TxDOT Statewide TSMO Data Platform

February 2021

Version 1.1

Prepared By

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DOCUMENT CONTROL		
Date	Version	Description
8-7-20	1.0	Traffic Safety Division Review (Prepared by AECOM)
2-15-21	1.1	Addresses TRF comments and formatting.

List of Acronyms

Acronym	Definition
AI	Artificial Intelligence
API	Application Programming Interface
ATMS	Advanced Traffic Management System
CAT	Cooperative Automated Transportation
CCTV	Closed Circuit Television
CMM	Capability Maturity Model
ConOps	Concept of Operations
CRIS	Crash Records Information System
DMS	Dynamic Message Sign
DOT	Department of Transportation
FHWA	Federal Highway Administration
GIS	Geographic Information System
ICM	Integrated Corridor Management
IT	Information Technology
ITD	Information Technology Division
ITS	Intelligent Transportation Systems
MPO	Metropolitan Planning Organization
NTCIP	National Transportation Communications for ITS Protocol
RITIS	Regional Integrated Transportation Information System
TIM	Traffic Incident Management
TMC	Transportation Management Center
TRF	Traffic Division
TMS	Traffic Management System
TSMO	Transportation Systems Management & Operations
TxDOT	Texas Department of Transportation
USDOT	United State Department of Transportation

1. Introduction

In recent years, the Texas Department of Transportation (TxDOT) has adopted an approach of *"spreading a culture of data"* with a goal of delivering the right information to the right user at the right time to optimize decisions, enhance efficiency and accelerate results (Reference 1).

1.1 TxDOT Data Pyramid

TxDOT has developed Key Performance Measures that are aligned to TxDOT Values, Vision, Mission, Goals and Objectives that were adopted in February 2016. Workshops were conducted with TxDOT Divisions resulting in a Data Pyramid structure. Design of the Data Pyramid was developed for decision-making at the Commission, Administration, and District/Division levels:

- Commission Level – to assist in policy decisions.
- Administration Level – to enhance effective running of the agency by drilling. down on the sub-elements at the Commission level and adding internal operational measures.
- Districts/Divisions Level – to benefit each district and division in managing their processes successfully, it comprises the most granular view of Key Performance Measures.

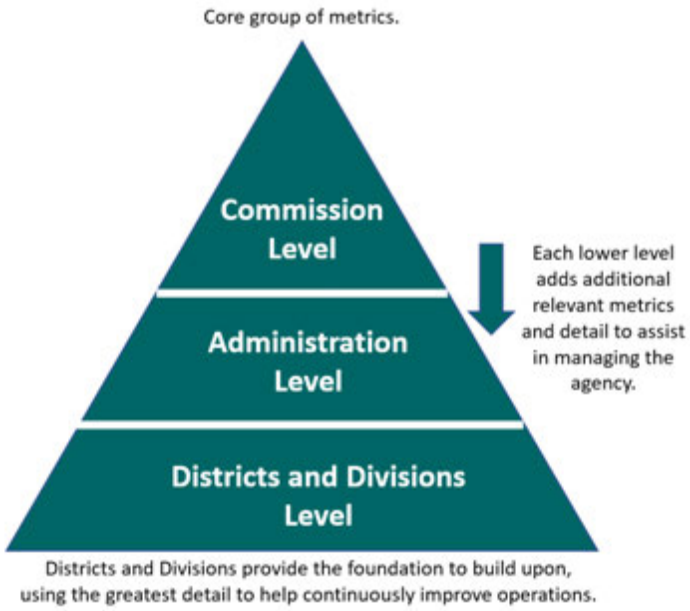

Figure 1: TxDOT Data Pyramid

TxDOT procured and deployed Tableau, in a collaborative effort with the Information Technology Division (ITD), to enable users at all three levels to have access to data and the Key Performance Measures.

Tableau is a data visualization tool used in the Business Intelligence industry. It helps in simplifying raw data into an understandable format. Data analysis and visualizations are created in the form of dashboards. Data created using Tableau can be understood by professionals at any level of an organization. It also allows a non-technical user to create customized dashboards. Tableau is being rolled out to TxDOT staff to empower users, increase usage, and drive a data culture.

1.2 TxDOT Data Lake

TxDOT is currently collecting data from several sources and storing it in a Data Lake. The TXDOT Data Lake is a repository of unstructured data while the Data Mart is a structured data platform that is brokered for specific user needs. A high-level overview of the architecture is presented in Figure 2.

