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16. Abstract

The operation and management of the transportation network generates enormous amounts of data. These data are a valuable asset to TxDOT users and, increasingly, external users as well. Frequently, data formats are incompatible and the data reside on incompatible storage media with different levels of accuracy and resolution. As a result, districts are finding that managing their operations data is an increasingly difficult task, which is only getting worse as the amount of data produced continues to grow. These inefficiencies result in unnecessary data redundancy, data integrity and quality control problems, underutilization of the data, and higher operating costs.

This report summarizes research conducted to assess transportation operations data characteristics, with a focus on data needs, data flows, and recommendations to help optimize the production, use, and archival of transportation operations data. The report describes the process to characterize current and potential data operations user needs, summarizes procedures and systems other state DOTs use for managing transportation operations data, describes a database model that represents information collected through surveys, summarizes relevant data management practices and implementation plans at TxDOT, outlines strategies for managing the data, and formulates implementation guidelines.

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TRANSPORTATION OPERATIONS DATA NEEDS AND RECOMMENDATIONS FOR IMPLEMENTATION

by

Cesar Quiroga, P.E.
Associate Research Engineer

Khaled Hamad
Assistant Research Scientist

Robert Brydia
Associate Research Scientist

Rajat Rajbhandari
Assistant Research Scientist

Robert Benz, P.E.
Associate Research Engineer

and

Srinivasa Sunkari, P.E.
Associate Research Engineer

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TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

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LIST OF ACRONYMS, ABBREVIATIONS, AND TERMS

AADT	Annual Average Daily Traffic
ADMS	Archived Data Management System
ADUS	Archived Data User Service
ATMS	Advanced Traffic Management System
BNP	Business Need Priority
C2C	Center to Center
CAD	Computer Aided Design
CCTV	Closed Circuit Television
COTS	Commercial-Off-The-Shelf
CSJ	Control Section Job
DCIS	Design and Construction Information System
DFD	Data Flow Diagram
DMS	Dynamic Message Sign
DOT	Department of Transportation
FHWA	Federal Highway Administration
FMS	File Management System
FTP	File Transfer Protocol
GAIP	GIS Architecture and Infrastructure Project
GIS	Geographic Information System
Hazmat	Hazardous Material
HCRS	Highway Condition Reporting System
HPTMS	Highway Project Task Management System

HOV	High Occupancy Vehicle
ICM	Integrated Corridor Management
ISD	Information Systems Division
ITS	Intelligent Transportation Systems
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
MST	Main Street Texas
LCS	Lane Control Signal
LOS	Level of Service
NGS	Network Ground Set
PS&E	Plans Specifications and Estimates
ROW	Right of Way
RSS	Rich Site Summary or Really Simple Syndication
SMS	Short Message Service
SwRI	Southwest Research Institute
TTI	Texas Transportation Institute
TMC	Transportation Management Center
TMDD	Traffic Management Data Dictionary
TP&P	Transportation Planning and Programming Division
TRM	Texas Reference Marker
TxDOT	Texas Department of Transportation
WFS	Web Feature Service
WMC	Web Map Context

WMS	Web Map Service
XML	Extensible Markup Language

CHAPTER 1. INTRODUCTION

The operation and management of the transportation network generates enormous amounts of data. Examples include real-time and archived intelligent transportation system (ITS) data; work zone and lane closure data; maintenance data; signal system data; traffic count data; crash data; aerial photography; and drawings depicting features such as highway alignments, pavement markings, ITS equipment, and traffic signal equipment. These data are valuable assets to TxDOT users and, increasingly, external users as well.

Frequently, data formats are incompatible, and the data reside on incompatible storage media with different levels of accuracy and resolution. As a result, districts are finding that managing their operations data is an increasingly difficult task, which is only getting worse as the amount of data produced continues to grow. This situation makes it very challenging for district personnel to be familiar with the wealth of data at their disposal and the applications/procedures that can make full, effective use of the data. These inefficiencies result in unnecessary data redundancy, data integrity and quality control problems, underutilization of the data, and higher operating costs.

This report summarizes research conducted to assess transportation operations data characteristics, with a focus on data needs, data flows, and recommendations to help optimize the production, use, and archival of transportation operations data. The research resulted in two products: 0-5257-P1 (which describes a database model that represents information collected through surveys) and 0-5257-P2 (which describes strategies and recommendations for implementation). The report describes the process to characterize current and potential data operations user needs, summarizes procedures and systems other state departments of transportation (DOTs) use for managing transportation operations data, describes a database model that represents information collected through surveys, summarizes relevant data management practices and implementation plans at TxDOT, outlines strategies for managing the data, and formulates implementation guidelines.

This report is organized as follows:

- Chapter 1 is this introductory chapter.
- Chapter 2 characterizes transportation operations data needs and practices. The database model in this chapter constitutes product 0-5257-P1.
- Chapter 3 provides a review of pertinent data management practices and implementation plans at TxDOT.
- Chapter 4 includes a summary of findings and outlines strategies and recommendations for implementation (which constitutes product 0-5257-P2).

CHAPTER 2. CHARACTERIZATION OF TRANSPORTATION OPERATIONS DATA

INTRODUCTION

This chapter describes processes that generate and use transportation operations data at TxDOT in terms of procedures, data/information flows, computer resources, and stakeholders. The researchers surveyed current and potential operations data users to fully characterize their needs. This work resulted in the development of a catalog of operations personnel data needs as well as data needs that other users (both internal TxDOT users and external users) could have concerning operations data. This chapter also provides a summary of procedures and systems other state DOTs use for managing transportation operations data. The analysis uses results from a survey of transportation operations data managers in Virginia, Florida, Washington, and California.

GENERAL DATA MANAGEMENT PRINCIPLES

Having appropriate data is the starting point, ending point, and the heart of virtually any application within transportation operations. Example applications include freeway incident detection, ramp metering, traffic signal adaptive control and many more. A critical issue for any application is that without the right data, correct data, and reliable data, any effort or action built upon that information will not provide the expected results. Having the ability to easily access the data is also critical.

Given the importance of these applications and the criticality of the data needs, it is therefore vital to manage data as an enterprise resource. While an entire storehouse of data can be expensive to collect, process, manage, and deliver, the alternative is multiple, independent, single-use data delivery systems. It is a generally accepted fact that it is more practical and efficient to manage data at the enterprise level where it can serve multiple needs and applications simultaneously.

Understanding Application Data Needs

There are numerous applications that use data in connection with transportation operations. Apart from the applications, there are a number of other factors to consider, including the following:

- Spatial resolution. Does that application need a point source, a corridor source, or a systemwide outlook? The question of spatial resolution is even more critical when comparing application need to data availability. If corridor or systemwide data are not available, it may be necessary to “construct” the data from point sources, which involves data and time calculations as well as potential inaccuracies and assumptions.

- Temporal resolution. Some applications, particularly those used in support of real-time information, use very frequent data points to power the analysis. Some applications with inductive pavement loops use data at the sub-second level of detail. On the other extreme, some systemwide assessments of traffic flow may use data at considerably higher levels of aggregation, e.g., day, week, or month. Devising a data storehouse that can simultaneously satisfy all of the application needs for temporal resolution is a critical, and very difficult, task.

- Data accuracy and precision. Data should be accurate, i.e., provide values equal to or near the true value. Data should also be precise, so that simultaneous measurements provide values that are very close to each other. However, it is widely known that some aspects of transportation data suffer from significant problems in both accuracy and precision. A data management system should identify suspect or invalid data and flag the data use to prevent the misuse or misinterpretation of any application results.

- Data reproducibility. Data should be sufficiently consistent to enable the replication of application results with different data sets.

- Data sampling intervals. If the application receives data points continuously but it only keeps a subset of the data, it is critical to know the sampling interval and understand its effect on application results.

- Metadata. The data characteristics detailed above are critical to the use of data and can have a substantial effect on application results. It is also critical to consider that in reality, all those characteristics are also data. To distinguish between the two types of data, commonly accepted terminology uses "resource" to designate the raw (or aggregated) data and "metadata" to designate the characteristics of the resource.

The Need for Data Management

One of the most significant challenges in creating and managing data repositories is combining resource data and metadata in an efficient mechanism that adapts to the needs of the various applications as well as the needs of different users. Without the metadata, users typically do not understand the limitations or ramifications of the data, resulting in process inefficiencies, inaccuracies, and unmet application needs.

Designing a system that addresses both data needs and takes into consideration data and metadata characteristics typically requires a development environment within an enterprise architecture. Within the context of data management, a viable definition of enterprise architecture would be the application of a comprehensive strategy to describe and utilize transportation data to support an agency's goals and strategic direction. Essentially, the enterprise architecture of a data management system is a business procedure to optimize the collection, processing, administration, and delivery of data.

PREVIOUS TRANSPORTATION OPERATIONS DATA MODELING EFFORTS

A brief review of relevant work in the transportation operations data modeling area follows.

The National Intelligent Transportation System Architecture

The National ITS Architecture provides a reference framework for planning, defining, and integrating systems that use computing, sensing, and communication technologies to address a host of transportation operation problems (*1*). As Figure 1 shows, the National ITS Architecture describes the following:

- functions to perform, e.g., gather traffic information, in order to implement user services;
- physical entities or subsystems where these functions reside (e.g., traffic management center (TMC), roadside, in-vehicle);
- interfaces and data flows between functions and physical subsystems; and
- the communication requirements for the information flows (e.g., wire line or wireless).

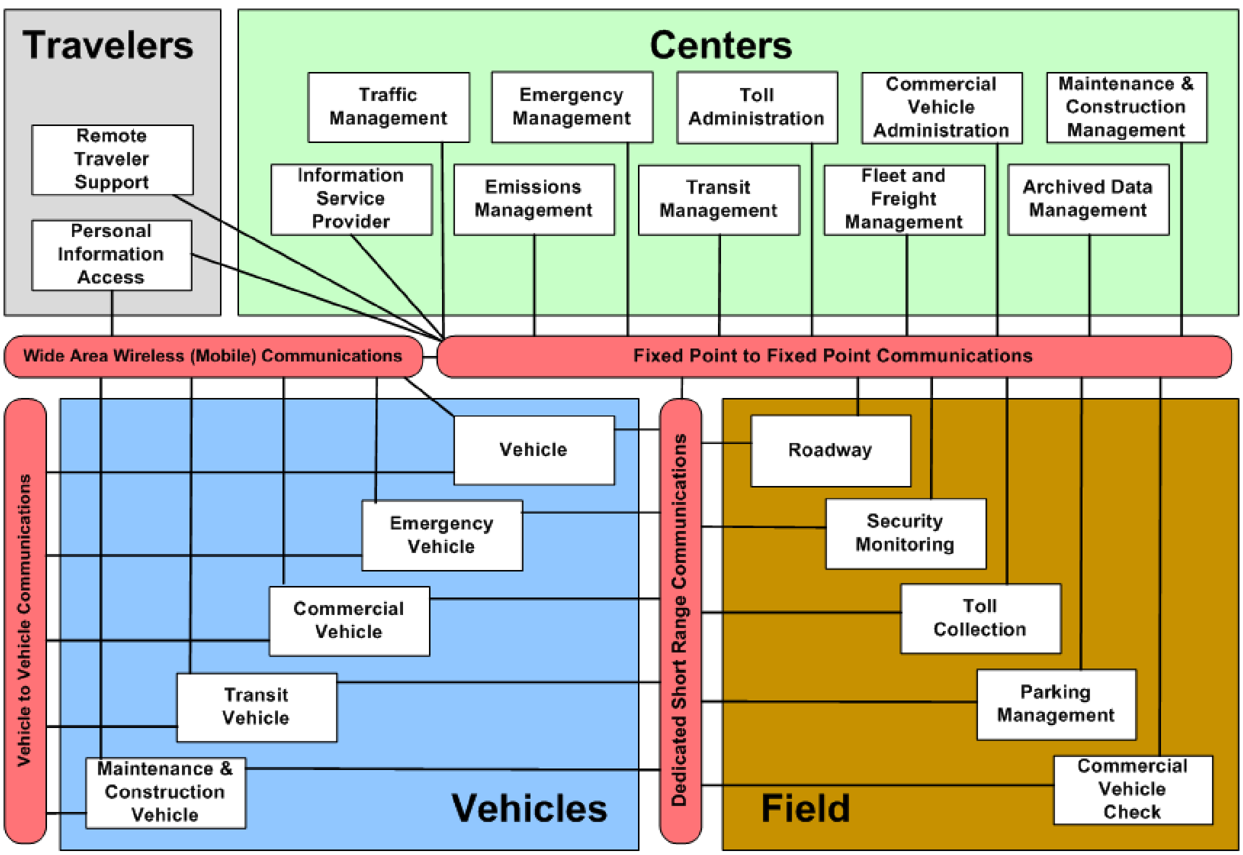


Figure 1. National ITS Architecture Subsystems (*1*).

The National Architecture includes the following components (*2*):

- *User Services*: User Services represent what the system will do from the perspective of the user. A user might be the public or a system operator. Currently, there are 33 user services bundled into eight categories: travel and traffic management, public transportation management, electronic payment, commercial vehicle operations, emergency management, advanced vehicle safety systems, information management, and maintenance and construction management.

- *Logical Architecture*: The logical architecture defines processes (i.e., activities and functions) required to satisfy the functional requirements of the 33 user services. It consists of processes, data flows, terminators, and data stores. The logical architecture relies on data flow diagrams (DFDs) at various decomposition levels to convey information to users (Figure 2).

- *Physical Architecture*: The physical architecture provides agencies with a physical representation (although not a detailed design) of how the system should provide the functionality defined by the user services. The physical architecture classifies the functionality defined in the logical architecture into physical subsystems (Figure 1) based on functional similarity of process specifications and physical locations of functions within the transportation systems.

The common structure the National ITS Architecture provides can be tailored to meet a region's unique transportation needs. Almost all major urban areas in Texas have developed their own regional ITS architectures using the framework of the National ITS Architecture (*3*, *4*, *5*).

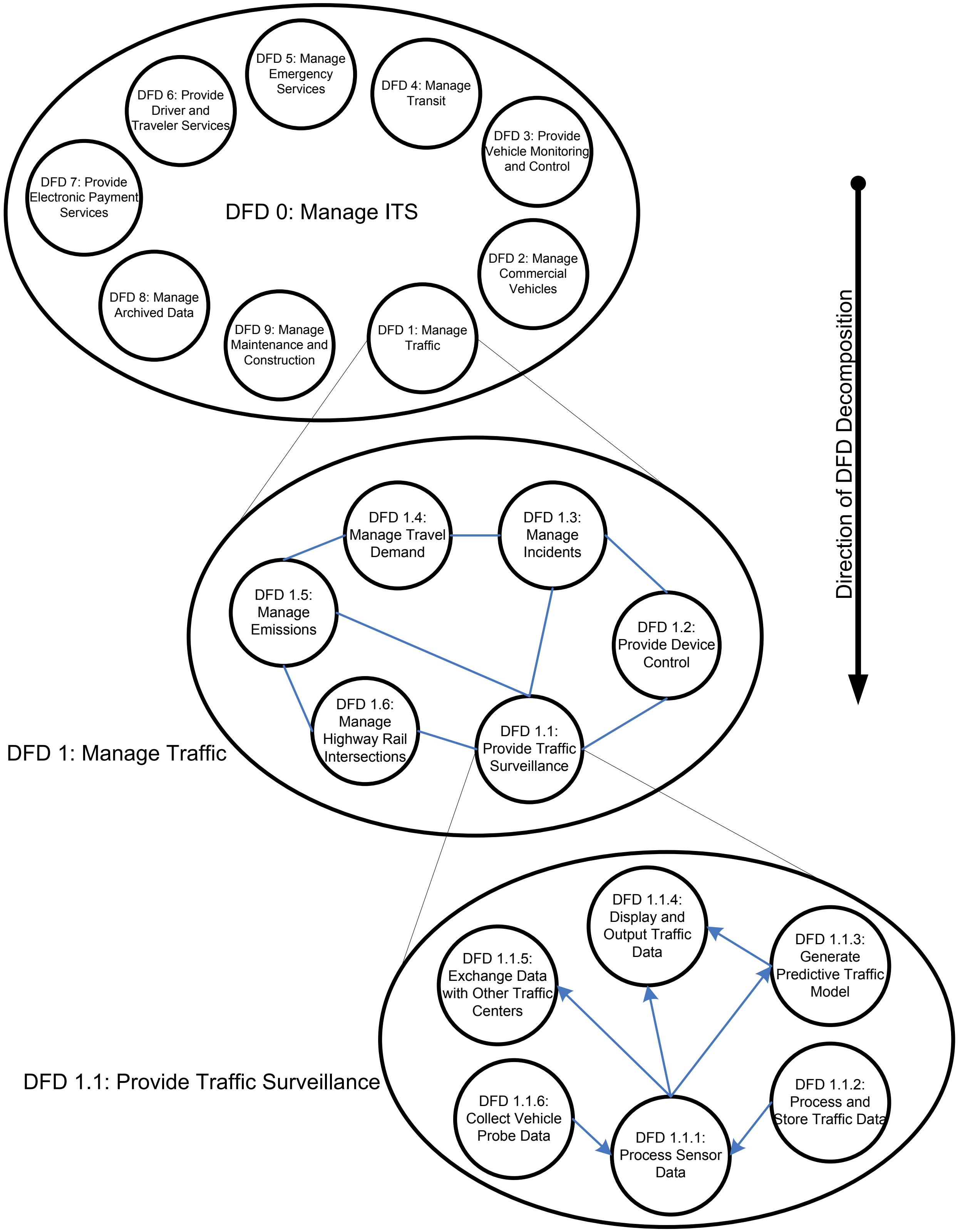


Figure 2. Example of Logical Architecture Functional Decomposition.

The Archived Data User Service (ADUS) is the user service that directly addresses traffic data collection program needs. ADUS requires ITS-related systems to have the capability to receive, collect, and archive ITS-generated operational data for historical, secondary, and non real-time uses. Specifically, ADUS prescribes the need for a data source for external user interfaces and provides data products to users. The physical entity that provides ADUS functions is the Archived Data Management System (ADMS), which is one of 19 such entities currently in the National ITS Architecture. ADMS is a "center" subsystem that collects, archives, manages, and distributes data generated from ITS sources for use in transportation administration, policy evaluation, safety, planning, performance monitoring, program assessment, operations, and research applications. Implementation of this subsystem may be possible in many different ways, including within an operational center or as a separate center that collects data from multiple agencies and sources to provide a general data warehouse service for a region.

National ITS Standards

National ITS standards are evolving in 13 key focus areas along three main categories: data dictionaries, message sets, and protocols (*6*). Additional information about the current development and implementation status of ITS standards is available on the US DOT ITS Standards Program website (*7*). Of interest to this research is the first published ADUS standard, ASTM E2259-03, Standard Guide for Archiving and Retrieving ITS-Generated Data (*7*). Although this standard is general in scope and does not strictly specify data formats or processes, it is expected to promote consistency in ADMS development (*7*). Another recently published standard is ASTM E2468-05, Standard Practice for Metadata to Support Archived Data Management Systems, which provides the exact structure for the metadata needed in addition to those attributes required for ITS data dictionaries (*8*). Currently under development is standard ASTM WK7604, Standard Specifications for Archiving ITS-Generated Traffic Monitoring Data, which provides a data dictionary for archiving traffic data, a record structure for creating data tables, and a file transfer format.

Another standard of interest is the Traffic Management Data Dictionary (TMDD). TMDD standards are intended to facilitate Center-to-Center (C2C) data exchange in all ITS functional areas (*9*). The TMDD identifies and defines the specific data elements that make up the messages exchanged between centers. A companion standard to TMDD is a Message Sets for External Traffic Management Center Communications (MS/ETMCC), which defines the messages that occur between TMCs and other external ITS centers. These message sets are based on the data elements as defined in the TMDD.

Transportation Operations Asset Management

The FHWA Office of Operations has embarked on a systematic program to define specific transportation asset management methodologies for operations through its Operations Asset Management Program Area (*10, 11*). This program has three main objectives: (1) to establish an analytical foundation for operations asset management that includes development of analytical capabilities, life-cycle cost analyses, performance measures, and alternative investment scenarios; (2) create linkages to facilitate integration of operations asset analysis results into the transportation asset management process; and (3) implement transportation asset management processes and principles.

One specific area of interest to FHWA within the transportation asset management initiative is the implementation of asset management principles to signal systems (*10*). A recent study developed a high-level prototype architecture for a signal system asset management system, and illustrated how such a system could assist in evaluating different signal system repair options (*12*). Based on information collected from the state-of-the-practice review and in-depth interviews, the study identified eight relevant characteristics of a traffic signal system, the logical interactions among these characteristics, and generic data element inputs and outputs. These characteristics include: physical characteristics (e.g., signal heads, controllers, detectors), operational characteristics (e.g., timing plans, coordination, control strategies), operating environment (e.g., intersection geometry, current volume, composition and distribution of traffic), performance (e.g., failure rate), actions (e.g., retiming, upgrades, routine maintenance, remedial repairs), resources (e.g., staff, vehicles, equipment), budgets, and funding.

Beyond asset management needs, operational data elements such as signal timing plans and system diagnostics are of particular interest to traffic engineers. There is also growing interest in the development of applications that integrate inventories with signal operation and coordination programs, particularly in the case of fully adaptive traffic signal systems. Those systems can provide traffic signal control (by adjusting and coordinating traffic signals in real time based on existing traffic conditions), surveillance (by monitoring traffic conditions with vehicle detectors and cameras), and maintenance (by monitoring for equipment failures) (*13, 14*). Although implementing fully adaptive systems can provide benefits, a number of challenges remain, including integration with old hardware, multi-agency coordination of traffic signal operations, and coordination of arterial traffic operations with freeway traffic operations.

In addition to data elements that pertain to the operation of traffic signal systems, which tend to be permanent in nature, there are other more infrequent sources of data such as turning movement counts, travel time data, and spot speed data. Typically, there are no data dissemination procedures in place to make these data resources usable to other users. However, it appears that considerable duplication of effort could be avoided if a data repository/exchange mechanism could be established.

OPERATIONS DATA CHARACTERIZATION AT TXDOT

This section summarizes activities the researchers completed to characterize current transportation operations data practices at TxDOT. At the kickoff meeting, the panel decided the research should focus on a broad characterization of data operations data practices, i.e., covering as many data subjects as possible. The alternative was to focus on a selected number of data subjects (e.g., speed, volume, occupancy, and travel time), which would have enabled a comprehensive characterization of data management practices and processes associated with the selected data subjects. The decision to focus on a broad range of data subjects reduced the time and resources available to evaluate each data subject in detail. While a comprehensive evaluation of associated data processes and practices was therefore not possible, a broad characterization approach enabled a general understanding of data practices and needs, which should provide valuable information to TxDOT, particularly in relation to the definition of general strategies to develop and provide data products to external and internal users.

The purpose of characterizing transportation operations data needs is to provide guidance regarding types of data subjects and data elements; justification for data collection, processing, and archival; and identification of general data management practices and procedures.

Characterizing transportation operations data needs involved the following activities:

- identify potential transportation operation data users,
- conduct surveys, and
- catalog and summarize survey results.

Potential Transportation Operations Data Users

It was necessary to select a broad range of internal and external users for a thorough assessment of transportation operations data needs. Examples of potential transportation operations data user groups included the following:

- district traffic management;
- district traffic engineering;
- district planning and development;
- district maintenance;
- district construction;
- district design;
- metropolitan planning organization (MPO);
- city office of traffic/transportation;
- city police department;
- city office of emergency management;
- transit authority;
- county office of public works;
- county office of emergency management;
- media outlets;
- commercial vehicle operators; and
- other relevant agencies, such as the port authority.

Surveying all 25 TxDOT districts was not feasible within the one-year time frame allocated for the research project. At the kick-off meeting, the panel outlined several potential districts, from which the researchers selected two large, urban districts (San Antonio and Houston) and two smaller districts (El Paso and Laredo). Table 1 lists different agencies the researchers contacted at each of the four districts.

Table 1. Agencies Contacted for Short Survey.

San Antonio	Houston	El Paso	Laredo
TxDOT District Traffic Management (TransGuide)	TxDOT District Traffic Management (TranStar)	TxDOT District Traffic Management (TransVista)	TxDOT District Traffic Management (STRATIS)
TxDOT District Traffic Engineering	TxDOT District Traffic Engineering	TxDOT District Traffic Engineering	TxDOT District Traffic Engineering
TxDOT District Planning and Development	TxDOT District Design	El Paso MPO	TxDOT District Planning and Development
TxDOT District Maintenance	TxDOT District Planning and Development	City of El Paso Public Works-Traffic Management	TxDOT District Maintenance/Construction
TxDOT District Construction	TxDOT District Maintenance	City of El Paso Office of Emergency Management	TxDOT District Design
TxDOT District Design	TxDOT District Construction	SunMetro Transit	Laredo Metropolitan Planning Organization
San Antonio-Bexar County Metropolitan Planning Organization	TxDOT District Safety	City of El Paso Fire Department	City of Laredo-Traffic Safety
City of San Antonio Public Works-Traffic Management	City of Houston Public Works, Traffic Section	City of El Paso Police Department	City of Laredo-Police Department
City of San Antonio Police Department-Traffic Section	Harris County Office of Emergency Management	El Paso Sheriff's Department	City of Laredo-Fire Department
City of San Antonio Office of Emergency Management	Metropolitan Transit Authority of Harris County (METRO)	KFOX TV Station	El Metro Transit-Operations & Maintenance
VIA Metropolitan Transit	Houston-Galveston Area Council	EPV Group	Laredo Trucking Association
Bexar County Office of Public Works-Traffic Section	Harris County Toll Road Authority		US Customs and Border-Laredo Port of Entry
Bexar County Office of Emergency Management	Harris County Traffic Management and Operations		US Department of Homeland Security-Laredo Port of Entry
WOAI TV Station	Harris County Sheriff's Department		
KSAT TV Station			
KENS TV Station			
Wal-Mart Regional Distribution Center			
HEB Transportation Terminal			
Alamo Regional Mobility Authority-Engineering and Operations			
San Antonio Airport-Operations and Maintenance			
Port Authority of San Antonio-Engineering			

Surveys

Because the spectrum of current and potential transportation operations data users encompassed a wide range of potential data needs, the researchers conducted surveys at two levels: a preliminary (or short survey) and a detailed (or long survey). Figure 3 summarizes the survey methodology. The purpose of the short survey was to find out data subjects of interest to individual users and to identify target participants for the more detailed survey. The purpose of the long survey was to fully assess data needs by collecting detailed information regarding a variety of topics such as data needs, justification for using the data, specific data elements needed, geographic scope of interest, temporal and spatial resolution, geographic reference, data source and data collection method, and access method and frequency.

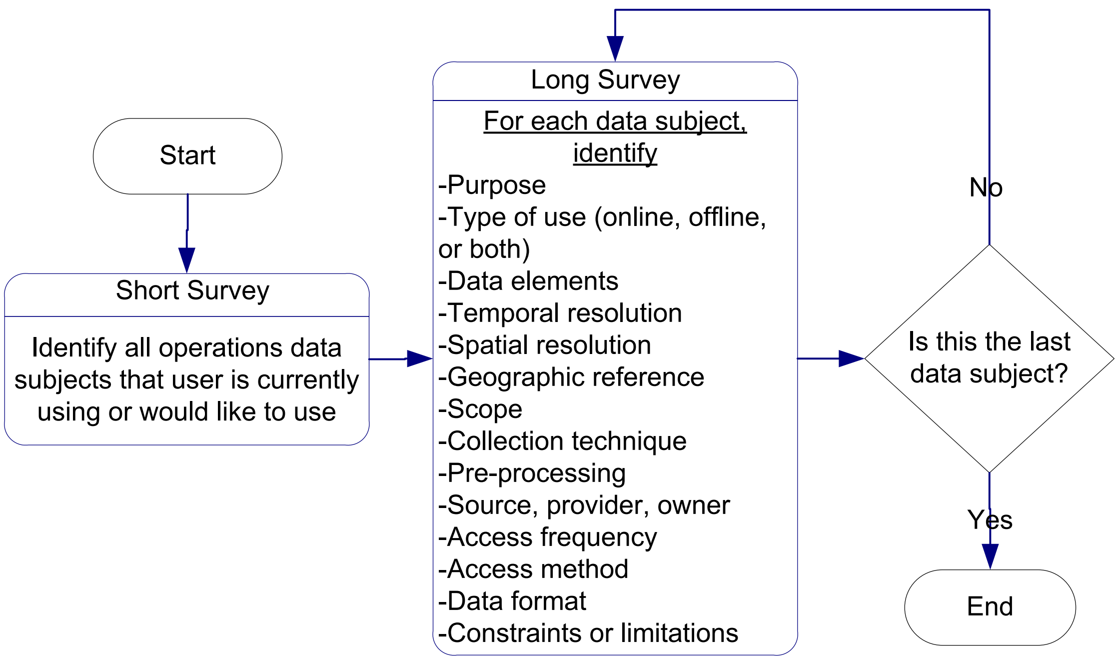


Figure 3. Survey Methodology.

The short survey included a list of 46 different data subjects (Table 2). For each data subject, relevant questions included whether the interviewee was currently using or would like to use that data subject, outline data subject use, indicate data ownership, and a point of contact for more detailed information. Appendix A shows a copy of the short survey form. The researchers sent out the short survey as an email attachment to users. Users had four options to complete and return the short survey: within the body of an email message, as an email attachment, by fax, or by regular mail. To encourage participation and increase survey response, the researchers further contacted non-respondents via email, phone calls, and fax.

Table 2. Operations Data Subjects.

Traffic Conditions 1. Volume Data from Detectors 2. Occupancy Data from Detectors 3. Speed Data from Detectors 4. Travel Time Data 5. Freeway Incident Data	Other Transportation Modes 26. Transit Operation Data 27. Ferry Operation Data 28. High Occupancy Vehicle (HOV) Lane Data 29. Commercial Vehicle Hazardous Material (Hazmat) Content Data 30. Railway Crossing Data
Traffic Management/Control 6. Dynamic Message Sign (DMS) Data 7. Lane Control Signal (LCS) Data 8. Ramp Metering Data 9. Traffic Control Detour Data 10. Roadway Event Data	Supporting Data 31. Aerial Photography Data 32. Roadway Inventory Data 33. Utility Installation Data 34. Survey/Topographic Data
ITS Equipment 11. ITS Equipment Inventory Data 12. ITS Equipment Maintenance Log Data 13. ITS Equipment Monitoring Data 14. Fiber Optic Network Management Data	Arterials 35. Intersection Geometrics and Control Data 36. Traffic Signal Operations and Control Data 37. Traffic Signal Maintenance Data 38. Intersection Vehicle Count/Turning Volume Data 39. Crash Data 40. Corridor Inventory Data 41. Traffic Simulation Model Data 42. Origin-destination Data
Other ITS 15. Scheduled Lane Closure Data 16. Motor Assistance Program Log Data 17. Toll Road Data 18. Closed Circuit Television (CCTV) Surveillance/ Snapshots 19. Parking Management Data 20. Police Computer Aided Dispatch Data 21. TMC Website Usage Data	Emergency Services 43. Emergency Management Data Other 44. Vehicle Classification Data 45. Emergency Evacuation Route/Procedure Data 46. Annual Average Daily Traffic (AADT) Volume Data
Environmental Data 22. Weather Data 23. Air Quality Data 24. Flood Data 25. Roadway Surface Condition Data (wet, icy, and so on)	

After completing the short surveys, the researchers developed a general understanding of data subjects of interest to external and internal groups. However, more detailed information was necessary to characterize individual data subjects. This realization led to the development of a longer follow-up survey to assess data use characteristics such as type of data used/needed, purpose and use of the data, data elements, geographic scope of interest, temporal and spatial resolution, spatial referencing, data source and data collection method, access method and frequency, and any other related issues that users identified. Appendix B shows a copy of the long survey form.

To gather more detailed information about individual data subjects (e.g., level of aggregation, data access method, and frequency), the researchers scheduled personal interviews with users. Typical questions asked during the interviews in relation to each data subject included the following:

- Are you currently using or interested in using the data subject?
- Are you using or interested in real-time (online), historical (offline), or both data?
- What do you use this data subject for (activity, function, purpose)?
- What data elements are associated with this data type that you need?
- What is the temporal resolution/aggregation?
- What is the spatial resolution/aggregation?
- Is there any data pre-processing (aggregation or transformation) performed on data before use?
- Are data geographically referenced? How?
- What is the scope (geographic coverage) of interest?
- Do data currently exist in a database? If yes, do you know who owns and manages the database?
- What is the source of these data?
- If you are the provider, can you share these data?
- How are data being collected?
- If you are not the provider, how are data accessible? (e.g., FTP, Internet, CD-ROM)
- How frequently do you need to access these data?
- In what electronic format are the data available? (Text, MS Excel, MS Access, etc.)
- Are there any storage or archiving issues?
- Are there any accessibility issues?
- Are there any known data quality concerns?
- Are there any known data completeness (gaps in data) concerns?
- Are there any privacy, security, or liability concerns?

Table 3 lists pertinent information relevant to the agencies interviewed. Individual interview durations varied widely depending on the number of data subjects of interest to individual users. The original plan was to interview users at all the agencies listed in Table 1. In practice, the number of respondents who agreed to participate in the long survey was considerably smaller than the number of short survey respondents. Table 4 summarizes the survey status for all agencies.

Table 3. Interviews for Detailed Survey of User Data Needs.

Agency	Department
San Antonio	
TxDOT	District Traffic Management (TransGuide)
	District Traffic Engineering
	District Planning and Development
	District Maintenance
	District Construction
City of San Antonio	City Office of Traffic/Transportation
San Antonio-Bexar County MPO	MPO
Transit Authority	VIA Metropolitan Transit
Bexar County	County Office of Public Works-Traffic Section
Media Outlet	WOAI
Houston	
TxDOT	District Traffic Management (TranStar)
	District Project Development
	District Planning
	District Maintenance
	District Safety
	District Design
	District Right of Way (ROW)
City of Houston	City Office of Public Works
Harris County	County Office of Emergency Management
El Paso	
TxDOT	District Traffic Management (TransVista)
El Paso MPO	MPO
City of El Paso	City Office of Traffic/Transportation
City of El Paso	Office of Emergency Management
Transit Authority	SunMetro
Media Outlet	KFOX
Private Firm	EPV Group
Laredo	
TxDOT	District Traffic Management (STRATIS)
	District Traffic Engineering
	District Planning and Development
	District Maintenance/Construction
	District Design
Laredo MPO	MPO/City of Laredo Planning Department
City of Laredo	City Office of Traffic Safety

Table 4. Summary of Survey Effort Status by District.

Agency	San Antonio	Houston	El Paso	Laredo
District Traffic Management	■	■	■	■
District Traffic Engineering	■	□	□	■
District Planning and Development	■	■	□	■
District Maintenance	■	■		◘
District Construction	■			■
District Design	◘	■		■
MPO	■	□	■	■
City Office of Traffic/Transportation	■	■	■	■
City Police Department	□			□
City Office of Emergency Management	□	□	◘	◘
Transit Authority	■	◘	◘	□
County Office of Public Works-Traffic	■			
County Office of Emergency Management	□	■	□	
Media Outlets (at least one)	■		◘	
Commercial Vehicle Operators (at least one)	□			□
Other relevant agencies	□	◘	◘	□

Legend: ■ Both short and long surveys completed
◘ Only short survey completed
□ Agency contacted but there was no response

Survey Results

Short Survey Results

Table 5 summarizes the results of the short survey. This table captures data subjects that different agencies are either currently using or would like to use. Figure 4 shows the frequency of citation for each data subject. To facilitate the analysis, the researchers sorted the 46 data subjects according to frequency of citation. Figure 5 shows the corresponding results. Figure 6 to Figure 10 show similar types of information but for the major user groups.

