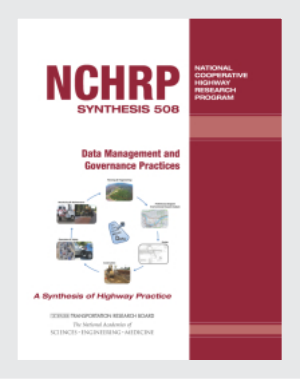

Data Management and Governance Practices

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 508

Data Management and Governance Practices

A Synthesis of Highway Practice

CONSULTANTS
Nasir Gharaibeh
Isaac Oti
David Schrank
and
Johanna Zmud
Texas A&M Transportation Institute
The Texas A&M University System
College Station, Texas

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2017

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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

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

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

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

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

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The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, non-governmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

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Learn more about the Transportation Research Board at **www.TRB.org**.

Cover figure: The transportation project/asset life cycle. Data are collected and produced at every phase, and good data are key to each phase's success. *Source*: Consultants' rendering.

FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Tanya M. Zwahlen
Consultant
Transportation Research Board

The objective of this study was to develop a collection of transportation agency data management practices and experiences. The report demonstrates how agencies currently access, manage, use, and share data. This information can be used by transportation agencies to learn about, and ultimately advance, the current state of the practice in transportation data management and governance.

The information provided in this synthesis was gathered through a review of the literature, a two-phase online survey, and follow-up interviews with four agencies. All 50 states, the District of Columbia, and Puerto Rico were invited to participate in the surveys. The surveys also were distributed to municipalities and metropolitan planning organizations through the National Association of City Transportation Officials and the Association of Metropolitan Planning Organizations.

Nasir Gharaibeh, Isaac Oti, David Schrank, and Johanna Zmud, Texas A&M Transportation Institute, The Texas A&M University System, College Station, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

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

DATA MANAGEMENT AND GOVERNANCE PRACTICES

SUMMARY

Data-driven processes and technological advances have led to a steady increase in the amount and complexity of data collected and managed by state departments of transportation (DOTs) and local transportation agencies, such as municipalities and metropolitan planning organizations (MPOs). Examples of these data include asset inventory and condition data, usage data from traffic counts, roadway design and construction data, and financial data. These data reside in attribute databases, geospatial databases, computer-aided design (CAD) files, three-dimensional models, multimedia files (e.g., image, video), and other forms. Increasingly, transportation agencies are viewing these data as assets that should be managed systematically and effectively, as physical infrastructure assets are managed.

Although data provide opportunities to facilitate decision making at transportation agencies, there are challenges involved in managing large and diverse data that serve multiple business needs. These challenges are manifested in various aspects of data management, such as data quality assurance, integration, and access. This synthesis provides information on current practices in data governance, data warehousing and cloud computing, data integration and sharing, and data quality assurance. This information can be used by transportation agencies to learn about and ultimately advance the current state of the practice in transportation data management and governance.

The information provided in this synthesis was gathered through a review of the literature, a two-phase online survey, and follow-up interviews with a sample of four agencies. All 52 DOTs (50 states, District of Columbia, and Puerto Rico) were invited to participate in the surveys. The surveys also were distributed to municipalities and MPOs through the National Association of City Transportation Officials (NACTO) and the Association of Metropolitan Planning Organizations (AMPO). Forty-three DOTs responded to the Phase 1 survey, and 34 DOTs responded to the follow-up survey, representing response rates of 83% and 65%, respectively. Of local agencies, 19 responded to the Phase 1 survey and 11 responded to the follow-up survey. The surveys were conducted through NCHRP in cooperation with AASHTO. AASHTO provided an e-mail distribution list to members of the Standing Committee on Planning (SCOP) and members of SCOP's Data Subcommittee.

In the data governance area, the study found that a pyramid-shaped data governance structure is commonly used in the literature. This structure consists of (1) an upper-level council or committee providing oversight and strategic direction, (2) enterprise data stewards providing coordination across business units, and (3) stewards accountable for the quality and use of individual information technology. Data stewards, coordinators, and custodians hold various positions in their business areas, such as planners, engineers, and geographic information system (GIS) specialists. Interviews conducted as part of this study with a sample of transportation agencies indicated that key motivations and early benefits of implementing data governance include (1) improved accountability to produce high quality and reliable data (sources of truth), (2) ensuring that the data are accessible and integrated using a common linear referencing system, and (3) engaging business areas within transportation agencies in their data, rather than viewing data as strictly an information technology (IT) issue.

Currently, a bottom-up approach for data management appears to be taking place. A more top-down data governance approach could help recognize and leverage the value of data generated and/or stored in various agency silos and could spur increased data integration. In most cases, DOTs have data

stewards and data coordinators for managing individual data sets and coordinating data management across multiple data sets within a business area (e.g., asset management, safety). However, most agencies indicated they do not have a data governance council or board (responsible for policy making and coordination at the enterprise level) and do not have a document that describes their data governance model and serves as a guide. Most survey respondents described the following as major factors in limiting progress toward implementing data governance: (1) lack of staffing, (2) other mission-related issues are more pressing, and (3) lack of resources.

With respect to data warehousing and cloud computing, the study found that most DOTs store and manage data collected during the operation and monitoring phases of roadway systems (e.g., roadway inventory, condition, and performance) in data warehouses or marts. Conversely, data collected at the early phases of the asset/project life cycle are more likely to reside in disparate files and databases. Although there is a general agreement in the literature that transportation agencies collect and manage large amounts of data, most DOTs and local agencies do not have reliable estimates of the amount of data they maintain. The use of cloud computing services for storing and managing data is expected to grow; however, most DOTs and local agencies are uncertain about the magnitude of this growth in their agencies.

Transportation agencies are using multiple linear and geographic referencing methods in their data sets, indicating that incompatibility among these methods remains an impediment to increased data integration within these agencies. The use of a common referencing system that unifies these methods can potentially facilitate data integration within transportation agencies.

Most survey respondents indicated that the following strategies have major effects on improving data sharing and access: (1) increased use of web-based data storage and access, (2) improved database management systems, and (3) reduced use of hardware and software that require specialized (e.g., proprietary) data formats.

The study addressed seven data quality dimensions: accuracy, completeness, timeliness, relevancy, consistency, accessibility, and access security. Most survey respondents indicated that these data quality dimensions are evaluated in at least some data areas in their agencies. For DOTs, timeliness, accuracy, and access security are most commonly evaluated. Conversely, consistency is the data quality dimension least evaluated by DOTs. Slightly more than half of the DOT respondents indicated their agencies have mechanisms in place for incorporating feedback from data users into the data collection process. These feedback mechanisms include ad hoc meetings, surveys, steering committees, web forms, and direct e-mails.

Finally, this study identified several areas of future research, including development of a data management and governance guidebook and training materials; identifying the benefits, costs, and risks (e.g., security risks) of adopting cloud computing services for transportation agencies; development of methods and metrics for evaluating data quality considering multiple quality dimensions; development of guidance and framework for integrating data within transportation agencies; case studies to assess the magnitude and complexity of data managed by transportation agencies; and development of methods and case studies for mining archived data at these agencies.

CHAPTER ONE

INTRODUCTION

BACKGROUND

Data-driven processes and technological advances have led to a steady increase in the amount and complexity of data collected and maintained by state departments of transportation (DOTs) and local transportation agencies, such as municipalities and metropolitan planning organizations (MPOs). Examples of these data include asset inventory and condition data, usage data from traffic counts, roadway design and construction data, and financial data. Data reside in attribute databases, geospatial databases, computer-aided design (CAD) files, three-dimensional models, multimedia files (e.g., image, video), and other forms. Increasingly, transportation agencies are viewing these data as assets to be managed systematically and effectively, in a manner similar to how physical infrastructure assets are managed (Spy Pond Partners, LLC and Iteris, Inc. 2015a). A rule of thumb often used in the private sector is that the volume of corporate data doubles every 18 months (Bhansali 2013), indicating the ever-increasing volume of data in today's world.

Although data provide opportunities to facilitate decision making at transportation agencies, there are challenges involved in managing large and diverse data that serve multiple business needs. These challenges are manifested in various aspects of data management, such as data quality assurance, integration, and access. The literature suggests that these challenges are more widespread in managing data across, rather than within, organizational units at transportation agencies (Spy Pond Partners, LLC and Iteris, Inc. 2015a). Data maintained by a specific unit within the agency often need to be shared with multiple users and integrated with multiple data sets. For example, traffic monitoring data are used for conducting safety analyses, developing transportation improvement programs, designing pavement, and developing asset management plans. As a result, it is important that traffic data be integrated with multiple data sets to serve multiple business needs (e.g., integration of traffic volume data with pavement condition data to develop pavement management plans). However, currently these data often reside in a collection of modern and legacy databases that are difficult to integrate (Cambridge Systematics, Inc. et al. 2010). These difficulties in integrating disparate data can lead to collecting data that already exist within other parts of the agency. An area prime for reducing the duplication of data is the creation of digital as-builts from three-dimensional models used in design and construction. However, the integration of these as-builts into legacy data management systems remains a challenge.

This synthesis provides information on current practices in data governance, quality assurance, integration and sharing, and warehousing at transportation agencies. This information can be used by transportation agencies to learn about, and ultimately advance, the current state of the practice in data management and governance.

SYNTHESIS SCOPE AND METHODS

The information provided in this synthesis was gathered through a review of the literature, a survey of state DOTs and local transportation agencies, and follow-up interviews with a sample of four agencies.

The survey was conducted in two phases, as follows:

- Phase 1—This phase of the survey focused on practices pertaining to:
  - Agencywide data governance and management.
  - Data warehousing, stewardship, and archival for 17 data areas that are inclusive of most data sets maintained by transportations agencies.

- Phase 2—This follow-up survey focused on detailed practices pertaining to:
  - The extent to which data quality is evaluated by transportation agencies.
  - Data integration and sharing, including data sets that are integrated or would be beneficial to integrate, consistency of location referencing systems within agency, strategies for improving data sharing and access, and methods for sharing data with outside users (public or private entities).
  - Use of data warehousing and cloud computing for storing and maintaining data.

The surveys were conducted through NCHRP in cooperation with AASHTO. AASHTO provided an e-mail distribution list to members of the Standing Committee on Planning (SCOP) and members of SCOP's Data Subcommittee. All 52 DOTs (50 states, District of Columbia, and Puerto Rico) were invited to participate in the surveys. The survey questionnaires also were distributed to municipalities and MPOs through the National Association of City Transportation Officials (NACTO) and the Association of Metropolitan Planning Organizations (AMPO).

The survey methodology consisted of the following steps:

- Step 1: NCHRP sent an initial invitation to SCOP members, NACTO, and AMPO through e-mail.
- Step 2: Approximately 2 weeks later, e-mail reminders were sent to invitees of state DOTs that had not responded to the initial invitation.
- Step 3: Approximately 2 weeks later, follow-up phone calls were made to invitees of state DOTs that had not responded to the second invitation.
- Step 4: NCHRP staff sent follow-up e-mail messages and made phone calls periodically to invitees to encourage participation.

Forty-three DOTs (83%) responded to the Phase 1 survey, and 34 DOTs (65%) responded to the follow-up survey. In accordance with NCHRP guidelines regarding survey response rates, data obtained from the Phase 1 survey are expressed as a percentage of the responses received, whereas data obtained from Phase 2 survey are expressed as the number of responses received. For local agencies, 19 agencies responded to the Phase 1 survey and 11 agencies responded to the follow-up survey. Figures 1 and 2 show maps of DOTs and local agencies that responded to the survey.

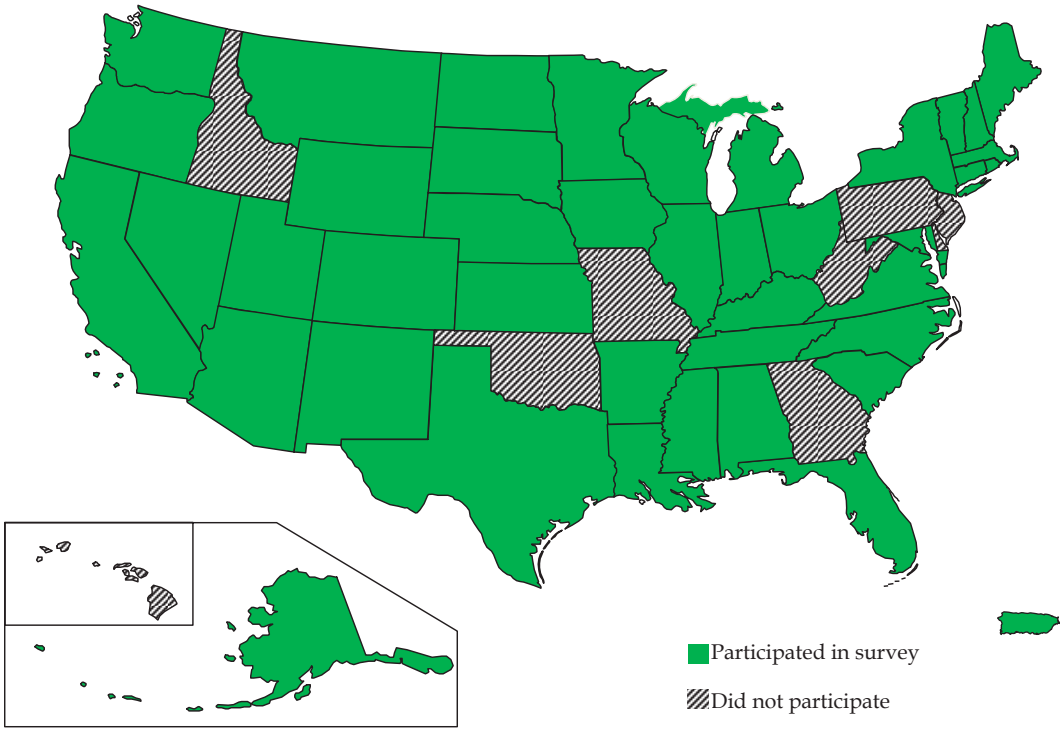


FIGURE 1 Map of DOTs that participated in the survey.

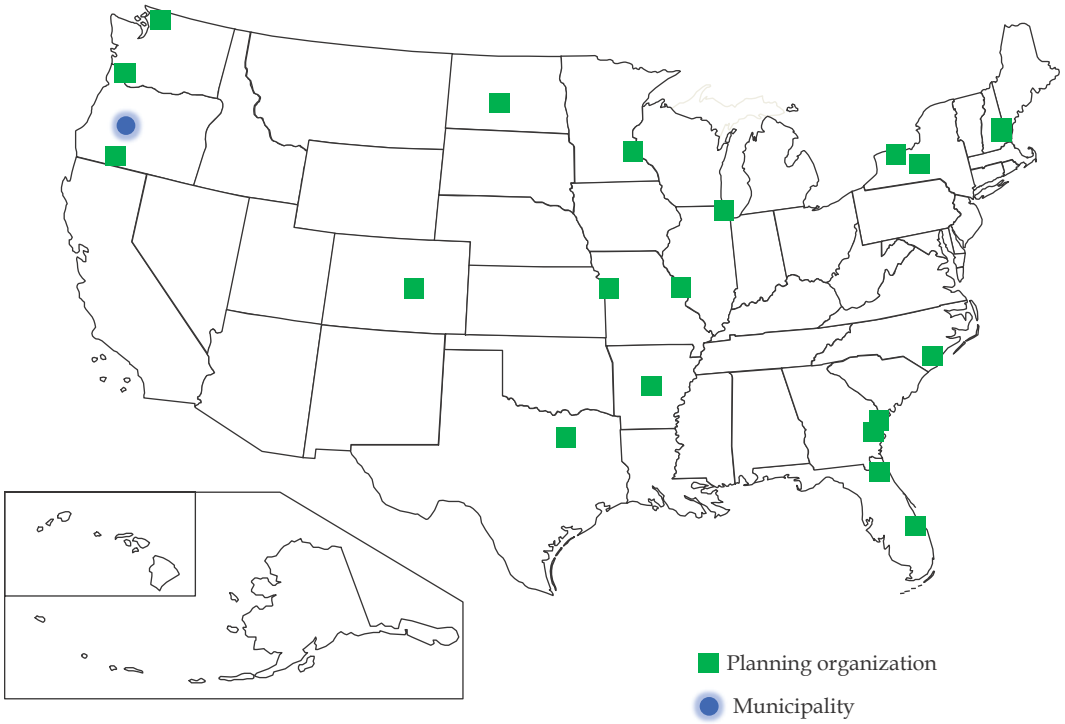


FIGURE 2 Map of local agencies that participated in the survey.

Three state DOTs (Alaska Department of Transportation and Public Facilities, Nebraska Department of Roads, and Iowa DOT) and one local agency (Chicago Metropolitan Agency for Planning) were interviewed regarding their data governance experiences and practices. The results of these interviews are presented throughout this report.

TERMINOLOGY

Key terms used in the survey instrument and in this report are defined as follows:

- Access security: Ability to restrict access to data to maintain security.
- Accessibility: Ability of authorized users to access the data.
- Accuracy: Closeness between a data value and the real-world value that it represents.
- Cloud computing: Date are stored and managed on remote computers "in the cloud." These computers are owned and operated by others and connect to users' computers by means of the Internet.
- Completeness: Absence of missing values in the data set.
- Consistency: Degree to which the data item is presented in the same format across agency.
- Data governance board/council/steering committee: Group that institutes policies and oversees activities regarding data governance throughout the organization. Data governance is defined as "the execution and enforcement of authority over the management of data assets and the performance of data functions" (Cambridge Systematics, Inc. et al. 2010).
- Data coordinator: Individual or committee that coordinates the organization, sharing, access, and use of multiple data sets within a business area (e.g., asset management, safety).
- Data warehouse/mart: A data warehouse is a unified repository of current and historical data obtained from multiple sources. A data mart is a scaled-down version of a data warehouse.
- Data steward: Individual who is accountable for assuring the quality of a specific data set, ensuring compliance with data rules and regulations, defining metadata, and relaying the appropriate use of the data.
- Data custodians: Cross-functional group of individuals, vendors, and data managers who are responsible for day-to-day execution of the governance rules and data management activities.

- Data archiving: The process of moving electronic data that are no longer actively used to a separate storage device for long-term retention (Spy Pond Partners, LLC and Iteris, Inc. 2015b).
- Enterprise data stewards: Group of individuals who facilitate cross-subject area and cross-business unit priorities, projects, and agreement, and act as champions of data governance within their program areas.
- Geographic coordinates: Geospatial coordinates, such as latitude and longitude, or state plane coordinates.
- Linear referencing systems (LRS): Location systems that define a known starting point and reference locations of objects at a linear distance from that point (Olsen et al. 2013).
- Location referencing method (LRM): A mechanism for finding and stating the location of an unknown point by referencing it to a known point (Adams et al. 2001).
- Multilevel linear referencing system: Includes multiple linear referencing methods and transformation mechanism to a common one (Pierce et al. 2013).
- Relevancy: Data are applicable and useful for the task at hand.
- Route mile point: Distance from the beginning of the route.
- Route reference post: Distance and direction from a physical mile marker posted on the route.
- Route street reference: Distance and direction on one street from its intersection with another street.
- Timeliness: How up-to-date the data are with respect to the task at hand.

Other terminology in this synthesis and in the literature review should be interpreted in context. The meanings generally will be clear from the definitions provided, the discussions presented, or through examples.

REPORT ORGANIZATION

This synthesis of practice is organized into six chapters:

- Chapter one—Introduction. The chapter introduces the synthesis by providing background information and summarizing the scope and organization of the synthesis report.
- Chapter two—Review of Literature on Transportation Data. The findings from the literature are summarized and presented. The chapter describes categories of data collected and generated at various phases of the transportation project/asset life cycle. It also includes a discussion of transportation data assembled by state DOTs to meet reporting and compliance requirements.
- Chapter three—Review of Literature on Data Management and Governance. The chapter provides a review of the literature on data governance, data warehousing and integration, and data quality.
- Chapter four—State Departments of Transportation Practices and Experiences. The chapter summarizes and discusses the findings of the surveys of state DOTs.
- Chapter five—Local Transportation Agencies' Practices and Experiences. The chapter summarizes and discusses the findings of the surveys of local transportation agencies.
- Chapter six—Conclusions and Future Research. The synthesis concludes with key observations and findings and suggestions for future research and outreach to advance the data maintenance state of practice within state DOTs and local transportation agencies.
- Appendices—Appendix A appears only in the web version of this report. It provides the questionnaire that was distributed electronically to the participants along with a summary of responses. Appendix B provides a list of respondents. Appendix C summarizes responses to data integration questions.

CHAPTER TWO

REVIEW OF LITERATURE ON TRANSPORTATION DATA

OVERVIEW OF TRANSPORTATION DATA

Various types and items of data are collected and produced at every phase of the transportation project/asset life cycle (Figure 3). An overview of the categories of data collected or produced at various phases of the transportation project/asset life cycle is provided next.

- Planning and programming: In this phase, multiple categories of transportation data (e.g., travel, system inventory, systems condition) are used to determine long- and short-range transportation improvement priorities and help identify candidate projects for improving facility conditions, enhancing safety, and mitigating congestion. The primary outcomes of this process include transportation improvement programs (TIPs) and state transportation improvement programs (STIPs). These improvement programs usually are accompanied by a financial plan that describes the cash flow and feasibility of the candidate projects (Sinha and Labi 2007). TIPs, STIPs, and accompanying financial plans [such as statewide long-range transportation plans (LRTPs)] in themselves turn to data that need to be maintained. For example, North Carolina DOT maintains a publicly available web-based geographic information system (GIS) for its STIP (Figure 4). Data items available for each project include STIP number, TIP number, route/city, project description, project costs, and construction year. The data in this system are usually updated every 2 years, after decisions have been made on projects to include in the program.
- Environmental analysis and preliminary design: In this phase, project location and scope are defined and alternative preliminary designs are evaluated to assess their potential social and environmental impacts. This process involves the collection and analysis of data related to these impacts. Data produced in this phase include environmental impact and compliance data and preliminary design plans.
- Design: In the design phase, many documents, drawings, and data sets are created in electronic format. Examples of these data include construction plans and drawings, right-of-way plans, digital terrain models, schedules of quantities, and spreadsheets of various data. Many state DOTs use electronic document management systems (e.g., ProjectWise) to organize, store, and share design data.
- Construction: Data generated in the preconstruction and construction phases include real estate data (e.g., appraisal document, acquisition date, demolition contract), procurement data (e.g., bid documents, bid tabulations), and field data (e.g., material samples and test results, payment data, daily work reports, change orders). State DOTs are beginning to embrace electronic collection, review, approval, and distribution of construction data and documents in a paperless environment; this process is known as e-Construction. This process has resulted in less use of paper documents but an increase in electronic data. Table 1 shows data and data management systems used in e-Construction at a sample of state DOTs. In addition, civil integrated management is emerging as a shift from document-based project delivery and management to a system based on three-dimensional models enabled by technologies such as light detection and ranging (Lidar) (Sankaran et al. 2016).
- Operations and safety: Transportation operations consists of a range of activities necessary for the proper functioning of a system, including routine traffic and transit operations, public safety responses, incident management, snow and ice management, network–facility management, planned construction disruptions, and traveler–shipper information (Neudorff et al. 2012). *NCHRP Synthesis 460: Sharing Operations Data among Agencies* (Pack and Ivanov 2014) identified numerous groups of operations data. These data are related to traffic incidents, traffic flow, weather, transit, computer-aided dispatch, connected vehicles, signal systems, and more.

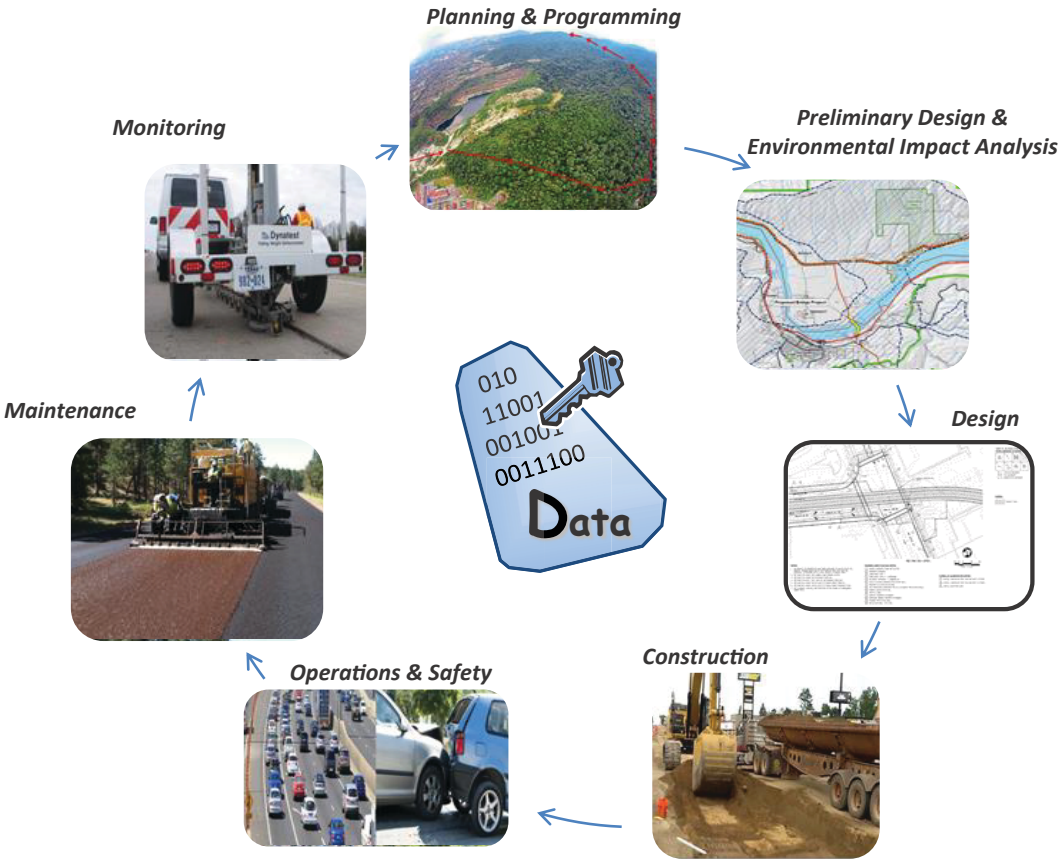


FIGURE 3 Transportation project/asset life cycle.

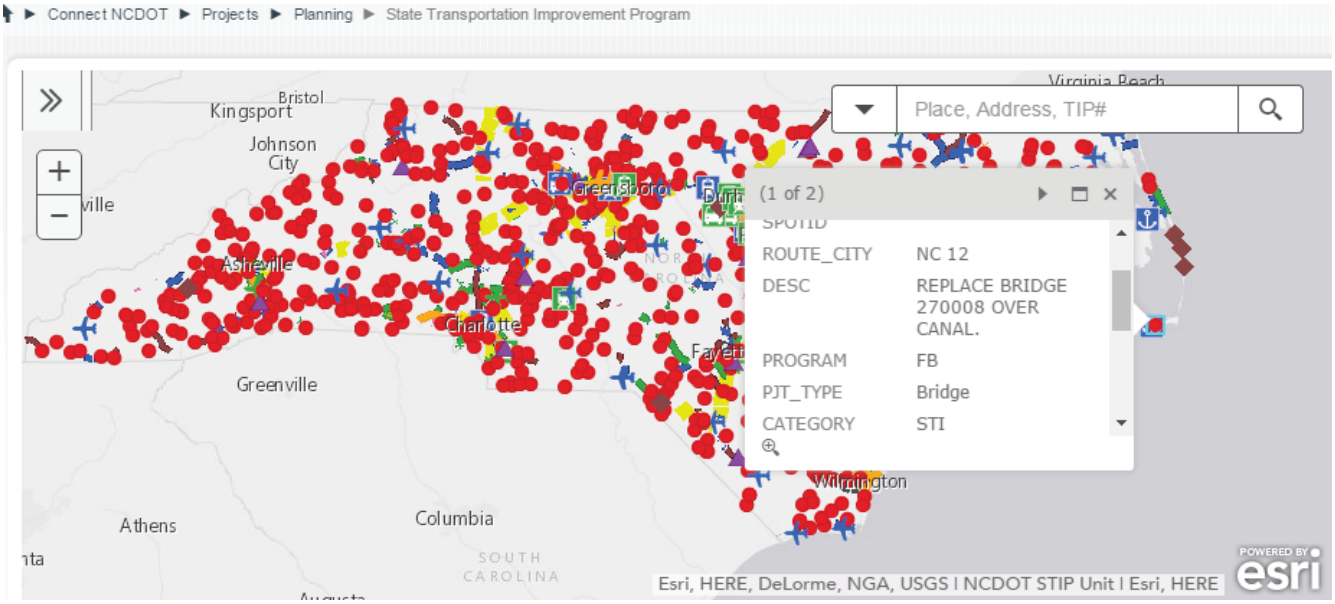


FIGURE 4 Example of a web-based data system for STIP, North Carolina DOT (https://connect.ncdot.gov/projects/planning/Pages/State-Transportation-Improvement-Program.aspx) (last accessed 7/16/2016).

TABLE 1
DATA AND DOCUMENT MANAGEMENT SYSTEMS USED IN E-CONSTRUCTION

State DOT	Electronic Document Management System	Field Data Management Software
Florida	ProjectSolveSP	SiteManager
Michigan	ProjectWise	FieldManager
Missouri	ProjectWise for contract plan and job special provision storage SharePoint for document storage	SiteManager
Texas	ProjectWise for document storage and minor workflow items Dropbox for file transfer	SiteManager
Utah	ProjectWise	MasterWorks

Traffic safety is a key component of transportation operations. A TRB peer exchange on improving safety programs through data governance and data business planning (Hall 2015) suggested that crash data typically are used to identify and evaluate countermeasures and perform predictive analysis. The peer exchange also indicated that how crash data are collected, stored, analyzed, and disseminated differ from state to state. For instance, in Iowa crash data records are collected by law enforcement personnel using the Traffic and Criminal Software (TraCS) for all crashes involving at least one fatality, one injury, or at least $1,500 property damage (all vehicular and nonvehicular property). The Iowa DOT's Motor Vehicle Division maintains crash data for the state's roadway system. The data consist of crash environment (e.g., date, time, severity, weather), roadway characteristics (e.g., road classification), driver details (e.g., age, gender, condition), vehicle descriptors (e.g., vehicle configuration, cargo body type, vehicle year), injured person details (e.g., age, gender, injury status), and nonmotorist information. Crash data are analyzed to produce various forms of crash reports and analytics (Figure 5), which are maintained and made available to the public on the Iowa DOT website.