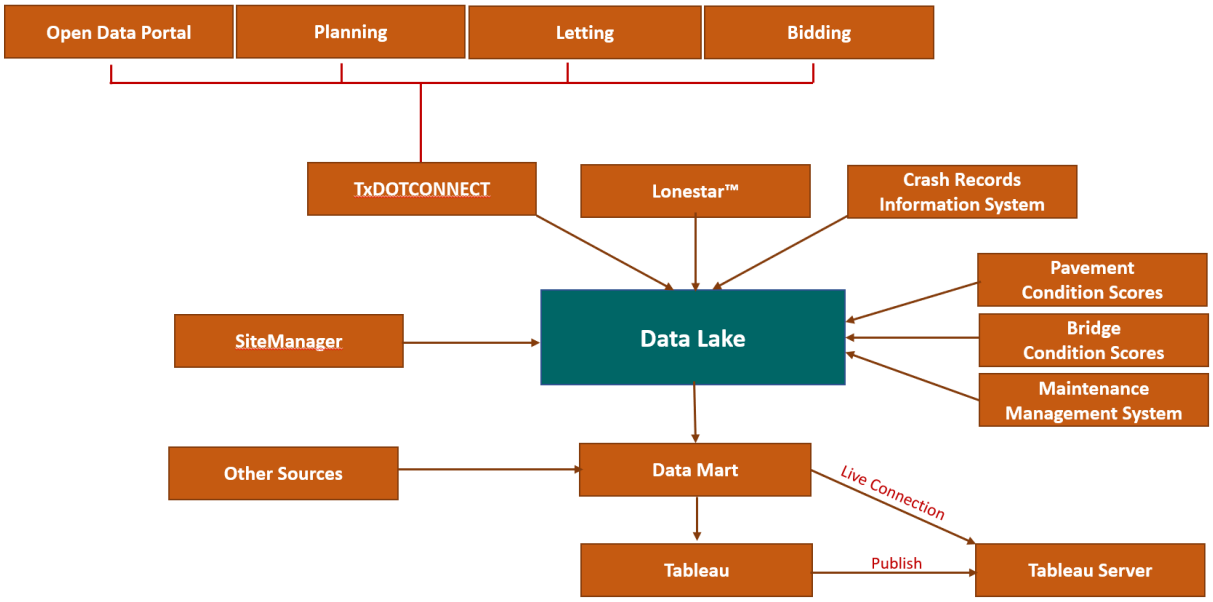

Figure 2: TxDOT Data Lake Architecture

A narrative description of each data source is described below. (Reference 2)

- **Open Data Portal:** The portal is TxDOT's platform for exploring and downloading Geographic Information System (GIS) datasets. It allows searching for data using keywords or categories to quickly view and display content or categories to quickly view and display content. The portal allows users to view datasets on a map, filter data using queries, and download data in various formats. The portal includes data on the following categories:
  - Assets: roadway assets such as reference markers and speed limits;
  - Boundaries: boundary datasets such as TxDOT districts, city limits, counties, legislative districts;
  - Highway Performance Reports: end-of-year roadway inventory, top 100 most congested roadways;
  - Infrastructure: datasets on infrastructure such as facilities, airports, seaports, etc.;
  - Planning: planning datasets including projects, freight networks, and MPOs;
  - Projects: planned and upcoming roadway projects;
  - Roadways: roadway and network datasets, such as control sections and national highway system;
  - Safety: safety-related data including speed limits, guardrails, and hurricane evacuation routes; and
  - Traffic: data such as permanent count stations, annual average daily traffic, and congestion

- **Planning:** TxDOT annually publishes its roadway inventory data in a variety of common GIS and tabular formats. Data includes GIS linework and all roadway inventory attributes. TxDOT submits this data annually to the Federal Highway Administration (FHWA) as part of the Highway Performance Monitoring System program. TxDOT also publishes a series of roadway inventory reports on an annual basis that contain statistics on the use of public roadways in the state. Statistics include miles, lane miles, daily vehicle miles

of travel and daily truck vehicle mileage of travel. These reports are summarized at county, district and state levels and are grouped by highway system, ownership, functional classification, population classification and national highway system categories. Historical chart and tabular summaries are available from 2013 forward. TxDOT also maintains the Statewide Traffic Analysis and Reporting System which is a data analysis and reporting database with detailed traffic data and statistics. Annual average daily traffic data is also available on transportation planning maps.

- **Letting:** TxDOT established its low-bid construction and maintenance contract letting process, which includes providing a public notice of the intent to offer work, issuing and receiving proposals, publicly opening bids, determining the apparent low bidder and executing contracts. Letting schedules and awards are posted on the TxDOT web site.
- **Bidding:** Average Low Bid Unit Prices are tables for individual bid items used in highway construction and highway maintenance projects. The data is organized statewide and by district, and the averages are based on three consecutive months and 12 consecutive months.
- **TXDOTCONNECT:** TXDOTCONNECT is a web-based, custom-built technology system used for automating the delivery of transportation programs, projects, and right of way. It will standardize TxDOT business processes while providing transparency in performance measurement and serve as a one-stop shop for project information and tasks. TXDOTCONNECT provides a GIS database of all projects at a state, district, and county level; funding assigned by project and timeframe; project description and typical section if available; and status of project (e.g., planning, design, construction, letting, etc.).
- **Lonestar™:** Lonestar™ is TxDOT's Advanced Traffic Management System (ATMS) software connecting Transportation Management Centers (TMC) with Intelligent Transportation System (ITS) field devices such as vehicle detectors, dynamic message signs, and Closed-Circuit Television (CCTV) cameras. Lonestar™ enables operational control of these devices and reports their health, status, and any operational data or responses back to the software, which sends commands and requests to the devices. Lonestar™ software makes real-time data received from devices available to all other processes via the command and status distribution process. The database contains configuration and other pertinent information about device identification, location, and communication parameters as well as other details of how the software should behave. Lonestar™ has a center-to-center interface for external systems to provide live traffic data in lieu of field devices as well as providing a channel to send information out for dissemination. The software integrates these devices and data interfaces in many ways that are useful to other operations. Lonestar™ has several software processes that are not device specific to process data and make it usable for various operations. Travel times and event management are two examples.
- **Crash Records Information System (CRIS):** TxDOT retains crash data from Jan. 1, 2010, to present, and will accrue data for 10 calendar years. Records prior to Jan. 1, 2010 have been purged and are no longer available. Summary reports of Texas crash data are published annually. The previous year's data is published by June of the following year. Statistics contained in these reports are generated from data provided by TxDOT's CRIS. Data may be presented in a variety of formats (i.e., location, type, fatalities, injuries, property damage only, etc.). Crash data is available for both highways and arterials.

