

MARYLAND DEPARTMENT OF TRANSPORTATION DATA GOVERNANCE AND DATA HUB

May 2019

This report was prepared by Cambridge Systematics, Inc. in support of the Maryland Department of Transportation (MDOT) Transportation Secretary's Office (TSO).

Message from the Secretary

It is an exciting time for transportation in Maryland, and I am pleased to be a part of the Maryland Department of Transportation's (MDOT's) ongoing efforts to serve our customers through the guidance of our mission statement.



MISSION STATEMENT

“The Maryland Department of Transportation is a customer-driven leader that delivers safe, sustainable, intelligent, and exceptional transportation solutions in order to connect our customers to life’s opportunities.”

Establishing MDOT Data Governance principles and a Data Hub are essential to ensuring that MDOT will be a leader at the forefront of integrating data and performance management to inform our decisions and guide our investments.

Data Governance principles will provide a shared understanding of data assets and information systems as valuable and critical assets. It will define and guide the overall management of data availability, usability, integrity, and security at MDOT. The Data Hub will be an integrated system for accessing timely, relevant, and trusted data to support decision-making. It will streamline work flows by reducing duplication of data entry, improving transparency of data sources, and automating work efforts, where possible.

These tools will help us to better serve our customers and keep us moving forward.

Pete K. Rahn

Transportation Secretary and Maryland Transportation Authority Chairman

Action Plan Contents

This Action Plan for Implementation of Data Governance and an MDOT Data Hub includes the following sections:

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Introduction

Data Governance Overview

In order to be a leader in using data to inform decision-making, the Data Office in MDOT Transportation Secretary's Office (TSO) has begun a process to implement **Data Governance**. This will allow MDOT to:

- Better understand and document the **data assets** and **information systems** used by our employees in support of daily activities and MDOT's broader mission;
- Define **data management roles, responsibilities, and procedures**; and
- Consistently manage **data availability, usability, integrity, and security**.

Data Hub Overview

As the initial framework for Data Governance is put in place, MDOT is developing a **Data Hub** that will connect data to the people who need it. When in place, a Data Hub will:

- Make **timely, relevant, and trusted** data and information available from the system of record in **accessible** formats to support **decision making** and **customer service** needs;
- **Streamline work flows by reducing duplication** of data entry, saving time associated with data requests, and automating recurring reporting and compliance-related activities; and
- Maintain **data security and confidentiality** while improving **transparency**.

Key Definitions

Data are facts, numbers, measurements, or statistics that people or machines collect, organize, and store in an electronic or printed format. Data can be filtered, sorted, analyzed, transformed, and summarized to help inform decision-making. Data are extremely valuable core business assets.

Data Governance establishes a framework for the acquisition, management, use, and disposal of MDOT's data assets throughout their lifecycles, detailing the who, what, where, when, why, and how of people, processes, and technologies that support MDOT's business functions.

Data Governance implementation is an ongoing process to align data use with business strategies, and it should be integrated with MDOT's overall efforts to strive for continuous improvement.

A **Data Hub** is an information management system that supports targeted data sets, supported by people with clearly defined roles. A Data Hub will make it easier for MDOT users to access targeted data.

Who Has a Role in Data Governance Implementation?

Anyone who collects, produces, manages, analyzes, or uses data has a role in Data Governance implementation. In early stages of implementation, MDOT will assign responsibilities at the program, transportation business unit, and enterprise levels to help create, maintain, and spread awareness about Data Governance policies and procedures.

What Is This Plan?

This Plan is the culmination of an initial effort to assess existing Data Governance capabilities at MDOT, compare these capabilities to national and international benchmarks, and determine where there are gaps that need to be addressed in:

- Staff training, organization, and culture (**people**);
- Procedures and documentation (**processes**); and
- Tools supporting Data Governance implementation (**technologies**).

The Plan summarizes the steps MDOT needs to take to:

- Fill the highest-priority gaps in Data Governance capabilities (across people, processes, and technologies);
- Develop and launch a Data Hub; and
- Ensure the Data Hub, and Data Governance more broadly, are sustainable, can be continuously updated and improved, and support a culture of customer service, performance management, and accountability at MDOT.

Process Used to Develop the Action Plan



Where Do We Want to Be?

Vision, Goals, and Objectives

MDOT has established a three-part vision, with corresponding goals and objectives, for Data Governance, as shown below.

VISION	GOALS	OBJECTIVES
<p>Make timely, relevant, and trusted data and information available from the system of record in accessible formats to support decision making.</p>	<p>Ensure data and information are timely, relevant, and trusted</p>	<ul style="list-style-type: none"> ▪ Establish clear data guidelines and standardized documentation for integrated data management. ▪ Enhance consistency in organization of data across Transportation Business Units (TBUs). ▪ Ensure that leadership at the TBU are informed of the data requests and (to the extent possible) the use of data in published reports.
	<p>Improve data accessibility</p>	<ul style="list-style-type: none"> ▪ Document and maintain a formal statement of roles, hierarchy, and responsibilities for internal/external data sharing and dissemination. ▪ Provide intuitive reports or data summaries in export formats (e.g., pdf, doc, xls, csv) with functionality and a user experience designed for people with a range of technical capabilities. ▪ Create clear paths between the Data Hub and systems of record.
<p>Streamline work flows by reducing duplication of data entry, saving time associated with data requests, and automating recurring reporting and compliance-related activities.</p>	<p>Reduce duplication of data entry</p>	<ul style="list-style-type: none"> ▪ Limit data redundancy during integration while maintaining data consistency.
	<p>Reduce time spent tracking and validating data, and reduce the need to respond to redundant data requests</p>	<ul style="list-style-type: none"> ▪ Maintain and provide up-to-date access to data and ensure any needed transformation is done in a timely manner. ▪ Set up a validation process and deploy tool(s) for automation and customization. ▪ Document information (e.g., in standardized metadata) on data owners including contact information for each data set.
<p>Maintain data validation, security and confidentiality while improving transparency</p>	<p>Improve data validation and transparency consistent with industry standards</p>	<ul style="list-style-type: none"> ▪ Provide better access to source data underlying reports, accompanied by attribute descriptions and other metadata to explain data collected/analyzed/published, completeness and reliability, limitations and appropriate uses, use restrictions, permissions or copyright, etc.

Principles to Guide Data Governance Implementation

The principles listed below are based on the seven Core Data Principles adopted by the American Association of State Highway and Transportation Officials (AASHTO)¹, with modifications to reflect input received from MDOT staff who participated in the development of this Action Plan. These principles suggest aspirational goals for Data Governance that MDOT can work toward during implementation:

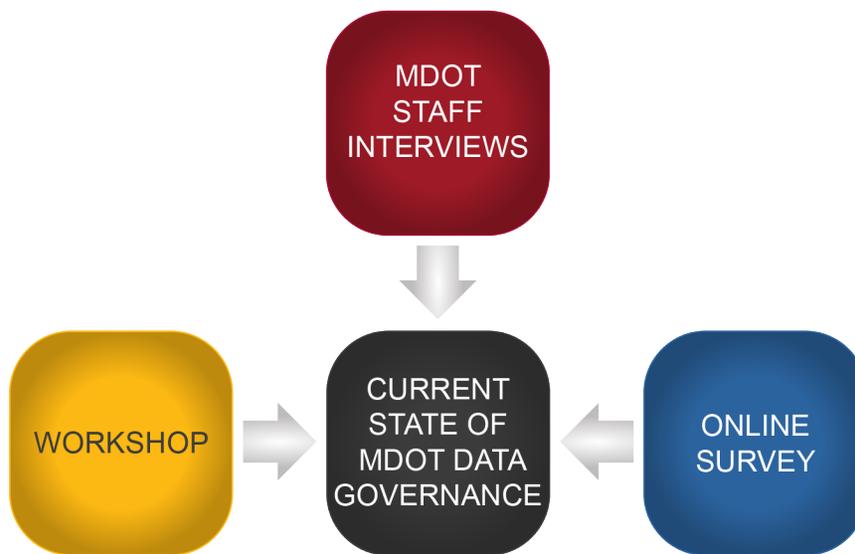
VALUABLE	Data is an asset.
	Data is a core business asset that has value and is managed accordingly.
AVAILABLE	Data is open, accessible, transparent and shared.
	As access to data is critical to performing duties and functions, data is open and usable for diverse applications.
VALIDATED	Data quality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

¹ <https://data.transportation.org/aashto-core-data-principles/>

What Did We Learn?

