will benefit the organization as a whole, it will take more effort for the individual. A strategy for convincing and/or requiring employees to change their current behavior will be needed. Activities will also need to be planned for training and reinforcement to make sure the system is being used as intended.

Human barriers to information management improvements that are related to resistance to change should be assessed and addressed as part of the planning for each initiative. These barriers can also be addressed more systemically in order to address entrenched ways of operating that are not in the agency's best interest, such as information hoarding, failure to provide adequate documentation or metadata, and reluctance to collaborate on data collection or reporting initiatives. Systemic improvements can also be initiated to improve workforce skills, capabilities, and motivations that are needed to operationalize and adhere to established information management policies and productively utilize available technologies.

Key Points

Agencies seeking to improve information management will need to ensure that they have the right set of workforce skills to implement and manage new processes, services, and technologies. They will also need to recognize and address cultural barriers that may inhibit the kinds of changes in employee behavior that are important to success. Specific strategies to consider include the following:

- Making strategic hires to build technical capabilities in weak areas or to introduce people to the organization who can promote changes to information management behaviors;
- Updating employee position descriptions to include desired information management skills;
- Proactively identifying people with information management skills and forming an information management community of practice;
- Conducting training to build information literacy;
- Conducting an organizational culture assessment to gauge employee attitudes and identify specific barriers to target;
- Highlighting roles, responsibilities, and expectations for information management behaviors in employee orientation and performance review activities;
- Creation of guidance documents on best practices; and
- Recognizing individuals or teams that exemplify good practice.

Step 9. Monitor Progress and Adjust Strategies

Information management should be viewed as a continuous improvement process rather than a one-time project. Ongoing review of what has been accomplished and what needs adjustment is required. Without regular attention, it will be difficult to make sustained progress toward established goals and objectives. In addition, given normal employee turnover and changes in priorities, short-term gains in changing behavior can be lost without continual reinforcement.

Updates and Course Corrections

The information management leader and governance group (established in Step 4) should request regular (e.g., quarterly) updates on the progress, accomplishments, and outcomes of each initiative. These updates can inform decisions about allocating resources and interventions that may be required.

A formal annual review of the information management plan and roadmap developed in Step 3 can provide a useful structure for assessing progress and making course corrections. Key questions to ask during this review are the following:

- Are we doing what we planned to do? If not, why not?
- Are we achieving what we hoped? If not, why not?

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- Does our plan need to be adjusted to better reflect the constraints we face?
- Should we adjust our resources and/or activities to enable faster progress?

In addition to looking for areas where improvements or adjustments are needed, it is important to identify, document, and celebrate successes.

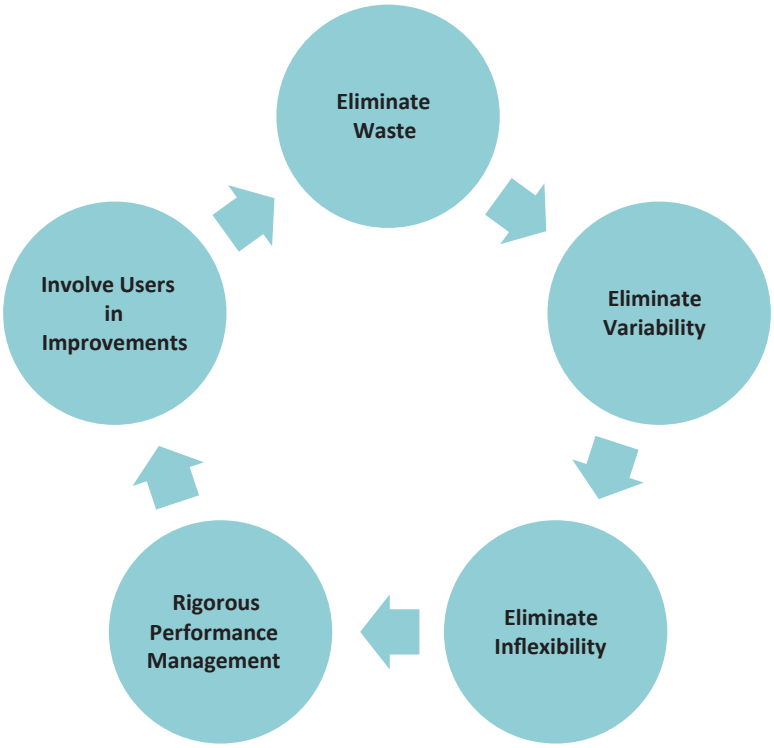
Applying Management Frameworks

A number of different management frameworks can help agencies with ongoing review and continuous improvement of information management practices (e.g., the Lean framework, the Six Sigma and Lean Six Sigma frameworks, the Balanced Scorecard framework, and the Baldridge framework). Although these frameworks were developed outside of the transportation industry, they have been applied by several DOTs.

The Lean Framework: Improving Operations by Eliminating Waste

The Lean process improvement framework (see Figure 16) was based primarily on the just-in-time manufacturing techniques put in place by Toyota. The goal of the Lean framework is to eliminate waste throughout the supply chain or work that adds no value to the product or service. The eight archetypes of waste are transport, inventory, motion, waiting, overproduction, over-processing, defects, and skills. Lean improves operations through data-driven experimentation and involves giving workers autonomy to find sources of efficiency in their jobs.

Lean principles are implemented in most successful manufacturing companies. Although not as repetitive and tangibly defined as manufacturing processes, information management



Source: (Sollerthoughts.com, 2010)

Figure 16. Lean framework cycle.

Lean Principles Applied to Information Management

Value: Specify value from the customer's perspective—what value is the information providing to internal and external agency users?

Value Stream: Identify the value-producing activities needed to capture, process, organize, store, retrieve, share, analyze, and communicate information.

Flow: Make the process of producing information as efficient as possible through automation (e.g., replacement of paper-based processes) and elimination of old and redundant content that slows down efficient information retrieval.

Pull: Make sure that information is produced only in response to a well-defined need, and provide information on demand using self-service methods.

Perfection: Continue to seek improvements to the process; don't rely on a one-time improvement effort.

Colorado DOT

The Colorado DOT launched a Lean process improvement program in 2011. The motto for the program is "Everyone, Every Day, Improving Every Process and Every Product, for Every Customer." The program's focus is to deliver excellent services and programs to citizens through the improvement of operations. CDOT uses Lean to create more value in the work it does on a daily basis by making sure its processes are effective and impactful. One Lean project has involved improving data consistency and accuracy for maintenance work orders. The goal is to make the work order easier to complete, cleaner to look at, and provide clear and consistent direction so that users spend less time and have fewer questions about entering the data. The recommended improvements were

- Consolidate two types of existing work orders for planned and reactive work and create a single work order for Maintenance, Traffic, and Specialty Units named "1DOT."
- Reduce the number of data fields from 300 to 99.
- Make it easier to enter data into the new work order.
- Make the new work order "error-proof" (e.g., through built-in data validation).