- **Pavement Condition Score:** The Pavement Condition score is a combined index of ride quality and pavement surface distress, adjusted for traffic and speed. Ride quality is calculated from pavement roughness. Pavement distress is calculated from measuring rut data and surface deterioration such as cracking, patching and failures. Data is collected once a year to determine the surface distresses and ride quality of the pavement on Texas roadways. The data from surface defects and ride quality is then combined to provide an overall score ranging from 1 (worst condition) to 100 (best condition) per lane mile. Percentage of lane miles in good or better condition is the ratio of pavement lane miles on Texas roadways that scored above 70 to the total analyzed lane miles. Tracking pavement quality helps identify roads in need of repair and plan funding for their maintenance and rehabilitation.
- **Bridge Condition Score:** The Bridge Condition score is based on the most severe primary component condition rating. The primary bridge components are deck, superstructure and substructure. The component rating is assigned a value between 9 (excellent) and 0 (failed) based on the overall condition of the component. A combined score for all bridges on Texas roadways is calculated as the average of each individual bridge's numeric score, weighted by deck area, calculated as a bridge's length multiplied by its width. Bridge conditions are typically discussed as a function of primary bridge components. For span-type structures, there are three components that receive condition ratings: deck, superstructure and substructure. Culverts are drainage structures that, if twenty feet in length or longer, are considered bridges. Culverts receive a single condition rating. For both types of structures (span bridges and culverts), the lowest scoring component determines the individual bridge condition score. A corresponding numeric score is then assigned to the bridge. Tracking overall bridge asset condition allows forecasting network performance and determine trends given various funding scenarios for bridge maintenance, repair and replacement.
- **Maintenance Management System:** ServiceNow is an Asset Management software application that TxDOT began using for tracking trouble tickets during 2014 and is now using it for tracking district ITS and signal assets. ServiceNow is hosted on a cloud server system (TxDOTNOW). It recently added a map interface. Incident tickets are submitted and converted to work orders. District staff are being trained on how to use the system by ServiceNow personnel.
- **SiteManager:** This is a software program that automates and streamlines the management of highway construction contracts. A properly maintained daily account of all construction project activities provides valuable documentation of the prosecution of work and related events. The SiteManager Daily Work Report is the official project record for construction projects.

1.3 Current Applications

TxDOT currently uses several dashboard systems including the following:

- **Planning Dashboard System:** A Transportation Systems Management & Operations (TSMO) Planning Dashboard system is under development. This Tableau tool will be useful in: (1) applying a "Scenario Planner" to predict the impacts of construction lane closures (e.g., length, duration, and location of queues); (2) assessing, approving (or rejecting) contractors' requests for extending lane closures beyond specified

hours; (3) providing live data (i.e., traffic speeds, volumes, travel times; status of ITS devices; status of incidents); and (4) archiving historic lane closure information, impacts, and lessons learned resulting from After Action Plans using selected Key Performance Measures (e.g., queue length and closure delays). This system can be linked to the TxDOT DataMart and serve as a tool to track the progress of projects and work programs. As TxDOT is already populating Tableau with Traffic Management System (TMS) operations metrics, this can be a powerful tool in improving situational awareness within each District as well as Statewide.

- **Operations & Maintenance Dashboards:** TMS Metric Dashboards are currently provided for the following TMS Metrics – incident clearance times; ITS asset uptime availability, and travel time reliability. Roadways may be filtered by segment, direction, and priorities. Comparative metrics are displayed in bar charts by month for each of the six metro districts.

1.4 Summary

In summary, the TSMO program should explore how Tableau can be used by TXDOT planning, design, construction, operations, and maintenance in conducting data analytics to continuously improve performance. The purpose of this technical report is to identify TxDOT data needs; evaluate new data generated by public and private sources; and develop the framework for a Data Platform. The existing Data Lake will serve as the foundation for a robust Data Platform to serve the needs of TSMO stakeholders.

2. User Needs

Data is needed by a diverse range of users at the Commission, Administration, District, and Division levels to perform their job more effectively.

