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Leadership Guide for Strategic Information Management for State Departments of Transportation

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List of Acronyms

AASHTO – American Association of State Highway and Transportation Officials

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

CIO – Chief Information Officer

DAMA – Data Management Association

DMBoK – Data Management Body of Knowledge

DOT – Department of Transportation

EA – Enterprise Architecture

EDRMS – Electronic Document and Records Management System

EIGG – Enterprise Information Governance Group

FEAF – Federal Enterprise Architecture Framework

FHWA – Federal Highway Administration

FMIS – Fiscal Management Information System

FOIA – Freedom of Information Act

FTE – Full-time-equivalents

GIS – Geographic Information System

GPS – Global Positioning System

HIPAA – Health Insurance Portability and Accountability Act

HPMS – Highway Performance Monitoring System

IA – Information Architecture

IM – Information Management

IRS – Internal Revenue Service

IT – Information Technology

ITS – Intelligent Transportation Systems

KDOT – Kansas Department of Transportation

LiDAR – Light Detection and Radar

MAP-21 – Moving Ahead for Progress in the 21st Century

MDIT – Michigan Department of Information Technology

MIT – Massachusetts Institute of Technology

MWO – Maintenance Work Order

NASCIO – National Association of State Chief Information Officers

NCDOT – North Carolina Department of Transportation

NCHRP – National Cooperative Highway Research Program

NHDOT – New Hampshire Department of Transportation

ODOT – Oregon Department of Transportation

ODOT – Ohio Department of Transportation

PD – Public Disclosure

PDR – Public Disclosure Request

PII – Personally Identifiable Information

PM – Preventive Maintenance

ROI – Return on Investment

SCONUL – Society of College, National and University Libraries

SCOP – Standing Committee on Planning

SCOQ – Standing Committee on Quality

SHA – State Highway Administration

SWOT – Strengths, Weaknesses, Opportunities, and Threats

TRB – Transportation Research Board

UAV – Unmanned Aerial Vehicle

USDA – United States Department of Agriculture

UDOT – Utah Department of Transportation

USDOT – United States Department of Transportation

VDOT – Virginia Department of Transportation

WisDOT – Wisconsin Department of Transportation

WSDOT – Washington State Department of Transportation

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Executive Summary

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. Its premise is that information is an asset that requires deliberate management in order to maximize value. Many 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 (IT) strategy. While IT 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 Department of Transportation (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 towards 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.

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 two 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 to 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). 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 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 (PD) and Freedom of Information Act (FOIA) requests for agency records are on the rise and can be extremely time consuming to fulfill.

Agency staff 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 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 of 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 its relationships with partners. Yet DOTs have limited resources to invest, and can only take on so many new initiatives for change.

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 across 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. It 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 projects include:

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

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. Increasing availability of "big data" including data streams from travelers and maintenance vehicles and imagery from LiDAR and other sensing technologies provide 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 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: FY2015 AASHTO Information Systems State DOT Survey (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 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. Related to the above, 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. It 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 require major investments to replace. Mature tools are available for information management but require investments – not only in technology but in people with necessary skills 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 to maintain security while at the same time meeting growing business needs to share information with external partners and stakeholders. This 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 manageable components to make progress on improvements. However, a fragmented and reactive approach to information management is all too common – and results 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 the guide. The roadmap is organized as follows:

- **Strategic Information Management** – introduces key elements of Strategic Information Management (see chapters 2-3)
- **Charting a Course** – covers activities for understanding strengths and weaknesses of how the 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 within the organization needed 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.

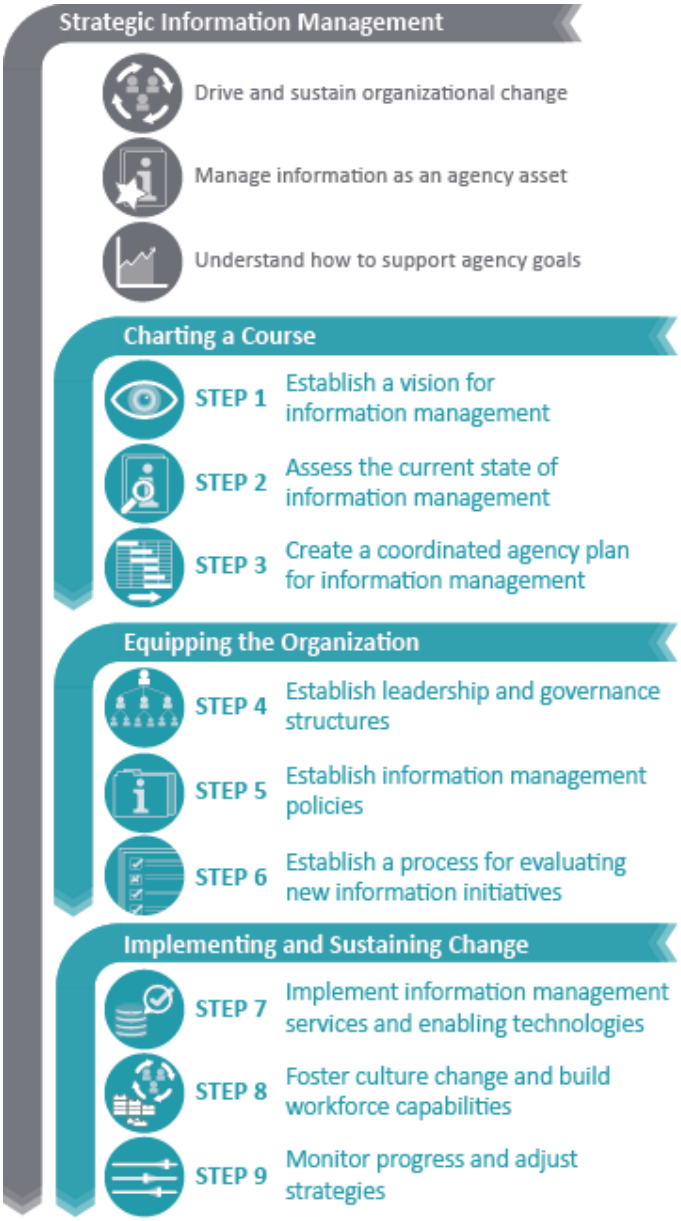


Figure 1. Roadmap for DOT Strategic Information Management

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. It 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 needs for improvement. This 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 comprehensive 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 near term (1-2 year), medium term (3-5 year) and longer term (6-10 year) actions to be taken to improve information management in a coordinated fashion across the agency – considering changes to governance, policy, processes and responsibilities; as well as implementation of enabling technologies and support services.

Expected Outcomes

The expected outcome is a plan and roadmap that chart a course to address the established goals for information management improvements.

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 to include responsibilities 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 to benefit the agency as a whole. It ensures that changes to existing responsibilities and processes in the organization have the necessary management support. It 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 value of information to the organization.

STEP 6: ESTABLISH A PROCESS FOR EVALUATING 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. 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 should be coordinated with existing processes that are in place to evaluate new initiatives for content management, records management, information architecture, library collection management and content management. It should also be coordinated or integrated with existing information technology review processes. The process should be designed in a manner

that does not impede individual business units from proceeding with information improvements that do not require agency-wide review.

Expected Outcomes

Optimize use of available resources for information acquisition and management to maximize value to the agency. Coordinate investments across different information management functions. Ensure that new initiatives are undertaken to minimize duplication, enable information integration, and leverage new technologies and commercial data sources. Ensure that any effort to collect new data is accompanied by adequate provisions to manage that data over time, convert it 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 encompasses data and information architecture-related activities that may currently be carried out by libraries, records managers, content managers, data managers, and IT 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

This activity puts an agency in a position to integrate available data and information in various forms (structured and unstructured), and make sure that it is findable and usable for different users and uses. It improves efficiency of information management by reducing the effort required to update and maintain code tables that are used within multiple data sets. It also 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 organizational culture assessment, making strategic hires, clarifying or updating roles and responsibilities in employee position descriptions, conducting information literacy and data management training, creating guidance documents, and making modifications to performance reviews, employee recognition and awards.

Expected Outcomes

This activity 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. It can improve 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

Sustained progress towards established goals and objectives for information management improvement; reinforcement of desired behaviors.

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 increases exponentially to satisfy more business demands and rising expectations, 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 ensure that each dollar invested in information is well spent.

Data and Information

In this report, the term "data" is generally used to refer to raw observations (e.g. traffic counts, bridge condition ratings, photographs) whereas "information" is used to refer to data that has 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 and translation of data into information, and distributing this information so that it can be used. It encompasses management of tabular data as well as other content types – documents, maps, charts, emails, etc. See the Glossary at the end of this report for further definitions.

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.

The situation in many agencies is quite different:

- There is a lot of data but limited ability to derive actionable information – a "data rich, information poor" state of affairs.
- Decisions about collecting data or improving information access are often made within individual divisions, offices and bureaus rather than 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 (IT) investments - with the promise of improving information for decision making. But many past IT projects have not delivered on expectations and it is a challenge to prioritize the many competing needs.

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. They 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 will benefit significantly and in similar ways as those businesses tracked in the MIT study. 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.

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 project delivery, reducing costs and ensuring quality

A 2006 study of transportation information assets and impacts (Schofer, 2006) summarized the main categories of information that can add value - including:

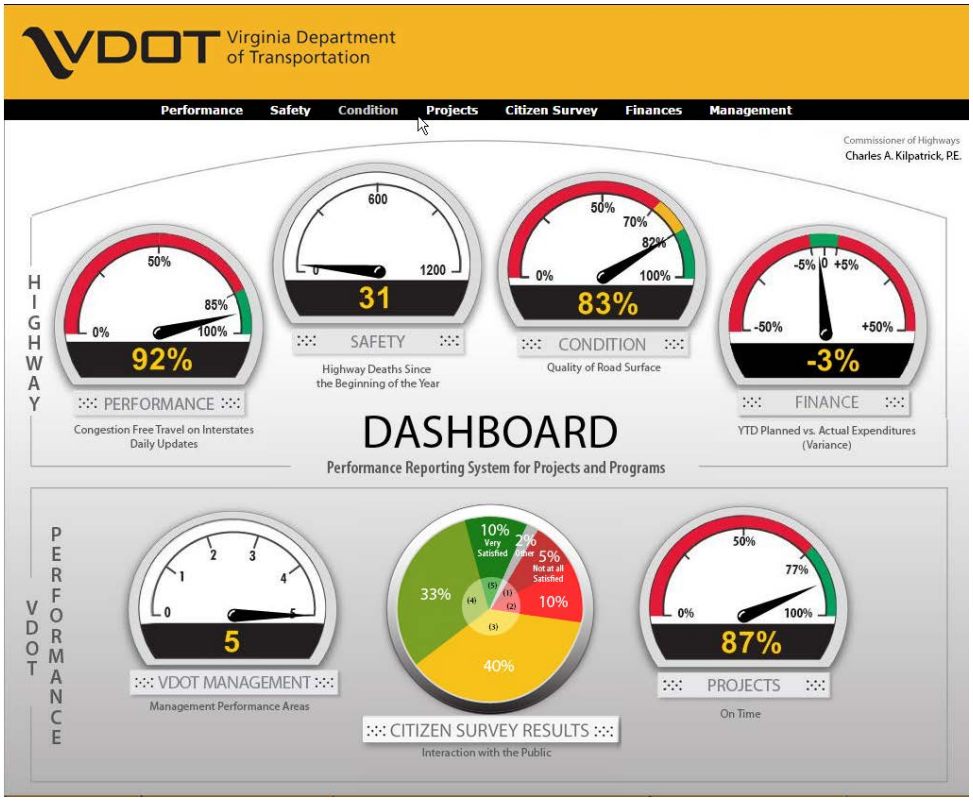
- Information that describes the nature and extent of problems that warrant action: current and projected future condition or performance;
- Information about alternative courses of action and their consequences; and

- Information about available resources and restrictions on their use.

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 – 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 the six 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 focus limited dollars on the most pressing problems – and 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: (Virginia Department of Transportation, 2015)
Figure 2. Virginia DOT 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 the 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 types of 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

more 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 the staff to use data from other business units 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.