Through their Lean process improvement projects, CDOT:

- Hires employees 17% faster.
- Issues Oversize and Overweight Permits 30% faster, enabling commercial vehicles to get their goods to where they need to go.
- Reimburses transit project grantees 75% faster, getting dollars to benefit customers more quickly.
- Uses inventions by CDOT employees to improve multiple areas—including a new hydraulic fluid holding box to improve environmental safety and techniques to speed repair of delineator posts.

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processes can also benefit from applying the Lean framework. For example, DOTs can identify instances of the following:

- **Overproduction**—producing or collecting more data than are needed by the agency.
- **Transport and motion**—unnecessary movement of data and content across repositories.
- **Inventory**—storage of data or content that are no longer needed.
- **Waiting**—time lag for fulfillment of information requests. Time lags may be due to availability of staff for data processing, lack of the right data, lack of availability of proper hardware and software for analysis, or delays due to the need for manual review and approval processes.
- **Extra processing**—extra activities that are performed when the agency doesn't have the right information to meet information needs or is not managing its information efficiently. These activities may include "fire drill" efforts to produce requested reports, excessive time spent searching for information, and time spent recovering information that was lost.
- **Defects**—poor quality information that does not meet user needs, and activities to identify defects that do not add value from a customer perspective.

The Lean framework can be used to identify improvements to particular data programs or information management functions in a DOT (e.g., traffic monitoring or team document sharing). Potential improvement initiatives can be assessed based on the degree to which they can streamline processes and reduce waste.

Six Sigma and Lean Six Sigma Frameworks for Process Improvement

Six Sigma is a well-known process improvement methodology. It has been applied in a wide range of industries and business processes to increase speed, improve efficiency, and provide more consistent, better quality outputs. Many organizations report substantial cost savings as a result of applying Six Sigma.

Applying Lean Six Sigma to Records Management

A 2005 article describes how Lean Six Sigma can provide a standard approach that can be systematically applied to managing records. Records management can be a complex process involving diverse groups in an organization (e.g., legal, finance, human resources, information technology, and auditing in addition to the formal records management team).

Define. Develop a problem statement based on assessment of policies and procedures, retention schedules, systems, and controls. For example, issues might include excessive storage requirements, gaps in record keeping, duplicate copies, or lack of compliance.

Measure. Map current records management processes and compile data on time, volume, frequency, impact, etc.

Analyze. Pinpoint bottlenecks and identify opportunities to eliminate activities that do not add value.

Improve. Implement solutions—piloting first as appropriate—including new technology, streamlined workflow, elimination of paper, creation of indices and taxonomies, etc.

(continued on next page)

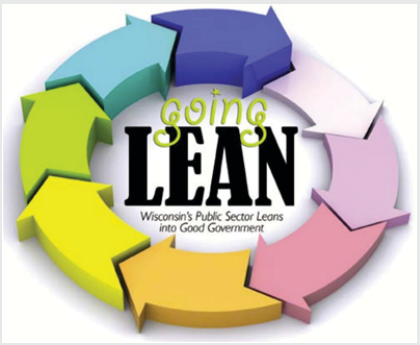
Applying Lean Six Sigma to Records Management *(Continued)*

Control. Establish auditing to quantify value (e.g., reduced risk, improved discovery and production, and cost avoidance) and evaluate reduction in redundancy and inefficiency. Track key process metrics and use these to promote continuous improvement. Revisit implementation after 3 to 6 months to ensure sustained progress.

Source: (Brett & Queen, 2005)

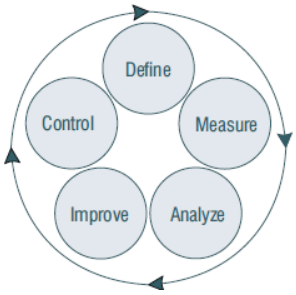
Wisconsin DOT

The Wisconsin DOT is actively engaged in improvements under the Governor's Executive Order #66 that requires state agencies to implement a Lean government initiative. Lean Six Sigma is one approach the department uses to support continuous improvement. Within its Lean initiative projects, the Wisconsin DOT establishes performance baselines and metrics to measure improvements. The Wisconsin DOT ties the Lean process improvement projects with supporting its MAPSS (mobility, accountability, preservation, safety, and service) performance improvement program. Within MAPSS, the Wisconsin DOT measures performance results and reports quarterly on measures with top agency management.



There were 43 process improvement projects completed as of June 2015 and 15 projects underway or planned for 2016. Many of these projects include information improvements, for example, the effort to improve the process for ordering information technology hardware documented in "Simplify the IT Hardware Purchase Process and State Trunk Highway Network Data Processing." The Wisconsin DOT is able to communicate that the 13 projects that were completed in fiscal 2015 have reduced 1,814 hours of process time and 232 days of lead time and eliminated 343 steps.

Sources: (Wisconsin Department of Transportation, n.d.; *Wisconsin Counties*, 2013)



Source: (AASHTO, 2011)

Figure 17. Six Sigma framework.

Six Sigma involves five steps (illustrated in Figure 17):

- **Define**—establishes goals for improvement.
- **Measure**—entails collecting data on the current process.
- **Analyze**—uses the data to understand root causes of problems and identify improvements.
- **Improve**—creates new processes and measures results.
- **Control**—monitors for deviations from future goals.

Lean Six Sigma combines Lean manufacturing methods with the Six Sigma methodology. Like Lean, Lean Six Sigma has most commonly been applied to manufacturing, but has broad applicability to improving any process, including information management. For example, Lean Six Sigma could be used to

- Speed delivery of data to users by improving efficiency of data collection and processing;
- Reduce duplication of information across multiple agency repositories;
- Improve quality of data through application of more consistent quality management processes; and
- Improve efficiency of external reporting processes.

Balanced Scorecard Framework for Strategic Performance Management

The Balanced Scorecard is a classic strategic management framework developed in the early 1990s (Kaplan & Norton, 2005). It provides senior executives with a high-level assessment of progress toward strategic goals of their organization. While originally developed for application to private, for-profit organizations, Balanced Scorecards have been used by many public-sector organizations, including several DOTs.