MDOT's Current State

MDOT collected information on the current state of Data Governance using three techniques:



- In October 2018, MDOT convened a Department-wide **workshop** to collect input from staff across MDOT on the direction of Data Governance and how to make an MDOT Data Hub a useful and beneficial tool. More than 50 people representing every Transportation Business Unit (TBU) attended the workshop to help the Data Office guide this process;
- Following the workshop, MDOT conducted one-on-one and small group **interviews** to gather additional information about Data Governance, aspirational goals, and potential uses of a Data Hub; and
- Finally, the Data Office conducted an **online survey** with a broad cross section of MDOT staff to assess the “as-is” (current) state of Data Governance, what steps (if any) MDOT’s Transportation Business Units have taken in their own implementation of Data Governance, and what they plan to do in the future.

There is a wide variation in capabilities across TBUs on Data Governance. Some TBUs will require more attention than others in order to bring all of MDOT up to the level of competency that is required to implement an MDOT-wide Data Governance framework. There may be opportunities to leverage existing Data Governance capabilities in the more advanced TBUs, particularly from the Transportation Secretary’s Office, MDOT MVA, MDOT SHA, and MDOT MTA.

The table on the next page summarizes key findings from the “as-is” state assessment and their implications for Data Governance implementation.

KEY FINDINGS OF “AS-IS” STATE ASSESSMENT (WORKSHOP DISCUSSIONS AND MDOT STAFF INTERVIEWS)

IMPLICATIONS FOR DATA GOVERNANCE IMPLEMENTATION

TSO and some TBUs and offices already have Data Governance in place or are already moving in their own direction on Data Governance. MDOT staff identified a need to establish **uniform Data Governance** for a large variety of data sources, information flows, and business processes, and to implement technology to accommodate multiple data sources.

Initial steps in Data Governance implementation include inventorying data and information systems, documenting data needs associated with formal and informal business processes they support, evaluating models for scaling up elements of Data Governance, and adopting technologies/tools for an MDOT-wide Data Governance framework. Integrating existing Data Governance frameworks and scaling-up desirable and proven elements will have to be coordinated by an MDOT-wide Data Governance group in coordination with TSO and TBU Data Governance groups.

Data validation and concerns about security, confidentiality, authority, and liability need to be addressed before there is widespread confidence in data sharing. **Data standards are difficult to enforce**, compounded by **general resource constraints** and the many day-to-day responsibilities of MDOT staff. **Accountability and individual roles** in facilitating access to valid, current data are not well-established at MDOT.

For each data asset, a Data Steward should be assigned responsibility for data validation and for ensuring that security, confidentiality, authority, and liability policies are established and enforced according to published and disseminated standards. Uniform standards should comply with Office of Transportation Technology Services (OTTS) and Maryland Department of Information Technology (DOIT) guidance. TSO and each TBU should implement a robust validation process as part of Data Governance along with appropriate tools for automation where applicable and needed.

Staff turnover, training/education, and difficulty finding domain experts was cited by TSO and nearly every TBU as an obstacle to implementation of uniform Data Governance across MDOT.

Investments in staff resources, training, and empowerment can be complemented by incentives such as recognition of groups and staff that exemplify Data Governance principles, certifications, and other forms of program promotion. Implementation of agency-wide guidelines, standards, and technology should include dissemination of that information through workshops and periodic training to institutionalize knowledge across the agency.

Organizational and process changes in a large multimodal organization like MDOT were noted as a challenge. Policy and program continuity are needed for ensuring initiatives are sustainable, particularly through changes in leadership.

Create and empower a Data Governance council to provide strategic guidance in developing, among other things, agency-level standards and policies that would anticipate, and be resilient to, organizational and process changes, as well as leadership changes, during Data Governance implementation.

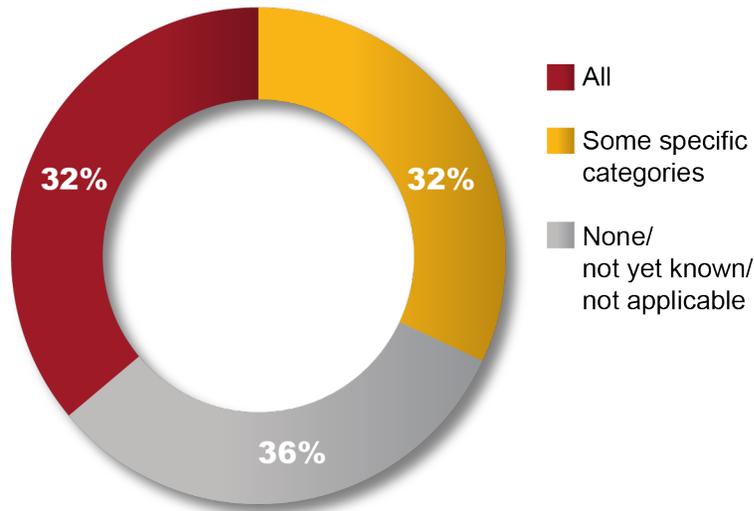
Stakeholders are uncertain what their **specific goals and expectations** are for Data Governance implementation.

Workshops and one-on-one engagement of managers can make them aware and supportive of implementation goals and planned outcomes. Management should send clear messages about the importance of Data Governance implementation to support the program.

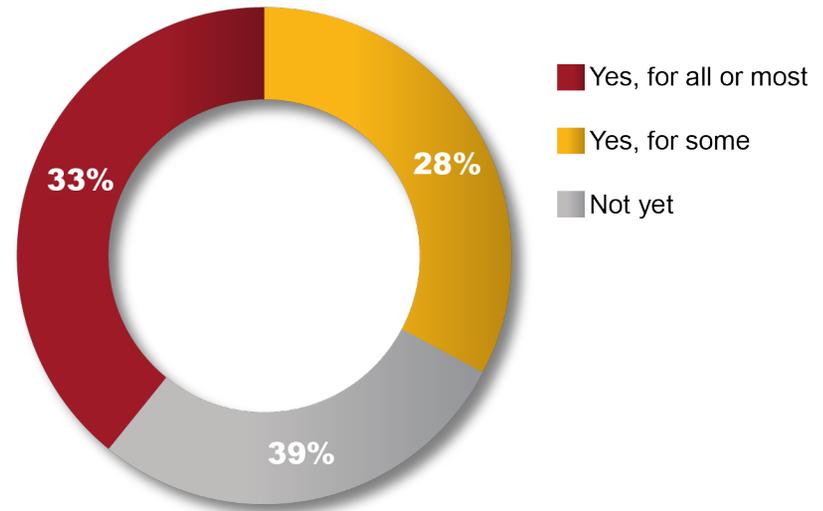
Online Survey Results

MDOT conducted an online survey of staff to delve deeper into the current state of Data Governance across all TBUs. There were 18 responses representing TSO and every TBU. The figures and tables in the following two pages summarize the survey responses.

Does Data Governance apply to all/some/none of your unit's data and information systems?



Have you mapped data and information flows associated with your business processes?



Which initial steps has your unit taken to implement Data Governance?

Data Governance implementation has been handled differently for data managed internally by TBUs vs. data managed or provided by external vendors. For some data sets, Data Governance is handled by contractors and vendors as part of their contractual agreements with MDOT. Even for internally-generated and managed data and information systems, practices vary widely across MDOT, and even across offices within a single TBU. The survey respondents were asked which initial steps their business unit had taken to implement Data Governance:



Inventory of Data Assets. The TSO's office and all TBUs have at least a partial inventory of data assets, but the inventories are in different formats and have different attributes to define and classify data assets. A needed step in Data Governance implementation is to standardize data asset inventories and determine which types of data assets need to be included in an MDOT-wide and/or TBU-specific inventory.



Inventory of Information Systems. Similar to the inventories of data assets, TSO's office and the TBUs have collected inventories of information systems in different formats, with different attributes. A needed step in Data Governance implementation is to standardize information system inventories and determine which types of information systems need to be included in an MDOT-wide and/or TBU-specific inventory.



Documented Roles and Responsibilities. Roles and responsibilities are documented in various ways across the TBUs, but there is no standard format and no defined business process to keep lists of key roles and responsibilities up to date and available across all MDOT.



Lifecycle Management of Data and Information Systems. Lifecycle management, including policies and processes to ensure data and information systems are acquired, integrated, used, and disposed of in a consistent manner, is in the early stages of implementation across MDOT's business units. MDOT-wide guidelines would help TBUs standardize their processes.



Data Security Policies and Procedures. Data security is perhaps the most advanced and uniform aspect of Data Governance in place at MDOT, due to the high priority placed on security by MDOT and TBU management.



Data Access, Transparency, Sharing, and Privacy Protocols. MDOT's TBUs are making progress on documentation of access restrictions and permissions, improving ability of staff to respond efficiently to Privacy Information Act requests, facilitating data sharing within and outside MDOT, and implementing privacy protocols for sensitive data, including data sets with personally-identifiable information. A consistent set of guidelines and mechanisms to ensure these protocols are kept up to date are needed.