2.1 TxDOT Key Performance Measures

TxDOT's performance dashboard focuses on those system and organizational performance measures that are most critical for current and future success. These performance measures are tied to TxDOT's values, vision, mission and goals. These measures are continually refined to improve methods to collect and analyze information, which may impact how visualization of these measures are presented in the future. The goal is to deliver the right information to the right user at the right time to optimize decisions, enhance efficiency, and accelerate results. Table 1 presents the objectives and Key Performance Measures for each of TxDOT's seven goals followed by a listing of TMS metrics. (Reference 2)

Table 1: TxDOT Key Performance Measures

Goal 1 - Optimize System Performance: Develop and operate an integrated transportation system that provides reliable and accessible mobility and enables economic growth.
Objectives
Mitigate congestion.
Enhance connectivity and mobility.
Improve the reliability of the TxDOT transportation system.
Facilitate the movement of freight and international trade.
Facilitate economic competitiveness through infrastructure investments.
Key Performance Measures
Congestion and Reliability Indexes.
Vehicle Miles Traveled.
Annual Delay Per Person.

Goal 2 - Deliver the Right Projects: Implement effective planning and forecasting processes that deliver the right projects on time and on budget.
Objectives
Use scenario-based forecasting, budgeting and resource-management practices to plan & program projects.
Align plans and programs with strategic goals.
Adhere to planned budgets and schedules.
Provide post-delivery project and program analysis.
Key Performance Measures
Percentage of Highway Infrastructure Contracts Completed on Time.
Percentage of Highway Infrastructure Contracts Completed on Budget.

Goal 3 - Promote Safety: Champion a culture of safety.
Objectives
Reduce crashes and fatalities by continuously improving guidelines and innovations along with increased targeted awareness and education.
Reduce employee incidents.
Key Performance Measures
Annual Fatalities and Fatality Rate.
Annual Serious Injuries and Serious Injury Rate.
Fatality Emphasis Areas.
Employee Injury Rate.

Goal 4 - Preserve TxDOT's Assets: Deliver preventive maintenance for TxDOT's system and capital assets to protect investments.
Objectives
Maintain and preserve system infrastructure to achieve a state of good repair and avoid asset deterioration.
Procure, secure, and maintain equipment, technology, and buildings to achieve a state of good repair and prolong life cycle and utilization.
Key Performance Measures
Percentage of Lane Miles in Good or Better Condition.
Bridge Condition Score.

Goal 5 - Focus on the Customer: People are at the center of everything TxDOT does.
Objectives
Be transparent, open, and forthright in agency communications.
Strengthen key partnerships and relationships with a customer service focus.
Incorporate customer feedback and comments into agency practices, project development, and policies.
Emphasize customer service in all TxDOT operations.
Key Performance Measures
Percentage of Customer Complaint Cases Closed on Time.
Customer Complaints (Top 5).
Average TxDOT Call Wait Time.
Average TxTag Call Handle Time.

Goal 6 - Value our Employees: Respect and care for the well-being and development of TxDOT's employees.
Objectives
Emphasize internal communications.
Support and facilitate the development of a successful and skilled workforce through recruitment, training and mentoring programs, succession planning, trust, and empowerment.
Encourage a healthy work environment through wellness programs and work-life balance.
Key Performance Measures
Employee Engagement Score.

Goal 7 - Foster Stewardship: Ensure efficient use of state resources.
Objectives
Use fiscal resources responsibly.
Protect natural resources.
Operate efficiently and manage risk.
Key Performance Measures
Disadvantaged Business Enterprise (DBE) Attainment.
Historically Underutilized Business (HUB) Attainment.
Direct Transportation Funding.
Traffic Management System Metrics
Asset Uptime: A measure of the percentage of traffic cameras, speed sensors, and mainline dynamic message signs which are operational more than 75% of the time.
Incident Clearance Time: A measure of the average time (in minutes) from incident detection to clearance for collisions and disabled vehicles.
Travel Time Reliability on Interstate Highways: A measure of the percentage of interstate highway segments in metro areas in which drivers experience relatively predictable travel time across various times of day.

2.2 User Data Needs

Table 2 below provides a summary of the data needed to support calculation of the above key performance measures as well as the data needed by TxDOT's Districts and Divisions to continuously improve operational performance.

Table 2: User Data Needs

Commission Level
Congestion and Reliability Indexes by District and Facility Type
Vehicle Miles Travelled on State Roads Classified by District and Facility Type
Annual Delay per Person by District and Facility Type
Annual Fatalities and Fatality Rate by District and Facility Type
Annual Serious Injuries and Serious Injury Rate by District and Facility Type
Annual Number of Fatalities by Cause, District, and Facility Type
Administration Level
Employee Engagement Score by District and Job Classification
Volume of Work Performed by Disadvantaged Business Enterprise (DBE) firms as a Prime or Subcontractor
Volume of Work Performed by Historically Underutilized Businesses (HUB) as a Prime or Subcontractor
Direct Transportation Funding per Fiscal Year by District and Funding Category
Number of Employee Injuries by District in Field and in Office
Districts and Divisions Level
Planning
Traffic Counts by Facility/Segment (Average Daily Traffic, Peak Hour, Intersection Turning Movement Counts)
Congestion Locations by Facility/Segment or Intersection(s)
Population and Employment by Traffic Analysis Zone (Present and Future)
Traffic Projections by Facility/Segment
Crash Records by Facility/Segment and Intersections
CCTV Images of High Crash Locations to Study Travel Behavior or Other Issues (e.g., Sun in Driver's Eyes)
Planned and Programmed Transportation Improvement Projects
Strategic Highway / Freight / Multimodal Transportation Network GIS Maps (Present and Future)