An analysis of the results in Table 5 and Figure 4 yields the following observations:

- The top five data subjects of interest to all users were detector volume data, travel time and detector speed data, crash data, freeway incident data, and aerial photography data. This result is not surprising because a substantial number of users surveyed were associated directly or indirectly with TMC activities. However, it is interesting to note that users expressed considerable interest in aerial photography, even though aerial photography is a data resource that is not "normally" associated with transportation operations. Moreover, many non-operations users expressed interest in freeway incident data as a surrogate data source for crash data on freeways.

- Users also expressed a high level of interest in the following TMC-related data: traffic control detour data, DMS data, CCTV surveillance/snapshot data, flood data, scheduled lane closure data, and roadway surface condition data. Both flood data and roadway surface condition data require special environmental sensors. While flood data already exist in some areas, capturing real-time roadway surface condition data, e.g., dry, wet, icy surface, is much less common. The high level of interest in these two data subjects is an indication that TxDOT should consider the systematic deployment of sensors to collect and manage those data items. Traffic detour data is critical for integrated traffic management between freeway and arterial networks. Users also expressed considerable interest in the following traditional traffic engineering data subjects: crash data, traffic signal operations and control data, intersection turning volume data, and intersection geometrics and control data.

- The top five data subjects of interest to TMCs were detector volume data, detector speed data, travel time data, freeway incident data, DMS data, and CCTV surveillance/snapshot data. Also highly ranked were TMC website usage data, detector occupancy data, LCS data, and ITS equipment-related data, such as ITS equipment inventory, maintenance log, and monitoring data.

- The top data subjects of interest to district traffic engineering users were traffic control detour data, aerial photography data, roadway inventory data, intersection geometrics and control data, traffic signal operation and control data, traffic signal maintenance data, intersection turning movement count data, crash data, and traffic simulation model data. The fact that traffic control detour data ranked first is worth mentioning because of the potential use of these data for arterial traffic management.

- The top data subjects of interest to district transportation planning and project development users were detector volume data, travel time data, crash data, traffic simulation model data, and origin-destination data. This user group also expressed significant interest in detector speed data. MPO users expressed similar interests, except MPO users indicated greater interest in using TMC-related data subjects such as travel time data, speed data, and freeway incident data.

- The top data subjects of interest to city users were CCTV surveillance/snapshot data, crash data, corridor inventory data, detector speed data, traffic signal operation and control data, and intersection turning movement count data. Other data subjects of interest were traffic simulation model data, vehicle classification data, emergency evacuation data, detour data, AADT volume data, and travel time data.

- To complete the analysis, the researchers compared the results of the survey to those reported in a study Southwest Research Institute (SwRI) conducted in 2000 to characterize user needs for the TransStar data warehouse (*15*). According to the SwRI study, the data subjects Houston users most frequently cited (out of a list of 44 data subjects) were volume/occupancy detector data, speed/travel time AVI data, incident data, and flood data. This list is very similar to the top five data subjects of interest identified as part of this research, except for flood data, which, not surprisingly, ranked near the top in the list of priorities for Houston area respondents. Flood data ranked high in the list this research produced, but not as high as DMS message sign data, which was among the top five data subjects identified in this research.

Table 5. Data Subject Use by User Agency and Department.

User Agency and Department	1. Volume Data from Detectors	2. Occupancy Data from Detectors	3. Speed Data from Detectors	4. Travel Time Data	5. Freeway Incident Data	6. DMS Data	7. Lane Control Signal Data	8. Ramp Metering Data	9. Traffic Control Detour Data	10. Roadway Event Data	11. ITS Equipment Inventory Data	12. ITS Equipment Maintenance Log Data	13. ITS Equipment Monitoring Data	14. Fiber Optic Network Management Data	15. Scheduled Lane Closure Data	16. Motor Assistance Program Log Data	17. Toll Road Data	18. CCTV Surveillance/ Snapshots	19. Parking Management Data	20. Police Computer Aided Dispatch Data	21. TMC Website Usage Data	22. Weather Data	23. Air Quality Data	24. Flood Data	25. Roadway Surface Condition Data	26. Transit Operation Data	27. Ferry Operation Data	28. HOV Lane Data	29. Commercial Vehicle Hazmat Content Data	30. Railway Crossing Data	31. Aerial Photography Data	32. Roadway Inventory Data	33. Utility Installation Data	34. Survey/Topographic Data	35. Intersection Geometrics and Control Data	36. Traffic Signal Operations and Control Data	37. Traffic Signal Maintenance Data	38. Intersection Vehicle Count/Turning Volume Data	39. Crash Data	40. Corridor Inventory Data	41. Traffic Simulation Model Data	42. Origin-destination Data	43. Emergency Management Data	44. Vehicle Classification Data	45. Emergency Evacuation Route/Procedure Data	46. AADT Volume Data
San Antonio																																														
District Traffic Management (TransGuide)	■	■	■	■	■	■	■		■	■	■	■	■	■	■		□	■	□	■	■			■												□	□	□								
District Traffic Engineering	■		■						□																						■	■			■	■	■	■	■		■					
District Planning and Development	■	□	■	■	■												□						■			□		□		□	■	■	■	■	■				■	■	■	■		■		■
District Maintenance							■		■			□	■		□	□	□	□		■	■									■											■					■
District Construction	■										■				■							■	■								■		□	□	■		■	■								
MPO	■		■	■	□										□			□				■			□	■					■	□				■		■	■		■	■	□			
City Office of Traffic/Transportation	■	□	■	■	□				□	□					□			□	□			□	□	□	□					□					■	■	□	■	■	■	■	■				
Transit Authority	□				□																					■		□			■	■			□	□		□	□	□	□	■				
County Office of Public Works	■		■	■	□																			□	□						■	■		■	■	■	■	■	■		■	□				
Media Outlets (at least one)	□	□	□	□	□	■	□		□	□	□				■			■		■				□	□					□						□										
Houston																																														
District Traffic Management (TranStar)	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	□	□	□	□	□	■	□	■		□	□	■	■	■	□
District Project Development	□		■	□	■	■	■		■																				■	■							■		■		■	■		■	■	
District Planning	□		□	□	□	■			□		□			□	■		□					■	■	■			■	■	■	■			■	■				□	■	■	■	■		■	■	■
District Maintenance	□		□	□	■	■	■		■			■	■							■		■		■	■			■		■	■		□	■			□		■			■			■	■
District Design	□		■	□	■		■		■													■								■	■								■	■		■		■		
Safety	□			■	■				■																														■							
City Office of Traffic/Transportation			■	□	□	□			□	□					□	□	□	■		□			□						■								■		□	□	□	□		■	■	□
County Office of Emergency Management																						■	■						□																□	

Legend: ■ User is currently using this data subject □ User would like to use this data subject

Table 5. Data Subject Use by User Agency and Department (Continued).

User Agency and Department	Data Subject																																												
	1. Volume Data from Detectors	2. Occupancy Data from Detectors	3. Speed Data from Detectors	4. Travel Time Data	5. Freeway Incident Data	6. DMS Data	7. Lane Control Signal Data	8. Ramp Metering Data	9. Traffic Control Detour Data	10. Roadway Event Data	11. ITS Equipment Inventory Data	12. ITS Equipment Maintenance Log Data	13. ITS Equipment Monitoring Data	14. Fiber Optic Network Management Data	15. Scheduled Lane Closure Data	16. Motor Assistance Program Log Data	17. Toll Road Data	18. CCTV Surveillance/ Snapshots	19. Parking Management Data	20. Police Computer Aided Dispatch Data	21. TMC Website Usage Data	22. Weather Data	23. Air Quality Data	24. Flood Data	25. Roadway Surface Condition Data	26. Transit Operation Data	27. Ferry Operation Data	28. HOV Lane Data	29. Commercial Vehicle Hazmat Content Data	30. Railway Crossing Data	31. Aerial Photography Data	32. Roadway Inventory Data	33. Utility Installation Data	34. Survey/Topographic Data	35. Intersection Geometrics and Control Data	36. Traffic Signal Operations and Control Data	37. Traffic Signal Maintenance Data	38. Intersection Vehicle Count/Turning Volume Data	39. Crash Data	40. Corridor Inventory Data	41. Traffic Simulation Model Data	42. Origin-destination Data	43. Emergency Management Data	44. Vehicle Classification Data	45. Emergency Evacuation Route/Procedure Data	46. AADT Volume Data
El Paso																																													
District Traffic Management (TransVista)	■	■	■	□	■	■	■		■	■	■	■	■	■	■	■	□	■		□	□	■	□	■	□				□		■					■							■		□	
MPO	■	■	□	□	□												□											□			■				□			□	■		□			■		■
City Office of Traffic/Transportation																		■													■		■		■	■		■	■	■			■	■	■	■
City Office of Emergency Management				□	■	□			□	□					■			■		■		■		□	□				□		■												■		□	
Transit Authority	□		□	□	□	□			□	□								□				□		□	□						■				□							□				
Media Outlets (at least one)			□	□		□									□			■				■		□	□	□																	■		□	
Other relevant agencies	■	■	■	□	□	□	□	□	□	□					□	□				□		□		□	□	□			□	□	■	■		■		□				□	□	□	□	□	□	□
Laredo																																													
District Traffic Management (STRATIS)	□	■	□	□	□	■	■	□			■	□	□					□			□			■						□	□	□	□	□		□										
District Traffic Engineering									□	□					□																□	■	□	■	■	■	■	■	■	■	■			□		
District Planning and Development	□			□																											■	■	■	■	■			■	■		□	■		■		■
District Maintenance/Construction																																							□							
District Design	■			□		■			■															■	■						■	■	■	■	■	■		■	■		■	■				
MPO	■		□	□	□					□																				□		■							□	□		■				■
City Office of Traffic/Transportation	□	□	□			□		□			□	□	□	□			■	□		□											■					■	■	■	■	□	■			□	□	■
City Fire Department																																											■	□	□	□

Legend: ■ User is currently using this data subject □ User would like to use this data subject

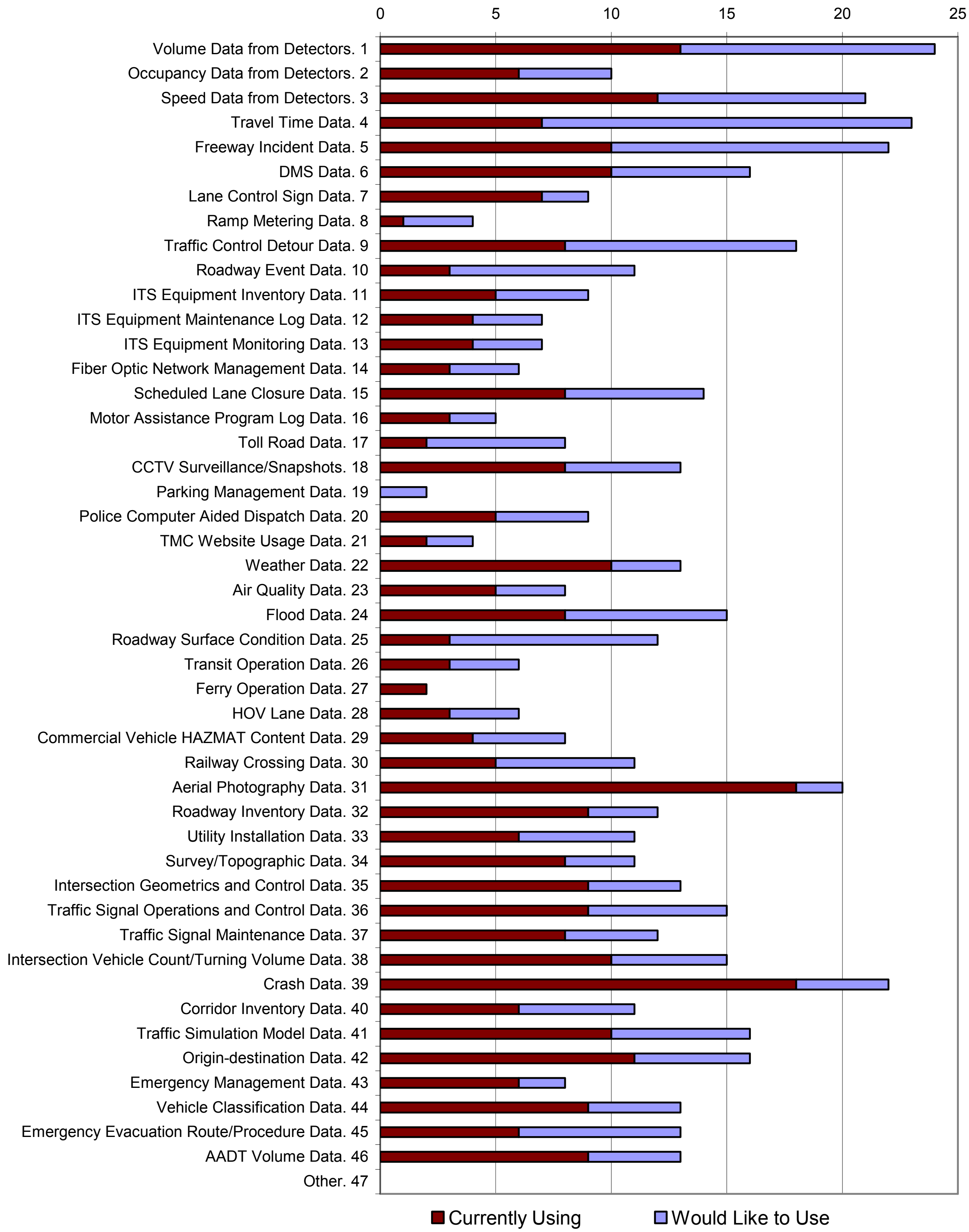


Figure 4. Frequency of Data Needs Cited by Users-Unsorted.

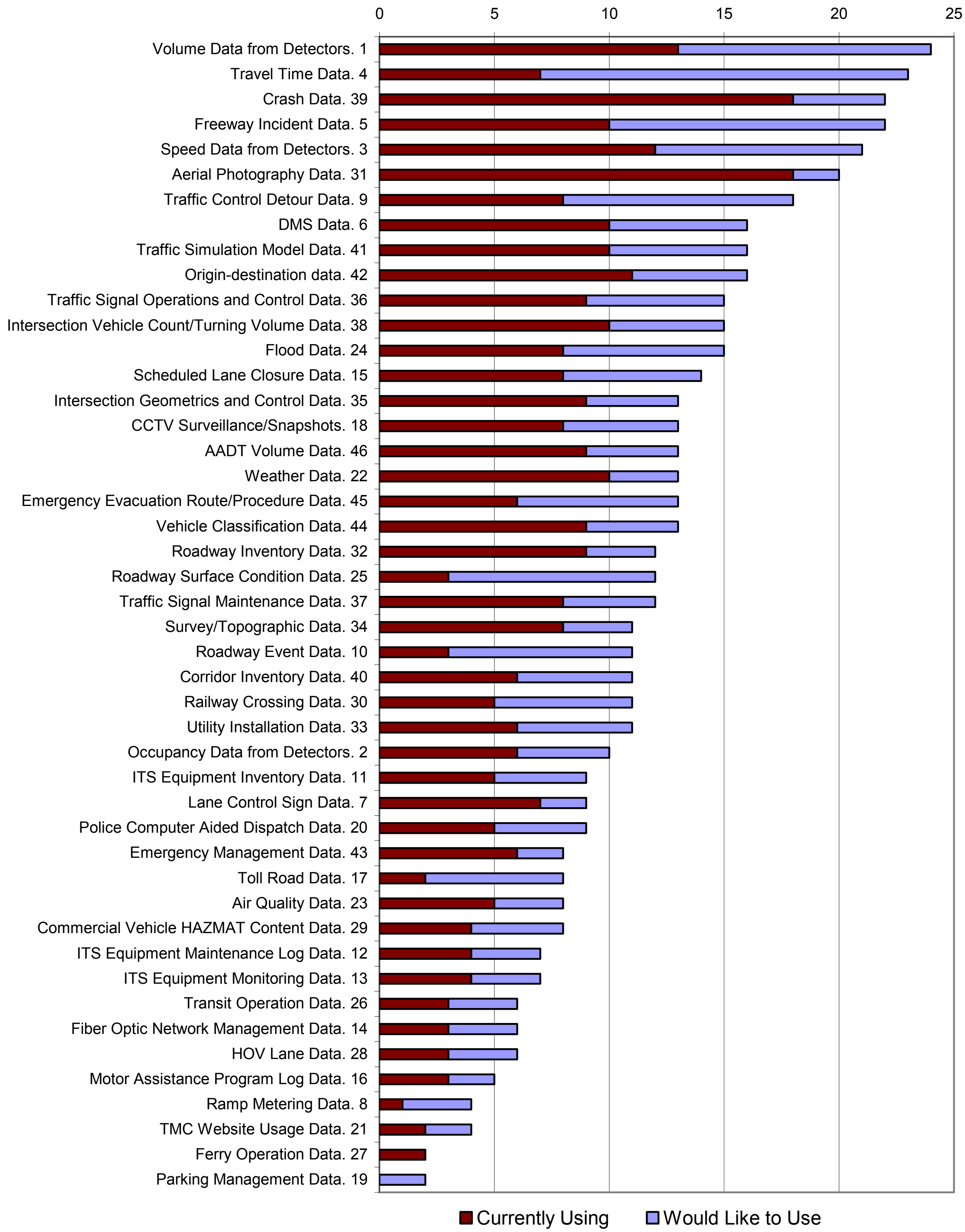


Figure 5. Frequency of Data Needs Cited by Users-Sorted.

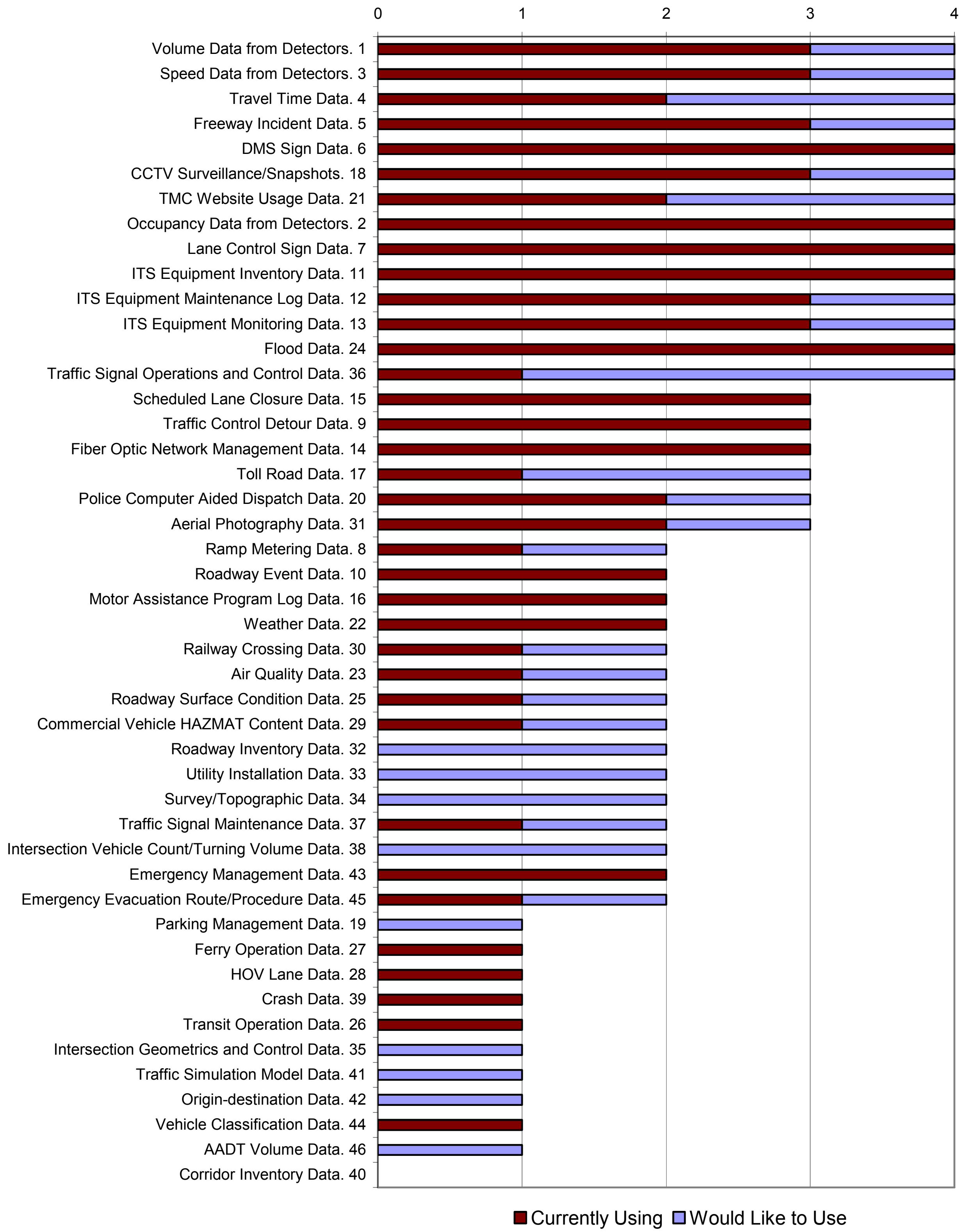


Figure 6. Frequency of Data Needs Cited by Users-TMC Users.

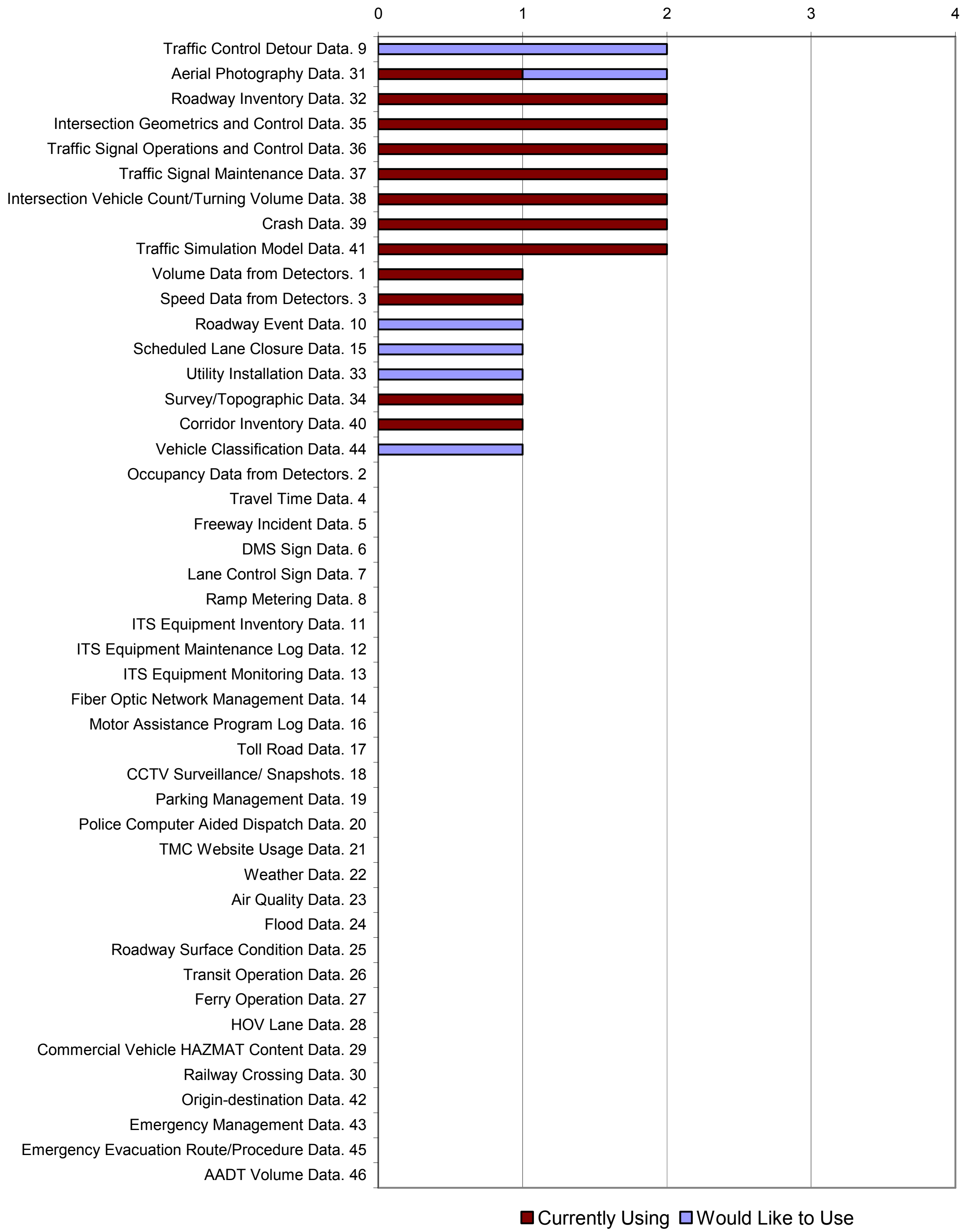


Figure 7. Frequency of Data Needs Cited by Users-Traffic Engineering Users.

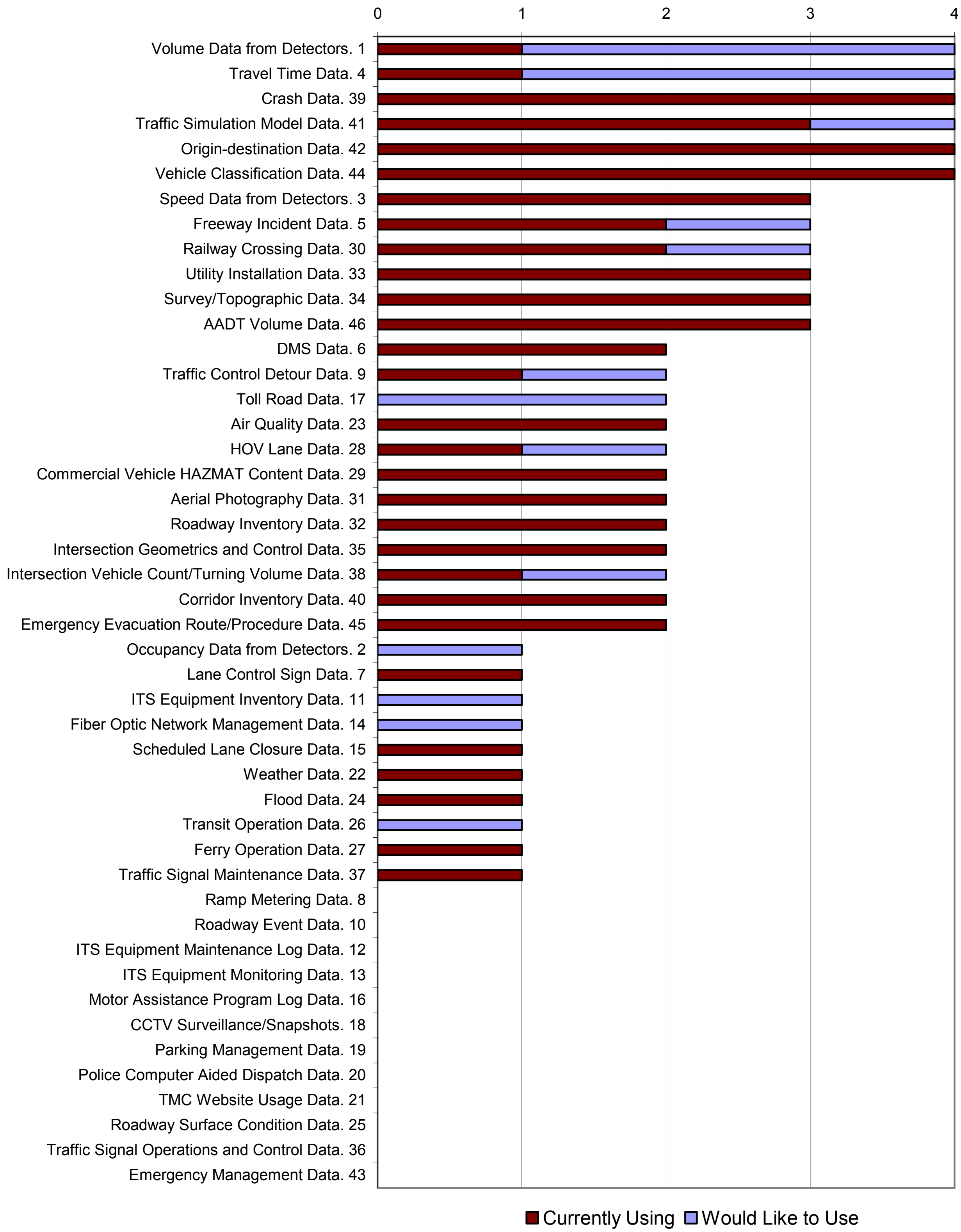


Figure 8. Frequency of Data Needs Cited by Users-Planning and Project Development Users.

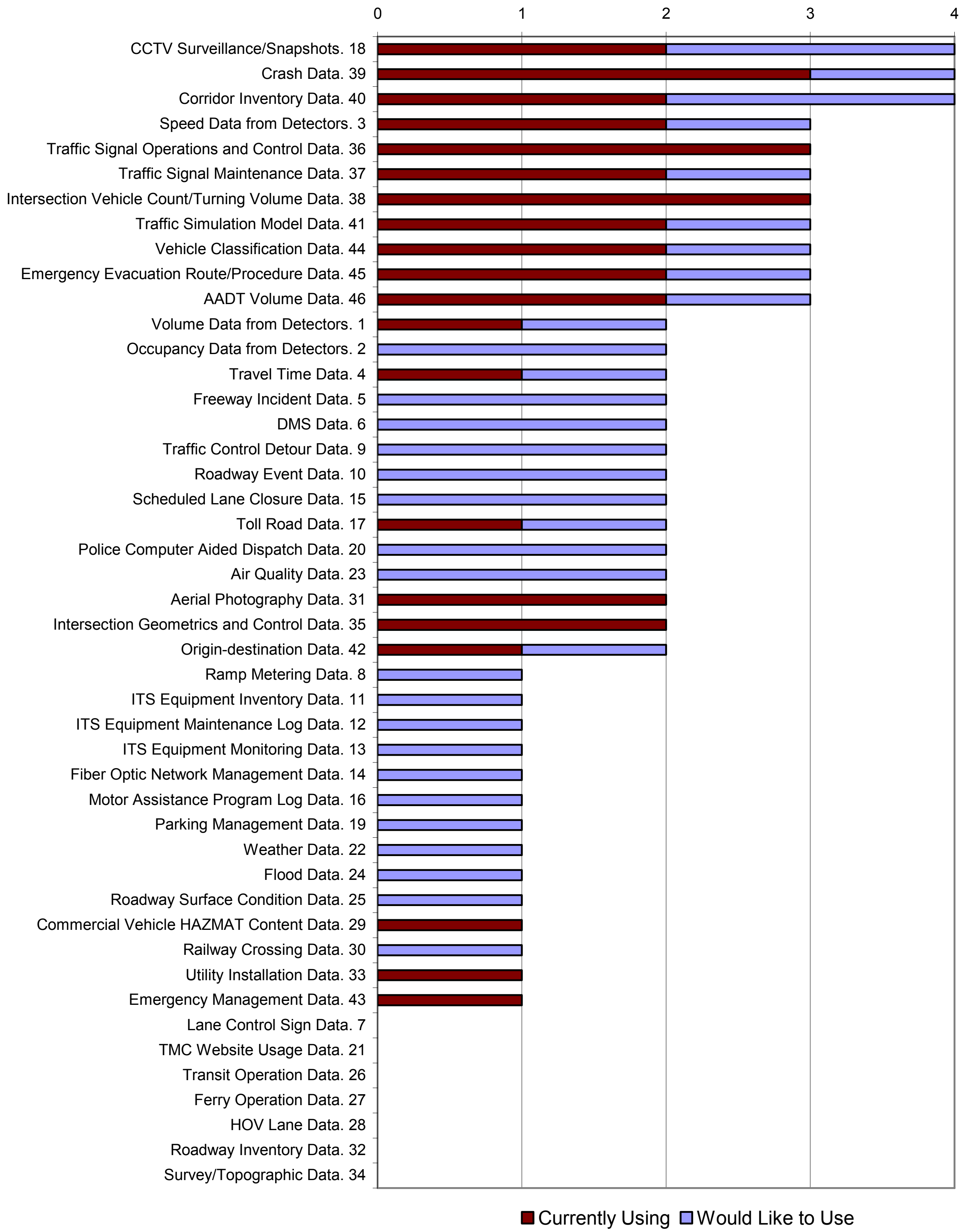


Figure 9. Frequency of Data Needs Cited by Users-City Users.

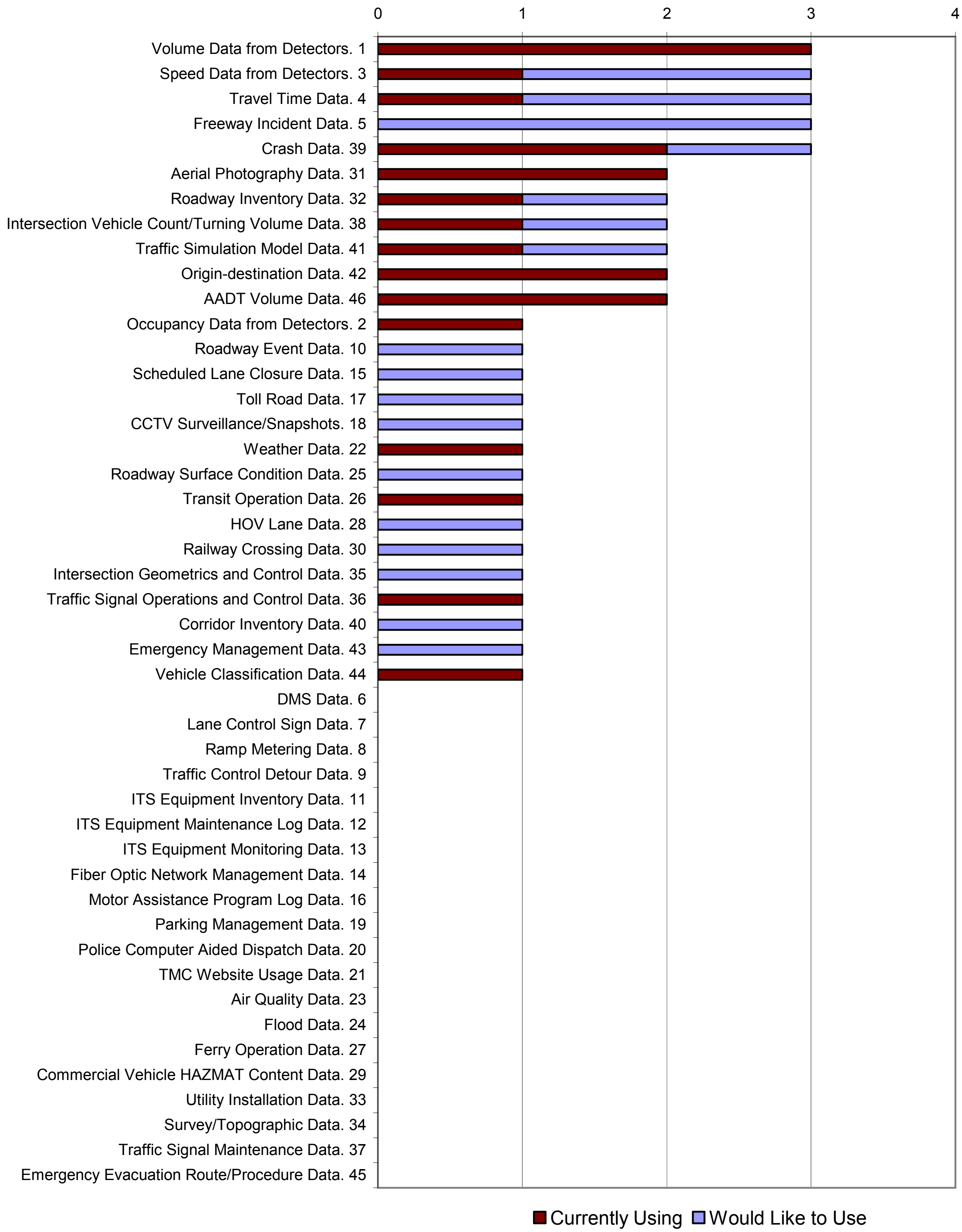


Figure 10. Frequency of Data Needs Cited by Users-MPO Users.