Guidelines and Procedures to Ensure Data Quality, Validation, and Integrity. One of the most common comments from survey respondents was the need to improve MDOT's quality control and data validation processes so that data would be more trustworthy.

Gaps in Data Governance

There is a wide variety of practices and capabilities in Data Governance across MDOT's functions and business units. The generic Capability Maturity Framework shown on the opposite page is one method of evaluating gaps between an organization's current state and either a desired future state or an industry benchmark. This generic framework was used in an exercise at the October 2018 Data Governance Workshop. A much more detailed framework was the basis for questions asked in the online survey administered by the Data Office in December 2018.

The framework is organized around the themes of people, processes, and technologies, as follows:

PEOPLE: MDOT TSO and the TBUs ranked their current capabilities lowest in the area of "People," and expected that making improvements to staff training, organization, and culture would be the biggest challenges associated with Data Governance implementation. The average score for current capabilities was 1.9 (Aware-Planning), while the average score for desired future capabilities was 3.1 (Implemented).

PROCESSES: MDOT TSO and the TBUs ranked themselves somewhat higher for "Processes," with a mean score of 2.3 (Planning) for current state compared to 3.5 (Implemented) for future state.

TECHNOLOGIES: In the area of "Technology," MDOT TSO and the TBUs gave themselves the highest average scores for current state (2.4, Planning) and future desired state (3.6, Implemented).

The Action Plan described in the next section contains specific activities that can be undertaken in each of these areas to transition MDOT from its current state to the desired, and recommended, future state.



People

- Staff resources and training
- Organization
- Culture



Processes

- Procedures and documentation
- Accountability and incentives



Technologies

- Data assets
- Information systems
- Tools for Data Governance implementation

Generic Capability Maturity Framework for Data Governance, with Average Scores from Workshop Participants

	<u>PEOPLE:</u> Staff resources and training, organization, and culture	<u>PROCESSES:</u> Procedures and documentation; accountability and incentives	<u>TECHNOLOGIES:</u> Tools for Data Governance implementation
1—Aware	Aware of need for and importance of improved data management but no action has been taken	Discussions of the need for a Data Governance plan/framework are occurring	Planning for technology and tools to support data management is occurring in some offices
2—Planning	Aware of need for/importance of improved data management and some steps have been made to improve staff capabilities in at least one office	Some level of data program assessment and formulation of roles for data managers is underway in one or more offices	Planning for technology and tools to support data management is occurring throughout the organization
3—Implemented	Aware of need for/importance of improved data management, and some steps have been made to improve staff capabilities and organization of staff across offices	Data governance planning is underway – including development of governance model for all/multiple offices in agency	Have implemented some technology/tools to support data management but implementation is not widespread across the organization
4—Managed	Data management improvements are under way across the organization to improve staff capabilities and relationships across offices in support of Data Governance implementation	Data governance plan is developed with data assessment complete and Data Governance structure is defined	Widespread implementation of technology and tools to support data management but not integrated across the organization
5—Integrated	Institutional settings and processes are in place and coordinated across the organization to support data management and staff knowledge, skills, and abilities	Fully operational Data Governance structure is in place; Data Governance plan is regularly maintained and updated	Integrated, widespread implementation of technology and tools to support data management and performance measurement across the organization
AVERAGES OF RESPONSES	Current State: 1.9 Desired Future State: 3.1	Current State: 2.3 Desired Future State: 3.5	Current State: 2.4 Desired Future State: 3.6

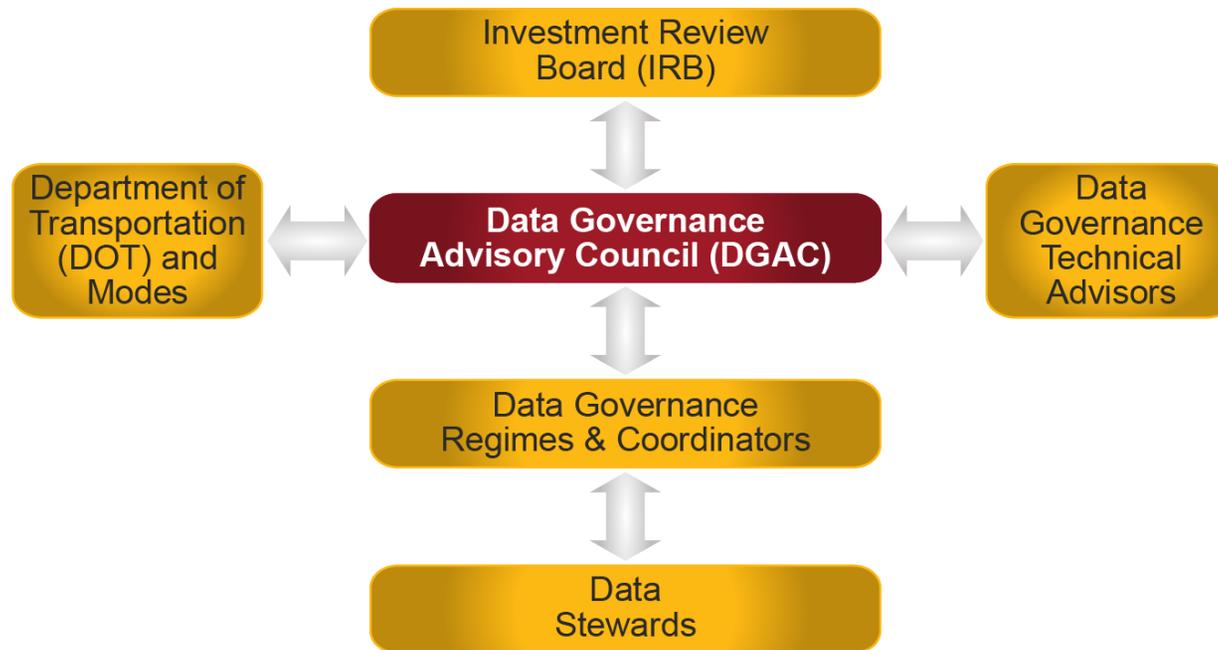
Review of Notable Data Governance Practices

A scan of notable practices in Data Governance implementation and data hub development revealed several common themes which might be of interest for MDOT during its own Data Governance implementation process. MDOT TSO and several TBUs have begun to develop and use their own organizational frameworks, and several examples below were drawn from outside Maryland.

Notable Practices: Data Governance Structure and Organization

Organization is crucial in establishing a Data Governance program, both in the data (naming conventions, formatting, etc.) and in the way different teams within the department have to organize themselves to work together in a Data Governance plan. Deciding who the key-members and leaders of the Data Governance strategy is an integral component, where organizational changes are made if needed.

FHWA's Organizational Hierarchy for Data Governance



The **Federal Highway Administration (FHWA)** has created a four-tiered organizational hierarchy² for Data Governance, as shown in the diagram on the facing page:

- **Investment Review Board (IRB)** provides a governance and oversight framework for effective decision making on all internal agency investments in data assets and information technologies. The IRB is chaired by the FHWA Chief Information Officer (CIO). FHWA data programs or data related activities within IT projects require Investment Review Board (IRB) approval prior to and during an ongoing effort. The review and approval process is typically initiated by Data Stewards (for data assets) or IT project managers (for information technologies).
- **Data Governance Advisory Council (DGAC)** is an agency-level, senior leadership governance committee responsible for developing and overseeing execution of the FHWA Data Governance Plan and Framework. The DGAC provides corporate advice on the management of FHWA data assets, reviews recommendations on strategic data decisions and resource allocations, approves data policies and standards, and annually reviews all FHWA data programs and recommends changes to the FHWA Investment Review Board. The DGAC serves as the contact for coordinating data collection efforts with the FHWA, other transportation modes, and other branches of the federal government.
- **Data Governance Regimes & Regime Coordinators** must follow the processes and procedures established by the DGAC. There are twelve “Regimes” roughly corresponding with FHWA’s organizational structure: Administration, Finance, Chief Counsel, Operations, Policy, Infrastructure, Safety, Research, Federal Lands, Division Offices, and Technical Service. The Regime Coordinators are responsible for the data programs within their Regime, and they liaise between the DGAC and the Data Stewards. They also serve in an oversight capacity, ensuring that the individual systems within the Regime are in full compliance with the policies and standards established by the DGAC. Some Regimes (for example, those with more extensive or complex data sets and information systems like Operations, Safety, and Infrastructure) may determine that they need to establish a Regime-specific Data Governance Plan with additional guidelines or procedures for the data programs in the regime. In this situation, the Regime Coordinator will also serve as the keeper and enforcer of the Regime’s specific Data Governance Plan.
- **Data Stewards** are the subject matter experts and points of contact for the data programs. These key people are expected to manage their data systems in accordance with the processes and procedures established by the Council and Regime Coordinator.