As illustrated in Figure 18, the Balanced Scorecard includes four perspectives:

- Financial performance or business value,
- Customer satisfaction (internal and external),

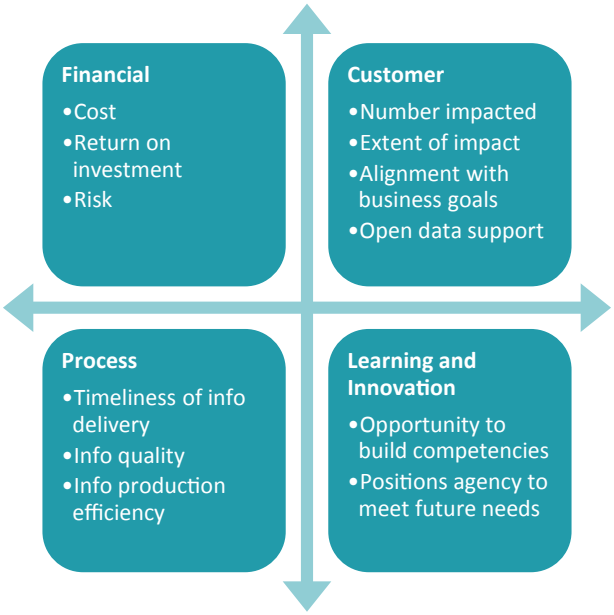


Figure 18. Balanced Scorecard framework for information improvement initiatives.

New Hampshire DOT

The New Hampshire DOT adopted the Balanced Scorecard approach for performance management in 2011. It addresses the New Hampshire DOT's three priorities: strategic management, performance measurement, and communication. The New Hampshire DOT had been measuring the performance and condition of the transportation system for many years. With the Balanced Scorecard approach, it expanded the measures collected and connected them to the DOT's strategies. These measures do not cover all aspects of the New Hampshire DOT's activities, but were chosen because of their importance, ease of understanding, and ability to be tracked. These measures are key indicators of progress toward the New Hampshire DOT's 12 strategic objectives. For each performance measure, the Scorecard reports data for the previous year, data for the current year, and data forecast for the next year, as well as providing projections and goals for 3 years in the future. Additional information for each performance measure is contained in the performance summary for each measure.

- Process efficiency, and
- Learning and innovation.

The framework emphasizes that no single metric can capture all areas of the business or all performance targets. The Balanced Scorecard concept can be applied to strategic information management by establishing specific goals and performance measures for each of the four perspectives and then evaluating and scoring candidate initiatives based on the established measures.

The Baldrige Framework: An Information-Based System for Comprehensive Organizational Improvement

The Malcolm Baldrige Award was established in 1987 to promote quality awareness and innovation in U.S. companies. A study conducted by the AASHTO Standing Committee on Quality in the mid-2000s found that 29 states were using some modified version of the Baldrige criteria (Oasis Consulting Services, 2006).

The Baldrige framework for performance excellence includes seven categories, as shown in Figure 19. The Measurement, Analysis, and Knowledge Management area is aligned with strategic information management and looks at two areas: (1) measurement, analysis, and improvement of organizational performance and (2) management of organizational knowledge assets, information, and information technology infrastructure. Like other quality frameworks, Baldrige emphasizes a process of continuous improvement based on periodic assessments to track progress.

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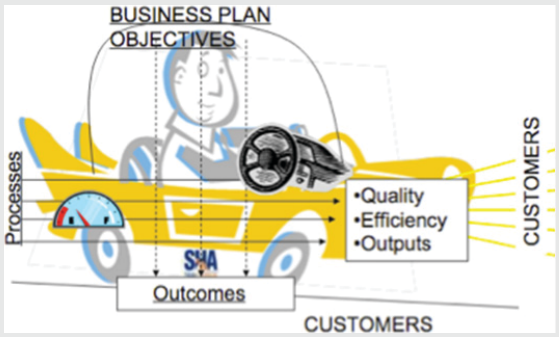
Source: (Baldrige Performance Excellence Program, 2015)

Figure 19. Baldrige framework.

Maryland State Highway Administration (SHA)

In recent years, SHA performed a statewide internal assessment based on the Malcolm Baldrige criteria for performance excellence. The Baldrige criteria are divided into seven categories: leadership; strategy; customers; measurement, analysis, and knowledge management; workforce; process; and results. At SHA, teams were formed for these different categories. Every senior manager was on one category team.



Some of the results were that the entire senior management team met periodically to discuss the budget process in order to have a more consistent approach to the budget and to promote efficiency and possible savings; a group worked with the assistant district engineers on a format to consistently decide when certain SHA assets should be retained for maintenance and when they should become candidates for capital projects; and the Workforce Planning Committee was expanded to be chaired by three senior managers and to broaden involvement across the agency.

Source: (Burk, 2014)

Key Points

This final step in the strategic information management process provides an essential feedback loop from implementation back to planning. This step emphasizes the fact that information management can be viewed as a continuous improvement process rather than a single initiative or project. As agencies go through the process of implementing improvements to information governance, information services, and information technologies, they will learn about what is working as intended and where refinements are needed in order to move closer to achieving the vision they have established.

Agencies that are using management frameworks such as Lean, Lean Six Sigma, Balanced Scorecard, or Baldrige can apply these frameworks to information management process improvement. The descriptions of these frameworks provided in this step can be used to identify opportunities for integrating consideration of information management within existing strategic management or business improvement practices.

CHAPTER 7

Conclusion

This guide began with a discussion of the changing information landscape impacting DOTs. Changes in both the demand for information and the supply of information are requiring DOTs to rethink how they collect, manage, share, and use various types of data and content. A step-by-step process is described that can help DOTs to chart a clear path forward and make the best use of limited staff and budget.

Agencies can use this guide and the resources included to begin managing information as a valued agency asset. Like a physical asset, information serves multiple customers. Information has a life cycle that needs to be planned for, and skilled staff members are required to design and maintain information, as well as coordinate across different areas of responsibility. Lack of attention to information management can result in missed opportunities, as well as increased risk exposure due to information loss or misuse.

Strategic information management involves changes in mindset, policy, process, organizational culture, and technology. It entails integrating consideration of information management services and enabling technologies within agency strategic and business planning, budgeting, organization and workforce development, and technology investment decision-making. Strategic information management can and should be an integral part of an agency's core business processes.

The nine-step process described in this guide is deliberately general to allow for different agencies to tailor it to their specific situation and needs. While every agency seeking to improve management of its information resources should establish a vision and plan informed by a current state assessment (Charting a Course); set up governance structures, policies, and investment processes (Equipping the Organization); and put in place services and technologies while building workforce capacity and monitoring progress (Implementing and Sustaining Change)—the details and areas of emphasis will vary.

As DOTs embark on information improvements, three important principles should be kept in mind:

- **Taking a unified approach.** Recognize that all types of information need to be stored, organized, documented, maintained, and discovered. Unified approaches across different types of information can reduce costs by making efficient use of staff and technology resources for information management and reducing the time and effort needed to track down information when it is needed.

- **Taking a value-driven approach.** Link every investment, policy, and process change back to how it will help the agency to deliver on its core mission.
- **Being flexible.** Anticipate and plan for changes in agency priorities and in the information and technology landscape. To do so will require regular re-examination of assumptions and strategies.

A unified approach to information management, driven by business objectives, regularly evaluated and adjusted to meet changing needs, will position DOTs to achieve efficiency gains and capture greater value from the data and information they collect and create.