Long Survey Results

Appendix C compiles the information gathered from each agency in relation to the questions asked as part of the long survey. That appendix lists user-specific information such as data subject needed, purpose and use of the data, data elements, geographic scope of interest, temporal resolution, spatial resolution, spatial referencing, data collection method, pre-processing techniques needed, data source, access method, access frequency, data format, and other related issues that users identified. Appendix C acts as a catalog of operations personnel data needs as well as data needs that other users (both internal TxDOT users and external users) could have concerning operations data.

An analysis of the results in Appendix C yields the following observations:

- User interests vary considerably even between the same user group in the four districts. Users vary in terms of what data subjects they are using and how they are using these data subjects. For example, San Antonio's TransGuide uses a 2-minute average of its 20-second speed loop data with no aggregation (i.e., lane level) to detect incidents while Laredo's TMC (i.e., STRATIS) uses a 5-minute average of its 1-minute occupancy loop data aggregated across all lanes.

- The level of interest between real-time vs. historical data of the same data subject varies among users. For example, while TMC users are interested in real-time loop data, district transportation planning and project development users are interested in archived loop data. Similarly, users may need the same data subject but at a different level of aggregation. This applies for both temporal and spatial aggregation of the data. For example, MPO users would like to use hourly loop data that are aggregated across lanes while TMC users prefer a sub-minute non-aggregated lane data. The implication is that many users would like to use ITS data if these data are made available in a format that these users can directly integrate into their businesses' processes. Ideally, a TMC should develop a user-friendly tool that can pre-process (aggregation, transfer, etc.) the high-resolution data into a format readable/useful to others.

- Some users were not necessarily interested in data from all geographic coverage but data from a specific area or corridors. For example, the City of San Antonio is interested in using data from exit ramps leading to the city street network but not interested in data from the freeway main lanes.

- TxDOT's various users almost uniformly preferred to access the data via TxDOT's intranet (e.g., Crossroads) while users from other agencies preferred accessing the data via the Internet when a direct connection with TxDOT does not exist. Nevertheless, cities and media outlets that have a direct fiber connection preferred to use this connection to access TMC data. The implication of this is that TMCs, as the main data providers, may have to re-design their web pages for easy access to both real-time and archived data. As mentioned above, new tools may be needed to allow users to format the data in a way that allows easy integration of these data into existing business processes.

- Generally, users indicated they are willing to share their data with users from other groups within their agency as well as with users from other agencies. Only in a few cases, the user indicated that some kind of a memorandum of understanding between the two agencies needs to be in place before they can share data with another agency beyond what they make available to the general public. For example, the City of San Antonio traffic management group raised a similar concern before it can share its signal operation data with TxDOT.

- Users indicated an interest in TMCs collecting additional data elements than what is currently typical. Examples of additional data elements include critical time stamps associated with incidents, such as incident time, detection time, verification time, traffic management scenario execution time, response time (for simplicity, time when the first responder arrived at the scene), moved-to-shoulder time, clearance time, scenario cancellation time, and back-to-normal-conditions time. Such time stamps provide important information about the way incidents evolve over time and can translate into useful quantitative performance measures for many users. Another example is scheduled lane closure data where detour information would be a useful addition.

- Many users use geographic information systems (GIS) in their business processes and therefore would prefer to have access to data they could integrate easily into their GIS applications. This is particularly true for transportation planning users. Almost all data subjects can be referenced using some geographic coordinate system. Examples of data subjects that are currently referenced in longitude/latitude coordinates include incident and lane closure data. Data subjects that cannot be referenced in geographic coordinates should be at least referenced using a common linear referencing method such as mile markers.

- Data users would benefit from the availability of metadata. Metadata provide information useful to users who need understandable descriptions of data to answer questions about the data. Metadata include important information about both data and the processes used to create and maintain the data. It would therefore be advisable for data providers at TxDOT to develop good metadata practices for increased return on data investment and to incorporate data documentation into everyday work patterns.

- There is not a systematic effort to manage traditional traffic engineering data subjects. An area where immediate help is necessary is traffic signal inventory and operations data. Research at the national level has identified the main components of an asset management-based logical model for traffic signals. However, additional work would be necessary to translate that information to a physical implementation. That model would be GIS-based to provide a spatial component to the inventory and include efficient management tools for traffic engineers and transportation planners. A standards-based model would boost regional cooperation because it would serve as a major resource for agencies in the region to manage signal systems effectively and as a useful tracking tool to show regional progress with respect to the implementation of interconnected signal systems. The signal data model would include static signal data such as signal hardware details and include signal maintenance data and real-time signal operations data.

Other areas would benefit from the implementation of formal data models. For example, a comprehensive data model for ITS infrastructure could depict field details to provide many users with needed details. For instance, maintenance management would need to keep record of every equipment detail in the field. This detailed level may not be necessary to the TMC operator, but it could help respond to utility installation queries. Another example mentioned earlier is that a data model for representing various signal data will also benefit many areas, including both signal operation and maintenance.

- Current procedures at some of the districts involve a considerable duplication of effort in entering and processing lane closure data. Recent research provided several recommendations concerning changes that would be necessary to make the lane closure database at TransGuide useful as a data resource for ITS data completeness assessments (*16*). In the larger picture, however, it appears that both the Highway Condition Reporting System (HCRS) and local lane closure databases would need enhancements to avoid duplication of data entry efforts and to ensure the resulting database design addresses both local district and division needs.

- Current implementations of the Traffic Operations Division's Advanced Traffic Management System (ATMS) software include a library of pre-canned messages TMC operators can upload, modify, and display on DMS signs as needed. The system also enables operators to save modified messages as new template messages in the library. However, ATMS does not enable full archiving of displayed messages, which makes the analysis of historical incident data very difficult.

- TMC operators sometimes require access to static or offline data. For example, an operator might need to know the location of the nearest facility (e.g., firehouse, school) or utility facility (e.g., gas pipeline) to help manage traffic in case of a hazmat spill incident. However, most operator consoles do not enable the easy display of those data layers. A GIS-based interface or portal that displays that information would provide considerable flexibility to operators.

OPERATIONS DATA CHARACTERIZATION AT OTHER STATE DOTS

The researchers conducted a survey of other Departments of Transportation to develop an understanding of current data management strategies at those agencies. This task is relevant because of the likelihood those other agencies may have developed and/or implemented strategies and solutions that could be useful to TxDOT. The overall focus of the research was the characterization of operations data management at TxDOT. Therefore, the limited survey at other DOTs focused on those states where the researchers already had prior knowledge of substantial data storage and management efforts.

Survey Mechanism

The realm of transportation operations data can be quite large. In order to assess the management functions for the most readily available data types, the researchers limited the scope of the survey to detector data, incident data, and scheduled lane closure data. These data types are common across virtually all systems and any lessons learned from the management of those data subjects could be readily applied to other operations data subjects.

The researchers developed a survey instrument with questions covering three main categories: data attributes and characteristics, data usage, and data storage and archival system design and operation. Appendix D includes a copy of the survey instrument. During the course of the interviews, the researchers asked additional questions, as the discussion warranted. The researchers included the responses to the additional questions in the overall survey analysis.

The researchers identified four states for this survey (California, Florida, Virginia, and Washington), which are recognized leaders not only in the collection of transportation data, but also in the retention and usage of the data for multiple applications to diverse audiences. The survey process involved making an initial contact via electronic mail or telephone for the purpose of introducing the survey topic and requesting time to perform the more detailed discussion of the actual survey questions. In most cases, the agency contacts agreed to cooperate with the survey and a mutually convenient date/time was established. In one instance, a target state declined to participate in the interview process, instead pointing the researchers to substantial information available on the Internet regarding the applications of archived data use.

The typical interview process took approximately 30 minutes to complete. Conversations were often wide-ranging, with some level of detail provided in the examples or description of various applications. It may be worth noting that different members of the research team spoke to different states. In retrospect, while this strategy shared the workload, it did not facilitate cross-over knowledge between different interviews. For future research efforts, a single interviewer should be a consideration to allow for a greater accumulation of survey knowledge in one research team member.

Survey Results

A summary of critical data management topics and an analysis of the responses gathered from the state interviews follows.

- Geographic referencing of data. All of the target states reported the use of a referencing system to identify the source of the data. Such systems are commonplace, for without knowledge of the data location and what portion of the roadway is represented, the resulting information or application results are of limited value. The type and number of geographic referencing systems varies across the states and depends in some part on the type of data. Data from inductive loops are typically referenced at a sub-milepost level or by using linear distances off of mileposts. Inductive loop data may also be referenced by roadway lane, depending on the level of aggregation. Other types of data may be referenced at a less detailed level.

- Data processing. All of the target states reported some degree of data processing. Typically, data processing serves three purposes. The first is to "clean" the data. Cleaning removes known bad data points and typically utilizes a set of "rules" to establish boundaries or limits for acceptable data. For example, it is physically impossible to have an inductive loop report an occupancy rate of 100 percent, a volume of 0 and any speed, unless the loop is in error. Testing for values outside of these known limits, using numerous layered rules provides a more believable data set and ultimately, more appropriate results from applications using the data. Cleaning data is an important consideration, as many locations experience a substantial failure rate for data sources such as inductive loops. One target state reported an average loop failure rate of 30 percent.

  Data processing is also performed to provide aggregation. Both spatial and temporal aggregation techniques are common. Temporal, or time, aggregation is perhaps the most common. Data from sources such as inductive loops are often collected on either a 20- or 30-second base. Aggregation levels of 1-minute, 5-minute, 15-minute, 1-hour, 1-day, and 1-month were reported from the target states. The particular usage varied by the application and end-user need. Spatial aggregation combines data over space or area. A simple example would consist of averaging the inductive loop detectors in each lane in one direction, to produce a directional roadway cross-section value. Varying levels of spatial granularity were reported by the target states, depending on the application. One state reported that some data are examined in a combined temporal-spatial aggregation, known as a county-hour statistic.

  The final usage of data processing is to support the computation of performance measures. A performance measure is "the use of statistical evidence to determine progress towards specific defined organizational objectives" (*17*). Data gathered from typical roadway sources are often collected and processed to computer performance measures. Performance measurement is a management application, which allows an agency to collect and evaluate information for the purpose of achieving goals, increasing efficiency, and meeting customer expectations. While this usage was currently not the most prevalent application of the data management systems, a number of target states indicated an increased focus on performance measurement in the future and the need to expand their system to support performance measurement applications.

- Data Usage. The target states reported a diverse array of applications and users for their data management systems. Common applications included:

  - real-time transportation operations;
  - performance monitoring;
  - air quality analyses;
  - transportation planning;
  - emergency operations;
  - emergency planning;

  - commercial vendors (3rd party information providers);
  - real-time public information;
  - system diagnostics;
  - historical trends;
  - operational analyses (delay, level of service (LOS), congestion level, etc.); and
  - research.

  The list of data users was also extensive, from multiple departments with the state DOT, to commercial vendors, other agencies involved in transportation operations, research organizations, contractors, and the general public.

- Data format and availability. The manner in which data were ultimately provided to applications and users was fairly common across the target states. In reality, this is due to cost efficiencies in designing the access mechanisms and the ease of information transfer. The most prevalent method of data transfer was via a web interface, either to an instant query system, or to an online repository of data files at various levels of temporal and spatial aggregation. The use of FTP was also identified as a means of providing access to a file repository. Some systems provide a capability for email delivery or CD-ROM. The data were most often provided in either text (e.g,. comma delimited format) or Excel format. One target state also reported some availability using the Access database format.

- Data quality. A number of the target states reported data quality issues associated not with the data management system, but with the original input. The colloquial saying of 'Garbage In, Garbage Out' certainly applies in this context. The previous discussion of data processing is directly applicable to the data quality issue. Target states certainly recognized the issue and had put steps in place to provide the highest quality data possible. Another aspect of data quality identified through the surveys is data usability—if the end-user can not determine how to use the data in a particular application, then the data quality is essentially minimal.

- Data gaps/Data completeness. While quality typically addresses data that are present, but bad, completeness typically addresses the comprehensiveness of the data, e.g., is it even present. Target states identified a number of situations where completeness issues occur, including construction activities, maintenance activities, equipment failure situations, communication failures, and perhaps least often, a failure or downtime in the data management system itself. Some systems provide for a data completeness check, describing, in various terms, the amount of data available compared to the amount of data that would be available at 100 percent completeness.

- Data security and privacy. The target states are certainly aware of the potential for data security issues. Many systems require pre-approved access with a login name and password being used to grant admission and use. Most respondents stated that although they have security systems in place, to date, they have not had security problems. Target states also did not indicate any significant problems with privacy concerns. At the current time, the stored data are not traceable to a particular vehicle or person. It is more generic, encompassing multiple vehicles or data points. In addition, the aggregation routines would remove any traceability to a particular vehicle, person, or incident.

- Components of data management system. The largest component of any data management system is the storage itself. Regardless of how data are stored (flat files, database, etc.), physical media is required. Many states reported starting with a small system and having a continual expansion process in place to accommodate ever-increasing amounts of data storage. Storage needs must be analyzed whenever new data are brought online to ensure adequate space, backup, temporary storage for processing, and so on.

  Other components and considerations that are critical to any data management design process include the number and speed of processors, the amount of memory the system utilizes, scalability, load balancing, power backup requirements, communication needs, and software. Web servers, database servers, data processing servers, and load balancing servers may all be integral components of an advanced data management system. The software platform is also a critical question, as it relates to cost, ultimate scalability ease of providing services, and more.

- Management of system. Target states reported the use of both a centralized and decentralized model for their data management systems. In the centralized systems, the DOT is typically responsible for the construction, maintenance, operation, and upkeep of the system. Data from across the state may be fed directly to the system in a near real-time basis or it may be uploaded on a set interval from various districts. The use of the term decentralized is somewhat problematic. The original intent was to determine if a data management system was developed and operated from one specific location as opposed to multiple, smaller systems, housed across the states. However, some states appeared to classify a system run by a contractor as a decentralized system. In this approach, even though the physical infrastructure is in one place, the construction and operation of the data management system was accomplished via a contracting mechanism. The DOT has full access and use of the data, but the contractor performs all of the tasks associated with the system, including maintenance and upkeep, data loading, and expansion. Both models received favorable discussion, and no particular approach stood out as being significantly better than the other. In light of how this wording was used, the correct summary of the existing solutions would state that they are all centralized, and were designed and managed using a number of different approaches, including in-house and contracting.

- System cost. Very little solid information was obtained pertaining to the cost of constructing and operating a data management system. A number of the target states appeared to simply consider the costs as part of their normal operation and had no special category or accounting mechanism to track them. This is an indication perhaps of the degree to which the data have become an integral component of daily activities and applications.

SURVEY DATA ABSTRACTION

The researchers developed a database representation of the survey data to assist in the compilation and analytical process. The result is a data model and tool to capture, characterize, and analyze transportation operations data needs and flows that, at the same time, could facilitate the development of strategies to help optimize transportation operations data processes.

Developing an abstraction of the survey data was challenging given the need to account for different user groups both within TxDOT (TMCs, district traffic engineering) and external users (city traffic management, media outlets) and different data needs (format, aggregation levels) to support their business processes. As Figure 11 illustrates, a typical TMC generates real-time data (e.g., traffic condition loop data) to feed TMC functions requiring real-time data, TMC functions requiring real-time and archived data, or data archival functions. The same TMC could use archived data later for any TMC function or feed the data to external user functions requiring either real-time data or both real-time and archived data.

The high-level exchange of data shown in Figure 11 illustrates the concept of data flowing between user functions, although it only shows data that originate at the TMC. To facilitate the modeling process, it was necessary to include additional information, such as what data subjects different TMC functional activities exchange. The resulting model shows not only data flows among user functional activities but also characterizes these data flows.

Figure 12 shows examples of some of those data flows. For example, it shows the real-time exchange of incident data between the TMC incident detection function and emergency management services and media outlets. Likewise, it shows the exchange of archived traffic condition data, district planning, and project development. In reality, Figure 12 only shows a few data flows. The database characterizes all the data flows captured during the survey.

The researchers developed a logical and physical representation of the survey data model that complies with current TxDOT data standards (*18*). Figure 13 shows the logical model, Figure 14 shows the corresponding physical model, Table 6 describes the various entities, and Appendix E includes the entity and attribute data dictionary.

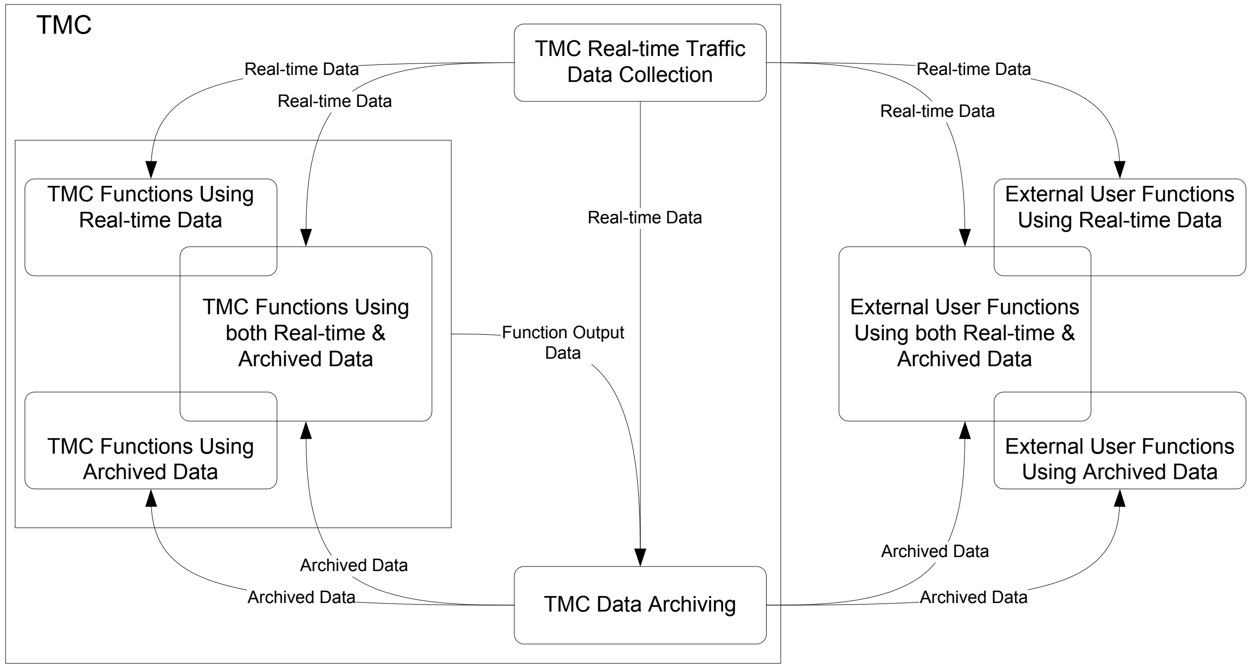


Figure 11. TMC Data Uses.

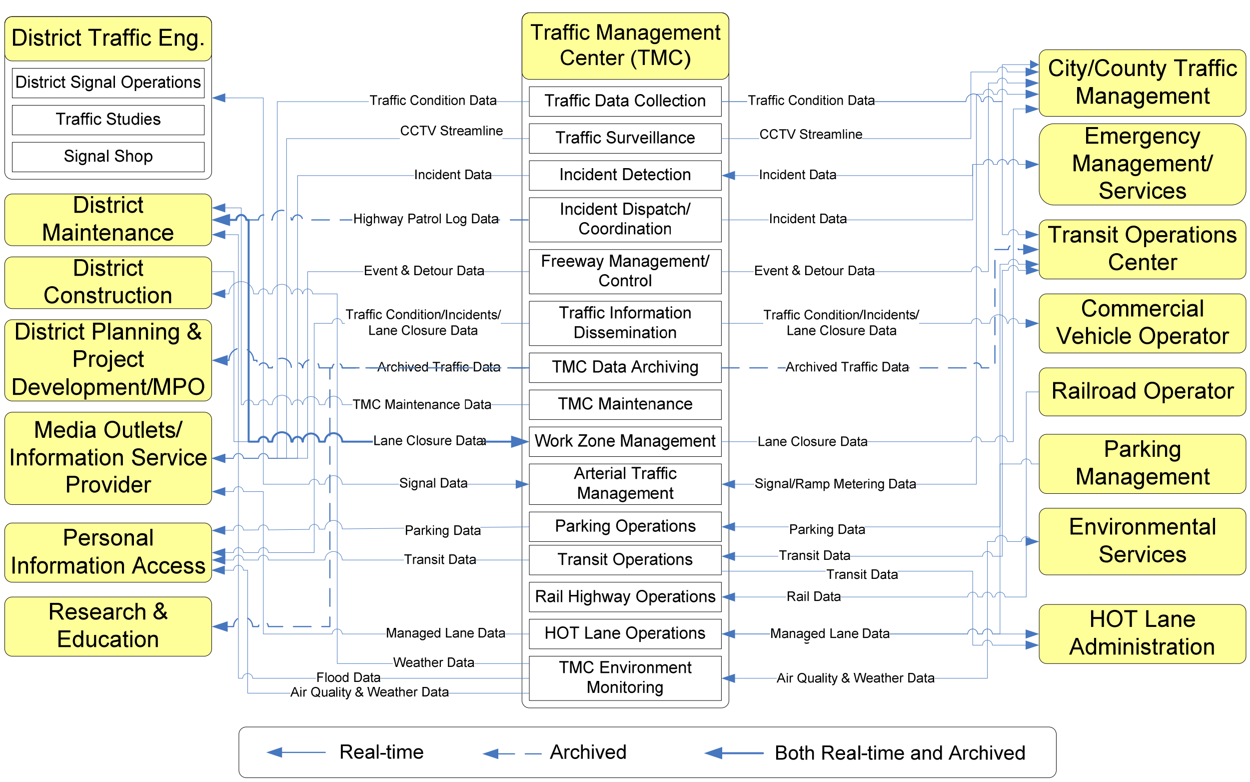


Figure 12. Sample of Data Flows.

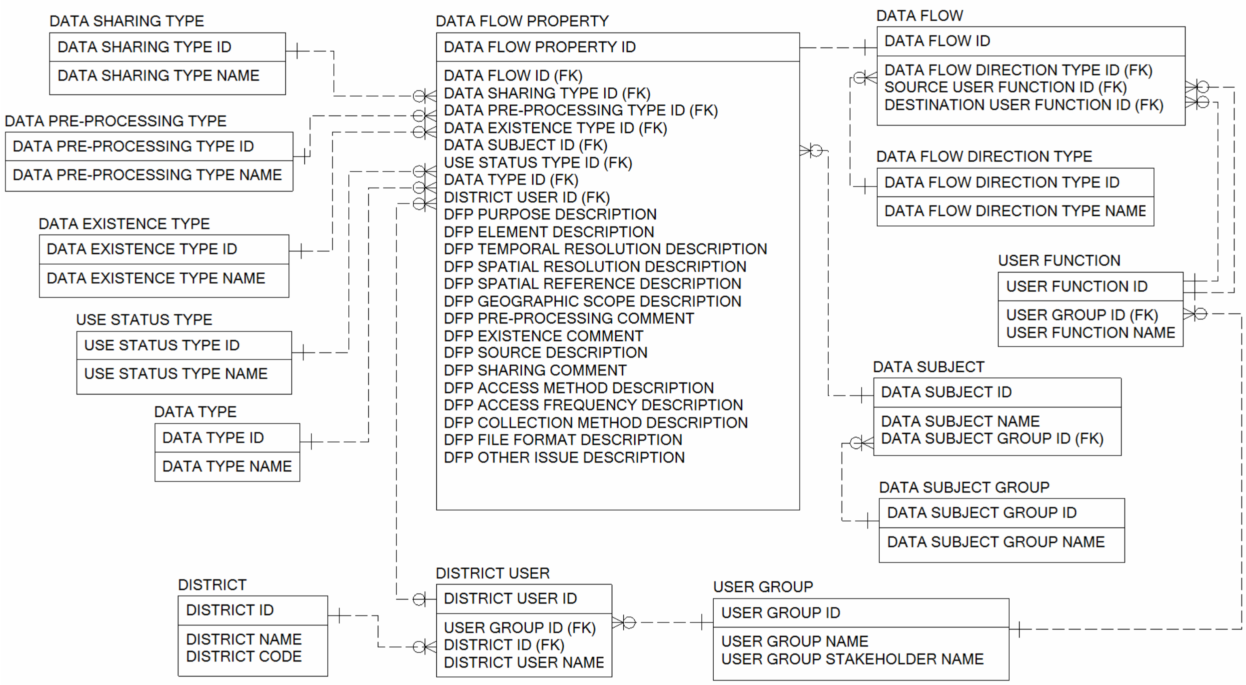


Figure 13. Logical Data Model.

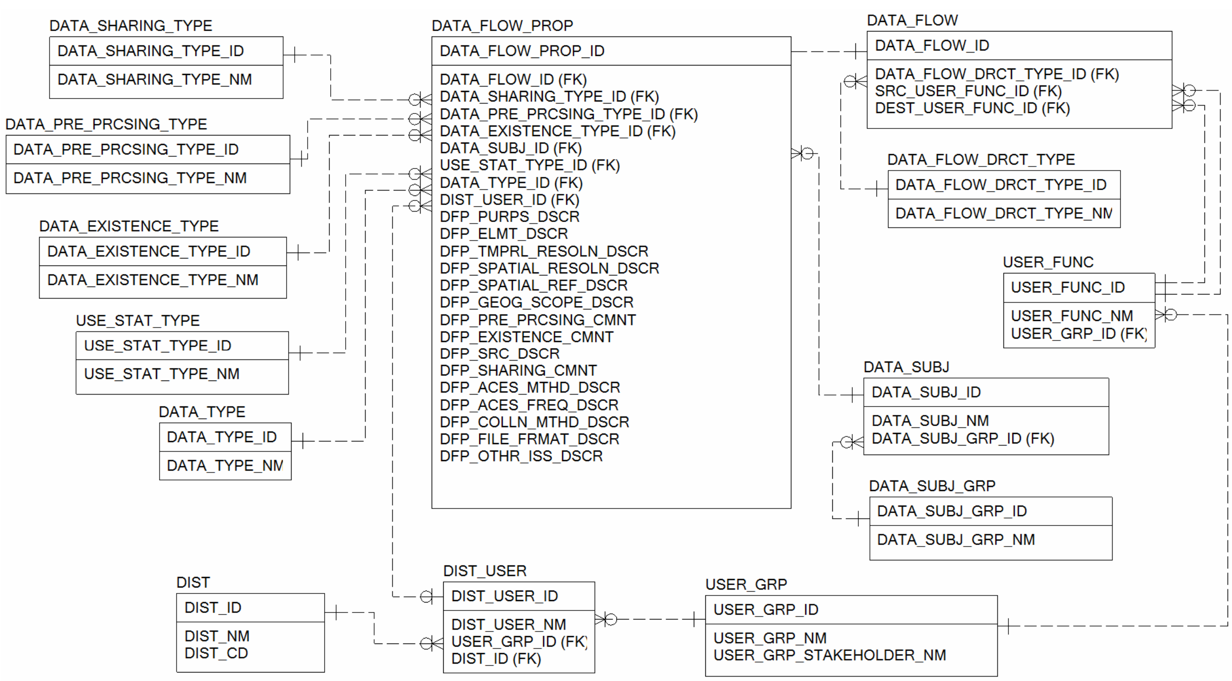


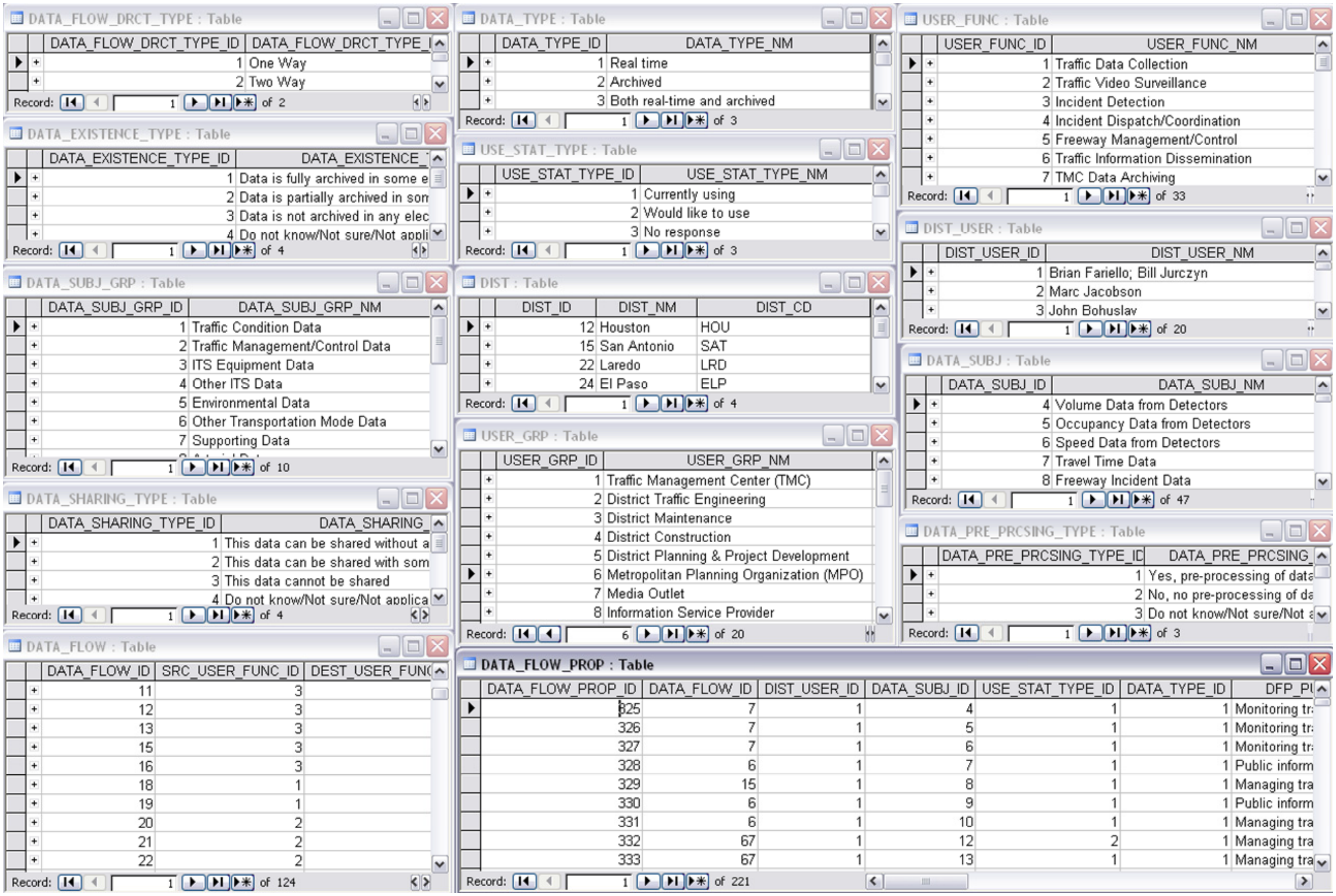
Figure 14. Physical Data Model.

Table 6. Database Entities.

Entity	Description
User Group	A User Group is an aggregation of individual users representing a class of transportation operations data users from a particular office/agency/organization. Examples of user groups include traffic management center, district traffic engineering, city traffic management, media outlet, etc.
District User	A District User is a user in one of the TxDOT districts surveyed for the purpose of characterizing transportation operations data needs. Table 2.3 lists these users.
District	A District is one of the 25 geographical areas within the state of Texas where TxDOT conducts its primary work activities. For the purpose of characterizing transportation operations data needs, only 4 districts were contacted: San Antonio, Houston, El Paso, and Laredo.
User Function	A User Function is a functional role or activity that a user group performs and for which transportations operations data is used or needed.
Data Subject	A Data Subject is the type of data being exchanged in a Data Flow. It is one of the 46 transportation operations data subjects listed in Table 2.
Data Subject Group	A Data Subject Group is a data type category into which Data Subjects are assigned. There are 10 data subject groups. Examples include traffic condition data, traffic management/control, ITS equipment, etc.
Data Flow	A Data Flow is an exchange of data between two User Functions. If Data Flow is one-way, then the data flows from an origin User Function to a destination User Function.
Data Flow Direction Type	A Data Flow Direction Type is a descriptor of whether a Data Flow represents a one-way or two-way data exchange.
Data Flow Property	A Data Flow Property is the description of a Data Flow. It provides a characterization of the data exchanges between User Functions based on direct user inputs from the detailed survey.
Data Type	A Data Type is a representation of whether the information exchanged in a DATA FLOW is real-time, archived, or both real-time and archived.
Use Status Type	A Use Status Type is a description of whether the type of information described by the Data Flow Property is currently in use or to be used in the future.
Data Existence Type	A Data Existence Type is a descriptor indicating the availability of the data in an electronic (softcopy) format.
Data Sharing Type	A Data Sharing Type is a descriptor of whether the data can be shared with other User Groups.
Pre-processing Type	A Pre-Processing Type is a descriptor indicating whether the user would need to process the data before use, or not.

The researchers developed an Access-format version of the physical model. To test the physical model and develop queries, the researchers populated the database using all the data captured during the long survey. As an illustration, Figure 15 shows screenshots of the 14 tables in the database. The researchers also developed a number of queries to extract data from the database in a usable format. Figure 16 shows two sample queries. Figure 16a shows a list of data flows between origin and destination functions, whereas Figure 16b shows the properties of the corresponding data flows. These two queries are perhaps the most important queries because they describe data flows and data flow characteristics, which are the foundation for more complex queries.

Figure 17 shows a sample Access form that results from joining the data flow and data flow characteristics queries. The form displays data flows between user function pairs, as well as the corresponding properties as captured during the survey.