- Maintenance: A 2015 survey of state DOTs found that most have a maintenance quality assurance (MQA) program in place or intend to implement a program within the next 5 years (Zimmerman 2015). As part of these MQA programs, state DOTs collect roadway condition data for pavements, roadsides (e.g., vegetation), drainage features (e.g., culverts, ditches), traffic features (e.g., signs, signals, guardrails), bridges, and special facilities (e.g., rest areas, tunnels). Typically, these data are collected annually through field surveys (Zimmerman 2015). In addition, many state DOTs track the cost and work history of highway maintenance activities in computerized maintenance management systems. Data collected through such systems and MQA programs are used for the planning, budgeting, and scheduling of maintenance activities.
- Monitoring: This phase involves the collection of data on the in-service performance and use of the transportation system. Increasingly, these data are collected through automated means that include sensors, nondestructive testing devices, and wired and wireless communication networks. For example, automated and semiautomated pavement condition surveys are conducted to collect data on surface distress, roughness, and friction. State DOTs commonly conduct these surveys annually or once every 2 years (Pierce et al. 2013). The collected data are stored in the agency's pavement management database along with other data categories, such as structural evaluation data collected through nondestructive testing, inventory, use (e.g., traffic volume), and pavement layer characteristics. Transportation agencies use these data to measure pavement performance and inform pavement maintenance, preservation, and rehabilitation decisions. In addition, pavement management data are the source of the pavement data reported to the highway performance monitoring system (HPMS) and will be used to meet the performance management reporting requirements established in MAP-21.

NATIONALLY MANDATED TRANSPORTATION DATA

In addition to data collected and generated throughout the project/asset life cycle, state DOTs assemble transportation data to meet reporting or compliance requirements. Examples of these data programs are described next.

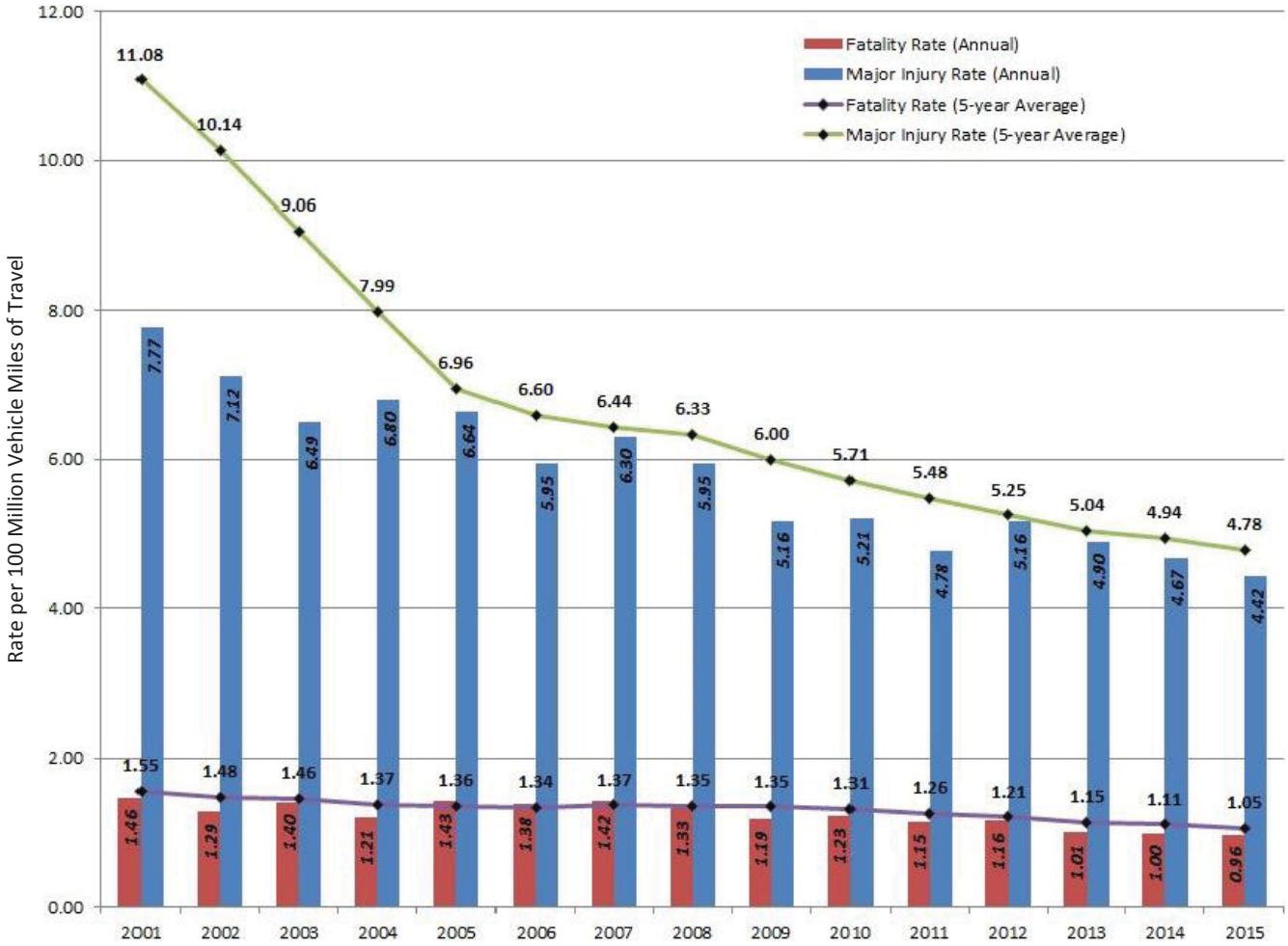


FIGURE 5 Example analysis of crash data from Iowa DOT.

Highway Performance Monitoring System

The HPMS is a national-level highway information system that integrates data on system inventory, asset condition, and operating characteristics. These data are used by FHWA, as mandated by Congress, to assess the extent, condition, investment needs, and changes brought about by improvement programs for the highway system. Although HPMS includes all of the nation's public road mileage as certified by the states' governors regardless of ownership, it covers in greater detail the National Highway System. Title 23 Code of Federal Regulations (CFR) 420.105(b) requires the states to provide data that support the FHWA's responsibilities to the Congress and the public. Thus, HPMS data are collected and reported annually by all states, the District of Columbia, Puerto Rico, and to a lesser extent U.S. territories. The HPMS Field Manual (FHWA 2015) states that "although there may be other participants in the collection and reporting process, the ultimate responsibility for the accuracy and timely reporting of HPMS data lies with the State highway agency."

The data required for the annual submittal of HPMS are categorized as full extent data (limited data items on all public roads), sample panel data (detailed data for designated sections of the arterial and collector functional systems), summary data (areawide information for urbanized, small urban, and rural areas), and linear referencing system data that provide a spatial reference for the full extent and sample panel data on selected highway functional systems. Authorized state personnel can use the HPMS software to upload, analyze, and process HPMS data for their agencies.

FHWA maintains web-based tools for downloading and viewing HPMS data by the general public, including shapefiles, containing 26 data items for each state. A shapefile is a preparatory

vector data storage format developed by Esri for storing the location, shape, and attributes of geographic features.

The National Bridge Inventory

The National Bridge Inspection Standard, implemented in 1971, requires states to regularly inspect highway bridges in the United States. This inspection is required for all bridges and culverts with a minimum length of 20 ft that are on public roads. The data are collected by state highway agencies and provided to the FHWA. The FHWA compiles and manages the database and makes it available to the public on the Internet. The National Bridge Inventory (NBI) database contains inventory and condition data for highway bridges and culverts since 1992. The 2015 NBI database has 611,845 bridge records, and each record contains 116 attributes (data fields).

The electronic NBI database was first assembled in 1972. Since then, the FHWA has changed its policies regarding public disclosure of NBI data several times to improve transportation security. Therefore, in some periods of time, research on NBI was conducted by the FHWA or other agencies that had access to the database for official use only. Currently, all elements of NBI data (inspected after 1992) are available publicly online.

Real-Time System Management Information

Title 23 CFR 511 requires state DOTs and other transportation agencies to establish real-time systems management information programs for traffic and travel conditions. These provisions are to be implemented in two stages: all U.S. Interstates by November 2014 and other metropolitan routes of significance by November 2016. Routes of significance are to be identified by states in collaboration with local agencies.

In 23 CFR 511, traffic and travel conditions include, but are not limited to, the following:

- Road or lane closures because of construction, traffic incidents, or other events;
- Roadway weather or other environmental conditions restricting or adversely affecting travel; and
- Travel times or speeds on limited access roadways in metropolitan areas that experience recurring congestion. Metropolitan areas are defined as the geographic areas designated as metropolitan statistical areas with a population exceeding 1,000,000 inhabitants.

CHAPTER THREE

REVIEW OF LITERATURE ON DATA MANAGEMENT AND GOVERNANCE

NCHRP Report 666 (Cambridge Systematics, Inc. et al. 2010) defines data management as "the development, execution and oversight of architectures, policies, practices, and procedures to manage the information life-cycle needs of an enterprise in an effective manner as it pertains to data collection, storage, security, data inventory, analysis, quality control, reporting, and visualization." The International Organization for Standardization (2003) offers a more concise definition of data management as "the activities of defining, creating, storing, maintaining and providing access to data and associated processes in one or more information systems." This synthesis focused on data governance, integration, sharing, warehousing, and quality.

DATA GOVERNANCE

Data governance deals with ensuring that the data are managed properly. It is the establishment, execution, and enforcement of authority over the management of data assets (Cambridge Systematics, Inc. et al. 2010; Ladley 2012). The terms "data governance," "data management," and "data business planning" are often used interchangeably or as components of one another (Stickel and Vandervalk 2014). Ladley (2012) suggested there should be a distinction between managing data (i.e., data management) and ensuring that data are managed properly (i.e., data governance) (Figure 6).

Transportation data are maintained by various business units (often called "data management areas") within transportation agencies. *NCHRP Report 814* (Spy Pond Partners, LLC and Iteris, Inc. 2015a) uses the terms "data management area" and "data program" interchangeably, defining them as an organizational function that is responsible for scoping, collecting, managing, and delivering a particular category or form of data. NCHRP Project 08-36 (Task 100) proposed a framework and conceptual design to develop a resource to help transportation agencies assess the adequacy, direction, and management of their data programs. Task 100 grouped transportation data into seven categories in developing the framework: travel data, system inventory data, system condition data, safety data, operational data, financial data, and customer relations data. *NCHRP Report 814* (Spy Pond Partners, LLC and Iteris, Inc. 2015a) provides a guidebook for transportation agencies to implement the self-inspection process, including self-assessment case studies of data management programs at Michigan DOT and Utah DOT for specific business areas: mobility/congestion, facilities management, maintenance, project scoping, and design. That guidebook can be useful for evaluating and improving the value of data for decision making and data-management practices.

In most cases, data governance is in the early stages of implementation; thus, its long-term benefits have not been measured. However, interviews conducted as part of this study with a sample of transportation agencies indicated that key motivations and early benefits of implementing data governance include:

1. Improved accountability to produce high-quality and reliable data (sources of truth).
2. Ensuring that the data are accessible and integrated using a common linear referencing system.
3. Engaging business areas within transportation agencies in their data, rather than viewing data as strictly an information technology (IT) issue.

During the past 10 years, several state DOTs have developed data business plans that describe data governance procedures, bodies/roles, and responsibilities. A recent TRB peer exchange empha-

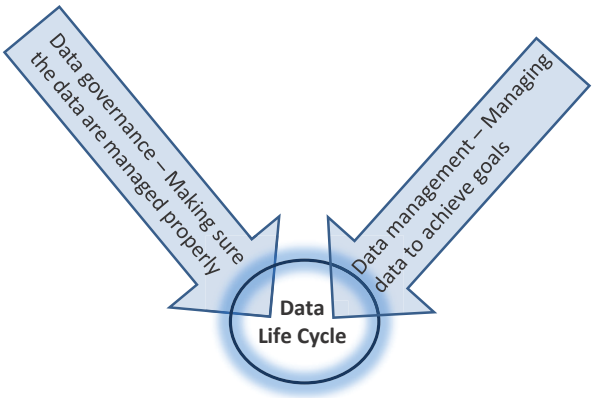


FIGURE 6 V-shaped illustration used to distinguish between data governance and data management.
Source: Adapted from Ladley (2012).

sized that data governance models be evaluated and assessed periodically (Hall 2015). An overview of data governance practices in three agencies (Florida DOT, Minnesota DOT, and U.S.DOT) is provided next.

Florida DOT

Florida DOT (FDOT) is implementing the ROADS (reliable, organized, and accurate data sharing) initiative for enterprise information management and data governance. The goal is to improve data reliability and simplify data sharing across FDOT so the agency has readily available and accurate data to make informed decisions.

In the FDOT ROADS project, data governance is the practice of managing information assets and realizing value with a set of standards, processes, and technologies executed through a well-defined governance structure to achieve business goals and objectives. As part of the ROADS project, a list of data/information gaps was identified throughout FDOT. The ROADS project consists of key elements related to people, process, and technology developed to address and close those data/information gaps. The following sections provide an overview of each of these key elements:

People: The FDOT ROADS project includes a data governance body consisting of a data governance steering committee, enterprise data stewards, data stewards, and data custodians. The responsibilities for each group are outlined in Figure 7.

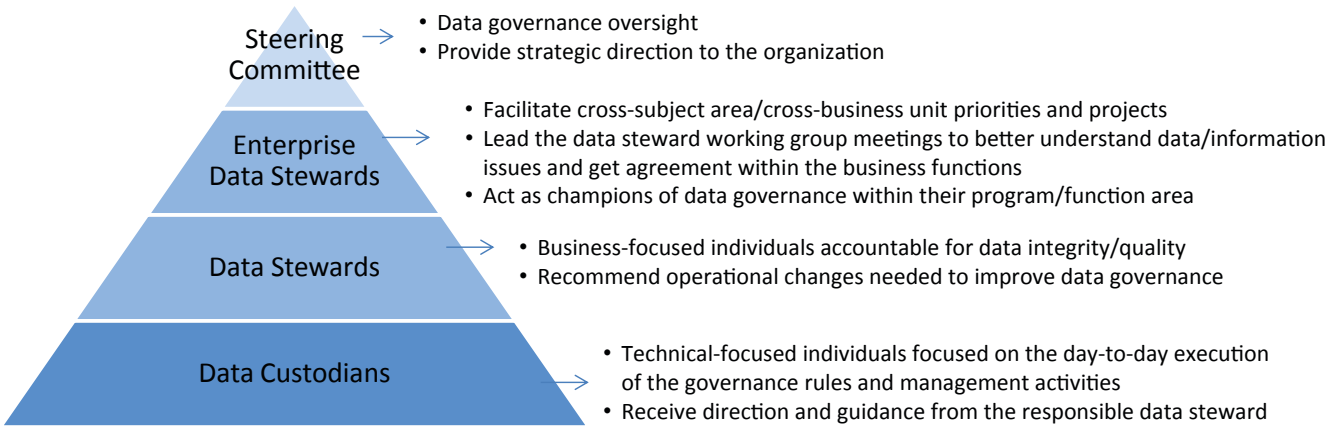


FIGURE 7 FDOT's data governing body.

Process: The FDOT data governance initiative consists of six categories of data governance processes/procedures, as follows:

- Business needs assessment: These procedures deal with collecting and documenting business requirements for each new business intelligence (BI) solution or data-related enhancement. BI technologies transform daily operational data into information that facilitates decision making. For instance, a roadway maintenance management system is a BI solution.
- Data standards update: These procedures are for updating the data and metadata standards based on ad hoc feedback from business users. Examples include adding, changing, or deleting data or metadata items.
- Data standards approval and maintenance: These procedures are for adding new standards, reviewing current ones, or deleting old and obsolete ones in response to requests submitted by business users.
- Education/Data guidance: These procedures are for providing training and guidance in response to requests submitted by business users.
- Quality monitoring: These procedures deal with establishing data quality agreements that specify the expected level of data quality, profiling data to determine base quality, cleansing data, and monitoring data entities to ensure quality agreements are kept.
- Road map: FDOT is organized by functions, and each function should have a road map that will align to the department's high level road map.

The data process/procedures identified are applied to the data governance components shown in Figure 8. A similar model is adopted by the Data Management Association International (Sullivan and Stickel 2015).

Technology: As part of the ROADS initiative, tools and technologies will be implemented to support the ROADS goal of leveraging and sharing data across the agency to help FDOT make better informed decisions. These capabilities are needed to support the rollout of the ROADS data governance initiatives that are under way and critical for FDOT to improve the quality and accessibility of data. These tools will support master data management; metadata recording and sharing; extract, transform, and load operations; and reporting efforts across the enterprise.

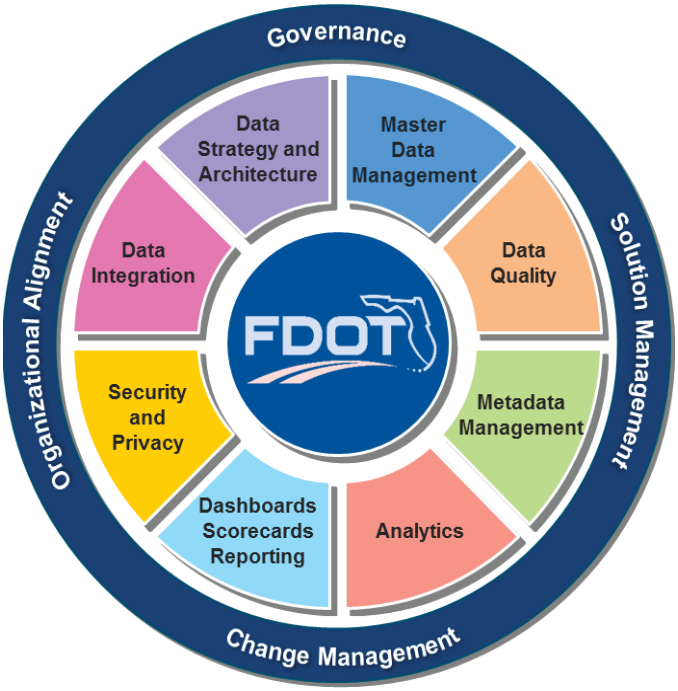


FIGURE 8 FDOT's data governance component model.

TABLE 2
DATA DOMAINS USED IN MINNESOTA DOT DATA GOVERNANCE MODEL

Data Domain	Domain Description	No. of Subject Areas
Business stakeholder/ customer	Data on the interface with external stakeholders with whom MnDOT has business or customer relationships and data about internal and external communications	10
Financial	Data related to receiving, managing, and spending funds	14
Human resources	Data about individual employees	10
Infrastructure	Data on the basic facilities that make up or interface with the transportation system	13
Planning, programming, and projects	Data that provide direction for and management of projects	11
Recorded events	Data on time-based occurrences that take place on the transportation system or that affect the transportation system	19
Regulatory	Data on topics that are controlled or directed by legal requirements	20
Spatial	Data that define locations on earth or in space, including GIS, CAD, latitude/longitude, xyz coordinates, sections of roadway, or boundaries	5
Supporting assets	Data on all items that affect or support the transportation system (e.g., building and facility, fleet, communications towers)	12

Minnesota DOT

Minnesota DOT's current data governance structure consists of nine data domains (with a steward identified for each domain) and five to 20 subject areas within each domain (with a data steward identified for each subject area). Table 2 describes these domains. Table 3 describes the subject areas within the infrastructure data domain, as an example, where a steward is identified for each data subject area.

TABLE 3
DATA SUBJECT AREAS WITHIN MINNESOTA DOT INFRASTRUCTURE DATA DOMAIN

Subject Area	Description
Airport data	Data on the publicly owned system of Minnesota airports.
Bicycle data	Data on bicycle facilities within Minnesota's transportation system, including existing/future data on state bikeways and U.S. bicycle routes, shared-use paths, protected bike lanes, bike lanes, shared lane markings and bicycle boulevards.
Bridge data	Data on the design, construction, and maintenance of bridges, including bridge condition and load ratings. Data can be contained within Pontis[a] and structure information management system (SIMS).
Drainage structure data	Data on hydraulic features such as culverts, channels, storm tunnels, retention ponds, and drains.
Interchange, intersection, and section data	Data that describe the location of roadway intersections, the location of specific portions (sections) of roadway, and the location of places where two roadways cross (intersect) designed to permit traffic to move freely from one road to another without crossing another line of traffic.
Parking facility data	Data on the ABC distributor ramps and other facilities in Minneapolis.
Rail crossing data	Data on the highway rail grade crossings and characteristics where roadways and railroad tracks intersect.
Right of way and contaminated property data	Data on the acquisition (purchase, lease) and management of real estate/property in transportation corridors or as part of the state rail bank, which is owned by or up for purchase by MnDOT.
Roadway data	Data on location, jurisdiction, classification, surface type and width, reference points, cross sections, control sections, oversize/overweight/twin trailer routes, and project history for the statewide highway system.
Safety feature data	Data on the guardrails, median barriers, railings, crash cushions, roadway lighting, rest areas, and similar hardware or facilities that are used to improve safety on the road system.
Sidewalk data	Data on pedestrian accommodations within MnDOT's transportation system, including Americans with Disabilities Act (ADA) compliance data on sidewalks, curb walks, and pedestrian bridges.
Smooth road data	Data on the ride rating (smooth ride) of the roadways.
Traffic control device data	Data on all signs, signals, markings, and other devices used to regulate, warn, or guide traffic, placed on, over, or adjacent to state trunk highways. Data on all of the devices covered by the *Manual on Uniform Traffic Control Devices*.

[a]Pontis has been updated to bridge management software (BrM).

TABLE 4
STAKEHOLDERS DEFINED IN U.S.DOT DATA BUSINESS PLAN

Role	Responsibility
Mobility Data Coordination Group	• Finalize data coordination framework with input from data working groups and internal community of interest • Develop and approve U.S. Mobility Data Coordination Group charter
Individual data working groups • Infrastructure/Inventory • Travel data • Climate (weather) data • Modal data • Connected vehicle data capture	• Address stakeholder needs related to respective group area • Identify and address gaps and redundancies in respective group area • Devise "rules of engagement" regarding collaboration and coordination • Develop data standards and stewardship recommendations for consideration by the U.S.DOT Mobility Data Coordination Group
Community of interest—internal	Coordinate with the data working groups to: • Address data gaps and overlaps • Share current activities and best practices in data management • Coordinate resources and cost sharing strategies to reduce redundancy in data collection, integration, and data systems • Facilitate sharing of data with internal/external stakeholders • Identify how current and planned data from the connected vehicle initiative can support existing roadway travel mobility data programs • Identify how data from roadway travel mobility data programs within U.S.DOT and FHWA can support the connected vehicle initiative • Identify existing/future data inventory and data structures/policies/governance practices that could be applicable to the Research Data Exchange
Community of interest—external	Not defined

U.S.DOT

In 2013, the U.S.DOT published a data business plan to help achieve two goals (Vandervalk et al. 2013):

- Improve the coordination and communication mechanism across U.S.DOT and FHWA offices involved with roadway travel mobility data.
- Improve the coordination of the data capture activities associated with sponsored research at the Intelligent Transportation Systems Joint Program Office in wirelessly connected vehicle technologies.

A key component of the U.S.DOT data business plan was a data coordination framework. The framework defines a set of data management practices (such as data governance, quality, standards, privacy, and security) and stakeholder groups that are responsible for coordinating these practices (Table 4).

DATA INTEGRATION AND WAREHOUSING

The terms "data warehouse," "data mart," and "operational database" are related but refer to different kinds of systems. Because most readers are familiar with the term "database," the first item of business is to compare data warehouses and data marts to operational databases.

An operational database is designed to support day-to-day operations of a particular application and has limited or no analytical capabilities. In contrast, a data warehouse is a repository that integrates data originating from multiple sources and various time frames. The integrated data are organized in a unified schema and reside in a single site. A data mart is a scaled-down version of a data warehouse. Both data warehouses and data marts have data analysis and decision-support capabilities.

Figure 9 depicts common architectures for data warehouses and data marts. The bottom tier consists of operational databases that contain data on day-to-day activities and operations of the agency, such as asset inventory and condition, crash records, and traffic counts. Normally, the data in these databases are too detailed and raw to be easily used for decision making. The data warehouse integrates data originating from multiple operational databases and various time frames. The data mart is linked to a single or limited number of operational databases and has fewer data integration and analytical capabilities. For transportation agencies, data marts appear to be more common than

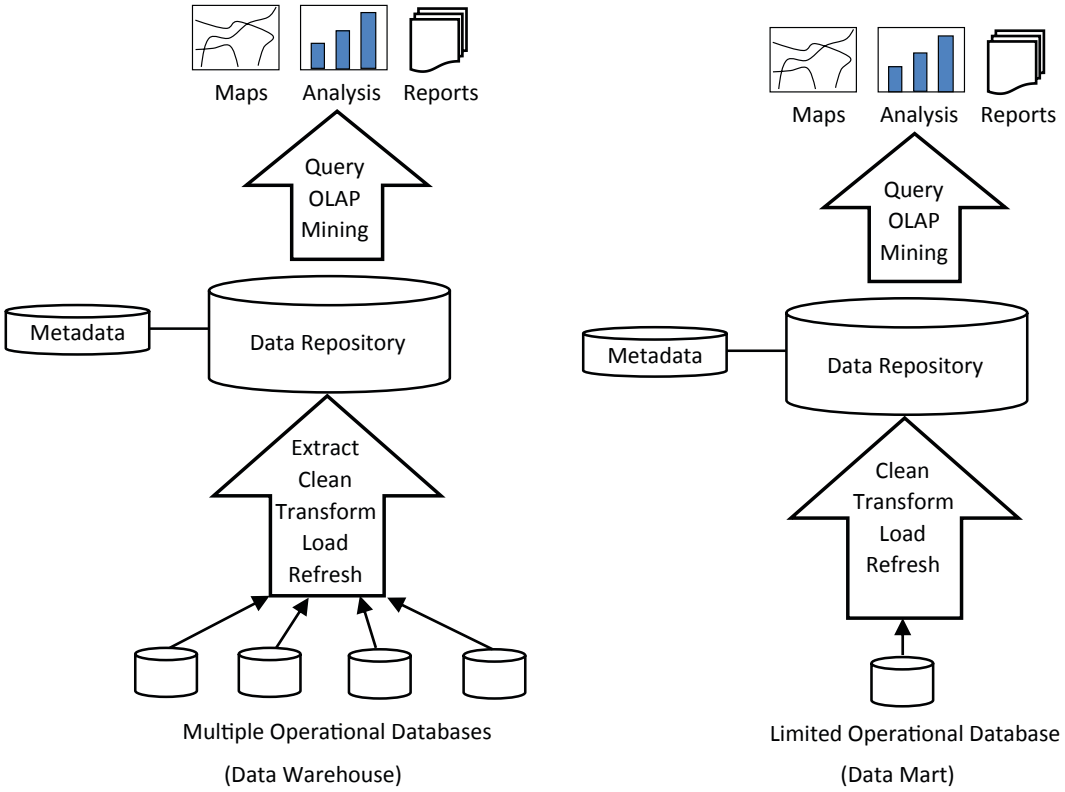


FIGURE 9 Architecture for data warehouses (*left*) and data marts (*right*).

enterprise data warehouses. The data repository in a warehouse or mart (middle tier) is constructed through a process of data cleaning, integration, transformation, loading, and periodic refreshing (Han et al. 2012). These processes are defined as follows (Han et al. 2012):

- Data extraction: gathering data from multiple, heterogeneous, and external sources.
- Data cleaning: detection of errors in the data and rectifying them when possible.
- Data transformation: conversion of data from legacy or host format to warehouse format.
- Data loading: sorting, summarizing, consolidating, checking integrity, and organizing the data in a unified schema.
- Refreshing: propagation of updates from the data sources to the warehouse repository.

The top tier of this architecture consists of data processing and analysis tools, including:

- Information processing: The warehouse or mart processes the data by means of querying, basic statistical analysis, and presentation (e.g., tables, graphs).
- Analytical processing: The warehouse or mart processes the data by means of online analytical processing—that is, analysis techniques with functionalities such as summarization and drilling down. For instance, one can drill down on yearly weather data to obtain monthly data. Similarly, one can roll up on performance data stored for roadway sections to obtain data summarized by county, district, or state.
- Data mining: The warehouse or mart is equipped with in-depth data mining capabilities, such as data clustering, outlier detection, and prediction.

Transportation data warehouses and marts often are equipped with GIS capabilities for visualization and spatial analysis. For example, Utah DOT (UDOT) uses the ArcGIS Online platform to access and share transportation data through the agency's open data portal (UGATE) and mapping application (UPlan) (http://uplan.maps.arcgis.com/home/index.html). UPlan contain multiple data categories, including safety and crash, roadway functional classification, access categories, maintenance stations, structure and bridge locations, planned and current construction projects, mile posts, pavement management, transit vehicles and dispersed funding, fiber-optic network, and freight

planning and operations data. Other state DOTs have embraced this approach for data access and sharing (e.g., Arizona, Florida, Kansas, Idaho, Montana, Pennsylvania).

In recent years, there has been increased interest in using cloud services to improve data management. The premise of this approach is that storing data in off-site data centers (the cloud) provides a degree of standardization and access that often is difficult to achieve in on-site data warehouses. Cloud computing resources are provided to individuals or organizations remotely through the Internet rather than directly on one's own computer. Some of the benefits of cloud computing include (Lei et al. 2012):

- Integrated computing and storage: The cloud computing model integrates computing power and storage. Computing resources can be abstracted from agencies. This eliminates the burdens of setting up hardware and software to store collected/generated data and perform computations.
- Ease of information provision: The degree of standardization and access offered by the web-based service model facilitates data integration and information sharing within agency and across agencies.
- Scalable and customized computing: Cloud computing provides a flexible storage and computing environment that allows agencies to rent storage and computing power as the need for such services fluctuates.
- Performance and security: Cloud computing service providers address many of the vital performance and security issues that ensure data integrity. Agencies can focus on using data maintained in clouds for business delivery.

DATA QUALITY

Data quality is a multidimensional concept (Wang et al. 2001; Lee et al. 2002; Batini and Scannapieca 2006). Accuracy, timeliness, consistency, and completeness are examples of these dimensions. The literature consistently organizes these quality dimensions in four categories: intrinsic, contextual, accessibility, and representational (Wang and Strong 1996; Pipino et al. 2002; Hazen et al. 2014). Intrinsic dimensions (e.g., accuracy) describe the quality of objective and native data. Contextual dimensions (e.g., relevancy) are dependent on the context in which the data are used. Representational dimensions refer to data understandability and conciseness. Accessibility refers to data sharing and security. Figure 10 shows the data quality dimensions considered in this study.