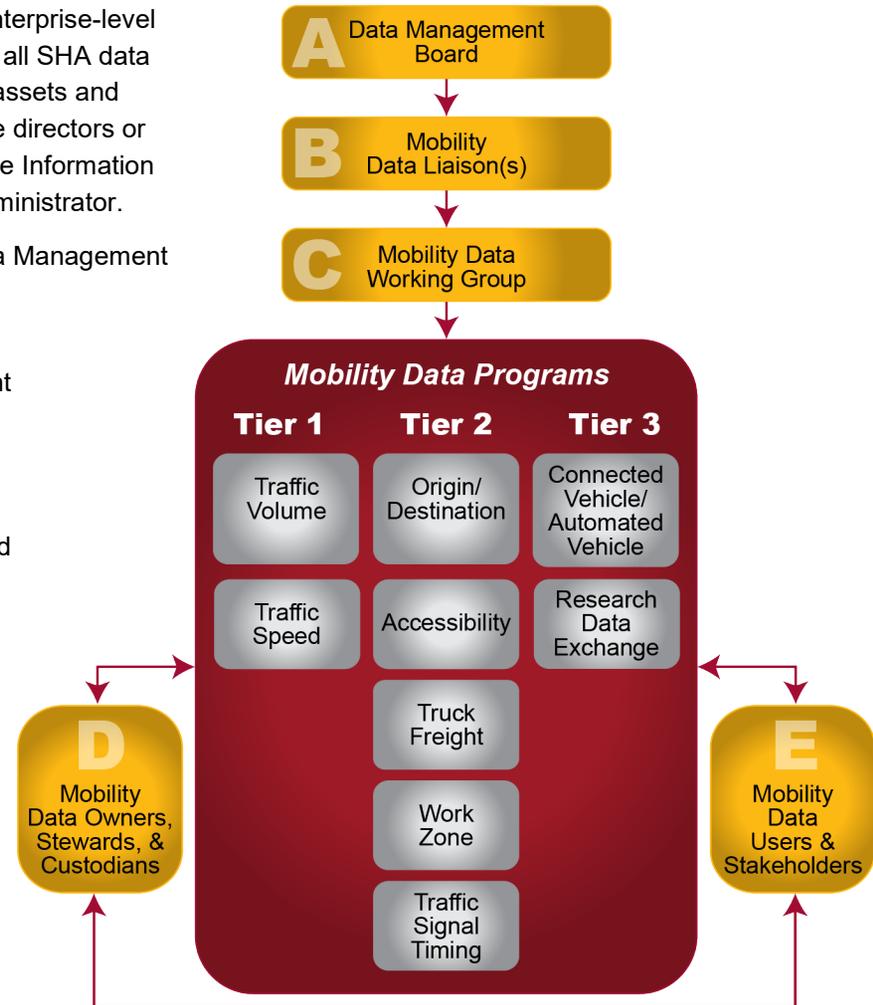
Data Governance Technical Advisors (shown to the right of the DGAC) assist in the development of all formal documentation and will provide input in the decision-making process on an ad hoc basis. Technical Advisors can include staff from the Office of Information Technology Services and the Office of Highway Policy Information, along with specific Data Stewards and Users.

² Source: FHWA Data Governance Plan, Volume 1 - Data Governance Primer, <https://www.fhwa.dot.gov/datagov/dgpvolume%201.pdf>

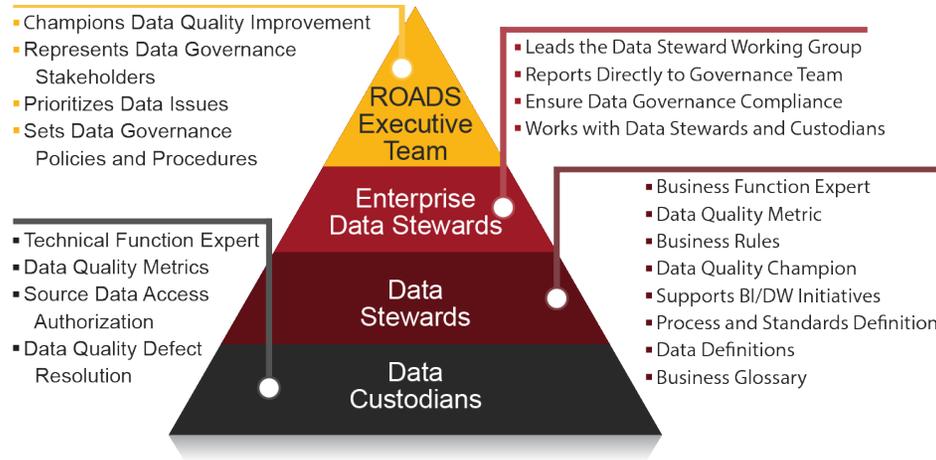
MDOT SHA's Proposed Organizational Structure for Mobility Data Governance

MDOT State Highway Administration (MDOT SHA) has proposed a formal structure for mobility Data Governance in its recently published *Data Business Plan Guidance for State and Local Departments of Transportation*. The proposed governance model builds on current governance initiatives and is specific to mobility data:

- A proposed **Data Management Board (A)** would serve as SHA's enterprise-level governance structure that establishes the principles and policies for all SHA data management issues and handles conflict resolution related to data assets and applications. The plan recommends that Board membership include directors or senior level managers from key business areas of SHA, including the Information Technology director. The Chair would be appointed by the SHA administrator.
- One or more **Mobility Data Liaisons (B)** would liaison with the Data Management Board and chair the Mobility Data Working Group.
- A **Mobility Data Working Group (C)** would include designated individuals from Maryland SHA's offices responsible for the oversight of mobility data programs to support the business functions of their offices. This group would dictate the policies, procedures, and business practices associated with SHA's mobility data programs.
- **Mobility Data Owners (D)** would be responsible for the creation and maintenance of a spatial or non-spatial mobility-related datasets.
- **Mobility Data Stewards (D)** would ensure mobility data is collected, maintained, and used in accordance with agency-adopted standards or policies, and that data are validated.
- **Mobility Data Application Custodians (D)** would provide technical development and support for mobility data applications.
- **Mobility Data Users and Stakeholders (E)** would include individuals or agencies that use or interface with, access, benefit from, or are otherwise affected by mobility data.



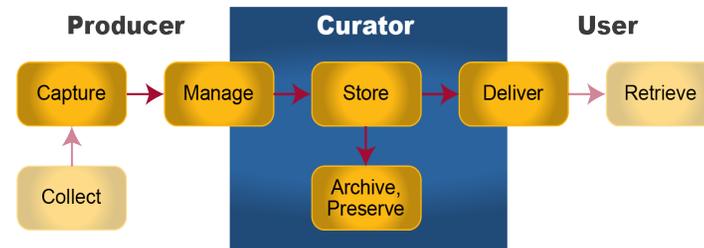
Data Governance Structure Proposed by FDOT



Florida Department of Transportation’s (FDOT) **Reliable, Organized, Data Sharing (ROADS) initiative**³ involves a ROADS Executive Team, Enterprise Data Stewards, office-specific Data Stewards, and Data Custodians (shown at left with their roles and responsibilities). Executives, technical experts, and business function experts all have roles in the structure.

Massachusetts Department of Transportation (MassDOT) defines roles in Data Governance according to the “**phases in the data lifecycle**” (see figure). At MassDOT IT, staff may perform technical maintenance and system development tasks at the request of the data and system owners, but not carry any direct ownership of the database. MassDOT’s divisions appoint a technical-side system owner alongside a “business” owner to directly oversee the technical maintenance of the system and ensure that it functions and uses contemporary architecture. Almost always, IT supports the hardware side of system development, providing servers, supporting cloud contracts, etc. While the system administrator may not be from the same working group that manages the assets, the data steward is always a direct report to the responsible owner – the group with the greatest expertise bears final authority over the product.