DATA_FLOW_DRCT_TYPE : Table

DATA_FLOW_DRCT_TYPE_ID	DATA_FLOW_DRCT_TYPE_I
1	One Way
2	Two Way

Record: 1 of 2

DATA_EXISTENCE_TYPE : Table

DATA_EXISTENCE_TYPE_ID	DATA_EXISTENCE_T
1	Data is fully archived in some e
2	Data is partially archived in son
3	Data is not archived in any elec
4	Do not know/Not sure/Not appli

Record: 1 of 4

DATA_SUBJ_GRP : Table

DATA_SUBJ_GRP_ID	DATA_SUBJ_GRP_NM
1	Traffic Condition Data
2	Traffic Management/Control Data
3	ITS Equipment Data
4	Other ITS Data
5	Environmental Data
6	Other Transportation Mode Data
7	Supporting Data

Record: 1 of 10

DATA_SHARING_TYPE : Table

DATA_SHARING_TYPE_ID	DATA_SHARING
1	This data can be shared without a
2	This data can be shared with som
3	This data cannot be shared
4	Do not know/Not sure/Not applica

Record: 1 of 4

DATA_FLOW : Table

DATA_FLOW_ID	SRC_USER_FUNC_ID	DEST_USER_FUN(
11	3	
12	3	
13	3	
15	3	
16	3	
18	1	
19	1	
20	2	
21	2	
22	2	

Record: 1 of 124

DATA_TYPE : Table

DATA_TYPE_ID	DATA_TYPE_NM
1	Real time
2	Archived
3	Both real-time and archived

Record: 1 of 3

USE_STAT_TYPE : Table

USE_STAT_TYPE_ID	USE_STAT_TYPE_NM
1	Currently using
2	Would like to use
3	No response

Record: 1 of 3

DIST : Table

DIST_ID	DIST_NM	DIST_CD
12	Houston	HOU
15	San Antonio	SAT
22	Laredo	LRD
24	El Paso	ELP

Record: 1 of 4

USER_GRP : Table

USER_GRP_ID	USER_GRP_NM
1	Traffic Management Center (TMC)
2	District Traffic Engineering
3	District Maintenance
4	District Construction
5	District Planning & Project Development
6	Metropolitan Planning Organization (MPO)
7	Media Outlet
8	Information Service Provider

Record: 6 of 20

USER_FUNC : Table

USER_FUNC_ID	USER_FUNC_NM
1	Traffic Data Collection
2	Traffic Video Surveillance
3	Incident Detection
4	Incident Dispatch/Coordination
5	Freeway Management/Control
6	Traffic Information Dissemination
7	TMC Data Archiving

Record: 1 of 33

DIST_USER : Table

DIST_USER_ID	DIST_USER_NM
1	Brian Fariello; Bill Jurczyn
2	Marc Jacobson
3	John Bohuslav

Record: 1 of 20

DATA_SUBJ : Table

DATA_SUBJ_ID	DATA_SUBJ_NM
4	Volume Data from Detectors
5	Occupancy Data from Detectors
6	Speed Data from Detectors
7	Travel Time Data
8	Freeway Incident Data

Record: 1 of 47

DATA_PRE_PRCSING_TYPE : Table

DATA_PRE_PRCSING_TYPE_ID	DATA_PRE_PRCSING
1	Yes, pre-processing of data
2	No, no pre-processing of da
3	Do not know/Not sure/Not a

Record: 1 of 3

DATA_FLOW_PROP : Table

DATA_FLOW_PROP_ID	DATA_FLOW_ID	DIST_USER_ID	DATA_SUBJ_ID	USE_STAT_TYPE_ID	DATA_TYPE_ID	DFP_PI
325	7	1	4	1	1	Monitoring tr
326	7	1	5	1	1	Monitoring tr
327	7	1	6	1	1	Monitoring tr
328	6	1	7	1	1	Public inform
329	15	1	8	1	1	Managing tra
330	6	1	9	1	1	Public inform
331	6	1	10	1	1	Managing tra
332	67	1	12	2	1	Managing tra
333	67	1	13	1	1	Managing tra

Record: 1 of 221

Figure 15. Screenshot of Database Tables.

(a) Data Flow Query

Data Flow : Select Query

Data Flow ID	Source User Group	Source User Function	Destination User Group	Destination User Function	Data Flow Direction
5	Traffic Management Center (TMC)	Traffic Data Collection	Traffic Management Center (TMC)	Incident Detection	One Way
15	Traffic Management Center (TMC)	Incident Detection	Traffic Management Center (TMC)	Incident Dispatch/Coordination	One Way
49	Traffic Management Center (TMC)	Traffic Data Collection	Traffic Management Center (TMC)	Freeway Management/Control	One Way
60	Traffic Management Center (TMC)	Incident Detection	Traffic Management Center (TMC)	Freeway Management/Control	One Way
6	Traffic Management Center (TMC)	Traffic Data Collection	Traffic Management Center (TMC)	Traffic Information Dissemination	One Way
12	Traffic Management Center (TMC)	Incident Detection	Traffic Management Center (TMC)	Traffic Information Dissemination	One Way
22	Traffic Management Center (TMC)	Traffic Video Surveillance	Traffic Management Center (TMC)	Traffic Information Dissemination	One Way
150	Traffic Management Center (TMC)	TMC Environment Monitoring	Traffic Management Center (TMC)	Traffic Information Dissemination	One Way
153	Traffic Management Center (TMC)	Parking Operations	Traffic Management Center (TMC)	Traffic Information Dissemination	One Way
7	Traffic Management Center (TMC)	Traffic Data Collection	Traffic Management Center (TMC)	TMC Data Archiving	One Way
11	Traffic Management Center (TMC)	Incident Detection	Traffic Management Center (TMC)	TMC Data Archiving	One Way
67	Traffic Management Center (TMC)	Freeway Management/Control	Traffic Management Center (TMC)	TMC Data Archiving	One Way
8	Traffic Management Center (TMC)	Traffic Data Collection	Traffic Management Center (TMC)	Arterial Traffic Management	One Way
13	Traffic Management Center (TMC)	Incident Detection	Traffic Management Center (TMC)	Arterial Traffic Management	One Way
68	Traffic Management Center (TMC)	Freeway Management/Control	Traffic Management Center (TMC)	Arterial Traffic Management	One Way
121	District Traffic Engineering	District Signal Shop	Traffic Management Center (TMC)	Arterial Traffic Management	One Way
143	District Traffic Engineering	District Traffic Studies	Traffic Management Center (TMC)	Arterial Traffic Management	One Way
16	Traffic Management Center (TMC)	Incident Detection	Traffic Management Center (TMC)	Transit Operations	One Way
19	Traffic Management Center (TMC)	Traffic Data Collection	Traffic Management Center (TMC)	Transit Operations	One Way
40	Traffic Management Center (TMC)	Transit Operations	Traffic Management Center (TMC)	Transit Operations	Two Way

Record: 20 of 124

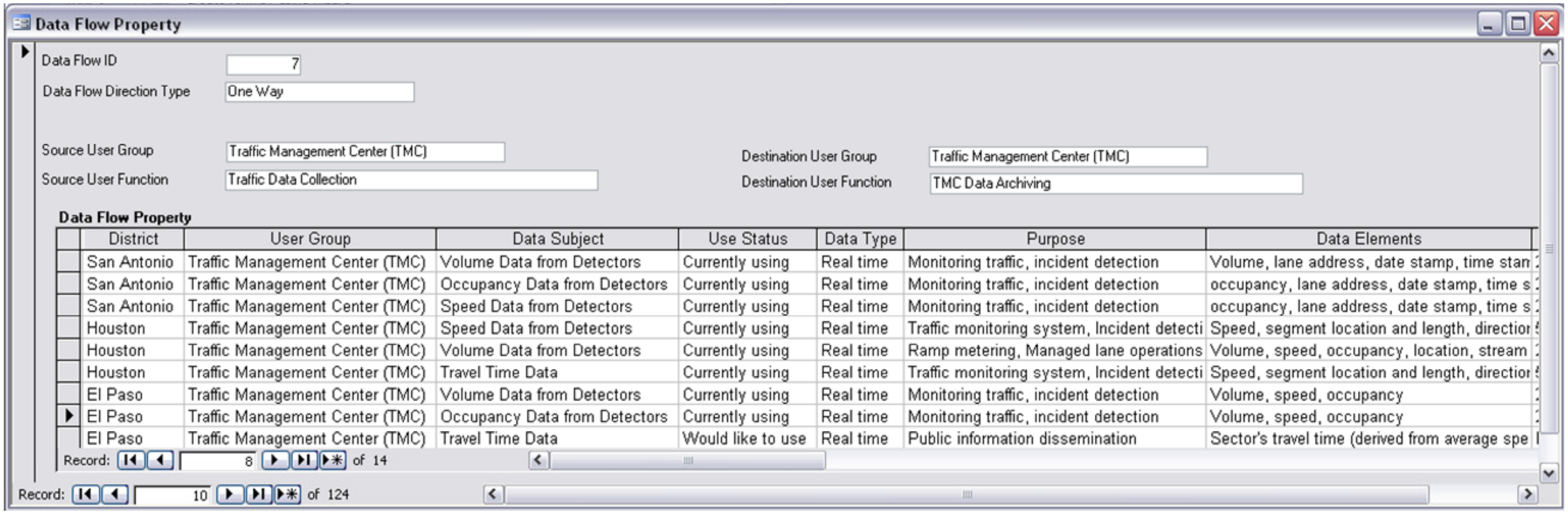
(b) Data Flow Property Query

Data Flow Property : Select Query

DFP ID	Data Flow ID	District	User Group	Data Subject	Use Status	Data Type	Purpose	Data Elements
325	7	San Antonio	Traffic Management Center (TMC)	Volume Data from Detectors	Currently using	Real time	Monitoring traffic, incident detection	Volume, lane address, da
326	7	San Antonio	Traffic Management Center (TMC)	Occupancy Data from Detectors	Currently using	Real time	Monitoring traffic, incident detection	occupancy, lane address
327	7	San Antonio	Traffic Management Center (TMC)	Speed Data from Detectors	Currently using	Real time	Monitoring traffic, incident detection	occupancy, lane address
328	6	San Antonio	Traffic Management Center (TMC)	Travel Time Data	Currently using	Real time	Public information dissemenation	Sector's travel time (deriv
329	15	San Antonio	Traffic Management Center (TMC)	Freeway Incident Data	Currently using	Real time	Managing traffic	Type, location (sector ad
330	6	San Antonio	Traffic Management Center (TMC)	Dynamic (Variable) Message Sign Data	Currently using	Real time	Public information dissemenation	Message content display
331	6	San Antonio	Traffic Management Center (TMC)	Lane Control Sign Data	Currently using	Real time	Managing traffic	State of arrows, date and
332	67	San Antonio	Traffic Management Center (TMC)	Traffic Control Detour Data	Would like to use	Real time	Managing traffic	Detour details
333	67	San Antonio	Traffic Management Center (TMC)	Roadway Event Data	Currently using	Real time	Managing traffic	Alarms, sector address,
334	6	San Antonio	Traffic Management Center (TMC)	ITS Equipment Inventory Data	Currently using	Archived	Managing TransGuide inventory	Device type, location, ma
335	6	San Antonio	Traffic Management Center (TMC)	ITS Equipment Maintenance Log Data	Currently using	Archived	Managing TransGuide inventory	Alarm, device ID, conditic
336	6	San Antonio	Traffic Management Center (TMC)	Fiber Optic Network Management Data	Currently using	Archived	Managing fiber optic communication :	End devices, intermediat
337	33	San Antonio	Traffic Management Center (TMC)	Scheduled Lane-closure Data	Currently using	Real time	Public information dissemination, traf	Closure status (active/ pl
338	42	San Antonio	Traffic Management Center (TMC)	Toll Road Data	Would like to use	Real time	Public information dissemination, traf	Same real-time data colle
339	22	San Antonio	Traffic Management Center (TMC)	Closed Circuit TV (CCTV) Surveillance/	Currently using	Real time	Monitoring traffic, public information d	Streamlined (live feed) vic
340	120	San Antonio	Traffic Management Center (TMC)	Parking Management Data	Would like to use	Real time	Public information dissemination thro	Space availability (numbe
341	25	San Antonio	Traffic Management Center (TMC)	Police CAD Data	Currently using	Real time	Dissemination to public	Incident ID, type, locatior
342	6	San Antonio	Traffic Management Center (TMC)	TMC Website Usage Data	Currently using	Both real-time	Evaluate public interest in information	Web site number of hits
343	150	San Antonio	Traffic Management Center (TMC)	Flood Data	Currently using	Real time	Feed data to maintenance office for n	Flow reading into well, flo
344	38	San Antonio	Traffic Management Center (TMC)	Traffic Signal Operations and Control D:	Would like to use	Real time	Traffic management (integration of art	Signal timing plans (depe
345	121	San Antonio	Traffic Management Center (TMC)	Traffic Signal Maintenance Data	Would like to use	Archived	Signal performance monitoring	Maintenance logs, servic
346	38	San Antonio	Traffic Management Center (TMC)	Intersection Vehicle Count/Turning Volu	Would like to use	Real time	Traffic control on service roads leadin	Turning volume (left, throu

Record: 4 of 212

Figure 16. Screenshots of Sample Queries.



Data Flow Property

Data Flow ID: 7

Data Flow Direction Type: One Way

Source User Group: Traffic Management Center (TMC)

Source User Function: Traffic Data Collection

Destination User Group: Traffic Management Center (TMC)

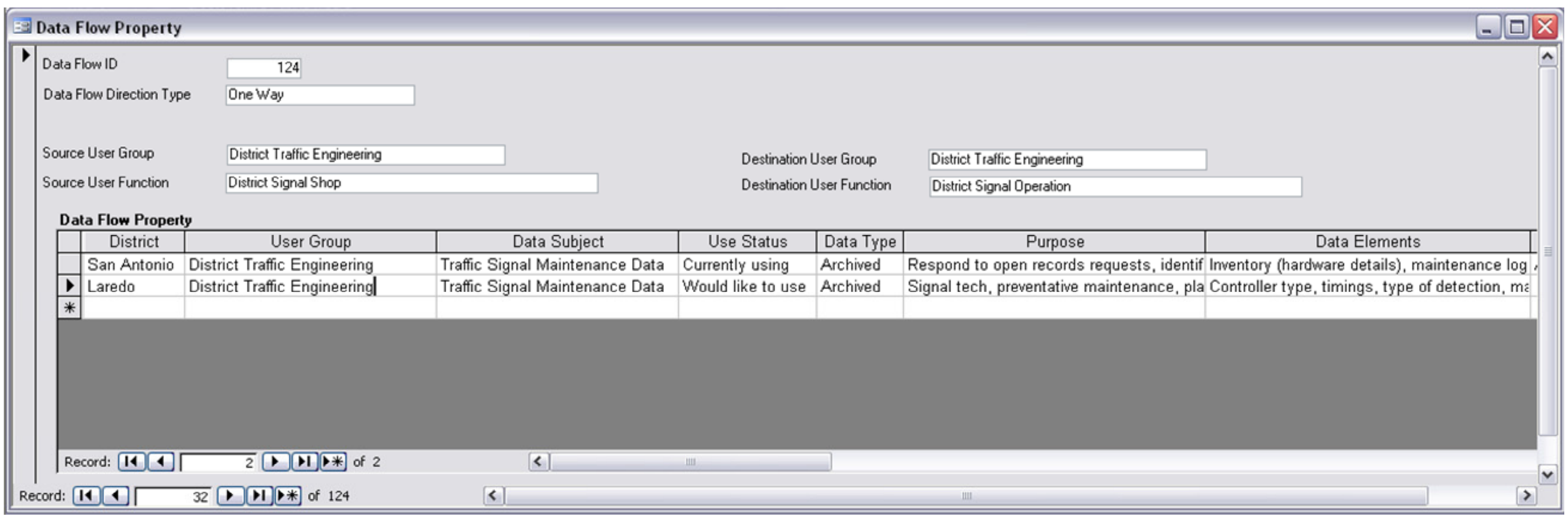
Destination User Function: TMC Data Archiving

Data Flow Property

District	User Group	Data Subject	Use Status	Data Type	Purpose	Data Elements
San Antonio	Traffic Management Center (TMC)	Volume Data from Detectors	Currently using	Real time	Monitoring traffic, incident detection	Volume, lane address, date stamp, time stan
San Antonio	Traffic Management Center (TMC)	Occupancy Data from Detectors	Currently using	Real time	Monitoring traffic, incident detection	occupancy, lane address, date stamp, time s
San Antonio	Traffic Management Center (TMC)	Speed Data from Detectors	Currently using	Real time	Monitoring traffic, incident detection	occupancy, lane address, date stamp, time s
Houston	Traffic Management Center (TMC)	Speed Data from Detectors	Currently using	Real time	Traffic monitoring system, Incident detecti	Speed, segment location and length, directior
Houston	Traffic Management Center (TMC)	Volume Data from Detectors	Currently using	Real time	Ramp metering, Managed lane operations	Volume, speed, occupancy, location, stream
Houston	Traffic Management Center (TMC)	Travel Time Data	Currently using	Real time	Traffic monitoring system, Incident detecti	Speed, segment location and length, directior
El Paso	Traffic Management Center (TMC)	Volume Data from Detectors	Currently using	Real time	Monitoring traffic, incident detection	Volume, speed, occupancy
El Paso	Traffic Management Center (TMC)	Occupancy Data from Detectors	Currently using	Real time	Monitoring traffic, incident detection	Volume, speed, occupancy
El Paso	Traffic Management Center (TMC)	Travel Time Data	Would like to use	Real time	Public information dissemination	Sector's travel time (derived from average spe

Record: 8 of 14

Record: 10 of 124



Data Flow Property

Data Flow ID: 124

Data Flow Direction Type: One Way

Source User Group: District Traffic Engineering

Source User Function: District Signal Shop

Destination User Group: District Traffic Engineering

Destination User Function: District Signal Operation

Data Flow Property

District	User Group	Data Subject	Use Status	Data Type	Purpose	Data Elements
San Antonio	District Traffic Engineering	Traffic Signal Maintenance Data	Currently using	Archived	Respond to open records requests, identif	Inventory (hardware details), maintenance log
Laredo	District Traffic Engineering	Traffic Signal Maintenance Data	Would like to use	Archived	Signal tech, preventative maintenance, pla	Controller type, timings, type of detection, mε

Record: 2 of 2

Record: 32 of 124

Figure 17. Screenshots of Sample Form.

CHAPTER 3. RELATED DATA MANAGEMENT PRACTICES AT TXDOT

INTRODUCTION

This chapter summarizes relevant data management practices and plans at TxDOT, including document archival practices, project management information, and data standards. The information is relevant because it reflects current practices and plans that currently (or eventually will) impact transportation operations data management at the department.

TXDOT DOCUMENT ARCHIVAL PROCESSES

TxDOT has well defined project-based hardcopy data archival and retention practices (*19*, *20*). For example, the Texas Records Retention Schedule documents retention periods, security codes, archival location, and medium (e.g., paper, microfilm, electronic, other) of record classifications for a given division, section or district (*19*). A code with an optional number notes document retention periods (e.g., AC+4, where "AC" represents terminated or completed, and "4" indicates years). In general, TxDOT scans documents, archives the corresponding digital images, and destroys original hardcopy documents (with some exceptions). Table 7 lists document files TxDOT divisions need to retain for the life of the asset or keep permanently.

Table 7. Documents TxDOT Divisions Need to Keep Permanently.

Division	Document
Bridge	Gauging station records and other instrumentation attached to bridges Bridge design exceptions Bridge special inspection reports Bridge inspection database Bridge project drilled shaft and pile driving records Statewide standard drawing file
Design	Design exception files
Information Services	Aerial photography files
Right of Way	Non ROW acquisitions Final ROW project files containing ROW conveyances and judgments, final ROW maps, title insurance policies, or other instruments pertaining to the State's title to land or interests
Traffic Operations	Railroad agreements and exhibits pertaining to specific crossing projects and railroad spur tracks crossing state highways

The District Record Copy Responsibility List is similar to the Texas Records Retention Schedule but only applies to records at the district level (*20*). The list makes a distinction between vital records, which are the first records to recuperate after a disaster, and non-vital records. Table 8 shows a summary of records districts need to retain. TxDOT typically retains highway construction project records for four years after closing a project (normally after the engineer in charge has accepted delivery of the finished construction project). For electronic records, both the Texas and district retention schedules require documents to be retained for five years after project closing. However, there is no enforcement of this policy. Further, management of electronic project documents is typically ad hoc and depends on specific office practices.

Table 8. Documents TxDOT Districts Need to Retain.

Section/Area	Document
Accounting and Fiscal Records	Federal grant information
Administrative Records	Administrative correspondence Performance measures documentation Agency rules, policies, and procedures Performance bonds Tort claim records maintained in district offices
District Bridge Operations	Records related to agreements with local participating agencies (LPAs) for bridge and other projects Records related to Waiver of Local Match Fund Participation requirements (PWP/EMP) for off-system bridge projects Consultant contract files Consultant contract procurement file **Design waiver records** **Bridge folders containing the original bridge inventory report, map, sketches, initial and subsequent inspection reports, appraisal worksheets, NBI printout, etc.** **Documents and exhibits prepared in support of railroad agreements related to grade separation projects (not vital)** **Historic bridge project records (not vital)** **Bridge inspection summary reports (not vital)**
Design, Engineering, and Construction Records	Building construction project files **Building plans and specifications** **Bridge engineering records**
District Design Records	Consultant contract files Consultant contract procurement file **Design waiver/variance records (not vital)**
District Maintenance/Facility Management Records	Agreements and permits Maintenance safety: local disaster plan Radio base station and mobile licenses Adopt-a-Highway agreements and documentation Certificates of insurance for maintenance projects Maintenance project contract files managed in districts **District buildings plans and records** **Traffic signal maintenance files (not vital)**
District Maintenance Section/Operations Records	Maintenance contract records Documentation of "Watch for Ice on Bridge Signs" Records related to underground or aboveground storage tanks (not vital) **Underground storage tank subsystems (not vital)**
District Transportation Planning & Development Records	**Federal Transit Authority Public Transportation Grant Program Files for equipment and facilities (not vital)**
District Right of Way Records	ROW project files for state, federal, and local participating agency ROW acquisition Non ROW acquisitions District ROW leasing files Utility Agreements Outdoor advertising sign permit files
District Traffic Operations Records	Traffic management project records for projects done by contract forces

Note: Records in bold represent district documents retained for the life of the asset or kept permanently.

PROJECT DEVELOPMENT PROCESS SUPPORTING INFORMATION SYSTEMS

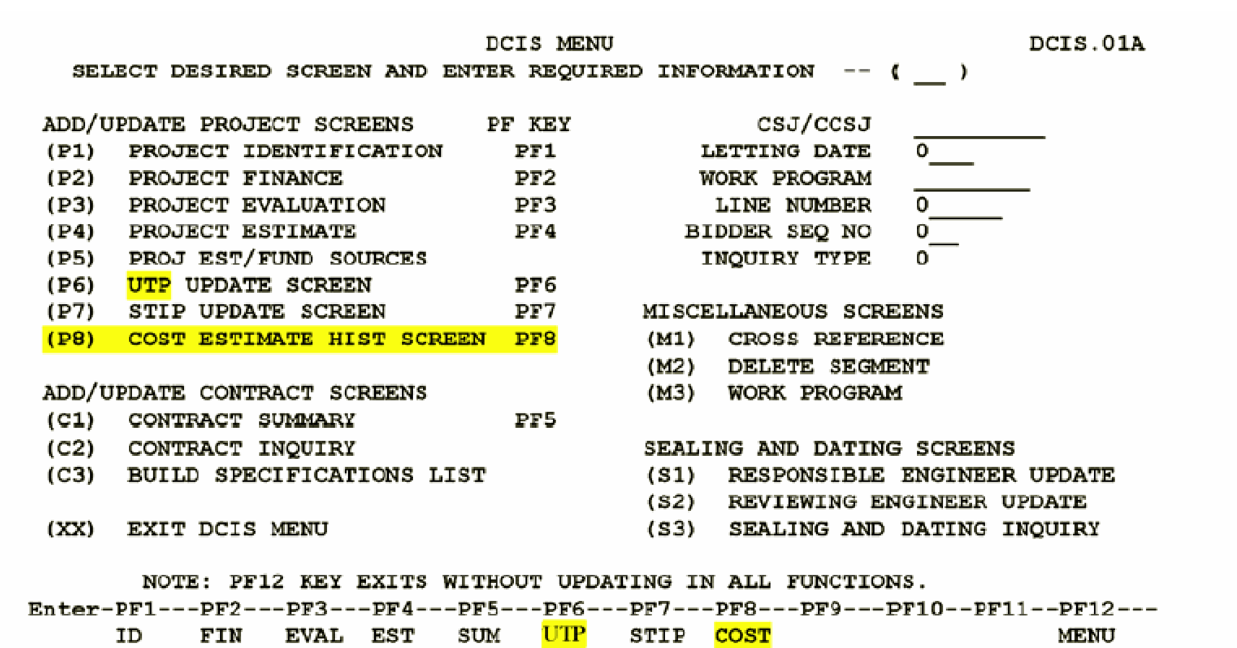
TxDOT uses several information systems to support the project development process, including the Design and Construction Information System (DCIS) and the Texas Reference Marker (TRM) System. A short description of each system follows.

Design and Construction Information System (DCIS)

TxDOT uses DCIS to prepare projects for project specification and estimation (PS&E) development and contract letting (*21*). This system contains project information such as work descriptions, funding requirements, and dates for proposed activities. DCIS relies on a Tables and Characteristics System that contains lookup codes and project specific files. The control section job (CSJ) number is the key descriptor for the record of each project in DCIS. Each CSJ record has information in four key files as follows:

- File 121 - DCIS project information
- File 122 - DCIS work program
- File 123 - DCIS project estimate
- File 124 - DCIS contract letting

Figure 18 and Figure 19 show a copy of the main DCIS menu screen and a sample project identification screen, respectively.



```
                                DCIS MENU                                   DCIS.01A
    SELECT DESIRED SCREEN AND ENTER REQUIRED INFORMATION  -- ( __ )

  ADD/UPDATE PROJECT SCREENS      PF KEY            CSJ/CCSJ     ________
  (P1)   PROJECT IDENTIFICATION     PF1         LETTING DATE     0___
  (P2)   PROJECT FINANCE            PF2         WORK PROGRAM     _______
  (P3)   PROJECT EVALUATION         PF3          LINE NUMBER     0_____
  (P4)   PROJECT ESTIMATE           PF4        BIDDER SEQ NO     0__
  (P5)   PROJ EST/FUND SOURCES                  INQUIRY TYPE     0
  (P6)   UTP UPDATE SCREEN          PF6
  (P7)   STIP UPDATE SCREEN         PF7     MISCELLANEOUS SCREENS
  (P8)   COST ESTIMATE HIST SCREEN  PF8     (M1)   CROSS REFERENCE
                                            (M2)   DELETE SEGMENT
  ADD/UPDATE CONTRACT SCREENS               (M3)   WORK PROGRAM
  (C1)   CONTRACT SUMMARY           PF5
  (C2)   CONTRACT INQUIRY                   SEALING AND DATING SCREENS
  (C3)   BUILD SPECIFICATIONS LIST          (S1)   RESPONSIBLE ENGINEER UPDATE
                                            (S2)   REVIEWING ENGINEER UPDATE
  (XX)   EXIT DCIS MENU                     (S3)   SEALING AND DATING INQUIRY

        NOTE: PF12 KEY EXITS WITHOUT UPDATING IN ALL FUNCTIONS.
 Enter-PF1---PF2---PF3---PF4---PF5---PF6---PF7---PF8---PF9---PF10--PF11--PF12---
       ID    FIN   EVAL  EST   SUM   UTP   STIP  COST                      MENU
```

Figure 18. DCIS Menu Screen (*21*).

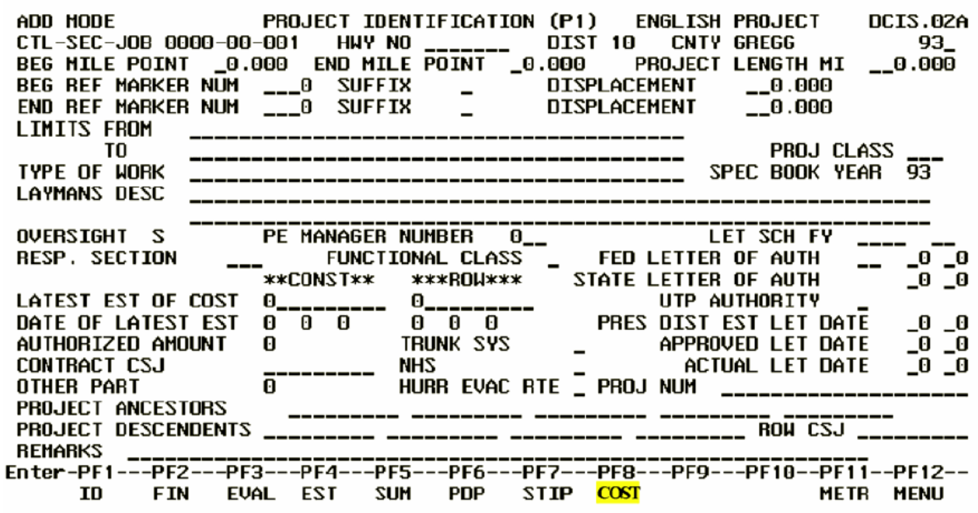

```
ADD MODE            PROJECT IDENTIFICATION (P1)  ENGLISH PROJECT    DCIS.02A
CTL-SEC-JOB 0000-00-001   HWY NO _______  DIST 10   CNTY GREGG          93_
BEG MILE POINT  _0.000  END MILE POINT  _0.000   PROJECT LENGTH MI  __0.000
BEG REF MARKER NUM  ___0  SUFFIX   _      DISPLACEMENT    __0.000
END REF MARKER NUM  ___0  SUFFIX   _      DISPLACEMENT    __0.000
LIMITS FROM    ________________________________________
       TO      ________________________________________      PROJ CLASS ___
TYPE OF WORK   ________________________________________  SPEC BOOK YEAR  93
LAYMANS DESC   ____________________________________________________________
               ____________________________________________________________
OVERSIGHT  S        PE MANAGER NUMBER  0__              LET SCH FY  ____ __
RESP. SECTION    ___     FUNCTIONAL CLASS  _   FED LETTER OF AUTH   __  _0 _0
                    **CONST**    ***ROW***    STATE LETTER OF AUTH      _0 _0
LATEST EST OF COST  0_________   0_________         UTP AUTHORITY   _
DATE OF LATEST EST  0  0  0      0  0  0       PRES DIST EST LET DATE   _0 _0
AUTHORIZED AMOUNT   0          TRUNK SYS    _       APPROVED LET DATE   _0 _0
CONTRACT CSJ        _________  NHS          _         ACTUAL LET DATE   _0 _0
OTHER PART          0          HURR EVAC RTE _  PROJ NUM  ____________________
PROJECT ANCESTORS       _________ _________ _________ _________ _________
PROJECT DESCENDENTS _________ _________ _________ _________ ROW CSJ _________
REMARKS        ____________________________________________________________
Enter-PF1---PF2---PF3---PF4---PF5---PF6---PF7---PF8---PF9---PF10--PF11--PF12--
      ID     FIN   EVAL   EST   SUM   PDP   STIP  COST              METR  MENU
```

Figure 19. DCIS Blank Project Identification Screen ([*21*](#)).

Because of intrinsic limitations associated with the structure and usability of DCIS, districts and divisions have found it necessary to develop custom-built applications to interact (mostly for downloading purposes) with DCIS. For example, the Corpus Christi District developed an Access-based application called the Highway Project Task Management System (HPTMS), which relies on daily data downloads from DCIS. HPTMS does not upload data to DCIS. The San Antonio District also uses HPTMS in its construction office (Figure 20).

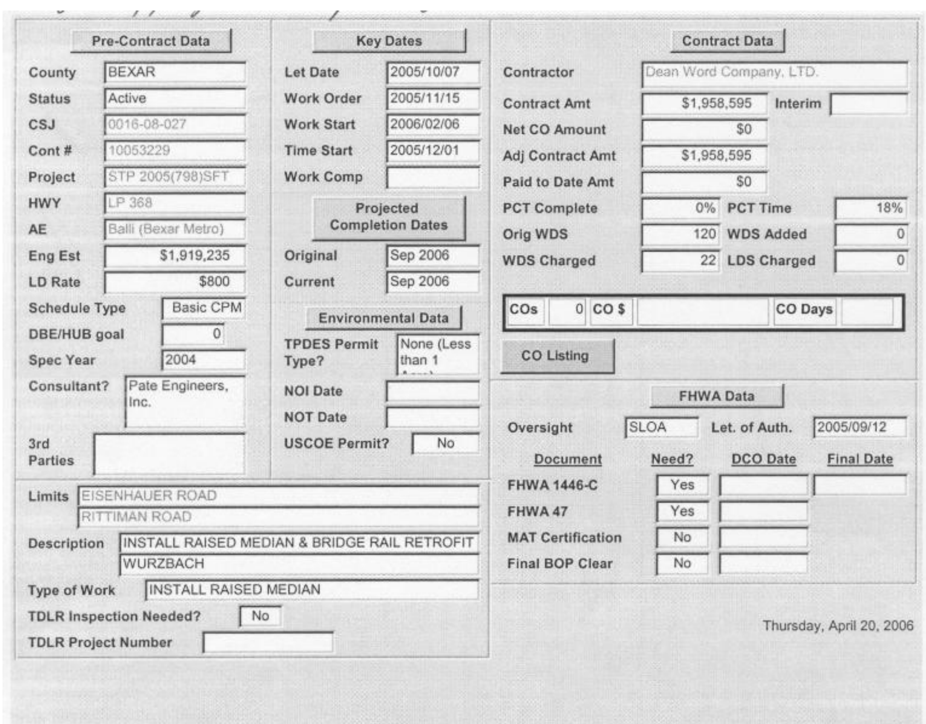


Figure 20. Sample San Antonio HPTMS Screen Capture.

TXDOT DOCUMENT MANAGEMENT SYSTEMS

With the enormous amounts of data TxDOT manages in a variety of data formats with varying levels of accuracy and resolution, TxDOT divisions and districts have recognized a growing need to implement electronic document management strategies to address the issue of decreasing file room space. As a result, several districts and divisions have implemented (or are in the process of implementing) systems to manage data. Of particular interest to this research are FileNet, ProjectWise, and the San Antonio District's File Management System (FMS).

FileNet

Currently, most TxDOT districts and divisions follow ad hoc procedures to manage electronic documentation. In 1996, the Houston District started using FileNet to track construction project as-builts, PS&E documents, and correspondence. FileNet is an enterprise content management system that enables officials to share and manage access to files, generate database records to keep track of every document processed, and produce queries and reports based on a number of attributes (*22*). FileNet resides on top of a database management system such as Oracle, IBM DB2, or Microsoft SQL Server. The TxDOT FileNet implementation stores files in the file structure of the server computer (although file embedding in the database is also possible) and pointers to those files in the database. FileNet installation is highly involved and requires the participation of licensed technicians. It is also not designed, in software and required hardware specifications and cost, for individual users or small groups. It may be worth noting that IBM is currently acquiring FileNet and that, as part of the agreement, IBM intends to integrate FileNet's operations into IBM's content management services (*23*).

TxDOT is currently implementing FileNet at the Austin District and at several divisions (such as Motor Carrier, Motor Vehicle, Finance, and Occupational Safety). The current plan is to implement FileNet statewide, with separate implementations for different units within the organization (*24*). TxDOT currently has two types of implementations: client-server (with FileNet software installed on client computers) and web-based. FileNet's interface includes a folder and file viewer (Figure 21) and functions such as viewing current file users, assigning file attributes or tags, querying, searching, and file versioning. Currently, TxDOT uses FileNet version 7.

TxDocsOnline is a web-based system that uses a FileNet engine and does not require the installation of FileNet software on client computers. For efficiency, the implementation works best with a T-1 connection for satellite offices. TxDocsOnline's implementation of FileNet relies on function-based libraries, not project-based libraries (as in the Houston District original FileNet implementation). Document classes are defined folders. Below document classes are record types and within a record type there is a predefined list of documents that go into that record type. Every document class has a record type, every record type has a document type, and every document type has a status and a date. Each breakdown has a glossary or definition associated with it. Each file in the library is assigned a location and tags/properties that permit file indexing. TxDOT's goal is to have a separate library for each business unit. However, the FileNet implementation will not be able to cross the entire organization and/or districts.

TxDocsOnline documentation includes a user guide and content services library standards (*25*, *26*). The standards include document classes, security, folder settings, standard properties, document properties, property definitions, recommended property values, recommended record types, and document types for standard document classes.