Design
% Traffic During Peak Hour by Facility/Segment (K Factor)
% Directional Distribution During Peak Hour by Facility/Segment (D Factor)
% Trucks by Facility/Segment (T Factor)
18K Equivalent Axle Loads by Facility/Segment
Utility Locations within the Roadway Right-of-Way
Roadway Segments Prone to Flooding
As-Built Plans
Right-of-Way Maps
Construction
Number and Type of Construction Projects by Facility/Segment
Number of Construction Projects Completed On Time considering Approved Change Orders
Number of Construction Projects Completed On Budget considering Approved Change Orders
Approved Lane Closure Permits (Time, Duration, Number of Lanes Closed, Limits)
Operations
Travel Time Reliability by Facility/Segment
Incident Clearance Times
Signal Phasing and Timing
Number and Type of Customer Complaints
Number and Type of Customer Complaint Cases Closed on Time
TxDOT Call Wait Times
TxTag Call Handle Time
Maintenance
TMS Asset Uptime by Device Type
TMS Mean Time Between Failures by Device Type
TMC Communications or Power Loss to Field Devices (% Uptime Availability)
Pavement Condition Scores by Facility/Segment
Bridge Condition Scores

2.3 Summary

In summary, the above represents the start of a "User Data Needs" list for the identified classification of user groups. As the Data Platform is advanced through the Systems Engineering process, additional data needs are anticipated to be identified. As connected automated vehicles become more commonplace, they will be generating new data sets that will likely have applications yet to be determined.

3. Data Platform

This section introduces the concept of advancing the Data Lake into a more robust Data Platform to serve the needs of TSMO stakeholders.

3.1 Data Platform Functions

TxDOT has adopted a TSMO vision and mission statement as presented below.

- **TSMO Vision Statement:** Improve safety and mobility for all modes of transportation by integrating planning, design, operations, construction, and maintenance activities and acknowledging all opportunities for innovation.
- **TSMO Mission Statement:** Through innovation, collaboration, and performance-based decision making, transportation facilities are developed, constructed, maintained, and operated cost-effectively, with the end user in mind.

In support of the above TSMO vision and mission statements, the "TxDOT Statewide TSMO Strategic Plan" was prepared and recently updated. TxDOT has an active TSMO program that includes a broad range of integrated strategies as shown in Table 3 below.

Table 3: TSMO Operations Strategies

Operations Strategies	
Work Zone Management	Traffic Signal Coordination
Traffic Incident Management	Traveler Information
Service Patrols	Ramp Management
Special Event Management	Managed Lanes
Road Weather Management	Active Traffic Management
Transit Management	Integrated Corridor Management
Freight Management	Rural Emergency Response

Each of these TSMO strategies, individually and collectively, generate significant amounts of data. As emerging technologies such as connected and automated vehicles come online in the future, this will generate substantially more information in real time (e.g., 10 data per second). Therefore, development of a Data Platform is needed to collect, store, and apply data generated from these programs and create a user-friendly, reliable, and repeatable data analytics and reporting platform. This data platform could be used by TxDOT executives, managers, and staff, as well as other stakeholders, for multiple purposes including real-time decision-making, short and long-term planning, and performance assessment. The Data Platform will require the following activities to be conducted (Reference 3):

- Collect and ingest data generated from TSMO projects.
- Develop device drivers, as needed, to ingest data from field devices into the Data Platform.
- Support development of data compression platforms such as edge or fog computing to manage the impact of massive data collection from field devices on the communication infrastructure and networks.
- Manage data security at the field level and integrate data transmission through the districtwide and statewide ITS communication networks.
- Coordinate with and integrate additional data sources and systems.
- Develop Application Programming Interfaces (APIs), as needed, to ingest data from other systems into the Data Platform.
- Provide data storage, security, normalization, filtering, and aggregation.
- Develop real-time and predictive analytics and tools with real-time and historical visualization dashboards and reporting capabilities.
- Write and publish data requirements, APIs, and specifications needed for future Cooperative Automated Transportation (CAT) deployments.

The Data Platform will provide management of data originated from a variety of sources resulting in useful real time information for all TxDOT TSMO projects. It will leverage existing infrastructure such as traffic signal controllers and detection devices to extract information and develop useful analytics for TSMO project outcome assessments at the required resolution and distribute data processing capabilities throughout the state of Texas.

3.2 Other Data Sources

The Data Platform would perform analytics using the ingested data and systems such as the Lonestar™ ATMS software and other sources. A fully integrated Data Platform including both traditional TSMO data and data from emerging CAT sources will provide the most opportunities for innovative data analytics. Other data sources may include:

- Bluetooth Readers
- 3rd Party Travel information Providers (i.e., WAZE, INRIX, HERE)
- Regional Integrated Transportation Information System (RITIS)
- Probe Vehicles

Figure 3 below presents a Data Flow Diagram being considered by the Florida DOT for a similar Data Platform (Reference 3) and may be applied as a starting point for the TxDOT Data Platform.