DOTs increasingly are facing new expectations for their data and information to be available to everyone, anytime, from anywhere. These expectations come both from internal agency staff as well as from 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.

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

DOT's are obtaining large amounts of operational data from private providers on weather conditions, traffic activities, and incidents, and care must be taken to assure that externally provided data can be integrated with other DOT data, and that its quality 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 utilizing 3D design models – creating opportunities for more dynamic and flexible management of project and infrastructure information across the 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 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 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.

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 (UAVs), increased use of mobile and aerial Light Detection and Ranging technology (LiDAR), 3D laser scanning, fatigue sensors on structures, new image processing algorithms that automate data extraction
- Crowd-Sourcing – reported maintenance issues or asset conditions from mobile apps
- 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

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:

- Information Silos

- Fragmented Information Management Responsibilities
- Information Findability
- DOT Organizational Culture
- DOT Workforce Challenges
- Information Security and Privacy
- 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 feel that they are in the best position to understand their information needs and make decisions about technology investments that are most appropriate to meet these needs. In some cases, restrictions on how available funds for information investments can be used necessitate a silo-based approach. However, silo-based decision-making about data and associated applications can constrain the value of information to the agency as a whole, and impede staff from gaining a multi-disciplinary perspective on issues and solutions. Potential negative impacts of information silos include:

- *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 this 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 is the official, authoritative source. At best, data users may need to expend valuable time tracking down the official data source. Of greater concern is that a user could unwittingly use the "wrong" version 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 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. 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 perspective. 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 – backed up by commitment from senior managers to make sure that these processes are followed. They can also establish standards 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 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 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, 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.

Increasing external expectations for DOTs to make their information available to the public are 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 will be important to ensure release of accurate and consistent information and minimize potential misinterpretation or misuse of information.

One specific area where a fragmented approach to information management is creating problems for DOTs is response to Freedom of Information Act (FOIA) requests. DOTs are facing increasing numbers of these requests, and they can be extremely resource intensive to fulfill. It can take weeks of staff time to locate and compile requested information. Lack of strong information governance and standardized information organization practices, and lack of cross-repository search tools make it difficult to efficiently respond to these requests. Fragmented information management practices

can also increase liability for a DOT – where it contributes to 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 they 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 re-invent old practices for identifying what information needs to be shared, and making sure that it is stored and documented to allow 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, etc. 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 the 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, etc. 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 a great deal of it is typically unmanaged and stored on agency shared 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 Freedom of Information Act, Public Records 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 response to these requests very labor intensive and costly.

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

DOT Organizational Culture

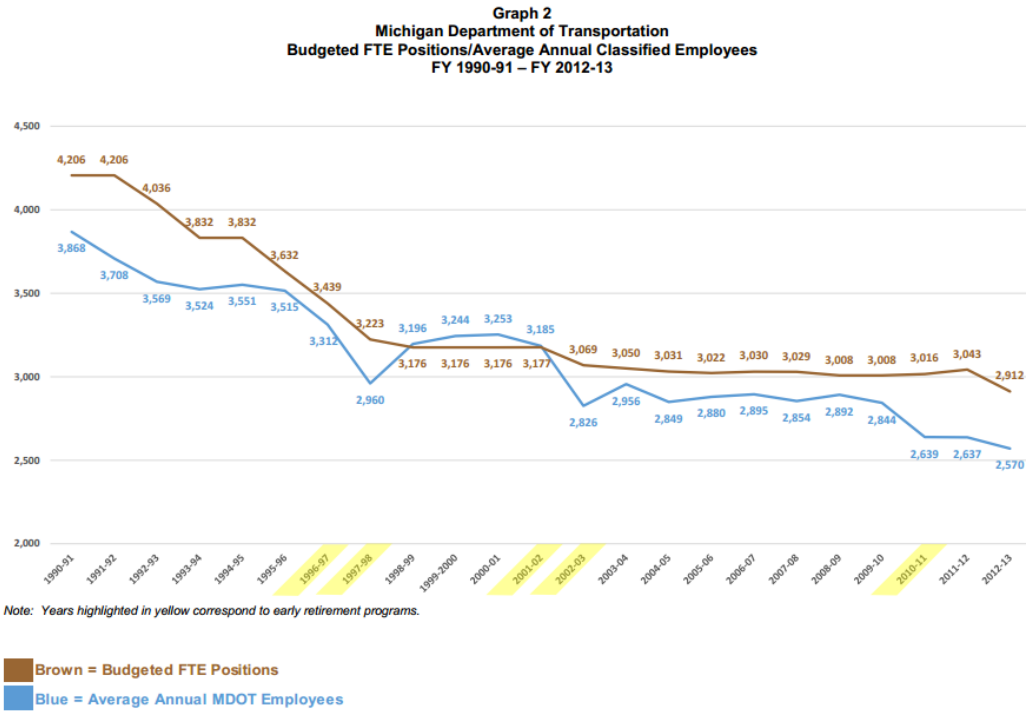
DOTs are typically hierarchical and somewhat bureaucratic organizations. There are detailed regulations, policies and procedures that govern how work is to be accomplished and how performance is to be evaluated. Management typically follows a "command and control" structure, with clearly established 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. 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 lack of an agency-wide approach.

Changes to processes, roles and personnel are not easy to make. Because of this, special efforts may be required to ask employees to take on new responsibilities related to information management, or engage in data sharing efforts across business units. These may include formal changes to job descriptions and consideration of information management practices in performance reviews. In addition, strong leadership is essential to counteract attitudes such as "this is not my job", "we've always done it this way", and "if it's not broke (for us), don't fix it."

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.



Source: (Hamilton, 2014)

Figure 3. Workforce Trends at Michigan DOT 1990-2013

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 skillsets that are in demand. From an information management perspective, implications are:

- Competencies and in-house training resources in information management are thin in many agencies. Individuals who were trained as engineers may be asked to take on data and information management responsibilities without requisite knowledge or training in information architecture, library science or data science. This 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 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 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 they were collected, what their limitations are, and how they 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, evolution of the "Internet of Things", and use of technologies including 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 ITS devices by following standard security protocols. DOTs that include motor vehicle registration and licensing functions including large stores of Personally Identifiable Information (PII) are particularly vulnerable to data breaches. DOTs must balance information security concerns with 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.

DOT 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 which is being phased out;
- They are based on operating system versions which are being phased out;
- They have serious data integrity issues due to a lack of edit and audit capabilities; and/or
- 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. Many times this requires a major technology project and investment, requiring careful analysis and planning to ensure 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 lessen 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 up-front effort to address data migration is best addressed at the beginning of any new modernization effort. It's a time to eliminate data that is 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 IT Services. A second issue that can constrain or influence selection and prioritization of IT investments for information management is IT centralization. For several states – including Michigan, Virginia, Texas and Minnesota – information technology services have been consolidated statewide. IT centralization is intended to reduce total costs and improve service to citizens through elimination of redundant functions and provision of shared services such as IT project management. IT centralization can achieve economies of scale for purchase of hardware, software licensing, and communications and network technologies. Additionally, state IT 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 IT services within state government – and have specialized data and IT needs to meet external reporting requirements and internal business needs, the transition to IT centralization can be challenging for DOTs that are working to improve use of information for decision-making. A DOT operating in a centralized IT environment may experience reduced agility 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.

3. DOT Strategic Information Management

What is Strategic Information Management

The previous chapter reviewed the importance of information to DOTs for getting better results, the changing nature of the information landscape, and the challenges for improving how information is managed. This chapter introduces the key elements of Strategic Information Management - which provide a way for DOTs to consider these factors and chart a clear path forward.

The term *Strategic Information Management* – as used here, 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 (IM) is not the same as Information Technology (IT). An IM 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 IT strategy identifies how information technology – computer hardware, software and communications links - can help to meet these needs. DOT's IT unit is an important enabler of IM and should have a seat at the table in developing and implementing the strategy; however, the IM 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.

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 forum, several current and former DOT directors spoke about data and information (University of Minnesota Center for Transportation Studies, 2013):

> *"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."*
>
> - John Njord, former Director, Utah DOT

> *"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."*
>
> - Paul Trombino, Director, Iowa DOT

Conversations on these topics continued at the 2014 CEO Leadership Forum. This meeting was held at the ITS World Congress meeting in Detroit – 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 on the part of state DOT leadership of the importance of data and information means that this 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 element 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 illustrative examples of how information supports DOT goals.

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 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 (PM) to Extend Asset Life	Identify assets in appropriate age or condition range for PM to be effective
Customer Satisfaction	Proactively Address Common Concerns	Discover patterns through analysis of customer issues from call center and social media – 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, 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.

Identifying information needs to support agency goals is relatively straightforward to do at a high level. Surveys and focus groups can be used to systematically assess needs and gaps. However, meeting these needs through data gathering and information system improvements are costly. If a DOT's employees and partners were asked to develop a wish list of unmet information needs and associated system improvements, the result would likely be a very long list with a price tag that well exceeds 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. This involves a more in-depth look at information criticality – both in terms of the consequences of not having the right information, and in terms of the true value that is (or could potentially be) added by information improvements. Therefore, to be useful, an information management strategy needs to make a compelling business case for how information investments support agency goals. It 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;
- Managing information throughout its life cycle to preserve its value: collection/acquisition, storage, retrieval, analysis & 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 that asset and decide whether to abandon, maintain or enhance it.

The AASHTO Standing Committee on Planning (SCOP) Data Subcommittee has defined a set of data principles for state DOTs (shown below) 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 similar themes to those that have been independently established by individual state DOTs in Minnesota, Alaska and Washington.

AASHTO Standing Committee on Planning 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.

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 utilize information. These may include:

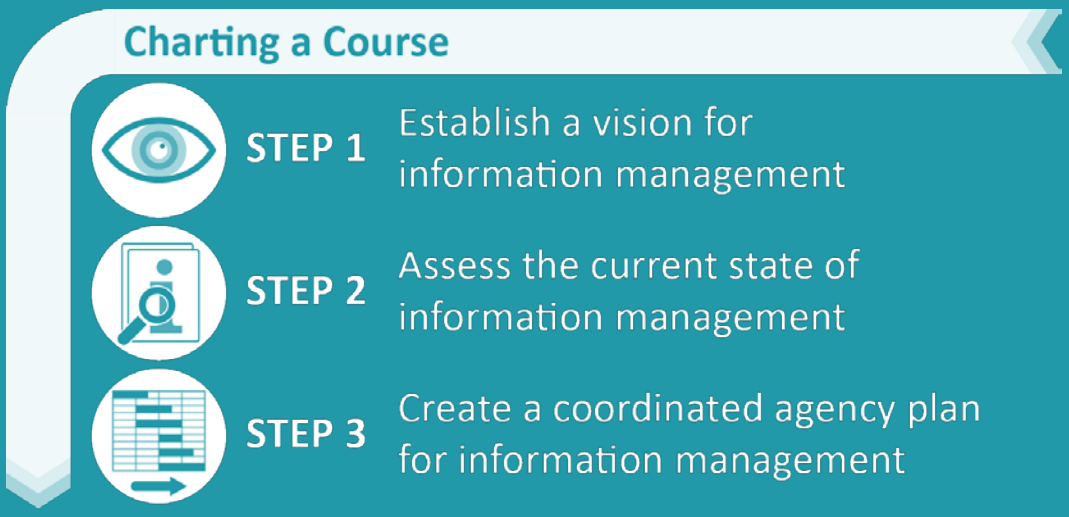
- Establishing standard operating procedures for how available information is to be utilized within planning, budgeting, project scoping, risk assessment, programming, monitoring, and communications functions;
- Assigning responsibilities and accountabilities for gathering, checking, managing and providing 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 needs strong leadership to take on entrenched behaviors and long established areas of autonomy. This can be addressed incrementally through a combination of strategic recruiting, education and communication, and changes to incentive and reward structures. Strong leadership is a necessary condition for driving organizational change; however, it is not sufficient. Successful and sustained change also requires agency champions "on the ground" who have credibility, believe in the proposed changes, and work through the details of implementation.

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. It 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 its 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.