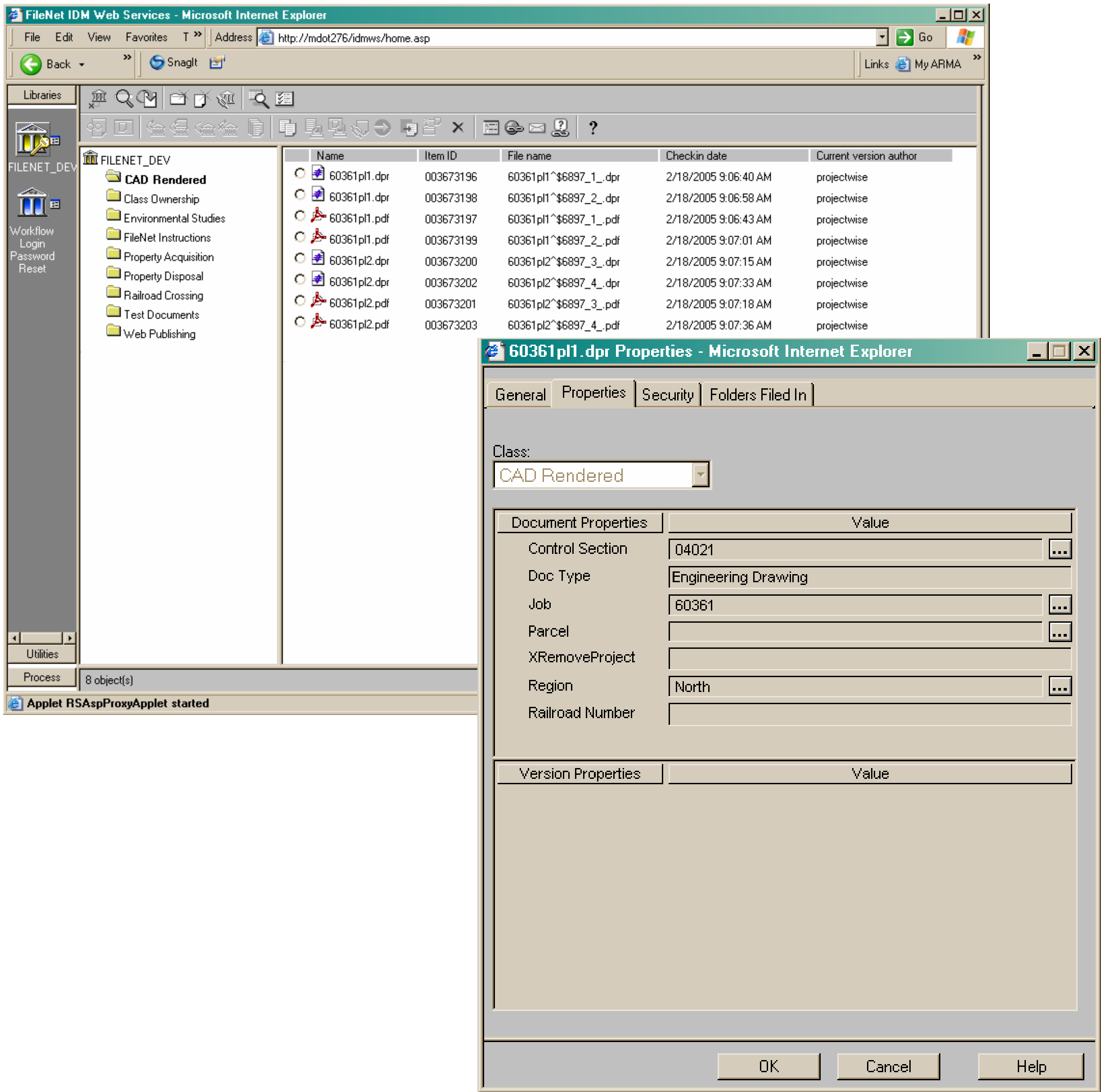


Figure 21. FileNet Sample Screens (*24*).

ProjectWise

TxDOT has begun to explore the feasibility of using Bentley's ProjectWise to assist in the management of (primarily) engineering design documents such as Microstation computer aided design (CAD) drawing files. TxDOT is currently using ProjectWise as a pilot on the SH 130 design-build project in Central Texas, which is managing over 32,000 files occupying some 22 gigabytes of hard drive space *(27)*. Currently, there is not a statewide implementation plan for ProjectWise.

ProjectWise is an electronic document management system that allows users to manage various project aspects through a graphical interface that includes a folder and file viewer (Figure 22). It is a client-server software application, in which files reside on a main server and users copy those files to local drives for editing. After editing, users place the files back on the server and the system deletes the local files, therefore helping to eliminate duplicate files. Like FileNet, ProjectWise manages files and provides querying and reporting capabilities. Unlike FileNet, ProjectWise includes tools and templates to automate the production of Microstation drawings. It also retains the structure of Microstation reference files.

According to some users, ProjectWise does not handle Microstation files prior to version 8 well. Additional drawbacks include the installation process inefficiencies (e.g., structuring the associated database and integrating, populating, and testing files), printing problems, speed, and labor intensive administration.

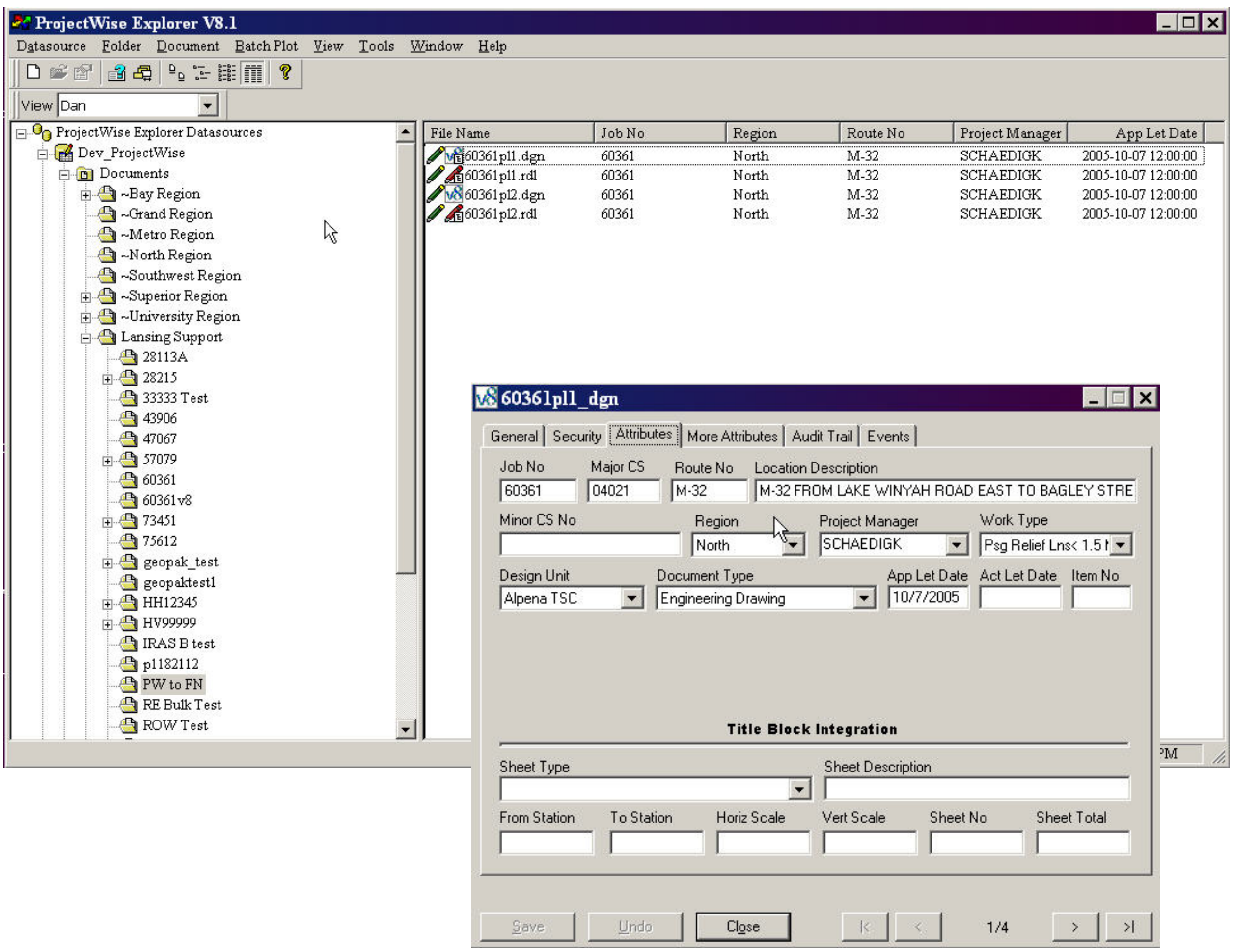


Figure 22. ProjectWise Sample Screens *(27)*.

San Antonio District's File Management System (FMS)

The San Antonio District's FMS is a systematic arrangement of folders, files, and procedures to create uniformity in project development and documentation *(28)*. FMS includes a project folder structure (Table 9), primary and secondary project files, Microstation libraries, and embedded quantity spreadsheets, which link quantity estimate spreadsheets to CAD files with quantity summaries. FMS relies on a file manager, who maintains the integrity of the project files. This manager reviews and incorporates all work into the primary files, maintains backups, and coordinates multi-user project development. The manager is the only person who accesses and makes changes to the primary files.

Table 9. File Management System Folders *(28)*.

FOLDER	DESCRIPTION
Batchplot	Batchplot
BRIDGE	Bridge Design
Change Orders	Change Orders
Correspondence	Project related letters, memos, etc.
Correspondence / PDP	Project Development Process (utility companies) Utility Company location files (S.U.E. files)
Correspondence / ENV	Environmental Correspondence Documents
DRAINAGE	Culvert Layouts, Storm Sewer Layouts, Hydraulic Data, etc.
ENVIRONMENTAL	Storm Water Pollution Preventions Plans, EPIC sheets
Estimate	Estimates
Estimate / Preliminary	Preliminary Estimates
File Structure	Level Assignment (.dgnlib)
GENERAL	Title Sheet, Project Layout, Typical Sections
GeoPak	GeoPak Files
MISC	Landscape and Irrigation layouts
Old Files	Files determined to not be needed are moved here rather than deleting. Do not delete ANY files.
P3	Contract, Time Determination & Schedules
P3 / Construction	Construction Schedules
P3 / Design	Design Schedules
Pavement Design	Pavement Design
PS&E	Necessary paperwork for PS&E submission
ReferenceFiles	Primary Files ONLY
ROADWAY	Plan Sheets & miscellaneous roadway details
ROADWAY/Driveways	Driveway layouts, Pictures of Driveways
Standards	District Standards included in PS&E package
Standards/Bridge	Bridge Standards
Standards/Drainage	Drainage Standards
Standards/Illumination	Illumination Standards
Standards/Illumination/Electrical	Electrical Standards
Standards/Retaining Walls	Retaining Walls Standards
Standards/Roadway	Roadway Standards
Standards/Signing	Signing Standards
Standards/Pavement Markers	Pavement Markers Standards
Standards/SW3P	SW3P Standards
Standards/TCP	TCP Standards
Standards/Traffic Signals	Traffic Signals Standards
Standards/TMS	TMS Standards
Summaries	Project Summaries
Summaries/Excel	Excel Summaries for calculations & linking
Survey	Survey Data, .arc files
TCP	Traffic Control Plans, Schedule of Barricades & Warning Device
TCP / Phase I, Phase II, etc.	Phase I, II, III, etc. of TCP
TRAFFIC	Illumination, Sign, Pavement Markings, Signal, and TMS layouts
UTILITY	Utility layouts
WALLS	Retaining Wall layouts
Xsec	Cross Sections

FMS stores all electronic files associated with a project in a root folder called \Projects\{CSJ}, where {CSJ} represents the project CSJ number. Each CSJ folder contains 25 subfolders (Table 9). The ReferenceFiles subfolder includes primary files. Subfolders that are in uppercase (e.g., ROADWAY) contain secondary files. For each project there are 11 primary files (Table 10).

These files are attached as references to the secondary files. To minimize erroneous modifications, only the file manager can access the primary files. The Primary file naming convention is:

{Prefix}{Abbreviation} (e.g., IH410map.dgn)

where *{Prefix}* is the roadway or project specific area and *{File Type Abbreviation}* is the file abbreviation (Table 10).

Table 10. FMS Primary File Types (*28*).

Primary File	Abbreviation	Purpose
Map	map	existing topography
Roadway	rdwy	surface improvements
Horizontal Alignment	haln	horizontal control
Vertical Alignment	valn	vertical control
Drainage	drn	subsurface improvements.
Utility	util	existing and proposed utilities
TCP-SW3P	tcp-sw3p	traffic control and pollution control items
Traffic	traf	proposed pavement markings, signs, signals, & illumination
Border	bord	sheet border with Title Block and legends
Pattern	patt	patterns and/or shading to differentiate project aspects
Quantity Box	qbox	linked plan sheet quantity boxes & summaries

Secondary files are the PS&E plan sheets. They may or may not require the use of primary files as references. The Secondary file naming convention is:

{Prefix}{Abbreviation}{sheet number} (e.g., IH410prj01.dgn)

where *{Prefix}* is the roadway or project specific area, *{File Type Abbreviation}* is the file abbreviation (Table 11), and *{Sheet number}* always begins with 01. A starting library (LEVELS.dgnlib) provides CAD level naming convention, color, line style, and line weight. A list of line weights, line styles, and other drafting guidelines is available online (*29*).

Table 11. FMS Secondary File Types (*28*).

Abbreviation	Sheet Type
GENERAL	
TSH	Titlesheet
IND	Index of Sheets
PRJ	Project Layout
TYP	Typical Section
SUM	Project Summary
TRAFFIC CONTROL PLAN	
TCP	Traffic Control Plan
BAR	Barricades & Warning Devices
ROADWAY DETAILS	
HC	Horizontal Control Data
VC	Vertical Control Data
PP	Plan & Profile
PLN	Plan View
PRF	Profile View
DET	Plan Detail
RMV	Removal Layout
WALL DETAILS	
RW	Retaining Wall Layout

Abbreviation	Sheet Type
DRAINAGE DETAILS	
HYD	Hydraulic Computations
DA	Drainage Area Layout
STR	Culvert Layout
SD	Storm Drain Layout
UTILITIES	
UTL	Utility Layout
BRIDGES	
BRG	Bridge
TRAFFIC ITEMS	
SIG	Signal Layout
ILM	Illumination Layout
SGN	Signing Layout
PM	Pavement Marking Layout
TMS	Traffic Management System
ENVIRONMENTAL	
SW3P	SW3P Layout
MISCELLANEOUS ITEMS	
LS	Landscape Layout

TxDOT Information Technology, Data Architecture, and Modeling Practices

TxDOT's Information Systems Division (ISD) has developed standards for information technology through core technology architecture and data architecture documents (*18*, *30*). The core technology architecture document includes guidelines, standards, specifications, and policies and procedures for networking, telecommunications, computer hardware, operating systems, database management systems, general purpose software, enterprise system management, and reliability and fault tolerance (*30*).

The data architecture document includes standards for diagramming, data structure, data modeling, naming and defining data conventions, special standards for GIS data, glossaries, as well as a process to integrate commercial-off-the-shelf (COTS) software with TxDOT data (*18*). Data modeling requirements include logical data models, physical data models, and data dictionaries. The manual also includes requirements for system interface diagrams, which document relationships between data and computer applications to facilitate the integration of systems and data at TxDOT (*31*).

Texas Reference Marker (TRM) System

The TRM system is a mainframe-based system that documents physical and performance characteristics of the state-maintained highway network using the statewide TRM grid (*32*). With the TRM system, features on the ground are referenced to markers using distance measures from the nearest marker (Figure 23). The TRM system is centerline-based, although it does provide for the identification of features on either side of the centerline. Although the TRM system relies on displacement from markers as the mechanism to reference features to the highway network, the system also enables the calculation of cumulative distances by using the relative location of the markers along the highway network. This conversion enables the production of maps documenting feature locations and characteristics in a GIS environment.

The TRM system is currently the major repository of state highway network and associated attribute data. Examples of roadway attributes include AADT, classification, widths, surface type, location of features (e.g., culverts, overhead signs, streams), and administrative data (e.g., county, district). The Transportation Planning and Programming (TP&P) Division produces a variety of data files based on the TRM system, e.g., the RHiNo file, the Point file, the GEO-Point file, the GEO2-HINI file, and the TRMEOY file.

The TRM system stores vast amounts of highway data, providing an important role in developing and mapping spatial data, especially in transportation planning. Several TxDOT asset management systems rely on data from the TRM system, e.g., the Pavement Management Information System, the Highway Performance Management System, and the Bridge Information System. TxDOT also relies on TRM data for the production of traffic count maps, which are important for highway project development. These systems produce roadway assessment and status maps that divisions and districts use through ad hoc mapping programs.

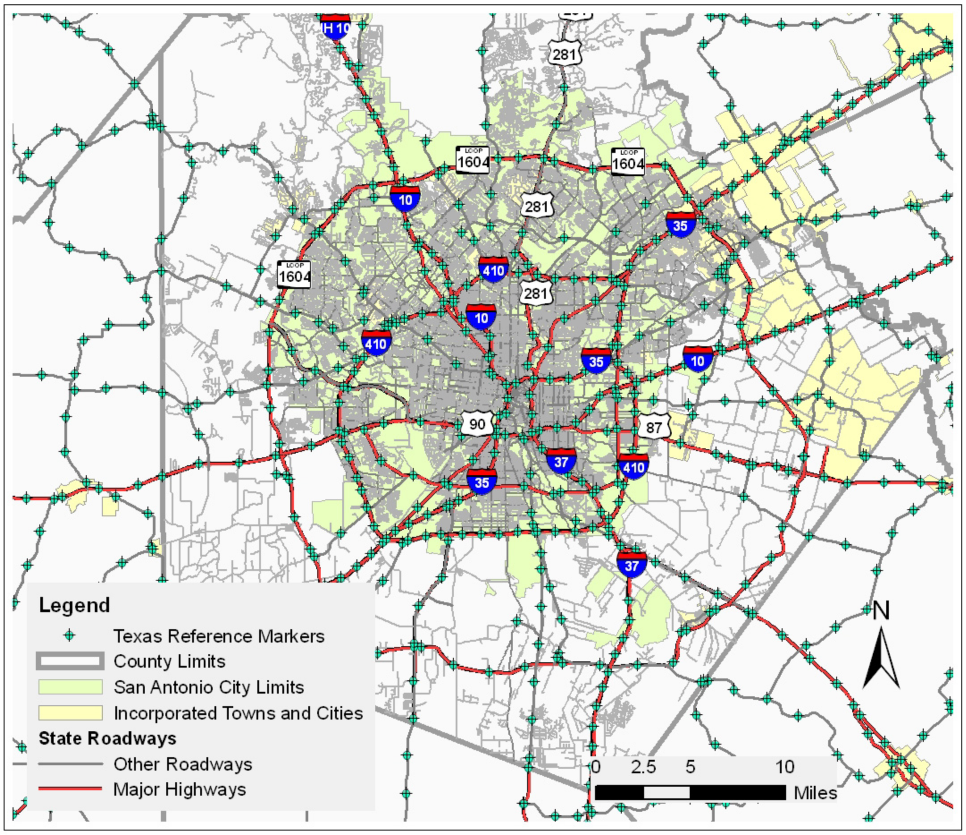


Figure 23. Reference Markers in the San Antonio Area.

While the TRM system provides data for a wide range of reporting options, the structure and characteristics of the data have a number of shortcomings that limit the usability of the system. For example, the TRM system is centerline-based, which means the positional accuracy of any feature or measure (such as ROW width or roadbed width) cannot be better than the positional accuracy of the underlying centerline map. The positional accuracy of the official TxDOT centerline map varies by location, but in general it is not unreasonable to expect accuracy levels of about 100 feet (the researchers have observed offsets up to 150 feet at some locations). The TRM system is also cumulative distance-dependent, which means the positional accuracy of any feature or measure cannot be better than the positional accuracy associated with individual reference markers. Although reference markers are intended to be permanent features on the ground, the reality is frequently quite different. As a result, it is very difficult to determine the actual location of features using cumulative distances alone.

TxDOT GIS Practices and Plans

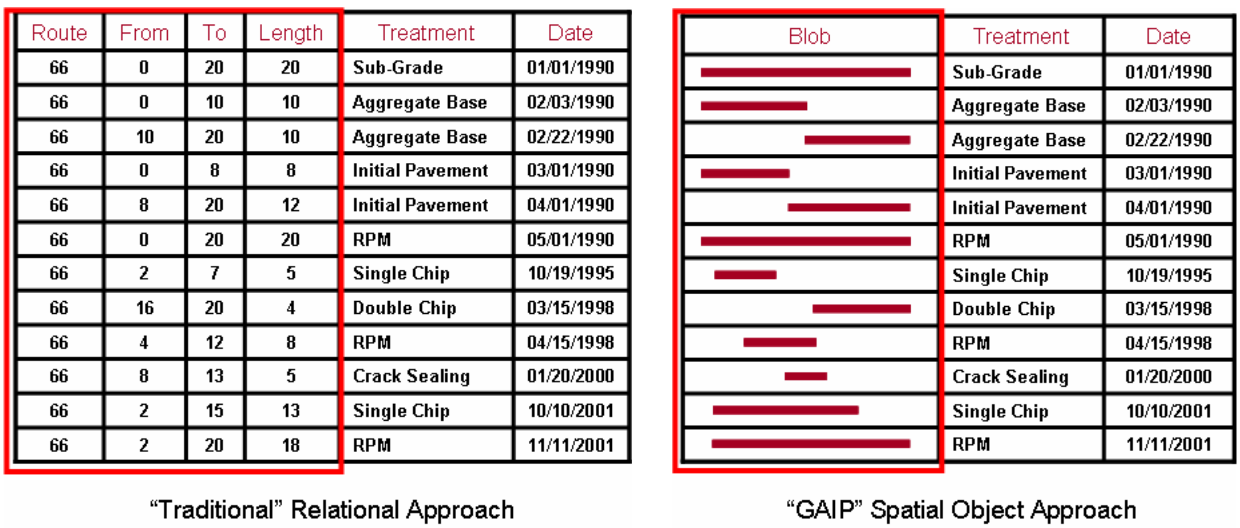
The traditional approach to develop GIS databases along highway networks involves the use of distances along those networks and abstract—usually centerline—representations of the network to map the features. A limitation of this approach is that the positional accuracy of the resulting features is limited by the accuracy of both underlying highway map and the cumulative distances measured along those routes. To address these limitations, transportation agencies are increasingly relying on absolute location approaches that provide independence from the highway network. Linear referencing is still useful to enable post-mapping of absolute locations into linear measures that are consistent with referencing systems such as control section/milepoint, distance from origin, and TRM *(33)*.

Transportation agencies are also experimenting with strategies to better handle temporal events in their inventory databases, as well as web-based online transaction and analysis processing, and GPS. Through the GIS Architecture and Infrastructure Project (GAIP), TxDOT has begun to implement a "second generation" enterprise framework for GIS *(34)*. GAIP includes the establishment of a roadbed linear referencing system, a roadbed specific base map, required computer platforms, hardware and software components, as well as standards for application development tool sets and databases. Development of GAIP followed the results of a business process and information technology needs assessment, which identified 18 business need priorities (BNPs) (Table 12). Four of these BNPs emphasized spatial and/or temporal data management, and 10 called for enterprise-wide data integration and access.

Table 12. Prioritized GAIP Business Needs *(35)*.

BNP	Business Need	Category
1	Link databases and provide access from all TxDOT offices	Data Integration
2	Provide a user-friendly mapping tool	Spatial/Temporal
3	Provide access to the data of other agencies	Data Integration
4	Implement historical data retrieval	Spatial/Temporal
5	Provide access to data typically maintained on the mainframe	Data Integration
6	Provide means to update data placed on the mainframe	Data Integration
7	Eliminate duplicate databases	Data Integration
8	Develop a common transportation vocabulary	Data Integration
9	Implement new technologies commonly found on the web	Other
10	Implement an accessible document management system	Data Integration
11	Time-stamp data	Spatial/Temporal
12	Implement a spatial user interface	Spatial/Temporal
13	Publish to all D/D/O what data are available across TxDOT	Data Integration
14	Update legacy applications	Other
15	Additional training in all TxDOT software	Other
16	Ensure enterprise-wide data integrity management	Data Integration
17	Provide a "single-point" log-in for data	Data Integration
18	Improved TxDOT bandwidth and servers	Other

The main goals of GAIP are to enable the integration of absolute location measures and relative location measures, facilitate route re-alignment and re-measurement, and facilitate temporal and spatial querying. This approach facilitates versioning control, backup, and recovery and makes monitoring feature life cycles in the database much more tractable. To accomplish these goals, the GAIP architecture replaces the traditional method of linear referencing (called dynamic segmentation) with another method called dynamic location (Figure 24). With dynamic segmentation, feature attribute tables defined by from/to values are necessarily associated with a route cartography. An attribute query results in a potential relational join between attribute tables and a segmentation of the route cartography. By comparison, with dynamic location, attribute tables contain all the attribute values (both spatial and non-spatial) that make up that feature at any specific point in space and time. When there is a feature change (either spatially or non-spatially), the system "retires" the old feature and, as needed, generates a new feature with new attribute values. Retiring a feature does not mean the system deletes the feature from the database. Instead, the system populates a time stamp indicating the completion of the life cycle for that feature. In the GAIP architecture, a feature can be any managed object within the ROW. Examples include roadbeds, pavement markings, pavement condition, highway signs, drainage features, ROW, and geopolitical boundaries. It may be worth noting that with dynamic location, it is no longer necessary to store route information in the attribute table. Instead, a spatial query enables the translation from absolute locations to linear referencing data elements (i.e., cartographic roadway and roadbed centerlines).



Route	From	To	Length	Treatment	Date
66	0	20	20	Sub-Grade	01/01/1990
66	0	10	10	Aggregate Base	02/03/1990
66	10	20	10	Aggregate Base	02/22/1990
66	0	8	8	Initial Pavement	03/01/1990
66	8	20	12	Initial Pavement	04/01/1990
66	0	20	20	RPM	05/01/1990
66	2	7	5	Single Chip	10/19/1995
66	16	20	4	Double Chip	03/15/1998
66	4	12	8	RPM	04/15/1998
66	8	13	5	Crack Sealing	01/20/2000
66	2	15	13	Single Chip	10/10/2001
66	2	20	18	RPM	11/11/2001

"Traditional" Relational Approach

Blob	Treatment	Date
	Sub-Grade	01/01/1990
	Aggregate Base	02/03/1990
	Aggregate Base	02/22/1990
	Initial Pavement	03/01/1990
	Initial Pavement	04/01/1990
	RPM	05/01/1990
	Single Chip	10/19/1995
	Double Chip	03/15/1998
	RPM	04/15/1998
	Crack Sealing	01/20/2000
	Single Chip	10/10/2001
	RPM	11/11/2001

"GAIP" Spatial Object Approach

Figure 24. Traditional and GAIP Approaches to Linear Referencing (*36*).

A key component of the TxDOT GAIP architecture is a cartographic set of roadbeds and roadway centerlines that make up the TxDOT network ground set (NGS) along with the logical and physical data models for the network ground set (*36*, *37*). TxDOT classifies NGS components according to jurisdiction, engineering function, and cartographic support. Currently, the NGS includes the following subtypes: on-system ramp, on-system connector, on-system turn-around, on-system single roadbed, on-system multi-roadbed, on-system multi-centerline, on-system centerline artificial terminals, county road, local road, and private road. TxDOT's preference for construction of the NGS is heads-up digitizing over a digital orthophoto rectified to a scale of 1:12,000 or better (*33*). The current standard is that each ground set segment should be within ±10 percent of the actual roadbed centerline. By definition, the NGS consists of links and nodes, where the nodes are the link end points and, as such, represent roadbed discontinuities such as merges, splits, and intersections.

Main Street Texas (MST)

Web-based mapping technology is radically changing the way agencies make GIS data available to internal and external users. There are several ongoing efforts at TxDOT in this area, of which the most relevant to this research is Main Street Texas (MST) (*38*, *39*). MST is a web-distributed, spatiotemporal, integrated information system that uses custom written software and a suite of database gateways to gain access to multiple database platforms and locations in addition to existing TxDOT GIS data. TxDOT is incorporating a number of applications within MST, including bridges, roadbeds, routes, geo-political layers (e.g., cities, district boundaries, zip codes), railroad lines, reference markers, county roads, ROW maps, and primary survey controls. The MST web-based portal uses location to query, correlate, and organize disparate data (e.g., spatial, relational, sequential) and enables relational and spatial intersect queries for the production of tabular and mapping reports (Figure 25). MST also supports online transaction and analysis processing to ensure data currency.

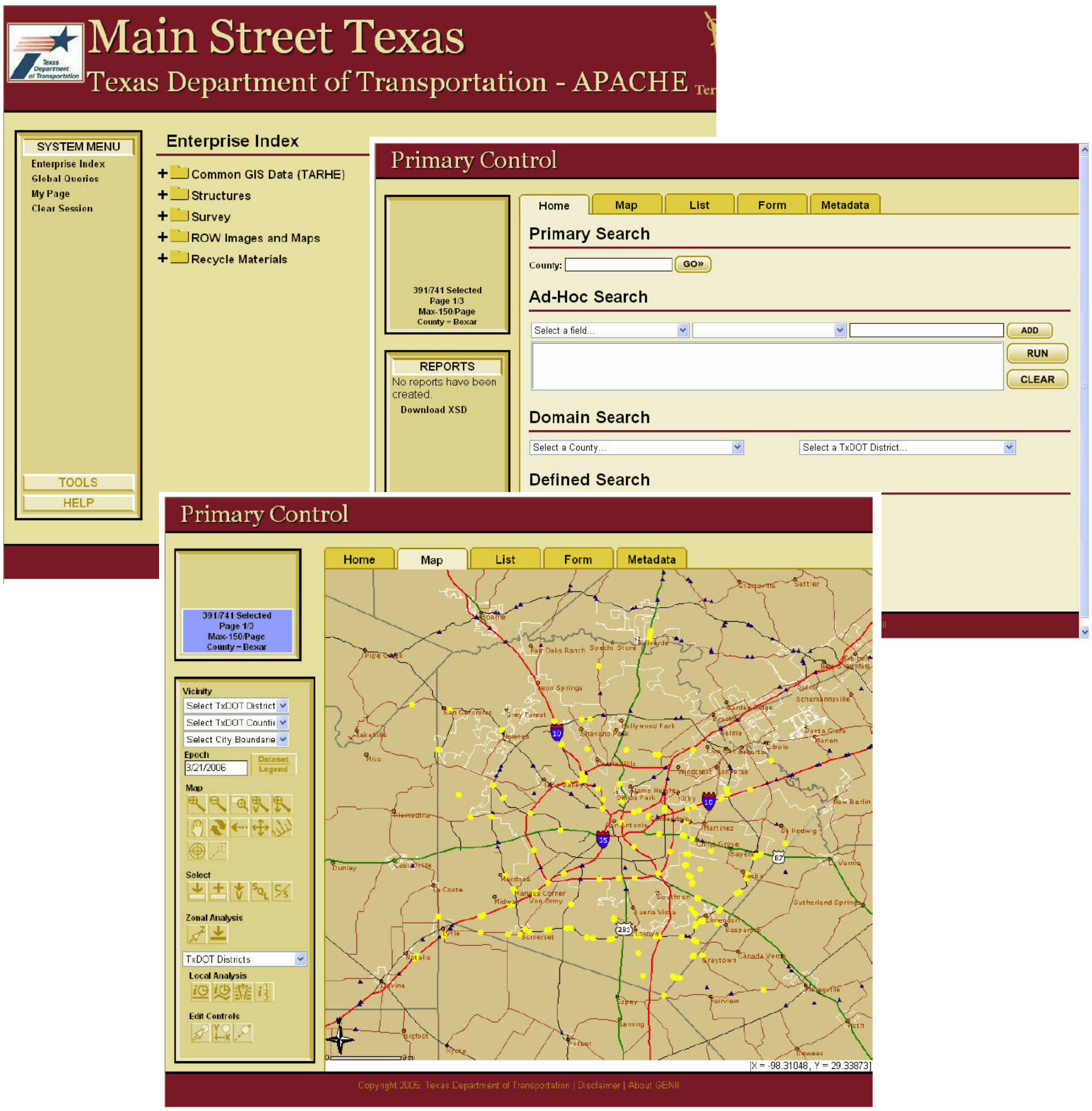


Figure 25. Main Street Texas Sample Screens (39).

Plans Online

Plans Online is a web-based application that allows TxDOT and outside users to view, search, email, and download project plans and related documentation (*40*). Project documents include engineering drawings, informational proposals, project addenda, contract plans, and bid tabs for construction, maintenance, building facility, and airport projects. The public Internet Plans Online website provides free access to documentation mostly for bidding purposes. The site hosts five months of project information: current and next month plus prior three months (Figure 26). The TxDOT Intranet Plans Online site provides access to project information and does not have a date limit (i.e., one can access data prior to the five month public restriction).

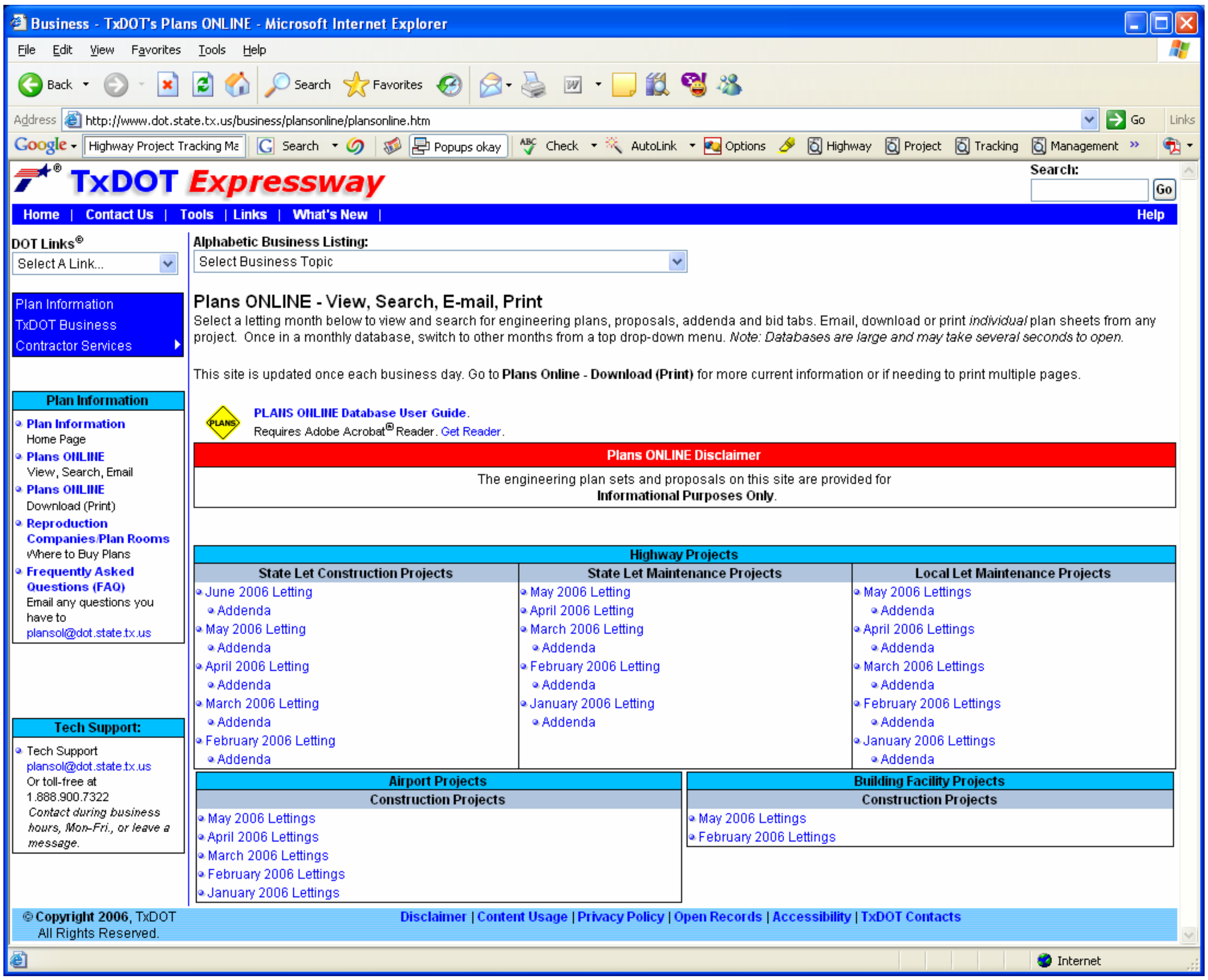


Figure 26. Internet Version of Plans Online Initial Web Page.

