Missouri Department of Transportation

Data Management & Spatial Integration

Missouri's Transportation Management System

SAFETY DATA CASE STUDY

FHWA-SA-21-016

Federal Highway Administration Office of Safety

Roadway Safety Data Program

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U.S. Department of Transportation
Federal Highway Administration

MoDOT

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

Acronyms

Acronym	Description
DOT	department of transportation
FHWA	Federal Highway Administration
GIS	geographic information system
HPMS	Highway Performance Monitoring System
ITS	Intelligent Transportation Systems
IS	Information Systems
ISTEA	Intermodal Surface Transportation Efficiency Act
LETS	Law Enforcement Traffic System
LRM	linear referencing method
LRS	linear referencing system
MIRE-FDE	Model Inventory of Roadway Elements Fundamental Data Elements
MMS	Maintenance Management System
MoDOT	Missouri Department of Transportation
MPO	metropolitan planning organization
MSHP	Missouri State Highway Patrol
RPC	regional planning commission
SME	subject matter expert
SP&R	State Planning and Research
STARS	State of Missouri's Accident Reporting System
STIP	Statewide Transportation Improvement Program
TMS	Transportation Management System
TPD	Transportation Planning Division
TRCC	Traffic Records Coordinating Committee

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Executive Summary

This case study documents how the Missouri Department of Transportation's (MoDOT's) Transportation Planning Division (TPD) coordinates with the Information Systems unit (the agency's information technology unit) and the State's Traffic Records Coordinating Committee (TRCC) to form a leadership group that supports the State's data management and integration activities. The State's Transportation Management System (TMS) stores all transportation-related data maintained by the agency. This Oracle-based database, directly managed by TPD, ties all asset data to a single, all public roads basemap and linear referencing system (LRS). This provides a tabular LRS location and a spatial location compatible with geographic information systems (GIS) software for all data elements located along Missouri's public roads network. This spatial orientation supports several data management and integration efforts between different business units within MoDOT, as well as with external partners that manage relevant safety data. The DOT committed to spatial data integration early in the development of the TMS, and it has led to the flexible and expandable repository that exists today.

Introduction

In 2019, the Federal Highway Administration (FHWA) completed the second U.S. Roadway Safety Data Capabilities Assessment (FHWA, 2019). This nationwide survey documented the safety data processes, policies, and procedures of all 50 States plus Washington D.C. and Puerto Rico. This survey not only highlighted the current state of practice with respect to all phases of safety data collection, management, integration, and analysis, but it also revealed that State Departments of Transportation (DOTs) were eager to improve their capacity for data management and integration. The purpose of this case study is to highlight a noteworthy example by the Missouri Department of Transportation (MoDOT) with respect to its data governance, management, and integration practices.

A core technology and data team within MoDOT, in coordination with the various data stewards throughout the agency, have continually developed the agency's enterprise data capabilities for decades (since the Intermodal Surface Transportation Efficiency Act – ISTEA – of 1991). The agency's enterprise database, the Transportation Management System (TMS), has been a cornerstone of MoDOT's abilities to spatially manage data and technology to support the agency's broader transportation objectives. In fact, the TMS has served as a model for other proprietary transportation data systems that have been implemented at State DOTs across the country. As the second U.S. Roadway Safety Data Capabilities Assessment revealed, MoDOT has become a leader in transportation data integration as a result of its policies and experience in enterprise data management.

Purpose and Need

This case study documents how MoDOT's Transportation Planning Division (TPD) coordinates with the Information Systems (IS) unit (the agency's information technology unit), and the State's Traffic Records Coordinating Committee (TRCC) to form a leadership group that supports the State's data management and integration activities. This leadership group coordinates with other business units within MoDOT to meet the agency's enterprise data and technology needs. This case study covers the following topics:

- Data collection and data standards
- Quality control and integration with a single public roads basemap
- Data management workflows
- Partnerships within the DOT
- Methods for sharing data between State and local agencies

Target Audience:

- Executive Leadership
- Data Governance Committees
- Information Technology Staff
- Data Managers, Analysts, and Stewards
- Subject Matter Experts (SMEs) in Planning and Engineering

Overview of the Transportation Management System

MoDOT stores all transportation-related data maintained by the agency in the TMS. This Oracle-based database, directly managed by TPD, ties all asset data to a single, all public roads basemap and linear referencing system (LRS). This provides a tabular LRS location and a spatial location compatible with geographic information systems (GIS) software for all data elements located along Missouri's public roads network, including:

- Roadway cross-section (e.g., lanes, median presence, etc.)
- Traffic volumes
- Crash locations
- Grade inventories
- Curve inventories
- Guard rail and barrier inventories
- Intelligent Transportation Systems (ITS) devices (e.g., cameras and speed signs)
- Pavement inventories
- Signs inventories
- Planned improvements; based on the Statewide Transportation Improvement Program (STIP)

The spatial component of the TMS allows the system to be very flexible with minimally processed data that may use different linear referencing methods (LRM). Although the system requires a minimum standard for data to be integrated into the relational database, the TMS is capable of integrating relatively unstructured data by converting each data element's unique location to a standardized location on the State's basemap. This single, comprehensive basemap is the key component that allows MoDOT to effectively maintain its spatial data inventories with minimal time spent converting messy or disparate datasets.

Data Collection and Standards

MoDOT uses several methods to collect the data that support the agency's strategic objectives. These include aerial imagery, video logs, mobile applications, and traffic counts. Individual MoDOT business units, district offices, and external partners collect the large volume of transportation data aggregated into the TMS. For instance, while MoDOT's central office is responsible for maintaining the functional classification of each road segment, district offices maintain rumble strip and striping inventories. The strength of the agency's data management process is its emphasis on spatial location. By focusing on spatial data as the backbone of the system, the TMS can accommodate data maintained by several different owners.

Local Data Aggregation

Local agencies submit data on local roads to MoDOT as part of an ongoing program. County agencies provide spatial information to MoDOT through red-lined map books. These contain the physical alignment of any local roads, as well as any supplementary information available to the county (e.g., number of lanes and surface type). This program serves as a primary method for collecting local Model

Inventory of Roadway Elements Fundamental Data Elements (MIRE-FDE) for non-State maintained roads.

Data Integration

Despite the range of individual data stewards and owners collecting and maintaining asset data elements, the TPD is able to effectively aggregate these data and spatially integrate them into the State's enterprise data systems. MoDOT adheres to documented metadata standards and data definitions for all data elements in its inventories. There are standardized processes and business rules for adding data elements to the TMS, and the agency applies a series of pre-validation checks on roadway and GIS data.

Figure 1. Graphic. MoDOT's Q2 2020 performance highlights in Tracker.

This emphasis on spatial integration, adherence to standards, and documentation provides a more efficient integration process. This not only allows the TMS to be a more flexible and expandable repository, but it also supports MoDOT's core function of providing a safe and reliable transportation system. Readily accessible data allow individual business units to perform their jobs more efficiently. The DOT relies on the efficient management and availability of the State's data to track the outcomes listed in the agency's quarterly performance assessment, *Tracker: Measures of Departmental Performance*. MoDOT is required to document these outcomes for its executive leadership and the general public (figure 1). The State's crash data system and partnership between the DOT and law enforcement agencies demonstrate this approach and the benefits of an integrated data system.

Integration with Law Enforcement

Missouri's crash data system is a practical example of inter-agency cooperation with the goal of safety data standardization and integration. In 2001, MoDOT and the Missouri State Highway Patrol (MSHP) collaborated on a joint data system that incorporated the MSHP's State of Missouri's Accident Reporting System (STARS) directly into the TMS. This cooperation between two of the largest traffic safety data managers in the State produced a single crash data location tool and repository housed within MoDOT. This system spatially links crash data from law enforcement with MoDOT's traffic and roadway asset inventories.

As of 2017, 237 local law enforcement agencies in the State use an electronic crash reporting system, the Law Enforcement Traffic System (LETS), that standardizes the crash data import into the TMS repository. To support this process, the IS staff at MoDOT developed a GIS-based user interface to assist crash mapping at State and local law enforcement agencies. The State Highway Patrol Mapping Tool is accessible via web-browser, and it allows reporting officers to both spatially locate crashes and link crash locations to the State's LRS; the interface is designed to be readily accessible by users with limited GIS experience and skill (figure 2).