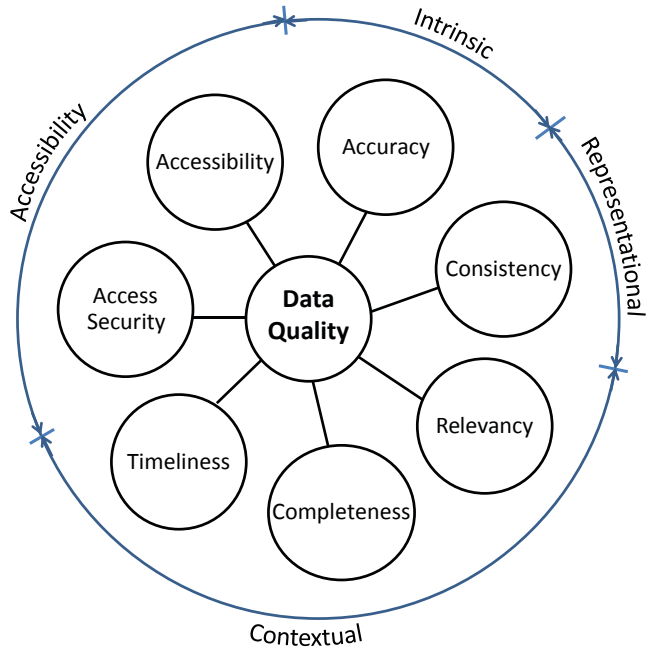


FIGURE 10 Data quality dimensions considered in this study.

Previous studies (such as *NCHRP Report 666* and *NCHRP Report 814*) suggest that the use of structured methods and instruments for gathering feedback from data users and data managers across agencies can help improve the quality of data maintained by transportation agencies. Depending on the size of the agency, methods that can be used include surveys, focus group meetings, data program workshops, and research studies (Cambridge Systematics, Inc. et al. 2010). *NCHRP Report 814* (Spy Pond Partners, LLC and Iteris, Inc. 2015a) provides a detailed self-assessment guide and tools for continuing data improvement.

CHAPTER FOUR

STATE DEPARTMENTS OF TRANSPORTATION PRACTICES AND EXPERIENCES

This chapter summarizes and discusses the findings of the surveys and follow-up interviews of representatives of state DOTs. It includes the experiences and practices of DOTs in the following topics:

- Data governance;
- Data warehousing and cloud computing;
- Data integration and sharing; and
- Data quality assurance.

To facilitate responses to the survey, the surveys addressed these topics as they apply to 17 data categories. These categories are sufficiently specific, without being overly detailed, and can be linked to the business functions and project/asset life cycle at transportation agencies. As mentioned, 43 DOTs responded to the Phase 1 survey and 34 DOTs responded to the follow-up survey, representing response rates of 83% and 65%, respectively.

DATA GOVERNANCE

An important step in data governance is the establishment of a data governance board or council (a group that institutes policies and oversees activities regarding data governance throughout the organization). Interviews with a sample of agencies indicated that this group normally consists of agency executives (e.g., division heads or directors).

Figure 11 shows that data governance boards/councils remain rare in DOTs. Of 43 responses received to this question, only eight agencies (19%) indicated the existence of a data governance board/council. However, 16 agencies (37%) indicated that a data governance body is in the development stage, signifying progress toward implementing data governance.

Most of the DOTs that have designated data governance boards and those in the process of developing ones provided a brief description of these boards/councils. The descriptions reveal different names for these bodies, including:

- Drive Team—Maine DOT;
- Data Governance Committee—Arkansas DOT;
- Data Governance Working Group—District of Columbia DOT;
- Reliable Organized Accurate Data Sharing (ROADS) Steering Committee (for data sharing)—Florida DOT;
- Enterprise Data Sharing and Storage Committee—Kentucky DOT; and
- Enterprise Information Governance Group—Washington State DOT.

In addition, most DOTs (e.g., Minnesota, New York, Maine, Michigan, Kentucky, Arkansas, and Washington State) have committees or are in the process of designating committees made up of members from different areas of the agency to provide leadership and support in making policies for data-related issues. Some agencies that do not have a fully functional agencywide governance board have structured governance policies for specific data programs. Other agencies designate the responsibility of data governance to a single program area (e.g., in Virginia DOT, data governance is managed by the policy division).

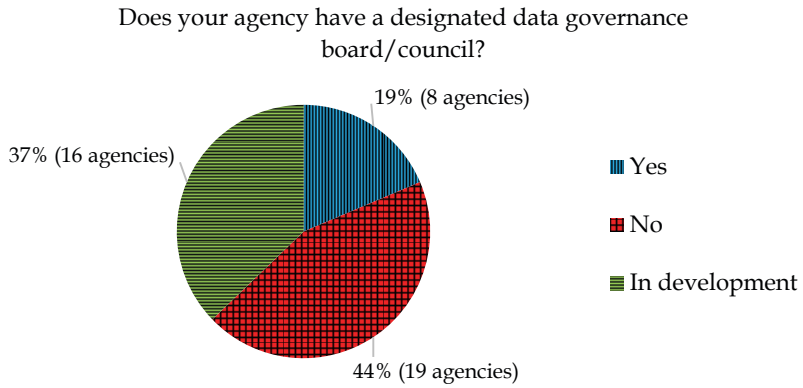


FIGURE 11 Data governance boards/councils at DOTs.

Data coordinators are individuals or committees that coordinate the organization, sharing, access, and use of multiple data sets within a business area (e.g., asset management, safety). Figure 12 shows that 26 (60%) responding agencies have data coordinators. Eleven (26%) agencies indicated they are in the process of establishing designated data coordinators, and only six (14%) agencies indicated they do not have data coordinators.

Agencies who reported having a data governance council/board indicated they also have data coordinators or are in the process of designating one.

Respondents from Florida, Illinois, Kentucky, Louisiana, and New York indicated they have designated individuals in different business areas performing the assignments of data coordinators for data sets within their units. In some DOTs, such as Minnesota, Nebraska, and Utah, data stewards perform the assignment of data coordinators. Some respondents mentioned specific data sets with data coordinators, including:

- Roadway inventory—Louisiana and Texas DOTs;
- Crash and safety data—Iowa, Arizona, and North Dakota DOTs;
- Traffic monitoring—North Dakota and Louisiana DOTs;
- HPMS—Arizona and Puerto Rico DOTs;
- Asset, bridge, and pavement condition—Iowa, Louisiana, North Dakota DOTs; and
- Maintenance—Iowa and Louisiana DOTs.

The survey asked the respondents to identify data sets (from a list of 17 data sets) for which their agencies have designated stewards. Figure 13 show the data sets and the percentage of DOTs that have designated stewards for the data sets. These results indicate that data collected during the system

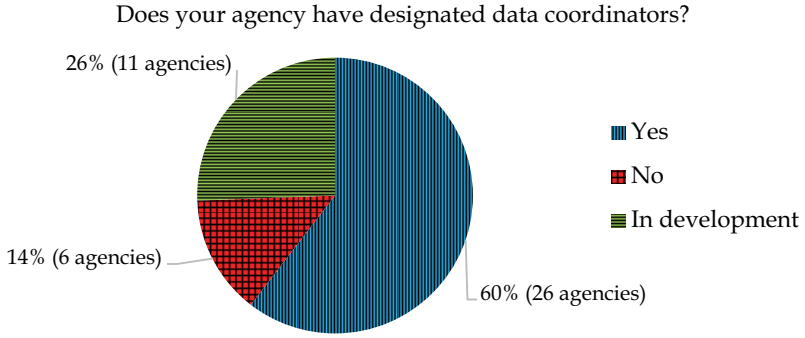


FIGURE 12 Presence of designated data coordinators at DOTs.

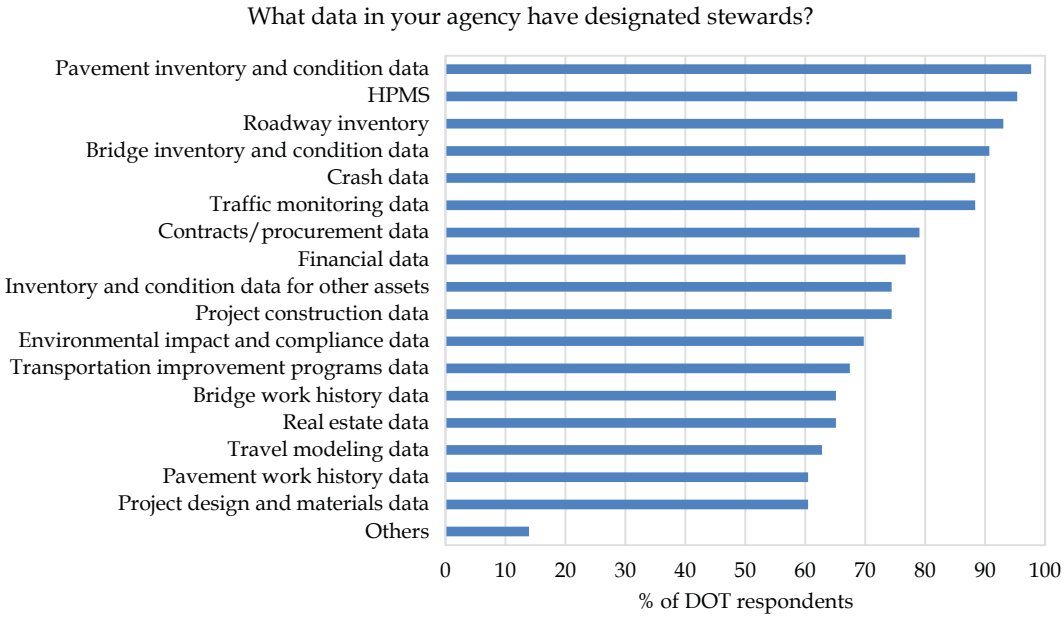


FIGURE 13 Presence of designated stewards for data sets at DOTs.

monitoring phase, specifically pavement inventory and condition, HPMS, and roadway inventory, are more likely to have designated data stewards than are data collected at earlier phases of the asset/project life cycle. Of note is that data sets that reside in data warehouses or marts (discussed in the following section of this synthesis) tend to have data stewards. Conversely, data sets that tend to reside in disparate files (as opposed to data warehouses or marts) are least likely to have designated stewards; examples include real estate data (e.g., property acquisition, agency-owned), pavement work history data, project design and materials data (e.g., design plans, structural design, mix design), and travel modeling data (e.g., household surveys, origin–destination).

Some respondents indicated their agencies have designated data stewards for other data not listed in the survey. For example, Puerto Rico DOT provides a steward for historical aerial data, and Alaska designates stewards for road weather information systems (RWIS) used to support winter weather maintenance decisions, seasonal weight restrictions, and travel decisions for the 511 traveler information systems. Arkansas has a steward for all public roads LRS and city/county boundaries data.

The follow-up interviews indicated that the data coordinators and stewards tend to be subject matter experts in their business areas (e.g., operations, safety, materials, research, design and engineering services, and project development). These individuals hold positions or titles in their business units such as transportation planner, pavement management engineer, and GIS specialist. One respondent indicated the agency had informal internal training for its data stewards and coordinators. The other interviewed agencies indicated they do not have any training or certification program for their data stewards and coordinators.

The development of a document describing the data governance model can serve as a reference and thus assist directly or indirectly in the implementation of data governance. Figure 14 shows that 11 responding agencies (26%) have such a document and 12 (28%) are in the process of developing one (totaling 23 agencies or 54%). However, 20 responding agencies (46%) do not have such a document and are not currently developing one.

The survey participants were asked to describe the effect of four factors on limiting progress toward the implementation of data governance in their agencies. These factors are: (1) other mission-related issues are more pressing, (2) hard to justify cost and effort, (3) lack of resources, and (4) lack of staffing.

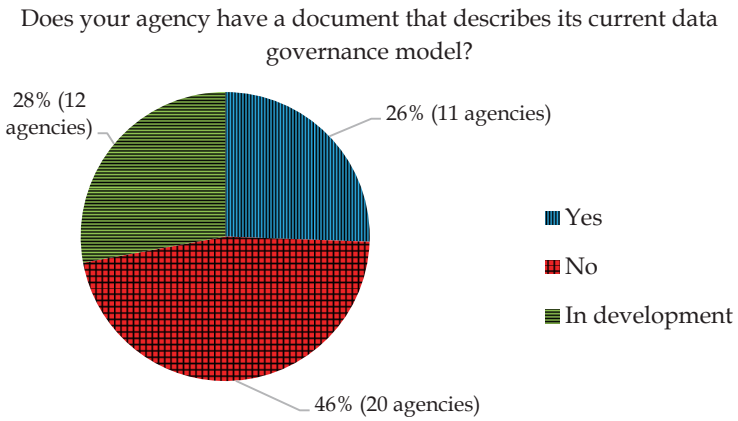


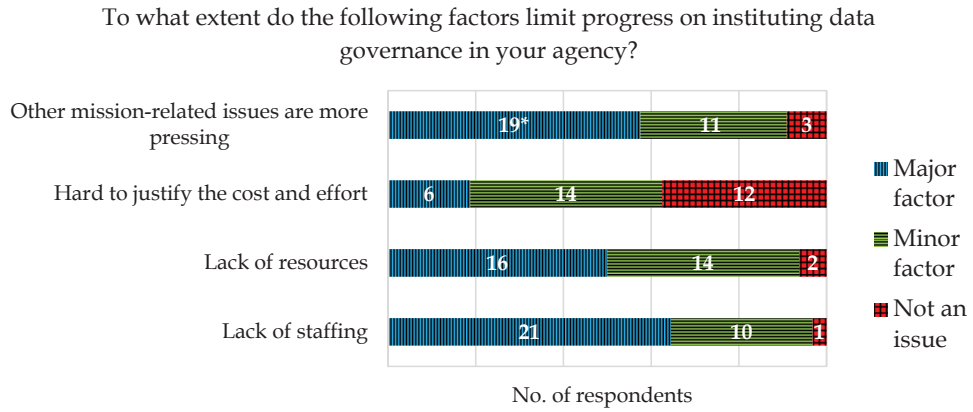
FIGURE 14 DOT practices in documenting data governance models.

Lack of staffing, "other mission-related issues are more pressing," and lack of resources were commonly described as major factors in limiting progress toward implementing data governance, with 21, 19, and 16 respondents, respectively (Figure 15). Only six of 32 respondents indicated difficulty in justifying cost and effort as a major factor. These results clearly show that lack of staffing is an important factor, whereas difficulty in justifying cost and effort appears to be a much less limiting factor in progress toward data governance at DOTs.

Respondents were given the opportunity to list at most two other factors. Other factors that respondents mentioned include lack of departmentwide compliance; lack of enterprise solutions; historic focus on projects (not underlying data); lack of formal governance policies, manuals, standards, and procedures; lack of leadership; lack of understanding of technical needs (geospatial/data integration/mapping) and how they should be envisioned for the enterprise; and lack of understanding the magnitude of data being managed by the agency.

Finally, the follow-up interviews identified the following hurdles that state DOTs faced while implementing data governance:

- Difficulty in getting the business areas to commit staff and time for the data governance working group;
- Staff turnover;
- Organizational restructuring; and
- Difficulty in reaching consensus within the data governance working group.



*Indicates number of respondents

FIGURE 15 Factors limiting progress on implementing data governance in DOTs.

DATA WAREHOUSING AND CLOUD COMPUTING

In response to questions about the use of data warehouses or marts, a wide range of practices across the 17 data sets used in the survey were identified, as shown in Figure 16. Most respondents indicated maintaining system inventory, condition, and performance data in warehouses or marts. These data tend to be collected during the system operation and monitoring phases. Conversely, data collected at the early phases of asset/project life cycle (e.g., real estate data, pavement work history data, project design and materials data, travel modeling data) are less likely to be stored in data warehouses or marts. As noted, data that are likely to be stored in data warehouses or marts tend to have designated stewards.

Few other DOTs, such as those in Puerto Rico, Indiana, Alaska, and Arkansas, indicated they maintain other data sets in warehouses or marts. Some of these data sets include historical aerial data maintained by Puerto Rico and RWIS maintained by Alaska.

A related question was included in the survey to determine what data are archived to retain historical information. Figure 17 shows that most respondents archive the 17 data sets used in the survey, with the exception of real estate data and travel modeling data. A clear majority of respondents (70% or more) archive the following types of data: pavement inventory and condition, roadway inventory, traffic monitoring, HPMS, project construction, crash, and bridge inventory and condition.

The respondents identified other data sets that are archived systematically in their agencies, including fleet management systems database (Oregon DOT), RWIS (Alaska DOT), and historical aerial data (Puerto Rico DOT).

When asked about the volume of data being maintained, the survey revealed that most DOTs do not have reliable estimates. Twenty-six of the 31 responses to this question indicated that such an estimate is not available. This may be because of the use of data silos, which makes it difficult to track all data within an agency as a whole. A few respondents mentioned that their agency has less than 2.2 terabytes of data; whereas, one respondent indicated the agency maintains about 50 terabytes of data. This wide range of data volume may be attributed to differences in the size of the agencies.

The use of cloud computing for maintaining transportation data is emerging but is in its infancy, as demonstrated in Figure 18. Of the 31 DOTs that responded to a question about the use of cloud

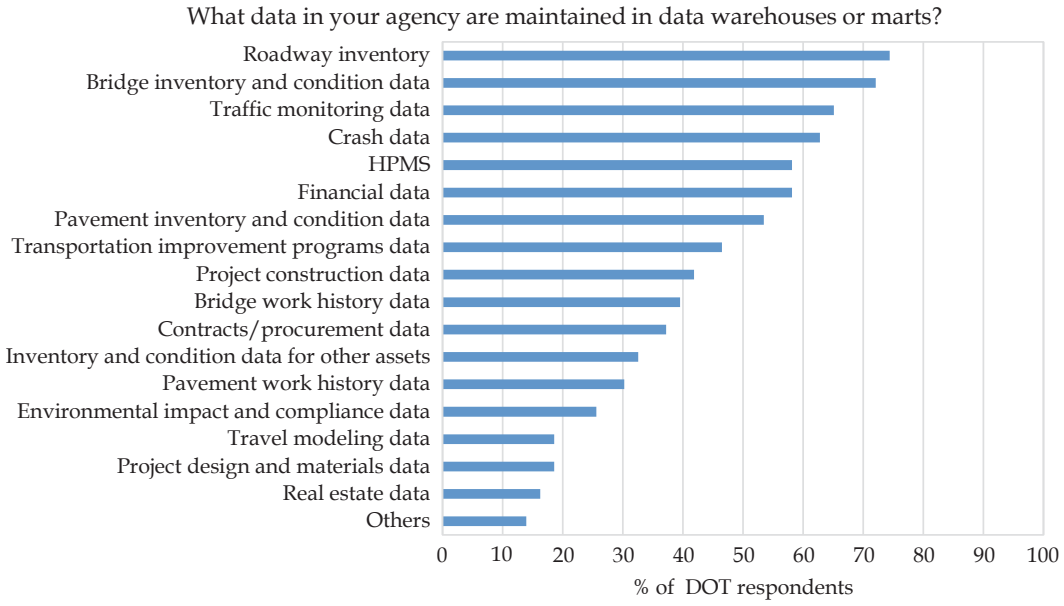


FIGURE 16 Data sets maintained in data warehouses or marts at DOTs.

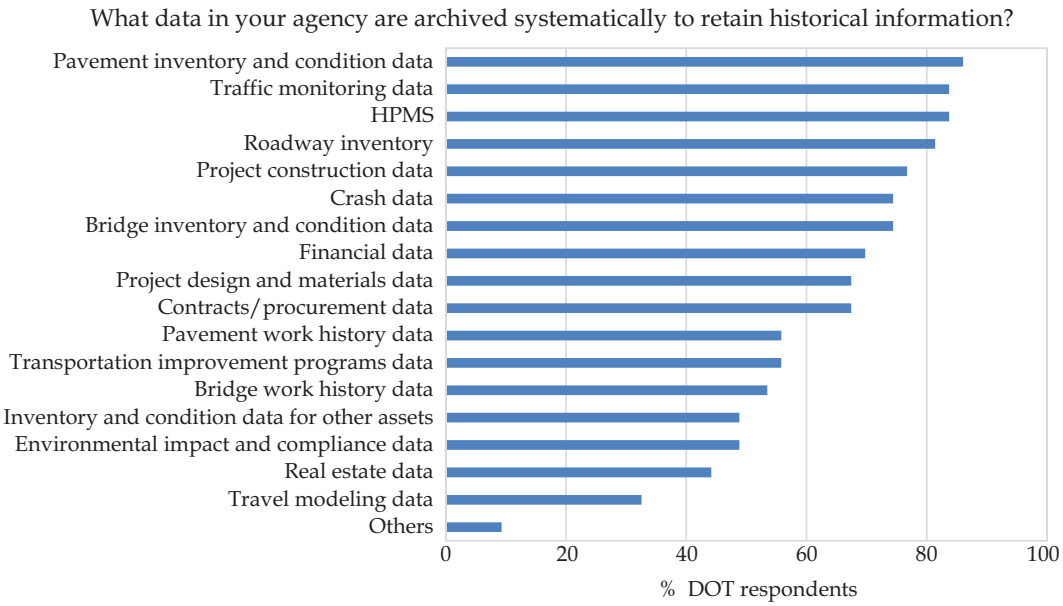


FIGURE 17 Use of data archiving to retain historical information at DOTs.

computing, 22 estimated that 1% to 10% of their data (as a whole) are being stored and managed in the cloud. Six agencies indicated that cloud computing is not being used or its use is unknown.

When asked about their predictions of the future use of cloud computing for storing and managing transportation data, the responses suggest that this practice is likely to grow in the future (Figure 19). Fourteen of 31 agencies expect that, in the next 5 years, more than 10% of transportation data in their agencies will be stored and managed in commercial cloud computing services. However, the same number of respondents indicated that making this prediction is not possible.

DATA INTEGRATION AND SHARING

The survey included questions to assess the level of data integration across the 17 data sets discussed. The survey also asked the participants to identify methods and tools used for integrating and sharing data within their agencies and with external stakeholders.

In all, the respondents identified 120 pairs of data sets that are integrated in their agencies to serve various business requirements. Figure 20 shows pairs of data sets that the majority (16 or more) of

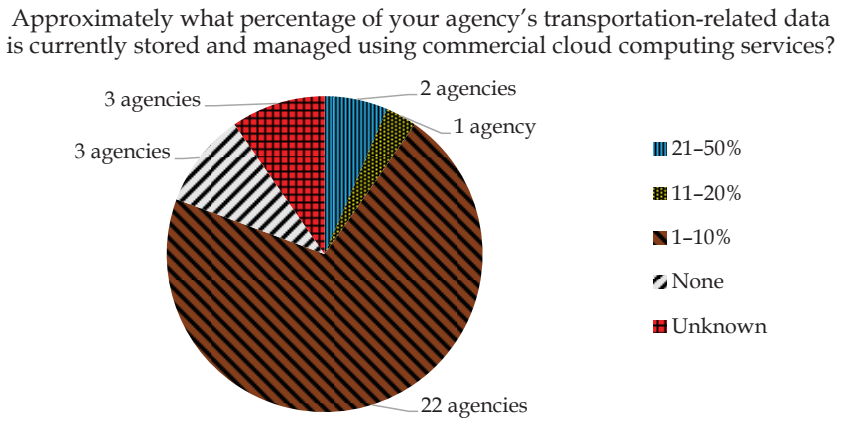


FIGURE 18 Use of cloud computing services at DOTs for storing and managing data.

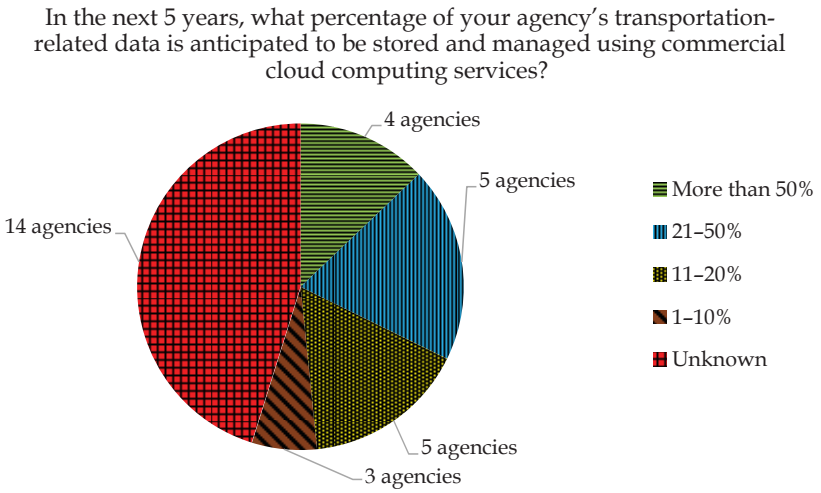
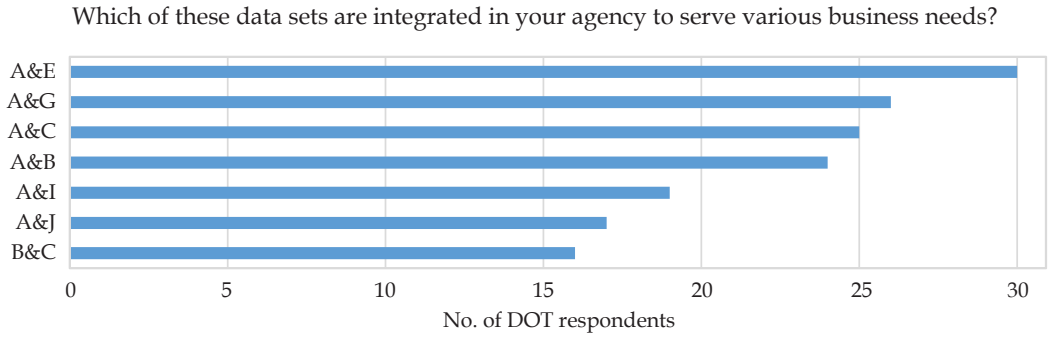


FIGURE 19 Future use of cloud computing services for storing and managing transportation data owned by DOTs.

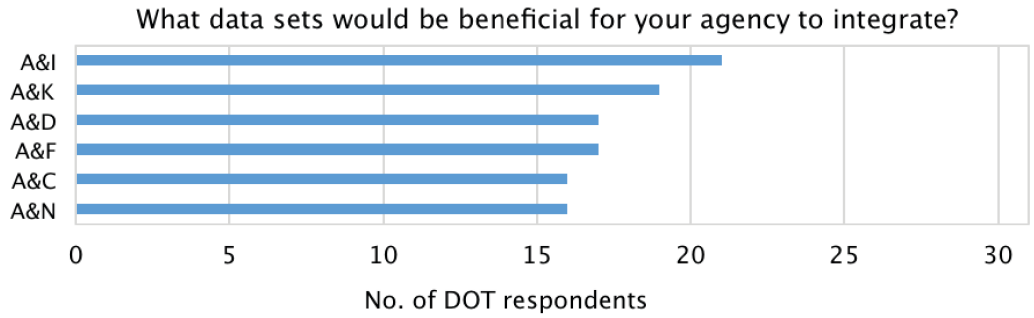
the 31 respondents identified as being integrated in their agencies. The extended form of this figure (showing all pairs of data sets) is presented in Appendix C. In most cases, these integrated pairs involve roadway inventory and another data set collected during system monitoring and operations. In fact, six of the seven most integrated pairs of data sets involve roadway inventory (data set A).

Participants were asked to identify pairs of data sets that would be beneficial for their agencies to integrate. Figure 21 shows pairs of data sets which the majority (16 or more) of the 31 respondents identified as potentially beneficial for their agencies to integrate. The extended form of this figure



A. Roadway inventory (e.g., location, classification, geometrics)
B. Crash data
C. Traffic monitoring data (e.g., speed, volume)
D. Travel modeling data (e.g., household surveys, origin–destination)
E. Pavement inventory and condition data
F. Pavement work history data
G. Bridge inventory and condition data
H. Bridge work history data
I. Inventory and condition data for other assets (e.g., traffic signs, signals, drainage assets)
J. Transportation improvement programs data
K. Environmental impact and compliance data
L. Project design and materials data (e.g., design plans, structural design, mix design)
M. Contracts/procurement data (e.g., bid tabs)
N. Project construction data (e.g., cost/payments, schedule, material acceptance testing, as-built plans)
O. Real estate data (e.g., property acquisition, agency-owned)
P. Financial data (e.g., current and historical revenues, expenditures, budgets)

FIGURE 20 Pairs of integrated data sets at a majority of responding DOTs.



A. Roadway inventory (e.g., location, classification, geometrics)
B. Crash data
C. Traffic monitoring data (e.g., speed, volume)
D. Travel modeling data (e.g., household surveys, origin–destination)
E. Pavement inventory and condition data
F. Pavement work history data
G. Bridge inventory and condition data
H. Bridge work history data
I. Inventory and condition data for other assets (e.g., traffic signs, signals, drainage assets)
J. Transportation improvement programs data
K. Environmental impact and compliance data
L. Project design and materials data (e.g., design plans, structural design, mix design)
M. Contracts/procurement data (e.g., bid tabs)
N. Project construction data (e.g., cost/payments, schedule, material acceptance testing, as-built plans)
O. Real estate data (e.g., property acquisition, agency-owned)
P. Financial data (e.g., current and historical revenues, expenditures, budgets)

FIGURE 21 Pairs of data sets that would be beneficial to integrate, as identified by the majority of responding DOTs.

(showing all identified pairs of data sets) is presented in Appendix C. All of these pairs involve roadway inventory (data set A). These results demonstrate the importance of roadway inventory data to multiple business functions at DOTs. However, these results are to be viewed within the context of many of the survey respondents being planners or analysts/managers of planning data, jobs for which roadway inventory plays a major role.

The integration of transportation data from different sources requires a common LRM or automated means for converting different LRMs to be compatible. Thus, the survey asked the participants to identify the LRMs used in existing data sets at their agencies. Six LRMs were given: route mile point, route reference post, link-node, route street reference, multilevel linear referencing system, and geographic coordinates. Figure 22 shows that all of these LRMs are being used by state DOTs in various data sets. However, geographic coordinates (e.g., longitude-latitude or state plane coordinates) and

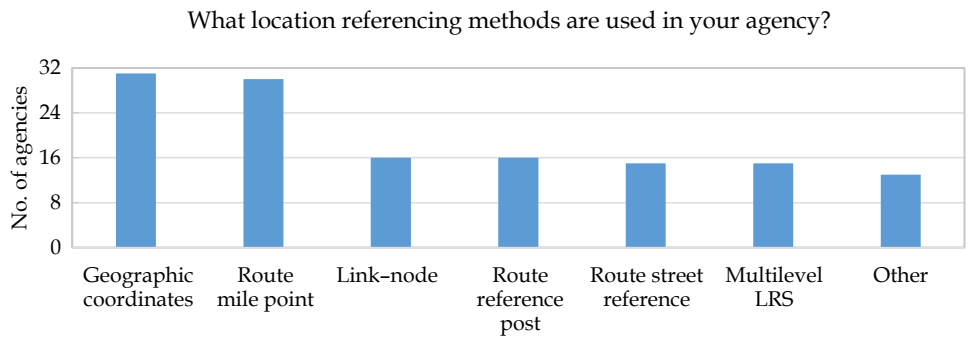


FIGURE 22 LRMs used by DOTs in at least one data set.

route mile point are the most commonly used LRMs. The wide use of geographic coordinates may be because of the prevalence of Global Positioning System (GPS) in current data collection technologies. The route mile point LRM is used to represent attributes (called events) on linear features (called routes). Table 5 shows that a similar conclusion can be made about the use of these LRMs for individual data sets. Comments made by some respondents indicated that some agencies use other LRMs, especially for contract/procurement data, project construction data, and travel modeling data.