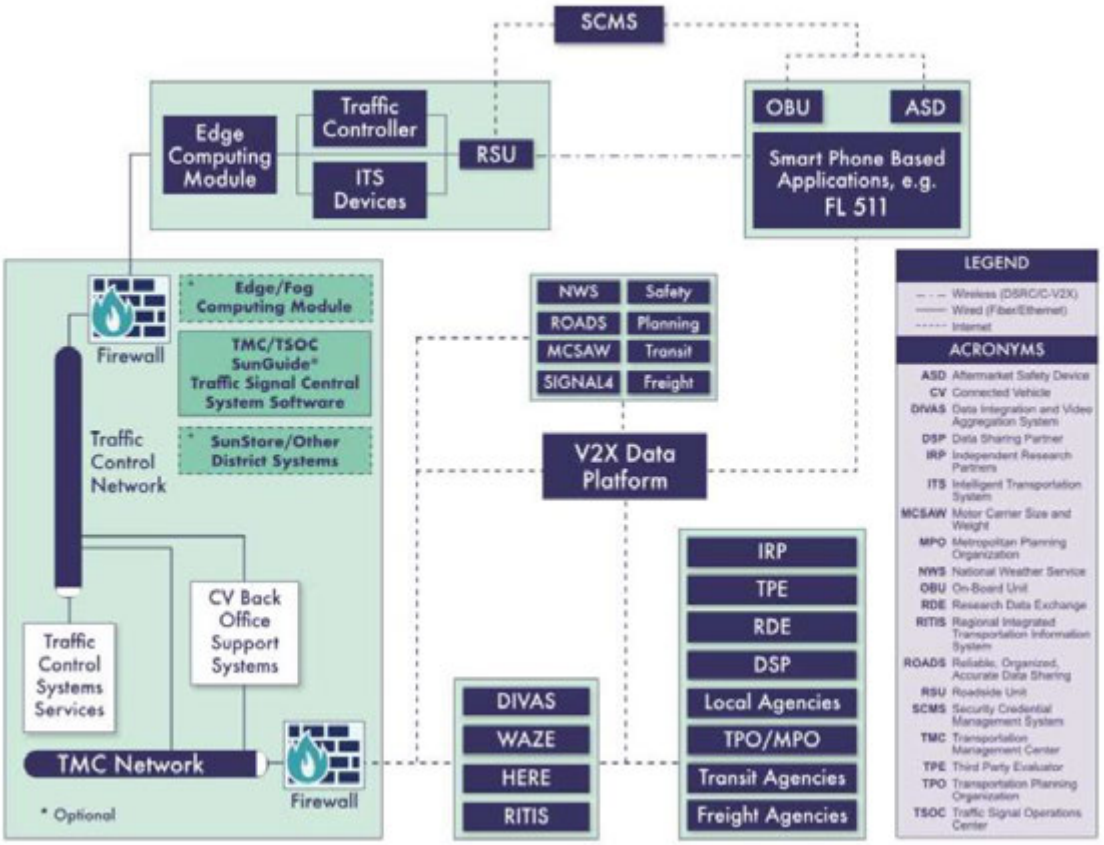

Figure 3: Data Platform Being Considered by the Florida DOT

TxDOT may consider hosting the Data Platform on a cloud to enable users to conduct analysis within their own environment. The cloud enables a secure, scalable, and reliable system to ingest data generated by public and private sources. APIs would be applied by the various users to access and manage the data. The cloud provides a flexible model for accessing historic and real time data; enables research offline in developing machine learning and predictive algorithms; offers an open architecture to integrate new data sets generated by emerging technologies; and is adaptable to serving other business needs as they are defined in the future. Care should be taken to only ingest data needed to be stored while interfacing with other data systems continuing to reside on their own servers. Furthermore, while it is not anticipated that CCTV images will be archived, data generated by video analytics could be stored for specific applications as needed (e.g., analysis of high crash location). This approach will enable more efficient management of data storage requirements and costs. As new data becomes available to replace older versions, alerts should be forwarded to the appropriate user groups.

3.3 Summary

In summary, the Data Platform would provide back-end solutions to data management and analytics for TSMO operational type scenarios. The Data Platform is not intended to provide safety-critical applications where microsecond (or less) latency is required. In the context of this initiative, therefore, real-time is intended to mean that when data becomes available to the Data Platform, that it is readily usable and that the analytics tools developed have minimal operational latency.

4. Use Case Scenarios

The Data Platform would be available to a broad range of users for various applications. These applications should address data needs at the Commission, Administration, District, and Division Levels. The following Use Case scenarios are provided to illustrate a representative sample of potential applications.