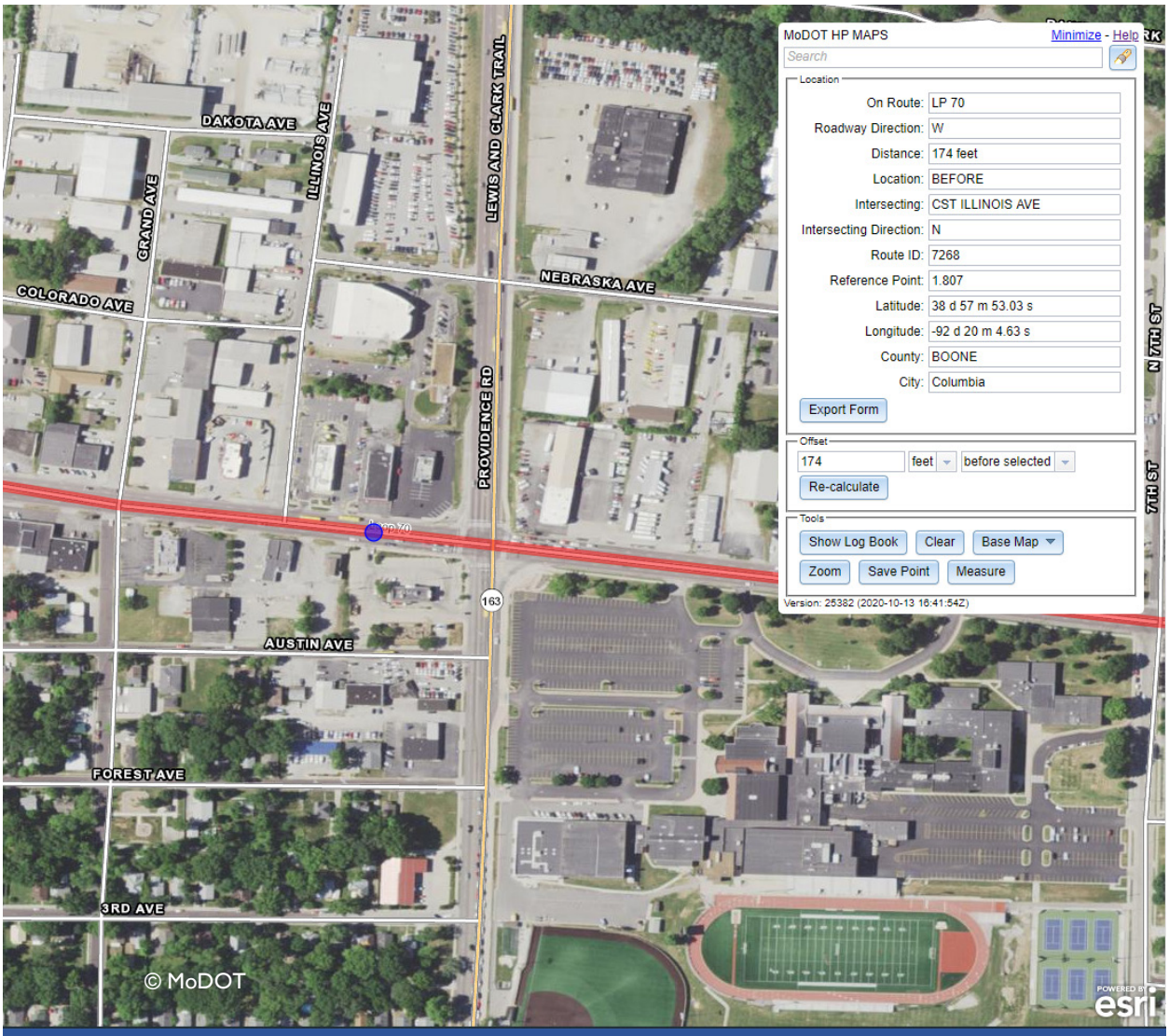

Figure 2. Graphic. Missouri's State Highway Patrol Mapping Tool.

By spatially integrating crash data with the State's road and asset inventories directly within the TMS, MoDOT is able to efficiently manage the State's safety data and produce the comprehensive summary reports that support the State's safety planning efforts, including Missouri's Strategic Highway Safety Plan. The DOT's ability to automatically merge crash data with other spatial data is an example of how standardized data collection workflows and systems (e.g., the crash locations) impacts data integration. Furthermore, inter-agency cooperation with technology solutions provides a framework that reduces duplicate and incompatible data across the State's safety data owners, managers, and users.