To evaluate agency data sharing methods with external stakeholders, including public and private entities, five options were provided to the respondents to select from: online open access, online preauthorized access, upon request (e.g., data sent by e-mail or a file-sharing service), not shared outside the agency, or data shared through other methods. Some DOT respondents indicated more than one sharing method for some data sets.

Figure 23 shows the use of these methods for all data sets, and Table 6 shows the use of these methods for each data set individually. Each responding DOT indicated the use of a combination of these methods to share data with external users. However, the online open access and "upon request" methods are used by most of the responding DOTs (Figure 23). Table 6 shows that online open access and upon request methods are consistently most common when the results are divided by individual data sets. Table 6 also indicates that the most shared data sets through online public access are traffic monitoring, TIPs, and roadway inventory. All respondents indicated that their agencies share roadway inventory and traffic monitoring data sets outside their agencies. Conversely, travel modeling and bridge work history are the data sets least shared with external entities.

TABLE 5
DOTs' USAGE OF LRMs IN INDIVIDUAL DATA SETS
(by number of respondents)

What location referencing methods are used in your agency?	Geographic coordinates	Route mile point	Link–node	Route reference post	Route street reference	Multilevel LRS	Other
Roadway inventory	17	27	7	8	8	13	1
Crash data	22	20	4	7	7	9	0
Traffic monitoring data	12	24	5	6	4	9	1
Travel modeling data	7	9	9	2	2	1	4
HPMS	14	26	7	5	6	11	0
Pavement inventory and condition data	17	25	5	8	2	8	0
Pavement work history data	7	17	2	4	1	5	1
Bridge inventory and condition data	24	23	3	8	2	9	0
Bridge work history data	13	14	2	5	1	7	3
Inventory and condition data for other assets	19	19	4	8	5	7	1
Transportation improvement programs data	7	18	0	7	1	8	3
Environmental impact and compliance data	12	12	0	6	1	2	3
Contracts/procurement data	6	15	0	8	1	3	8
Project construction data	7	14	0	7	2	4	7

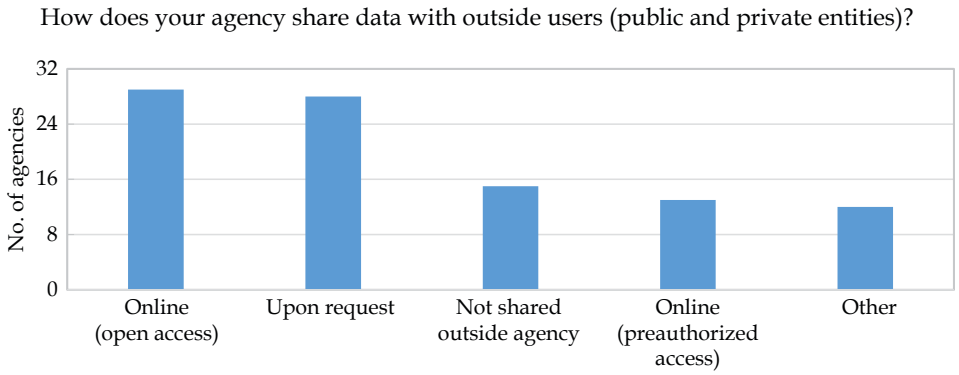


FIGURE 23 Data sharing methods used by DOTs for at least one data set.

Respondents were asked to identify strategies that would improve or have improved data sharing and access at their agencies. Four strategies were presented to the respondents: improved metadata, increased use of web-based data storage and access, improved data management systems, and reduced use of hardware and software that require specialized data format. The respondents were asked to describe these strategies as having major effect, minor factor, no effect, or not applicable. Respondents were also given the opportunity to list two other strategies.

TABLE 6
METHODS USED BY DOTs FOR SHARING INDIVIDUAL DATA SETS WITH EXTERNAL USERS
(by number of respondents)

How does your agency share data with outside users (public and private entities)?	Online (open access)	Upon request	Not shared outside agency	Online (preauthorized access)	Other
Roadway inventory	20	25	0	7	2
Crash data	10	16	3	8	2
Traffic monitoring data	22	18	0	2	3
Travel modeling data	2	17	5	0	5
HPMS	10	21	4	3	1
Pavement inventory and condition data	10	22	1	4	1
Pavement work history data	7	17	3	3	1
Bridge inventory and condition data	15	21	1	6	2
Bridge work history data	5	14	5	4	3
Inventory and condition data for other assets	8	17	4	5	3
Transportation improvement programs data	20	16	0	6	1
Environmental impact and compliance data	6	16	4	5	4
Contracts/procurement data	11	15	3	5	2
Project construction data	7	16	4	6	0
Financial data	5	15	4	6	2

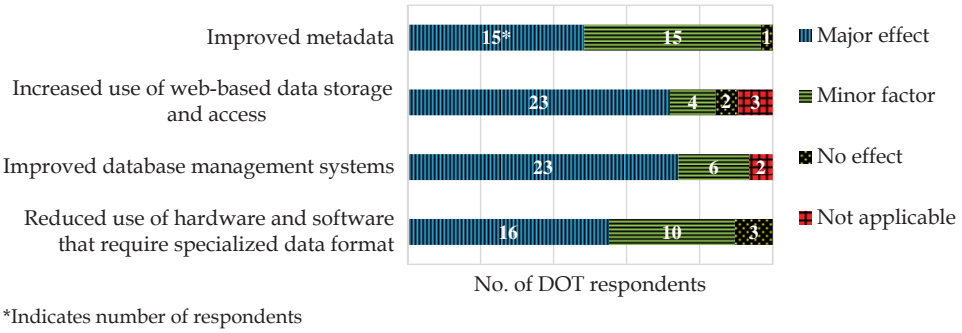


FIGURE 24 Strategies for improving data sharing and access at DOTs.

Most respondents indicated that two of these strategies have a major effect on improving data sharing and access: (1) increased use of web-based data storage and access, and (2) improved database management systems (Figure 24).

Other strategies mentioned by respondents include implementation of data governance, establishment of standards and requirements for sharing, implementation of civil integrated management, having a data registry, use of enterprise-level business intelligence vendor products, and the presence of a senior management champion.

Respondents also listed data management tools most useful for accessing and sharing data within their agencies. These tools can be generally grouped into:

- GIS and geospatial and mapping tools;
- Tools for integrating different location referencing systems;
- Specific tools, such as Structured Query Language (SQL) Server Reporting Services (SSRS), SharePoint, Excel, SAP Business Objects Suite, and Oracle Business Intelligence Suite;
- Data warehouses, including cloud storage;
- Representational State Transfer (REST) services (the software architectural style of the World Wide Web); and
- ER/Studio (identified by one of the interviewed agencies). This is a commercially available software tool for managing data assets, including documenting data elements and objects; showing their sources, interactions, and dependencies; and setting permissions for access controls.

DATA QUALITY

The participants were asked to identify the extent to which various data quality elements are evaluated in their agencies. The quality elements provided in the survey included accuracy, completeness, timeliness, relevancy, consistency, accessibility, and access security. Table 7 summarizes the responses

TABLE 7
EVALUATION OF DATA QUALITY AT DOTs
(by number of respondents)

Quality Element	Accuracy	Completeness	Timeliness	Relevancy	Consistency	Accessibility	Access Security
Evaluated in all or most areas	14	13	13	12	7	8	16
Evaluated in some areas	17	16	21	17	13	19	13
Evaluated in a few areas	3	5	0	5	14	7	5

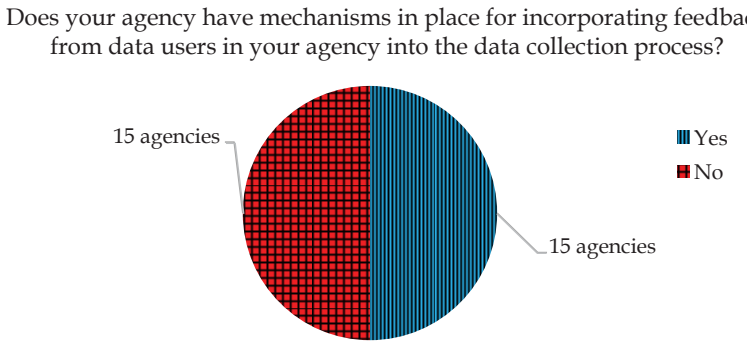


FIGURE 25 Presence of mechanisms for incorporating users' feedback into the data collection process.

received. No respondents indicated that any of these data quality elements is entirely ignored in their agencies. Most respondents indicated that all of these data quality elements are evaluated in at least some data areas in their agencies. Timeliness, accuracy, and access security are most commonly evaluated. Consistency is the data quality element least evaluated by DOTs.

Because it can be reasonably assumed that feedback from data users would improve data quality, the survey participants were asked to specify if their agencies have mechanisms in place for incorporating users' feedback into the data collection process. Figure 25 shows that 15 of 30 respondents indicated that their agencies have mechanisms in place for incorporating this type of feedback. The respondents described these feedback mechanisms as ad hoc meetings, surveys, steering committees, web forms, and direct e-mails.

CHAPTER FIVE

LOCAL TRANSPORTATION AGENCIES' PRACTICES AND EXPERIENCES

This chapter summarizes and discusses the findings of the surveys of local transportation agencies (MPOs and cities). It is important that these results be considered preliminary because of the small number of responding agencies. Similar to the discussion of the DOTs' surveys (chapter three), this chapter includes the experiences and practices of local agencies in the following topics:

- Data governance;
- Data warehousing and cloud computing;
- Data integration and sharing; and
- Data quality assurance.

DATA GOVERNANCE

Of 19 local agencies that participated, only one reported having a data governance board; however, five respondents indicated their agencies have data coordinators, and two respondents indicated their agencies are in the process of designating data coordinators. The remaining 12 respondents indicated their agencies do not have data coordinators. Additional inputs from respondents who indicated their agencies have data coordinators indicated the coordinators are GIS staff, transportation planners, or data management specialists. No respondents indicated their agency has a document describing its data governance model.

The survey asked the respondents to identify data sets (from a list of 17) for which their agencies have designated stewards (Figure 26). These results indicate that data collected during the planning phase (particularly data about travel modeling and transportation improvement programs) are more likely to have designated data stewards at local transportation agencies than are data collected at later phases of the asset/project life cycle.

Survey participants were asked to describe the extent of the effect of four factors on limiting progress toward implementing data governance in their agencies. As shown in Figure 27, lack of staffing and "other mission-related issues are more pressing" were commonly described as major factors, with eight and seven responses, respectively. These results are consistent with the results obtained from the DOTs' surveys.

DATA WAREHOUSING AND CLOUD COMPUTING

Results of the survey question about the use of data warehouses or marts indicate that most local agencies do not use data warehouses or marts for managing their transportation data (Figure 28). However, the results also indicate that road inventory data, crash data, traffic monitoring data, travel modeling data, and TIPs are more likely than other data sets to be managed in data warehouses or marts.

A related question was included in the survey to determine what data are archived at local agencies to retain historical information. Figure 29 shows that most responding agencies do not archive their transportation data. However, the results also show that travel modeling and TIPs data at local agencies are more likely to be archived than are other data sets.

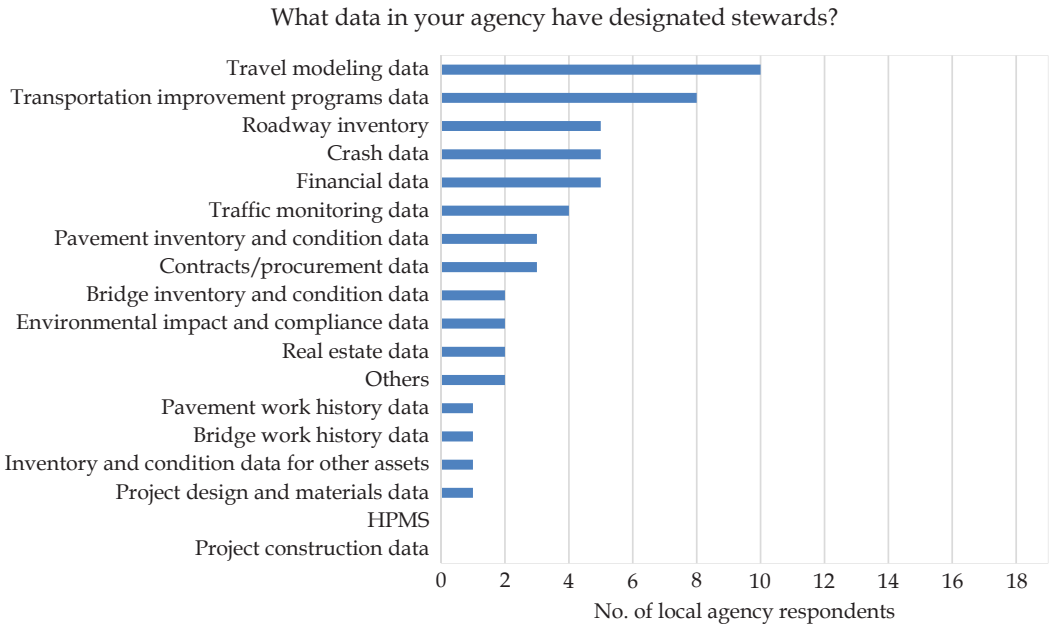
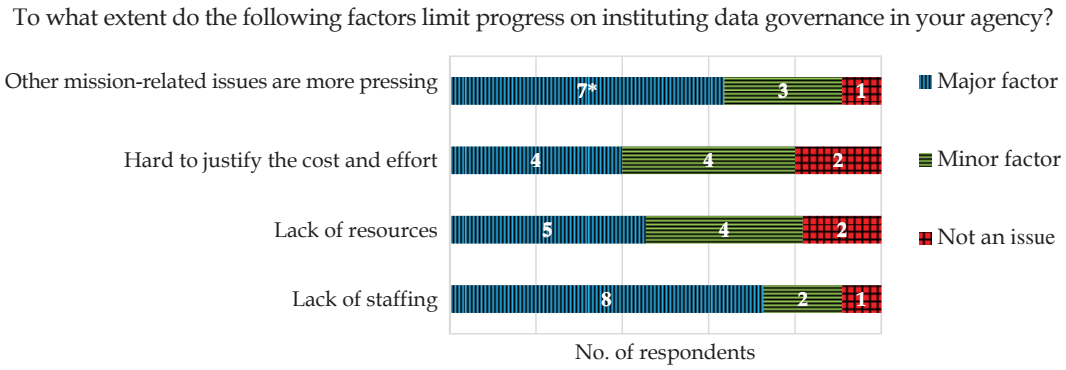


FIGURE 26 Designation of data stewards at local agencies.



*Indicates number of respondents

FIGURE 27 Factors limiting progress toward implementing data governance in local agencies.

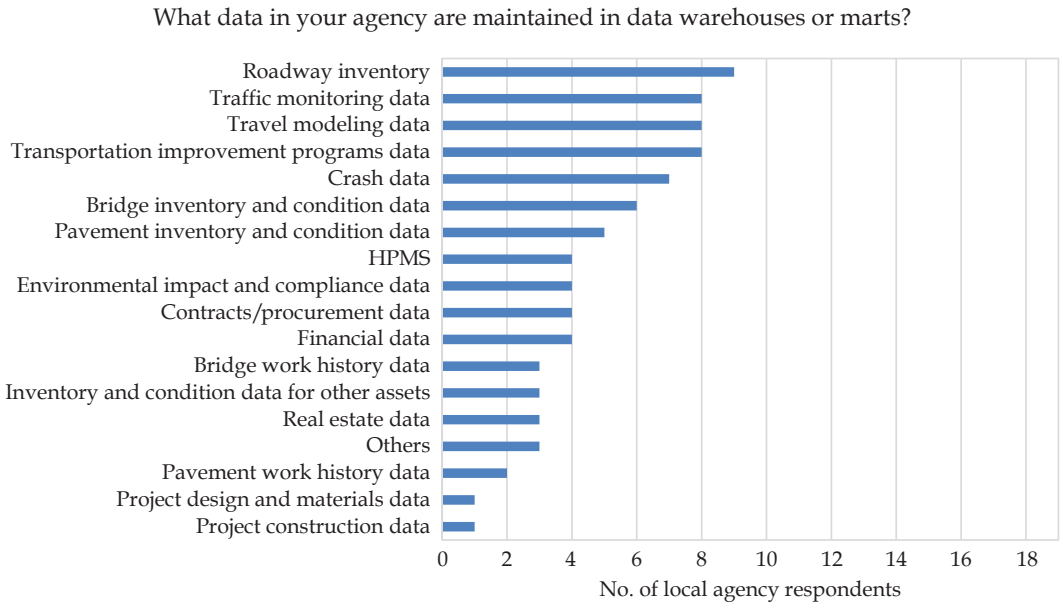


FIGURE 28 Use of data warehouses or marts at local agencies.

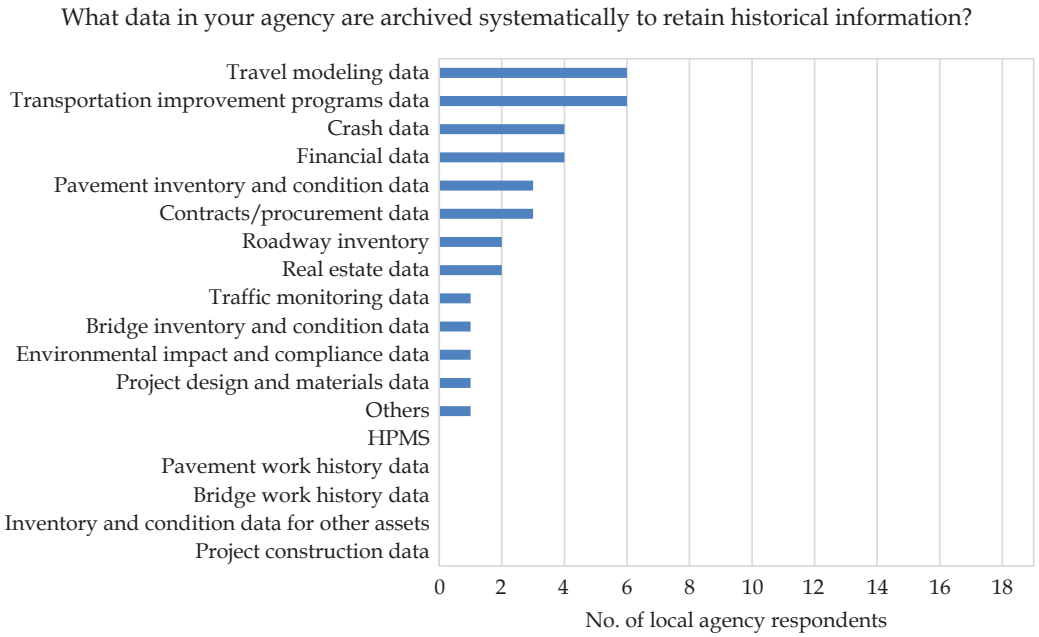


FIGURE 29 Use of data archiving to retain historical information at local agencies.

When asked about the volume of data they maintain, eight of nine respondents answered "unknown," indicating that most local agencies do not have reliable estimates of the amount of data they maintain.

Of nine agencies that responded to a question about the use of cloud computing services for managing data, five indicated that the services are not used by their agencies, one indicated that the answer is unknown, and three indicated that 1% to 10% of their data are stored and managed using cloud computing services.

When asked to estimate the percentage of their transportation data stored and managed using cloud computing in the next 5 years, four respondents could not provide an estimate, two estimated the amount to be 1% to 10%, two estimated the amount to be zero, and one estimated the amount to be more than 50%. These results indicate that local agencies are uncertain how cloud computing would affect their data management practices in the future.

DATA INTEGRATION AND SHARING

The survey included questions to assess the level of data integration at local agencies across the 17 data sets discussed. In all, the respondents identified 37 pairs of data sets that are integrated in their agencies to serve various business needs (Figure C3 in Appendix C). Fifty percent of the respondents indicated that their agencies integrate the following data sets:

- Roadway inventory data and traffic monitoring data;
- Roadway inventory data and travel modeling data; and
- Environmental impact and compliance data and project design and materials data.

The respondents identified 80 pairs of data sets that would be beneficial for their agencies to integrate (Figure C4 in Appendix C). Fifty percent of local agency respondents indicated their agencies would benefit from integrating the following pairs of data sets:

- Roadway inventory data and crash data; and
- Roadway inventory data and travel modeling data.

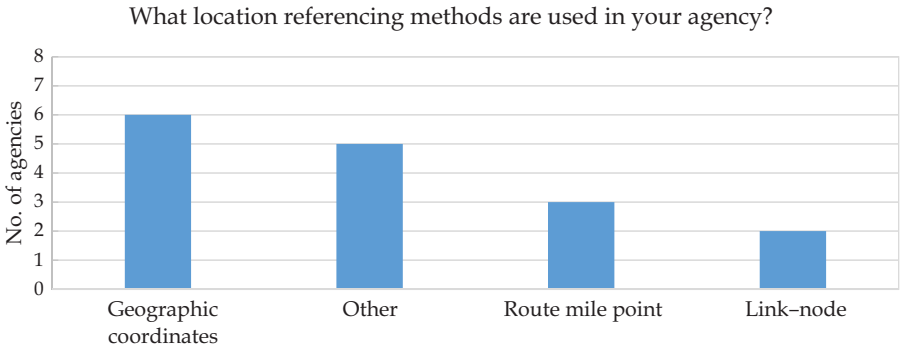


FIGURE 30 Use of LRMs at local agencies.

The survey examined the use of six LRMs by local agencies, including route mile point, route reference post, link-node, route street reference, multilevel LRS, and geographic coordinates. The results of eight responses related to this issue are shown in Figure 30. These results show that multiple LRMs are being used by local agencies in various data sets. However, local agencies use fewer LRMs than do DOTs. Geographic coordinates appear to be the most commonly used LRM at local agencies, followed by the route mile point and link-node methods. As discussed, the use of GPS in current data collection technologies may have contributed to the increasing use of geographic coordinates as an LRM. The survey further shows that the route street reference, route reference point, and multilevel LRS are not used in the surveyed local agencies. A similar conclusion can be made about the use of these LRMs for individual data sets.

To evaluate agency data sharing methods with external stakeholders, including public and private entities, five options were provided to the respondents to select from: online open access, online preauthorized access, upon request (e.g., data sent by e-mail or a file sharing service), not shared outside the agency, or data shared through other methods. Some agencies indicated more than one sharing method for some data sets. The online open access and "upon request" methods are used by more than half of the responding agencies (Figure 31). In addition, online open access and "upon request" methods are most commonly used when the results are divided by individual data sets. However, for all data sets, at least one respondent indicated that the agency does not share these data sets with users outside the agency. Most agencies that indicated other sharing methods pointed out that the data sets are not owned by their agencies.

Respondents were asked to identify strategies that would improve or have improved data sharing and access at their agencies. As shown in Figure 32, four respondents indicated that two of these

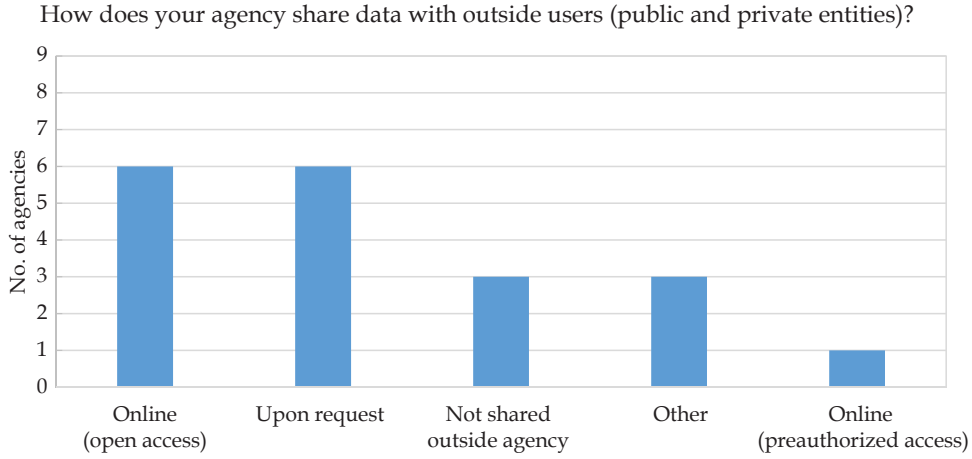


FIGURE 31 Data sharing methods with external users at local agencies.

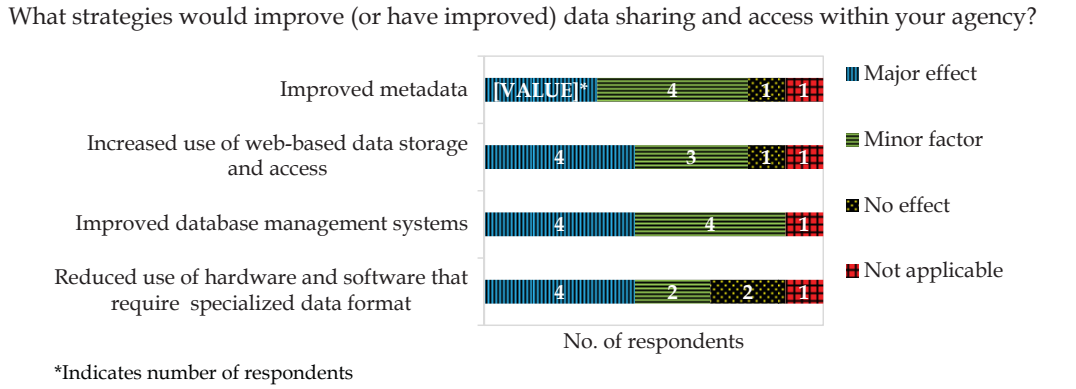


FIGURE 32 Strategies for improving data sharing and access at local agencies.

strategies have a major effect on improving data sharing and access: (1) improved database management systems, and (2) reduced use of hardware and software that require specialized data format. A respondent commented that improved framework to centralized data has a major effect on data sharing and access.

Responding to a question about data management tools most useful for accessing and sharing data within agencies, some local agencies identified the following:

- Relational databases, such as MS Access, and spreadsheets;
- GIS tools; and
- Data marts.

DATA QUALITY

As shown in Table 8, most respondents indicated that all of these data quality elements are evaluated in at least some data areas within their agencies. These results suggest that accuracy, completeness, and relevancy are the most commonly evaluated data quality element by local agencies.

On incorporating feedback from data users, only one agency (of eight that responded to this question) indicated that it has mechanisms in place for incorporating feedback from data users in the data collection process. That agency's respondent further explained that the process is implemented through meetings and comments dropped in suggestion boxes.

TABLE 8
DATA QUALITY ELEMENTS EVALUATED AT LOCAL AGENCIES
(number of agencies)

To What Extent Are Data Quality Elements Evaluated in Your Agency?	Accuracy	Completeness	Timeliness	Relevancy	Consistency	Accessibility	Access Security
Evaluated in all or most areas	6	4	3	4	4	4	3
Evaluated in some areas	3	3	6	4	2	3	4
Evaluated in a few areas	1	2	1	1	4	2	2
Not evaluated	1	1	1	1	1	2	2

CHAPTER SIX

CONCLUSIONS AND FUTURE RESEARCH

This synthesis describes and discusses data management and governance practices at departments of transportation (DOTs) (including those of states, the District of Columbia, and Puerto Rico) and local transportation agencies [metropolitan planning organizations (MPOs) and municipalities]. The information provided in this synthesis was gathered through a review of the literature, a two-phase online survey, and follow-up interviews with a sample of agencies. Forty-three DOTs responded to the Phase 1 survey, and 34 DOTs responded to the follow-up survey, representing response rates of 83% and 65%, respectively. For local agencies, 19 agencies responded to the Phase 1 survey, and 11 agencies responded to the follow-up survey.

CONCLUSIONS

The conclusions of this study in four areas (data governance, data warehousing and cloud computing, data integration and sharing, and data quality) are presented here.

Data Governance

- A bottom-up approach for data management appears to be taking place. A more top-down data governance approach could help recognize and leverage the value of data generated and/or stored in various agency silos and could spur increased data integration and sharing. In most cases, DOTs have data stewards and data coordinators for managing individual data sets and coordinating data management within a business area (e.g., asset management, safety). What is lacking, in most cases, is a data governance council/board for policy making and coordination at the enterprise level.
- Most survey respondents described the following as major factors in limiting progress toward implementing data governance: (1) lack of staffing, (2) other mission-related issues are more pressing, and (3) lack of resources. Currently, data stewards, coordinators, and custodians hold various positions in their business areas, such as planners, engineers, geographic information system (GIS) specialists, and information technology specialists.
- Data governance is more mature in DOTs than local agencies. However, this conclusion should be viewed with caution because (1) a small sample of local agencies responded to the survey, and (2) some local agencies commented that their agencies are users, rather than owners, of data.

Data Warehousing and Cloud Computing

- There is an association between the presence of designated data stewards and the use of data warehousing systems. Data sets that have data stewards tend to reside in data warehouses or marts. Conversely, data sets that do not have designated stewards tend to reside in disparate files and databases.
- Transportation agencies have a wealth of archived data. For DOTs, a clear majority of respondents (70% or more) routinely archive pavement inventory and condition data, roadway inventory, traffic monitoring data, highway performance monitoring system data, project construction data, crash data, and bridge inventory and condition data.
- Although there is a general agreement in the literature that transportation agencies collect and manage large amounts of data, most DOTs and local agencies do not have reliable estimates of the amount of data they maintain.

- The use of cloud computing services is expected to grow in the future, but most DOTs and local agencies are uncertain about the magnitude of this growth in their agencies.

Data Integration and Sharing

- Transportation agencies use multiple location referencing method (LRMs), indicating that the use of incompatible LRMs remains an impediment to increased data integration in these agencies. However, geographic coordinates (e.g., longitude-latitude or state plane coordinates) and route mile points are commonly used LRMs by both DOTs and local agencies.
- An area prime for reducing the duplication of data within DOTs is the creation of digital as-builts from three-dimensional models used in design and construction. However, the integration of these as-builts into legacy data management systems is challenging, in part because of the inherent limitations of legacy systems (e.g., some legacy systems do not use georeferenced data) and broader institutional issues (e.g., data owned/managed by different parts of the agency).
- Most DOT survey respondents indicated that the following strategies have a major effect on improving data sharing and access: (1) increased use of web-based data storage and access, and (2) improved database management systems. For local agencies, the reduced use of hardware and software that require a specialized data format also appears to have a major effect.

