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1. Introduction

The purpose of this report is to define and develop a plan to implement a Regional ITS Architecture for the Tulsa region. The Tulsa Regional ITS Architecture is based on the National ITS Architecture. The architecture will consist of five systems: Regional Traffic Management System (RTMS), Local Traffic Operations System (LTOS), Local Emergency Response System (LERS), Transit Management System (TRMS), and Information Service Providers (ISP). The five systems are interrelated and contain subsystems that can also be interconnected within each system.

The architecture defines "how" information is transferred between transportation systems (Communication Layer), what transportation systems transfer what information (Transportation Layer), and the supporting institutional structure, policy and strategies (Institutional Layer) so that the desired user services are implemented. Market packages composed of subsystems and data flows are the foundation of the physical architecture. Market packages implement transportation services and architecture flows allowing the exchange of information between the subsystems and terminators within the Tulsa region.

This document consists of three main sections: introduction, summary of the existing ITS elements in the Tulsa region, and the Tulsa Regional ITS architecture. The architecture chapter defines the physical architecture subdivided into the three layers (transportation, institutional and communications).

2. Inventory of Existing ITS in the Tulsa Region

The stakeholder involvement process conducted throughout the Tulsa Region identified numerous elements of the regional ITS architecture that are currently operating or are in various stages of planning or design. These elements are listed in the table below in reference to their corresponding stakeholder.

Table 1: Stakeholder Mapped to Element Name

Stakeholder	Element Name	Element Status
Broken Arrow Transit	Broken Arrow Transit Center	Existing
Tulsa Traffic Engineering	City of Tulsa Operations Center_Roadside Equipment	Existing
	City of Tulsa Traffic Operations Center	Existing
	City of Tulsa Traffic Operations Center_Personnel	Existing
INCOG	INCOG	Planned
Local Counties and Cities	Local 911 Center	Existing
	Local TOC	Existing
Oklahoma DOT District 8	ODOT District 8 FMC	Planned
	ODOT District 8 FMC_Personnel	Planned
	ODOT District 8 FMC_Roadside Equipment	Planned
	Weather Service	Planned
	User Personal Computing Devices (Website)	Existing
Oklahoma Highway Patrol	Oklahoma Highway Patrol Center	Planned
	Oklahoma Highway Patrol Center Personnel	Existing
	Oklahoma Highway Patrol Center Vehicles	Existing
Oklahoma Turnpike Authority	Oklahoma Turnpike	Existing
	Oklahoma Turnpike_Personnel	Existing
	Oklahoma Turnpike_Roadside Equipment	Existing
Tulsa Transit	Transit Vehicles	Planned
Tulsa 911	Tulsa 911 Center	Planned
	Tulsa 911 Center Personnel	Existing
	Tulsa 911 Center Roadside Equipment	Existing
Tulsa Public Safety	Tulsa Emergency Management Center	Planned
	Tulsa Emergency Vehicles	Existing
Tulsa International Authority	Tulsa International Airport	Planned
Tulsa Public Schools	Tulsa Public School Buses	Existing
Tulsa Transit	Tulsa Transit Center	Existing
	Tulsa Transit Center_Kiosks	Existing
	Tulsa Transit Center_Personnel	Existing

3. Development of the Tulsa Regional ITS Architecture

3.1 Conformity with the ITS National Architecture

The Tulsa regional ITS architecture must conform to federal guidelines, if agencies wish to remain eligible for Federal funds to support ITS projects.

Certain outcomes are required by the Rule at the planning level. The following section is organized to indicate the rule language in italics, with interpretation following. The NIA Rule reference number is also noted..

Rule: *The regional ITS architecture shall include, at a minimum, the following* (940.9(d)):

1. *A description of the region* (940.9(d)(1));

The rule defines a region as the geographical area that identifies the boundaries of the regional ITS architecture and is defined by and based on the needs of the participating agencies and other stakeholders. In metropolitan areas, a region should be no less than the boundaries of the metropolitan planning area.

The regional description should identify features that are relevant to the deployment of ITS projects as shown in the regional architecture. For example, the regional description includes major cities, the modes being addressed, key geographical features that introduce congestion (e.g. waterways and bridges), major traffic generators, weather events that affect traffic operations, and tourism.

Rule: 2. *Identification of participating agencies and other stakeholders* (940.9(d)(2));

All agencies contacted, and if pertinent, those contacted that did not respond may be listed. The regional workshop, in-person interviews and other contacts may be noted.

Rule: 3. *An operational concept that identifies the roles and responsibilities of participating agencies and stakeholders in the operation and implementation of the systems included in the regional ITS architecture* (940.9(d)(3)).

An operational concept identifies the who, what, when and where of integrated operations. This architecture includes an Institutional layer which defines portions of the concept of operations. The concept of operations is supplied under a separate cover.