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)

In the example above, the US Forest Service emphasizes agency adoption of information management practices.

A complementary approach to vision development is illustrated in Figure 4. Utah DOT has integrated consideration of data and information as part of their 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 towards improved decision-making (ability to select the right project at the right place at the right time), and sustained results (longer lasting pavements).

Sustainability – Culture, Philosophy, Pavement that Endures

Wisdom – Maintenance Management Levels

Knowledge – Select the Right Project, at the Right Time, at the Right Cost

Organized Information – "A Plan for Every Section of Every Road"

Data – Collect with Current Technologies

Strategic Direction – Preserve Infrastructure

Vision – "Good Roads Cost Less"

Source: Utah Department of Transportation Pavement Status Report (Burns)
Figure 4. Utah DOT's Vision for Data-Driven Pavement Management

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 involvement of important stakeholders for information including:

- Leadership team
- Representatives of major departments or functions – e.g. planning, design, construction, maintenance, operations

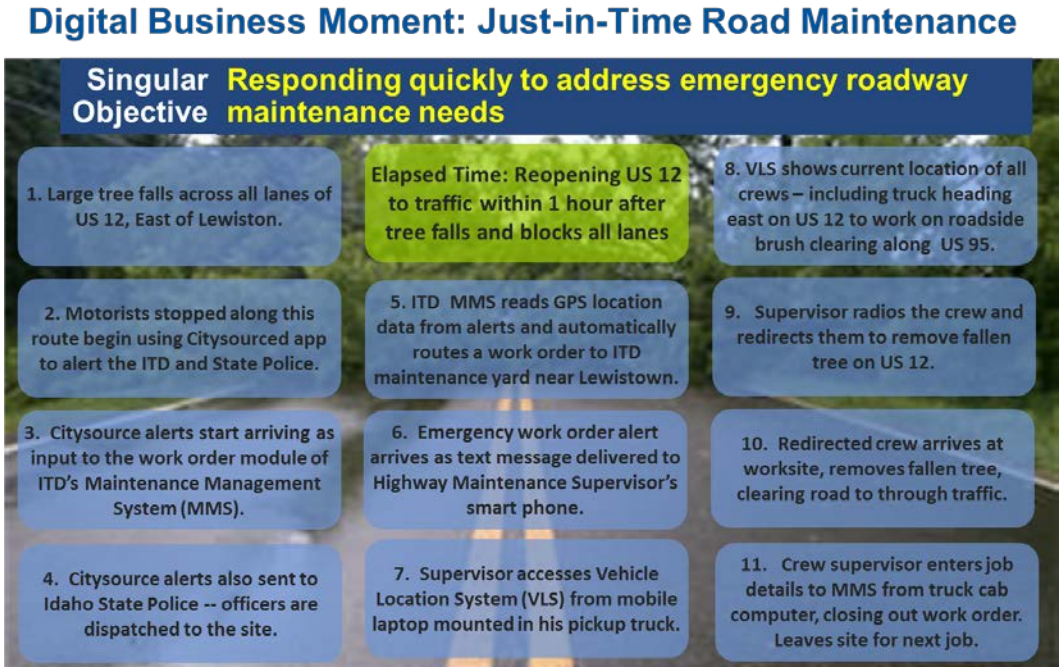
- Representatives of information management and technology functions – e.g. data warehouse/reporting, GIS, internal and external web sites, social media, library management, records management
- Representatives of major data programs – e.g. traffic, safety, road inventory, asset management

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 (Lorenz, 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.

Table A-1 presents possible elements of a DOT information management vision that can be used as a starting point.

One visioning technique is to develop specific examples of how information would add value. Figure 5 below provides an example of a "digital business moment" developed by the Idaho Transportation Department that provides a concrete illustration of how information would be used in an emergency maintenance situation.



Source: (Gartner, 2014)

Figure 5. Idaho Transportation Department Digital Business Moment

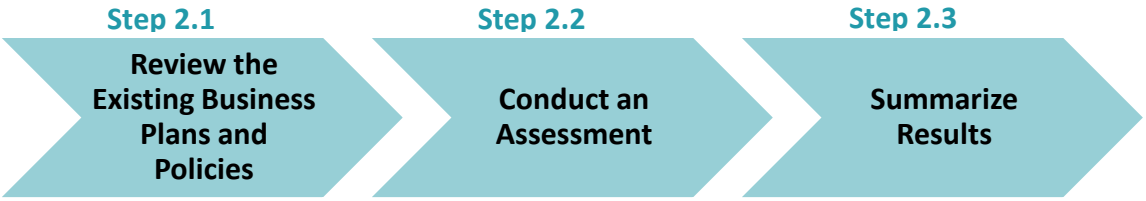
This example can then drive the coordinated deployment of information systems and technologies (e.g. maintenance management system, mobile devices, vehicle location systems) and information management strategies (e.g. standardized location referencing, compilation and integration of incident response 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 ensure that a firm foundation is established to guide subsequent steps. Techniques for visioning include:

- 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 strengths 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:

- Agency strategic plan
- Agency business plan
- Unit/Division business plans
- Information technology (IT) strategic plan
- Information Management (IM) 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
- Risk management policies

Key questions to consider in reviewing these existing documents are:

- 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 document 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 & 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 towards 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 is structured to facilitate linking assessment results to three typical high level goals for information management: (A) improving information to support internal agency decisions and actions, (B) responding to external information requests and reporting requirements and (C) improving information usability and reliability.

The first tool (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.

The second tool (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 – i.e. 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.

The third tool (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 that can build on results from the above three tools 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 utilize 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 below in Table A-5. These can be used as a starting point for agencies to discuss and identify more specific items.

STEP 2.3: SUMMARIZE RESULTS

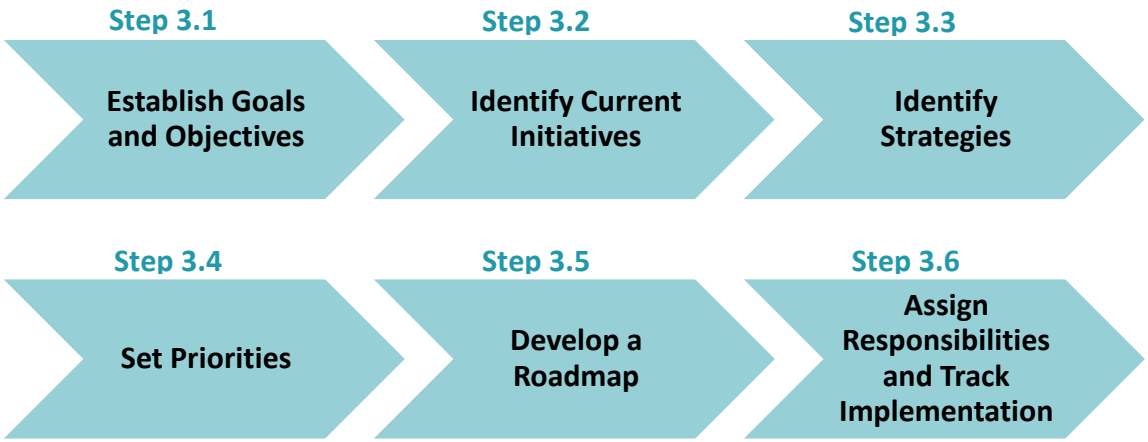
The assessment should provide a good picture of needs and priorities for shoring up agency information. It should inform the development of a coordinated agency plan for information management. The summary can include:

- 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.

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 the appendix 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 (1-2 year), medium term (3-5 year) and longer term (6-10 year) 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 with the agency's strategic or business plan, or serve as a business-focused component of the IT 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 can 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.

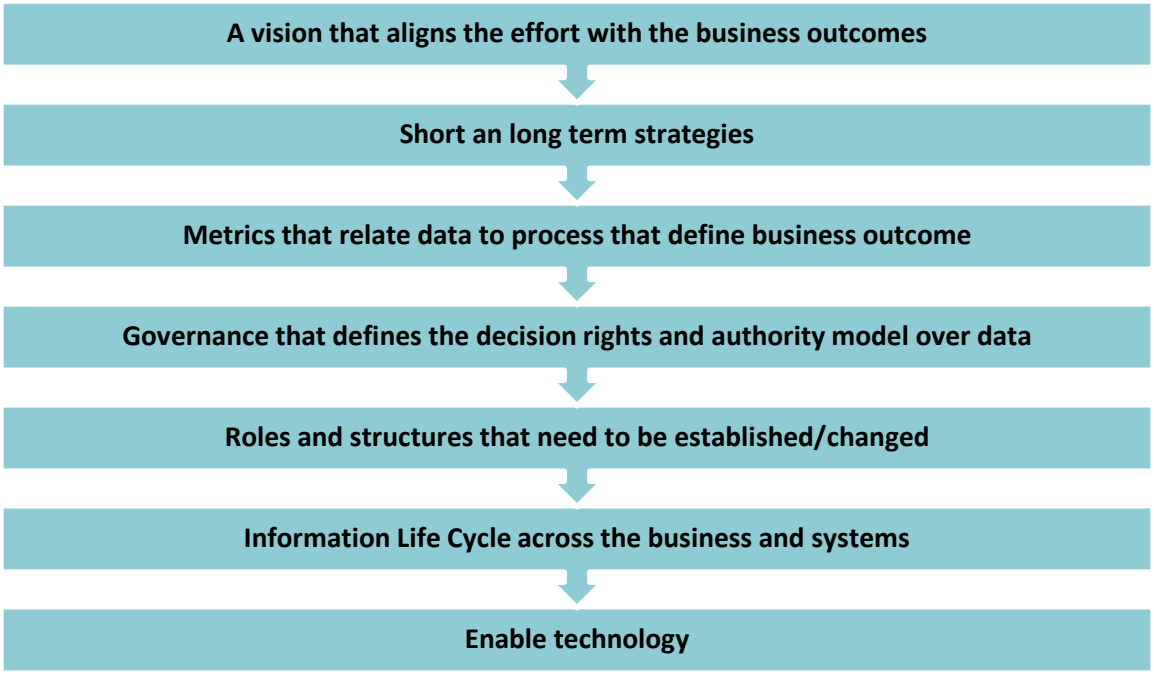
STEP 3.3: IDENTIFY STRATEGIES

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:

- Changes to decision making structures and information governance policies to provide better *alignment* between information investments and agency priorities (see Steps 4-6);
- Developing 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 Idaho DOTs 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. It also highlights the fact that changes to governance, roles and organization structures are important components of effective information management.



Source: (Idaho Transportation Department)
Figure 6. Idaho Transportation Department Building Blocks for an Enterprise Information Strategy

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.

STEP 3.5: DEVELOP A ROADMAP

The fifth step 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.

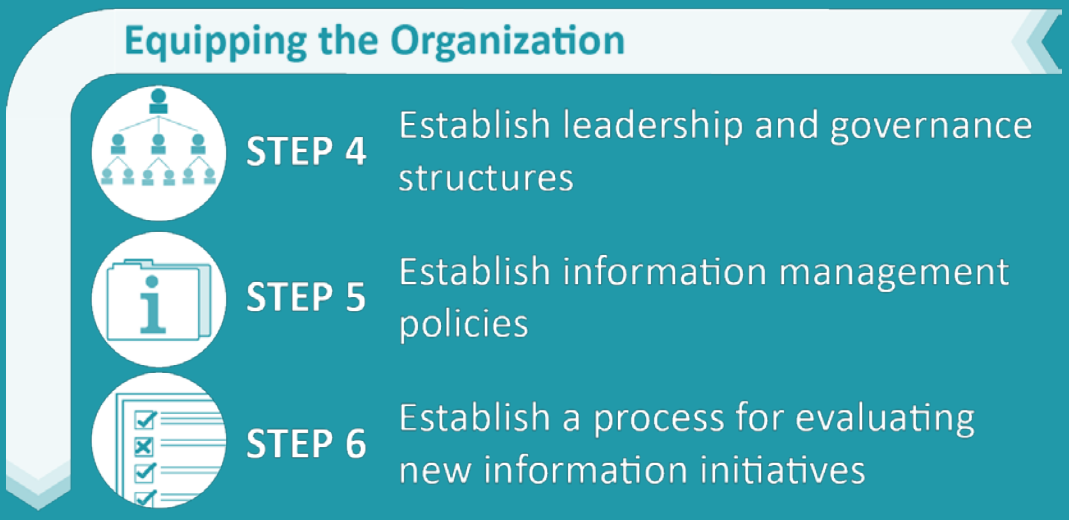
STEP 3.6: ASSIGN RESPONSIBILITIES AND TRACK IMPLEMENTATION

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.