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Additional Resources

Enterprise Information and Content Management

Baan, P., ed. (2012). *Enterprise Information Management: When Information Becomes Inspiration.* Vol. 2. Springer Science and Business Media.
Data Management Body of Knowledge (DMBoK)—Data Management Association International: https://www.dama.org/content/body-knowledge
Smallwood, R. F. (2014). *Information Governance: Concepts, Strategies, and Best Practices*. John Wiley & Sons.
vom Brocke, J., and A. Simons. (2014). *Enterprise Content Management in Information Systems Research.* Springer-Verlag, Berlin, Heidelberg.

Records Management

ARMA—Generally Accepted Record Keeping Principles: http://www.arma.org/docs/sharepoint-roadshow/the-principles_executive-summaries_final.doc
National Archives Records Management Toolkit: http://www.archives.gov/records-mgmt/toolkit/excel/all-toolkit-data.xls
National Archives Website: http://www.archives.gov/records-mgmt/toolkit/#list

Email Management

ARMA Hot Topics—Managing the Email Maelstrom: http://www.arma.org/docs/hot-topic/managingtheemaelstrom.pdf?sfvrsn=0
Best Practices: Email Archiving: http://www.usdatavault.com/library/email_archiving_best_practices.pdf
Email Archive Software—Library Journal—November 27, 2015, http://lj.libraryjournal.com/2015/09/digital-resources/open-source-email-archiving-software-expands-with-imls-grant/#_

DOT Library Management

http://libraryconnectivity.org/files/Toolkit-Second-Edition-Web-Final1.pdf

Information Architecture

Maeder, M., T. Hädrich, and R. Peinl. (2009). *Enterprise Knowledge Infrastructures*, Second Edition, Springer-Verlag.
Rosenfeld, L., P. Morville and J. Arango. (2015). *Information Architecture: For the Web and Beyond*, O'Reilly Media, Inc.

Glossary

Sources

In developing this glossary, the authors have drawn verbatim wherever possible from other authoritative sources. In some instances, minor wording changes have been made to enhance clarity and precision. The following sources are cited as appropriate:

- AIIM—Association for Information and Image Management Glossary: http://www.aiim.org/community/wiki/view/glossary
- ANSI/NISO Z39.19—Guidelines for the Construction, Format, and Management of Monolingual Controlled Vocabularies (2005) ISBN: 1-880124-65-3 is p. 157–167: http://www.niso.org/apps/group_public/download.php/12591/z39-19-2005r2010.pdf
- DAMA—Data Management Association Dictionary of Data Management: http://www.dama.org/content/body-knowledge
- IRMT—International Records Management Trust (IRMT) Glossary of Terms: http://www.irmt.org/documents/educ_training/term%20modules/IRMT%20TERM%20Glossary%20of%20Terms.pdf
- OMB Circular A-130: http://www.whitehouse.gov/omb/circulars_a130_a130trans4/
- SAA—Society of American Archivists Glossary: http://www2.archivists.org/glossary
- W3C—W3C Data Catalog Vocabulary: http://www.w3.org/TR/vocab-dcat/#class--dataset

Where no reference is noted, definitions were developed by the authors, based on a review of multiple existing sources. A number of other professionals were invited to suggest terms that should be included and to review the definitions, including members of NCHRP project panels and standing committees of TRB. However, responsibility for these definitions and any errors they may contain remains with the authors.

Terms

Analytics. Techniques for transforming data into information to provide insights into current conditions and/or likely implications of potential future actions.

Best Bets. Manually created lists of content objects to be returned in response to common search queries in order to improve search results.

Big Data Analytics. Methods for processing and deriving information from data streams that are too large, dynamic, and/or heterogeneous to manage using traditional tools such as spreadsheets or relational databases.

Catalog. An organized, searchable, annotated list of content objects in a collection (e.g., the National Transportation Library Catalog).

Content. Information that has been packaged in a format suitable for retrieval, re-use, and publication. Content includes documents, data sets, web pages, image files, email, social media posts, video files, audio files, and other rich media assets. (Source: Adapted from AIIM)

Content Management. The process of establishing policies, systems, and procedures in an organization in order to oversee the systematic creation, organization, access, and use of content. Content Management is a subset of Information Management. (Source: Adapted from IRMT)

Content Object. An individual unit of content that may be described for inclusion in an information retrieval system, website, or other information source. A content object can itself be made up of content objects (e.g., both a website and an individual web page; a journal and an article in the journal). A content object may also include metadata. (Source: adapted from ANSI/NISO Z39.19)

Controlled Vocabulary. A list of terms that have been enumerated explicitly. This list is controlled by and available from a controlled vocabulary registration authority (e.g., Library of Congress Subject Headings). (Source: Adapted from ANSI/NISO Z39.19)

Data. Representation of observations, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or computers (e.g., a crash record, pavement roughness measurements). (Source: adapted from AIIM)

Data Architecture. A master set of data models and design approaches identifying the strategic data requirements and the components of data management solutions, usually at an enterprise level. (Source: DAMA)

Data Archiving. The process of moving data that are no longer actively used to a separate data storage device for long-term retention.

Data Business Plan. A document that establishes data collection and management strategies that align with business objectives.

Data Catalog. A listing of available data resources (e.g., data sets, query tools, maps, reports) including descriptive information on what is included and how to access, compiled for the purpose of facilitating discovery and understanding of available data.

Data Dictionary. A place where a limited set of "data about the data" or metadata are stored. It may include technical metadata including column names and formats and/or business metadata such as data definitions, business rules, and code values. (Source: Adapted from DAMA)

Data Entities. A classification of the types of objects found in the real world—persons, places, things, concepts, and events—of interest to the enterprise. (Source: DAMA)

Data Management. A subset of information management that is concerned with management of structured data.

Data Quality. The degree to which data are accurate, complete, timely, and consistent with requirements and business rules and relevant for a given use. (Source: Adapted from DAMA).

Data Quality Assurance. Processes to ensure that data meet specified requirements.

Data Quality Control. Processes to detect defects in collected data and take appropriate action.

Data Set. A collection of data made available for access or download in one or more formats (e.g., a state's crash records for a single year, a database with roughness measures for pavement segments on the state highway system). (Source: adapted from W3C)

Data Steward(s). People who are accountable for the quality, value, and appropriate use of data.

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Data Stewardship. The formal, specifically assigned and entrusted accountability for business (non-technical) responsibilities ensuring effective control and use of data and information assets.

Data Visualization. Techniques for graphical representation of trends, patterns, and other information. (Source: Adapted from DAMA)

Data Warehouse. An integrated, centralized, decision support database and related software programs that can be used to collect, cleanse, transform, and store data from a variety of sources to support business needs. (Source: Adapted from DAMA)

Digital Curation. Selection, preservation, maintenance, collection, and archiving of digital content objects.