MassDOT’s Roles in “Three Phases of the Data Life

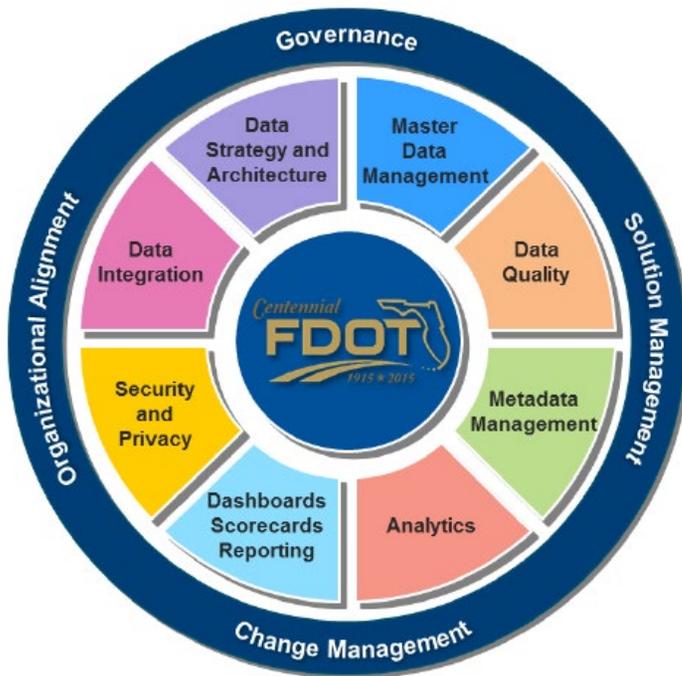


³ Source: “Transportation Technology” presentation by April Blackburn, FDOT Chief of Transportation Technology, delivered to 2017 FDOT Design Training Expo.

Notable Practices: Development of Data Hubs within Broader Data Governance Framework

Successful implementation of a Data Hub requires systematic planning and visualization of the desired functionality of the Data Hub and its connection to the agency’s mission and core business needs. This leads to the proper design, planning, and implementation of an architecture that feeds the needs of the department. Once this is envisioned based on the needs of the agency, the teams responsible for the development of the portal and systems must organize and understand all available datasets and visualize their different uses to adequately construct the architecture needed for the system.

- After investigating options for development of a Data Hub, the **Alaska DOT&PF** settled on two main architecture components for its **Transportation Asset Management Information System (TAMIS)**, a data warehouse and a data viewer, along with a collection of business processes that support decision making. With the TAMIS Data Governance framework in place, Alaska DOT&PF was able to develop robust functional and technical requirements for a **maintenance management system (MMS)** and a **pavement management system (PMS)** that are sustainable over the long term, support the agency’s core asset management needs, and link asset management to broader strategic goals.

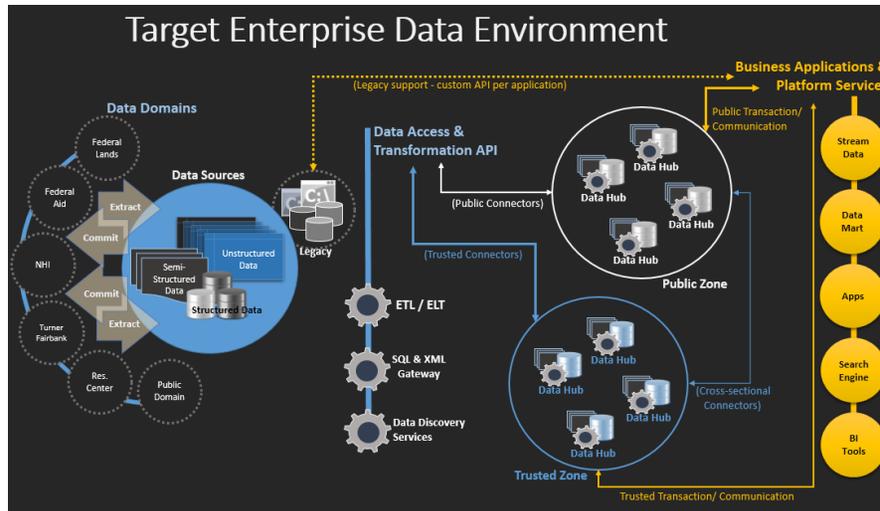


- FDOT’s Reliable, Organized, Data Sharing (ROADS) initiative** will provide a formal structure for **Data Governance, Solution Management, Change Management, and Organizational Alignment**. The structure will guide decisions related to information, standardized processes and routines to formalize Data Governance implementation, a set of resources for training FDOT staff on Data Governance, and common, standardized approaches to acquiring, managing, and disposing of **business intelligence and data warehousing tools** that will be used across FDOT to make information more accessible. As an initial step in implementing Data Governance as part of this framework, FDOT has developed and released a **Transportation Data Portal** for visualizing, questioning, analyzing, and interpreting available data. The Transportation Data Portal is a platform for locating data related to FDOT’s core mission and will be enhanced and maintained in a manner that is consistent with the Data Governance structure.

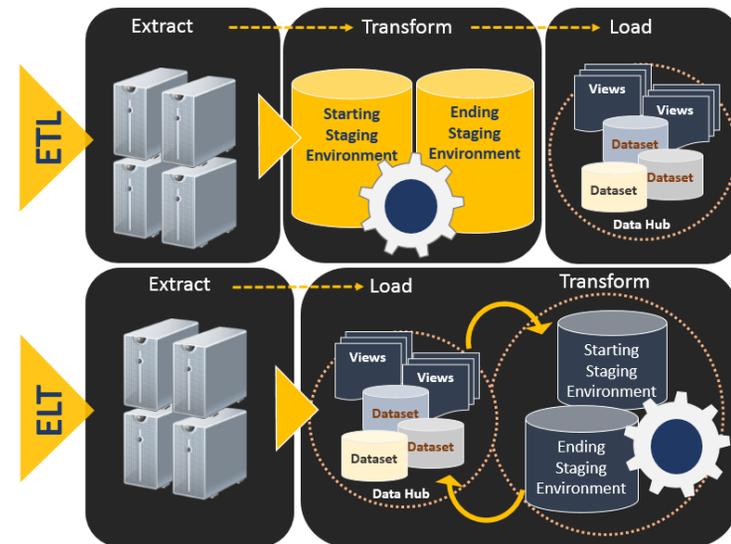
Notable Practices: Data Hub Architecture

During the development and implementation of FHWA's Target Enterprise Data Environment (T-EDE), the agency first set the goal of developing a unified ecosystem for FHWA data, established standardized interfaces for linking and processing information, and offered advanced capabilities such as Big Data Storage/Analytics and Business Intelligence applications as part of T-EDE common services, based on their needs. Then, they set up the steps required to complete their envisioned T-EDE. As illustrated below, in the T-EDE architecture, data domain hubs will be used as in-memory staging areas for information content and will consist of various data types ready for consumption by their receiving nodes. Both Extract Transform Load (ETL) and Extract Load Transform (ELT) will be used in the architecture of the Cloud Data Hub Environment.

FHWA T-EDE Architecture/Environment



Cloud Data Hub ETL and ELT Architecture



Source: FHWA, Enterprise Data Architecture

What Do We Need to Do?

This section describes actions MDOT can undertake to develop an MDOT Data Hub and address gaps in Data Governance.