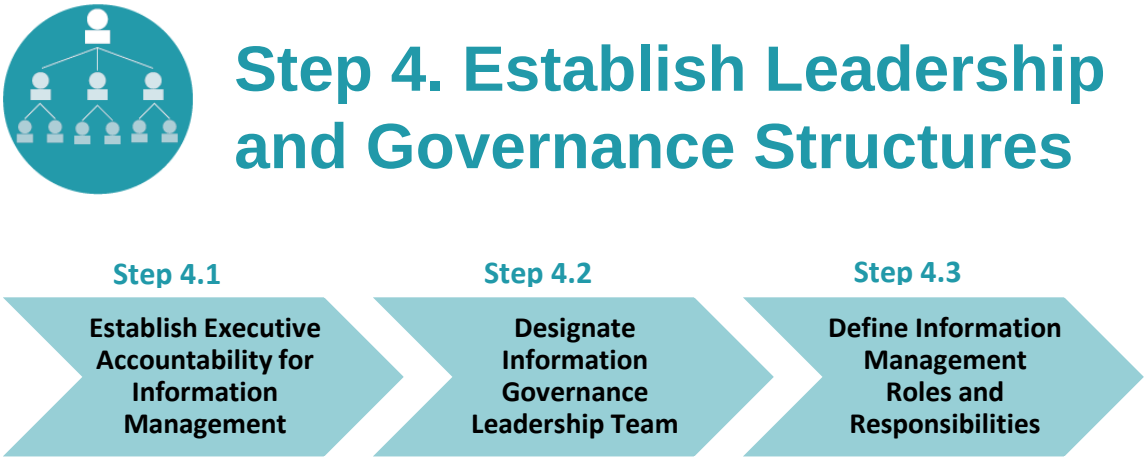
Key Points

The coordinated plan for information management lays out what the agency is going to do to move towards the vision it has established in step 1, and address 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 this plan and assigning responsibility for its implementation and tracking means that the agency intends to move forward. It sets the stage for the remaining six steps of the strategic information management process.

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 suboptimal 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 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 the 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 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 often have a primary focus 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 USDOT) 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 multi-media 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 Y. e., (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: Data Space (big data versus traditional data), Collaboration Direction (inward versus outward), and Value Impact (strategy versus service). Table B-1 summarizes these roles – and can provide a useful reference for DOTs considering establishing a CDO (or other positions with similar functions).

United States Department of Transportation, Chief Data Officer

The United States Department of Transportation added a Chief Data Officer position in 2014, to report to the Chief Technical Officer (who reports to the Chief Information Officer). The DOT Chief Data Officer role includes:

- 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, Chief Data Officer

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

- 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
- Improving Data Management maturity, including and requiring the ability to measure it
- 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 increasing infrastructure and operations value through more modern, consolidated systems.

Source: (Gerber, undated)

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 box below for one example). Some agencies may have existing groups that can take on 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
- Information management units including records management, web content management, engineering document management, 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 – such as: 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 presents sample information governance group objectives and functions. Although these objectives and functions are likely to change based on an agency's focus and 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 IT 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.

WSDOT – Enterprise Information Governance Group (EIGG)

WSDOT'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 WSDOT data and information management related issues. It 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 towards 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)

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, change management). It may also involve establishing metrics to track progress and regular monitoring. Table B-3 provides a sample list of information management 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 the previous section. 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:

- 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
- 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:

- Reducing agency performance in other areas by requiring the transfer of limited resources (e.g. employee time, financial resources) towards 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.

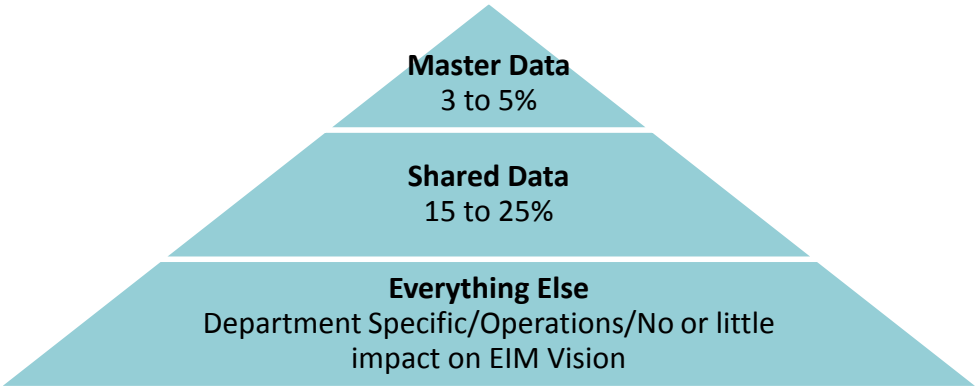
An incremental approach can be taken by developing and rolling out guidance and training on recommended practices prior to establishing formal policies. This gives the agency a chance to test different approaches and adjust them as needed.

The following process 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, policy documents) and lays the foundation for searching across different repositories. Several different types of classifications are useful: scope (agency-wide, department-wide, work unit, personal); topic or subject (environmental, construction, financial, etc.), content type (manual, work order, data set, 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 Department of Transportation, 3-5% of data is master data for the agency, 15-25% is shared, and the remainder (at least 70%) is 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.



Source: (Michigan Department of Transportation)
Figure 7. Michigan DOT Agency-Department Data Categorization

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, specific project teams, or for 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, 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 at the Virginia Department of Transportation. Each triangle represents a high level facet that could be used to classify different types of information at the agency. 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 mandates. The Money and Funding facet would be used for content related to management of financial resources and transactions, including funding and programming.

Source: (Smith, 2015)
Figure 8. Virginia DOT Information Taxonomy

The Minnesota Department of Transportation defined nine different subject area domains as part of their data business planning efforts (see box below). These categories

provide the structure for their data governance activities – a domain steward is assigned to each area to serve as the point person for data related to that subject.

Minnesota Department of Transportation: Data Domain Classification by Subject Area

The Minnesota Department of Transportation has created a set of nine data domains (below), reflecting high-level subject areas in the Department. Each data domain has a Steward, an individual assuming responsibility for the data and serving as a point of contact. The list of domains, types of data contained in the domain, and domain Steward is 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)

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

Hawley Committee Information Categories

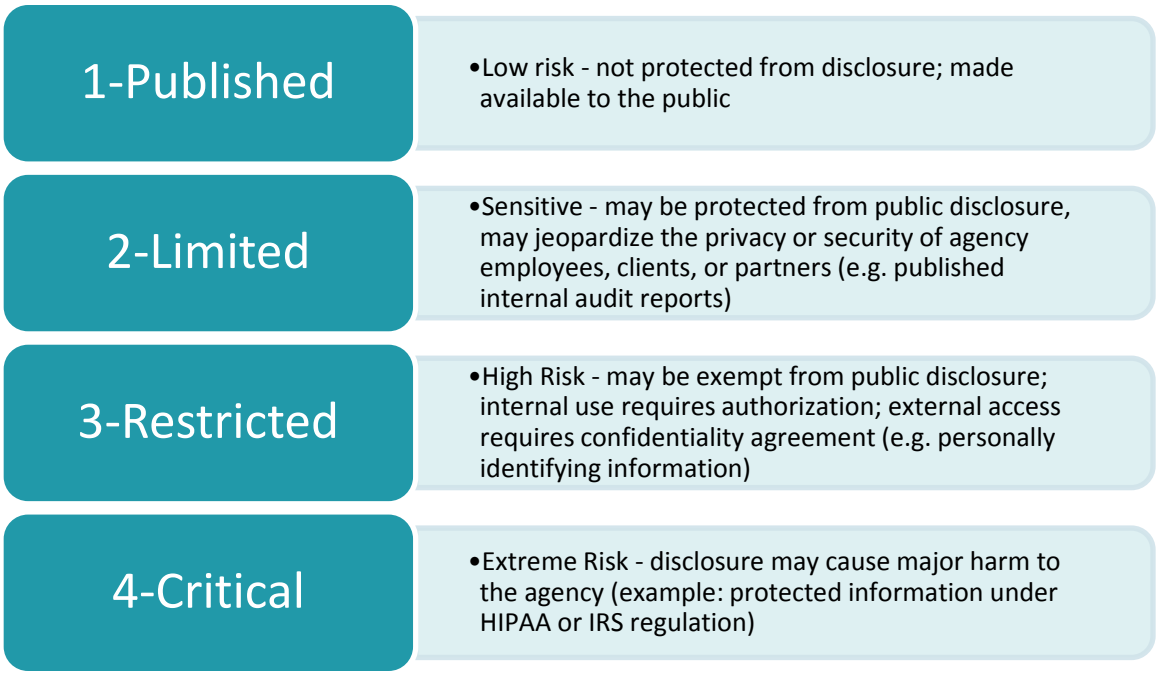
The Hawley Committee was set up in the United Kingdom, and consisted of 15 business executives from private and public sector organizations. Their charge was to develop a model for encouraging boards of directors to recognize and treat information as an asset. The Committee researched information assets and associated risks and opportunities at 40 organizations. They 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 these assets. The research identified eight types of information that can provide a starting point for identification of strategic information assets in any organization. These are listed below, along with examples of the research team's interpretation of DOT information types that would fit within each category.

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, 2001)

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 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 the state of Oregon.



Source: Based on (State of Oregon Department of Administrative Services, 2015)
Figure 9. Risk-Based Information Asset Classification

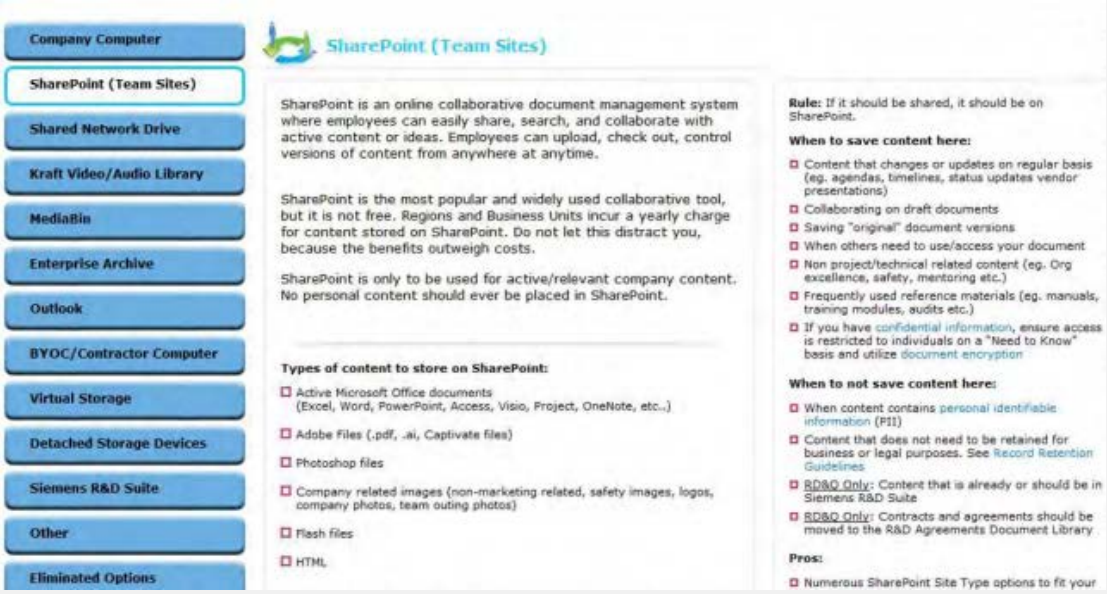
STEP 5.2: ESTABLISH INFORMATION STORAGE POLICIES

The second step 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 boxes below provide two examples of information storage policies. The first, from Kraft Foods lists the different storage options that are available, and describes the intended uses for each one. The second, from VDOT illustrates how information classifications (discussed above in step 5.1) can provide the basis for an information storage (and governance) policy within an agency's intranet site.