Digital Repository. An electronic information system in which digital content objects are stored, managed, and made available for retrieval.

Document. Recorded data or information fixed in any media, which can be treated as a self-contained unit. May consist of one or more content objects (e.g., a strategic highway safety plan, a DOT transportation asset management plan). (Source: adapted from AIIM and SAA)

Document Management. Techniques that ensure that documents are properly distributed, used, stored, retrieved, protected, and preserved according to established policies and procedures. Document management systems typically include capabilities for storage, retrieval, check-in/check-out, version control, and maintenance of audit trails for changes made. Document management is a subset of content management and is typically concerned with management of stand-alone documents (e.g., reports, presentations, and spreadsheets) rather than more atomic content objects such as images, social media posts, links, or web pages. (Source: Adapted from SAA)

Electronic Discovery (or e-Discovery). A process in which electronic data are sought, located, secured, and searched with the intent of being used as evidence in a civil or criminal legal case.

Enterprise Data Architecture. An integrated collection of models and design approaches to align information, data, processes, projects, data systems/applications, and technology with the goals of the agency. (Source: Adapted from DAMA)

Enterprise Search. The practice of identifying and enabling specific content across the enterprise to be indexed, searched, and displayed to authorized users. (Source: AIIM)

Faceted Classification. A system for organizing content into categories based on a systematic combination of mutually exclusive and collectively exhaustive characteristics of the materials (facets) and displaying the characteristics in a manner that shows their relationships. (Source: Adapted from SAA)

Faceted Navigation. Technique for accessing content based on a faceted classification system. Faceted navigation is commonly used for e-commerce web sites.

Federated Search. Simultaneous search of multiple online databases. (Source: AIIM)

Findability. The degree to which relevant information is easy to find when needed; findability is improved through application of metadata, taxonomies and other organizing tools, and search technologies. (Source: adapted from AIIM)

Index. List of the contents of a file, document, or collection of content objects together with keys or references for locating the contents. (Source: Adapted from AIIM)

Indexing. A method by which terms or subject headings are selected by a human or computer to represent the concepts in or attributes of a content object. (Source: Adapted from ANSI/NISO Z39.19)

Information. Presentation of data to facilitate interpretation or understanding; may include textual, numerical, graphic, cartographic, narrative, or audiovisual forms (e.g., map of high crash locations, trend line showing changes in pavement roughness over time). (Source: adapted from AIIM and OMB Circular A-130)

Note: the term "information" is frequently used to refer generally to both raw data and processed or packaged data.

Information Classifications. A set of categories used to distinguish key characteristics of a given information resource such as level of sensitivity or degree of importance, used to determine appropriate governance policies.

Information Governance. The accountability for the management of an organization's information assets in order to achieve its business purposes and compliance with any relevant legislation, regulation, and business practice. Includes data governance, which focuses on governance of structured data. (Source: Adapted from AIIM)

Information Life Cycle. The stages through which information passes, typically characterized as creation or collection, processing, dissemination, use, storage, and disposition. (Source: OMB Circular A-130)

Information Management. The means by which an organization (e.g., a DOT) efficiently plans, collects, creates, organizes, uses, controls, stores, disseminates, and disposes of information and ensures that the value of that information is understood and fully exploited.

Note: Information management encompasses content management, data management, and digital curation but is broader in scope.

Information Resource. See content object.

Information Resource Management. Principles and techniques to oversee and administer the creation, use, access, and preservation of information in an organization, founded on the belief that information is an asset comparable to financial, human, and physical resources. Similar in concept to information management (included here given use of this term in OMB Circular A-130). (Source: Adapted from SAA)

Information Store. See digital repository.

Keyword. One of a small set of words used to characterize the contents of a document for use in retrieval systems. May also be referred to as a "tag." (Source: Adapted from SAA)

Master Data. Shared data about the core entities of an enterprise. In a private company, examples of core entities are customers, products, and vendors; in a DOT, examples of core entities are routes, projects, funding sources, and district offices.

Metadata. Data describing context, content, and structure of documents and records and the management of such documents and records through time. Literally, data about data. (Source: Adapted from AIIM/ISO 15489)

Ontology. A type of controlled vocabulary that describes objects and the relations between them in a formal way, and has a grammar for using the vocabulary terms to express something meaningful within a specified domain of interest. For example, an ontology might define a relationship called "is a structural member of" to describe the structural elements of a bridge (e.g., trusses) and distinguish these from non-structural elements (e.g., railings). (Source: Adapted from AIIM)

Portal. An entry point, especially a web page, that provides access to information from a variety of sources and that offers a variety of services. (Source: SAA)

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Precision. In the context of information retrieval, precision is a measure of how relevant the returned results are to the user's query. It is calculated as the fraction of items returned from a search that are relevant to the user's search query.

Recall. In the context of information retrieval, recall is a measure of a search engine's ability to locate all of the relevant results that are available. It is calculated as the fraction of all relevant items that were returned from a search.

Record. Data or information in a fixed form that are created or received in the course of individual or institutional activity and set aside (preserved) as evidence of that activity for future reference. Records may include paper documents, digital documents, data sets, emails, and other content types. (Source: Adapted from SAA)

Records Management. The systematic and administrative control of records throughout their life cycle to ensure efficiency and economy in their creation, use, handling, control, maintenance, and disposition. Similar to document management, but focused on documents that have been designated as official records with an emphasis on legal, regulatory, and risk management concerns. (Source: Adapted from SAA)

Reference Data. Data used to organize and categorize information, consisting of code tables and other shared lists of values.

Search-Based Application. A specialized application developed to support a specific business process or task that features search as a central component. These applications may bring together information from multiple information repositories.

Search Engine. A coordinated set of programs for spidering, indexing, and querying content available on the World Wide Web. The spidering program "crawls" the web and creates a list of available pages, using the hypertext links available on each page. The indexing program creates indices based on the words and phrases included in each content object. The query program accepts a search request and returns a set of matching results from an index, sorted using an algorithm that seeks to present the results that will be most relevant to the user based on factors including match with search term, currency, geographic location, source authority, etc.

Search Interface. A user interface that provides a mechanism for users to specify their search query, refine their results set, and navigate to results of interest.

Semantic Resources. Synonym rings, taxonomies, thesauri, ontologies, and other resources that can be used for classifying and tagging content.

Semi-Structured Data. Non-tabular data that include tags or other structural elements to represent relationships among elements, but do not conform to a predictable model (e.g., XML file, social media post).

Sensitive Data. Data that are confidential, privileged, or proprietary that should be protected from unauthorized disclosure, loss, misuse, or corruption in order to avoid serious consequences to the organization owning the data.

Spider. A computer program that scans the World Wide Web, following links on each page to identify new sites.

Strategic Information Management. Techniques for managing information and information technology to maximize improvements in organizational performance.

Structured Data. Data that conform to a predefined data model, typically structured as a series of columns (fields) and rows (records) and stored in relational databases, spreadsheets, or flat files.