In the Internet version of Plans Online, the user first selects what type of project and month is of interest. A pop-up window provides the user two views for retrieving documents: Explore and Search. The Explore view (default) allows the user to browse through database contents in a folder hierarchy of county, CSJ number, plans, proposal, and proposal agenda. Proposals and proposal addenda are in PDF format. A special PDF viewer shows plans with associated metadata data (Figure 27). The Search view allows users to do a simple search or an advanced search. A simple search allows users to query by document text, document title, and/or file name, whereas an advanced search allows users to define detailed search criteria that searches in the document contents, document profile fields, folder profile fields, or document annotations. Both types of searches allow queries on multiple databases.

In addition to supporting highway construction and maintenance project bidding, Plans Online also serves as a repository of archived plan documents. After project closeout, mylar plans are scanned and posted on Plans Online. TxDOT is looking at potential vendors to scan remaining plans. Plans Online is currently evaluating TxDocsOnline (FileNet) and Main Street Texas as possibilities for posting plans.

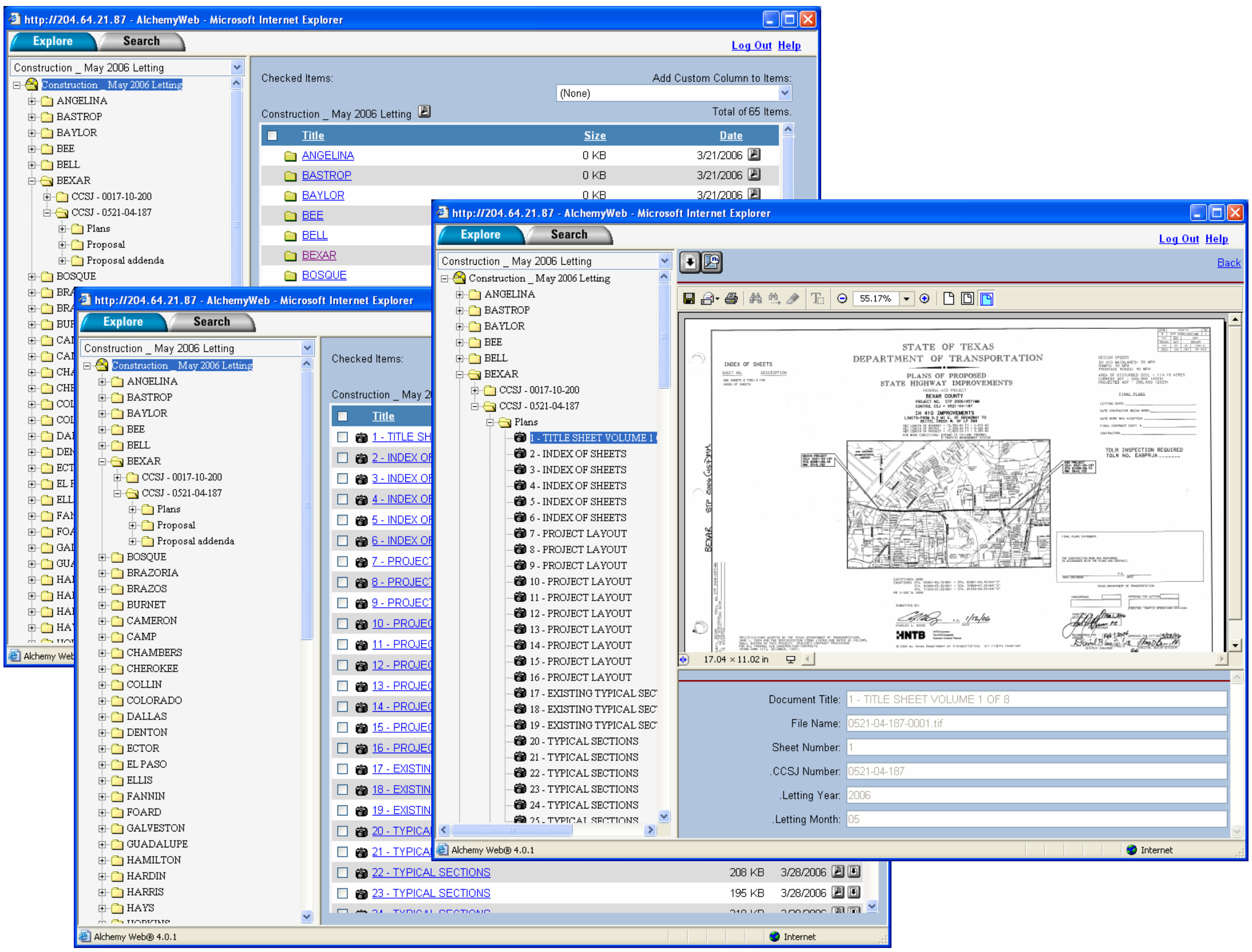


Figure 27. Plans Online Explore Option.

CHAPTER 4. SUMMARY OF FINDINGS AND RECOMMENDATIONS

Previous chapters described a characterization of transportation operations data needs based on a survey of existing and potential users of such data. This chapter summarizes research findings and highlights strategies and recommendations for implementation.

SUMMARY OF FINDINGS

Characterization of Transportation Operations Data

The researchers surveyed current and potential operations data users to characterize their data needs, reviewed procedures and systems that other state DOTs use for managing transportation operations data, and reviewed pertinent data management practices and implementation plans at TxDOT.

To characterize current transportation operations data user needs, the researchers surveyed a broad range of internal and external data users from four TxDOT districts: El Paso, Houston, Laredo, and San Antonio. Examples of transportation operations data user groups targeted for the survey at each district included district traffic management, district traffic engineering, district planning and development, district maintenance and construction, MPO, city office of traffic/transportation, transit authority, and media outlets. The research included two surveys: a short, preliminary survey and a long, detailed survey. The purpose of the short survey was to find out data subjects of interest to individual users and to identify target participants for the more detailed survey. The purpose of the long survey was to assess data needs by collecting detailed information about topics such as data needs, justification for using the data, specific data elements needed, geographic scope of interest, temporal and spatial resolution, geographic reference, data source and data collection method, and access method and frequency.

The short survey included a list of 46 different data subjects. For each data subject, respondents indicated whether they currently used or would like to use that data subject. The top five data subjects of interest to all users were detector volume data, travel time and detector speed data, crash data, freeway incident data, and aerial photography data. This result is not surprising because a substantial number of users surveyed were associated directly or indirectly with TMC activities. However, it is interesting to note that users expressed considerable interest in aerial photography, even though aerial photography is a data resource not "normally" associated with transportation operations. Other data subjects that ranked high included traffic control detour data, freeway incident data, dynamic message sign data, and traffic signal operation and control data. With respect to traditional traffic engineering data subjects, the top five subjects of interest to all users were aerial photography, crash data, traffic signal operation and control data, intersection vehicle count (turning volume) data, and intersection geometrics and control data. Additional data subjects included roadway inventory data and traffic simulation data.

The long survey gathered data user characteristics such as type of data used/needed, purpose and use of the data, data elements, geographic scope of interest, temporal and spatial resolution, spatial referencing, data source and data collection method, access method and frequency, and any other related issues that users identified. The researchers cataloged the information gathered from each user in a tabular format. This exercise revealed interesting variations with respect to user interest in data subjects, use type (real-time data versus historical data), and level of aggregation (spatial and temporal). External (outside TxDOT) users stated an interest to access data via the Internet. Users outside TMCs indicated an interest in using TMC data if a tool to query and download the data in a useful format is available and easy to use. The long survey also helped to identify a number of potential areas for improvement. Examples include collecting additional data elements traditionally not provided (such as critical time stamps associated with incidents, e.g., incident time, detection time, verification time, and so on), implementing new practices to provide metadata to users, developing strategies to avoid duplication in the collection and management of transportation operations data, and developing formal data models for ITS infrastructure and signals.

The research included an assessment of transportation operations data management procedures and systems at other DOTs. The review included four states: California, Florida, Virginia, and Washington, which are recognized leaders not only in the collection of transportation data, but also in the retention and usage of the data for multiple applications to diverse audiences. All of the target states reported using geographic referencing methods to identify data sources. The type and number of geographic referencing methods varied across the states and depended in part on the data subject. All of the target states reported some degree of data processing for cleaning erroneous data points, spatial and temporal aggregation, and computation of performance measures. The most prevalent data sharing method was web-based, either to an instant query system or to an online repository of data files at various levels of spatial and temporal aggregation.

To address input data issues, a number of states are implementing measures to provide the highest quality data possible. Target states identified a number of situations where data completeness issues occur, including construction activities, maintenance activities, equipment failure situations, communication failures, and, perhaps least often, a failure or downtime in the data management system itself. Some systems provide for a data completeness check, describing, in various terms, the amount of data available compared to the amount of data that would be available at 100 percent completeness.

The target states are certainly aware of the potential for data security issues. Many systems use a login/password authentication to grant admission and use. Most respondents stated that although they have security systems in place, to date, they have not had security problems. Target states also did not indicate any significant problems with privacy concerns. With respect to data storage issues, states reported starting with a small system and having a continual expansion process in place to accommodate ever-increasing amounts of data storage.

The researchers developed a database representation of the survey data to assist in the compilation and analysis of the data. The result is a data model and tool to capture, characterize, and analyze transportation operations data needs and flows that, at the same time, could facilitate the development of strategies to help optimize transportation operations data processes. The model shows exchange of data flows between user functions, in addition to the characteristics of these data flows as captured during the user survey. The researchers developed logical and physical representations of the survey data model and a data dictionary that comply with current

TxDOT data standards. To test the physical model, which was implemented in Microsoft Access, the researchers populated the database using data captured during the long survey. The researchers also developed a number of queries to extract data from the database in a usable format.

Related Data Management Practices at TxDOT

For completeness, the researchers reviewed existing data management procedures at TxDOT, including document archival practices, project management information, and data standards. TxDOT has well-defined project-based hardcopy data archival and retention practices. In contrast, management of electronic project documents is typically ad hoc and depends on district, office, and project manager practices. To address the issue of how to manage huge numbers of document files, several districts and divisions have implemented (or are in the process of implementing) systems such as FileNet, which enable users to share and manage access to files, generate database records to keep track of every document processed, and produce queries and reports based on a number of attributes. TxDOT's ISD is developing a strategy for using FileNet statewide. TxDocsOnline is a web-based FileNet branding strategy for document management at TxDOT, which uses a FileNet engine and does not require the installation of FileNet software on client computers. While TxDOT envisions FileNet as the main mechanism for content services (i.e., document management), TxDOT is considering the use of Bentley's ProjectWise to manage engineering documents such as Microstation CAD drawing files. Like FileNet, ProjectWise manages files and provides querying and reporting capabilities.

TRM is a legacy mainframe system at TxDOT that documents physical and performance characteristics of the state-maintained highway network using the statewide TRM grid. TRM enables the reference of features on the ground in terms of mileage displacement from the nearest marker. The TRM system is currently the major repository of state highway network and associated data. It holds detailed attribute data that characterize the network, such as AADT, classification, widths, surface type, location of features, and administrative data. The TRM system stores vast amounts of highway data, providing an important role in developing and mapping spatial data, especially for asset management systems.

TxDOT is implementing a "second generation" GIS framework called GAIP to enable the integration of absolute location measures and relative location measures, facilitate route re-alignment and re-measurement, and facilitate temporal and spatial querying. Closely associated with GAIP is the MST portal. MST is a web-based spatiotemporal, integrated system that uses location to query, correlate, and organize disparate data (e.g., spatial, relational, sequential) and enables relational and spatial intersect queries for the production of tabular and mapping reports.

Plans Online is a web-based system that allows users to view, search, email and download project documents such as engineering drawings, informational proposals, project addenda, contract plans and bid tabs for construction, maintenance, building facility, and airport projects. In addition to supporting highway construction and maintenance project bidding, Plans Online also serves as a repository of archived plan documents. Plans Online is currently evaluating TxDocsOnline and MST as possibilities for posting plans.

RECOMMENDATIONS FOR IMPLEMENTATION

The research identified a number of recommendations for implementation to help optimize the management of transportation operations data:

- Use electronic document management systems to manage (store, retrieve, and share) transportation operations documents and deliverables resulting from a wide range of applications such as traffic engineering studies and ITS implementation projects. TxDOT has currently implemented FileNet in the Houston and Austin Districts as well as a number of divisions, and is currently planning to implement FileNet statewide. It would be advisable to include transportation operations data in the development of FileNet libraries and, in general, to include transportation operations personnel in the FileNet implementation decision-making process. Implementation of this recommendation would help to eliminate data redundancy and facilitate accessibility to transportation operations data.

  The current FileNet implementation at TxDOT does not enable mapping between documents and geographic location. However, for an agency such as TxDOT that relies on geographic location for most of its business processes, it is critical to have the ability to map and visualize documents in relation to physical locations on the road network and to derive intelligent information from the documents (not just basic indexing information). It would therefore be advisable to include a spatial mapping component to the TxDOT FileNet implementation.

  A word of caution may be in order at this point. As mentioned previously, as part of the FileNet acquisition, IBM intends to integrate FileNet's operations into IBM's content management services. Although IBM intends to preserve the FileNet content management platform, in the long run the implications for current FileNet implementations are less clear. It would be advisable for TxDOT to continue to monitor the FileNet acquisition and IBM integration process.

- Implement data quality mechanisms. Recommendations include creating lookup tables to list and describe the various quality control tests and flags used, developing modules to conduct data quality control tests and assign flags to affected records immediately after receiving data from the field, and developing performance measures to assess system reliability with respect to data quality and completeness. Recent research has addressed the issue of data quality control tests, particularly in the case of TMC data such as detector speed, volume, and occupancy rates (*16*, *41*, *42*). Data quality control tests and flags could also extend to other types of transportation data, e.g., data received from traffic signal systems. Implementation of this recommendation would result in better data quality control and therefore help to increase the reliability of the data. The importance of implementing this recommendation will become more critical as the level of data exchange both internally and externally increases, with each user group increasingly adopting the role of data provider.

- Develop comprehensive GIS-based ITS device inventories with ties to real-time and archived ITS databases. Those inventories would depict adequate details of ITS devices in the field to satisfy operation and maintenance needs and provide linkages between ITS devices and associated non-spatial information. Recent research developed a GIS-based model for the inventory of ITS devices at TransGuide, which could provide the foundation for comprehensive inventory models at other districts *(43)*. Those models would need to support a minimum set of common elements and definitions to facilitate data exchange, while, at the same time, supporting distributed data repositories. Those models would also need to comply with TxDOT's GIS and data architecture requirements. Implementation of this recommendation would facilitate real-time TMC operations and make the exchange of real-time and archived ITS data with a wide range of internal and external users much more effective.

- Increase the use of online and offline GIS-based mapping components to support TMC operations. TMC operators would benefit from a tool that displays geographically referenced data, even in the case of data other agencies have provided. Examples include locating important landmarks such as buildings or major utility installations (e.g., gas, communications, or electric transmission lines), which would be useful in the event of a major emergency, particularly at a time when the role of TMCs in emergency management is increasing. Implementation of this recommendation would help to make TMC operations more efficient and would contribute to make the overall TMC role in emergency management more effective.

- Develop user-friendly, web-based interfaces to query and retrieve archived ITS data. During the course of the research, many potential users expressed interest in using TMC data if the data could be formatted in a way that enables effective integration into their business processes. For the interfaces to be useful, they should allow users to query data both spatially and temporally and save data in a format that is useful to the users. The interfaces should also enable users to aggregate data (both in space and time) and include reporting mechanisms that make data quality and completeness an integral component of any report that involves data. Several other states (e.g., California, Virginia, and Washington) have several years of experience in the development and implementation of web-based reporting tools that incorporate data from several TMCs. An assessment of their experience in this area and formulation of an implementation plan in Texas would be advisable. Implementation of this recommendation would provide access to archived ITS data to many internal and external users and contribute to significantly increase the value of the services TMCs provide.

- Leverage and/or augment the capability of existing web-based platforms at TxDOT to manage and disseminate transportation operations data to internal and external users throughout the state with the help of technologies such as web map service (WMS), web map context (WMC), and web feature service (WFS) that now make it possible to link, superimpose, and serve spatial and non-spatial data coming from remote and heterogeneous sources *(44)*. These technologies facilitate decentralized data storage and archival, enabling individual user groups to continue to store, manage, and serve their own data independently. A decentralized architecture could enhance communications among user groups and also provide a foundation for the implementation of systems such as the 511 traffic information system, which is currently in the planning stages in Texas (*45*). It could also provide a foundation for the implementation of information products that rely on extensible markup language (XML)-based formats designed to share data such as rich site summary or really simple syndication (RSS) or that make use of cell phone network-based services such as short message service (SMS) messages to deliver traffic information to end users. Implementation of this recommendation could result, in the long run, in more effective management and dissemination of transportation operations data in Texas.

- Archive transportation operations data at the finest disaggregation level possible. Thanks to computer hardware innovations, electronic storage media is becoming less expensive. At the same time, database server and application technologies are becoming more efficient, which means it is increasingly possible to store massive amounts of data and, at the same time, query and retrieve the data at various aggregation levels quickly and cost-effectively. In general, the information technology decision-making process is migrating from one where the cost of the data storage hardware was the main driving force to another one where it is critical to identify optimal combinations of data storage hardware characteristics, appropriate database design (including indexing), database software and application interfaces, and future expansions. Taking these variables into consideration is critical to ensure the success of archived ITS data system deployments. Implementation of this recommendation would increase the type and number of potential users of the data, which is critical considering the wide range of interests, applications, and data needs that characterizes the pool of potential data users.

- Modify ATMS to enable the archival of displayed DMS messages. As mentioned previously, current ATMS implementations enable operators to save modified messages as new template messages in the library, but they do not archive displayed messages, limiting the ability to conduct complete analyses on historical incident data. Implementation of this recommendation would result in more comprehensive data archival systems and would facilitate the analysis of historical incident records.

- Develop guidelines and templates for the preparation of agreements between TxDOT and other agencies describing data access, responsibilities, compliance with relevant data standards, and other related matters. Frequently, agreements do not properly define duties and responsibilities of individual agencies and do not provide adequate guidance as to what data to share, how frequently, in what format, or what data standards should apply. The guidelines would need to be flexible to suit the needs of individual TMCs and regions and robust enough to handle typical day-to-day operations. For the guidelines and templates to be useful, they need to make explicit references to applicable data standards, including metadata standards. Implementation of this recommendation would improve the quality of the interaction between TxDOT and local agencies and would result in more effective data exchange programs.

- Include traffic forecasting to the list of user data needs when considering ITS implementations in Texas. As the capability to disseminate traffic conditions in near real-time increases, there is a growing level of interest in the transportation community in the dissemination of predicted traffic condition data, particularly in the short term, e.g., 5 – 30 minutes into the future. Along with this increased interest is the need to develop traffic forecasting models that rely on a combination of real-time data and historical data to predict traffic conditions. The basic premise behind this development work is that predicted data should enable ITS systems, managers, and operators to work more proactively instead of reactively. Recognition of this perception is the fact that the National ITS Architecture includes traffic forecasting as part of the traffic forecast and demand management market package. Implementation of this recommendation would enable TMCs in the long run to offer more comprehensive information products to users by including not just near real-time data and historical data but also short-term traffic predicted data.

The previous recommendations are recommendations that are ready for implementation or that are currently undergoing implementation. The following are recommendations that may need additional research work:

- Develop metadata guidelines to capture important information about transportation operations data and the processes that generate and maintain the data. Metadata provide useful information to both end users, who need data descriptions that are understandable, and data producers (generators), who have the responsibility to support the maintenance of the data generation process. Metadata provide information about this process, data tables and fields, information on when and how the data were collected and moved, data sources, and transformation operations. Implementation of this recommendation would result in information products that contain adequate information about data definitions, processing rules, geographic extent and reference, and temporal and spatial resolutions, therefore reducing confusion and uncertainty when users request and use data.

- Develop comprehensive traffic signal data models. The modeling effort would include physical characteristics (e.g., signal heads, controllers, detectors), operational characteristics (e.g., timing plans, coordination, control strategies), operating environment (e.g., intersection geometry, current volume, composition and distribution of traffic), and operation and maintenance actions (e.g., retiming, upgrades, routine maintenance, remedial repairs). Standards-based models would boost regional cooperation because they would facilitate data exchange and promote the implementation of regional signal system management approaches. To facilitate data exchange, those models would need to support a minimum set of common elements and definitions, while, at the same time, supporting the data needs of individual agencies. Implementation of this recommendation would result in more effective, integrated traffic signal operations.

- Develop procedures, data models, and implementation roadmaps for integrating traffic signal and freeway operations and data. Integration of arterial signal operations (both from local jurisdictions and TxDOT) and freeway operations is increasingly important at a time when initiatives at the federal, state, and local levels are actively promoting the benefits of system and data integration. Some districts, particularly in large urban areas, are beginning to develop plans to help integrate traffic signal operations into TMC operations (in some cases, the TMC collocates TMC operations and traffic signal operations). However, for the most part the current state-of-the-practice is one of disaggregation. FHWA recently unveiled an initiative to promote integrated corridor management (ICM) by supporting the deployment of several demonstration projects in selected metropolitan corridors around the country to demonstrate the coordination of operations among separate corridor networks (freeway, arterial, and transit) (*46*). It would be advisable to explore the implementation of the ICM concept to all urban areas in Texas that have both traffic signal systems and ITS implementations. Implementation of this recommendation would facilitate system integration, facilitate data exchange, and contribute to eliminate inefficiencies in the overall operation of the transportation system.

- Develop a generic lane closure data model and associated database and data management procedures to address both district needs and TxDOT highway condition reporting needs. Current procedures at some of the districts involve a considerable duplication of effort in entering and processing lane closure data. Recent research provided recommendations concerning changes that would be necessary to make the lane closure database at TransGuide useful as a data resource for ITS data completeness assessments (*16*). In the larger picture, however, it appears that both HCRS and local lane closure databases would need enhancements to avoid duplication of data entry efforts and to ensure the resulting database design addresses both local district and division needs. It would be advisable to develop a data model that takes into account modern web-based mapping and data management tools to facilitate the data entry, query, and reporting processes. The data model would need to provide a common set of data elements and definitions, while supporting specific needs at the district level. Implementation of this recommendation would help to reduce redundant information and effort regarding the management of lane closure data.

REFERENCES

1. The National ITS Architecture. US Department of Transportation Joint Program Office for Intelligent Transportation Systems. http://www.iteris.com/itsarch/index.htm. Accessed August 1, 2006.
2. *National ITS Architecture Logical Architecture – Volume I Description*. Federal Highway Administration, US Department of Transportation, Washington D.C., October 2003.
3. *San Antonio Regional ITS Architecture*. TransGuide, Texas Department of Transportation, Austin, TX, June 2003.
4. *State of Texas Regional ITS Architectures: El Paso Region*. Texas Department of Transportation, Austin, TX, October 2003.
5. *State of Texas Regional ITS Architectures: Laredo Region*. Texas Department of Transportation, Austin, TX, June 2003.
6. *Archived Data Management System Data Model: Final Report*. Federal Highway Administration, US Department of Transportation, Washington D.C., September 2002.
7. ASTM E2259-03. *Standard Guide for Archiving and Retrieving ITS-Generated Data*. ASTM International, 2003. http://www.astm.org. Accessed August 8, 2006.
8. ASTM E2468-05. *Standard Practice for Metadata to Support Archived Data Management Systems*. ASTM International, 2005. http://www.astm.org. Accessed August 8, 2006.
9. *Guide to Traffic Management Data Dictionary (TMDD) Standards for Traffic Management Center-to-Center Communications-DRAFT*. Institute of Transportation Engineers and the American Association of State Highway and Transportation Officials, December 2005.
10. *Operations Asset Management*. Publication FHWA-OP-04-037. Office of Operations, Federal Highway Administration, US Department of Transportation, Washington, D.C., April 2004. http://ops.fhwa.dot.gov/aboutus/one_pagers/asset_mgmt.pdf. Accessed August 8, 2006.
11. Paral, J. *Identification of Operation Assets.* Publication FHWA-HOP-05-056. Battelle Memorial Institute, Federal Highway Administration, Washington D.C., April 2004. http://ops.fhwa.dot.gov/publications/indenti_op_assets/pdf/final_report(v4).pdf. Accessed August 8, 2004.
12. Harrison, F., Krechner, D., Strasser, J., and Sterzin, E. *Elements of a Comprehensive Signals Asset Management System.* Publication FHWA-HOP-05-006. Cambridge Systematics, Federal Highway Administration, Washington D.C., December 2004.
13. *Developing Traffic Signal Control Systems Using the National ITS Architecture*. U. S. Department of Transportation, Washington D.C., February 1998.
14. Hauser, T., Scherer, W., and Smith, B. *Data Mining Tools for the Support of Traffic Signal Timing Plan Development in Arterial Networks*. Research Report No. UVACTS-15-13-33, Center for Transportation Studies: University of Virginia, May 2001.
15. *TranStar Data Warehouse User Data Needs-Draft*. Texas Department of Transportation. Prepared by Southwest Research Institute, March 2000.
16. Quiroga, C., Hamad, K., and Park. E. *Incident Detection Optimization and Data Quality Control*. Publication FHWA/TX-06/0-4745-3. Texas Department of Transportation, Austin, TX, October 2005.

17. *Performance Measures for Operational Effectiveness of Highway Segments and Systems*. Publication NCHRP Synthesis 311. Transportation Research Board, National Research Council, Washington, D.C., 2003.
18. *Data Architecture*. Texas Department of Transportation, Austin, TX, February 2006.
19. State of Texas Records Retention Schedule for Texas Department of Transportation: Form SLR 105. Texas State Library and Archives Commission, Austin, TX, July 2005.
20. State of Texas Records Retention Schedule for Texas Department of Transportation: District Record Copy Responsibility List. Texas State Library and Archives Commission, Austin, TX, May 2005.
21. *DCIS User Manual*. Texas Department of Transportation, Austin, TX, March 2006.
22. FileNet. FileNet Corporation. http://www.filenet.com. Accessed August 1, 2006.
23. IBM to Acquire FileNet to Advance Information On Demand Strategy. FileNet Corporation. http://www.filenet.com/English/About_FileNet/acquisition.asp. Accessed August 31, 2006.
24. TxDocs Online Document Management System. Austin District Project Briefing, Texas Department of Transportation, Austin, TX, September 2005.
25. *TxDocs Online Document Management System. Users Guide for Accessing Austin District's Electronic Document Management System – TxDocs Online*. Information Systems Division, Texas Department of Transportation, Austin, TX, November 2005.
26. *Electronic Document Technologies Implementation and Support (EDTIS). Content Services Library Standards Version 3.4*. Information Systems Division, Texas Department of Transportation, Austin, TX, January 2006.
27. Baker, G. ProjectWise and You. Presentation (10 slides), Lone Star Infrastructure, February 2005.
28. File Management System (FMS). San Antonio District, Texas Department of Transportation, San Antonio, TX, March 2006. ftp://ftp.dot.state.tx.us/pub/txdot-info/sat/specinfo/sat-fms.pdf. Accessed August 11, 2006.
29. CAD Standards. Texas Department of Transportation, Austin, TX, 2006. http://www.dot.state.tx.us/business/standards.htm. Accessed August 1, 2006.
30. *Core Technology Architecture Version 5.2*. Texas Department of Transportation, Austin, TX, February 2005.
31. TxDOT System Interface Diagrams. TxDOT Online Data and Application Inventory (TODAI). Information Systems Division, Texas Department of Transportation, Austin, TX, 2006. http://crossroads/isdinfo/data/edm/todai/. Accessed February 3, 2006.
32. *Texas Reference Marker (TRM) System User's Manual*. Texas Department of Transportation, Austin, TX, January 2005.
33. *TxDOT Graphic Data Standard*. Information Systems Division, Texas Department of Transportation, August 2004.
34. *GIS Technical Architecture*. Information Systems Division, Texas Department of Transportation, Austin, TX, August 2004.
35. TxDOT Business Needs Assessment and GAIP Business Solutions Document Version 2.2. Information Systems Division, Texas Department of Transportation, Austin, TX, April 2003.
36. Patterson, J. Texas GIS Architecture and Infrastructure Project: An Enterprise Experience. 2004 GIS-T Symposium, Rapid City, SD, March 28-31, 2004.

37. Miller, B. *TxDOT GAIP Logical and Physical LRM Data Subjects and Geopolitical Boundary Data Subjects*. Information Systems Division, Texas Department of Transportation, Austin, TX, March 2006.
38. Patterson, J. Geographic Information Systems Architecture and Infrastructure: Doing Business on Main Street (Presentation 24 slides). Information Systems Division, Texas Department of Transportation, Austin, TX, n.d.
39. Main Street Texas. Information Systems Division, Texas Department of Transportation, Austin, TX, 2006.
40. Plans Online User Guide. Texas Department of Transportation, Austin, TX, March 2006. http://www.dot.state.tx.us/business/plansonline/PlansOnlineManual.pdf. Accessed August 11, 2006.
41. Turner, S. *Guidelines for Developing ITS Data Archiving Systems*. Publication 0-2127-3. Texas Department of Transportation, Austin, Texas, September 2001.
42. Turner, S., Eisele, W., Gajewski, B., Albert, L., and Benz, R. *ITS Data Archiving: Case Study Analyses of San Antonio TransGuide Data*. Publication FHWA-PL-99-024. Federal Highway Administration, Washington, D.C., August 1999.
43. Quiroga, C., Kraus, E., Pina, R., Hamad, K., and Park, E. *Incident Characteristics and Impact on Freeway Traffic*. Publication FHWA/TX-05/0-4745-1. Texas Department of Transportation, Austin, TX, October 2004.
44. OpenGIS Specifications. Open Geospatial Consortium, Inc., 2006. http://www.opengeospatial.org/standards. Accessed August 31, 2006.
45. Kosik, A. User Perspective on Deploying 511. Web presentation at Rural Issues: 511 and Traveler Information Session, National Transportation Operations Coalition, July 27, 2005. http://www.ntoctalks.com/web_casts_archive.php. Accessed August 10, 2006.
46. *Discretionary Cooperative Agreement for Integrated Corridor Management*. Executive Summary. Request for Applications No. DTFH61-06-RA-00007. Federal Highway Administration, Washington, D.C., March 2006.

APPENDIX A. SHORT SURVEY FORM

Dear Participant,

The Texas Transportation Institute is conducting a research project for TxDOT (0-5257 "Strategies for Managing Transportation Operations Data") to evaluate business processes related to the use of transportation operations data. As part of this research, we are conducting a survey, which we believe should not take more than 10 minutes of your time. Thank you in advance for your assistance.

If you have any questions, please contact Khaled Hamad at 210-731-9938 or by email at k-hamad@tamu.edu.

The Research Project 0-5257 Team

If you received this survey electronically, you can simply fill in the blanks and e-mail the completed form to k-hamad@tamu.edu. You can also fax it to 210-731-8904 or mail it back to:

Khaled Hamad
Texas Transportation Institute
3500 NW Loop 410 Ste 315
San Antonio, TX 78229

Please complete the following information, or, if you prefer, attach your business card.

Name: ____

Title: ____

Agency: ____

Telephone: ____

E-mail: ____

Could we contact you for a follow-up interview?

☐ Yes, the best time for the meeting would be___________________________________

☐ No

As part of the research, we are examining sample operations data. Could we obtain sample data from you?

☐ Yes, the best way to obtain this data would be________________________________

☐ No

☐ Not available

(1)	(2)	(3)	(4)	(5)	(6)
Type of Operations Data	Check data you currently use	Check data you do not use but would like to use	Briefly outline how you are using this data (e.g., incident detection, dissemination to public, etc; See sample list in last page)	Check here if this is TxDOT data	Provide a point of contact for more detailed information
Traffic Conditions					
1. Volume Data from Detectors					
2. Occupancy Data from Detectors					
3. Speed Data from Detectors					
4. Travel Time Data					
5. Freeway Incident Data					
Traffic Management/Control					
6. Dynamic (Variable) Message Sign Data					
7. Lane Control Signal Data					
8. Ramp Metering Data					
9. Traffic Control Detour Data					
10. Roadway Event Data					
ITS Equipment					
11. ITS Equipment Inventory Data					
12. ITS Equipment Maintenance Log Data					
13. ITS Equipment Monitoring Data					
14. Fiber Optic Network Management Data					
Other ITS					
15. Scheduled Lane Closure Data					
16. Motor Assistance Program Log Data					
17. Toll Road Data					
18. Closed Circuit TV (CCTV) Surveillance/ Snapshots					
19. Parking Management Data					
20. Police CAD Data					
21. TMC Website Usage Data					
Environmental Data					
22. Weather Data					
23. Air Quality Data					

(1)	(2)	(3)	(4)	(5)	(6)
Type of Operations Data	Check data you currently use	Check data you do not use but would like to use	Briefly outline how you are using this data (e.g., incident detection, dissemination to public, etc; See sample list in last page)	Check here if this is TxDOT data	Provide a point of contact for more detailed information
24. Flood Data					
25. Roadway Surface Condition Data (wet, icy, etc)					
Other Transportation Modes					
26. Transit Operation Data					
27. Ferry Operation Data					
28. HOV Lane Data					
29. Commercial Vehicle HAZMAT Content Data					
30. Railway Crossing Data					
Supporting Data					
31. Aerial Photography Data					
32. Roadway Inventory Data					
33. Utility Installation Data					
34. Survey/Topographic Data					
Arterials					
35. Intersection Geometrics and Control Data					
36. Traffic Signal Operations and Control Data					
37. Traffic Signal Maintenance Data					
38. Intersection Vehicle Count/Turning Volume Data					
39. Accident (Crash) Data					
40. Corridor Inventory Data					
41. Traffic Simulation Model Data					
42. Origin-destination data					
Emergency Services					
43. Emergency Management Data					
Other					
44. Vehicle Classification					
45. Emergency Evacuation Route/Procedure Data					
46. Average Daily Traffic Volume					

You can use the following activities (or their corresponding numbers) as a guideline in filling in Column (4) above.

For Transportation Management Center Operations:

1. Traffic monitoring system
2. Incident detection and management
3. Traffic condition prediction
4. Dissemination to the public
5. Traffic management
6. Ramp metering
7. Operation planning/analysis
8. Monitor system performance
9. Managed lane operations
10. Emergency traffic control

Traffic Section:

11. Traffic analysis
12. Signal timing
13. Traffic simulation modeling
14. Safety analysis

Other:

15. Congestion monitoring
16. Travel demand forecasting
17. Construction impact determination
18. Capital planning/analysis
19. Roadway impact analysis

APPENDIX B. LONG SURVEY FORM

Comments: ____
____

Are you ☐ currently using, or ☐ you would like to use this data?
Are you interested in ☐ real-time, ☐ historical (offline), or ☐ both real-time and historical data?

What do you use this operations data type for (activity, function, purpose)?
____
____

What data elements are associated with this data type that you need?

____
____
____
____
____
____
____
____
____

For example, incident data type may include the following data elements:
- Incident location
- Incident type
- Incident detection time
- Incident response time
- Incident clearance time
- Number of freeway lanes blocked
- Time of day

How often do you need to access the data?
☐ Continuously ☐ Hourly ☐ Daily
☐ Weekly ☐ Monthly ☐ Yearly
☐ As needed/per occurrence ☐ Other; specify ______________________

What is the temporal resolution/aggregation?
☐ Every 20-sec ☐ Every 1-min ☐ Every 5-min
☐ Every 15-min ☐ Every 1-hour ☐ Every 24-hour
☐ Per occurrence ☐ Other; specify ____________

What is the spatial resolution/aggregation?
☐ By lane ☐ By sector ☐ By intersection/interchange
☐ By corridor ☐ Other, specify ____________

Is data geographically referenced?
☐ By lane address ☐ By sector address ☐ By control section
☐ Other; specify ____________

What is the scope (geographic coverage) of the data?
☐ Lane ☐ Sector ☐ Corridor
☐ Systemwide ☐ Spot location ☐ Other; specify ____________

Do you have to perform any pre-processing before use?
☐ No, I use raw data (e.g., sensor feed)
☐ Aggregation, explain ______________________________
☐ Transformation, explain ______________________________
☐ Other, specify ______________________________

Is this data being currently archived in a database?
☐ Yes
☐ No (whom do you think should archive it? ____________________________________)
☐ No, but it exists in paper/hardcopy form (do you prefer an electronic form instead?____________)
☐ Don't know

If yes, who archives this data ______________________________
who owns it ______________________________
who serves it ______________________________

who maintains this archives ___________________________________

How is this data being collected?