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 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.

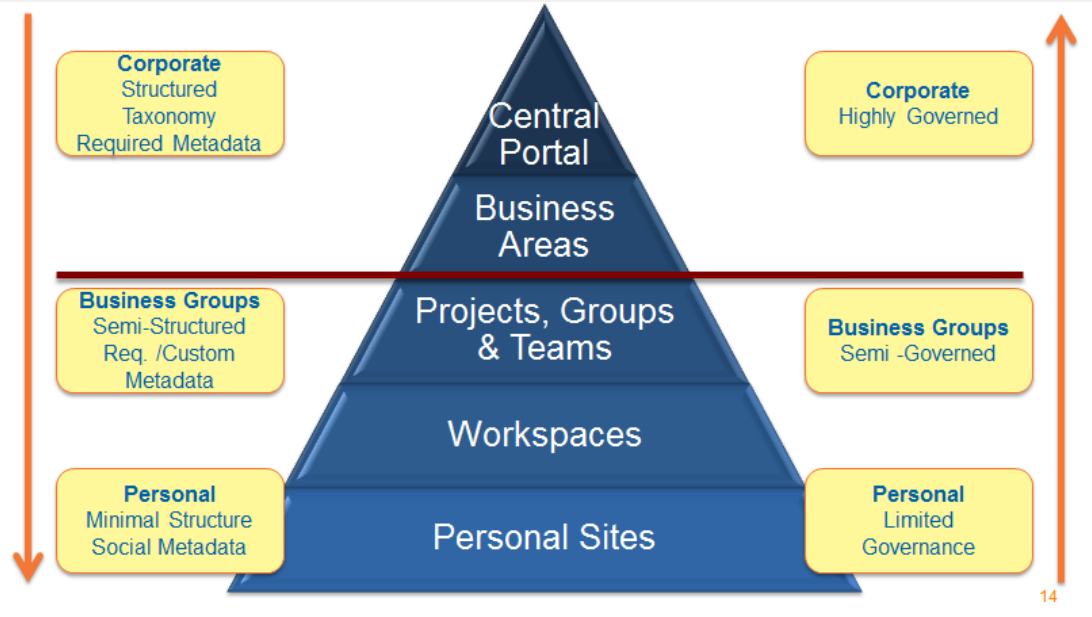


Source: (Transportation Research Board of the National Academies, 2014)

Virginia DOT Governance of Corporate Documents in Transition to SharePoint 2010

The Virginia Department of Transportation (VDOT) 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, VDOT recognized that it needed to focus its governance efforts on a smaller portion of information. VDOT 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, VDOT has prioritized the centralization and storage of about 1,400 corporate documents, documents essential to VDOT's functions. These documents have the highest level of governance and are classified into highly structured areas. The VDOT 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)

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 which are to be archived permanently. However, these 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 between records management functions that are compliance-oriented with 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 has security concerns and 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 Department of Transportation (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. They 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 risk of information loss and ensure 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.

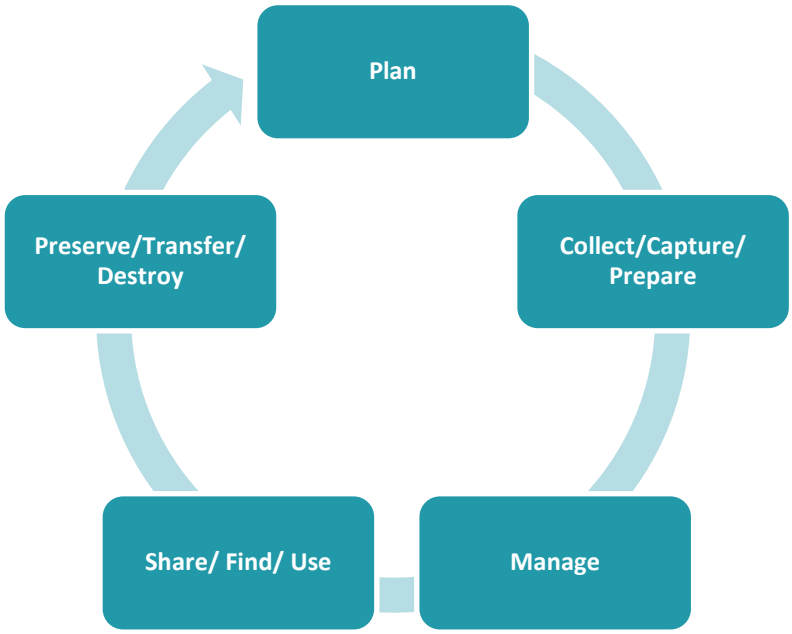


Figure 10. Standard Information Life Cycle

- *Plan:* The Plan phase includes preparatory activities prior to collection of new data or 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 previous 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.
- *Share/Find/Use:* Information is shared, published, or disseminated via appropriate channels. It is discovered by users, who may utilize 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 tool is included in Table A-6 to provide a structure for following the information life cycle. This tool could be adapted to address specific focus areas, or could be used as-is. The tool lists 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 business unit taking the lead. This will impact 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 it 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, 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 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

A fourth type of policy concerns standardization and integration. This 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.

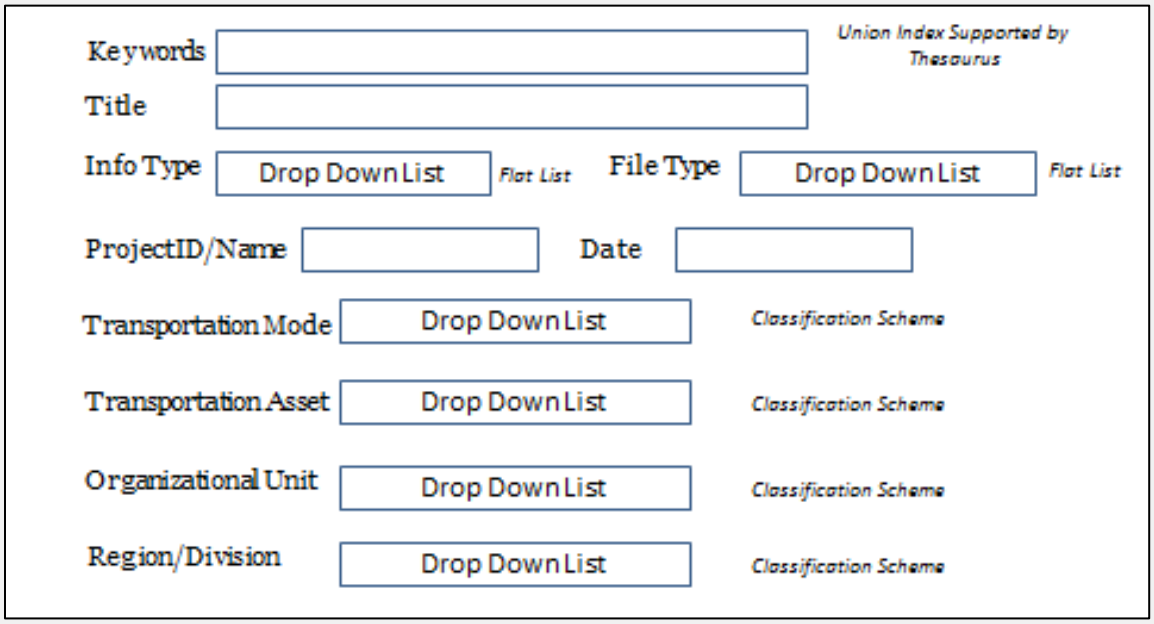
- Standardizing spatial and temporal referencing so that different data sets and content types can be integrated based on location and time frame.
- Standardizing metadata elements across different information repositories – some of which may utilize authoritative sources of master data (e.g. any so that document or data record about a construction project would be tagged with a common project identifier) as well as spatial and temporal referencing.

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.

Standard Metadata Elements

A recent project for WSDOT 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 K. , 2014)

Geospatial Data Management Policies

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

North Carolina (NCDOT) 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. NCDOT also outlines geospatial data and metadata standards, which 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 NCDOT geospatial standards include:

- Standard spatial reference (North American Datum of 1983)
- Standard measurement units (United States Survey Foot or 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 (ODOT) 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)
- Global Positioning Systems (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)

Key Points

Most DOTs have policies and procedures that establish common practices and ensure consistency. This step 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 New Information Initiatives

Developing an Evaluation and Prioritization Process

Step 3 discussed developing a coordinated agency plan for information management, which includes identifying and prioritizing initiatives to move the agency towards its vision. Once the roadmap has been completed, there will be a need 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 – for 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 which can impede agility of business units and an overly decentralized approach which makes it more difficult to move towards 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 - based on size, scope of use/impact within the agency or use of information technology resources. Many agencies already have an established IT 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.

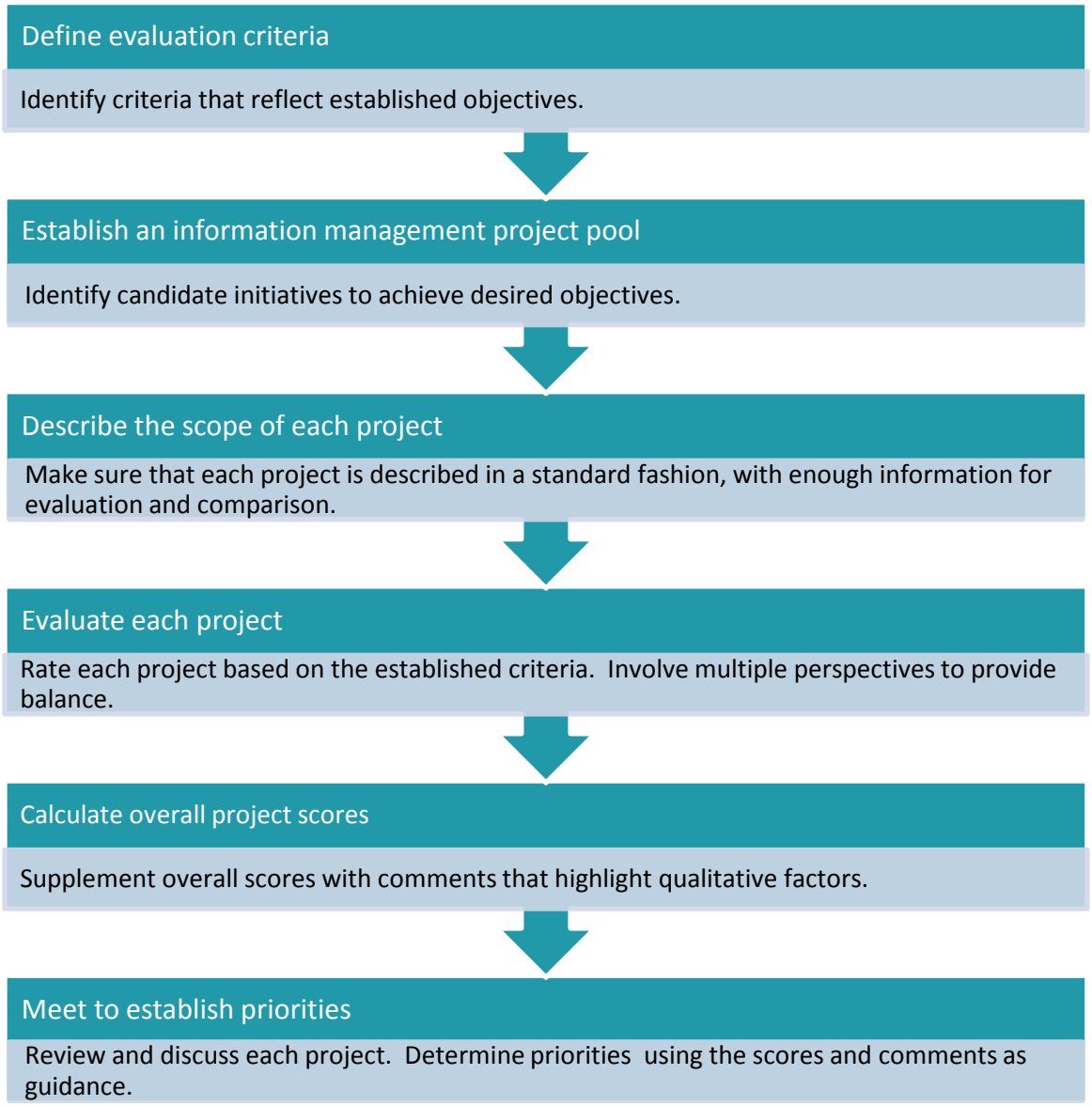


Figure 11. Sample Project Prioritization Approach

The evaluation and prioritization 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 below in Table A-7. This form could be used as part of the sample approach in Figure 11, as a way to "establish criteria for determining project impact."