4.1 Commission Level

Performance dashboards would be available to Commissioners to readily assess the performance of TxDOT's transportation system based on the approved Key Performance Measures aligned with the seven goals. For example,

- A concerned citizen indicates that a roadway segment is always congested resulting in severe traffic delays. The Commissioner can access the congestion and reliability indexes for the roadway segment to verify the validity and severity of the problem so that appropriate follow up action (e.g., capacity or operational improvement) can be initiated, if necessary.
- A Commissioner needs to understand TxDOT's progress towards Mission Zero in *"achieving zero fatalities on roadways by 2050 and cutting fatalities in half by 2035."* The Commissioner can access the Data Platform to view the trends in the number of statewide fatalities in recent years and report on his findings at the next Commission meeting for TxDOT to take appropriate action, if necessary.
- The Commission is about to receive a briefing on employee morale within TxDOT. As part of the agenda packet, the trends in "Employee Engagement Scores" are provided to determine the effectiveness of recent engagement initiatives.

This high-level application in having Commissioners view data on the Data Platform provides a valuable tool to maintain transparency and accountability in achieving TxDOT's values, vision, and goals.

4.2 Administration Level

Data would be accessible to Administration Level Managers to monitor, report, and make recommendations on actions needed to achieve approved Key Performance Measures where they are held accountable. For example,

- TxDOT has specific goals on the amount of work being performed by DBE and HUB firms. The Procurement Manager can access the Data Platform to view current trends and determine if corrective action is needed.
- A new Safety Manager was hired to replace the previous manager who recently retired. Her initial task is to assess the existing Safety program and make improvements if necessary. She accesses the Data Platform, views trends in "Employee Injury Rates", identifies problem areas and root causes, then modifies the Safety Improvement Plan accordingly.

- A Private Sector Partner desires to explore a partnership with the TxDOT. This partner requests to receive the data it sees on the Data Platform after discussing it with TxDOT representatives. In return, TxDOT would like to ingest the private sector partner's data into the Data Platform.

Administration Managers need access to the Data Platform to enable them to more efficiently perform their job with transparency and accountability in complying with Department policies, guidelines, and directives.

4.3 Districts and Divisions Level

TxDOT District and Division staff are charged with the day-to-day functions of Planning, Design, Construction, Operations, and Maintenance. They would benefit by having access to the Data Platform in making data-driven decisions. For example,

4.3.1 Planning

Planners would be one of the primary beneficiaries of a Data Platform in supporting their functional responsibilities including identifying, prioritizing, and programming projects to be included in the short and long-range transportation plans. For example,

- A District Planning Engineer is preparing a list of projects to be considered for the upcoming work program. He views information on his dashboard on locations which have the worst recurring congestion, traffic signals that need upgrading for an upcoming TSMO project, and related performance measures. He applies the Key Performance Measures in helping to prioritize these projects based on need and cost effectiveness.
- A Planner is developing traffic forecasts using a transportation planning model that needs calibration and validation. She uses the traffic data on the Data Platform to provide the baseline conditions to support these efforts.
- TxDOT receives a grant from the United State Department of Transportation (USDOT) for a model deployment that requires a before-and-after study to evaluate the effectiveness of the program. The USDOT and their independent evaluator can use the Data Platform to store data and provide the necessary analytics to determine and document the benefits.

Planners can also use the information on the Data Platform to support presentations to Metropolitan Planning Organizations (MPO), TxDOT Executives, and other stakeholders in providing input to subsequent tasks such as Conceptual Design and Project Development & Environment Studies.

4.3.2 Design

Design Engineers have various uses for data residing on the Data Platform as they pertain to geometric design, pavement design, bridge design, traffic capacity analyses, traffic safety analyses, etc. While existing data sets serve today's needs, they may be augmented by considering new data sets (e.g., frequency and severity of flooding) to enable engineers to consider a broad range of factors impacting roadway design. For example,

- Peak hour traffic volumes and forecasts residing on the Data Platform are accessed to study a weaving section for proposed express lanes to be constructed along an Interstate Highway. The Design Engineer analyzes the data in determining the proper spacing and location of access and egress points between the general-purpose lanes and express lanes.
- A roadway improvement project includes adding new lanes as well as resurfacing existing lanes. Pavement Condition Scores residing on the Data Platform are used by the Design Engineer to determine whether the existing pavement is salvageable based on its current condition and projected residual service life.
- The Crash Records Inventory System is used to identify the worst locations based on crashes per vehicle mile travelled. The data is further analyzed using collision and condition diagrams to determine the root cause of crashes and possible mitigation measures. Connected vehicle data and data derived from video analytics is used to study travel behavior. Data extracted from the Data Platform is then used to support the calculation of benefit-cost ratios to select the most cost-effective solution.

Design Engineers may have other applications of the Data Platform such as supporting a Road Safety Audit (RSA) team. RSAs are a formal examination of the design components and the associated operational effects of a proposed or existing roadway from a safety perspective. RSAs are performed by a team who represent a variety of experience and expertise (e.g., design, traffic, maintenance, construction, safety, local officials, enforcement personnel, first-responders, human factors) specifically tailored to the project. Designers will have an opportunity to "think outside the box" by having the ability to analyze various data sets in combination to discover non-traditional solutions to traffic safety and operational problems.