Taxonomy. A type of controlled vocabulary consisting of categories and sub-categories that is used for classifying information. (Source: Adapted from AIIM)

Text Analytics. Techniques that utilize software and semantic resources to add structure to text-based content objects (e.g., text files, Word documents, web sites, etc.). The main capabilities of text analytics include text mining, sentiment analysis, entity or noun phrase extraction, auto-summarization, and auto-categorization.

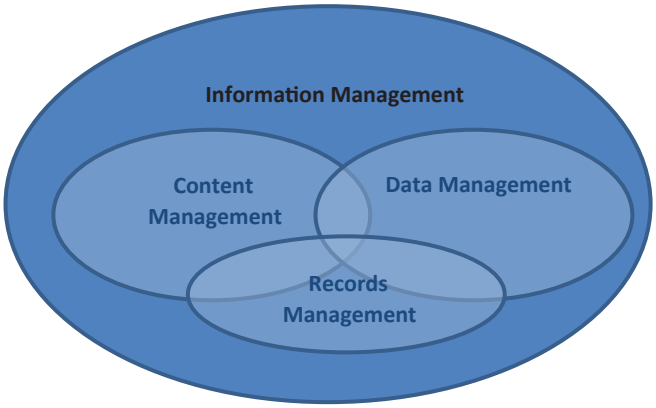
Thesaurus. A type of controlled vocabulary consisting of terms linked together by semantic, hierarchical (i.e., parent-child), associative (i.e., related) or equivalence (i.e., synonymous) relationships. Such a tool acts as a guide to allocating classification terms to individual records. (Source: Adapted from ISO/TR 15489-2:2001)

Unstructured Data. Data that do not conform to any predefined organization, sequence, or type (e.g., text, video, sound, images).

Web Content Management. Processes and tools for creating, updating, and maintaining web site content including text, images, links, and forms.

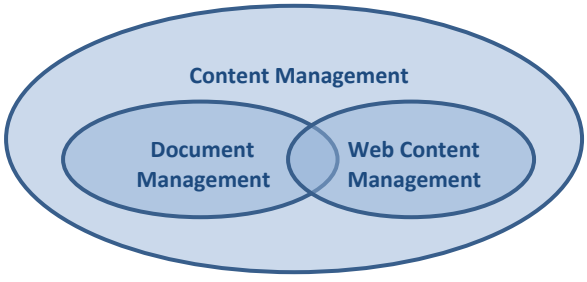
A Note on Information, Data, Content, and Records Management

The word *management* appears in a number of the terms in the above glossary. The scopes of these several management activities often overlap.



Information management is used in this guide as the highest level umbrella term. It encompasses content, data, and records management. Whether data—structured or unstructured—are viewed as records, content, or a distinct form of information is often determined by institutional history, professional practice, or usage custom. Each of these management activities may entail procedures and protocols considered unique to that particular activity as practiced in a particular setting.

Because content encompasses a variety of media, *content management* entails a very broad range of practices associated with information that has been packaged for retrieval, re-use, and publication. Current usage distinguishes *web content management* from *document management*, because of the technologies involved and relationships among communities of professional practice.



List of Acronyms

ARNOLD	All Road Network of Linear Referenced Data
CAD	Computer-aided design
CDO	Chief data officer
CDOT	Colorado Department of Transportation
CEO	Chief Executive Officer
DAMA	Data Management Association
DMBoK	Data Management Body of Knowledge
DOT	Department of transportation
DOTS	Data or term search
EDRMS	Electronic Document and Records Management System
EIGG	Enterprise Information Governance Group
FEAF	Federal Enterprise Architecture Framework
FMIS	Financial Management Information System
FOIA	Freedom of Information Act
FTE	Full-time-equivalent
GIS	Geographic information system
GPS	Global positioning system
HIPAA	Health Insurance Portability and Accountability Act
HPMS	Highway Performance Monitoring System
IRS	Internal Revenue Service
ITD	Idaho Transportation Department
ITS	Intelligent Transportation Systems
LiDAR	Light Detection and Radar
LTCCS	Large Truck Crash Causation Study
MAPSS	Mobility, accountability, preservation, safety, and service
MIT	Massachusetts Institute of Technology
MMS	Maintenance management system
NASCIO	National Association of State Chief Information Officers
OLAP	Online analytical processing
ORION	On-road integrated optimization and navigation
PDR	Public Disclosure Request
SCONUL	Society of College, National and University Libraries
SCOP	Standing Committee on Planning
SHA	State Highway Administration
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UPS	United Parcel Service
USDA	United States Department of Agriculture
VLS	Vehicle Location System

APPENDIX A

Assessment Tools and Checklists

Table A-1. Elements of a DOT information management vision.

Information Improves Agency Decision-Making
Staff at all levels have easy, efficient, and managed access to the right information at the right time in the right form to make good decisions and effectively carry out their responsibilities.
We use the best available information to target our available funds and resources where they will have greatest impact.
We use current technologies to provide real-time situational awareness that allows our field staff and contractors to operate in a safe and efficient manner.
Information Is Shared to Provide Transparency and Accountability
We provide our customers and stakeholders with meaningful and timely information about the condition and performance of the system, and what we are doing to maintain and improve it, through multiple channels.
We maintain readily accessible information about the basis for project selection and other key decisions.
Information Is Integral to Effective Delivery of Service to Customers
We provide travelers with timely and accurate information that helps them to travel as efficiently and safely as possible.
We leverage social media to provide two-way communication with our customers.
We provide timely information on the status of customer work requests.
Information is managed to ensure regulatory compliance and minimize risk exposure.
We maintain information needed to efficiently meet our reporting obligations.
We maintain information needed to efficiently respond to public information requests.
We actively manage agency risk exposure associated with information protection, retention, and access control.
Information Is Acquired and Managed Efficiently
We ensure that information acquisition and management efforts leverage current technologies and services and are sustainable with available funding.
We minimize duplicative or redundant collection, manipulation, storage, and reporting of data and information.

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Table A-2. Assessment Tool 1: Prioritization of Needs for Better Information.