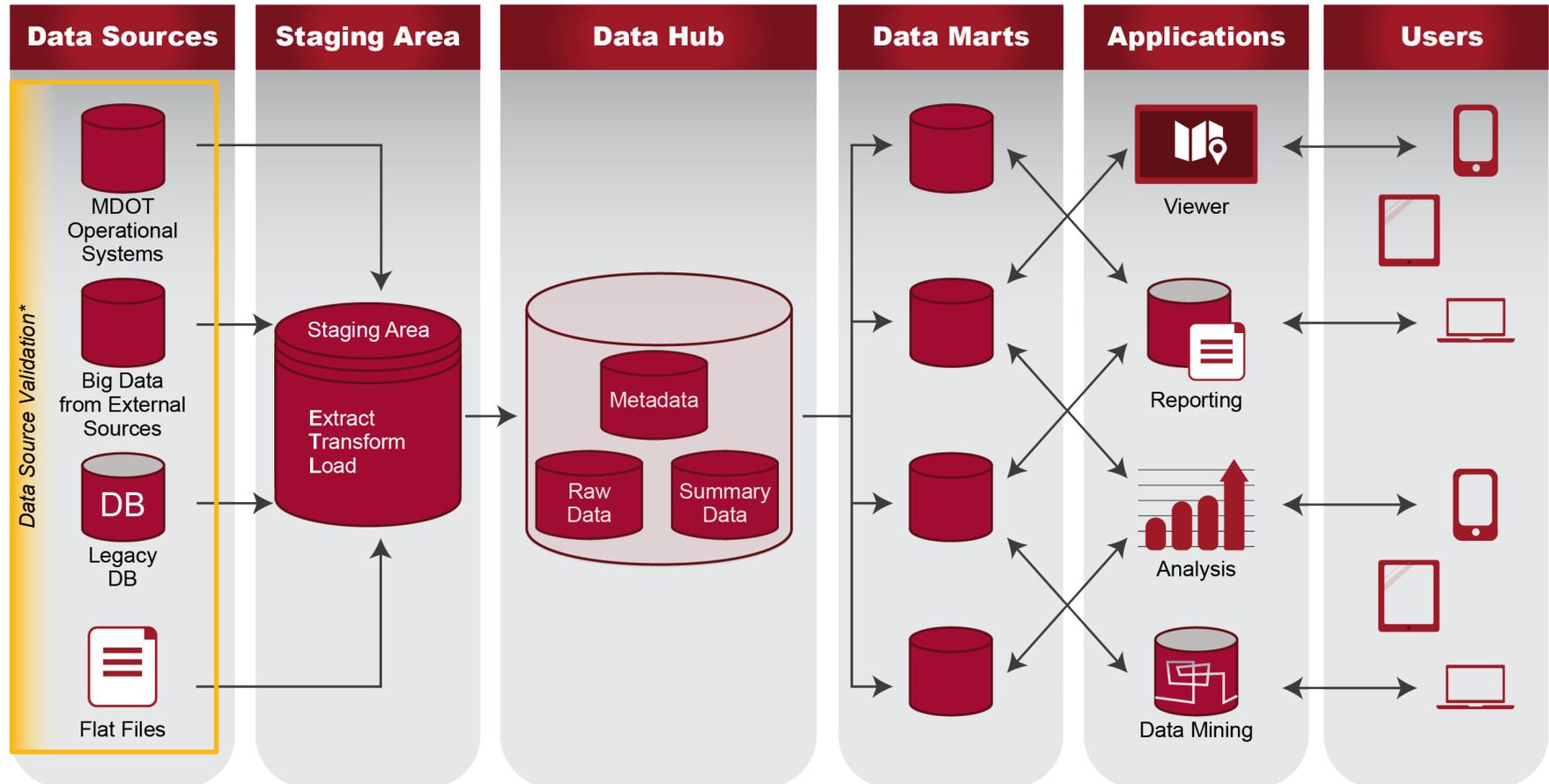
Develop an MDOT Data Hub

The MDOT Data Hub is envisioned as an information system that supports a set of defined datasets and processes, supported by people with clearly defined roles.

The figure on the opposite page shows potential conceptual elements, or layers, that may be considered for the implementation of a Data Hub. This framework could include the following layers:

- **Data Sources:** Where original data, collected from various sources, resides in each operational and legacy database. So-called “Big Data” sources and streams of data from third-party sources and vendors also could potentially be accessed. Particularly with respect to legacy databases and flat files, any data cleaning (for example, to address incomplete records), validation, screening (for example, to remove personally identifiable information), or other preparation is assumed to be the responsibility of Data Stewards assigned to each data asset. These tasks would be completed prior to the Extract Transform Load procedure.
- **Staging Area:** The middle layer between data sources and the MDOT Data Hub. Extract, Transform, Load (ETL) tools would be used to extract validated data from original sources, transform and prepare data to conform to the Data Hub’s storage structure and meet other requirements, and finally load data into the hub.
- **Data Hub:** Where all clean and organized data would be stored. In addition to the raw data storage space, it would also have separate metadata database to store data descriptions. Summary data stores could pre-calculate time-consuming data aggregation operations, which could optimize the data hub usage, particularly with respect to very large data tables.
- **Data Marts:** A subset of the Data Hub storage designed to serve specific business domains and processes. Subject-oriented data marts could accelerate business processes and help users gain insights quickly.
- **Applications:** A suite of tools to support data viewing, reporting, analysis, and mining. Each tool would be built on top of one or more related data marts. For instance, the data viewer in Alaska DOT & PF’s TAMIS and FDOT’s Transportation Data Portal (both described above) are examples. These applications would serve as platforms through which end users could interact with both data marts. They would process data inputs and deliver data outputs in various formats.
- **Users:** MDOT staff and others with permission to view outputs of the Data Hub in various formats.

Conceptual Framework for an MDOT Data Hub



**Note: Prior to the ETL process to bring data into the Data Hub Staging Area, Data Stewards are responsible for data validation and for ensuring that security, confidentiality, authority, and liability policies are established and enforced according to published and disseminated standards.*

The table below summarizes the implementation steps that will be necessary to develop the first iteration of an MDOT Data Hub, consistent with the Vision, Goals and Objectives for Data Governance implementation. A full set of prioritized action items for Data Governance implementation is in the next section.

Objectives of MDOT Data Governance	Actions Needed to Implement an MDOT Data Hub
<ul style="list-style-type: none"> Establish clear data guidelines and standardized documentation for integrated data management. Enhance consistency in organization of data across Transportation Business Units (TBUs). Ensure that leadership at the TBUs are informed of data requests and (to the extent possible) the use of data in published reports. 	<ul style="list-style-type: none"> Draft a Data Governance Manual that formalizes Data Governance roles and responsibilities, data standards, policies, and procedures, focusing initially on the data assets and information systems related to the <i>MDOT Attainment Report</i>, <i>MDOT Managing for Results</i> and <i>MDOT Excellerator</i>, which will be the initial focus of the Data Hub.
<ul style="list-style-type: none"> Document and maintain a formal statement of roles, hierarchy, and responsibilities for internal/external data sharing and dissemination. Provide intuitive reports or data summaries in export formats (e.g., pdf, doc, xls, csv) with functionality and a user experience designed for people with a range of technical capabilities. Create clear paths between the Data Hub and systems of record Limit data redundancy during integration while maintaining data consistency. 	<ul style="list-style-type: none"> Assign roles (e.g., owners, stewards, and custodians) with clear responsibilities in Data Governance implementation. Draft user experience (UX) guidelines and principles as part of a functional requirements document. Develop an inventory of data assets that will feed the Data Hub, indicating which are contained in systems of record. Develop an inventory of data assets that will feed the Data Hub. Identify redundancies in data collection and/or maintenance. Assign roles (e.g., owners, stewards, and custodians) with clear responsibilities in Data Governance implementation.
<ul style="list-style-type: none"> Maintain and provide up-to-date access to data, facilitate timely transformation and validation for integration. Document information (standardized metadata) to include information on data owners including contact information for each data set. 	<ul style="list-style-type: none"> Develop an inventory of data assets that will feed the Data Hub. Develop a data dictionary and standardize metadata, with tools and processes for maintaining them as specified in the Data Governance Manual. Develop a data validation process to encompass extract-transform-load (ETL) testing, to automate and enhance data validation by deploying tools that are suited for use across various MDOT/TBU environments.
<ul style="list-style-type: none"> Provide better access to source data underlying reports, accompanied by attribute descriptions and other metadata to explain data collected/analyzed/published, completeness and reliability, limitations and appropriate uses, use restrictions, permissions or copyright, etc. 	<ul style="list-style-type: none"> Develop an inventory of data assets that will feed the Data Hub. Develop a data dictionary and standardize metadata, with tools and processes for maintaining them as specified in the Data Governance Manual.

Road Map for Data Hub Development

<p>Finalize Data Hub architecture and associated technical components</p> 	<ul style="list-style-type: none"> Interview representatives of TBUs and MDOT TSO to document what data sources they own; how data can be transferred from those sources (API, ad hoc export, existing reports, etc.); end uses of the data they generate and relative priorities; what data they consume from other TBUs and/or from MDOT TSO, and their priorities for inclusion into the data hub; and any additional functionalities (reports, data mining, etc.) desired from data hub that are not currently available, and their relative priorities. Interview MDOT Office of Transportation Technology Services (OTTS) staff to backfill any needed information about data sources and transfer methods from different TBUs and TSO (if applicable) and review current technologies used/preferred by MDOT OTTS. Summarize and distill information from results of the above interviews to assess the general needs of the MDOT Data Hub and finalize the architecture and associated technical components.
<p>Review and prioritize data for inclusion in the Data Hub</p> 	<ul style="list-style-type: none"> After assembling initial data asset catalogue, convene Data Governance Council to prioritize data sets for inclusion in the Data Hub (starting with <i>MDOT Attainment Report</i>, <i>MDOT Managing for Results</i>, and <i>MDOT Excellerator</i>). Determine how often these data are updated, process for verification, sensitivity for internal vs. external consumption, etc. Enumerate end uses for different data sets.
<p>Develop Data Hub requirements</p> 	<ul style="list-style-type: none"> Design schema for all priority data sets (include tabular, spatial, and network data). Specify access rules for elements of the schema (e.g., data that can be accessed in provisional form vs. final form). Determine near-term methods for transferring data from source systems to the Data Hub (initial extract-transform-load (ETL) processes and longer-term methods and technologies to automate ETL). Design APIs or export routines for transferring data to end-use systems (e.g., Open Gov, Socrata). Enumerate any customized user interface or reporting requirements (beyond what is already provided by core technical components such as GIS).
<p>Build initial version of the Data Hub</p> 	<ul style="list-style-type: none"> Implement schema and data access controls. Develop any needed scripts/code for data transfer/transformation methods. Import initial data. Develop APIs/export routines. Develop any additional required UI or reporting components.
<p>Make enhancements to the Data Hub</p>	<ul style="list-style-type: none"> Prioritize additional data sets related to MDOT and TBU core business processes. Develop more advanced (automated) methods for extract, transform, and load (ETL) functions. Augment APIs/export routes to include additional datasets. Develop any additional desired UI or reporting components.