Data Quality

- This study addressed seven dimensions of data quality: accuracy, completeness, timeliness, relevancy, consistency, accessibility, and access security. Most survey respondents indicated that these data quality dimensions are evaluated in at least some data areas in their agencies.
- For DOTs, timeliness, accuracy, and access security are most commonly evaluated. Conversely, consistency is the data quality dimension least evaluated by DOTs.
- Slightly more than half of the DOT respondents indicated that their agencies have mechanisms in place for incorporating feedback from data users into the data collection process. These feedback mechanisms include ad hoc meetings, surveys, steering committees, web forms, and direct e-mails.

FUTURE RESEARCH

This study identified the following gaps in current knowledge that are suggested for future research:

- Develop a data management and governance guidebook and training materials for transportation agencies.
- Conduct case studies to assess and quantify the magnitude and complexity of data managed by state DOTs and identify resources for managing these data effectively.
- Identify and measure the benefits, costs, and risks (e.g., data security risks) of adopting cloud computing services for transportation agencies (considering both state-owned and commercially owned data centers/clouds).
- Develop methods and metrics for evaluating data quality considering multiple quality dimensions (e.g., accuracy, completeness, timeliness, relevancy, consistency, accessibility, and access security).
- Develop guidance for integrating data sets that are typically not integrated but would be beneficial to integrate with roadway inventory. Examples of these data sets include environmental data, travel modeling data, pavement work history data, and project construction data.
- Investigate the potential of georeferenced digital as-builts and roadway data as a framework for integrating data within transportation agencies.
- Develop methods and case studies for mining archived data at transportation agencies to discover hidden patterns and learn from past experiences.

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APPENDIX A

Survey Questionnaires and Responses

Phase 1 Survey

Dear Members of AASHTO Subcommittee on Data/AASHTO SCOP Committee and Agency Representatives:

The transportation Research Board (TRB) is preparing a synthesis that will summarize current practices related to the topic Data Maintenance Practices. This is being done for the National Cooperative Highway Research Program (NCHRP), under the sponsorship of the American Association of State Highway and transportation Officials (AASHTO), in cooperation with the Federal Highway Administration (FHWA).

Transportation agencies are increasingly collecting large amounts of data for use in various business areas, such as planning, operations, construction, maintenance, and resource allocation. This questionnaire is part of the effort in NCHRP Synthesis Topic 47-05 to gather information on data management practices at transportation agencies. The results of this synthesis project will show how transportation agencies currently govern, manage, integrate, and share data in the interest of sharing best practices among transportation agencies.

The survey is divided into two phases:

- Phase 1 (this questionnaire): Screening survey to gather information that will be used to customize Phase 2 questions to pertain only to those data management practices and policies of responding organizations. The intent is to make the Phase 2 survey as short and specific as possible.
- Phase 2: Tailored follow-up survey that will be launched upon analyzing the responses to Phase 1.

Your cooperation in completing the questionnaire will ensure the success of this effort. If you are not the appropriate person at your organization to complete this questionnaire, please forward it to the correct person.

Please complete and submit this survey by May 13, 2016. We estimate that it should take approximately 10–15 minutes to complete. It could take longer if the participant needs to contact other individuals in his/her organizations to help answer some of the questions. If you have any questions, please contact our Principal Investigator, Dr. Nasir Gharaibeh, at (979) 845-3362 or ngharaibeh@civil.tamu.edu.

Thank you very much for your time and expertise.

Please enter your contact information below. NCHRP will e-mail you a link to the online report when it is completed.

First Name*: _____

Last Name*: _____

Title*: _____

Agency/Organization*: _____

E-mail Address*: _____

Phone Number*: _____

Phase 1 Survey

1) Does your agency have a designated data governance board/council?

   *Data Governance Board/Council: Group that institutes policies and oversees activities regarding data governance throughout the organization. Data governance is defined as "the execution and enforcement of authority over the management of data assets and the performance of data functions" (NCHRP Report 666, 2010).**

   Responses of DOTs

   ☐ Yes – 8 responses

   ☐ No – 19 responses

   ☐ In Development – 16 responses

Responses of Local Agencies

☐ Yes – 1 response

☐ No – 18 responses

☐ In Development – No response

2) If you answered "yes" or "in development" to Question 1, please describe this board/council briefly (e.g., group name, staff positions/titles, contact person):

Responses of DOTs

Response 1 – "We have Data Governance Board, which will include the CIO and Data Management Coordinator for strategic leadership. It provides leadership and strategic direction for a broad range of governance issues including but not limited to internal controls, data governance, administrative policy, data practices, and records management. Data Domain Stewards are for tactical leadership. The agency has identified nine data domains and assigned a domain steward to each. There are over 100 subject areas organized by domain. Examples of subject area would include: grant data, bicycle data, and roadway condition data. The Domain Steward is usually an office director."

Response 2 – "Through an effort under the Program and Special Studies Area, a unify database is under development to consolidate pavement, traffic, and road inventory data, as a first phase. In a second and third phase, all data develop and/or acquire by the agency, will be feed into the system for a complete Roads and transportation Database Management System."

Response 3 – "An informal assembly of business owners and asset stewards across bureaus."

Response 4 – "At one point, Agency had the Data Governance Council, no longer active. The Asset Data Management Committee (ADMC) was formed to represent primarily linear assets. Policy direction for that committee is provided by Asset Management Exec. Committee. What current governance bodies there are through committees could be restructured or incorporated into a new system. Agency is currently developing a Strategic Data Business Plan (SDBP) for the agency which is expected to include governance."

Response 5 – "We are in the infancy stages of a data governance council. The intended positions are: Data Governance Board Chair, Data Coordinator, Data Steward, Data Management Coordinator, Metadata Specialist, Data Warehouse Architect, Business Analyst, Database Administrator, Data Architect."

Response 6 – "Agency has a Geospatial Data Governance Board focusing on geospatial data. The Board is run by agency's Geospatial Information Office."

Response 7 – "Agency has structured governance policies for the core data programs: traffic, road network, and crash. The road network entails road centerlines, LRS, and roadway features. We currently are converting our GIS over to ESRI's Roads and Highways, which will provide a more well defined and efficient governance. The DOT as a whole developed a strawman data governance policy and an accompanying data governance procedure manual as part of our asset management program. Since completing that effort, the Department had a major reorganization - creating a separate Information Systems and Services Division (ISSD). ISSD will take the lead on data governance. There have been substantive IT infrastructure, personnel, and operational policies to deal with during the reorganization, but the data governance policy and procedures are now being addressed. Probably will be the end of the year before they get completed. I could share the strawman documents if there is interest."

Response 8 – "Data Governance Working Group."

Response 9 – "Reliable Organized Accurate Data Sharing (ROADS) Steering Committee."

Response 10 – "Enterprise Data Sharing and Storage Committee. Comprised of business areas (Maintenance, traffic Operations, Safety, Planning) and Office of Information Technology (OIT) personnel. Generally comprised of the data managers of the business areas along with enterprise solutions personnel in OIT."

Response 11 – "The agency's Enterprise Information Governance Group is composed of division directors who represent the various organizational business activities, the Knowledge Strategist, and IT specialists in Information Management. The prime focal point of the group is on establishing and reviewing agency policies regarding data and information management. There are also other specialized data governance groups - Formation of an asset management governance group is underway and there is also a Data Warehouse Governance group."

Response 12 – "The Council is a joint entity of the Information Technology Agency and the Department of transportation. It is made up of mid-career professional and technical unionized workforce members from each transportation program area and information technology program area. Members are designated by their program area to vet proposals with colleagues within the program

area and speak to the interests of the program area with respect to proposals submitted for clearance review."

Response 13 – "Name: Data Governance Committee Purpose: To discuss and coordinate efforts that deal with collecting, creating, maintaining and analyzing data across the agency. This includes data awareness, availability, accessibility, maintenance, security, storage, and usage. Members: Various Division Heads throughout the Department."

Response 14 – "There are various efforts with our IT department, and as part of Asset Management contracts"

Response 15 – "Data Governance Board – GIS Manager, Chair – Data SME – Asset Mang – DMV – Document Management"

Response 16 – "Data governance is managed by agency's Policy Division. This was rolled out a week ago and I am not familiar with all the staff positions/titles."

Response 17 – "We currently have a policy document outlining data collection and coordination along with internal rules within the GIS office for data policies."

Response 18 – "The Chief Information Officer and his staff are responsible for ensuring that the business goals and initiatives for agency have a strategy that is sound in technology, ultimately becoming a beneficial and operational business process and decision support facility for agency staff."

Response 19 – "Agency is currently in the process of developing a Data Governance model; the current model is distributed across various divisions and is informally maintained via corporate culture. A formal approach to Governance is being approached in steps with the initial efforts originating with the IT division identifying standardized processes and procedures for both internal and external data consumers."

Response 20 – "The board is called the 'Drive Team.' Made up of directors from around the Department, the Drive Team is charged with implementation of the Department's Asset Management business model and serves as the advisory council to the executive management team, primary decision-making body for Data Standards, major data/information initiatives and oversight ongoing 'portfolio' of IT application development projects and investments."

Response 21 – "This council consists of 6 second or third line DOT supervisors representing the major data areas of the department. It also includes 2 IT representatives. There is no staff—this is a policy board."

Response 22 – "The Department has an Asset Management and Performance Strategies (AMPS) section within the Bureau of Planning whose responsibility it is to work with all Data Managers throughout the agency to develop governance policies for agency data needs"

Response 23 – "We have a weekly Data Governance Working Group that consists of data stewards from our various divisions. We also have a Data Governance Executive Committee that meets every month and they are updated on the activities of the DG Working Group and they will also approve or disapprove any issues that the DG Working Group has. The DG Exec Committee sets the priorities for the DG Working Group."

Response of Local Agency

Response 1 – "IT Department maintains and archives agency data, no protocols specific to transportation data. Supports COOP function."

3) Does your agency have designated data coordinators?

*Data Coordinator: Committee or individual that coordinates the organization, sharing, access, and use of multiple data sets within a business area (e.g., asset management, safety).**

Responses of DOTs

☐ Yes – 26 responses

☐ No – 6 responses

☐ In Development – 11 responses

Responses of Local Agencies

☐ Yes – 5 responses

☐ No – 12 responses

☐ In Development – 2 responses

4) If you answered "yes" or "in development" to question 3, please describe these coordinators briefly (e.g., business areas, staff positions/titles, contact persons):

1.

2.

3.

Responses of DOTs

Response 1 – "Subject Area Stewards are responsible for the data within their purview. They coordinate with other Subject Area Stewards as needed to facilitate sharing of data, reduction of duplication and increasing access to data."

Response 2 – "Asset management coordinator is responsible for gathering all necessary data sets, and keeping them updated in the State Planning and Operations Database (SPOD)."

Response 3 – "The agency has officially two coordinators in terms of data interchange and exchange for other state agencies, municipalities, the private sector, and the federal government. These are the GIS Coordinator and the HPMS Coordinator. The GIS Coordinator a primarily task is to oversees data exchange between entities and keep external data up to date. The HPMS Coordinator primarily task is to coordinate data compilation, management and processing to meet FHWA reporting requirements."

Response 4 – "The MIS department is coordinating a data warehouse concept. Weekly meetings with major data areas coordinate dashboards, data audits, and development."

Response 5 – "Engineering, Planning and Asset Management"

Response 6 – "Data Management and Statistical Support Section, Safety Data, and Data Manager positions exist. Primarily this covers asset condition data, traffic data, and safety data."

Response 7 – "Data Coordinators do exist for many program areas with a variety of titles and classifications. There is not a formal designation. People acting as coordinators may not have consistent roles, responsibilities, or provide the same level of effort and completeness."

Response 8 – "Data management is still spread throughout the agency until we establish the data council, which could up to take 5 years to fully implement. For now, SHA has fund managers and asset owners who manage their data. 20% of physical asset data is in an asset data warehouse; not all reported metrics are in the data set. Asset Data Stewards are spread throughout the agency in various district offices; examples of assets include rumble strips, signs, park and ride, highway system, guard rails."

Response 9 – "Under the Asset Management and Performance Management efforts, Caltrans is developing a more systematic method for data coordination."

Response 10 – "One data governance area of need is to identify the data systems and subject matter experts with each business area. There is interest in creating a data registry for this. Again, we have a strawman data registry completed, but undoubtedly will be reformatted before rolling out to the Department."

Response 11 – "We have coordinators for the Highway Performance Monitoring System and for Safety data."

Response 12 – "Each Functional Group (business area) within the agency has a designated Enterprise Data Steward, Data Stewards and Data Custodians. This list of persons (330+) is fairly well established, but is changing during the development phase of the project."

Response 13 – "1 GIS Coordinator and 1 Roadway Inventory Coordinator per Agency district."

Response 14 – "The Enterprise Data Branch of OIT are responsible for ensuring business data is available at an organizational level via transportation Enterprise Database (TED). Data managers in each business area coordinate, as needed, for clarity of purpose when using data that originates in another business area."

Response 15 – "Some areas of the department have well-formed data stewardship and coordination of data access roles - the transportation Data and GIS Office (crash, roadway and traffic data) and Accounting and financial Services. Other areas either do not have or are in the process of growing such roles."

Response 16 – "We have system administrators for each automated business system who administer user requests for access to the application and data within the application. They train users and do data QA/QC for the system they administer. Also have data stewards who oversee matters such as OLTP Data, time series warehouse data, data reporting quick marts, data integration among systems, and business intelligence among multiple systems within a knowledge domain and in some cases across multiple domains. The information technology agency roles are concerned with regular backups of data, disaster recovery strategy, and classification of data from the lenses of security (confidential vs. public) and criticality (i.e., service level agreements for outages)."

Response 17 – "The Data Governance committee serves as the top-level data coordination council. In addition, there is an Enterprise GIS Data committee that consists of individual data coordinators from various business areas across the agency such as: Planning, environmental, bridge, Maintenance, System Information, Right of Way etc."

Response 18 – "We have some staff within our GIS section that coordinate data sets and sharing with other divisions and work units within the DOT."

Response 19 – "We have data stewards for many data sets but [their] responsibilities are not well defined."

Response 20 – "The Office of Technical Services is the main repository for transportation Asset data because of our business responsibility of Locational Referencing System (LRS) and Geographical Information Systems (GIS). Our Office is also responsible for updating enterprise data sets to the most current year LRS. We also coordinate the TAM activities for the department in terms of data collection, standards, working with the various businesses to ensure data integrity as well as access and distribution of data."

Response 21 – "Data sharing is coordinated between agency's Information Technology Division and agency's Business Data Owners/Business Stakeholders. The Business Data Owners represent the business units, i.e., Local Assistance, Maintenance, transportation and Mobility Planning, and traffic and Engineering, Structure and bridge, Infrastructure Investment, etc."

Response 22 – "Through the process of developing the EGIS (Enterprise-wide GIS) program, several committees were formed to develop collaboration and integrate individual data silos into the EGIS program. This process is on-going."

Response 23 – "They are in business areas."

Response 24 – "Data Coordinators for highway, pavement, traffic, photolog, and highway performance monitoring are in the Bureau of State Highway Programs. Managers of these programs are responsible for implementing policy and data life cycle."

Response 25 – "Data owners/managers responsible for certain datasets."

Response 26 – "Agency has historically practiced a data steward model that ranged from formal to informal depending upon the division. The role is not dedicated at 100% FTE but instead is practiced by an individual serving as a designated point of contact who manages data maintenance, data distribution, etc. according to the division's business model. Department IT is currently attempting to formalize a GIS stewards model across divisions as part of a recent effort to centralize GIS information."

Response 27 – "We have a group of what we call 'system administrators' that oversee individual information systems (databases and associated data, coordination, training, software, and processes). These system administrators convene monthly to share updates and ask/answer questions about upcoming changes and issues. Typically, these system administrators act as go-to people for users and help to disseminate knowledge and understanding to users and others affected by information system changes."

Response 28 – "Same AMPS Section—one administrator position, two civil engineers, one business system analyst, and one more being developed."

Response 29 – "We have data stewards in every Division that will coordinate the sharing and permissions of their data."

Responses of Local Agencies

Response 1 – "IT Department maintains and archives agency data, no protocols specific to transportation data. GIS department publishes multiple data sets from various sources, many without metadata."

Response 2 – "Title: Data Management Specialist"

Response 3 – "We do not have designated data coordinators, but we do have a de-facto data coordinator. The head of the Long-Range transportation Planning Group has been making data organization decisions."

Response 4 – "No formal designation of specific staff, distributed among several."

Response 5 – "GIS Program Manager"

Response 6 – "Not necessarily 'designated' but we have a GIS staff person who organizes/shares/accesses data sets."

Response 7 – "Not 'in development' so much as 'partial.' Principal Analyst (survey respondent) is project manager for CMAP's Data and Information Services project: oversees acquisition of public datasets for and archiving of obsolete datasets for our internal data warehouse."

Response 8 – "Responsible for posting agency-developed datasets on public data portal. We also maintain a Regional transportation Data Archive and probe data."

5) Does your agency have a document that describes its current data governance model?

Responses of DOTs

☐ Yes – 11 responses

☐ No – 20 responses

☐ In Development – 12 responses

Responses of Local Agencies

☐ Yes – No response

☐ No – 19 responses

☐ In Development – No response

6) If you answered "yes" to Question 5, would you be willing to provide the research team with a copy of your agency's data governance document for use as an example?

Responses of DOTs

☐ Yes – 12 responses

☐ No – 4 responses

Responses of Local Agencies

No response

7) Please answer the questions in the table below. Please check all that apply.

Data Warehouse/Mart: A data warehouse is a unified repository of current and historical data obtained from multiple sources. A data mart is a scaled-down version of a data warehouse.

Data Steward: Individual who is accountable for assuring the quality of a specific data set, ensuring compliance with data rules and regulations, defining metadata, and relaying the appropriate use of the data.

*Data archiving: The process of moving electronic data that is no longer actively used to a separate storage device for long-term retention. (NCHRP Report 814)**

Data Set	What data in your agency are maintained in data warehouses or marts (as opposed to disparate files and databases)?	What data in your agency have designated stewards?	What data in your agency are archived systematically to retain historical information?
Roadway inventory (e.g., location, classification, geometrics)	☐	☐	☐
Crash data	☐	☐	☐
Traffic monitoring data (e.g., speed, volume)	☐	☐	☐
Travel modeling data (e.g., household surveys, origin-destination)	☐	☐	☐
Highway Performance Monitoring System (HPMS)	☐	☐	☐
Pavement inventory and condition data	☐	☐	☐
Pavement work history data	☐	☐	☐
Bridge inventory and condition data	☐	☐	☐

Data Set	What data in your agency are maintained in data warehouses or marts (as opposed to disparate files and databases)?	What data in your agency have designated stewards?	What data in your agency are archived systematically to retain historical information?
Bridge work history data	☐	☐	☐
Inventory and condition data for other assets (e.g., traffic signs, signals, drainage assets)	☐	☐	☐
Transportation improvement programs data	☐	☐	☐
Environmental impact and compliance data	☐	☐	☐
Project design and materials data (e.g., design plans, structural design, mix design)	☐	☐	☐
Contracts/procurement data (e.g., bid tabs)	☐	☐	☐
Project construction data (e.g., cost/payments, schedule, material acceptance testing, as-built plans)	☐	☐	☐
Real estate data (e.g., property acquisition, agency-owned parcels)	☐	☐	☐
Financial data (e.g., current and historical revenues, expenditures, budgets)	☐	☐	☐
Others	☐	☐	☐

Responses of DOTs

Response 1 – Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs data, contracts/procurement data, project construction data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs data, contracts/procurement data, project construction data, financial data.

Response 2 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, financial data, others.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data, others.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data, others.

Response 3 – Data maintained in data warehouses or marts: pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs data, project construction data, financial data.

Data that have designated stewards: crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, Inventory and condition data for other assets, real estate data, financial data.

Data that are archived systematically to retain historical records: traffic monitoring data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, project design and materials data, project construction data.

Response 4 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, contracts/procurement data, project construction data, financial data.

Data that have designated stewards: Roadway inventory, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement data, project construction data, financial data.

Response 5 – Data maintained in data warehouses or marts: Roadway inventory, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, contracts/procurement data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, contracts/procurement data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, contracts/procurement data, financial data, contracts/procurement data, financial data.

Response 6 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that have designated stewards: Roadway, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 7 – Data that have designated stewards: Roadway inventory, crash data, Travel modeling data, HPMS, pavement inventory and condition data. bridge inventory and condition data, transportation improvement programs.

Data that are archived systematically to retain, historical records: Roadway inventory, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, financial data

Response 8 – Data that have designated stewards: traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data,

Response 9 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, financial data

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, project design and materials data, contracts/procurement data, financial data.

Response 10 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 11 – Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 12 – Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 13 – Data maintained in data warehouses or marts: crash data

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance

data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 14 – Data maintained in data warehouses or marts: crash data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, project design and materials data, contracts/procurement data, project construction data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs, project design and materials data, contracts/procurement data, project construction data, financial data.

Response 15 – Data maintained in data warehouses or marts: HPMS, bridge inventory and condition data, bridge work history data, transportation improvement programs, contracts/procurement data, real estate data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 16 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, environmental impact and compliance data, contracts/procurement data, project construction data, financial data.

Response 17 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 18 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and

compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, financial data.

Response 19 – Data maintained in data warehouses or marts: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs data.

Data that have designated stewards: Roadway inventory, crash data, HPMS, pavement inventory and condition data

Response 20 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, financial data.

Response 21 – Data maintained in data warehouses or marts: Roadway inventory, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs data, financial data, others

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement, programs data, financial data, others.

Data that are archived systematically to retain historical records: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, Inventory and condition data for other assets, transportation improvement programs data.

Response 22 – Data maintained in data warehouses or marts: Roadway inventory, crash data, bridge inventory and condition data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data.

Data that are archived systematically to retain historical records: traffic monitoring data, HPMS, project design and materials data, project construction data.

Response 23 – Data maintained in data warehouses or marts: Roadway inventory, traffic monitoring data, bridge inventory and condition data, Inventory and condition data for other assets.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, project design and materials data, project construction data.

Response 24 – Data maintained in data warehouses or marts: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, transportation improvement programs data, environmental impact and compliance data, contracts/procurement data, project construction data, financial data, others.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data, others.

Data that are archived systematically to retain historical records: Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data, others.

Response 25 – Data maintained in data warehouses or marts: transportation improvement programs data, financial data, others.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 26 – Data maintained in data warehouses or marts: Roadway inventory, traffic monitoring data, HPMS, bridge inventory and condition data, bridge work history data, contracts/procurement data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, project design and materials data, contracts/procurement data, project construction data, financial data.

Response 27 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, transportation improvement programs data, contracts/procurement data, project construction data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: crash data, financial data.

Response 28 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, bridge inventory and condition data, transportation improvement programs data, project construction data, financial data.

Data that have designated stewards: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, contracts/procurement data, project construction data, real estate data, financial data.

Response 29 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data.

Response 30 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, environmental impact and compliance data, contracts/procurement data, project construction data, real estate data, financial data.

Data that have designated stewards: Roadway inventory, crash data, pavement inventory and condition data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: crash data, pavement inventory and condition data, environmental impact and compliance data, contracts/procurement data, project construction data, real estate data, financial data.

Response 31 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, others.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data, others.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, others.

Response 32 – Data maintained in data warehouses or marts: Roadway inventory, traffic monitoring data, HPMS, bridge inventory and condition data, Inventory and condition data for other assets, project design and materials data, project construction data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, project construction data, real estate data, others.

Data that are archived systematically to retain historical records: Roadway inventory, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, project design and materials data, contracts/procurement data, project construction data, financial data.

Response 33 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental

impact and compliance data, project design and materials data, contracts/procurement data, project construction data.

Response 34 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs data

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs data.

Response 35 – Data maintained in data warehouses or marts: Roadway inventory, bridge inventory and condition data, transportation improvement programs data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data, others.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data, others.

Response 36 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement data, project construction data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 37 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, bridge inventory and condition data, project design and materials data, project construction data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, transportation improvement programs data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 38 – Data maintained in data warehouses or marts: Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets,

transportation improvement programs data, contracts/procurement data, project construction data, real estate data, financial data, others.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, contracts/procurement data, project construction data, real estate data, financial data, others.

Data that are archived systematically to retain historical records: Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data, others.

Response 39 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, others.

Data that have designated stewards: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, others.

Data that are archived systematically to retain historical records: Roadway inventory, HPMS.

Response 40 – Data maintained in data warehouses or marts: crash data, HPMS, bridge inventory and condition data, bridge work history data, transportation improvement programs data, contracts/procurement data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, financial data.

Data that are archived systematically to retain historical records: crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Response 41 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic, monitoring data, bridge inventory and condition data, environmental impact and compliance data, project design and materials data, project construction data, real estate data, financial data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modelling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, project design and materials data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, environmental impact and compliance data, project design and materials data, project construction data, real estate data, financial data.

Response 42 – Data maintained in data warehouses or marts: Roadway inventory, traffic monitoring data, pavement inventory and condition data, pavement work history data.

Data that are archived systematically to retain historical records: Roadway inventory, traffic monitoring data, pavement inventory and condition data, pavement work history data.

Response 43 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, project construction data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, project design and materials data, contracts/procurement data, project construction data, real estate data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, project design and materials data, contracts/procurement data, project construction data.

Responses of Local Agencies

Response 1 – Data maintained in data warehouses or marts: transportation improvement programs data, financial data.

Data that are archived systematically to retain historical records: transportation improvement programs data.

Response 2 – Data maintained in data warehouses or marts: Roadway inventory, transportation improvement programs data, real estate data, financial data.

Data that have designated stewards: Roadway inventory, transportation improvement programs data, real estate data, financial data.

Data that are archived systematically to retain historical records: Roadway inventory, pavement inventory and condition data, transportation improvement programs data, real estate data, financial data.

Response 3 – Data maintained in data warehouses or marts: contracts/procurement data, real estate data, financial data.

Data that have designated stewards: Travel modeling data, contracts/procurement data, real estate data, financial data.

Data that are archived systematically to retain historical records: Travel modeling data, transportation improvement programs data, contracts/procurement data, real estate data, financial data.

Response 4 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs data, others.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs data, others.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs data, others.

Response 5 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs data, environmental impact and compliance data, contracts/procurement data.

Data that have designated stewards: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, contracts/procurement data.

Response 6 – Data that have designated stewards: transportation improvement programs data, financial data, others.

Response 7 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, HPMS, bridge inventory and condition data, contracts/procurement data.

Data that have designated stewards: Travel modeling data, pavement inventory and condition data, transportation improvement programs data, financial data.

Data that are archived systematically to retain historical records: Travel modeling data, pavement inventory and condition data, transportation improvement programs data, contracts/procurement data, financial data.

Response 8 – Data maintained in data warehouses or marts: traffic monitoring data, others.

Data that are archived systematically to retain historical records: Travel modeling data.

Response 9 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, transportation improvement programs data.

Data that are archived systematically to retain historical records: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, transportation improvement programs data, environmental impact and compliance data.

Response 10 – Data that are archived systematically to retain historical records: crash data.

Response 11 – Data maintained in data warehouses or marts: Travel modelling data.

Data that have designated stewards: Travel modelling data.

Data that are archived systematically to retain historical records: Travel modelling data.

Response 12 – Data maintained in data warehouses or marts: Travel modelling data.

Response 13 – Data maintained in data warehouses or marts: crash data, project design and materials data.

Data that have designated stewards: Travel modeling data, Inventory and condition data for other assets, project design and materials data.

Data that are archived systematically to retain historical records: crash data, project design and materials data.

Response 14 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets.

Response 15 – Data maintained in data warehouses or marts: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data.

Data that have designated stewards: Roadway inventory, crash data, Travel modeling data, transportation improvement programs data, environmental impact and compliance data.

Response 16 – Data maintained in data warehouses or marts: Roadway inventory, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data.

Data that have designated stewards: crash data, traffic monitoring data, Travel modeling data, transportation improvement programs data.

Response 17 – Data maintained in data warehouses or marts: Travel modeling data, transportation improvement programs data, environmental impact and compliance data.

Response 18 – Data maintained in data warehouses or marts: others.

Data that have designated stewards: Travel modeling data, transportation improvement programs data, contracts/procurement data, financial data.

Data that are archived systematically to retain historical records: Travel modeling data, transportation improvement programs data, contracts/procurement data, financial data.

Response 19 – Data maintained in data warehouses or marts: Roadway inventory, traffic monitoring data, Travel modeling data, Inventory and condition data for other assets, transportation improvement programs data, environmental impact and compliance data, contracts/procurement data, project construction data, real estate data, financial data.

Data that are archived systematically to retain historical records: crash data, environmental impact and compliance data.

8) If you checked “others” in question 7, please describe these data.

Responses of DOTs

Response 1 – Historical Aerial Photographs of state from 1930 to 2007.

Response 2 – Maintenance Management System with plan vs accomplishment, major activity amounts and costs, Consultant contract Administration for PE selections and cost.

Response 3 – HR; Motor Carrier; Fleet Management System; Safety; Aggregate; Unstable Slopes (Landslides).

Response 4 – Road Weather Information Systems (RWIS) is a major area for Agency. RWIS supports three primary areas: a) Winter weather maintenance decisions b) Seasonal weight restrictions—implementing and removing c) Travel decisions for the 511 traveler information systems. RWIS provides: a) Atmospheric conditions b) pavement surface conditions c) Soil temperature profiles d) Camera images, including nighttime images using infrared illuminators. With the exception of camera images (which are retained only for 24 hours), we archive and make available (publicly for most of the information, the one exception is pavement condition).

Response 5 – The ARRA data reporting requirements (circa 2009) were fulfilled by building a warehouse environment for that program only. It is in process of being decommissioned as vendor version upgrades of the platforms for business intelligence necessitate migration of warehouses to new environments, and business needs for the data diminish to close to zero usage.

Response 6 – All Public Roads LRS and City Limit/County Boundaries.

Responses of Local Agencies

Response 1 – GIS department publishes various datasets from multiple sources, many without metadata.

Response 2 – Cross-border estimated delay for passenger and commercial vehicles.

Response 3 – Title VI/Env. Justice related data.

Response 4 – Regional transportation Data Archive includes: incident and construction data. Probe Database includes: National Performance Measurement Research Dataset, additional HERE (Navteq) data, and license plate odometer readings.

9) Please enter any additional comments you may have in the space below:

Responses of DOTs

Response 1 – "In the agency there are a number of individual databases for finance, construction, design, contracts, environment, etc. But is only access is restrained."