Utah DOT Information Technology Project Evaluation and Prioritization

Utah DOT (UDOT) piloted an information technology (IT) 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:

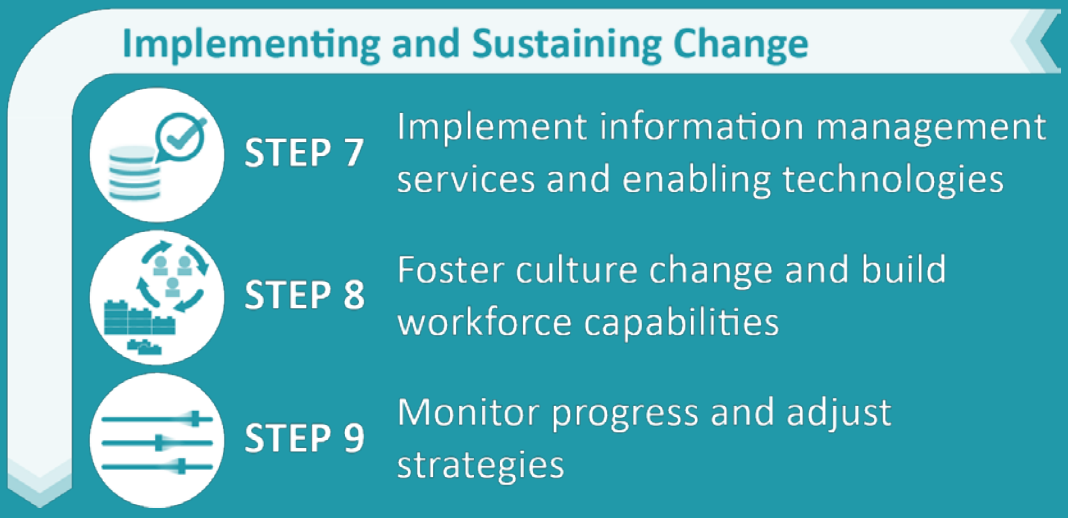
- Organizational impacts (e.g. preserve infrastructure, optimize mobility, number of users)
- System condition (e.g. meets current business requirements, meets security requirements)
- Project value and funding source
- Project risks (e.g. level of impact on business processes, anticipated user/customer 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 UDOT Deputy Director and includes UDOT 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 creating a process that creates unnecessary bottlenecks for division or department-level efforts.

6. Implementing and Sustaining Change



Step 7. Implement Information Management Services and Enabling Technologies

This step involves establishing standards and processes to implement and maintain a consistent agency-wide structure for classifying, defining, describing, integrating, and finding data and information. It encompasses coordination of data and information architecture-related activities that may currently be carried out by libraries, records managers, content managers, data offices and IT 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
- Data Integration, Reporting and Analytics

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

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.

Service	Description	Enabling Technologies
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 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. It will identify ways to achieve synergies across these different functions.

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 is a critical activity that provides a common "map of the territory" when it comes to information management. If done well, it 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 consistent standards and integration methods. The scope of architecture efforts can vary – from a single system to organization-wide. 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:

- 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;

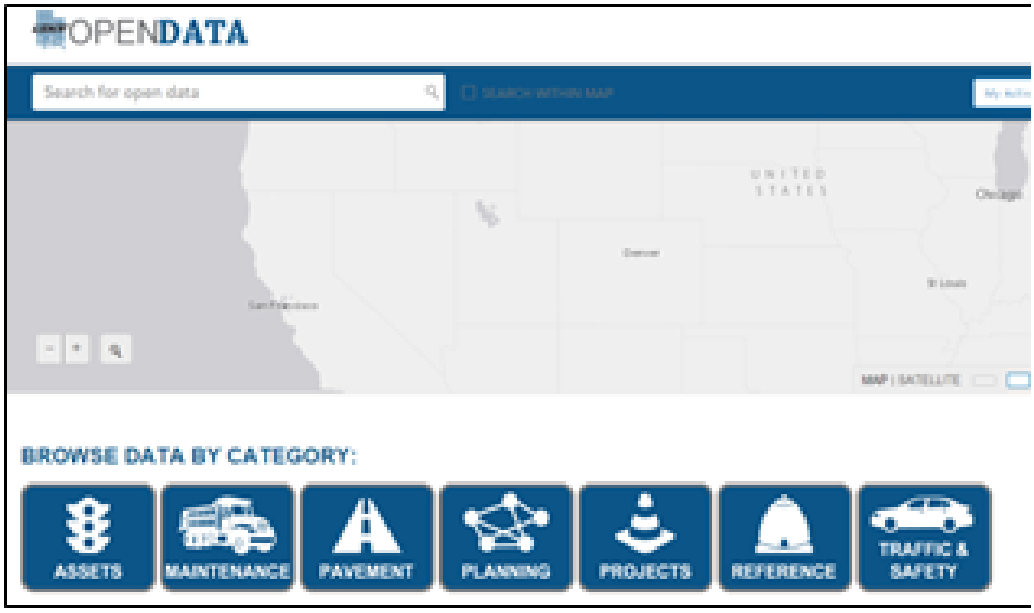
- Agency staff responsible for developing and updating content on the agency's external facing website;
- Agency staff responsible for developing and updating content on the agency's intranet;
- Library staff and archivists responsible for developing and maintaining collections of agency publications;
- 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, the architecture 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, architecture 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 (IA) is an evolving discipline that has been defined as "art and science of shaping information products and experiences to support usability and findability." IA 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. IA efforts commonly focus on design of web sites, but IA 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.



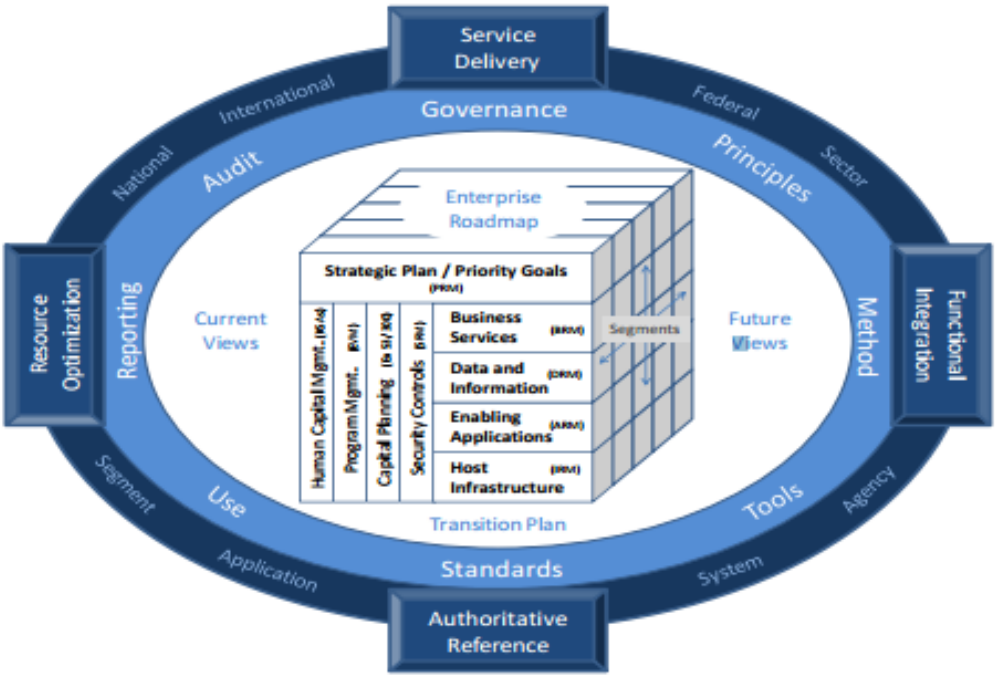
Source: (Utah Department of Transportation, 2015)
Figure 12. Utah DOT Open Data Categories

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

ENTERPRISE ARCHITECTURE

Enterprise Architecture (EA) is broader than information architecture – it 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 EA frameworks (both commercial and open source), including the Federal Enterprise Architecture Framework (FEAF) illustrated in Figure 13 (Executive Office of the President of the United States – Office of Management and Budget, 2013).



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

Figure 13. Federal Enterprise Architecture Methodology

From a DOT Strategic Information Management perspective, the business process and data/information components of EA 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 2000's involving diagramming of data flows across business units and external entities (e.g. FHWA) for major business processes (e.g. Program Management, Preconstruction, Project Initiation). Ohio DOT completed an EA design study in early 2014 that included a data architecture to "establish data standards for all of Ohio DOT's systems 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 – and enabling technologies provide an important mechanism for ensuring that a DOTs 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, these 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 the 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 USDOT record keeping requirements, and handle information requests related to audits and litigation. Public Records are typically broadly defined (see box below).

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, surveys).

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."

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 Department'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; ODOT fulfills request – redacting exempt portions or denies request and cites legal authority for denial; copying fee is collected if hard copies are requested.

Source: Public Records Act Policy and Procedures (Ohio Department of Transportation)

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 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:

- Clarity on what the goals of the system are and how to measure success
- Governance – who will be tasked with establishing "rules of the game" 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 way 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 Systems Implementation (from National Archives of Australia)

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

Change Management is Required. Agencies felt that the implementation of an EDRMS should be treated as a change management project. Staff 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 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.

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

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 their 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 (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, state transportation legislation) as well as national transportation information resources (e.g. engineering standards, USDOT, TRB and AASHTO reports, 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 web content development, develop and manage controlled vocabularies (for broader application beyond indexing of library collections), create metadata for data sets, perform literature reviews to support agency research, and provide reference and advisory services.

Wisconsin DOT (WisDOT) Transportation Library Web Site

A unique aspect of the WisDOT Library Web site is the philosophy of partnership with different areas and personnel within the department. 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 which they maintain. The result is the library as a central conduit and repository for others within the department.

Source: (Wisconsin Department of Transportation, 2009)

Metadata and Terminology Management

METADATA MANAGEMENT

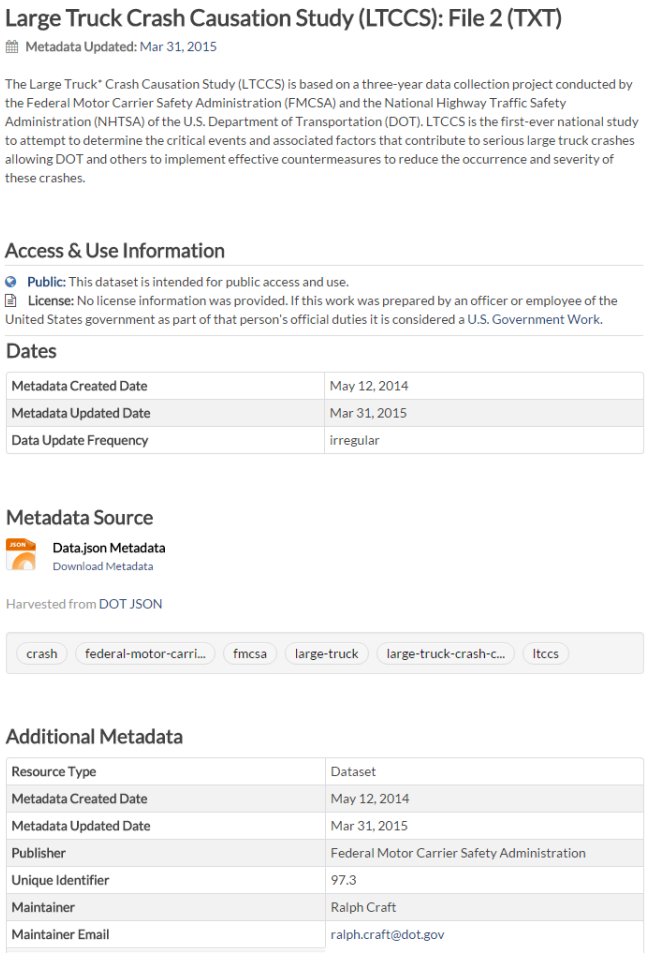
Metadata is "structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource" (National Information Standards Organization, 2004). Metadata comes in multiple forms – for example each of the following would be considered to be metadata:

- 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
- A detailed description of a data set

Creating and maintaining metadata is essential to effective information management. However, it 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 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 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 the agency's 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.)