Issues/Improvement Needs	Priority of Taking Action to Address Issue/Need			
A. Improving Information for Better Internal Decisions				
Improve ability to get reliable answers to basic questions about what we manage and what we are delivering	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to provide senior management with an up-to-date picture of key agency performance indicators	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to analyze implications of future major investment strategies	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to make better-informed decisions about allocating funds or prioritizing projects	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to ensure that available funds are fully leveraged	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to maximize maintenance and operations efficiency based on information about staff and equipment availability and location	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to track current project delivery status (schedule, scope, and budget)	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to guide response to incidents and emergency situations based on real-time information and cooperation with first responders	☐ Urgent	☐ High	☐ Moderate	☐ Low
B. Meeting External Information Requests and Reporting Requirements				
Reduce time and effort required to respond to Freedom of Information or Public Disclosure Requests and legal discovery orders (including e-Discovery)	☐ Urgent	☐ High	☐ Moderate	☐ Low
Reduce time and effort required to answer questions from the legislature	☐ Urgent	☐ High	☐ Moderate	☐ Low
Meet current and emerging federal reporting requirements (FMIS, HPMS, ARNOLD, MAP-21, etc.)	☐ Urgent	☐ High	☐ Moderate	☐ Low
Meet current and emerging state reporting requirements	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to meet public expectations for sharing information about current travel conditions	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve ability to meet public expectations for sharing information about plans, programs, and projects	☐ Urgent	☐ High	☐ Moderate	☐ Low
C. Improving Information Usability and Reliability				
Make it easier to find and access information collected or maintained within the DOT	☐ Urgent	☐ High	☐ Moderate	☐ Low
Take additional actions to avoid loss of unique knowledge about how to access, analyze, and use data (as staff with specialized skills leave the DOT)	☐ Urgent	☐ High	☐ Moderate	☐ Low
Upgrade or replace older information systems that are no longer meeting agency needs	☐ Urgent	☐ High	☐ Moderate	☐ Low
Improve data quality to reduce risk of providing inaccurate information to elected officials and the public	☐ Urgent	☐ High	☐ Moderate	☐ Low

Table A-3. Assessment Tool 2: Risks Related to Information Management.

Risk	Likelihood (if no action is taken)	Consequences/ Impacts	Score (Likelihood × Impacts)
A. Improving Information for Internal Decisions			
Increased incident or emergency response time due to lack of readily available information to guide resource deployment	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Slower progress on crash reduction due to lack of information required to optimize targeting of safety countermeasures	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Slower progress on improving infrastructure condition due to lack of information required to optimize asset maintenance and rehabilitation	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Increased average project costs due to lack of available information to inform scoping and design or insufficient project tracking information during construction	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
B. Meeting External Information Requests and Reporting Requirements			
Loss of federal funding or reduced funding flexibility (due to lack of compliance with reporting requirements)	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Inability to produce supporting evidence in defense of lawsuits or claims	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Inability to comply with external information requests	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Loss of public confidence in the agency due to lack of transparency and information sharing	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
C. Improving Information Usability and Reliability			
Loss of valuable information (e.g., data stored on individual computer hard disks, thumb drives, or mobile devices)	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Exposure of sensitive information	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Misuse or misinterpretation of data due to staff turnover and/or inadequate documentation	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	
Release of inaccurate information to the public resulting in loss of agency credibility	3-High 2-Medium 1-Low	3-High 2-Medium 1-Low	

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Table A-4. Assessment Tool 3: Current State of Information Management Practice.

Practice	Use of this Practice			
A. Improving Information for Internal Decisions				
We have identified information resources that should be shared across business units and therefore managed from an agency-wide perspective.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We have an agency-wide body that makes sure data and information investments are coordinated across business units and aligned with agency priorities.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
B. Meeting External Information Requests and Reporting Requirements				
We have automated reporting processes and tools to meet routine external reporting needs.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We have implemented consistent ways of storing and classifying our information to enable rapid retrieval and linkage of information in order to respond to requests.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We consistently and actively identify and protect sensitive information.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
C. Improving Information Usability and Reliability				
We coordinate across information technology, GIS, data management, library management, web content management, and communications and records management functions to avoid duplication of effort and enhance integration and findability across different types of information in the agency.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We have converted our most valuable paper records to electronic formats to facilitate preservation and future retrieval.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We have a process to limit the proliferation of systems with similar functions for managing documents, design plans, and other digital assets.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We have a process for users to identify erroneous data and correct them after review by the data owner.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We assign ownership and accountability for different types of information to ensure quality and maximize usability.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We manage policies, procedures, and standards to ensure that staff and contractors are accessing and following current and authoritative versions.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We set and enforce agency-wide data standards to enable integration of information across different systems.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree
We actively identify opportunities for elimination or consolidation of duplicative data and documents across the agency.	☐ Strongly Agree	☐ Mostly Agree	☐ Partly Agree	☐ Disagree

Table A-5. Sample strengths, weaknesses, opportunities, and threats for DOT information management.

Strengths	Weaknesses	Opportunities	Threats
• Ample pool of available skilled data analysts • Well-defined information management processes and roles • Dependable funding streams for information management • Well-documented information assets • Modern tools and technologies	• Shallow bench strength in data management and analysis • Limited awareness of good information management practices • Lack of stable funding for information management • Unreliable data • Undocumented information assets • Outdated tools and technologies	• New performance management requirements • New funding for data/information improvements • New information sources (e.g., GPS data streams) • New analysis and visualization tools • Cross-agency collaboration opportunities	• Loss of funding • Loss of specialized expertise • Increasing volume and complexity of information requests • New expectations for open data • Discontinued support for existing technology platforms • Discontinued availability of current external data source

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Table A-6. Sample information life cycle checklist.

Information Life Cycle Phase/Issues		
A. Plan		
Are intended uses identified?	☐ Yes	☐ No
Are accuracy requirements defined based on business needs?	☐ Yes	☐ No
Is the Business Owner identified?	☐ Yes	☐ No
Is the Information Steward identified?	☐ Yes	☐ No
Is an individual assigned responsibility for creation of data dictionary and data set metadata?	☐ Yes	☐ No
Does the plan have realistic assumptions?	☐ Yes	☐ No
Are resources available to meet the desired information requirements?	☐ Yes	☐ No
Has information project been approved?	☐ Yes	☐ No
B. Obtain or Update		
Do opportunities exist to take advantage of existing data collection or acquisition?	☐ Yes	☐ No
Do opportunities exist to use new technology for data collection and acquisition?	☐ Yes	☐ No
Are staff and equipment identified for data collection (either in-house or outsourced)?	☐ Yes	☐ No
Is there a plan in place for quality assurance and certification?	☐ Yes	☐ No
C. Process and Store		
Are access restrictions defined based on sensitivity?	☐ Yes	☐ No
Is a suitable storage location identified?	☐ Yes	☐ No
Does the information meet agency standards (e.g., spatial referencing standards)	☐ Yes	☐ No
Does the information need to be cleaned and standardized?	☐ Yes	☐ No
Is all necessary information documented, including data dictionary and metadata?	☐ Yes	☐ No
Is an information retention plan in place?	☐ Yes	☐ No
Information Life Cycle Phase/Issues		
D. Analyze		
Is there availability for agency-wide mapping and reporting?	☐ Yes	☐ No
Is method of analysis identified, and does information work with this method?	☐ Yes	☐ No

Table A-7. Sample form with criteria for evaluating and prioritizing new information management initiatives.