Take Action to Address Gaps in Data Governance

The recommended actions are organized into three buckets corresponding to the priority of implementation:

- **Immediate priorities** represent the actions needed in the next 1 to 2 years for MDOT TSO and each TBU unit to achieve a minimum threshold of Data Governance capabilities so that MDOT can proceed with enterprise-wide implementation with a consistent foundation.
- **Medium-term priorities** constitute a 3- to 5-year action plan for MDOT.
- **Other elements** can be implemented as resources are available.

Data Governance Implementation Actions: People

Immediate priorities (next 1-2 years)	<ul style="list-style-type: none"> ▪ Identify Data Governance Champions at the executive level for all MDOT. ▪ Establish an MDOT Data Governance Council. ▪ Establish TSO and TBU Data Governance Councils or Data Governance Boards. ▪ Define and document Data Governance Implementation Roles and Responsibilities (see next page). ▪ Conduct training and outreach to introduce Data Governance and build support for implementation.
Medium-term priorities (3-5 year Action Plan)	<ul style="list-style-type: none"> ▪ Establish Data Governance Working Groups as needed within MDOT TSO and at TBUs to oversee specific data programs to support the business functions of associated offices. ▪ Define and document Data Governance Implementation Roles and Responsibilities for data assets and information systems supporting all core business processes across MDOT.
Other elements (to be implemented as resources are available)	<p>Sustainability of Data Governance</p> <ul style="list-style-type: none"> ▪ Identify mentors/mentees and trainers/trainees to facilitate transfers of knowledge and responsibilities related to Data Governance over time, increase redundancy to prevent sudden loss of capabilities with staff departures. <p>Continuous Improvement</p> <ul style="list-style-type: none"> ▪ Identify formal training needs (e.g., for those assigned new roles in Data Governance implementation). ▪ Undertake organizational change management (addressing culture) for Data Governance and elsewhere as needed to improve outcomes associated with core business processes. <p>Performance Management</p> <ul style="list-style-type: none"> ▪ Set staff goals and expectations that are aligned with needs of Data Governance Implementation. Periodic 360 reviews for people in key roles, realignment of responsibilities, job descriptions, reporting relationships, and organizational structures as needed when business needs, processes, and/or technologies change.

Strategic Roles in Management and Administration of Data Governance Implementation

Role	Members	Responsibilities
MDOT Data Governance Council	Administrators or senior level managers from TSO and each TBU, and the head of OTTS Chair appointed by the MDOT Secretary	Enterprise-level Data Governance group that establishes MDOT-wide principles and policies for Data Governance and handles conflict resolution related to data assets and information systems
TSO and TBU Data Governance Councils or Boards	Members represent core TBU business processes Chair appointed by the MDOT Secretary (TSO) or the TBU Administrator (TBUs)	Provide oversight and coordination of Data Governance implementation at MDOT TSO and each TBU
Data Working Groups <i>(as needed)</i>	Business process and IT staff from MDOT TSO and TBU offices responsible for the oversight of Data Governance implementation for data programs that support the business functions of their offices	Oversee implementation of and adherence to the policies, procedures, and business practices associated with their respective data programs Provide regularly scheduled updates on key initiatives to the TSO or TBU Data Governance Council

Tactical and Operational Roles in Data Governance Implementation

Role	Characteristic	Responsibilities
Data Steward	Person familiar with data's use in support of business processes	Accountable for a specific type of data or data domains (groups or categories of related data that support a common business process) Ensure data is collected, maintained, and used in accordance with agency-adopted standards or policies, data validation occurs, and security, confidentiality, authority, and liability policies are established and enforced. Coordinate closely with Data Owners and Information System Custodians
Data Owner	Business analyst	Create and maintain discrete data assets
Information System Custodians	IT staff	Provide technical development and support for information systems that are fed by and supply data to support MDOT's business processes
Data User or Stakeholder	Individual or agency internal or external to MDOT	Use or interface with, access, benefit from, or be otherwise affected by MDOT's data

Data Governance Implementation Actions: Processes

<p>Immediate priorities (next 1-2 years)</p>	<ul style="list-style-type: none"> ▪ Draft and disseminate a Data Governance Manual that formalizes Data Governance roles and responsibilities, data standards, policies, and procedures (<i>see next page</i>). ▪ Coordinate and harmonize Data Governance Standards across MDOT TSO and the TBUs. ▪ Map data and information flows starting with <i>MDOT Attainment Report</i>, <i>MDOT Managing for Results</i>, and <i>MDOT Excellerator</i>. ▪ Develop standard language for vendor and consultant contracts to enforce data standards. ▪ Document procedures, roles, and responsibilities for maintaining the data inventory and information systems inventory on a regular schedule; tools and processes for maintaining metadata and data dictionaries; and accountability to these procedures and standards. ▪ Draft and disseminate plain English resources and reference materials that are accessible to all (e.g., glossary or dictionary of commonly used business terms).
<p>Medium-term priorities (3-5 year Action Plan)</p>	<ul style="list-style-type: none"> ▪ Map data and information flows for all core business processes across MDOT. <i>The MDOT Data Governance Council will determine priority of additional business processes to include in Data Governance Implementation.</i>
<p>Other elements (to be implemented as resources are available)</p>	<p>Sustainability of Data Governance</p> <ul style="list-style-type: none"> ▪ Insulate Data Governance Manual from changes in leadership. <p>Continuous Improvement</p> <ul style="list-style-type: none"> ▪ Revisit process flows in response to performance issues, changing staff, or changing technologies. ▪ Periodically review standards and procedures across TBUs (including to/from TSO) via Data Governance Council discussions and via periodic audits. ▪ Periodically review and evaluate Data Governance Manual components. <i>Triggers for revisions may include discrete events or time elapsed since last revision. Example: Periodically revisit business needs and refresh User Stories for key information systems.</i> ▪ Update security standards, along with related procedures, roles, and responsibilities, as needed to comply with changing laws and regulations, match available resources and staff capabilities, and improve organizational or strategic performance. <p>Performance Management</p> <ul style="list-style-type: none"> ▪ Regularly reassess Data Governance performance relative to business needs. ▪ Assess performance of and update, enhance, and replace data and information systems, along with related procedures, roles, and responsibilities, as needed, to better align data assets with business needs, available resources, and staff capabilities, and ultimately to improve organizational or strategic performance. ▪ Ensure people with assigned roles and responsibilities follow documented procedures consistently, and they and/or contractors are held accountable to the standards.

Components of a Data Governance Manual	
Data governance roles and responsibilities	Roles and responsibilities for oversight, approval, dispute resolution, and execution of all policies, procedures, and standards listed in the manual, including members of oversight and management groups and data owners, stewards, custodians, and liaisons with responsibility for specific data assets and information systems
Data collection and acquisition guidelines	Policies governing acquisition of new or replacement data and information systems
Data quality, validation, and integrity policies	<p>Policies and processes to ensure any given dataset or data is trusted (because it is complete, accurate, reliable, valid, and consistent with requirements):</p> <ul style="list-style-type: none"> ▪ Standards for quality assurance and quality control during data collection ▪ Data validation to ensure accuracy and timeliness ▪ Validation of metadata and information in data dictionaries ▪ Adjustments to data collection and management (people, processes, and technologies) in response to failed validation ▪ Maintenance of geospatial data attributes and underlying systems, such as linear referencing systems
Data usability guidelines	The degree to which data can be used for its end purpose of analysis, reporting, or other outcomes; while minimizing the need for interpretation and risk of misinterpretation. It can also be defined as the degree to which the data is “application-ready”
Data security policies	Controls and policies to prevent unauthorized access to data or data corruption
Data access, transparency, sharing, and privacy policies	Data access controls and clearances; Public Information Act (PIA) compliance; privacy and confidentiality standards; protection of legitimate MDOT interests, including work products not intended for public consumption; shielding proprietary information; providing public access to appropriate data; development of extract, transform, load (ETL) functions
Data preservation policies	Rules and protocols on data retention, archiving, and decommissioning/disposal/deletion