4.3.3 Construction

Construction Engineers and Inspectors would interface with the Data Platform primarily through SiteManager which is the official project record for construction projects. The Data Platform offers valuable information on the status of each construction project. For example,

- Provides a status report summarizing which construction projects are on time and within budget considering all approved change orders. This is an important Key Performance Measure that is visible at all levels of the Department (i.e., District, Division, Administration, Commission).
- Provides traffic data to make decisions on whether to approve lane closure permits for construction operations (e.g., time and duration of lane closures).
- Enables Construction Engineers and managers to make decisions on whether different construction projects within the same corridor have conflicting maintenance of traffic plans that will adversely impact traffic safety and operations.

The Data Platform can also be applied for other uses such as analyzing the merits of change orders and time extensions as well as providing the information needed to resolve disputes between the Department and Contractor.

4.3.4 Operations

Traffic Operations Engineers have a variety of uses for historic and near real-time data residing on the Data Platform. This information is critical in identifying hot spots in terms of incidents and bottlenecks and quickly implementing incident management and mitigation plans. For example,

- A TMC Operations Manager identifies a major crash along the Interstate Highway that involves a truck rollover with a hazardous materials spill that is anticipated to close all northbound lanes for at least four hours. She accesses the Data Platform to determine which diversion routes are available, and special signal timing plans to be activated, as indicated in the standard operating procedure included in the interagency agreement with the municipality it traverses.
- A District Engineer receives an email from a citizen about traffic congestion on a state road with TSMO infrastructure. The District Engineer views performance measures of the road in real time and pulls its historical information. The District Engineer discusses the current and past traffic volumes, congestion, and other information obtained from other sources with the citizen, then notifies the appropriate party to take action to resolve the issue.
- A Traffic Engineer is responsible for managing hundreds of signals in her agency. She views the information on her screen with ITS devices that indicates a queue is forming on the Interstate Highway that could potentially lead to a crash. It presents her with choices to notify law enforcement and issue warning messages on dynamic message signs about heavy congestion ahead. At this point, the Lonestar™ ATMS software posts the appropriate information on the applicable dynamic message signs.

As connected vehicles achieve a higher level of vehicle fleet penetration in the future, the data stored on the Data Platform will become more robust enabling the development of predictive algorithms. This predictive data would be ingested by decision support systems. This will enable TMCs to become significantly more proactive in addressing problems before they occur.

4.3.5 Maintenance

Maintenance Engineers will also benefit from information they can access on the Data Platform. This information includes Pavement Condition Scores, Bridge Condition Scores, as well as TMS Metrics. For example,

- A District Maintenance Engineer reviews the Bridge Maintenance Scores as well as data generated by bridge sensor systems for all bridges within his District. This information is used to prioritize bridge maintenance, repair, and replacement.
- Similarly, a District Maintenance Engineer reviews the Pavement Condition Scores for all roadway segments within his District and uses this information to schedule repairs, rehabilitation, and resurfacing contracts for upcoming fiscal years.
- TMS metrics are reviewed as part of monthly dashboards posted on the Data Platform. This information is used to assign in-house as well contract employees to address preventive, corrective, and emergency repairs

on CCTV cameras, dynamic message signs, vehicle detectors, lane control signs, and communication systems.

As Asset Management Systems evolve to meet the Department's needs, Maintenance Engineers should have a seat at the table in defining the type of data to be stored as well as its format and content.

4.4 Summary

In summary, the Use Case Scenarios presented herein addresses the core functions by executives, managers, and staff operating at different levels, districts and divisions. The Data Platform architecture should be designed to provide flexibility, adaptability, and scalability to meet the needs of virtually all users as they develop and apply APIs to address their specific needs.

5. Recommendations

The Data Platform enables users to access transportation data in one location. The fusion of data sets into a single platform provides analysts with relief from tedious and repetitive data analytic tasks, and also provides managers with better information with which to make short-term and long-term decisions about the transportation system. The following recommendations are provided to advance the existing Data Lake into a more robust Data Platform:

- The Data Platform should be designed to support the migration of data as sources change over time. The platform architecture should be developed with maximum scalability and extensibility to accommodate future data needs, including connected automated vehicles, while providing data safeguards, security, and appropriate access for system users.
- A Data Manager should be assigned to champion the development, implementation, and maintenance of the Data Platform in terms of quality control of data; normalization of disparate data sets generated by different sources (e.g., travel times); and development of APIs for each user group by applying consistent methods.
- Apply the Systems Engineering process to develop a Concept of Operations and system requirements for the Data Platform by conducting formalized user workshops with the Planning, Design, Construction, Operations, and Maintenance Divisions as well as users representing Administrators and Commissioners.
- Establish a Configuration Management Board, and Systems User Group, to address upgrades or new APIs in addressing evolving data needs. For example, this may include the need for machine learning algorithms and decision support systems in beginning to automate (or semi-automate) manual processes. The Systems User Group would identify needed changes and propose them to the Change Management Board for approval and securing funding.

In summary, the Data Platform should be designed to "deliver the right information to the right user at the right time to optimize decisions, enhance efficiency, and accelerate results." The Data Platform has the potential to enable TxDOT staff, consultants, contractors, and stakeholders to be more entrepreneurial in applying data to innovate in performing their jobs more efficiently and creating new solutions to align with TxDOT's TSMO vision, mission, and goals.

References

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