- ☐ Manually, including handheld counters
  - What technique/method is used? ____________________________
- ☐ Automatically
  - ☐ inductive loop detectors ☐ video detectors ☐ acoustic detectors
  - ☐ Automatic Vehicle Identification (AVI)
  - ☐ Global Positioning System (GPS)/Automatic Vehicle Location (AVL)
  - ☐ other, specify____

How do you obtain this data?

- ☐ I am in charge of collecting this data
- ☐ Another office within my agency, specify ____
- ☐ Outside source, specify ____
  - How do you access this data?
    - ☐ Intranet (direct link) ☐ On-line (web) ☐ FTP ☐ CD-ROM
    - ☐ Paper ☐ Other, specify ________________________________
  - In what electronic format do you obtain this data?
    - ☐ Text ☐ MS Excel ☐ MS Access ☐ Other, specify _____________

If you collect this data, what happens to the data after you use it?

- ☐ Data is archived and shared ☐ Data is saved on a local PC
- ☐ Data is used in another activity/function without archiving
- ☐ Discarded ☐ Do not know

If you collect this data and you are not discarding it, can it be accessed by outside users?

- ☐ No
- ☐ Yes, this data is currently accessible by (you can select multiple choices)
  - ☐ Travelers ☐ Media outlets ☐ Information service providers
  - ☐ Researchers ☐ Local governments ☐ Other transportation agencies
  - ☐ Other offices within my agency; specify_________________________

  If yes, how can data be accessed from outside?

  - ☐ Intranet (direct link) ☐ On-line (web) ☐ FTP ☐ CD-Rom
  - ☐ Paper ☐ Other, specify ________________________________

  In what electronic format is the data available?

  - ☐ Text ☐ MS Excel ☐ MS Access ☐ Other, specify _____________

  Do you process the data before you store it?

  - ☐ No
  - ☐ Aggregate, explain ____
  - ☐ Transform or convert, explain ____
  - ☐ Other, specify ____

If you collect this data, can we obtain a sample of this data? ☐ Yes ☐ No ☐ Not sure,_______________

Are there any known concerns regarding …

- Data access____
- Data export/exchange____
- Data storage/archiving____
- Data quality____
- Data completeness____
- Privacy, security, or liability ____

The above information pertains to how data is currently being used. Would you like (or are you planning) to make any changes to how this data can be accessed, used, or exported? __________________________________

____

APPENDIX C. USER DATA NEEDS CATALOG

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
San Antonio District (Traffic Management)																	
Volume, speed, and occupancy	Currently used	Real-time	Monitoring traffic, incident detection	Volume, speed, occupancy, lane address, date stamp, time stamps	20-second	By lane	Lane address	TransGuide coverage area	No	Yes, in flat file format	Provider	Yes	Loop detectors, VIVIDs				Add capacity and new equipment to improve accessibility to their archive. VIVIDs data is saved similar to loop detector data in a new server, i.e., Server 7.
Travel time	Currently used	Real-time	Public information dissemination	Sector's travel time (derived from average speed)	2-minute	By sector		Certain corridors	Yes, derive travel times from average speeds	No	Provider	No, it is not archived	Derive travel times from average speeds				Need to be more flexible to allow users to customize their routes. Travel time information displayed on DMS is not archived.
Incidents	Currently used	Real-time	Managing traffic	Type, location (sector address), date and time stamp, lanes affected	Per occurrence	By sector	Sector address	TransGuide coverage area	Incidents generated internally are combined with City of San Antonio's traffic incidents	In two separate tables	Provider	Yes	Incident detection, 911 traffic incidents, camera tours				Operators are limited in terms of information that they can enter. TransGuide's existing data archive system does not have a standalone incident table.
DMS Data	Currently used	Real-time	Public information dissemination	Message content displayed, date and time stamp, devices address	Per occurrence		CMS sector address	TransGuide coverage area	No	Yes	Provider	Yes	System and/or Manually by operators				DMS archived data is used to respond to open record requests. They share with other emergency centers through C2C connection or XML feed. Historical DMS usage data, such as the frequency of sign usage and the length of time the sign was activated, if linked to maintenance data can be used for evaluating different messages and bulb types as well as in benefit/cost analysis. The content of DMS messages could also be used to improve the effectiveness of their operations.
Lane Control Signal (LCS) Data	Currently used	Real-time	Managing traffic	State of arrows, date and time stamp, devices address	Per occurrence		LCS sector address	TransGuide coverage area	No	Yes	Provider	Yes	System and/or Manually by operators				LCS archived data is used to respond to open record requests. No feedback loop/linkage currently exists between scenarios loaded in response to events on the highway and the history of effectiveness of these scenarios. For example, if traffic data showed that a particular scenario was successful in managing traffic efficiently during that event, it will be reinforced next time it is loaded!
Traffic Control Detour Data	Currently used	Real-time	Managing traffic	Detour details	As needed			With the exception of severe incidents, traffic is diverted to state roads only		Detours are occasionally displayed on DMS signs for incidents or added to lane-closure data for scheduled closures.	Provider	No, it is not archived per se					TxDOT cannot divert traffic on city streets. When a COSA signal operation is brought to TransGuide, an interagency agreement between city and TxDOT could be negotiated to allow for TransGuide to detour traffic on local streets.
Roadway Event Data	Currently used	Real-time	Managing traffic	Alarms, sector address, lanes affected, scenario loaded	Per occurrence		Sector address	TransGuide coverage area		Yes	Provider	Yes	Different subsystems				Incidents need to be separated from other events like recurrent congestion events.
ITS Equipment Inventory Data and Maintenance Log Data	Currently used	Offline	Managing TransGuide inventory	Device type, location, manufacturer, communication setup, technical details, construction details, maintenance history			Coordinates	TransGuide systemwide		Geodatabase exists that includes limited information (device ID and location). Hardcopies of maintenance logs exists.	Provider	Yes	Created by TTI based on construction plans and augmented by aerial photo				Comprehensive ITS equipment inventory database is needed, which could be based on formal data model.
ITS Equipment Monitoring Data	Currently used	Offline	Managing TransGuide inventory	Alarm, device ID, condition status						Database exists but outdated	Provider	No					Monitoring system is currently turned off due to a large number of false alarms. Therefore, data is not currently being archived. Existing system is not web-based.
Fiber Optic Network Management Data	Currently used	Offline	Managing fiber optic communication assets	End devices, intermediate devices, black fiber, copper connections, splice points, connecting devices, manholes, cable capacity, switches, hubs, duct capacity			Coordinates	TransGuide systemwide		Simple geodatabase that includes limited information based on design drawings	Provider	Yes	Created by SwRI based on construction plans, which is still work in progress				A comprehensive fiber network inventory database is needed and should be based on field conditions and not design drawings. Each month TransGuide processes 20 to 30 requests by utility companies to locate a fiber network. A comprehensive database for fiber network data will make it easier to respond to these requests.
Scheduled Lane Closure Data	Currently used	Real-time	Public information dissemination, traffic management	Closure status (active/ planned), nature of closure, location/coverage, lanes closed, direction, detour information, extra delay expected (desired)	Per occurrence	Varies	Approximate coordinates depending on how close operators click on map on their screen	Bexar County			Provider	Yes	Operators enter information based on faxed construction reports				There are three sources for lane closure data: TransGuide, TxDOT HCRS system, and San Antonio District's web page. This creates a duplication of data entry effort. More coordination is needed to avoid such extra wasted effort. Data validation should be built into the system. Existing TransGuide systems show these lane closures as points rather than linear features. To overcome the duplication effort problem, an algorithm could be developed to query HCRS system and filter out unnecessary entries that are not relevant to TransGuide.

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
CCTV Surveillance/ Snapshots	Currently used	Real-time	Monitoring traffic, public information dissemination through media outlets	Streamlined (live feed) video, static snapshots	Snapshots are updated every 5 minutes		Camera address	TransGuide coverage area	Decoding	Snapshots are overwritten every 5 minutes, streamline video is not archived	Provider	Streamline is shared with media outlets using private fiber connection. Snapshots are available to public through TransGuide website, which will also soon start to provide streamline video as well.	Auto scope cameras and VIVIDs				Snapshots are available in JPEG format both in low and high resolution. Snapshots are only taken from cameras that are active (i.e., used by operator) at the minute the system reads these cameras every 5 minutes. TransGuide can share CCTV streamline video with other local emergency management centers. EXIF standard has great potential to be used in the near future. This standard adds many attributes, such as time stamps and a camera address that could be used.
Parking Management Data	Would like to use	Real-time	Public information dissemination through DMSs and website	Space availability (number or percentage) by facility	As needed					Data does not exist, but San Antonio International Airport contacted TransGuide to share this information on real-time basis when it is available in the near future.		City of San Antonio/San Antonio International Airport	Acoustic detectors	Fiber connection	As needed		Besides parking information, TransGuide can disseminate to public other airport-related information, such as delays and security alerts.
Police CAD Data	Currently used	Real-time	Dissemination to public	Incident ID, type, location, time stamp	Per occurrence		Coordinates	City of San Antonio limits	TransGuide reads City of San Antonio's 911 logs every 5 minutes, filters this log to keep only traffic accidents, then adds coordinates to display these incidents on its map.	Yes	City of San Antonio Police CAD system		SAPD CAD	Direct/socket connection	Every 5 minutes		Add traffic incidents from incorporated cities' police CAD systems when they become available. TransGuide is not collecting this information therefore TransGuide is not responsible for the accuracy of this data. SAPD classifies incident type (major vs. minor) in a different way to TransGuide.
TMC Website Usage Data	Currently used	Both real-time and historical	Evaluate public interest in information provided by TransGuide	Website number of hits	Possibly hourly					Log files exist that records every request to access TransGuide website.							Collecting information about users requesting access to TransGuide website doubles the load on available bandwidth. A more specialized, standalone application may be needed to monitor and analyze website band width instead of ad-hoc queries.
Flood Data	Currently used	Real-time	Feed data to maintenance office for monitoring pumps	Flow reading into well, flow reading out of well, net flow (wet well readings), number of running pumps	Continuously		Nearest crossing street	Data is collected from 15 low-water crossing locations in Bexar County (only 5 stations are currently operational)		No		TransGuide feeds this data to Maintenance, but it is not shared with public	Sensors send readings to PC connected to pump well				System suffers from constant communication and hardware maintenance problems.
Traffic Signal Operations and Control Data	Would like to use	Real-time	Traffic management (integration of arterial or signal operation with freeway operation)	Signal timing plans (depends on District's traffic engineer and COSA needs)	Continuously			City of San Antonio	The City uses 170 controllers while District uses different types. Data collected from heterogeneous controllers will require some kind of transformation.	Since City of San Antonio signal operation has not yet been integrated into TransGuide, there is currently no available source of this data.	City of San Antonio signal system, but it is likely that TransGuide will serve and archive this data.	TransGuide will likely to serve as data repository for this data.	Video and loop detectors	Fiber connection	Continuously		San Antonio District is developing a partnership with City of San Antonio in which the District is transferring its signals within the city limits to the City of San Antonio. The City will upgrade, maintain, and operate these signals. The District will cover the involved costs for the first five years and will allow the City to use TransGuide fiber network. The City will share signal operation data with TransGuide. Integrating signal data with TransGuide will translate into an extra load on TransGuide existing servers. It will be challenging to convert signal data that is already in a proprietary format to a useful one that could be readable by TransGuide system. TransGuide will have to develop interfaces for their operators to allow them to access and view this data.

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
Traffic Signal Maintenance Data	Would like to use	Offline	Signal performance monitoring	Maintenance logs, service logs, parts replaced	Per occurrence					SwRI developed a signal maintenance module to be part of TransGuide IMDBMS to track equipment diagnostic and work orders. The system was never fully implemented, therefore data is very limited.	TxDOT						SwRI model needs to be linked to TransGuide IMDBMS. This will become less of a burden on TxDOT if signals are transferred to City of San Antonio.
Intersection Vehicle Count/Turning Volume Data	Would like to use	Real-time	Traffic control on service roads leading to entrance and exit ramps.	Turning volume (left, through, right) from each direction	Possibly 1-minute	Turning group per direction		Signals on service roads		No	TxDOT, City of San Antonio		Loop and video detectors	Direct fiber connection	Continuously		Collecting this information will depend on the integration of TxDOT and City of San Antonio signal operation.
San Antonio District (Traffic Engineering)																	
Traffic Control Detour Data	Would like to use	Real-time	Managing traffic on arterials	Detour details	As needed			Service and state roads		Not sure	TransGuide			Direct link	As needed	Any readable electronic format	Changing timing plans on real time is not currently possible due to signal controller limitations. Need to closely coordinate with City of San Antonio in order to coordinate new signal timing plans.
Aerial Photography Data	Currently used	Offline	Operational and signal warranty studies	Aerial photo	NA	NA	Not sure	District	No	Electronic format	District TP&D (acquired from Bexar County Appraisal Office)			Intranet (Crossroads)	As needed	Any suitable electronic format	Timelines and resolution of these aerial photos has improved in the past few years.
Roadway Inventory Data	Currently used	Offline	Operational and signal warranty studies	Control sections and mileposts, number of lanes, lane width, shoulder existence	NA	NA	Not sure	District	No	Server version exists though rarely used; mainly use paper data	TxDOT			Prefer intranet	As needed	GIS format	Paper data is very outdated (created in 1950s). A user-friendly interface to view this data, preferably in GIS, would really help.
Intersection Geometrics and Control Data	Currently used	Offline	Operational and signal warranty studies	Turning assignment, number of lanes available for each turn, channelization, type of control device		Intersection	Control section	All intersections with state roads in District	No	No	TxDOT	Yes, with local governments and consultants	Field visits and aerial photos	Prefer intranet	As needed	GIS format or Microstation	
Traffic Signal Operations and Control Data	Currently used	Both real-time and historical	Signal warrant and operation improvement studies	Location, signal timing parameters (both static and real-time activities), alarm (i.e., door open)		Intersection	Control section	District	No	Initial work just started to create a limited database	TxDOT	Yes, with local governments and consultants			Daily	Database, preferably in GIS	Server communication problems currently exist with controllers in the field. San Antonio District has offered the City of San Antonio to transfer its signals within the city limits to the City of San Antonio to maintain and operate in real-time basis through TransGuide. In return, the City will upgrade, maintain, and operate these signals and the District will cover the involved costs for the first five years. Details of this agreement will be further negotiated between the District and the City.
Traffic Signal Maintenance Data	Currently used	Offline	Respond to open records requests, identify areas where upgrades are needed	Inventory (hardware details), maintenance logs, history of service logs	As needed, daily for signal shop	Signal	Intersecting roads	District		Only paper form at Signal Shop	TxDOT	Yes, if requested			Daily		This will become less of a burden on TxDOT if signals are transferred to the City of San Antonio.
Intersection Vehicle Count/Turning Volume Data	Currently used	Offline	Signal warrant and operation improvement studies	Turning volume (left, through, right) counts, volume on each approach	24-hour for approach volume and 15-minute for turning counts	Intersection	Intersecting roads	District		Some exist in spreadsheets	TxDOT through consultants	Yes with local governments	Consultants		Daily		A system to store and retrieve traffic counts at intersections will certainly translate into big savings, especially consultant's time.
Crash Data	Currently used	Offline	Signal warrant and operation improvement studies	Crash frequency, type, severity, factors involved, location, collision diagram			Control section	District	Aggregate individual crashes to obtain crash frequency	Mainframe server	DPS, TxDOT, city police, county sheriff		Manually entered	Intranet or Internet	As needed	Access or Excel	Currently available data is outdated (up to year 2001). CRIS system, which is a joint effort between TxDPS and TxDOT, is promised to be available in June 2006.
Traffic Simulation Model Data	Currently used	Offline	Signal warrant and operation improvement studies	Intersection Geometrics and Control Data, intersection Geometrics and Control Data, intersection Geometrics and Control Data[AUTHOR: repeating?]				Project specific		Simulation projects if submitted by consultants are saved locally	TxDOT		Consultants		As needed		Different simulation packages are currently used. A system to store and retrieve simulation models for projects will save considerable resources.
San Antonio District (Planning and Project Development)																	
Volume	Would like to use	Offline	Design and operation	Volume per hour, peak characteristics, % of total	1-hour	By sector	No preference	Corridor	Yes	Yes	TransGuide		Loop detectors	Prefer intranet	Monthly	Text/MS Excel	
Occupancy	Would like to use	Offline	Determine LOS	Occupancy	15-minute	By sector	Sector address	Systemwide	Yes	Yes	TransGuide		Loop detectors	Prefer intranet	Monthly	Text/MS Excel/MS Access	
Speed & Travel Times	Would like to use	Offline	Operational analysis, speed studies, travel time	Speed	15-minute	By sector	Sector address	Corridor	Yes	Yes	TransGuide		Loop detectors	Prefer intranet	Monthly	Text/MS Excel/MS Access	

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
Incidents	Would like to use	Offline	Locating hotspots	Causal effects, frequencies, spatial, delay/queue lengths	Per occurrence		Longitude & latitude	By sector & corridor	Yes	Yes	TransGuide		Operators	Prefer intranet	Monthly	Text/MS Excel/MS Access	
Toll Road Data	Would like to use	Offline	Develop pricing strategies	Volume, price, revenue	Weekly	By corridor	Milepost	Corridor	Yes	No	Alamo Regional Mobility Authority			Prefer intranet	Yearly	Text/MS Excel	
Railway Crossing Data	Would like to use	Offline	Improvements, need assessment for upgrading at-grade crossing	Train volume, train speeds, warning times	24-hour						TransGuide				As needed		
Intersection Geometrics and Control Data	Currently used	Offline	Operations and design	Capacity, traffic controller device, lane assignment											Monthly		
Crash Data	Currently used	Offline	Determine problem areas for improvement	Type, cause/effect, location, severity			Mile marker							Intranet or Internet	Quarterly	GIS layer	
San Antonio District (Maintenance)																	
Incidents	Currently used	Both real-time and historical	Respond to damages on road, planning and management decisions	Type of incidents, location, # of lanes closed, potential delay, any damages	Per occurrence		Highway/crossing street							Intranet or Internet	Yearly	MS Access	Need areas outside of TransGuide territory.
DMS Data	Currently used	Real-time	Display information during emergencies	Displayed message	Per occurrence		Description of location							Intranet or Internet	During emergencies	MS Access	
Traffic Control Detour Data	Would like to use	Both real-time and historical	Analyze problems or correct problems (planning)	On/off, when, analytical time, congestion conditions/backups, contour flow (yes/no), how fast traffic is moving	Per occurrence									Intranet or Internet	As needed per occurrence		
Roadway Event Data	Would like to use	Both real-time and historical	Planning (right from wrong)	Detour, traffic conditions, damage/maintenance related, response	Per occurrence										As needed per occurrence		
Fiber Optic Network Management Data	Currently used	Offline	Provide to utility company	Location of cables and manholes										Prefer internet			
Scheduled Lane Closure Data	Currently used	Real-time	Dissemination to public	Road, lanes, location, time span/frame, who made notification, type of work	Per occurrence					Yes	TransGuide		Manually entered		Continuously		Coordinate with HCRS (one system).
Toll Road Data	Would like to use	Both real-time and historical		Demand/ volume	1-hour					No					As needed per occurrence		
Courtesy Patrol		Offline	Management/planning	Time & date						No			Manually entered	Intranet or Internet	Monthly	MS Excel/MS Access	Prefer one/no public access/crews have palms on field.
San Antonio District (Construction)																	
Volume	Currently used	Offline		Main lane, ramps, intersections	1-hour	Per direction					TransGuide			Prefer intranet	As needed per occurrence		
Speed	Currently used	Offline				By sector									As needed per occurrence	Some simple email	
Scheduled Lane Closure Data	Currently used	Real-time	How to put verification if posted	Closure type, how many lanes, limits, effective time spans			Cross roads							Prefer intranet	Continuously		Would like to enter information once instead of three times.
Weather Data	Currently used	Offline	Monitor for construction	Temperature, rain													
Air Quality Data				Ozone, not level													
Flood Data			Monitoring on specific projects														
Utilities	Currently used	Offline									Maintenance				Continuously		
Survey/Topographic Data																	Different coordinate systems, project specific not standardized.
Traffic Signal Operations and Control Data																	Tell traffic if there is a problem. They should fix.
Crash Data																	
Volume and occupancy	Currently used	Both real-time and historical	Managing traffic on arterials, monitor system performance, traffic analysis, signal timing	Volume, speed, occupancy, ramp location, date stamp, time stamps	15-minute	Ramp	Lane address	Entrance and exit ramps	Yes, aggregate from 20-second to 15-minute intervals	Yes	TxDOT-TransGuide		Loop detectors, Vivids	Direct link	Continuously	No preference	Develop interfaces with TransGuide system to obtain this data in a more useful format. The City of San Antonio is interested in receiving real-time information on exit and entrance ramps especially in situations of incidents, special events, and hurricane evacuation, to manage traffic on city streets.
City of San Antonio (Traffic Management)																	
Incidents	Would like to use	Real-time	Managing traffic on arterials	Location, type, date and time stamp, lanes closed, expected duration	Per occurrence		Prefer x, y coordinates	City of San Antonio limits	Filter incidents to those affecting City streets.	Not sure	TxDOT-TransGuide		Manually entered	Direct link	Continuously	No preference	City of San Antonio is interested in freeway incidents that will impact the city streets.
Traffic Control Detour Data	Would like to use	Real-time	Managing traffic on arterials especially during incidents	Detour route, normal route, duration, expected diverted traffic volume, exit ramp number, entrance ramp number	As needed	Route	Prefer x, y coordinates	City of San Antonio limits	Filter detours to those affecting City streets.	Not sure	TxDOT-TransGuide		Manually entered	Direct link or web based	As needed	Any readable electronic format	Two-way communication between the City and TransGuide will need to be established in such cases. The City would like to receive an alarm notification not just the data. City is also interested in receiving detour information pertaining to construction and maintenance as well.

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
Traffic Control Detour Data	Would like to use	Real-time	Managing traffic on arterials especially during incidents	Detour route, normal route, duration, expected diverted traffic volume, exit ramp number, entrance ramp number	As needed	Route	Prefer x, y coordinates	City of San Antonio limits	Filter detours to those affecting City streets.	Not sure	TxDOT-TransGuide		Manually entered	Direct link or web based	As needed	Any readable electronic format	Two-way communication between the City and TransGuide will need to be established in such cases. The City would like to receive an alarm notification not just the data. City is also interested in receiving detour information pertaining to construction and maintenance as well.
Roadway Event Data	Would like to use	Real-time	Managing traffic on arterials	Type of event, nature of event (emergency vs. non-emergency), expected duration	Per occurrence	Sector	Prefer x, y coordinates	City of San Antonio limits		Not sure	TxDOT-TransGuide			Direct link or web based	As needed	Text	
Scheduled Lane Closure Data	Would like to use	Real-time	Managing traffic on arterials	Location/coverage, detour information, expected duration, expected diverted volume	Per occurrence	Sector	Prefer x, y coordinates	City of San Antonio limits		Not sure	TxDOT						TxDOT construction or maintenance information may need to be integrated with Bexar County and City of San Antonio scheduled closures.
CCTV Surveillance/ Snapshots	Currently used	Real-time	Monitoring traffic during incident and special event situations	Streamlined (live feed) video and snapshots				City of San Antonio limits			TxDOT-TransGuide			Direct link or web based	As needed		The City has a console at TransGuide that is used to access cameras if needed.
Parking Management Data	Would like to use	Real-time	Dissemination to public during special events	Number of vacant spaces available; whether facility is full or not		Parking facility		City of San Antonio limits		City of San Antonio does not collect this data in a real-time basis.	Possibly City of San Antonio	Yes with TxDOT-TransGuide		Direct link or web based	As needed (special events)		City of San Antonio is considering automating its parking management system, in which real time may become available.
Weather Data	Would like to use	Real-time	Traffic management during inclement weather conditions	Current and forecasted conditions, fog or ice existence		Area wide		City of San Antonio limits		City of San Antonio does not collect this data			Weather sensors	Direct link or web based	Every 30 minutes		
Air Quality Data	Would like to use	Both real-time and historical	Monitor air quality	Nox and CO levels		Station		City of San Antonio limits		City of San Antonio does not collect this data			Air quality sensors	Direct link or web based	Once or twice a day		
Flood Data	Would like to use	Real-time	Manage traffic during emergency	Alarm of flooded street		Spot		City of San Antonio limits		City of San Antonio does not collect this data			Sensors	Direct link or web based	Continuously during emergency		
Roadway Surface Condition Data (wet, icy, etc)	Would like to use	Real-time	Traffic management during inclement weather conditions	Surface condition (wet, icy, etc.)				City of San Antonio limits		City of San Antonio does not collect this data				Direct link or web based			
Railway Crossing Data	Would like to use	Both real-time and historical	Traffic management on local streets especially at-grade railroad intersections	Alarms, duration, frequency				City of San Antonio limits		Not sure				Direct link or web based			
Aerial Photography Data	Currently used	Offline	Operational and signal warranty studies	Aerial photo	NA	NA	Not sure	Bexar County	No	Electronic format	From Bexar County Appraisal Office			CD ROM	As needed		
Roadway Inventory Data	Currently used	Offline	Operational and signal warranty studies	Control sections and mileposts, number of lanes, lane width, shoulder presence				City of San Antonio			City of San Antonio	Yes with TxDOT		Prefer intranet	As needed	GIS format	Paper data is very outdated (created in 1950s). A user-friendly interface to view this data, preferably in GIS, would really help.
Intersection Geometrics and Control Data	Currently used	Offline	Operational and signal warranty studies	Turning assignment, number of lanes available for each turn, channelization, type of control device		Intersection	GIS based	City of San Antonio		No, but would like to have	City of San Antonio	Yes, with local governments and consultants	Field visits and aerial photos	Prefer intranet	As needed (at least daily)	GIS format or Microstation	It would be useful to be able to view intersection details on a map.
Traffic Signal Operations and Control Data	Currently used	Both real-time and historical	Signal warrant and operation improvement studies	Location, signal timing parameters (both static and real-time activities), alarm (i.e., door open)		Intersection	Control section	City of San Antonio		COSA maintains a GIS database that includes basic signal information for each signal in San Antonio. Information in these GIS databases include name of intersecting streets, owner, systems it belongs to, preemption capability, coordination capability, and detection type. Signal timing data exists in a separate, proprietary database (Bi Tran System).	City of San Antonio	It is possible to share this data with TxDOT but after addressing some legal issues			Daily	Database, preferably in GIS	District operates NEMA signal controllers while City operates 170 controllers. There is an ongoing project to synchronize TxDOT and City signals (currently working independently) to achieve seamless operation. There are legal issues to be solved before the City can share this information with outside agencies. San Antonio District has offered the City of San Antonio to transfer its signals within the city limits to the City of San Antonio to maintain and operate in real-time basis through TransGuide. In return, the City will upgrade, maintain, and operate these signals and the District will cover the involved costs for the first five years. Details of this agreement will be further negotiated between the District and the City.
Traffic Signal Maintenance Data	Currently used	Offline	Respond to open records requests, identify areas where upgrades are needed	Inventory (hardware details), maintenance logs, history of service logs	As needed, daily for signal shop	Signal	Intersecting roads	City of San Antonio		Only paper form at City Signal Shop	City of San Antonio	Yes with TxDOT	Field technicians		Daily	Paper	Signal technicians do not change signal timings permanently without work orders from traffic operation. TxDOT signal maintenance data will be less critical because the City will be upgrading signal equipment at TxDOT intersections.

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
Intersection Vehicle Count/Turning Volume Data	Currently used	Offline	Signal warrant and operation improvement studies	Turning volume (left, through, right) counts, volume on each approach	24-hour for approach volume and 15-minute for turning counts	Intersection	Intersecting roads	City of San Antonio		City data exists in spreadsheets	City of San Antonio		Consultants		Daily		
Crash Data	Currently used	Offline	Signal warrant and operation improvement studies	Crash frequency, type, severity, factors involved, location, collision diagram			Control section	City of San Antonio		No (database exists that only provides the number of incidents at a particular location without further details)	City of San Antonio Police Department		Manually entered	Intranet or Internet	As needed	Access or Excel	City would like to have access to TxDOT/DPS new crash database if it is kept up-to-date.
Traffic Simulation Model Data	Currently used	Offline	Signal warrant and operation improvement studies	Intersection Geometrics and Control Data, intersection Geometrics and Control Data,				Project specific		Simulation projects if submitted by consultants are saved locally	Consultants		Consultants		As needed		An idea is to build a city-wide simulation model (in Synchro or CORSIM) that can be tailored to certain corridors of interest.
San Antonio-Bexar County Metropolitan Planning Organization (MPO)																	
Volume, speed, and occupancy	Would like to use	Offline		Volume, speed, occupancy	1-hour	By corridor (exit to exit)	Longitude & latitude	Systemwide	Yes to aggregate data						Quarterly	MS Excel/MS Access	
Travel time	Would like to use	Offline	Public information, B&A studies	Travel time, location	Different levels of aggregation	By corridor	Longitude & latitude	Systemwide							Quarterly	MS Excel	
Incidents	Would like to use	Offline	Safety studies to identify hotspots		Per occurrence		Longitude & latitude								Monthly	MS Excel	
Scheduled Lane Closure Data	Would like to use	Offline	Public information dissemination	Sectors/lanes affected, type of work, effective duration	Per occurrence		Longitude & latitude	Systemwide							Weekly	MS Excel	
Weather Data	Would like to use	Offline		Precipitation, wind, pressure	1-hour										Quarterly	MS Excel	
Roadway Surface Condition Data (wet, icy, etc.)	Would like to use	Offline	Contributing factors to incidents	Condition	1-hour	By sector									Monthly		
Roadway Inventory Data	Would like to use	Offline	Modeling for travel demand forecasting	# of lanes, posted speed, pavement conditions, geometrics			Longitude & latitude								Quarterly		
Average Daily Traffic Volume & Vehicle Classification	Currently used	Offline	Travel demand forecasting	AADT, truck volume	Daily	By sector									As needed per occurrence		
Bexar County (Traffic Engineering)																	
Volume	Currently used	Both real-time and historical	Emergency, planning	Volume, location	15-minute (real-time) 24-hour (offline)	By sector	Milepost		Yes						As needed per occurrence	MS Access	
Flood Data	Would like to use	Real-time	Managing closures	Alarms	Per occurrence		Intersecting street				Water Mark Safety			Internet	Continuously		Talking with TransGuide.
Crash Data	Would like to use	Offline	Safety analysis	Individual crash reports, severity, type of collision			Coordinates				Sheriff's Department						
Speed	Would like	Both real-time and historical	Updating scheduling outcome		Current	By sector	By sector address							Internet	As needed per occurrence		
VIA Transit Authority																	
Incidents	Would like	Offline	Historical incident for research on routing	Incident rates, delay										Internet	As needed per occurrence		
Transit Operation Data	Currently used	Real-time	Bus dispatching real-time ranges	Location, time, bus, driver	1-minute					Yes		Yes	GPS/AVL		Continuously		
Intersection Geometrics and Control Data	Would like	Offline	Route scheduling	# of lanes, width, geometrics/sidewalks, slopes			GIS								As needed per occurrence		
Traffic Signal Operations and Control Data	Would like	Both real-time and historical	Scheduling/bottlenecks	Cycle times, delay						Yes	VIA			Internet	As needed per occurrence		
Intersection Vehicle Count/Turning Volume Data	Would like	Offline	Scheduling/operation designing routes	Volumes/per application	15-minute										As needed per occurrence		
Crash Data	Would like	Offline	Determining lanes	Type of crash, cause, pedestrian/cyclist											As needed per occurrence		
Corridor Inventory Data	Currently used	Offline	Routing	Volume, accidents, physical aspects													
WOAI TV Station																	
Volume, speed, and occupancy	Would like to use	Both real-time and historical		Speed, volume, occupancy	Aggregated	By sector	By sector address	Systemwide	No	Not sure	TransGuide		Loop detectors	Prefer intranet	5-7 AM M-F	Raw	They are currently receiving this data but not using it for any purpose. They obtain data through a leased and fiber optic line from Grande Telecom. Volume, speed, and occupancy
Travel time	Would like to use	Real-time	Dissemination to public	Travel time											5-7 AM M-F		Travel time

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
Incidents	Would like to use	Both real-time and historical	Dissemination to public	Severity (nature of crash), location, direction, # of lanes closed, expected duration/delay			Coordinates/cross streets	Systemwide	Not sure					Prefer intranet	Continuously	Text	The data is currently from Clear Channel Traffic. They would like to utilize the existing link to TransGuide. Incidents.
DMS Data	Currently used	Real-time	Dissemination to public	Message displayed					Not sure		TransGuide			Prefer intranet	Continuously		DMS Data
Lane Control Signal (LCS) Data	Would like to use	Real-time	Use it to prepare traffic report	Lane status		By lane								Prefer intranet	Continuously		Lane Control Signal (LCS) Data
Traffic Control Detour Data	Would like to use	Real-time	Dissemination to public	Alternative routes													Currently provides to public some made up alternatives. Traffic Control Detour Data
Roadway Event Data	Would like to use	Real-time	Prepare traffic reports	Nature of event, time, detour, location													Roadway Event Data
ITS Equipment Inventory Data	Would like to use	Both real-time and historical	Know the location of TransGuide devices	Location of device													ITS Equipment Inventory Data
Scheduled Lane Closure Data	Would like to use	Real-time	Prepare traffic reports	Nature of closure, # of lanes closed, beginning time, ending time, detours											Continuously		They use both TransGuide's and TxDOT's Highway Condition Reporting System at a much less frequency. Scheduled Lane Closure Data
CCTV Surveillance/ Snapshots	Currently used	Real-time	Monitor incident conditions and broadcast it to public	Stream line video	N/A	N/A		Systemwide		Not sure				Prefer intranet	Continuously, but mostly interested in feed from 5-7 AM	Video	CCTV Surveillance/ Snapshots
Flood Data	Would like to use	Both real-time and historical	Report to public														Only if water is crossing the street. Flood Data
Roadway Surface Condition Data (wet, icy, etc)	Would like to use	Real-time	Report to public														Roadway Surface Condition Data (wet, icy, etc.)
Traffic Signal Operations and Control Data	Would like to use	Real-time	Signal delays at major intersections	Queue length, signal active status	15-minute										Continuously		Traffic Signal Operations and Control Data
Houston District (Traffic Management)																	
Volume	Currently used	Real-time	Ramp metering, Managed lane operations, Construction impact determination	Volume, speed, occupancy, location, stream sensors	20-second and 5 minute	By lane and sector	GPS Card	Systemwide	No	No	Provider		ILD, VIVIDS, acoustic detectors, road tubes		Continuously	FTP	
Speed and Travel time	Currently used	Real-time	Traffic monitoring system, Incident detection and management	Speed, segment location and length, direction, facility name, # of lanes	5 minutes	By sector	By sector	Systemwide	Depends on the use.	Yes	Provider	Yes (limited)	AVI		Continuously	Online	
Incident data	Currently used	Real-time	Traffic monitoring system, Incident detection and management, Dissemination to the public, Traffic management, Emergency traffic control	Location, incident type, # of lanes, # of vehicles, weather, vehicle type	Per occurrence	By lane	Segments and cross streets	Systemwide	No	Yes	Provider	Yes	Manually		Continuously	Online	
DMS Data	Currently used	Real-time	Dissemination to the public, Traffic management, Emergency traffic control, Roadway impact analysis	Time posted, message, location, Time out, automated vs. incident, Flash on/off	Per occurrence	By sector	Location	Systemwide	No	Yes	Provider	No	Data entered by operators, automated travel time		As needed per occurrence	Online	
Ramp Metering	Currently used	Real-time	Traffic management, Ramp metering, Emergency traffic control	Location, period control, direction of travel, time and date of modification	20 seconds	By lane	Location and GPS	Systemwide	No	No	Provider	No	ILD, VIVIDS, Acoustic detectors		Continuously		
Scheduled Lane Closure Data	Currently used	Real-time	Traffic management, Ramp metering, Emergency traffic control, Construction impact determination	# of lanes, location, date and time of lane closure and opening	Per occurrence	By lane	Limits of closure (cross-street)	Systemwide	No	Yes	Provider	No	Manually		Continuously	Online	
Motorists Assistance Program	Currently used	Real-time	Incident detection and management, Traffic management		Per occurrence	By lane	Cross-street	Systemwide	Aggregation (reports)	Yes	Provider	No	Manually		Monthly	CD	
Closed Circuit Television	Currently used	Real-time	Traffic monitoring system, Incident detection and management, Dissemination to the public, Traffic management, Emergency traffic control	Location, time, date	1 minute	By lane	Cross-street	Systemwide	Raw data, snapshots on web from videogram	Yes	Provider	Yes	Automatically, CC TV		Continuously	Online	