Response 2 – "The Strategic Data Business Plan under development used a stakeholder input process and workshops to develop a common strategic data vision, goals and objectives for the agency. The current focus is on development of 1) a common 'toolbox' for achieving the goals and objectives and 2) an agency Baseline to help direct the development of strategies. For additional information contact Denise."

Response 3 – "HPMS data is archived by FHWA."

Response 4 – "Data Stewards and Data Custodians are actively being identified and designated at this time."

Response 5 – "Inventory and Conditions Data . . . includes a strong inventory of signals and a developing inventory of signs and drainage assets. Pavement Inventory Data is close to being accessible via TED. Working on resolving LRS between pavement Data and TED."

Response 6 – "There are many stewards of the agency's asset data and there is overlap between the various systems. Most of these systems were created as independent efforts and rarely include a full accounting of all assets in the subject area. There is no standard way of tying items together between systems. We do employ ECM solutions to house design plans, and we have an extensive investment in GIS data and tools. Many of the GIS data sets are spatial renditions of subsets of information from our tabular systems."

Response 7 – "I will forward an updated answer to questions 5 and 6, if my preliminary 'No' for question 5 turns out to be false upon further investigation with my colleagues."

Response 8 – "Data governance is a growing area of interest and concern for the agency. Within another year or so, we will likely have made much more progress in this area."

Response 9 – "We have one enterprise repository which is accessible via our transportation Information Mapping System (TIMS). We have over 85 datasets currently in the enterprise and a request for up to 150 that we are working towards. The data has been structured to allow for easy integration with other datasets and various systems; i.e., pavement management, maintenance management. All of this is supported on the back in by geospatial platforms and tools (ESRI). We utilize ESRI Roads and Highways to update our Roadway Network and then register the various datasets and perpetuate the changes."

Response 10 – "The department is currently developing a system to incorporate data from all of these various sources into a single viewing/retrieval/querying platform. Although this system is not complete, we have crossed the major hurdle of getting all of the various Bureaus and groups on board with the system."

Response 11 – "We have very little formal methods to even keep track of stewards as stewards, even though we know who is responsible for what. We have not formalized this. An ongoing discussion about data retention is currently in play. We tend to hold on to lots of data that should be either archived or disposed of. Current retention policies have not been extended to electronic data, partially because we designed our systems assuming the data would always be there."

Responses of Local Agencies

Response 1: "As an MPO we use the data collected by the State or municipalities. We do run the AQ advisory committee and are responsible for AQ related database."

Response 2: "Although as an MPO we use many of the data sources cited; we do not generate, maintain, or archive those copied files."

The Phase 1 survey is complete. Thank you for your participation!

Phase 2 Survey

Dear Participants:

This questionnaire is the second phase of the survey being conducted as part of NCHRP Synthesis Topic 47-05 (Data Maintenance Practices). The questions in this survey were designed based on the results of Phase 1 survey.

This synthesis project is being conducted for the National Cooperative Highway Research Program (NCHRP), under the sponsorship of the American Association of State Highway and transportation Officials (AASHTO), in cooperation with the Federal Highway Administration (FHWA).

Your cooperation in completing the questionnaire will ensure the success of this effort. If you are not the appropriate person at your organization to complete this questionnaire, please forward it to the correct person.

Please complete and submit this survey by May 13, 2016. We estimate that it should take approximately 15 minutes to complete. It could take longer if the participant needs to contact other individuals in his/her organizations to help answer some of the questions. If you have any questions, please contact our Principal Investigator, Dr. Nasir Gharaibeh, at (979) 845-3362 or ngharaibeh@civil.tamu.edu

Thank you very much for your time and expertise.

Please enter your contact information below. NCHRP will e-mail you a link to the online report when it is completed.

First Name*: _____

Last Name*: _____

Title*: _____

Agency/Organization*: _____

E-mail Address*: _____

Phone Number*: _____

Data Governance and Quality

1) To what extent do the following factors limit progress on instituting data governance in your agency?

If other factors are applicable, please specify them in the entry boxes titled "Enter another option."

Factor	Major Factor	Minor Factor	Not an Issue
Other mission-related issues are more pressing	☐	☐	☐
Hard to justify the cost and effort	☐	☐	☐
Lack of resources	☐	☐	☐
Lack of staffing	☐	☐	☐
Enter another option	☐	☐	☐
Enter another option	☐	☐	☐

Responses of DOTs

Response 1 – Major factor: Other mission-related issues are more pressing, lack of resources, lack of staffing. Minor factor: Hard to justify the cost and effort.

Response 2 – Major factor: Lack of staffing. Minor factor: lack of resources and lack of communication. Not an issue: Other mission-related issues are more pressing and hard to justify the cost and effort.

Response 3 – Major factor: Other mission-related issues are more pressing. Minor factor: Hard to justify the cost and effort, lack of resources and lack of staffing.

Response 4 – Major factor: Other mission-related issues are more pressing, lack of resources and lack of staffing. Minor factor: Hard to justify the cost and effort.

Response 5 – Major factor: Other mission-related issues are more pressing, cost and effort, lack of resources and lack of staffing. Minor factor: Hard to justify the cost and effort.

Response 6 – Major factor: Hard to justify the cost and effort, lack of staffing. Minor Factor: Other mission-related issues are more pressing, small community of data managers allows for simple communication. Not an Issue: Lack of staffing.

Response 7 – Minor Factor: Other mission-related issues are more pressing.

Response 8 – Major Factor: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of resources, lack of staffing. Minor Factor: Lack of understanding.

Response 9 – Major Factor: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of understanding from Executive staff.

Response 10 – Major Factor: Other mission-related issues are more pressing, lack of staffing. Minor Factor: Lack of resources. Not an Issue: Hard to justify the cost and effort.

Response 11 – Major Factor: Other mission-related issues are more pressing, lack of staffing, lack of policies and procedures, lack of standards. Minor Factor: Lack of resources. Not an Issue: Hard to justify the cost and effort.

Response 12 – Major Factor: Lack of resources. Minor Factor: Other mission-related issues are more pressing, lack of staffing. Not an Issue: Hard to justify the cost and effort.

Response 13 – Major Factor: Other mission-related issues are more pressing. Minor Factor: Hard to justify the cost and effort, lack of resources, lack of staffing.

Response 14 – Major Factor: Lack of resources, lack of staffing. Minor Factor: Other mission-related issues are more pressing. Not an Issue: Hard to justify the cost and effort.

Response 15 – Major Factor: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of resources and lack of staffing.

Response 16 – Major Factor: Lack of resources, lack of staffing. Minor Factor: Other mission-related issues are more pressing, hard to justify the cost and effort.

Response 17 – Not an Issue: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of resources and lack of staffing.

Response 18 – Major Factor: Other mission-related issues are more pressing, lack of resources, lack of staffing, Lack of understanding the magnitude of the data collected—number of datasets . . . and lack of communication. Minor Factor: Hard to justify the cost and effort.

Response 19 – Major Factor: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of resources. Minor Factor: Lack of staffing.

Response 20 – Major Factor: Lack of staffing. Minor Factor: Lack of resources. Not an Issue: Other mission-related issues are more pressing, Hard to justify the cost and effort.

Response 21 – Minor Factor: Other mission-related issues are more pressing, lack of resources, lack of staffing, Not an issue: Hard to justify the cost and effort.

Response 22 – Major Factor: Other mission-related issues are more pressing. Minor Factor: Lack of resources, lack of staffing. Not an Issue: Hard to justify the cost and effort.

Response 23 – Major Factor: Other mission-related issues are more pressing, lack of staffing, historical focus on projects, not underlying data. Minor Factor: Hard to justify the cost and effort, lack of resources.

Response 24 – Major Factor: Lack of resources, lack of staffing, competing priorities (Asset Management, Safety, IT), Development of an enterprise solution, IT resources are committed to other initiatives, Lack of understanding of technical needs (geospatial/data integration/mapping) and how they should be envisioned for the enterprise. Minor Factor: Other mission-related issues are more pressing, Hard to justify the cost and effort.

Response 25 – Major Factor: Lack of resources, lack of staffing. Minor Factor: Other mission-related issues are more pressing, hard to justify the cost and effort.

Response 26 – Major Factor: Lack of program lead and leadership instructions, Lack of formal governance policy and manuals. Minor Factor: Other mission-related issues are more pressing, Lack of resources, lack of staffing. Not an Issue: Hard to justify cost and effort.

Response 27 – Major Factor: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of resources, lack of staffing.

Response 28 – Major Factor: Lack of resources, lack of staffing, lack of flexibility in communications on governance in IT, Siloed thinking. Minor Factor: Other mission-related issues are more pressing, hard to justify the cost and effort.

Response 29 – Major Factor: Other mission-related issues are more pressing. Minor Factor: Lack of resources, lack of staffing. Not an Issue: Hard to justify the cost and effort.

Response 30 – Major Factor: Lack of resources, lack of staffing. Minor Factor: Other mission-related issues are more pressing, hard to justify the cost and effort.

Response 31 – Major Factor: Other mission-related issues are more pressing. Minor Factor: Hard to justify the cost and effort, lack of resources, lack of staffing.

Response 32 – Major Factor: Lack of resources, lack of staffing. Minor Factor: Other mission-related issues are more pressing. Not an Issue: Hard to justify the cost and effort, lack of resources, lack of staffing.

Response 33 – Major Factor: Other mission-related issues are more pressing, lack of staffing, culture of separate "fiefdoms" (this matters FAR more than anything else). Minor Factor: Hard to justify the cost and effort, lack of resources.

Responses of Local Agencies

Response 1 – Major Factor: Hard to justify the cost and effort, lack of resources, lack of staffing. Minor Factor: Other mission-related issues are more pressing.

Response 2 – Not an Issue: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of resources, lack of staffing.

Response 3 – Major Factor: Other mission-related issues are more pressing, lack of staffing. Not an Issue: Hard to justify the cost and effort, lack of resources.

Response 4 – Major Factor: Lack of resources, lack of staffing. Minor Factor: Other mission-related issues are more pressing, hard to justify the cost and effort.

Response 5 – Major Factor: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of resources, lack of upper management support. Minor Factor: Lack of staffing.

Response 6 – Major Factor: Hard to justify the cost and effort, lack of staffing. Minor Factor: Other mission-related issues are more pressing, lack of resources.

Response 7 – Major Factor: Other mission-related issues are more pressing, lack of resources, lack of staffing. Minor Factor: Hard to justify the cost and effort.

Response 8 – Major Factor: Other mission-related issues are more pressing, lack of resources, lack of staffing. Minor Factor: Hard to justify the cost and effort.

Response 9 – Major Factor: Other mission-related issues are more pressing. Minor Factor: Lack of resources, lack of staffing.

Response 10 – Major Factor: Hard to justify the cost and effort, lack of resources, lack of staffing. Minor Factor: Other mission-related issues are more pressing.

Response 11 – Major Factor: Other mission-related issues are more pressing, hard to justify the cost and effort, lack of staffing. Minor Factor: Lack of resources.

2) To what extent are data quality elements evaluated in your agency?

Data Quality Element	Evaluated in All or Most Areas	Evaluated in Some Areas	Evaluated in a Few Areas	Not Evaluated
Accuracy (closeness between a data value and the real-world value that it represents)	☐	☐	☐	☐
Completeness (absence of missing values in the dataset)	☐	☐	☐	☐
Timeliness (how up-to-date the data are with respect to the task at hand)	☐	☐	☐	☐
Relevancy (data are applicable and useful for the task at hand)	☐	☐	☐	☐
Consistency (degree to which the data item is presented in the same format across agency)	☐	☐	☐	☐
Accessibility (ability of authorized users to access the data)	☐	☐	☐	☐
Access security (ability to restrict access to data to maintain security)	☐	☐	☐	☐

Responses of DOTs

Response 1 – Evaluated in All or Most Areas: Accuracy. Evaluated in Some Areas: Completeness, Timeliness, Relevancy and Consistency. Evaluated in a Few Areas: Accessibility, Access security.

Response 2 – Evaluated in All or Most Areas: Timeliness. Evaluated in Some Areas: Accuracy, Completeness, Relevancy, Access security. Evaluated in a Few Areas: Consistency, Accessibility.

Response 3 – Evaluated in All or Most Areas: Accuracy, Completeness, Consistency. Evaluated in Some Areas: Timeliness, Relevancy, Accessibility, Access security.

Response 4 – Evaluated in All or Most Areas: Accuracy, Access security. Evaluated in Some Areas: Completeness Timeliness, Relevancy, Consistency, Accessibility.

Response 5 – Evaluated in All or Most Areas: Accessibility. Evaluated in Some Areas: Accuracy, Timeliness, Relevancy, Access security. Evaluated in a Few Areas: Completeness Consistency.

Response 6 – Evaluated in All or Most Areas: Timeliness, Accessibility. Evaluated in Some Areas: Relevancy, Consistency. Evaluated in a Few Areas: Accuracy, Completeness, Access security.

Response 7 – Evaluated in All or Most Areas: Access security. Evaluated in Some Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Accessibility.

Response 8 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness. Evaluated in Some Areas: Accessibility. Evaluated in a Few Areas: Relevancy, Consistency, Access security.

Response 9 – Evaluated in All or Most Areas: Relevancy, Access security. Evaluated in Some Areas: Accuracy, Completeness, Timeliness, Accessibility. Evaluated in a Few Areas: Consistency.

Response 10 – Evaluated in Some Areas: Accuracy, Completeness, Timeliness, Relevancy. Evaluated in a Few Areas: Consistency, Accessibility, Access security.

Response 11 – Evaluated in Some Areas: Accuracy, Completeness, Timeliness, Relevancy, Accessibility, Access security. Evaluated in a Few Areas: Consistency.

Response 12 – Evaluated in All or Most Areas: Completeness, Timeliness, Consistency, Accessibility, Access security. Evaluated in Some Areas: Accuracy, Relevancy.

Response 13 – Evaluated in All or Most Areas: Accessibility, Access security. Evaluated in Some Areas: Accuracy, Completeness, Timeliness, Relevancy. Evaluated in a Few Areas: Consistency.

Response 14 – Evaluated in All or Most Areas: Accuracy, Timeliness, Relevancy. Evaluated in Some Areas: Completeness, Consistency, Accessibility, Access security.

Response 15 – Evaluated in Some Areas: Accuracy, Completeness Timeliness, Relevancy, Accessibility, Access security. Evaluated in a Few Areas: Consistency.

Response 16 – Evaluated in All or Most Areas: Accuracy, Completeness, Access security. Evaluated in Some Areas: Timeliness, Relevancy, Consistency, Accessibility.

Response 17 – Evaluated in Some Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Accessibility, Access security.

Response 18 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Accessibility, Access security.

Response 19 – Evaluated in All or Most Areas: Timeliness, Relevancy, Access security. Evaluated in Some Areas: Completeness, Accessibility. Evaluated in a Few Areas: Accuracy, Consistency.

Response 20 – Evaluated in All or Most Areas: Completeness, Timeliness, Relevancy. Evaluated in Some Areas: Accuracy, Consistency, Accessibility, Access security.

Response 21 – Evaluated in All or Most Areas: Accuracy, Completeness. Evaluated in Some Areas: Timeliness, Relevancy. Evaluated in a Few Areas: Accuracy, Consistency, Accessibility, Access security.

Response 22 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency. Evaluated in Some Areas: Accessibility, Access security.

Response 23 – Evaluated in All or Most Areas: Access security. Evaluated in Some Areas: Accuracy, Timeliness. Evaluated in a Few Areas: Completeness, Relevancy, Consistency, Accessibility.

Response 24 – Evaluated in All or Most Areas: Completeness, Relevancy, Access security. Evaluated in Some Areas: Accuracy, Timeliness, Consistency. Evaluated in a Few Areas: Accessibility.

Response 25 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness, Accessibility, Access security. Evaluated in a Few Areas: Relevancy, Consistency.

Response 26 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Accessibility, Access security.

Response 27 – Evaluated in Some Areas: Accuracy, Timeliness, Accessibility, Access security. Evaluated in a Few Areas: Completeness, Relevancy, Consistency.

Response 28 – Evaluated in Some Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Accessibility, Access security.

Response 29 – Evaluated in All or Most Areas: Relevancy, Consistency, Access security. Evaluated in Some Areas: Accuracy, Completeness, Timeliness, Accessibility.

Response 30 – Evaluated in All or Most Areas: Relevancy, Access security. Evaluated in Some Areas: Timeliness. Evaluated in a Few Areas: Accuracy, Completeness, Consistency, Accessibility.

Response 31 – Evaluated in All or Most Areas: Accuracy, Accessibility, Access security. Evaluated in Some Areas: Completeness, Timeliness, Consistency. Evaluated in a Few Areas: Relevancy.

Response 32 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness. Evaluated in Some Areas: Relevancy, Consistency, Accessibility, Access security.

Response 33 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Accessibility, Access security.

Response 34 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness, Relevancy, Access security. Evaluated in Some Areas: Consistency, Accessibility.

Responses of Local Agencies

Response 1 – Evaluated in All or Most Areas: Relevancy, Accessibility. Evaluated in Some Areas: Evaluated in a Few Areas: Accuracy, Completeness, Timeliness, Consistency, Access security.

Response 2 – Evaluated in All or Most Areas: Accuracy, Consistency. Evaluated in Some Areas: Completeness, Timeliness, Relevancy, Accessibility, Access security.

Response 3 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Accessibility, Access security.

Response 4 – Evaluated in All or Most Areas: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Access security. Evaluated in Some Areas: Accessibility.

Response 5 – Not Evaluated: Accuracy, Completeness, Timeliness, Relevancy, Consistency, Accessibility, Access security.

Response 6 – Evaluated in All or Most Areas: Accuracy, Completeness. Evaluated in Some Areas: Timeliness, Relevancy, Access security. Evaluated in a Few Areas: Consistency, Accessibility.

Response 7 – Evaluated in All or Most Areas: Accuracy, Completeness, Relevancy, Consistency, Accessibility. Evaluated in Some Areas: Timeliness, Access security.

Response 8 – Evaluated in All or Most Areas: Timeliness, Relevancy, Accessibility. Evaluated in Some Areas: Accuracy, Completeness, Consistency, Access security.

Response 9 – Evaluated in Some Areas: Timeliness, Accessibility. Evaluated in a Few Areas: Accuracy, Completeness, Relevancy, Consistency, Access security.

Response 10 – Evaluated in All or Most Areas: Accuracy. Evaluated in Some Areas: Completeness. Evaluated in a Few Areas: Timeliness, Consistency. Not Evaluated: Accessibility, Access security

Response 11 – Evaluated in Some Areas: Accuracy, Completeness Timeliness, Relevancy. Evaluated in a Few Areas: Consistency, Accessibility, Access security.

Data Integration and Sharing

3) Which of these data sets are integrated in your agency to serve various business needs? Please check all that apply in the grid below.

Example: Check the box at the intersection of Row A and Column B to indicate that roadway inventory (A) and crash data (B) are integrated.

A. Roadway inventory (e.g., location, classification, geometrics)	B. Crash Data	C. Traffic monitoring data (e.g., speed, volume)	D. Travel modeling data (e.g., household surveys, origin-destination)
E. Pavement inventory & condition data	F. Pavement work history data	G. Bridge inventory & condition data	H. Bridge work history data
I. Inventory and condition data for other assets (e.g., traffic signs, signals, drainage assets)	J. Transportation improvement programs data	K. Environmental impact and compliance data	L. Project design and materials data (e.g., design plans, structural design, mix design)
M. Contracts/procurement data (e.g., bid tabs)	N. Project construction data (e.g., cost/payments, schedule, material acceptance testing, as-built plans)	O. Real estate data (e.g., property acquisition, agency-owned)	P. Financial data (e.g., current and historical revenues, expenditures, budgets)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
C	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
D	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
E	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
F	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
G	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
H	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
I	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
J	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
K	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
L	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
M	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
N	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
O	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
P	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Responses: Please see Appendix C.

Comments of DOTs

Response 1: "The other systems (the unchecked ones) often include LRS information as part of their attribution, but sometimes this information is incomplete and not associated with a date. This makes calculations between the state of the roadway at different time periods difficult. Differing levels of resolution also makes the data difficult to integrate."

Response 2: "Some of the integrated datasets are only partially integrated at this time."

Response 3: "Best guesses, not thoroughly vetted."

Response 4: "State System only J-used Enhanced Priority Formula System (EPFS) M-used WinCMPS."

Response 5: "I only marked above the diagonal because 'integrated' could be interpreted as primary flow direction, reverse flow direction, or both."

Response 6: "Our enterprise GIS datasets and Location References or unique identifiers provide us with at least one point of integration in every category listed. However, while some data is routinely integrated in systems such as a data warehouse, other datasets need to be linked to each other using a manual/custom process."

Response 7: "Details of integration beyond Items A through D and J are unknown to this reporter."

Response 8: "The format for this is very confusing. Also, we can relate data across data sets, but that doesn't mean they are 'integrated' in the technical sense (in the same database)."

Response 9: "Everything is linked via route ID and Measure, and location functions that can snap to the centerline. All these can be intersected or unioned. Not all of these are pre-intersected or pre-unioned."

Response 10: "I am assuming it is a given that certain datasets are integrated such as bridge Inventory/bridge Work History and contracts/financial. I did not take the time to confirm them all, but rather checked the disparate ones that I know are integrated."

Response 11: "All will be beneficial."

Comments of Local Agencies

Response 1: "We have access to and maintain many of these datasets. However, none of those included above are wholly integrated beyond existing in the same file structure. They are very much silo-ed despite their obvious relationship to one another."

Response 2: "Most of these data sets are not owned/maintained by our agency and are therefore not applicable."

4) What data sets would be beneficial for your agency to integrate? Please check all that apply in the grid below.

Example: Check the box at the intersection of Row E and Column G to indicate that it would be beneficial for your agency to integrate pavement inventory and condition data (E) and bridge inventory and condition data (G).

A. Roadway inventory (e.g., location, classification, geometrics)	B. Crash Data	C. Traffic monitoring data (e.g., speed, volume)	D. Travel modeling data (e.g., household surveys, origin-destination)
E. Pavement inventory & condition data	F. Pavement work history data	G. Bridge inventory & condition data	H. Bridge work history data
I. Inventory and condition data for other assets (e.g., traffic signs, signals, drainage assets)	J. Transportation improvement programs data	K. Environmental impact and compliance data	L. Project design and materials data (e.g., design plans, structural design, mix design)
M. Contracts/procurement data (e.g., bid tabs)	N. Project construction data (e.g., cost/payments, schedule, material acceptance testing, as-built plans)	O. Real estate data (e.g., property acquisition, agency-owned)	P. Financial data (e.g., current and historical revenues, expenditures, budgets)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
C	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
D	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
E	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
F	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
G	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
H	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
I	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
J	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
K	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
L	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
M	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
N	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
O	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
P	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Responses: Please see Appendix C.

Comments of DOTs

Response 1: "The Agency is striving for presenting these datasets is a way that they can be used for analysis together by the end user. Our focus is not to integrate these datasets unless it is required by the transactional system and instead to rely on source systems to manage ancillary datasets and present them through other means for analytics."

Response 2: "We are currently working on tying all of our data system in to our roadway inventory."

Response 3: "I only marked above the diagonal because 'integrated' could be interpreted as primary flow direction, reverse flow direction, or both."

Response 4: "This is solely from my perspective (Items A-D, J). There are very likely other integrations that I'm missing that Agency would benefit from."

Response 5: "Again, this is confusing. We're working on integrating roadway features inventories, changing our financial system, and extracting engineering features from construction into maintainable asset inventories."

Response 6: "Take the converse set from #3, and that would be the start point. Somewhere in the diverse organization a DOT is, it would be beneficial."

Response 7: "It would be beneficial if all these data sets were integrated. Therefore, I did not bother to check all the boxes"

Comment of Local Agency

Response 1: "Most of these data sets are not owned/maintained by our agency and are therefore not applicable."

5) What location referencing methods are used in your agency? (Please check all that apply.)

Route mile point: Distance from the beginning of the route.

Route reference post: Distance and direction from a physical mile marker posted on the route in the field.

Route street reference: Distance and direction on one street from another intersecting street.

Multilevel linear referencing systems (MLLRS): Includes multiple linear referencing methods and transformation mechanism to a common one.

Geographic coordinates: Geospatial coordinates such as latitude and longitude; or State plane coordinates.

Data Set	Route mile point	Route reference post	Link-node	Route street reference	Multilevel LRS	Geographic coordinates	Other or NA
Roadway inventory (e.g., location, classification, geometrics)	☐	☐	☐	☐	☐	☐	☐
Crash data	☐	☐	☐	☐	☐	☐	☐
Traffic monitoring data (e.g., speed, volume)	☐	☐	☐	☐	☐	☐	☐
Travel modeling data (e.g., household surveys, origin-destination)	☐	☐	☐	☐	☐	☐	☐
Highway Performance Monitoring System (HPMS)	☐	☐	☐	☐	☐	☐	☐
Pavement inventory and condition data	☐	☐	☐	☐	☐	☐	☐
Pavement work history data	☐	☐	☐	☐	☐	☐	☐
Bridge inventory and condition data	☐	☐	☐	☐	☐	☐	☐
Bridge work history data	☐	☐	☐	☐	☐	☐	☐
Inventory and condition data for other assets (e.g., traffic signs, signals, drainage assets)	☐	☐	☐	☐	☐	☐	☐
Transportation improvement programs data	☐	☐	☐	☐	☐	☐	☐
Environmental impact and compliance data	☐	☐	☐	☐	☐	☐	☐
Contracts/procurement (e.g., bid tabs)	☐	☐	☐	☐	☐	☐	☐
Project construction data (e.g., cost/ payments, schedule, material acceptance testing, as-built plans)	☐	☐	☐	☐	☐	☐	☐

Responses of DOTs

Response 1 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets.

Route reference post: pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Route street reference: crash data.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets.

Response 2 – Route mile point: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs, project construction data.

Route reference post: bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement, project construction data.

Link node: crash data

Geographic coordinates: pavement inventory and condition data

Response 3 – Route mile point: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs, environmental impact and compliance data.

Geographic coordinates: crash data, Inventory and condition data for other assets.

Response 4 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data.

Response 5 – Route mile point: roadway inventory, crash data, traffic monitoring data, travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Route—street reference: HPMS

Geographic coordinates: roadway inventory, crash data, traffic monitoring data, travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, inventory and condition data for other assets, environmental impact and compliance data, project construction data.

Response 6 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs.

Geographic coordinates: crash data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs.

Other or NA: Travel modeling data, bridge work history data, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Response 7 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data.

Link node: Travel modeling data.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring data, pavement work history data, bridge inventory and condition data.

Response 8 – Route mile point: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Geographic coordinates: Roadway inventory, crash data, bridge inventory and condition data, Inventory and condition data for other assets.

Other or NA: Travel modeling data, contracts/procurement, project construction data.

Response 9 – Route mile point: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, contracts/procurement.

Route reference post: Travel modeling data, contracts/procurement.

Link node: Roadway inventory, crash data, HPMS.

Route street reference: Roadway inventory, crash data, Travel modeling data.

Multilevel LRS: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement.

Geographic coordinates: Roadway inventory, HPMS, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement.

Response 10 – Route mile point: Roadway inventory, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data.

Route reference post: pavement inventory and condition data, environmental impact and compliance data, contracts/procurement.

Link–node: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets.

Route street reference: environmental impact and compliance data.

Geographic coordinates: pavement inventory and condition data, environmental impact and compliance data.

Other or NA: contracts/procurement, project construction data.

Response 11 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement, project construction data.

Link node: Travel modeling data.

Route street reference: HPMS.

Multilevel LRS: Roadway inventory:

Geographic coordinates: Roadway inventory, crash data, Travel modeling data, pavement inventory and condition data, bridge inventory and condition data.

Other or NA: Roadway inventory.

Response 12 – Route mile point: Roadway inventory.

Route reference post: Roadway inventory.

Link node: Roadway inventory.

Route street reference: Roadway inventory, HPMS.

Multilevel LRS: Roadway inventory, HPMS.

Geographic coordinates: HPMS.

Response 13 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data.

Route street reference: Roadway inventory, crash data, Travel modeling data.

Multilevel LRS: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data.

Other or NA: contracts/procurement, project construction data.

Response 14 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs, project construction data.

Geographic coordinates: crash data, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, project construction data.

Other or NA: contracts/procurement.

Response 15 – Route reference post: pavement inventory and condition data.

Route street reference: crash data.

Geographic coordinates: Roadway inventory, crash data, pavement inventory and condition data.

Response 16 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs, contracts/procurement.

Route reference post: Roadway inventory, crash data, traffic monitoring data, bridge inventory and condition data, bridge work history data, project construction data.

Multilevel LRS: Roadway inventory.

Geographic coordinates: Roadway inventory, crash data, bridge inventory and condition data, bridge work history data, contracts/procurement.

Other or NA: Travel modeling data, Inventory and condition data for other assets.

Response 17 – Route mile point: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement.

Route reference post: pavement inventory and condition data, pavement work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Link node: crash data, traffic monitoring data, Travel modeling data.

Geographic coordinates: crash data, bridge inventory and condition data, bridge work history data, environmental impact and compliance data.

Response 18 – Route mile point: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement.

Link node: Travel modeling data.

Multilevel LRS: crash data.

Geographic coordinates: crash data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets.

Other or NA: project construction data.

Response 19 – Route mile point: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data.

Route reference post: crash data.

Geographic coordinates: crash data, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, project construction data.

Response 20 – Route mile point: Roadway inventory, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data.

Other or NA: transportation improvement programs, contracts/procurement, project construction data.

Response 21 – Multilevel LRS: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, project construction data.

Geographic coordinates: traffic monitoring data, Travel modeling data, environmental impact and compliance data.

Other or NA: contracts/procurement.

Response 22 – Route mile point: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Link node: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data.

Route street reference: Roadway inventory.

Multilevel LRS: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Response 23 – Route mile point: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs.

Link node: Travel modeling data.

Route street reference: Roadway inventory, HPMS.

Multilevel LRS: Roadway inventory, traffic monitoring data, HPMS, transportation improvement programs.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs.

Response 24 – Route mile point: environmental impact and compliance data, project construction data.

Link–node: Travel modeling data.

Route street reference: crash data, traffic monitoring data, Inventory and condition data for other assets.

Multilevel LRS: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs, contracts/procurement, project construction data.

Geographic coordinates: crash data, bridge inventory and condition data, Inventory and condition data for other assets.

Other or NA: pavement work history data, bridge work history data, environmental impact and compliance data, contracts/procurement, project construction data.

Response 25 – Route mile point: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement, project construction data.

Route reference post: Roadway inventory, traffic monitoring data, Inventory and condition data for other assets.

Link node: Roadway inventory, traffic monitoring data, Travel modeling data, HPMS, Inventory and condition data for other assets.