Data Governance Implementation Actions: Technologies

<p>Immediate priorities (next 1-2 years)</p>	<ul style="list-style-type: none"> ▪ Develop an inventory of data assets (sources and databases) that support <i>MDOT Attainment Report</i>, <i>MDOT Managing for Results</i>, and <i>MDOT Excelsior</i>. Establish the attributes required to filter, sort, and understand data assets in place now, and determine gaps in information and related staff capabilities (to collect, manage, analyze, and report data) to support business process improvements. ▪ Develop an inventory of information systems that support <i>MDOT Attainment Report</i>, <i>MDOT Managing for Results</i>, and <i>MDOT Excelsior</i>. Establish the attributes required to filter, sort, and understand information systems in place now; longer term: determine gaps in information systems and related staff capabilities (to use the systems) to support business process improvements. ▪ Develop a data dictionary focusing on data assets supporting <i>MDOT Attainment Report</i>, <i>MDOT Managing for Results</i>, and <i>MDOT Excelsior</i>. ▪ Develop the initial iteration of the Data Hub focusing on <i>MDOT Attainment Report</i>, <i>MDOT Managing for Results</i>, and <i>MDOT Excelsior</i> (see <i>Road Map for Data Hub Development</i> above).
<p>Medium-term priorities (3-5 year Action Plan)</p>	<ul style="list-style-type: none"> ▪ Expand the data asset inventory to include data assets that support all core business processes. ▪ Expand the information systems inventory to include information systems that support all core business processes. <ul style="list-style-type: none"> – <i>The MDOT Data Governance Council will determine the priority for including additional data assets and information systems in the respective inventories.</i>
<p>Other elements (to be implemented as resources are available)</p>	<p>Sustainability of Data Governance</p> <ul style="list-style-type: none"> ▪ Draft and disseminate a Continuity of Operations (COOP) Plan including data backups and safeguards; communications needs. <p>Continuous Improvement</p> <ul style="list-style-type: none"> ▪ Develop or acquire tools to automate data access, data validation, quality assurance/quality control, metadata mapping, tracking data lineage, and master data management. ▪ Draft Data Governance Workflow Management tools and related processes. ▪ Develop extract, transform, load (ETL) functions and other mechanisms to enable automated sharing of data across information systems and platforms, for all business processes. <p>Performance Management</p> <ul style="list-style-type: none"> ▪ Periodically assess the performance of technologies and adjust or replace as needed.

Inventorying Data Assets and Information Systems

The purpose of an inventory of data assets, often referred to as a **data catalog**, is to provide a centralized location for information about the data used by MDOT. An **information systems catalog** serves a similar purpose. The catalogs should be reviewed and revised by data business owners within each stakeholder office to ensure that all data systems, data standards, roles, and responsibilities, etc., are correctly identified. They should also be revised at least on an annual basis, or monthly if changes occur that require updating the information listed in the catalog.

Data Catalog: Sample Attributes

- The name of the data asset
- A brief description of the function of the data asset
- Core business processes at MDOT that are supported by the data asset
- An indication of which information systems rely on the data comprising that data asset
- List of data business owners, with their contact information. Data business owners may be associated with an office who manages the data and metadata for information systems within their area of responsibility for a business unit, maintain the data dictionaries for the data assets within their office, and establish business requirements for the use of the data
- List of data stewards responsible for the data, with their contact information. Data stewards ensure data is managed according to MDOT policies
- Instructions for accessing data standards and definitions associated with the collection and use of the data

Information Systems Catalog: Sample Attributes

- The name of the information system
- A brief description of the information system
- Core business processes at MDOT that are supported by the information system
- An indication of whether the information system is a system of record, and, if so, for what
- List of associated data assets that feed into or are generated by the information system
- System developer
- Operating System
- Software Language
- Version
- Instructions for accessing standards and definitions associated with the use of the information system
- List of IT staff who are responsible for managing and maintaining the information system, with their contact information. The information system owners may be associated with an office who manages the information systems within their area of responsibility for a business unit, and establish business requirements that are supported by the information system
- Permissions and level of access granted to classes of system users

Data Dictionary: Overview

A **data dictionary** is a descriptive list of data elements collected and maintained to ensure consistency of terminology. It is typically developed by data stewards and their IT counterparts often in consultation with each other. A data dictionary should be standardized across the TBUs and can be built manually or using software applications.

The following elements are typically included in a data dictionary⁴:

- A listing of data objects including names and definitions
- Properties of data elements (data type, size, indexes, etc.)
- Reference data (classification and descriptive domains)
- Missing data and quality-indicator codes
- Business rules, such as for validation of a schema or data quality

Data Dictionary: Benefits

Among the benefits of creating and maintaining data dictionaries are:

- Communication of a common/consistent definition of data elements
- Enhanced data quality and integrity
- Limiting data redundancy
- Enabling data validation
- Increased sharing and agency-wide integration

⁴ USGS Data Management, Data Dictionaries, <https://www.usgs.gov/products/data-and-tools/data-management/data-dictionaries>

Detailed Actions for Developing a Data Dictionary:

Development of common elements in a data dictionary is one of many steps in the overall design and development process to facilitate proper use by all the users. The following guidelines⁵ may be loosely adopted in developing an MDOT-wide data dictionary by using the Data Governance group as a venue for consultation, approval, and overall outreach:

1. **Design a plan:** Preplan the development, implementation, and maintenance of the data dictionary.
2. **Develop an enterprise data dictionary:** Integrate common data elements across the entire institution to ensure consistency.
3. **Ensure collaborative involvement:** Make sure there is support from all key stakeholders.
4. **Develop an approvals process:** Ensure a documentation trail for all decisions, updates, and maintenance.
5. **Identify and retain details of data versions:** Version control is important.
6. **Design for flexibility and growth.**
7. **Design room for expansion of field values.**
8. **Follow established ISO/International guidelines for metadata registry:** to promote interoperability follow standards.
9. **Adopt nationally recognized standards.**
10. **Beware of differing standards for the same concepts.**
11. **Use geographic codes and conform to the National Spatial Data Infrastructure and the Federal Geographic Data Committee.**
12. **Test the information system:** Develop a test plan to ensure the system supports the data dictionary.
13. **Provide ongoing education and training.**
14. **Assess the extent to which the data elements maintain consistency and avoid duplication.**

⁵ e-HIM Workgroup of the American Health Information Management Association (AHIMA)

How Can We Monitor and Evaluate Data Governance Implementation?

MDOT will keep track of progress and actions taken, and monitor evidence of achievement of desired outcomes in the implementation of Data Governance and the Data Hub. Tracking tools can help organize priority actions and assign responsibilities, while optimizing resources and tracking progress towards the overall vision, goals, and objectives of the initiatives. Regular meetings of the MDOT Data Governance Council, TBU-specific groups, and subgroups are opportunities to provide progress updates, but progress should be shared more widely using tracking tools such as an online progress dashboard that shows progress toward broader goals of Data Governance and intermediate objectives.

Data Governance implementation outcomes can be tracked broadly along the same themes as the Data Governance framework – people, processes, and technology – as follows:

People	<ul style="list-style-type: none"> ▪ Number of staff trained/certified on Data Governance ▪ Ongoing participation of staff by TBU ▪ Periodic 360-degree reviews of people in key roles ▪ Adoption rate (number of data owners enrolled in the Data Governance implementation)
Processes	<p>Data Availability and Access:</p> <ul style="list-style-type: none"> ▪ Number of business processes prioritized and included under Data Governance ▪ Number of TBUs/business processes following Data Governance Policies (Compliance assessment – periodic evaluation of As-Is) ▪ TBUs tracking progress of Data Inventories (% Complete) ▪ Extent of implementation of metadata standards (% datasets with standardized metadata) <p>Data Validation:</p> <ul style="list-style-type: none"> ▪ Number of business processes/datasets with validation controls and compliance before sharing (% of total) ▪ Integrated Data Management guidelines implemented (% by TBU/by Business Process/of total datasets selected) <p>Data Security:</p> <ul style="list-style-type: none"> ▪ Share of applicable datasets by TBU in compliance with security regulations ▪ Identification of usage limitations, use restrictions, and permissions (% of datasets designated) <p>Data Efficiency:</p> <ul style="list-style-type: none"> ▪ Share of business processes for which data sources and roles in Data Governance are defined
Technologies	<ul style="list-style-type: none"> ▪ Number of datasets/business processes using tools/technology for master data management ▪ Percent of applicable staff trained to use Data Governance tools ▪ Tracking usage statistics of published data reports

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