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
Maintainer	Ralph Craft
Maintainer Email	ralph.craft@dot.gov

Source: (U.S. General Services Administration, 2015)
Figure 14. Metadata from DATA.GOV

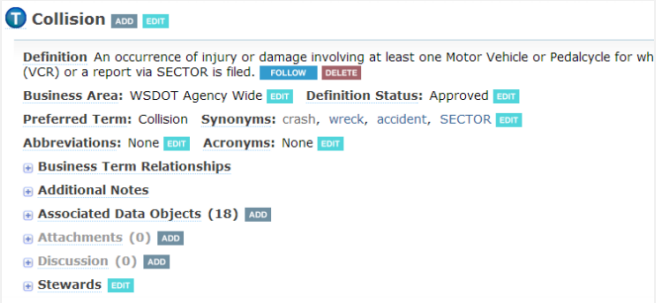
TERMINOLOGY MANAGEMENT

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

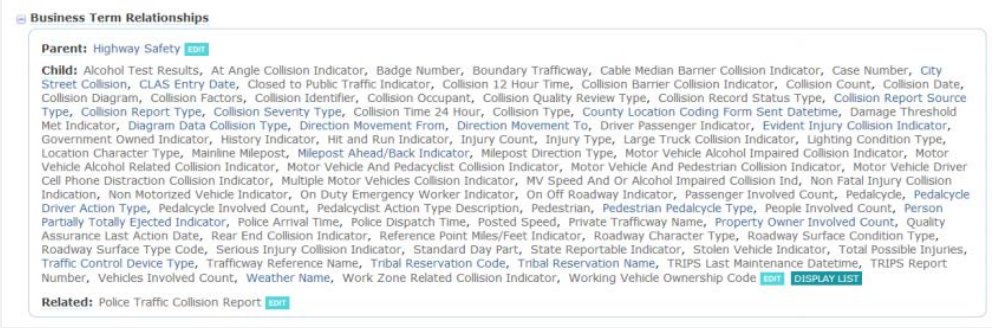
answer basic questions such as: “what is a project?” or “what is the definition of a divided highway?” Other terminology management tools such as taxonomies and thesauri can be used to further define how different terms are related to one another (e.g. a crash is a synonym for a collision; coal is a type of commodity, etc.) The Transportation Research Board (TRB) and the United States Department of Transportation (USDOT) have worked for many years to create and maintain a set of standard terminology for indexing transportation research products (the Transportation Research Thesaurus) (The National Academies of Sciences, Engineering, and Medicine, 2012). 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).

Washington State DOT: DOTS Metadata Repository and Taxonomy Management System

Washington State DOT has implemented the DOTS (“Data or Term Search”) 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. It also includes a search capability to provide users 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)

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. This involves 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 use 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, ensuring sufficient ongoing staff resources and expectation management are all important to success.

Utah Department of Transportation: Data Warehouse Development

The Utah Department of Transportation 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. UDOT 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 is more integrated with conventional (non-spatial) database systems, and there are now end-user tools for creating and updating spatial data, and creating maps, and performing spatial analysis. This shift allows DOTs to re-think how they manage and support spatial data. It 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 programs, and manage and track work (Transportation Research Board of the National Academies, 2015).

OTHER DATA INTEGRATION METHODS

While not as common, some organizations use middleware technologies 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 is stored in its 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).

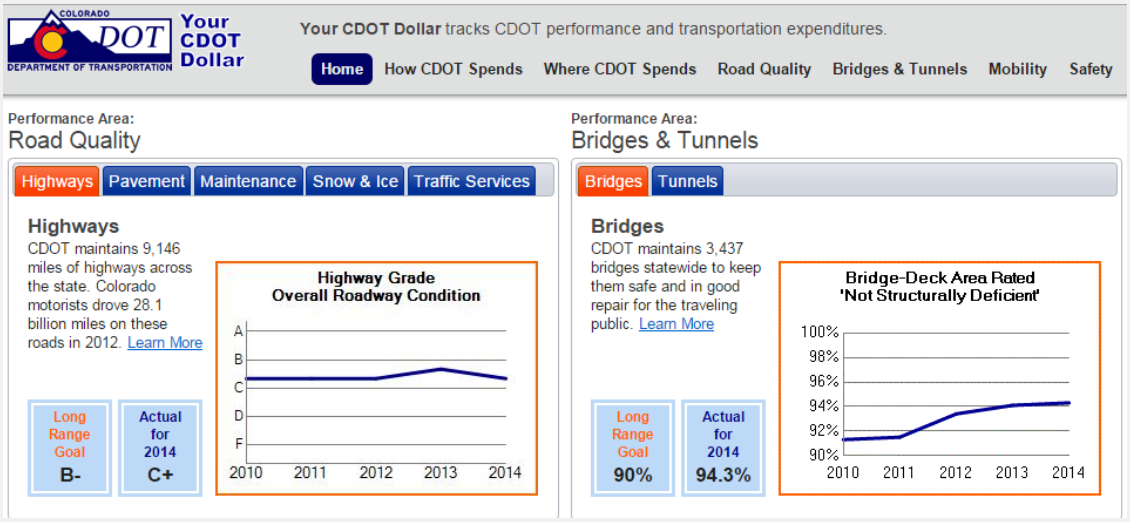
REPORTING, MAPPING, BUSINESS INTELLIGENCE AND DASHBOARDS

Reports, maps, dashboards, charts, and other interactive data and content exploration tools are the visible products of an organization's information management initiatives. Without any 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 IT 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 otherwise occur. However, strong leadership and governance is required to make this work – to gain agreement on needs and to balance competing priorities.

Colorado Department of Transportation: Your CDOT Dollar

CDOT developed a dashboard for performance reporting, which is also made publicly available online. This dashboard compares agency performance to the CDOT long range goal across different areas. It also visually 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)

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 – and 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 UPS and is shown in the highlighted text box below.

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

UPS had a wealth of data: vehicle sensors captured engine performance, idling, and vehicle location, and driver handhelds captured 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 CO2 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 towards their strategic information management vision. Agencies can develop specific initiatives for each of the six categories of services discussed above 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. The references provided above can provide a starting point for this activity.

Step 8. Foster Culture Change and Build Workforce Capabilities

All successful information management improvements require attention to the human side of the equation. There are two basic questions to ask:

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

Workforce Capabilities. Implementing the information management services discussed above in Step 7 requires a number of specialized skills. Getting the right people with the right competencies involved is important to maximize success. 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 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.

Colorado DOT: Bridging the Organizational Gap between Business and Technical

Whether in small private businesses or large government enterprises, communicating information business needs often must flow through IT 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 Department of Transportation (CDOT) 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. It 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 CDOT and their parts of the organization. The Business Process Experts work together to develop common approaches, solutions, and priorities for their departments and for CDOT.

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

Source: (SCONUL Working Group on Information Literacy, 2011)
Figure 15. SCONUL Information Literacy Landscape

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:

- Value of information for the employee's job and to the agency as a whole
- Importance of sharing information – and understanding of how to store and organize shared information
- Coping with information overload
- Evaluating information needs
- Identifying available information sources – including online sources, physical sources, and people
- Leveraging available information services (e.g. reference desk, 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, 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.

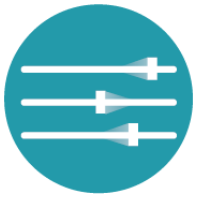
Human barriers to information management improvements that are related to resistance to change should be assessed and addressed as part of the planning for each initiative.

They 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:

- Making strategic hires to build technical capabilities in weak areas, or to introduce people to the organization who can evangelize 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 focus to review what has been accomplished and adjust as needed is required. Without regular attention, it will be difficult to make sustained progress towards 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 resourcing 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 to assess progress and make course corrections. Key questions to ask during this review are:

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

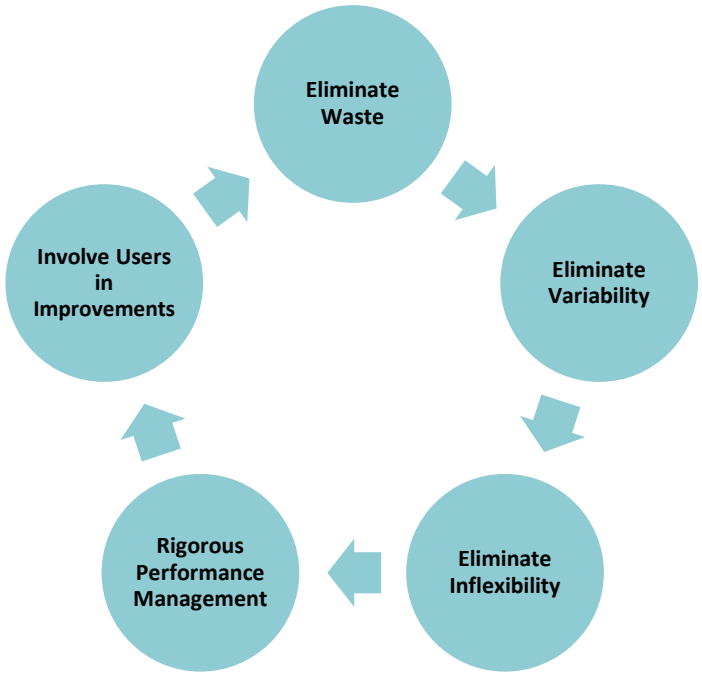
In addition to looking for areas where improvements or adjustments are needed, it is important to identify, document and celebrate successes.

Applying Management Frameworks

A number of different management frameworks can help agencies with ongoing review and continuous improvement of information management practices. 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 primarily based 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.



Source: (Sollerthoughts.com)
Figure 16. Lean Framework Cycle

Lean principles are implemented in most successful manufacturing companies. Although not as repetitive and tangibly defined, information management processes can also benefit from applying the Lean framework. For example, DOTs can identify instances of:

- Over-production: producing or collecting more data than is needed by the agency
- Transport and Motion: unnecessary movement of data and content across repositories
- Inventory: storage of data or content that is 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 the needs, or is not managing its information efficiently. These 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.

Lean 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.

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 Department of Transportation

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 our operations. CDOT uses Lean to create more value in the work they do on a daily basis by making sure their 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:

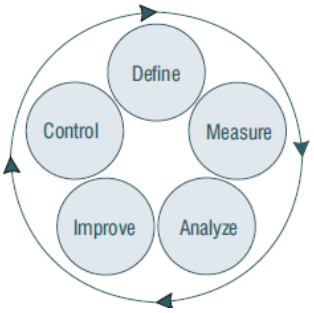
- hires employees 17% faster,
- issues Oversize and Overweight Permits 30% faster, enabling commercial vehicles to get their goods to where they need to go;
- reimburses transit project grantees 75% faster, getting dollars to benefit customers more quickly; and
- uses inventions by CDOT employees to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

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.

Six Sigma involves five steps as 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.



Source: (AASHTO, 2011)
Figure 17. Six Sigma Framework

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.

Applying Lean Six Sigma for 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 (legal, finance, human resources, information technology, 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 non value-added activities.