Route street reference: Roadway inventory, traffic monitoring data, Inventory and condition data for other assets.

Multilevel LRS: Roadway inventory, crash data, traffic monitoring data, HPMS, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, project construction data.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data.

Response 26 – Route mile point: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, contracts/procurement, project construction data.

Route reference post: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, contracts/procurement, project construction data.

Link node: Roadway inventory, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets.

Geographic coordinates: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, contracts/procurement, project construction data.

Other or NA: traffic monitoring data, Travel modeling data, transportation improvement programs, environmental impact and compliance data.

Response 27 – Route mile point: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Route reference post: crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets.

Link node: HPMS, pavement inventory and condition data, bridge work history data.

Multilevel LRS: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data.

Response 28 – Route reference post: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data.

Link node: Roadway inventory, HPMS, pavement inventory and condition data, pavement work history data, Inventory and condition data for other assets.

Route street reference: Roadway inventory, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets.

Multilevel LRS: Roadway inventory.

Geographic coordinates: Roadway inventory, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data.

Response 29 – Route mile point: Roadway inventory, crash data, HPMS, pavement inventory and condition data, Inventory and condition data for other assets, transportation improvement programs.

Route reference post: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Link node: traffic monitoring data, Travel modeling data.

Geographic coordinates: Roadway inventory, crash data, HPMS, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data.

Other or NA: bridge work history data.

Response 30 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, bridge inventory and condition data.

Route reference post: Roadway inventory, crash data, traffic monitoring data, pavement inventory and condition data, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Geographic coordinates: bridge inventory and condition data.

Response 31 – Route mile point: crash data, traffic monitoring data, pavement inventory and condition data, pavement work history data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data.

Route reference post: Roadway inventory, traffic monitoring data, HPMS, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs.

Route street reference: crash data, traffic monitoring data, Inventory and condition data for other assets, project construction data.

Multilevel LRS: crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, project construction data.

Geographic coordinates: HPMS, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data.

Response 32 – Route mile point: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement, project construction data.

Route street reference: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement, project construction data.

Multilevel LRS: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement, project construction data.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement, project construction data.

Responses of Local Agencies

Response 1 – Geographic coordinates: crash data, traffic monitoring data, bridge inventory and condition data, Inventory and condition data for other assets.

Other or NA: Road inventory, Travel modeling data, pavement inventory and condition data, transportation improvement programs.

Response 2 – Link node: Roadway inventory, traffic monitoring data, Travel modeling data.

Geographic coordinates: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, Inventory and condition data for other assets.

Other or NA: transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Response 3 – Geographic coordinates: Travel modeling data, pavement inventory and condition data, transportation improvement programs.

Response 4 – Geographic coordinates: traffic monitoring data, Travel modeling data, transportation improvement programs.

Other or NA: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data.

Response 5 – Route mile point: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS.

Response 6 – Route mile point: Roadway inventory, transportation improvement programs.

Other or NA: crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data.

Response 7 – Route mile point: Roadway inventory, crash data, traffic monitoring data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs.

Link node: Travel modeling data, transportation improvement programs.

Geographic coordinates: crash data, transportation improvement programs.

Other or NA: HPMS, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data.

Response 8 – Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

6) If you answered "other" to Question 5, please describe this location referencing method:

Responses of DOTs

Response 1: "Historic work against bridges is being recorded by project delivery against the actual asset not a location. We derive locations through this association back to the asset but it also simplifies the linkage between projects and the assets they affect."

Response 2: "project coordinate systems are used—modified state plane"

Response 3: "contracts/procurement = Districts/Counties, construction = Roadway acceptance data in mileposts. Station numbers (feet) with offsets."

Response 4: "County-Route-Postmile (postmile is not the same as odometer)."

Response 5: "Key number for contracts and construction."

Response 6: "Ground Survey Stationing"

Response 7: "Work histories, plans, environmental, contracts, and project construction each have their own referencing systems as their primary reference (like a bridge ID). These things have references to assets in the asset databases."

Response 8: "Not available at this time."

Response 9: "bridge Work History is linked to bridge inventory"

Responses of Local Agencies

Response 1: "Several of the datasets listed above have road-segment-based location referencing."

Response 2: "Most of these data sets are not owned/maintained by our agency and are therefore not applicable."

Response 3: "The majority are NA. As an MPO, we don't maintain the physical asset data."

Response 4: "bridge Inventory and bridge Work History: unique ID in addition to route/mile point. Signals ('other assets') based on route/mile point of 'primary' contributing link."

7) How does your agency share data with outside users (public and private entities)?

Data Set	Online (open access)	Online (pre-authorized access)	Upon request (e.g., data sent via e-mail or a file sharing service)	Not shared outside agency	Other
Roadway inventory (e.g., location, classification, geometrics)	☐	☐	☐	☐	☐
Crash data	☐	☐	☐	☐	☐
Traffic monitoring data (e.g., speed, volume)	☐	☐	☐	☐	☐
Travel modeling data (e.g., household surveys, origin-destination)	☐	☐	☐	☐	☐
Highway Performance Monitoring System (HPMS)	☐	☐	☐	☐	☐
Pavement inventory and condition data	☐	☐	☐	☐	☐
Pavement work history data	☐	☐	☐	☐	☐
Bridge inventory and condition data	☐	☐	☐	☐	☐
Bridge work history data	☐	☐	☐	☐	☐
Inventory and condition data for other assets (e.g., traffic signs, signals, drainage assets)	☐	☐	☐	☐	☐
Transportation improvement programs data	☐	☐	☐	☐	☐
Environmental impact and compliance data	☐	☐	☐	☐	☐
Contracts/procurement data (e.g., bid tabs)					
Project construction data (e.g., cost/payments, schedule, material acceptance testing, as-built plans)	☐	☐	☐	☐	☐
Financial data (e.g., current and historical revenues, expenditures, budgets)	☐	☐	☐	☐	☐

Responses of DOTs

Response 1 – Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 2 – Online (open access): HPMS

Upon request: Roadway inventory

Response 3 – Online (open access): Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data,

bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data,

Response 4 – Online (open access): traffic monitoring transportation improvement programs, environmental impact and compliance data.

Upon request: Roadway inventory, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, contracts/procurement, project construction data, financial data.

Not shared outside agency: crash data

Response 5 – Online (open access): Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs, environmental impact and compliance data.

Online (pre-authorized access): crash data, transportation improvement programs, environmental impact and compliance data, project construction data, financial data.

Upon request: roadway inventory, crash data, traffic monitoring data, travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 6 – Online (open access): crash data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs project construction data.

Upon request: Roadway inventory, traffic monitoring data, HPMS, financial data.

Not shared outside agency: environmental impact and compliance data, contracts/procurement.

Other or NA: Travel modeling data.

Response 7 – Online (open access): Roadway inventory, crash data, contracts/procurement, project construction data, financial data.

Online (pre-authorized access): Roadway inventory, crash data.

Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS.

Response 8 – Online (open access): Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, project construction data, financial data.

Not shared outside agency: bridge work history data, contracts/procurement.

Response 9 – Online (open access): transportation improvement programs, contracts/procurement.

Online (pre-authorized access): Roadway inventory, crash data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Other or NA: traffic monitoring data.

Response 10 – Online (open access): Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data, financial data.

Online (pre-authorized access): environmental impact and compliance data, contracts/procurement.

Upon request: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data.

Not shared outside agency: project construction data.

Other or NA: Travel modeling data, bridge work history data, contracts/procurement.

Response 11 – Online (open access): traffic monitoring data, HPMS.

Online (pre-authorized access): transportation improvement programs.

Upon request: Roadway inventory, Travel modeling data.

Not shared outside agency: crash data, traffic monitoring data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Other or NA: Roadway inventory.

Response 12 – Online (pre-authorized access): Roadway inventory, HPMS.

Upon request: Roadway inventory, HPMS.

Response 13 – Online (open access): Roadway inventory, crash data, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement, financial data.

Upon request: Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs.

Not shared outside agency: project construction data.

Other or NA: Roadway inventory, Travel modeling data, pavement work history data, bridge work history data, environmental impact and compliance data.

Response 14 – Online (open access): Roadway inventory, traffic monitoring data, HPMS, bridge inventory and condition data, transportation improvement programs, contracts/procurement, project construction data.

Upon request: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, transportation improvement programs, contracts/procurement, project construction data.

Not shared outside agency: crash data, Travel modeling data, bridge work history data, environmental impact and compliance data.

Other or NA: bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, financial data

Response 15 – Online (open access): Roadway inventory, crash data

Upon request: Travel modeling data

Response 16 – Online (open access): Roadway inventory, traffic monitoring data, HPMS, bridge inventory and condition data.

Online (pre-authorized access): Roadway inventory, crash data, bridge inventory and condition data.

Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Other or NA: Inventory and condition data for other assets.

Response 17 – Online (open access): Roadway inventory, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, transportation improvement programs.

Upon request: Roadway inventory, crash data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data.

Not shared outside agency: bridge work history data, financial data.

Response 18 – Online (open access): Roadway inventory, traffic monitoring data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, transportation improvement programs, contracts/procurement.

Online (pre-authorized access): crash data, bridge inventory and condition data, bridge work history data, contracts/procurement, project construction data, financial data.

Not shared outside agency: Travel modeling data, HPMS, Inventory and condition data for other assets, environmental impact and compliance data.

Response 19 – Online (open access): Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs, contracts/procurement, project construction data.

Upon request: Roadway inventory, Travel modeling data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, environmental impact and compliance data.

Not shared outside agency: Inventory and condition data for other assets, financial data.

Other or NA: Roadway inventory, traffic monitoring data, HPMS, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, environmental impact and compliance data.

Response 20 – Online (open access): crash data, traffic monitoring data, transportation improvement programs, contracts/procurement.

Upon request: pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, environmental impact and compliance data, project construction data.

Not shared outside agency: Travel modeling data, HPMS, Inventory and condition data for other assets, financial data.

Response 21 – Online (open access): HPMS, transportation improvement programs.

Online (pre-authorized access): Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, project construction data.

Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 22 – Online (open access): Roadway inventory, crash data, traffic monitoring data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, transportation improvement programs.

Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 23 – Online (open access): traffic monitoring data.

Upon request: Roadway inventory, Travel modeling data, HPMS, transportation improvement programs.

Response 24 – Online (open access): Roadway inventory, traffic monitoring data, Inventory and condition data for other assets, transportation improvement programs.

Upon request: HPMS, pavement inventory and condition data, bridge inventory and condition data, bridge work history data, environmental impact and compliance data, contracts/procurement, financial data.

Not shared outside agency: Travel modeling data, pavement work history data, project construction data.

Other or NA: crash data.

Response 25 – Online (open access): Roadway inventory, crash data, traffic monitoring data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, contracts/procurement, project construction data.

Upon request: Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs.

Other or NA: Travel modeling data, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 26 – Online (open access): Roadway inventory.

Online (pre-authorized access): Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, contracts/procurement, project construction data, financial data.

Upon request: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, contracts/procurement, project construction data, financial data.

Other or NA: traffic monitoring data, Travel modeling data, transportation improvement programs, environmental impact and compliance data.

Response 27 – Online (open access): traffic monitoring data, transportation improvement programs, contracts/procurement.

Online (pre-authorized access): Roadway inventory, traffic monitoring data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, financial data.

Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 28 – Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 29 – Online (open access): Roadway inventory, traffic monitoring data, pavement work history data, bridge inventory and condition data, bridge work history data, transportation improvement programs, financial data.

Online (pre-authorized access): crash data, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Upon request: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, pavement inventory and condition data, Inventory and condition data for other assets, contracts/procurement.

Not shared outside agency: HPMS.

Response 30 – Online (open access): Roadway inventory, traffic monitoring data, bridge inventory and condition data, transportation improvement programs.

Upon request: Roadway inventory, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Other or NA: crash data.

Response 31 – Online (open access): Roadway inventory, traffic monitoring data, transportation improvement programs, environmental impact and compliance data, contracts/procurement.

Online (pre-authorized access): traffic monitoring data, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data.

Upon request: crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, project construction data, financial data.

Response 32 – Online (open access): Roadway inventory, traffic monitoring data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, contracts/procurement.

Upon request: Roadway inventory, crash data, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Not shared outside agency: Travel modeling data, HPMS, pavement work history data, bridge work history data.

Responses of Local Agencies

Response 1 – Upon request: Roadway inventory, crash data, traffic monitoring data, pavement inventory and condition data, bridge inventory and condition data, Inventory and condition data for other assets, financial data.

Not shared outside agency: Travel modeling data, transportation improvement programs.

Other or NA: HPMS, pavement work history data, bridge work history data, environmental impact and compliance data, contracts/procurement, project construction data.

Response 2 – Online (open access): Roadway inventory, traffic monitoring data.

Online (pre-authorized access): crash data, Travel modeling data, HPMS, transportation improvement programs.

Response 3 – Upon request: Travel modeling data, pavement inventory and condition data, transportation improvement programs, contracts/procurement, financial data.

Response 4 – Online (open access): transportation improvement programs.

Upon request: traffic monitoring data, Travel modeling data, financial data.

Not shared outside agency: contracts/procurement.

Other or NA: Roadway inventory, crash data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, project construction data, financial data.

Response 5 – Not shared outside agency: Roadway inventory, crash data, traffic monitoring data, Travel modeling data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 6 – Online (open access): Roadway inventory, transportation improvement programs.

Upon request: Travel modeling data.

Other or NA: crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, environmental impact and compliance data, contracts/procurement, project construction data, financial data.

Response 7 – Online (open access): crash data, traffic monitoring data, Travel modeling data, Inventory and condition data for other assets, transportation improvement programs, environmental impact and compliance data, financial data.

Other or NA: Roadway inventory, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, contracts/procurement, project construction data, Response.

Response 8 – Online (open access): Roadway inventory, crash data, traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, transportation improvement programs, financial data.

Upon request: Travel modeling data, environmental impact and compliance data, contracts/procurement.

Response 9 – Online (open access): Roadway inventory, transportation improvement programs, environmental impact and compliance data.

Upon request: Travel modeling data.

Other or NA: traffic monitoring data, HPMS, pavement inventory and condition data, pavement work history data, bridge inventory and condition data, bridge work history data, Inventory and condition data for other assets, contracts/procurement, project construction data, financial data.

8) If you answered "other" to Question 7, please describe this data sharing method:

Responses of DOTs

Response 1: "The majority of most frequently requested data has been moved to our public portal for viewing. All of the data on this site can be downloaded for the public's use at the links on this site to our open data portal."

Response 2: "real time roadside message boards."

Response 3: "contracts/procurement = Although some information is confidential per Federal Law, most contract information is available online, or by request if not available online. Procurement information is exempt from public records law until after selection meetings. Once the final selection meeting has been held, information can be made available to the public."

Response 4: "Public Records Act request."

Response 5: “crash data owner is the Maryland State Police which is associated to a milepost or intersection/ This is shared on the State Open Data Portal. SHA analyzes and edits the data to its true location via mile point. this analyzed data is not shared to the public and is highly sensitive even within the agency. SHA has an internal system to display and share data called Enterprise GIS. All data in the Other column is shared via eGIS internally. project and contract info is shared on the SHA website in the project Life Cycle sharepoint pages in tabular form; there are some maps but not all projects make it on this page. It is not comprehensive. pavement, bridge and asset inventory is currently in progress for a GIS centric public accessible dashboard. It has not been approved for release but is ready for release.”

Response 6: “crash data is ‘owned’ by the State Police.”

Response 7: “Don’t know would have been a useful additional category.”

Response 8: “Not available at this time.”

Response 9: “crash data is shared in a limited capacity (certain details only) and then upon request.”

Responses of Local Agencies

Response 1: “Most of these data sets are not owned/maintained by our agency and are therefore not shared.”

Response 2: “Other or N/A: we are not the owners of these datasets.”

Response 3: “As an MPO we often serve as a clearinghouse for data. The data that is not ours, identified as Other here, we prefer to first direct them to the original data collection agency or provide data available and identify the source for direct contact for additional details.”

9) What strategies would improve (or have improved) data sharing and access within your agency?

If other strategies *are applicable, please specify them in the entry boxes titled “Enter another option.”*

Strategy	Major Effect	Minor Factor	No Effect	Not Applicable
Improved metadata	☐	☐	☐	☐
Increased use of web-based data storage and access	☐	☐	☐	☐
Improved database management systems	☐	☐	☐	☐
Reduced use of hardware and software that require specialized data format	☐	☐	☐	☐
Enter another option	☐	☐	☐	☐
Enter another option	☐	☐	☐	☐

Responses of DOTs

Response 1 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 2 – Major Effect: Improved metadata, Increased use of web-based data storage and access. Minor Factor: Improved database management systems. No Effect: Reduced use of hardware and software that require specialized data format.

Response 3 – Major Effect: Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format. Minor Factor: Improved metadata.

Response 4 – Minor Factor: Improved metadata, Improved database management systems. No Effect: Increased use of web-based data storage and access, Reduced use of hardware and software that require specialized data format.

Response 5 – Major Effect: Improved metadata, Improved database management systems, Reduced use of hardware and software that require specialized data format. Minor Factor: Increased use of web-based data storage and access.

Response 6 – Major Effect: Increased use of web-based data storage and access, Improved database management systems, Improved framework to centralize and present data. Minor Factor: Improved metadata, Reduced use of hardware and software that require specialized data format.

Response 7 – Major Effect: Increased use of web-based data storage and access, Improved database management systems.

Response 8 – Major Effect: Increased use of web-based data storage and access, Reduced use of hardware and software that require specialized data format. Minor Factor: Improved metadata. Not Applicable: Improved database management systems

Response 9 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 10 – Major Effect: Improved metadata, SharePoint. Minor Factor: Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 11 – Major Effect: Increased use of web-based data storage and access, Improved database management systems, Governance. Minor Factor: Improved metadata, Reduced use of hardware and software that require specialized data format.

Response 12 – Major Effect: Increased use of web-based data storage and access. Minor Factor: Improved metadata.

Response 13 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 14 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 15 – Major Effect: Improved metadata, Reduced use of hardware and software that require specialized data format. Not Applicable: Increased use of web-based data storage and access, Improved database management systems.

Response 16 – Major Effect: Improved database management systems, Reduced use of hardware and software that require specialized data format. Minor Factor: Improved metadata. Not Applicable: Increased use of web-based data storage and access.

Response 17 – Major Effect: Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format. Minor Factor: Improved metadata.

Response 18 – Major Effect: Use of Enterprise-Level Business Intelligence Vendor Products, Civil Integrated Management Imitative, Development of an Enterprise Data Warehouse (based on and designed for current and planned business processes and needs, and developed in collaboration with program areas). Minor Factor: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 19 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Senior management champion.

Response 20 – Major Effect: Improved database management systems. Minor Factor: Improved metadata, Reduced use of hardware and software that require specialized data format. No Effect: Increased use of web-based data storage and access.

Response 21 – Major Effect: Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format. Minor Factor: Improved metadata.

Response 22 – Major Effect: Increased use of web-based data storage and access, Improved database management systems, Web-GIS Interactive Mapping of Enterprise Data. Minor Factor: Improved metadata, Reduced use of hardware and software that require specialized data format.

Response 23 – Major Effect: Increased use of web-based data storage and access, Improved database management systems. Minor Factor: Improved metadata. No Effect: Reduced use of hardware and software that require specialized data format.

Response 24 – Major Effect: Improved metadata, Increased use of web-based data storage and access. Minor Factor: Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 25 – Major Effect: Increased use of web-based data storage and access, Improved database management systems. Minor Factor: Improved metadata, Reduced use of hardware and software that require specialized data format.

Response 26 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems. Minor Factor: Reduced use of hardware and software that require specialized data format.

Response 27 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Data registry. Minor Factor: Reduced use of hardware and software that require specialized data format.

Response 28 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 29 – Major Effect: Improved metadata, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 30 – Major Effect: Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format, Data governance, standards and requirements for sharing/availability. No Effect: Improved metadata.

Response 31 – Major Effect: Reduced use of hardware and software that require specialized data format. Minor Factor: Improved metadata, Increased use of web-based data storage and access, Improved database management systems.

Response 32 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Responses of Local Agencies

Response 1 – Major Effect: Increased use of web-based data storage and access. Minor Factor: Improved metadata, Improved database management systems. No Effect: Reduced use of hardware and software that require specialized data format.

Response 2 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems. Minor Factor: Reduced use of hardware and software that require specialized data format.

Response 3 – Minor Factor: Improved metadata, Improved database management systems.

No Effect: Increased use of web-based data storage and access, Reduced use of hardware and software that require specialized data format.

Response 4 – Major Effect: Reduced use of hardware and software that require specialized data format. Minor Factor: Improved metadata, Increased use of web-based data storage and access, Improved database management systems.

Response 5 – Not Applicable: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 6 – Minor Factor: Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format. No Effect: Improved metadata.

Response 7 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

Response 8 – Major Effect: Improved database management systems, Reduced use of hardware and software that require specialized data format. Minor Factor: Improved metadata, Increased use of web-based data storage and

Response 9 – Major Effect: Improved metadata, Increased use of web-based data storage and access, Improved database management systems, Reduced use of hardware and software that require specialized data format.

10) What data management tools are most useful for accessing and sharing data within your agency?

Responses of DOTs

Response 1 – "SQL Server, ETL tools to regularly create packaged datasets, ArcGIS Online."

Response 2 – "We currently use an access front end to access our warehoused data. This has proved challenging for our casual users. We are moving to a web based portal for internal users that presents reports/maps/dashboards and SQL connected excel worksheets for users to filter and work with enterprise data."

Response 3 – "file servers, Sharepoint Intranet."

Response 4 – "ESRI Open Data, ArcServer, GeoServer, Custom Oracle Application."

Response 5 – "The most useful tool has been a system that integrates all the different referencing systems."

Response 6 – "Microsoft Office (Excel); Access; MySQL; IBI Managed Reporting Environment; SSRS; Crystal Reports; SharePoint."

Response 7 – "Document Retrieval System, Data Libraries (GIS and non-GIS), Enterprise databases."

Response 8 – "We are in the process of implementing ArcGIS for Server and ArcGIS Online as part of a multi-user/editor and transparent environment. Other than that, communication is the biggest key factor on having a successful enterprise data system for us."

Response 9 – "GIS, Data Warehouse, Web tools, starting to use BI/Visualization, specialty software."

Response 10 – "KanPlan (Kansas GIS portal), Data Warehouse Reports Portal."

Response 11 – "We are still researching this."

Response 12 – "REST services are becoming a standard."

Response 13 – "SAP Business Objects Suite, Oracle Business Intelligence Suite, Data Connections in Microsoft Access and Excel."

Response 14 – "eGIS Portal."

Response 15 – "Using the same database platform."

Response 16 – "Data Warehouses, Web-GIS interface for Viewing Data."

Response 17 – "Online repositories are the most useful tools for sharing data."

Response 18 – "Web based GiS mapping and data location creation and maintenance tools."

Response 19 – "SSRS, SharePoint with BI tools."

Response 20 – "LRS, Geospatial and mapping tools: a) ArcGIS Online, aka UPlan b) Spatial applications d) Roadway digital imaging c) roadlog tied to mapping and roadway digital imaging."

Response 21 – "GIS, EXCEL."

Response 22 – "Special Apps, TOAD, MS Access, Oracle, SQL server."

Response 23 – "ArcGIS, ArcGIS Online, Oracle, SQL, various file sharing methods."

Responses of Local Agencies

Response 1 – "Not sure."

Response 2 – "Relational databases, GIS, statistical software, internal data library ("Data Depot"), external data library (Data Hub)."

Response 3 – "In the process of learning some."

Response 4 – "Shapefiles and excel. Not everyone is the agency is familiar with RDBMS or ever MS Access so excel becomes the best choice followed by ArcGIS."

11) Does your agency have mechanisms in place for incorporating feedback from data users in your agency into the data collection process?

☐ Yes (please describe or provide examples in the box below) ☐ No

Responses of DOTs

☐ Yes: 15 responses

Response 1 – Yes: "Not as an agency practice, but there are some instances where users can directly provide feedback."

Response 2 – Yes: "Somewhat, but definitely could be improved."

Response 3 – Yes: "Web forms and e-mail."

Response 4 – Yes: "Multiple methods based on application—Web—Helpline—Internal e-mail."

Response 5 – Yes: "E-mail comments options, steering committees, surveys."

Response 6 – Yes: "Currently, we communicate ideas, methods and issues with each other, but not a formal process in place yet."

Response 7 – Yes: "We take suggestions and incorporate them to guide future improvements."

Response 8 – Yes: "Users can request that data items and subject areas be mapped from specific systems to reporting warehouses and business intelligence suites. Users can request that data value pick lists be maintained (e.g., add, retire, or modify usage)."

Response 9 – Yes: "traffic Counts."

Response 10 – Yes: "We encourage users of data to report errors and since it's quick/easy (and we make changes immediately), users freely supply feedback."

Response 11 – Yes: "Only through notification to the data owners at the users' initiative."

Response 12 – Yes: "Very informal, formative stage as we develop new LRS and data integration."

Response 13 – Yes: "Collaborate with pavement management and HPMS on data collection priorities."

Response 14 – Yes: "mail or Call - the content contact is on most web pages."

Response 15 – Yes: "occasional surveys, but mostly ad hoc meetings/discussions as needed."

☐ No: 15 responses

Responses of Local Agencies

Response 1 – Yes: "Through meetings and comments delivered on suggestion boxes."

☐ No: 7

Data Warehousing

12) What is the estimated amount of data that your agency maintains [expressed in data storage units, such as terabytes (1012 bytes)]? If no reliable estimate is available, please enter "unknown."

Responses of DOTs

Response 1 – Roadway inventory; Oracle current 6992 MB, historical 6413 MB, DB2 0.28 gigabyte.

Response 2 – "50 terabytes."

Response 3 – "At least 1/2 TB."

Response 4 – "0.5 terabytes; but really unknown."

Response 5 – "2 TB."

Response 6 – "Several terabytes as a min."

Unknown – 25 respondents

Responses of Local Agencies

Response 1 – "Approx. 20 terabytes."

Unknown – 8 responses

13) Approximately what percentage of your agency's transportation-related data is currently stored and managed using commercial cloud computing services?

Cloud Computing: Date are stored and managed on remote computers "in the cloud." These computers are owned and operated by others and connect to users' computers via the Internet.

More than 50%	21–50%	11–20%	1–10%	None	Unknown
☐	☐	☐	☐	☐	☐

Responses of DOTs

- ☐ More than 50% – None
- ☐ 21–50% – 2 responses
- ☐ 11–20% – 1 response
- ☐ 1–10% – 22 responses
- ☐ None – 3 responses
- ☐ Unknown – 3 responses

Responses of Local Agencies

- ☐ More than 50% – None
- ☐ 21–50% – None
- ☐ 11–20% – None
- ☐ 1–10% – 3 responses
- ☐ None – 5 responses
- ☐ Unknown – 1 response

14) In the next five years, what percentage of your agency's transportation-related data is anticipated to be stored and managed using commercial cloud computing services?

More than 50	21–50%	11–20%	1–10%	None	Unknown
☐	☐	☐	☐	☐	☐

Responses of DOTs

- ☐ More than 50% – 4 responses
- ☐ 21–50% – 5 responses
- ☐ 11–20% – 5 responses
- ☐ 1–10% – 3 responses
- ☐ None – None
- ☐ Unknown – 14 responses

Responses of Local Agencies

- ☐ More than 50% – 1 response
- ☐ 21–50% – None
- ☐ 11–20% – None
- ☐ 1–10% – 2 responses
- ☐ None – 2 responses
- ☐ Unknown – 4 responses

The survey is complete. Thank you for your participation!