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
TMC Website	Currently used		Dissemination to the public, Traffic analysis, Travel demand forecasting	# of hits, date, time, IP, pages accessed	Per occurrence	By site	Not applicable	Entire website	Aggregation (reports)	Yes	Provider	No	Automatically		Monthly and as needed		
Weather Data and Flooding	Currently used		Traffic condition prediction, Dissemination to the public, Traffic management, Operation planning/analysis, Emergency traffic control, Safety analysis	Water level reading, stream level, wind speed and direction, rain and surface temperature	20 seconds and per occurrence	By location	GPS	Systemwide	Aggregation (proprietary)	Yes	Provider	No	Automatically		Continuously	Online	
Ferry Waiting	Currently used			Wait time, time and date	5 minutes	By ferry		Boliver only	No	Yes		No			Continuously	Online	
HOV lanes	Currently used		Traffic monitoring system	Road tubes, volume, speeds,	20 seconds	By lane	Select location	Systemwide	No and aggregation	Yes	Metro	No	Manually, Road tubes		Continuously		
Railroad Crossing	Currently used	Real-time	Sugarland and COH	Speed, track, condition	1 minute	By corridor	Cross-street	Corridor	No	Yes	TxDOT/COH	No	Camera/Doppler radar		Continuously	Online	
Houston District (Design)																	
Hydraulic Design	Currently used	Offline model	Hydraulic design	Flood plain maps	Event based	N/A	N/A	N/A	No	Yes	Provider	Yes	Maps	On-line	2 times a week	Web based	
Roadway Surface Conditions	Currently used	Offline	Pavement management	Quality of ride	N/A	TxDOT facilities	Reference marker	TxDOT facilities	No	Yes	Provider	If needed	Drive/DMI	On-line	Yearly	Main frame	
Roadway Inventory Data	Currently used	Offline	Pavement management	Signs, lanes, shoulders	N/A	TxDOT facilities	Distance from origin/Mile pt marker/reference marker	TxDOT facilities	No	Yes	Provider	Yes	Plans	N/A	As needed	Main frame	
Intersection geometry and control data	Currently used	Offline	Roadway Design	Average daily traffic, # of lanes	N/A	By intersection/interchange	Intersection	TxDOT facilities	No	Yes	Provider	Yes	Plans	N/A	Weekly	Text	
Intersection vehicle count and turning volume data	Currently used	Offline	Access management	Turning movement data	1 hour	By intersection/interchange	Intersection	TxDOT facilities	No	Yes	Provider	Yes	Another office	N/A	As needed	MS Excel	
El Paso District (Traffic Management)																	
Volume, speed, and occupancy	Currently used	Real-time	Monitoring traffic, incident detection	Volume, speed, occupancy	20-second	By lane	GPS Coordinates	Corridor	No	Yes, in flat file format	Provider	Yes	Loop detectors, Microwave Detectors				How to mirror raw data from data server to web server?
Travel time	Not Used	Real-time	Public information dissemination	Sector's travel time (derived from average speed)	NA	By sector		Certain corridors		No							
Incidents	Currently used	Offline	Managing traffic	Type, location (sector address), date and time stamp	Per occurrence	By sector		Transvista Coverage Area	No		EP PD		911 traffic incidents, camera tours				
DMS Data	Currently used	Real-time	Public information dissemination	Message displayed, date and time stamp, devices address	Per occurrence		CMS address	Transvista Coverage Area	No	Yes	Provider	Yes, but do not have the capability to do so.	System and/or Manually by operators				
Lane Control Signal (LCS) Data	Currently used	Real-time	Managing traffic	State of arrows, date and time stamp, devices address	Per occurrence		LCS address	Transvista Coverage Area	No	Yes	Provider	Yes, but do not have the capability to do so.	System and/or Manually by operators				
Traffic Control Detour Data	Currently used	Offline	Managing traffic	Detour details	As needed			Transvista Coverage Area		Detours are given in lane closure data and occasionally displayed on CMSs	Provider						
Roadway Event Data	Currently used	Real-time	Managing traffic	Alarms, sector address, lanes affected, scenario loaded	Per occurrence		Sector address	Transvista Coverage Area		Yes	Provider	Yes	Different subsystems				
ITS Equipment Inventory Data and Maintenance Log Data	Currently used	Offline	Managing Transvista inventory	Device type, location, manufacturer, communication setup, technical details, construction details, maintenance history			Coordinates	Transvista Coverage Area		Geodatabase exists that includes limited information (device ID and location)	Provider	Yes	Created by Kimley Horn as part of FMSGIS				
ITS Equipment Monitoring Data	Currently used	Offline	Managing Transvista inventory	Alarm, device ID, condition status													
Fiber Optic Network Management Data	Currently used	Offline	Managing Transvista inventory and Performance Tracking	End devices, intermediate devices, black fiber, copper connections, splice points, connecting devices, manholes, cable capacity, switches, hubs, duct capacity			Coordinates	Transvista Coverage Area									
Motor Assistance Program Log Data	Currently used	Offline	ITS Benefits Assessment	Incidents, Time of Occurrence, First Responder	Per occurrence	Varies	Route Number and Exit Number	Transvista Coverage Area	No	TTI is helping transfer the paper log into a database	Paper Log	Yes	Operators enter information on paper				

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
El Paso Metropolitan Organization (MPO)																	
Volume, speed, and occupancy	Currently used	Offline	Validation and Calibration of Simulation Models	Volume and speed	24-hour	By Corridor	Regional	Corridor	Aggregation and Transformation	CD-ROM and Spreadsheet	TxDOT	No	Loop detectors, Microwave Detectors	Website, FTP	As Required	Flat Text File	
Laredo District (Traffic Management)																	
Volume & Speed	Currently used	Real-time	Monitoring traffic	Volume, speed	1-minute	By lane	By intersecting roads	Systemwide	No			Yes (it is currently shared with City)	Loop detectors (11), microwave detectors (14 under construction)		Continuously		This data is not currently used other than display. Microwave detectors should be collecting same information as loop detectors.
Occupancy	Currently used	Real-time	Monitoring traffic, incident detection	Occupancy	1-minute	By lane	By intersecting roads			No		Yes					Station occupancy data is used for incident detection. Alarms generated are discarded. Incidents from other sources are not collected.
Incidents	Would like to use	Real-time	Manage traffic	ITS equipment used	Per occurrence	By sector				No	Provider	No					Event data is not currently archived, though ATMS allows for archiving incidents. Due to lack of personnel, there is no continuous operator presence at STRATIS at this time. Therefore, this data is not even collected.
DMS Data	Currently used	Real-time	Display traffic conditions and amber alert	DMS ID, displayed message	Per occurrence		By intersecting roads	Systemwide		No. Only new, different message templates are saved but not the actual message displayed in response to a particular event.	Provider	Yes	System and/or Manually by operators				STRATIS is constantly making changes to the pre-canned messages. STRATIS can display certain messages to City on special occasions after approval by the Director of Transportation Operations. ATMS may need to be changed to allow documenting the history of what messages were displayed, where, and when.
Lane Control Signal (LCS) Data	Currently used	Real-time	Managing traffic	State of arrows, date and time stamp, devices address	Per occurrence		LCS sign address		No	No	Provider	Yes					LCS archived data is used to respond to open record requests.
ITS Inventory Data		Offline	To know where ITS equipment is	Type of equipment, location, status, manufacturer, last maintenance			Coordinates			Yes	Provider	Yes	Manually				
CCTV Surveillance/ Snapshots	Currently used	Real-time	Monitoring traffic	Streamlined (live feed) video			Equipment address			Data is not archived	Provider	Streamline is shared with the City of Laredo. No static snapshots are taken.	Autoscope cameras				STRATIS shares its streamline with the City, which can have camera control if approved by TxDOT.
Flood Data	Would like to use		Monitoring water conditions	Text message warning (alarm)	Per occurrence						Provider		TxDOT area office				
Railroad Crossing	Would like to use		Monitoring traffic	Location	Per occurrence												
Aerial Photo	Would like to use	Real-time	Generate map, reference		As needed		Coordinates	Systemwide					TP&P	Online			
Roadway Inventory	Would like to use	Real-time	General reference	Street names (numbers), Mile markers, classification		By sector	Mileposts										
Utilities	Would like to use	Offline	Future installation, association utilities with providers	Provider/owner, type of utility, highway (mile marker), location	As needed												
Survey/Topographic Data	Currently used	Offline	Planning future projects	Elevations, existing features	As needed												
Signal Control	Would like to use	Real-time	Inventory, traffic management	Location, type of controller, phasing, different times, signal height elevations, detection type			Coordinates					Yes	Automatically				
Laredo District (Traffic Engineering)																	
Traffic Control Detour Data	Would like to use	Real-time	Managing traffic during incidents, construction, and special events on state roads	Roads/streets affected, duration	Per occurrence	By corridor		Systemwide		No	STRATIS	Yes, if agreement/understanding with City is reached.				MS Excel, MS Access	Laredo District policy is not to detour traffic on city streets. Traffic can only be routed to state roads on which TxDOT can modify timing plans as needed. Incident and/or special event management protocols will need to be negotiated with other agencies.
Events Data	Would like to use	Real-time	Managing traffic during events	Construction, incident, accidents	Per occurrence	By lane		STRATIS systemwide		No	STRATIS	Yes		Direct link	As needed		Event data is not currently archived, though ATMS allows for archiving roadway events such as incidents and lane closures. Due to lack of personnel, there is no continuous operator presence at STRATIS at this time.
Scheduled Lane Closures	Would like to use	Real-time	Traffic management	Duration, date & time, # of lanes affected, location, type and level of traffic control	Per occurrence	By sector	Coordinates	STRATIS systemwide		No	District maintenance or construction may need to provide and enter this information.	No	District	Direct link	As needed	MS Excel, MS Access	
Aerial Photo	Currently used	Offline	Intersection design	Aerial photo			Coordinates	District						Direct link	As needed		

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
Roadway Inventory	Currently used	Offline	Site inventory, traffic engineering studies, speed zoning	Geometry, # of lanes, traffic control devices, curbs, channelization, grade, curves, pt & pc, lane widths,		By sector	By control section	District		Microstation	TxDOT - pavement group					Paper	Would like to have it in electronic format.
Traffic Signal Operations & Control Data	Currently used	Offline	Signal timing	Phasing configuration, vehicle classification, turning moving counts, plan times, yellow min green, urban/rural, type of controller, last time upgraded, actuation/detection	15-minute	By intersection/inter change	Coordinates	District		Some data already exist in a database that was collected by GPS	Provider	Yes	Signal technicians		Daily	MS Access/GIS enabled	The District has just recently updated their signals with Ethernet-based controllers to control signal timing (still work-in-progress). Another concern is that the City may not have the technology infrastructure to control TxDOT's signals. The City used to control and maintain all signals until recently when TxDOT took over its signals on frontage roads. The District and City will have to work an agreement to allow the City to control a few TxDOT signals in town.
Intersection Geometrics & Control Data & Turning Volume	Currently used	Offline	Traffic studies	# of lanes, lane configurations, traffic control devices, lane width, channelization			By intersection			Yes	Provider		Consultants			MS Excel	
Traffic Signal Maintenance Data	Would like to use	Offline	Signal tech, preventative maintenance, planning & management of signals	Controller type, timings, type of detection, mast vs. span wire instrument, illuminated or not, LEDs, preventative maintenance history, trouble call history			By intersection	District		Some Excel sheets and trouble log web-based application exists	Provider						District would like to integrate this into GIS. Old maintenance logs could be scanned and saved in PDF format. Comprehensive data model that represents the three areas of interest (static signal data, real time data, and signal maintenance data) may help to integrate these inter-dependent areas together.
Traffic Simulation Model Data	Currently used	Offline	Traffic studies (case by case)	Geometry, volume, traffic devices, detection, model network							Consultants						Saved on shared folder and shared internally. GIS enabled system would be efficient. Archiving traditional traffic study information, mostly conducted by consultants, would save much of wasted duplication effort.
Vehicle Classification	Currently used	Offline	Traffic	% of heavy vehicles									Operator	Paper			Data is saved on local machines.
Average Daily Traffic Volume	Currently used	Offline	Traffic studies	AADT base year, AADT design, segments	24-hour			County			TP&P		TP&P	Paper			
Laredo District (Planning)																	
Travel Time	Would like to use	Offline	Travel times between A to B	Average travel time along corridor daily	1-hour	By sector		Corridor	Yes	Yes			Automatically			MS Excel, MS Access	
Aerial Photo	Currently used	Offline	Planning to look for routes, environmental documents, alternative routes, land use							Yes		Yes		Intranet			
Utilities	Currently used	Offline	Planning and environmental to help with alignments and impacts	Type, location			It depends on project			No			Sources				Not the same for each project, different sources
Intersection Vehicle Count & Turning Volume	Currently used	Offline	Planning purposes for median related project	Location, time, volumes (different turns), peaks	1-hour	Direction	By intersection		No	Yes		Yes	Manually			Paper	
Crash Data	Currently used	Offline	Identify location, frequency of accident type, to enter into project matrix	Location of accident, type, time, surface conditions (pavement conditions)			Milepoints		Yes	Yes		Yes	Manually			Intranet	There are two sources (mainframe and ROSS) only 2001 or older
Traffic Simulation Model Data	Currently used	Offline	Different roadway improvements	Congestion, traffic patterns, turning				Corridor		No							
Origin Destination Data	Currently used	Offline	Planning	Location/zones, timing, flows/traffic patterns, peaks				Area	No	Yes		Yes	Consultants				
Vehicle Classification	Currently used	Offline	Planning and environmental	(light/med/heavy), % of traffic for each class, non-directional	24-hour	Non-directional	Milepoints	Sector	No	Yes			Loop detectors			Paper	
Laredo District (Design)																	
Volume & Average Daily Traffic Volume	Would like to use	Offline	Design	Design	1-hour	By lane			Yes							MS Excel	
Travel Time	Would like to use	Offline	Define scope of project	Travel time peak and off-peak					Yes							MS Excel	
Flood Data	Would like to use	Offline	Monitoring, identify problematic areas	Water level, time closure (duration)													
Aerial Photo	Currently used	Offline	Design	Lane configuration						Yes							It is expensive and geographically referenced, every 3 years.
ITS Equipment Inventory Data	Would like to use	Offline	Design	Width, limits (reference marker), surface data, intersecting and connecting roads													No visual representation of data, sheets are less time consuming.
Utilities	Would like to use	Offline	Project Development	XYZ, dimensions, type of utility, owner													
Survey/Topographic Data	Currently used	Offline	Identify features														

Data subject	Use status	Data type	Purpose	Data elements	Temporal resolution	Spatial resolution	Spatial reference	Scope	Pre-processing	Data existence	Data source	Data sharing preference	Collection methods	Data access preference	Data access frequency	File format	Other issues
Roadway Inventory	Currently used	Offline	Site inventory, traffic engineering studies, speed zoning	Geometry, # of lanes, traffic control devices, curbs, channelization, grade, curves, pt & pc, lane widths,		By sector	By control section	District		Microstation	TxDOT - pavement group					Paper	Would like to have it in electronic format.
Intersection Vehicle Count & Turning Volume	Currently used	Offline	Design (determine storage lane)	Turning volume, lane data		By lane											
Vehicle Classification	Currently used	Offline	Design	% of heavy traffic, FHWA closures													
Traffic Simulation Model Data	Currently used	Offline	Design (scope correctly)	Overall, final results, LOS approaches													
Laredo Metropolitan Planning Organization (MPO)																	
Volume, Occupancy & Speed	Would like to use	Both	General planning	Volume, location	1-hour	By lane	GIS compatible	Exit to Exit	Yes		TxDOT			Internet		Text/MS Excel	
Travel Time	Would like to use	Offline	Monitor and locate hot spots		1-hour	By road	GIS compatible		Yes		TxDOT/City			Internet			
Incidents	Would like to use	Offline	Hazard elimination	Delay	Per occurrence		GIS compatible				TxDOT			Internet			
Railroad Crossing	Currently used	Offline	Policy decision	Frequency	1-hour		GIS compatible							Internet			
Roadway Inventory	Currently used	Offline	Travel demand forecasting	Road Alignment and characteristics			GIS compatible				TxDOT/City			Internet			
Crash Data	Currently used	Offline	Planning projects	Frequency and severity			GIS compatible		Yes		City		City DPS	Internet			
Average Daily Traffic Volume	Would like to use	Offline	Travel demand forecasting	AADT, seasonal factors	24-hour		GIS compatible		No		Provider		TxDOT area office	Internet			
City of Laredo (Traffic)																	
Volume, Occupancy & Speed	Would like to use	Real-time	Managing traffic as it pertains to service	Volume, speed, occupancy	15-minute			Exit and Entrance ramps	No				Loop detectors, acoustic detectors				The City operates a small operation center that is connected to STRATIS via a fiber connection. The City has a terminal that has TxDOT's ATMS installed. The City can control STRATIS camera when needed after coordinating with TxDOT.
DMS Data	Currently used	Real-time	Disseminating information to travelers	Location, message				City limits		No						Intranet	
Traffic Control Detour Data	Would like to use	Real-time	Detouring/alternate information	Detour plan, signage along route	1-hour												
ITS Inventory Data	Would like to use	Offline	Develop city's ITS system	Location, type of equipment, make/provider												MS Access	
ITS Development Maintenance Log	Would like to use	Offline	Planning	Quality of devices, emergency repairs													
ITS Inventory Data			To know where ITS equipment is	Type of equipment, location, status, manufacturer, last maintenance			Coordinates						Manually				
Equipment Monitoring	Would like to use	Real-time	To ensure equipment is operational	Status, reason			Coordinates									Intranet	
Fiber Optic	Currently used	Offline	Planning future city's ITS system	Capacity, map of fiber optic network			Map							Online			
Scheduled Lane Closures	Would like to use	Real-time	Traffic management as it pertains to city	Location, date & time, nature of closure			Mile point	City limits								Intranet	
CCTV	Currently used	Real-time	Monitoring traffic	Video, camera location, snapshots					No	No			Automatically			Intranet	
Police CAD	Would like to use	Real-time	Traffic incidents	Traffic incidents, location													
Signal Operations Data	Currently used	Real-time	Coordinate signals	Control plans, schedules, real-time status						Yes			Automatically			Intranet	
Signal Maintenance	Currently used	Offline								No							
Turning Volume	Would like to use	Offline	Signal timing on corridor	Turning volume	15-minute	By lane		Corridor	As needed				Contractors				
Signal Simulation Data		Offline	Signal optimization														

APPENDIX D. OTHER STATE DOT SURVEY FORMS

Research Project 0-5257: Survey of Other State DOTs

Target states: Washington, California, Florida, and Virginia

The Texas Transportation Institute (TTI) is conducting a research study for TxDOT to document operations data management practices and outline strategies to manage operations data more effectively. The research will build a conceptual data model for transportation operations data management, outline strategies for managing the data, and formulate implementation guidelines.

Realizing that transportation operations data can be quite broad, we are limiting the inquiry to the following data types: detector data (including speed, volume, occupancy, and travel time), incident data, and scheduled lane closure data.

One of the tasks is to explore what other DOTs around the country are doing in this general area and, in particular, their experience in making operations data available to other external and internal users. Relevant questions include the following:

<u>Data attributes and characteristics (most of the information may be available on their website)</u>
What temporal resolution/aggregation?
What spatial resolution/aggregation?
Is there any data pre-processing (aggregation or transformation) performed on data before use?
Are data geographically referenced?
How are data accessible? (File Transfer Protocol (FTP), Internet, Direct Link, CD-ROM, etc.)
In what format are the data available? (Text, MS Excel, MS Access, etc.)

<u>Data usage</u>
Who uses the data and for what purpose?
Who is not currently using the data but has expressed interest in using it?
Is there any storage or archiving issues?
Are there any known data quality concerns?
Are there any known data completeness (gaps in data) concerns?
Are there any privacy, security, or liability concerns?
Besides lane detector data, do they archive other data types? (Ask for more details if they archive incidents or scheduled lane closures)

<u>Data storage and archival system design and operation</u>
Is their system a centralized (statewide) or a decentralized one?
Who manages the system? (DOT or contractor(s))
What are the major hardware and software components of the system?
How much does it cost to operate/maintain the system?
Is there any formal system design documentation, including

- Assessment of user data needs
- Business process and data models

<u>Lessons learned</u>

APPENDIX E. DATA DICTIONARY

This appendix includes the data dictionary of the database model described in Chapter 2. The data dictionary describes 14 entities in the logical data model. Each of the tables below includes the entity definition, along with a description of each of the attributes in the entity, including relevant data such as attribute name, definition, purpose, format, and example.

DATA EXISTENCE TYPE: A DATA EXISTENCE TYPE is a descriptor indicating the electronic availability of the data.	
DATA EXISTENCE TYPE ID	**Definition:** A DATA EXISTENCE TYPE ID is a unique numerical identifier for a DATA EXISTENCE TYPE. **Purpose:** To provide a DATA EXISTENCE TYPE a unique identification. **Example:** 1, 2 **Format:** Numeric
DATA EXISTENCE TYPE NAME	**Definition:** A DATA EXISTENCE TYPE NAME is the name of a DATA EXISTENCE TYPE to indicate whether the data fully exists in an electronic archive, partially exists, or does not exist in an electronic archive. **Purpose:** To provide a common identifier of a DATA EXISTENCE TYPE. **Example:** Fully archived in electronic format **Format:** Alpha

DATA FLOW: A DATA FLOW is an exchange of data between two USER FUNCTIONS.	
DATA FLOW ID	**Definition:** A DATA FLOW ID is a unique numerical identifier for a DATA FLOW. **Purpose:** To provide DATA FLOW a unique identification. **Example:** 1, 2 **Format:** Numeric
SOURCE USER FUNCTION ID	**Definition:** A SOURCE USER FUNCTION ID is a unique numerical identifier that shows the USER FUNCTION that initiated of the data flow. **Purpose:** To identify a source USER FUNCTION for a DATA FLOW. **Example:** 1, 2 **Format:** Numeric
DESTINATION USER FUNCTION ID	**Definition:** A DESTINATION USER FUNCTION ID is a unique numerical identifier that shows the USER FUNCTION that is the recipient of the data flow. **Purpose:** To identify a destination USER FUNCTION for a DATA FLOW. **Example:** 1, 2 **Format:** Numeric

DATA FLOW DIRECTION TYPE: A DATA FLOW DIRECTION TYPE is a descriptor of whether a DATA FLOW represents a one-way or two-way data exchange.	
DATA FLOW DIRECTION TYPE ID	**Definition:** A DATA FLOW DIRECTION TYPE IDENTIFIER is a unique numerical identifier for a DATA FLOW DIRECTION TYPE. **Purpose:** To give a DATA FLOW DIRECTION a unique identification. **Example:** 1, 2 **Format:** Numeric
DATA FLOW DIRECTION TYPE NAME	**Definition:** A DATA FLOW DIRECTION TYPE NAME is the type of data flow that is being performed. **Purpose:** To provide a common identifier for a DATA FLOW DIRECTION TYPE. **Valid Values:** one-way, two-way **Format:** Alpha

DATA FLOW PROPERTY: A DATA FLOW PROPERTY is the description of a DATA FLOW.	
DATA FLOW PROPERTY ID	**Definition:** A DATA FLOW PROPERTY ID is a unique numerical identifier for a DATA FLOW PROPERTY. **Purpose:** To provide DATA FLOW PROPERTY a unique identification. **Example:** 1, 2 **Format:** Numeric
DFP PURPOSE DESCRIPTION	**Definition:** A DFP PURPOSE DESCRIPTION is a description of the broad purpose for which the data is or will be used. **Purpose:** To describe the purpose for which the data is commonly used. **Example:** managing traffic, incident detection **Format:** Alpha
DFP ELEMENT DESCRIPTION	**Definition:** A DFP ELEMENT DESCRIPTION is a description of the data elements. **Purpose:** To provide a listing of the data elements. **Example:** incident data: incident time stamps, severity **Format:** Alpha
DFP TEMPORAL RESOLUTION DESCRIPTION	**Definition:** A DFP TEMPORAL RESOLUTION DESCRIPTION is a description of the temporal aggregation level of the data. **Purpose:** To describe the temporal resolution (level of aggregation) of the data. **Example:** every 20 seconds, per occurrence **Format:** Alpha
DFP SPATIAL RESOLUTION DESCRIPTION	**Definition:** A DFP SPATIAL RESOLUTION DESCRIPTION is a description of the spatial aggregation level of the data. **Purpose:** To describe the spatial resolution (level of aggregation) of the data. **Example:** by lane, by sector **Format:** Alpha
DFP SPATIAL REFERENCE DESCRIPTION	**Definition:** A DFP SPATIAL REFERENCE DESCRIPTION is a description of how the data is spatially referenced. **Purpose:** To describe how the data is spatially referenced. **Example:** coordinates, lane address, sector address **Format:** Alpha
DFP GEOGRAPHIC SCOPE DESCRIPTION	**Definition:** A DFP GEOGRAPHIC SCOPE DESCRIPTION is a description of the scope (coverage area) of the data. **Purpose:** To describe the scope (coverage area) of the data. **Example:** district-wide, TMC coverage area **Format:** Alpha

DATA FLOW PROPERTY: A DATA FLOW PROPERTY is the description of a DATA FLOW.	
DFP PRE-PROCESSING COMMENT	**Definition:** A DFP PRE-PROCESSING COMMENT is a description of what kind of pre-processing has been applied to the data, if any. **Purpose:** To provide a user with a description of any data processing that has already been or likely to be performed on the data. **Example:** aggregation, averaging **Format:** Alpha
DFP EXISTENCE COMMENT	**Definition:** A DFP EXISTENCE COMMENT is a description of whether the data exists in a usable and accessible electronic format. **Purpose:** To describe whether the data can be accessed electronically. **Example:** N/A **Format:** Alpha
DFP SOURCE DESCRIPTION	**Definition:** A DFP SOURCE DESCRIPTION is a description of the source or origin (if known) of the data. **Purpose:** To describe the source or origin (if known) of the data. **Example:** provider, TxDOT TP&P **Format:** Alpha
DFP SHARING COMMENT	**Definition:** A DFP SHARING COMMENT is a description of how, and with whom, the data may be shared. **Purpose:** To describe any constraints that the user may have on the sharing of the data with other parties. **Example:** N/A **Format:** Alpha
DFP ACCESS METHOD DESCRIPTION	**Definition:** A DFP ACCESS METHOD DESCRIPTION is a description of how the data may be accessed. **Purpose:** To describe the method by which the data may be accessed. **Example:** Direct connection, Internet, CD-ROM **Format:** Alpha
DFP ACCESS FREQUENCY DESCRIPTION	**Definition:** A DFP FREQUENCY DESCRIPTION is a description of how often the data is accessed. **Purpose:** To describe how frequent the user needs to access the data. **Example:** continuously, hourly, daily **Format:** Alpha
DFP COLLECTION METHOD DESCRIPTION	**Definition:** A DFP COLLECTION METHOD DESCRIPTION is a description of the method by which the data is collected. **Purpose:** To describe how the data was originally collected. **Example:** loop detectors, cameras **Format:** Alpha
DFP FILE FORMAT DESCRIPTION	**Definition:** A DFP FILE FORMAT DESCRIPTION is a description of the format in which the data is available. **Purpose:** To identify the electronic file format of the data. **Valid Values:** raw data, Bentley Microstation, Microsoft Excel **Format:** Alpha
DFP OTHER ISSUE DESCRIPTION	**Definition:** A DFP OTHER ISSUE DESCRIPTION is a description of other miscellaneous information relating the data, such as data quality, completeness. **Purpose:** To describe any miscellaneous comments the user may have on this data. **Example:** N/A **Format:** Alpha

DATA PRE-PROCESSING TYPE: A DATA PRE-PROCESSING TYPE is a descriptor indicating how the data has been pre-processed.	
DATA PRE-PROCESSING TYPE ID	**Definition:** A DATA PRE-PROCESSING ID is a unique numerical identifier for a DATA PRE-PROCESSING TYPE. **Purpose:** To provide a DATA FLOW PRE-PROCESSING TYPE a unique identification. **Example:** 1, 2 **Format:** Numeric
DATA PRE-PROCESSING TYPE NAME	**Definition:** A DATA PRE-PROCESSING TYPE NAME is the name of a DATA PRE-PROCESSING TYPE to indicate whether any pre-processing of the data was or likely will be performed. **Purpose:** To provide a common identifier of a DATA PRE-PROCESSING TYPE. **Example:** N/A **Format:** Alpha

DATA SHARING TYPE: A DATA SHARING TYPE is a descriptor of how data may be shared with third parties.	
DATA SHARING TYPE ID	**Definition:** A DATA SHARING TYPE ID is a unique numerical identifier for a DATA SHARING TYPE. **Purpose:** To provide a DATA FLOW SHARING TYPE a unique identification. **Example:** 1, 2 **Format:** Numeric
DATA SHARING TYPE NAME	**Definition:** A DATA SHARING TYPE NAME is the name of a DATA SHARING TYPE to indicate how the data may be shared with third parties. **Purpose:** To provide a common identifier of a DATA SHARING TYPE. **Example:** Can be shared, Can be shared with restrictions. **Format:** Alpha

DATA SUBJECT: A DATA SUBJECT is the type of data being exchanged in a DATA FLOW.	
DATA SUBJECT ID	**Definition:** A DATA SUBJECT ID is a unique numerical identifier for a DATA SUBJECT. **Purpose:** To provide DATA SUBJECT a unique identification. **Example:** 1, 2 **Format:** Numeric
DATA SUBJECT NAME	**Definition:** A DATA SUBJECT NAME is a name of a DATA SUBJECT. **Purpose:** To provide a common identifier of a DATA SUBJECT. **Example:** Travel Time Data, Incident Data **Format:** Alpha

DATA SUBJECT GROUP: A DATA SUBJECT GROUP is a data type category into which DATA SUBJECTS are assigned.	
DATA SUBJECT GROUP ID	**Definition:** A DATA SUBJECT GROUP ID is a unique numerical identifier for a DATA SUBJECT GROUP. **Purpose:** To provide a DATA SUBJECT GROUP a unique identification. **Example:** 1, 2 **Format:** Numeric
DATA SUBJECT GROUP NAME	**Definition:** A DATA SUBJECT GROUP NAME is a name of a DATA SUBJECT GROUP **Purpose:** To provide a common identifier for a DATA SUBJECT GROUP. **Example:** Traffic Conditions Data, Environmental Data **Format:** Alpha

DATA TYPE: A DATA TYPE is a representation of whether the information exchanged in a DATA FLOW is real-time or archived.	
DATA TYPE ID	**Definition:** A DATA TYPE ID is a unique numerical identifier for a DATA TYPE. **Purpose:** To provide a DATA TYPE a unique identification. **Example:** 1, 2 **Format:** Numeric
DATA TYPE NAME	**Definition:** A DATA TYPE NAME is a name of a DATA TYPE to indicate whether the data is needed in real-time, archived, or both real-time and archived. **Purpose:** To provide a common identifier of a DATA TYPE. **Valid Values:** Real-time, Archived, Real-time and archived **Format:** Alpha

DISTRICT: A DISTRICT is one of the 25 geographical areas within the state of Texas where the Texas Department of Transportation conducts its primary work activities.	
DISTRICT ID	**Definition:** A DISTRICT ID is a unique numerical identifier for a DISTRICT. **Purpose:** To provide a DISTRICT a unique identification. **Example:** 15, 22 **Format:** Numeric
DISTRICT NAME	**Definition:** A DISTRICT NAME is a name of a TxDOT DISTRICT. **Definition:** To provide a common identifier for a TxDOT DISTRICT. **Example:** San Antonio, Houston **Format:** Alpha
DISTRICT CODE	**Definition:** A DISTRICT CODE is a 3-letter shortened word or phrase that provides a distinctive designation for a TxDOT DISTRICT. **Purpose:** To provide an identifier used on reports, in lieu of the full DISTRICT NAME. **Example:** HOU = Houston **Format:** Alpha

DISTRICT USER: A DISTRICT USER is a user in one of the TxDOT districts surveyed for the purpose of characterizing data needs.	
DISTRICT USER ID	**Definition:** A DISTRICT USER ID is a unique numerical identifier for a DISTRICT USER. **Purpose:** To provide a DISTRICT USER a unique identification. **Example:** 1, 2 **Format:** Numeric
DISTRICT USER NAME	**Definition:** A DISTRICT USER NAME is a name of a DISTRICT

DISTRICT USER: A DISTRICT USER is a user in one of the TxDOT districts surveyed for the purpose of characterizing data needs.	
	USER. **Purpose:** To provide a common identifier for a DISTRICT USER. **Example:** N/A **Format:** Alpha

USER FUNCTION: A USER FUNCTION is a functional role or activity that a USER GROUP performs and for which transportation operations data is used or needed.	
USER FUNCTION ID	**Definition:** A USER FUNCTION ID is a unique numerical identifier for a USER FUNCTION. **Purpose:** To provide a USER FUNCTION a unique identification. **Example:** 1, 2 **Format:** Numeric
USER FUNCTION NAME	**Definition:** A USER FUNCTION NAME is a name of the functional activity or organizational role that the user performs. **Purpose:** To provide a common identifier for a USER FUNCTION. **Example:** Transportation Planning, Emergency Management **Format:** Alpha

USER GROUP: A USER GROUP is an aggregation of individual users representing a class of data users from a particular office, agency, or organization.	
USER GROUP ID	**Definition:** A USER GROUP ID is a unique numerical identifier for a USER GROUP. **Purpose:** To provide a USER GROUP a unique identification. **Example:** 1, 2 **Format:** Numeric
USER GROUP NAME	**Definition:** A USER GROUP NAME is a name of a USER GROUP. **Purpose:** To provide a common identifier to a USER GROUP. **Example:** Media Outlet, District Maintenance **Format:** Alpha
USER GROUP STAKEHOLDER NAME	**Definition:** A USER GROUP STAKEHOLDER NAME is a name of a user group stakeholder. **Purpose:** To provide a common name for a USER GROUP STAKEHOLDER. **Example:** TxDOT, city **Format:** Alpha

USE STATUS TYPE: A USE STATUS TYPE is a description of whether the type of information described by the DATA FLOW PROPERTY is currently in use.	
USE STATUS TYPE ID	**Definition:** A USE STATUS TYPE ID is a unique numerical identifier of USE STATUS TYPE. **Purpose:** To provide a USE STATUS TYPE a unique identification. **Example:** 1, 2 **Format:** Numeric
USE STATUS TYPE NAME	**Definition:** A USE STATUS TYPE NAME is the name of a USE STATUS TYPE to indicate whether the user is currently using this data or would like to use it in the near future. **Purpose:** To provide a common identifier of a USE STATUS TYPE. **Valid Values:** Currently using, Would like to use **Format:** Alpha