Quality Assurance and Control

MoDOT runs a series of standardized, automated, and documented quality control checks on data elements in the TMS each night. These checks identify logical errors or unusual conditions in the data (e.g., roads with a coded median type being misclassified as undivided); the system flags errors for MoDOT staff to investigate. MoDOT's single, authoritative all roads basemap makes performing these checks more efficient. The structured data within the TMS allow the automated checks to run with minimal translation of data (as opposed to a system that relied on converting data elements between basemaps). In addition to automated checks, video logs collected along the network as part of the agency's pavement inventory process allow MoDOT staff to manually note and report any inconsistencies between the video and the data coded in the TMS.

Data Management

MoDOT Partnerships

Institutional partnerships form a key component of MoDOT's data management activities. The TPD and IS units form a steering committee that manages the TMS. The goal of this partnership is to reduce redundancy and enhance data availability. The TPD houses and manages the system, while the IS provides development support and the core funding for the system. Staff from TPD and IS, including director-level staff, meet monthly to discuss new opportunities, ongoing projects, and the status of the TMS. If a specific business unit within MoDOT proposes to make adjustments or additions to the agency's data, TPD or IS will receive the request and communicate the purpose and need to its TMS partner. This collaboration between data stewards and developers helps prevent the creation of systems and data that are not compatible with the agency's enterprise technology.

An example of this cooperation in practice at MoDOT was the recently completed Maintenance Management System (MMS). This two-year effort required weekly interaction between the TPD, IS, and relevant DOT staff, and demonstrates the effectiveness of well-managed spatial data. The MMS platform simplifies tracking of maintenance work performed on the State's roads by spatially locating project bounds on the State's basemap and synchronizing with personnel timesheets. From a safety analysis perspective, this spatially integrated records system allows DOT staff to track work zone-related crashes, among other fiscal, project management, and data integration benefits within MoDOT.

This partnership within MoDOT is able to handle requests for data additions and technology upgrades costing up to $250,000. For larger requests, especially those that could reshape MoDOT's institutional technology and data, the State's TRCC acts as the executive forum for transportation data governance activities. The TRCC strategically plans the State's investment in transportation and safety-related data,

and it programs a mix of Federal and State funds to achieve short- and medium-term goals. In addition to data-related guidance such as the Highway Performance Monitoring System (HPMS) guidelines and the FHWA's *Traffic Monitoring Guide* (FHWA, 2016), the TRCC's Strategic Plan serves as the primary data business plan for the State. As a part of this strategic planning, all major strategic investments in traffic data and technology require a benefit/cost analysis to be approved by the TRCC.

The active and engaged TRCC representing traffic safety partners is key to MoDOT's successful program of enterprise-level data integration. TRCC membership is comprised of a broad coalition of data stakeholders with memoranda of understanding formalizing each agency's participation. The technical TRCC meets monthly to discuss ongoing efforts and new business.

Interagency Data Sharing

A strong relationship with local planning agencies is a critical component of MoDOT's data management program. In addition to collecting map books from local agencies as a means to aggregate local road data, MoDOT also publishes select components of the State's data in a browser-based platform, the TMS Data Zone (figure 3). Prior to the development of Data Zone, MoDOT provided yearly packages of data (e.g., crashes by route) to local partner agencies, such as metropolitan planning organizations (MPOs) and regional planning commissions (RPCs). Local agencies could then query the data for their own analysis purposes.

Although MoDOT still provides this service on an annual basis, the Data Zone provides direct access to select spatial datasets, such as the State's HPMS data and STIP project locations. The State does not publish crash data and other sensitive information publicly, but local partners may access it through Data Zone with MoDOT's approval. MPOs and RPCs may also request additional datasets that are not provided through Data Zone from the State.