Rule: 4. *Any agreements (existing or new) required for operations, including at a minimum those affecting ITS project interoperability, utilization of ITS related standards, and the operation of the projects identified in the regional ITS architecture* (940.9(d)(4));

Currently, no agreements have been identified as specifically required by the Tulsa Regional ITS Architecture. Often, the architecture itself constitutes the agreement between agencies to integrate and operate together. Funding agreements for capital or operations funding, data privacy agreements, and operations agreements can sometimes be required. With the exception of funding agreements, many regions find that they can integrate and operate together without written agreements.

Rule: 5. *System functional requirements* (940.9(d)(5));

This architecture provides planning level system functional requirements, based on the user service requirements.

Rule: *6. Interface requirements and information exchanges with planned and existing systems and subsystems (for example, subsystems and architecture flows as defined in the National ITS Architecture)* (940.9(d)(6));

All selected market package data flows and system interface requirements have been identified and referenced to the National ITS Architecture.

Rule: *7. Identification of ITS standards supporting regional and national interoperability* (940.9(d)(7));

Each data flow identified is connected to a supporting standard, if one exists. The standards will support regional and national systems interoperability. Some of the standards may become USDOT-adopted "critical" standards that specifically support national interoperability. As of this writing, there are no critical standards currently adopted by USDOT. If USDOT does adopt any standards, they will require that they be implemented on Federally-funded ITS projects.

Rule: *8. The sequence of projects required for implementation* (940.9(d)(8)).

The Tulsa regional ITS plan will identify any required sequencing. The NIA Rule emphasizes that the region ensure that projects be implemented in a logical sequence. For example, a communications backbone may be required before field devices can be connected.

Rule: *9. The agencies and other stakeholders participating in the development of the regional ITS architecture shall develop and implement procedures and responsibilities for maintaining it, as needs evolve within the region* (940.9(f)).

The region has yet to identify the roles and responsibilities for maintaining and updating the architecture. ODOT would be the likely agency with primary responsibility for architecture maintenance, to incorporate new proposals developed by existing or new partners, and to reflect changes that may develop as projects are implemented.

This document and other activities already completed by the Tulsa region are intended to conform to the requirements of the Rule on ITS Architecture Consistency.

3.2 Physical Architecture

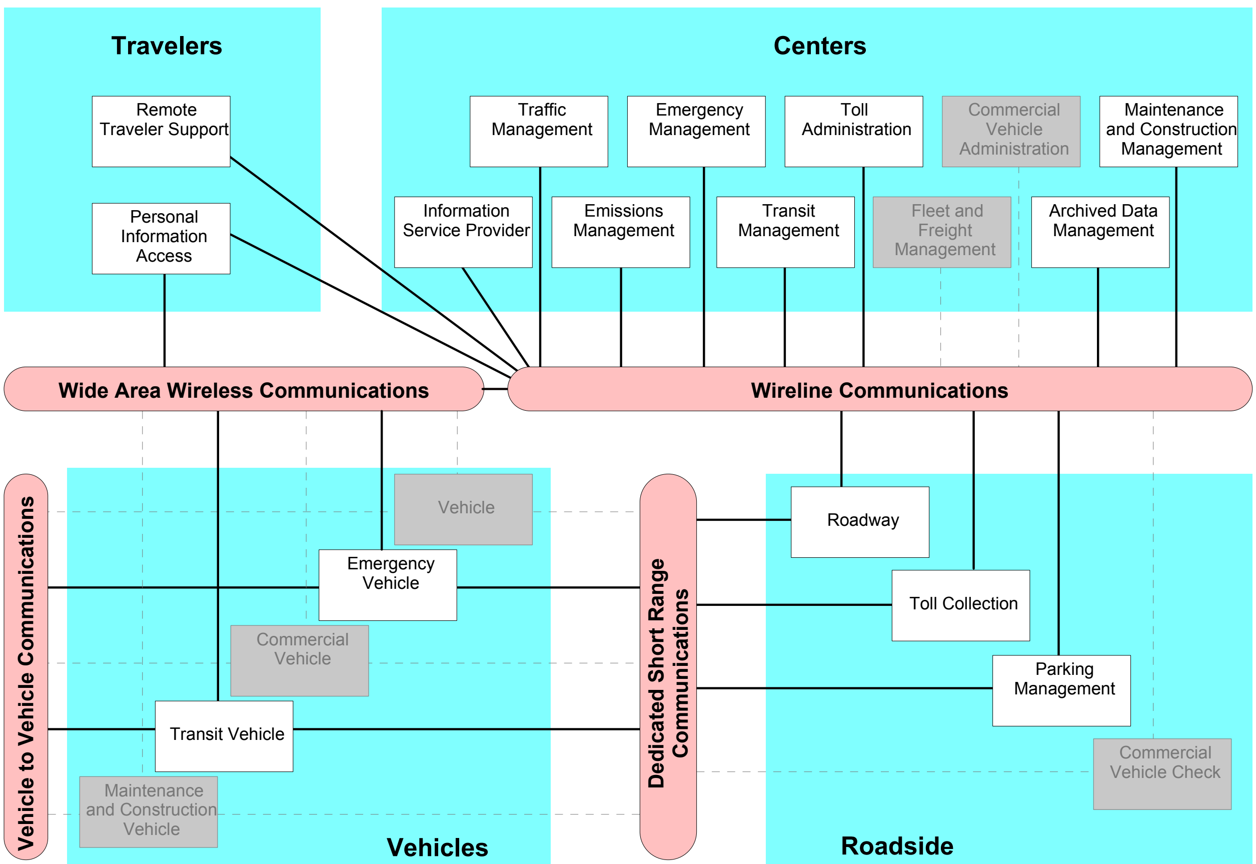
This document describes the physical architecture for implementation of a Regional Traffic Management System for the Tulsa Regional area. It is based on the National ITS Architecture providing a common framework for planning, defining, and integrating intelligent transportation systems. The architecture defines:

- The functions (e.g., gather traffic information or request a route) that are required for ITS; and

- The physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle).

The Physical Architecture provides agencies with a physical representation, independent of technology and design, of important ITS interfaces and major system components. Its principal elements are the 21 subsystems, the related communications flows that connect these subsystems, and the terminators that demarcate the subsystems. A physical architecture takes the processes and assigns them to subsystems. In addition, the data flows are grouped together into architecture flows. These architecture flows and their communication requirements define the interfaces required between subsystems, which form the basis for much of the ongoing standards work in the National ITS program. The architecture flows which were selected for the Tulsa Regional Architecture are provided in The Appendix. The figure below depicts a high level physical architecture identifying the subsystems involved in the regional architecture. The subsystems that are in gray were not selected for this architecture.

Figure 1: Tulsa Regional ITS Architecture Sausage Diagram



3.2.1 *Subsystems and Terminators*

The following describes in detail the subsystems and terminators that are relevant to the Tulsa regional ITS architecture depicted in Figure 1.

Archived Data Management Subsystem (ADMS) Represented by INCOG

The Archived Data Management Subsystem 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. The data received is formatted, tagged with attributes that define the data source, conditions under which it was collected, data transformations, and other information (i.e. meta data) necessary to interpret the data. The subsystem can fuse ITS generated data with data from non-ITS sources and other archives to generate information products utilizing data from multiple functional areas, modes, and jurisdictions. The subsystem prepares data products that can serve as inputs to Federal, State, and local data reporting systems. This subsystem may be implemented in many different ways. It may reside within an operational center and provide focused access to a particular agency's data archives. Alternatively, it may operate as a distinct center that collects data from multiple agencies and sources and provides a general virtual data warehouse service for a region.

Emergency Management Subsystem (EM) Represented by Oklahoma Highway Patrol

The Emergency Management Subsystem operates in various emergency centers supporting public safety including police and fire stations, search and rescue special detachments, and HAZMAT response teams. This subsystem interfaces with other Emergency Management Subsystems to support coordinated emergency response involving multiple agencies. The subsystem creates, stores, and utilizes emergency response plans to facilitate coordinated response. The subsystem tracks and manages emergency vehicle fleets using automated vehicle location technology and two way communications with the vehicle fleet. Real-time traffic information received from the other center subsystems is used to further aide the emergency dispatcher in selecting the emergency vehicle(s) and routes that will provide the most timely response. Interface with the Traffic Management Subsystem allows strategic coordination in tailoring traffic control to support en-route emergency vehicles. Interface with the Transit Management Subsystem allows coordinated use of transit vehicles to facilitate response to major emergencies.

Information Service Provider Subsystem (ISP) Represented by ODOT

The ISP is also its own system containing twelve subsystems. The ISP communicates with each LTOS, LERS, TRMS and the RTMS individually to disseminate transportation information pertaining to system operators and the public. The ISP plays many roles in the transfer of information. Dynamic ridesharing is included as one of the twelve subsystems. ODOT, local traffic management agencies and transit agencies may act as ISPs. However, private entities will also be ISPs in the future.

Traffic Management Subsystem (TMS) Represented by ODOT

The Traffic Management Subsystem operates within a traffic management center or other fixed location. This subsystem communicates with the Roadway Subsystem to monitor and manage traffic flow. Incidents are detected and verified and incident information is provided to the Emergency Management Subsystem, travelers (through Roadway Subsystem Highway Advisory Radio and Dynamic Message Signs), and to third party providers. The subsystem supports HOV lane management and coordination, road pricing, and other demand management policies that can alleviate congestion and influence mode selection. The subsystem monitors and manages maintenance work and disseminates maintenance work schedules and road closures. The subsystem also manages reversible lane facilities, and processes probe vehicle information. The subsystem communicates with other Traffic Management Subsystems to coordinate traffic information and control strategies in neighboring jurisdictions. It also coordinates with rail operations to support safer and more efficient highway traffic management at highway-rail intersections. Finally, the Traffic Management Subsystem provides the capabilities to exercise control over those devices utilized for automated highway system (AHS) traffic and vehicle control.