Criteria	Rating			
Consistency with information management vision and roadmap	☐ High	☐ Moderate	☐ Low	
Consistency with other agency plans (information technology strategic plan, GIS strategic plan)	☐ High	☐ Moderate	☐ Low	
Time or cost savings	☐ High	☐ Moderate	☐ Low	
Sustainability—staff capabilities to maintain and existence of champion to support	☐ High	☐ Moderate	☐ Low	
Coordination and integration (score low if duplicates existing functions; score high if coordinated or integrated across information management functions [web, data, library, records, etc.])	☐ High	☐ Moderate	☐ Low	
Project risk level (e.g., acceptance, resources)	☐ High	☐ Moderate	☐ Low	
Scope of impact	☐ Impacting multiple areas	☐ Specific to one area		
Necessary for external mandate	☐ Yes	☐ No		
Number of staff impacted	Directly:	Indirectly:		
Likely number of external customers affected				
Likely number of external stakeholders affected				
Scale of budget decision impacted				
Estimate of savings and cost avoidance/costs				
Life cycle requirements and costs				
Urgency	☐ Must do	☐ Should do	☐ Would like to do	☐ Don't need to do

APPENDIX B

Information Management Functions, Roles, and Competencies

Table B-1. Sample roles for a chief data officer.

Role	Data Space	Collaboration Direction	Value Impact
Coordinator Deliver high-quality data to internal business units. Optimize collaboration across business units (e.g., lead internal agency dashboard development)	Traditional	Inward	Service
Reporter Deliver high-quality enterprise data for external reporting purposes (e.g., lead agency performance reporting initiative)	Traditional	Outward	Service
Architect Develop new opportunities to deliver and use data within/across agency business units (e.g., lead agency data warehouse effort)	Traditional	Inward	Strategy
Ambassador Promote development of inter-enterprise data policy for business strategy and external collaboration (e.g., sponsor an open data policy)	Traditional	Outward	Strategy
Analyst Improve internal business performance by exploiting big data, which involves implementation of new data management and data analysis capabilities (e.g., advocate for, prioritize, and direct work to integrate LiDAR data with agency systems)	Big Data	Inward	Service
Marketer Develops relationships with external data partners and stakeholders to improve externally provided data services using big data (e.g., negotiate data-sharing agreements with private data providers)	Big Data	Outward	Service

Table B-1. (Continued).

Role	Data Space	Collaboration Direction	Value Impact
Developer Navigate and negotiate with internal agency divisions to develop new opportunities for exploiting big data (e.g., provide executive direction for agency's approach to analyzing real-time data feeds)	Big Data	Inward	Strategy
Experimenter Engage with external collaborators (stakeholder or peer agencies) to explore new, unidentified markets and products based on insights from big data (e.g., explore opportunities for collaboration with neighboring states on purchase of supply chain data)	Big Data	Outward	Strategy

Table B-2. Sample objectives and functions for DOT information governance team.

Objectives	Functions
• Reduce costs of data storage and management by avoiding duplication and working to consolidate information where possible across the organization • Ensure a single authoritative source of agency information • Foster development of agency-wide solutions that improve access to information for priority business needs • Ensure consistent management of core agency information assets to maximize information value and minimize risk • Reduce the level of effort required to respond to public disclosure requests	• Develop, review, and update information management policies • Facilitate adoption of new information management practices (e.g., serve as ambassadors within their respective business units) • Serve as unified enforcement body to ensure that standards and policies are followed • Initiate and/or advocate for efforts to improve information services and technologies to meet common business needs and address risks • Review and comment on major new data collection or information management initiatives

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Table B-3. Sample information governance roles and responsibilities.

Role	Responsibility
Executive Sponsor	Provides leadership and guidance. Provides sponsorship for information governance process and acts as final arbiter or decision-maker.
Information Strategist	Understands agency information management issues and perspectives; facilitates agreement on goals, strategies, and priorities; elevates issues to executive sponsor as needed; leads and/or coordinates improvement initiatives. Provides liaison across organizational functions to promote coordination and achieve synergies.
Information Steward	Business unit manager or subject matter expert assigned responsibility for a type of information. Stewards may be assigned to subject areas (e.g., highway safety, corridor planning) or content types (e.g., corporate policies, design plans). Responsible for liaison with information users and ensuring value of the information to the organization.
Records Manager	Oversees development and implementation of records management policies, guidance, and management systems. Plans, organizes, directs, coordinates, and establishes controls for agency records activities. Coordinates with agency program managers to ensure records creation, maintenance, use, and disposition are in accordance with agency policy. Works with the agency information technology executive to incorporate records management functionality into information systems appropriate to the records supported.
Library Manager	Oversees: (1) development and maintenance of physical, digital, and archive library collections to meet the agency's current information needs and document its history; (2) provision of reference, research, and other information services in support of agency business activities; (3) maintenance of web-based information systems and databases providing agency staff access to library collections and other information resources.
Content Management System Owner	Serves as business lead for a content management system (which may include a web content management system, an engineering content management system, an image management system, etc.). Establishes workflow and governance policies and supports their implementation with training and monitoring activities.
Data System Owner	Serves as business lead for a data warehouse, GIS portal, or business application providing data reporting and analysis functions. Solicits feedback from system users and plans, prioritizes and signs off on system improvements.
Information System Custodian/ Operational Steward	Serves as technical lead for a data or content management system. Performs "hands on" information management tasks that require specialized information technology skills and permissions.
Information User	Stakeholders who provide input to Information Stewards and abide by established information management policies and guidance related to information storage, organization, naming conventions, documentation, and metadata. Become informed about available information resources and how to navigate them.

Table B-4. Sample information management areas of expertise.

Topic	Description
Information Curation and Provisioning	Information creation, production, distribution, selection, collection, and access services; clarification of user information needs; information retrieval and evaluation; information synthesis and presentation; information delivery via different modalities
Information Preservation	Information appraisal, preservation, and archiving technologies; standards and issues; formats; protection approaches
Information Strategy	Organizational analysis, business information assessment, information audits, organizational readiness assessment, return-on-investment analysis, information system development life cycle
Information Architecture and Organization	User-centered design; human-information interaction; database design; data and content modeling and classification methods; creation of controlled vocabularies and taxonomies; search algorithms, tools, and methods; search engine optimization; web analytics; website design including navigation, workflow, and labeling; prototyping
Information Assurance	Information risk assessment and mitigation; handling private and confidential information; copyright and intellectual property
Records Management	Records appraisal, retention, and disposal principles and practices; assessment of compliance needs based on understanding of legal and regulatory requirements; ability to analyze business process and develop appropriate policies and workflow
Business Intelligence	Data warehouse design, dimensional modeling, online analytical processing (OLAP), data governance
Data Analysis/ Data Science	Statistical analysis and modeling, optimization, algorithms, data visualization, data mining, data integration, data modeling, programming and scripting, machine learning, analytics tools, and function libraries

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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ISBN 978-0-309-37550-4
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