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

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

Source: (Brett & Queen, 2005)

Wisconsin Department of Transportation

The Wisconsin DOT (WisDOT) is actively engaged in improvements under the Governor's Executive Order #66 that requires state agencies to implement a Lean government initiative. WisDOT's lean approach is based on Lean Six Sigma. They are establishing performance baselines and metrics to measure improvement; determining whether these metrics can be added to or replace current monthly (statewide) Scorecard metrics; reporting quarterly on projects chosen for redesign/improvement and project results; and reporting on their Lean initiative monthly at cabinet-level meetings. WisDOT ties the Lean process improvement projects with supporting their MAPSS (mobility, accountability, preservation, safety, and service) performance management program.

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 including: *Simplify the IT Hardware Purchase Process* and *State Trunk Highway Network Data Processing*. They are 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.

Balanced Scorecard Framework for Strategic Performance Management

The Balanced Scorecard is a classic strategic management framework developed in the early 1990's (Kaplan & Norton, 2005). It provides senior executives with a high level assessment of progress towards 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)
- Process Efficiency
- 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.

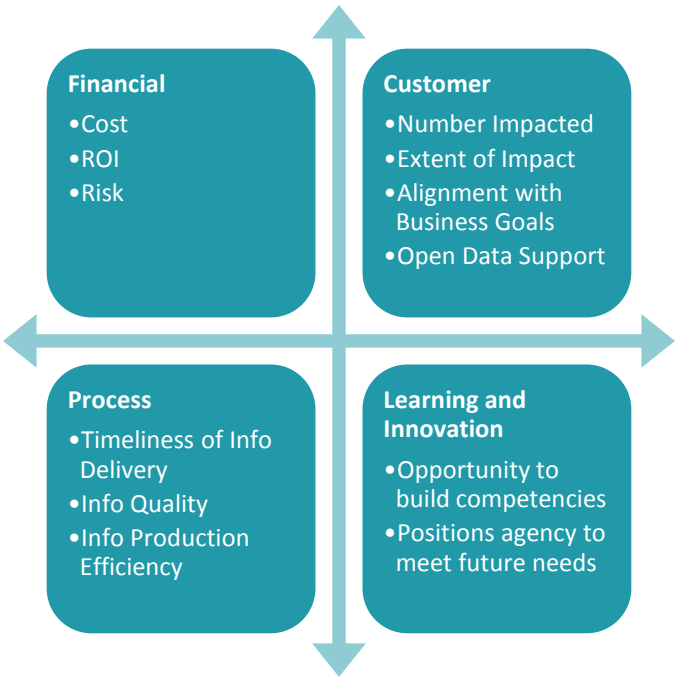
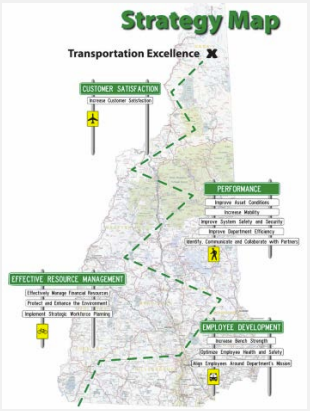


Figure 18. Balanced Scorecard Framework for Information Improvement Initiatives

New Hampshire Department of Transportation

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



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

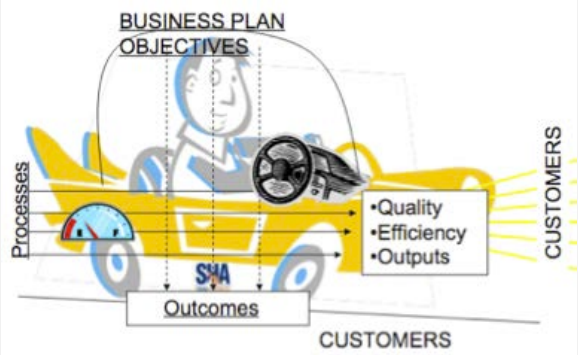
The Malcolm Baldrige Award was established in 1987 to promote quality awareness and innovation in U.S. companies. A study conducted by the AASHTO Standing Committee on Quality (SCOQ) in the mid 2000's found that 29 States were using some modified version of the Baldrige Criteria (Oasis Consulting Services,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

Source: (Baldrige Performance Excellence Program, 2015)
Figure 19. Baldrige Framework

Maryland State Highway Administration

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



Some of the results were: the entire senior management team met periodically to discuss the budget process, 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.

Key Points

This final step in the strategic information management process provides an essential feedback loop from implementation back into planning. It 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 technologies, they will learn about what is working as intended, and where refinements are needed in order to move closer towards the vision they have established.

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

7. Summary

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 enables DOTs to chart a clear path forward and make 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. Analogous to a physical asset, Information serves multiple customers, it has a life cycle that needs to be planned for; it requires skilled staff to design and maintain – as well as coordination 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 the 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 (Chart the Course), set up governance structures, policies and investment processes (Equipping the Organization), 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:

- 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.
- Value-Driven Approach – link every investment, policy and process change back to how it will help the agency to deliver on its core mission.
- Flexibility – anticipate and plan for changes in agency priorities, and in the information and technology landscape – which 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 data and information they collect and create.

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
- 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
- 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
- SAA - Society of American Archivists Glossary: http://www2.archivists.org/glossary

- OMB Circular A-130: http://www.whitehouse.gov/omb/circulars_a130_a130trans4/
- 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 review of multiple existing sources. A number of other professionals have been invited to suggest terms that should be included and to review the definitions, including members of the NCHRP project panels and standing committees of the Transportation Research Board. 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.** 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. *Example*: 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. *Example*: Library of Congress Subject Headings. (Source: Adapted from ANSI/NISO Z39.19)

- **Digital Curation.** Selection, preservation, maintenance, collection and archiving of digital content objects.
- **Data.** Representation of observations, concepts or instructions in a formalized manner suitable for communication, interpretation or processing by humans or computers. *Examples*: 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. (DAMA)
- **Data Archiving.** The process of moving data that is 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 meta data 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 is 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 meets 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. *Examples*: 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 the data.
- **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 databased 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)
- **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)
- **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. *Examples*: 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 is sought, located, secured, and searched with the intent of using it as evidence in a civil or criminal legal case.
- **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. *Examples*: 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 Department of Transportation) 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.
- **Meta Data.** 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)
- **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 is created or received in the course of individual or institutional activity and set aside (preserved) as evidence

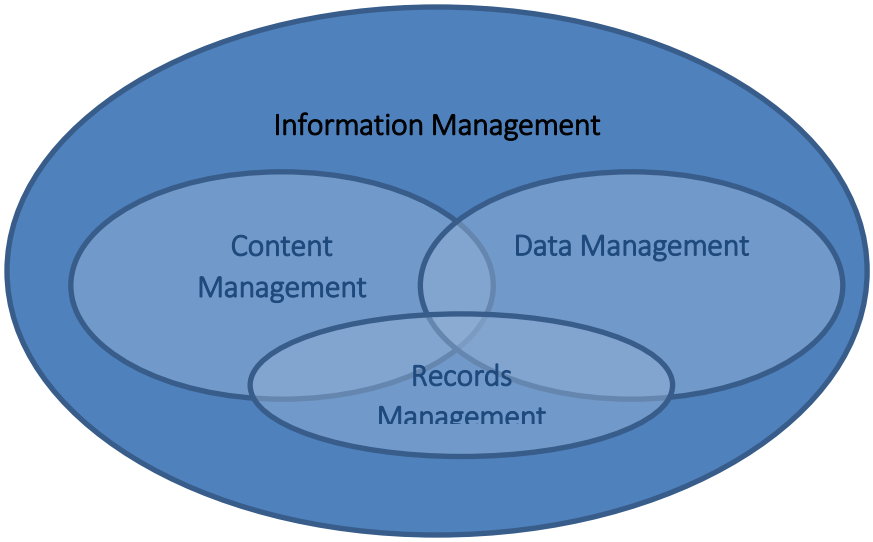
of that activity for future reference. Records may include paper documents, digital documents, data sets, emails, and other content types. (Source: Adapted from SAA)

- 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. Examples: XML file, social media post.
- Sensitive Data. Data that is confidential, privileged, or proprietary that should be protected from unauthorized disclosure, loss, misuse, or corruption in order to avoid serious consequences to the organization that owns it.
- 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 pre-defined 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 (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. *Examples*: text, video, sound, images.
- **Web Content Management.** Processes and tools for creating, updating and maintaining web site content including text, images, links, and forms.

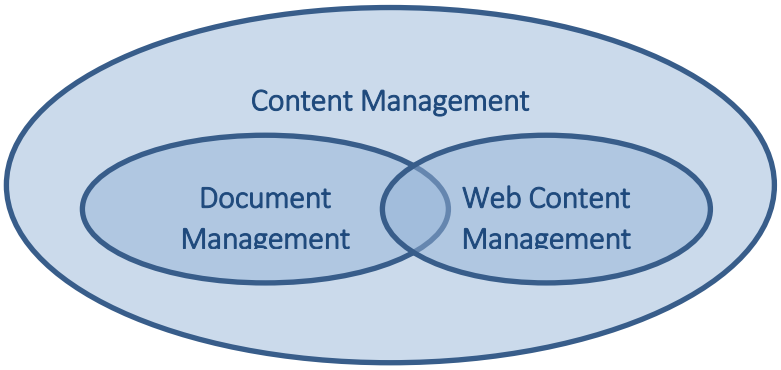
A Note on Information, Data, Content and Records Management

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 here as the highest-level umbrella term. It encompasses content, data and records management. Whether data—structured or unstructured—is 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.



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Records Management

National Archives Website: http://www.archives.gov/records-mgmt/toolkit/#list

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

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Appendix A: Assessment Tools and Checklists

This appendix contains assessment tools and checklists referenced in the body of the Guide.

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 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.

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 eDiscovery)	☐ Urgent	☐ High	☐ Moderate	☐ Low
Reduce time and effort required to answer questions from the Legislature	☐ Urgent	☐ High	☐ Moderate	☐ Low

Issues/Improvement Needs	Priority of Taking Action to Address Issue/Need			
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 x 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	

Risk	Likelihood (if no action is taken)	Consequences/ Impacts	Score (Likelihood x Impacts)
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	

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 IT, GIS, data management, library management, web content management, 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

Practice	Use of this Practice:			
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 it 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

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
Is 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. Assessment Tool: Evaluating and Prioritizing New Information Management Initiatives

Criteria	Rating			
Consistency with information management vision and roadmap	☐ High	☐ Moderate	☐ Low	
Consistency with other agency plans (IT strategic plan, GIS strategic plan)	☐ High	☐ Moderate	☐ Low	
Time or cost savings	☐ High	☐ Moderate	☐ Low	
Sustainability – staff capabilities to maintain, existence of champion to support	☐ High	☐ Moderate	☐ Low	
Coordination and Integration – score low if duplicates existing functions; 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

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

Table B-3. Sample Information Governance Roles and Responsibilities

Role	Responsibility
Executive Sponsor	Provide leadership and guidance. Provide sponsorship for information governance process, and act as final arbiter or decision-maker.
Information Strategist	Understand agency information management issues and perspectives; facilitate agreement on goals, strategies and priorities; elevate issues to executive sponsor as needed; lead and/or coordinate improvement initiatives. Provide 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	Oversee development and implementation of records management policies, guidance and management systems. Plan, organize, direct, coordinate and establish controls for agency records activities. Coordinate with agency program managers to ensure records creation, maintenance, use and disposition are in accordance with agency policy. Work with the agency IT executive to incorporate records management functionality into information systems appropriate to the records they support.
Library Manager	Oversee: (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	Serve 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.). Establish workflow and governance policies and support their implementation with training and monitoring activities.

Role	Responsibility
Data System Owner	Serve as business lead for a data warehouse, GIS portal or business application providing data reporting and analysis functions. Solicit feedback from system users and plan, prioritize and sign off on system improvements.
Information System Custodian/ Operational Steward	Serve as technical lead for a data or content management system. Perform "hands on" information management tasks that require specialized IT skills and permissions.
Information User	Stakeholders – 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, classification methods; creation of controlled vocabularies and taxonomies; search algorithms, tools and methods; search engine optimization; web analytics; website design – navigation, workflow, 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