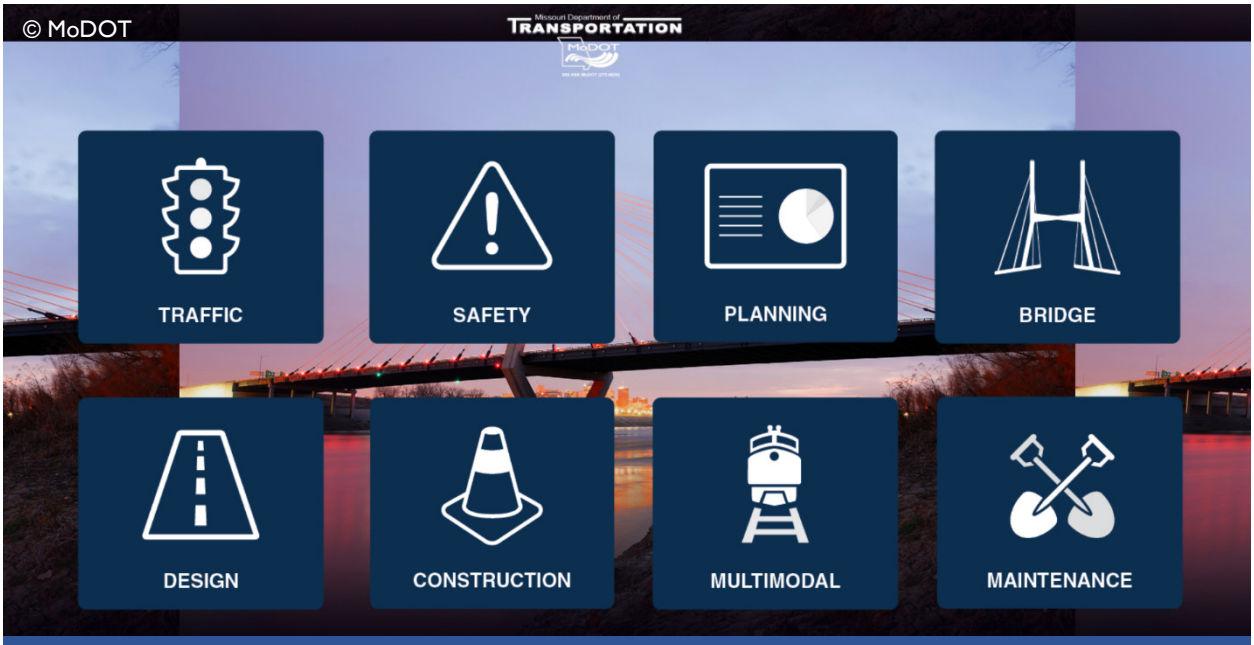

Figure 3. Graphic. MoDOT's Data Zone.

Training

As the SMEs, owners, and stewards of the TMS and MoDOT's transportation data, the TPD provides customer assistance and training to individual data element stewards and end users as needed; however, MoDOT offers biannual training for the State's Traveler Information System in the spring and fall. All data inventories collected and maintained in the TMS have an associated manual and metadata documentation that support training efforts across the agency.

Funding

The TRCC allocates several Federal and State funding streams to manage data and technology improvements in Missouri. MoDOT mostly funds the TMS and many of the technology improvements intended to improve data integration under the IS unit's budget. Within IS's budget, State Planning and Research (SP&R) funds cover most activities related to data integration technology and data management. TPD supplements with funding for customer service and data management activities (e.g., GIS data management), and these are also typically covered by SP&R funds. Individual business units support specific relevant data needs for that unit (e.g., application development for maintenance management).

Challenges

While effective data governance, management, and integration can open data to a broader user base and provide greater efficiency to the core functions at a State DOT, the process of data collection and maintenance still requires active management. The TMS allows MoDOT to store and manage a diverse range of data elements, but individual business units must still be effective stewards of their data and

invest in keeping that data maintained. Data management and data integration can support the enterprise needs across all departments within MoDOT, but it cannot maintain quality, accuracy, and timeliness of data without active management from the responsible data stewards.

Finally, MoDOT has a process by which it acquires certain data elements from local agencies, but not all data collected by local agencies are applicable at the State level. For instance, local agencies might collect traffic counts to support a local analysis (e.g., a signal timing or a traffic impact analysis), but these data may not be sufficient for estimating annual average daily traffic. These data would not be stored in the TMS.

Conclusions and Lessons Learned

MoDOT built its institutional knowledge, data, and partnerships over time, and recognizes that this gradual approach provides stability to the overall data program and with its external partners. The DOT committed to spatial data integration early in the development of the TMS, and it has led to the flexible and expandable repository that exists today. Documentation of the State's transportation data and processes has been an invaluable component of keeping MoDOT's enterprise data organized and available to the authorized users.

The State does not currently have a formalized data governance committee with a documented charter and other formal structures, but the partnership between TPD and IS forms the leadership group that guides the management of data and technology at MoDOT. Furthermore, the State's active and engaged TRCC performs many of the functions, and brings together many of the same partners, that a data governance committee would accomplish (e.g., coordination and integration of data generated outside of the DOT, such as the MSHP's STARS platform and LETS program). The TRCC strategic plan serves as the agency's core data business plan, and projects are prioritized and programmed in this forum. This combination of active management and a commitment to consistent, integrated, spatial data has made MoDOT a leader in the realm of transportation data management.

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