APPENDIX B

Survey Respondents

PHASE 1 RESPONDENTS (by alphabetical order of agency name)

Title	Agency
Surveying and Mapping Administrator	Alabama DOT
Geospatial Engineering Systems Manager	Alaska Department of Transportation and Public Facilities
Transportation Data Programs Manager	Alaska Department of Transportation & Public Facilities
Director, Transportation Systems Analysis	Arizona DOT
Staff GIS and Mapping Administrator	Arkansas State Highway and Transportation Department
Transportation Specialist	Bismarck Mandan MPO
Deputy Director, Planning and Modal Programs	California Department of Transportation
Principal Analyst	Chicago Metropolitan Agency for Planning
GIS Performance Analyst	City of Bend
Director of Transportation and Programs	Coastal Region MPO
Manager, Information Management Branch	Colorado Department of Transportation
Assistant Trans Planning Director	Connecticut DOT
Transportation Planner III	Cowlitz Wahkiakum Council of Governments
Technical Writer/Business Analyst	District Department of Transportation
Division Manager	East West Gateway Council of Governments
Pavement Evaluation Specialist	Florida Department of Transportation
Assistant Program Manager	Genesee Transportation Council
Planning & Systems Section Chief	Illinois DOT
Statewide Asset Management Engineer	Indiana DOT
Director, Office of Research & Analytics	Iowa Department of Transportation
Staff Director	Ithaca–Tompkins County Transportation Council
Division Director	Kansas DOT
Planning Director	Kentucky Transportation Cabinet
Administrator, Data Collection & Management Systems	Louisiana DOTD
Director—GIS Services	Maine DOT
Assistant Division Chief	Maryland State Highway Administration
Director of Project-Oriented Planning	Massachusetts DOT—Office of Transportation Planning
Study Director	Metroplan, Central Arkansas
Planning Analyst	Metropolitan Council, St. Paul, MN
Chief Data Steward	Michigan DOT
Transportation Planner	Mid-America Regional Council
Data Systems & Coordination Section Director	Minnesota Department of Transportation

(*Continued on next page*)

PHASE 1 RESPONDENTS (by alphabetical order of agency name)
(*continued*)

Title	**Agency**
Traffic Analysis Manager	Mississippi Department of Transportation
Bureau Chief	Montana DOT
GIS Manager	North Carolina DOT
Principal Transportation Engineer	North Central Texas Council of Governments
IT Pro 4	Nevada Department of Transportation, IT Division
Division Director, Asset Management & Planning	New Mexico DOT
Transportation Manager 1	New York State Department of Transportation
Administrator	NHDOT Bureau of Planning
Assistant Planning/Asset Management Engineer	North Dakota Department of Transportation
Transportation Planner	North Florida TPO
Administrator Office of Technical Services	Ohio Department of Transportation
Strategic Data Business Plan Project Manager	Oregon DOT
Geographer/Analyst	Pikes Peak Area Council of Governments
GIS Administrator	Puerto Rico Highway and Transportation Authority
Chief Civil Engineer/Asset Manager	Rhode Island DOT
Senior Planner	Rogue Valley Council of Governments (RVMPO & MRMPO)
Road Data Services Engineer	South Carolina DOT
Engineering Supervisor	South Dakota DOT
Executive Director	St. Lucie Transportation Planning Organization
IT Supervisor	State of Nebraska—Department of Roads
GIS & Technical Analyst	Strafford Regional Planning Commission
Transportation Coordinator	Tennessee Department of Transportation
Data Management Director	Texas DOT
Statewide GIS Manager	Utah Department of Transportation
Data Management Supervisor	Vermont Agency of Transportation
Planning Data and GIS Manager	Virginia DOT
Data Management Services Manager	Washington State DOT
Principal Planner	Whatcom Council of Governments
Senior Transportation Planner	Wilmington Metropolitan Planning Organization
Chief, Data Management Section	Wisconsin DOT
Systems Planning Engineer	Wyoming DOT

PHASE 2 RESPONDENTS (by alphabetical order of agency name)

Title	Agency
GIS Specialist Senior	Alabama Department of Transportation
Geospatial Engineering Systems Manager	Alaska Department of Transportation & Public Facilities
Transportation Data Programs Manager	Alaska Department of Transportation & Public Facilities
Director, Transportation Systems Analysis	Arizona DOT
Staff GIS and Mapping Administrator	Arkansas State Highway and Transportation Department
Chief, Division of Research, Innovation and System Information	Caltrans
Principal Analyst	Chicago Metropolitan Agency for Planning
GIS Performance Analyst	City of Bend
Manager, Information Management Branch	Colorado DOT
Transportation Assistant Planning Director	Connecticut DOT
Principal Engineer	Connecticut DOT
Transportation Planner III	Cowlitz Wahkiakum Council of Governments
Technical Writer/Business Analyst	District Department of Transportation
Division Manager	East West Gateway
Pavement Assessment Specialist	Florida Department of Transportation
Asst. Program Manager	Genesee Transportation Council
Transportation Planner	Iowa Department of Transportation
Assistant Bureau Chief—Transportation Planning	Kansas DOT
GIS Administrator	Maine Department of Transportation
Assistant Division Chief, Data Services IT and GIS	Maryland State Highway Administration
Transportation Director	Metro Planning Commission
Senior Planner	Metropolitan Council, St. Paul, MN
Chief Data Steward	Michigan DOT
Transportation Planner	Mid-America Regional Council
Data Systems & Coordination Section Director	Minnesota DOT
Traffic Analysis Manager	Mississippi Department of Transportation
Data and Statistics Bureau Chief	Montana DOT
GIS Manager	North Carolina DOT
IT Pro 4	Nevada Department of Transportation
Division Director, Asset Management & Planning	New Mexico DOT
Transportation Manager 1	New York State DOT
Administrator	NHDOT Bureau of Planning

(*Continued on next page*)

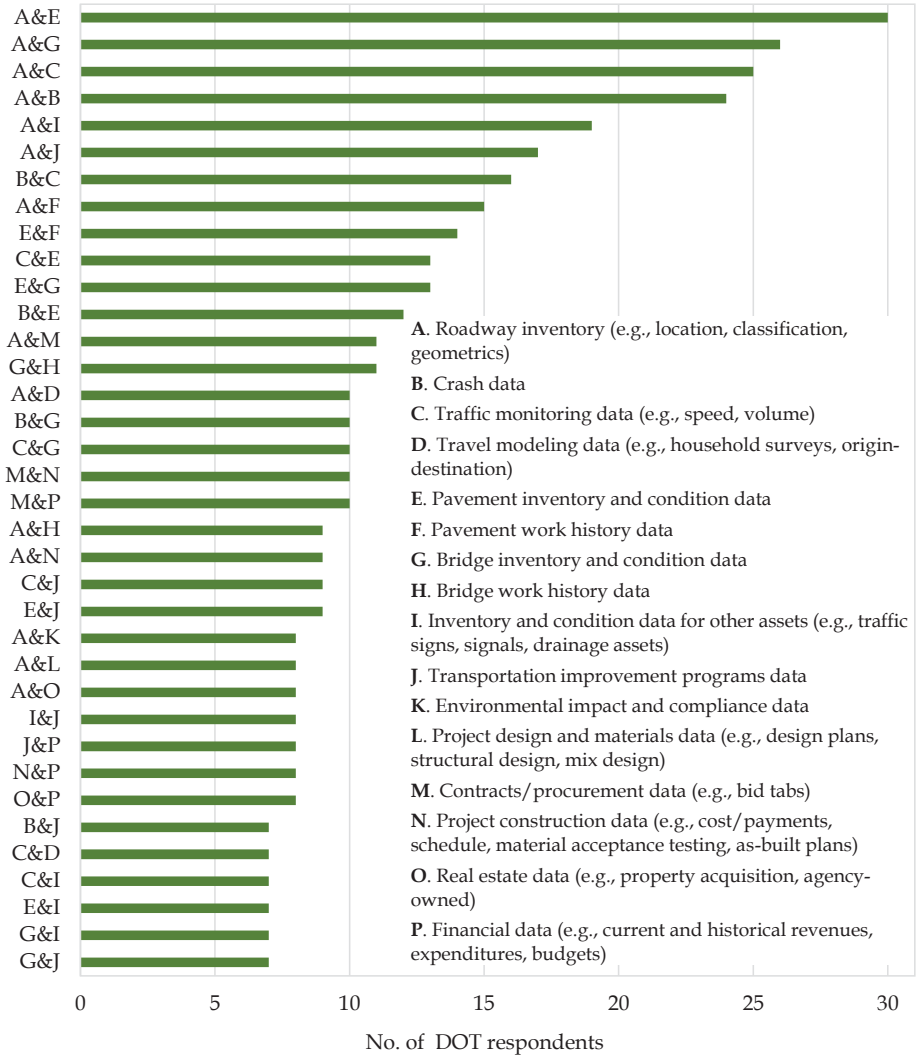
PHASE 2 RESPONDENTS (by alphabetical order of agency name)
(*continued*)

Title	**Agency**
Senior Transportation Modeler	North Central Texas Council of Governments (NCTCOG)
Information Strategist	Oregon Department of Transportation
Geographer/Analyst	Pikes Peak Area Council of Governments
GIS Administrator	Puerto Rico Highway and Transportation Authority
Chief Civil Engineer/Asset Manager	Rhode Island DOT
Road Data Services Engineer	South Carolina DOT
IT Supervisor	State of Nebraska—Department of Roads
Senior Regional Planner	Strafford Regional Planning Commission (SRPC)
Transportation Modeler	Tennessee Department of Transportation
Statewide GIS Manager	Utah Department of Transportation
Planning Data and GIS Manager	Virginia DOT
Data Management Supervisor	Vermont Agency of Transportation
Data Management Services Manager	Washington State DOT
Highway Data Unit Supervisor	Wisconsin DOT
Systems Planning Engineer	Wyoming DOT

APPENDIX C

Integration of Data Sets

Figure C1 summarizes the DOTs' responses to the question, "Which of these data sets are integrated in your agency to serve various business needs?" This figure is an extended form of Figure 20 in the body of the report.



(*Continued on next page*)

FIGURE C1 Pairs of integrated data sets at responding DOTs.

C-2

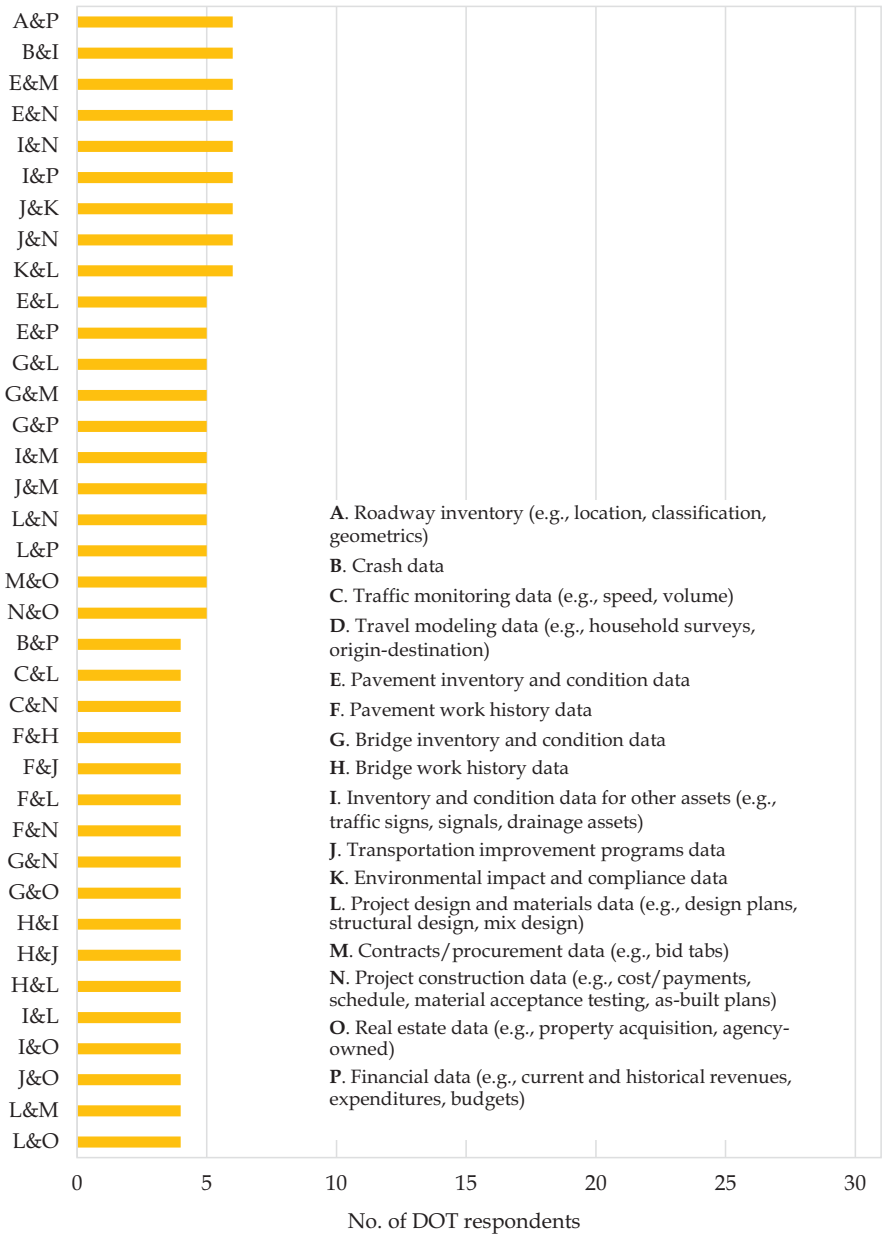


FIGURE C1 (*continued*).

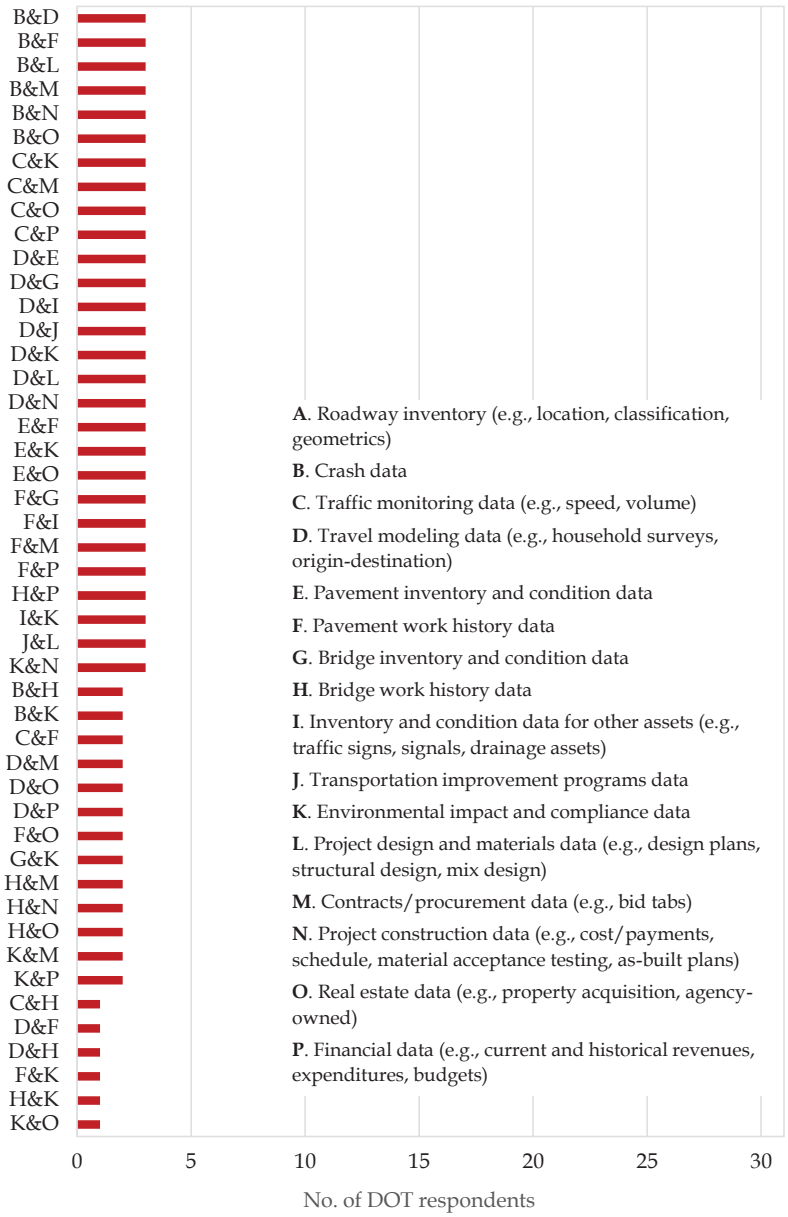


FIGURE C1 (*continued*).

Figure C2 summarizes the DOTs' responses to the question, "What data sets would be beneficial for your agency to integrate?" This figure is an extended form of Figure 21 in the body of the report.

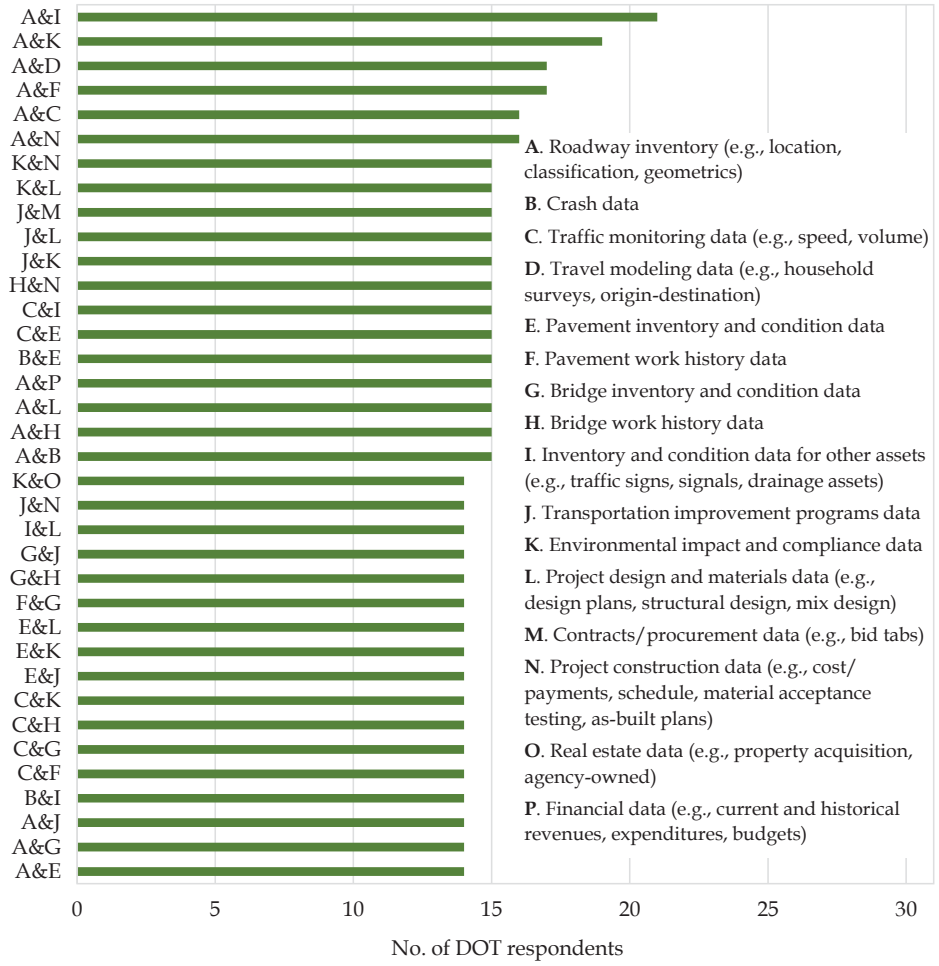


FIGURE C2 Pairs of data sets that would be beneficial to integrate at responding DOTs.

(*Continued on next page*)

FIGURE C2 (*continued*).

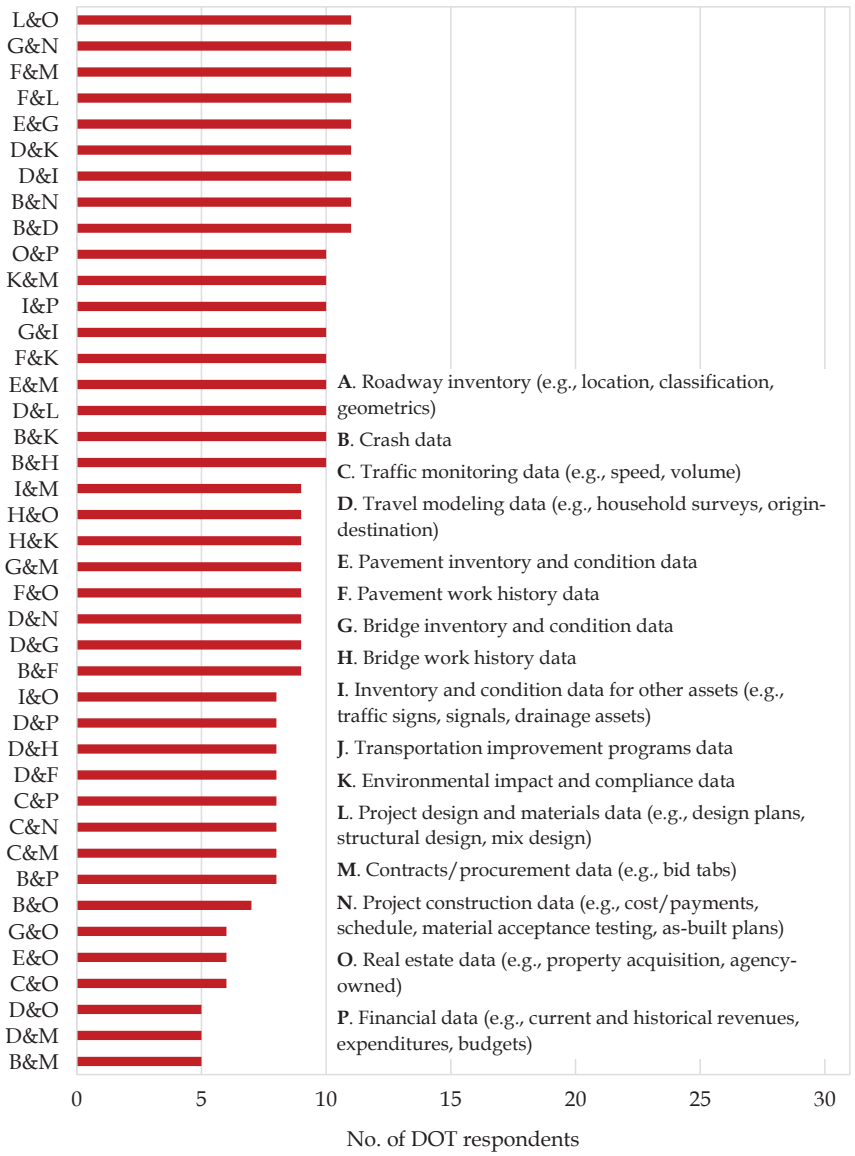


FIGURE C2 (*continued*).

Figure C3 summarizes the local agencies' responses to the question, "Which of these data sets are integrated in your agency to serve various business needs?"

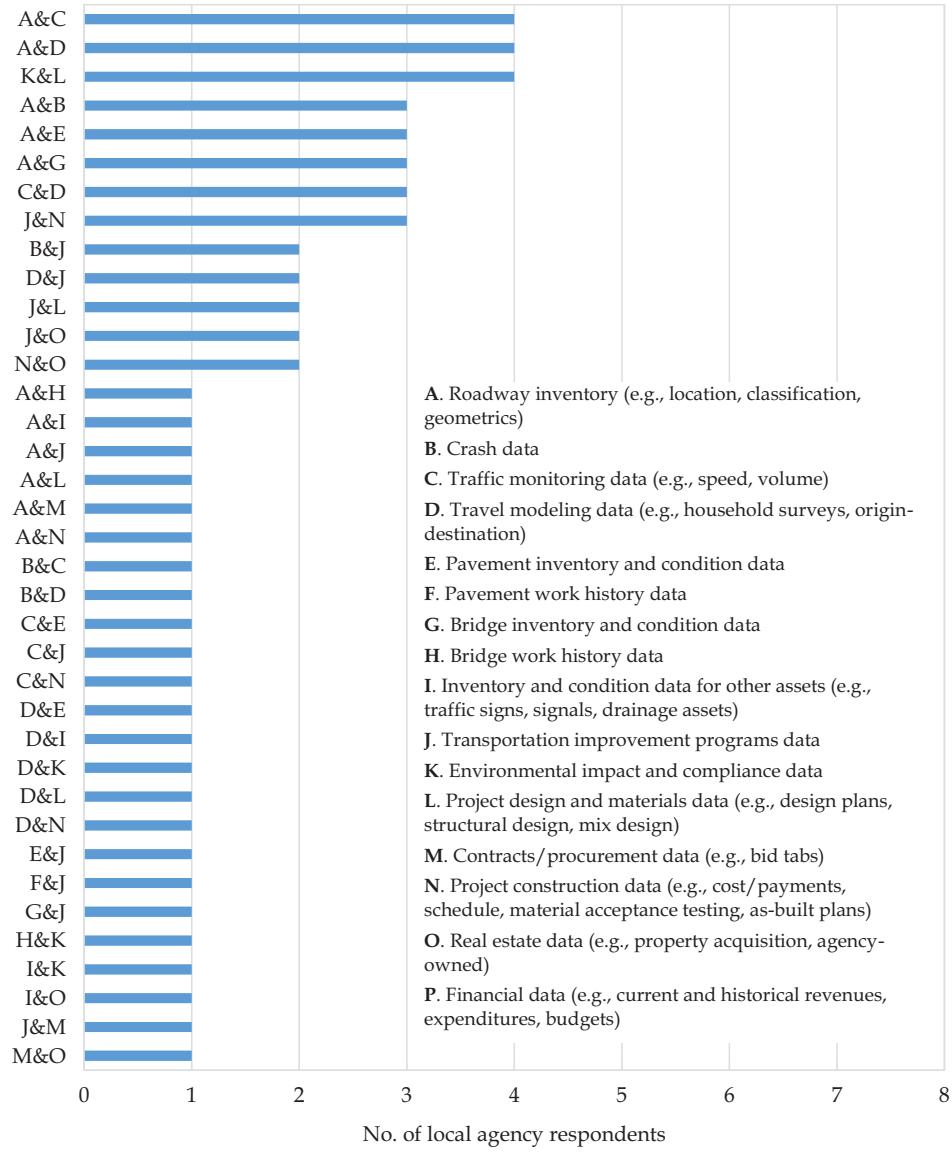


FIGURE C3 Pairs of integrated data sets at responding local agencies.

Figure C4 summarizes the local agencies' responses to the question, "What data sets would be beneficial for your agency to integrate?"

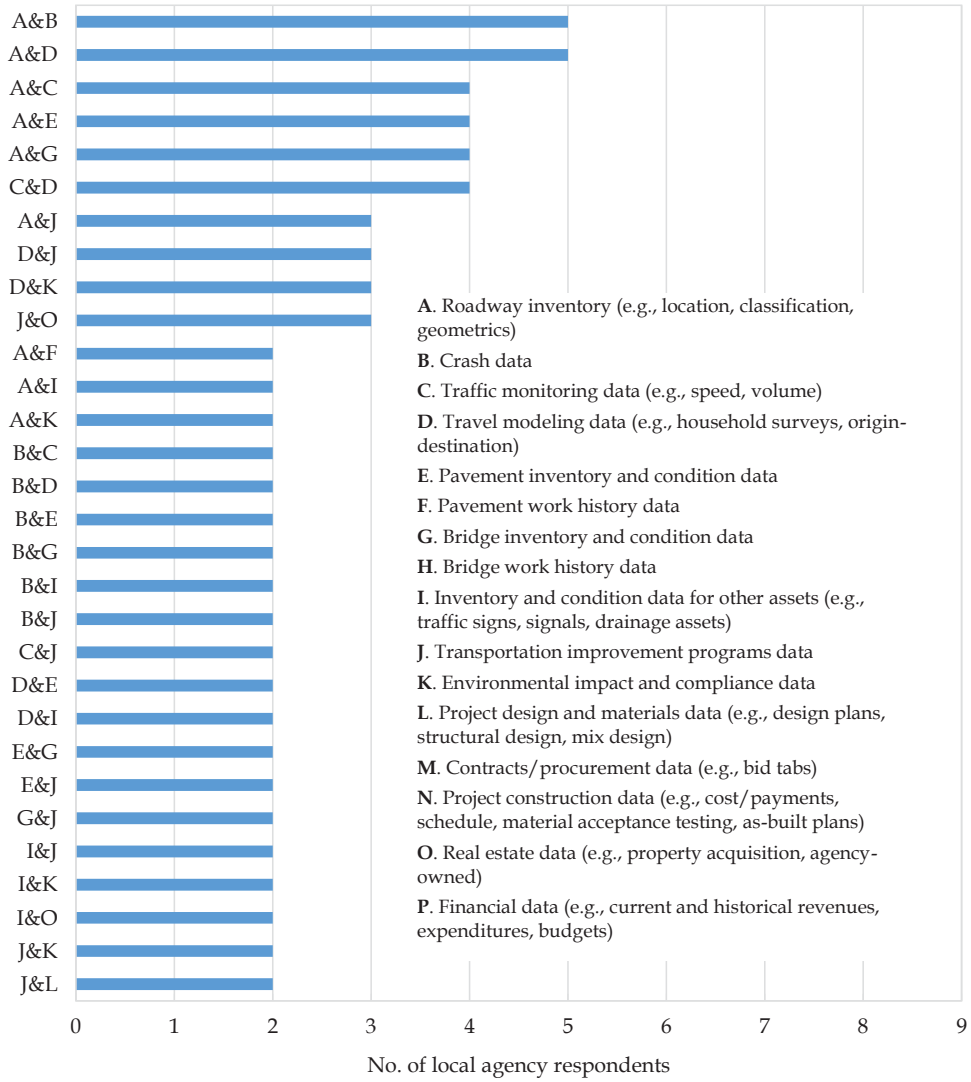


FIGURE C4 Pairs of integrated data sets at responding local agencies.

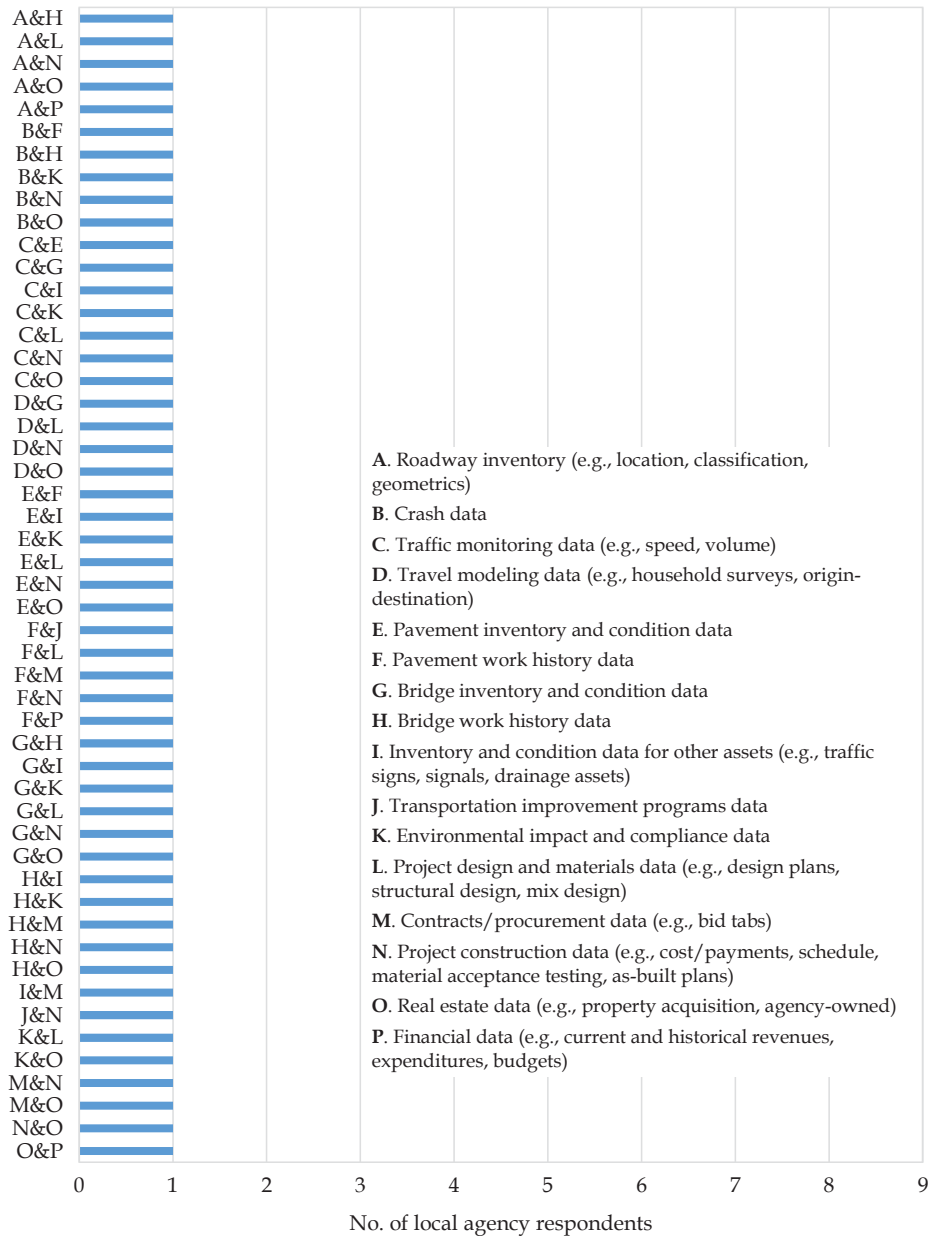


FIGURE C4 (*continued*).

Abbreviations and acronyms used without definitions in TRB publications:

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

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