<u>Roadway Subsystem (RS) Represented by Tulsa Traffic Operations and ODOT</u>

The Roadway subsystem includes the equipment distributed on and along the roadway, which monitors and controls traffic. Equipment includes highway advisory radios, dynamic message signs, cellular call boxes, CCTV cameras and video image processing systems for incident detection and verification, vehicle detectors, traffic signals, grade crossing warning systems and freeway ramp metering systems. The subsystem also provides the capability for emissions and environmental condition monitoring including weather sensors, pavement icing sensors, fog, etc. HOV lane management and reversible lane management functions are also available. In advanced implementations, this subsystem supports automated vehicle safety systems by safely controlling access to and egress from an Automated Highway System (AHS) through monitoring of and communications with AHS vehicles. Intersection collision avoidance functions are provided by determining the probability of a collision in the intersection and sending appropriate warnings and/or control actions to the approaching vehicles.

<u>Personal Information Access Subsystem (PIAS) Represented by Travelers</u>

This subsystem provides the capability for travelers to receive formatted traffic advisories from their homes, place of work, major trip generation sites, personal portable devices, and over multiple types of electronic media. These capabilities shall also provide basic routing information and allow users to select those transportation modes that allow them to avoid congestion, or more advanced capabilities to allow users to specify those transportation parameters that are unique to their individual needs and receive travel information. This subsystem shall provide capabilities to receive route planning from the infrastructure at fixed locations such as in their homes, their place of work, and at mobile locations such as from personal portable devices and in the vehicle or perform the route planning process at a mobile information access location. This subsystem shall also provide the capability to initiate a distress signal and cancel a prior issued manual request for help.

<u>Toll Administration Subsystem Represented by Oklahoma Turnpike Authority</u>

The Toll Administration Subsystem provides general payment administration capabilities and supports the electronic transfer of authenticated funds from the customer to the transportation system operator. This subsystem supports traveler enrollment and collection of both pre-payment and post-payment transportation fees in coordination with the existing, and evolving financial infrastructure supporting electronic payment transactions. The system may establish and administer escrow accounts depending on the clearinghouse scheme and the type of payments involved. This subsystem posts a transaction to the customer account and generates a bill (for post-payment accounts), debits an escrow account, or interfaces to the financial infrastructure to debit a customer designated account. It supports communications with the Toll Collection Subsystem to support fee collection operations. The subsystem also sets and administers the pricing structures and includes the capability to implement road pricing policies in coordination with the Traffic Management Subsystem. The electronic financial transactions in which this subsystem is an intermediary between the customer and the financial infrastructure shall be cryptographically protected and authenticated to preserve privacy and ensure authenticity and auditability.

Maintenance and Construction Management Represented by ODOT

This subsystem resides in a maintenance, construction, or other specialized service vehicles or equipment and provides the sensory, processing, storage, and communications functions necessary to support highway maintenance and construction. All types of maintenance and construction vehicles are covered, including heavy equipment and supervisory vehicles. The subsystem provides two-way communications between drivers/operators and dispatchers and maintains and communicates current location and status information. A wide range of operational status is monitored, measured, and made available, depending on the specific type of vehicle or equipment. For example, for a snow plow, the information would include whether the plow is up or down and material usage information. The subsystem may also contain capabilities to monitor vehicle systems to support maintenance of the vehicle itself and other sensors that monitor environmental conditions including the road condition and surface weather information. This subsystem can represent a diverse set of mobile environmental sensing platforms, including wheeled vehicles and any other vehicle that collects and reports environmental information.

The table below maps the subsystems shown above to their respective architecture elements.

Table 2: Subsystem Mapped to Element

Architecture Entity	Subsystem Name	Element Name	Element Status
Subsystems	Archived Data Management Subsystem	INCOG	Planned
	Emergency Management	Local 911 Center	Planned
		Oklahoma Highway Patrol Center	Planned
		Oklahoma Highway Patrol Center Vehicles	Existing
		Tulsa 911 Center	Planned
		Tulsa Emergency Management Center	Planned
	Emergency Vehicle Subsystem	Oklahoma Highway Patrol Center Vehicles	Existing
		Tulsa Emergency Vehicles	Existing
	Emissions Management	Tulsa 911 Center	Existing
	Information Service Provider	ODOT District 8 FMC	Planned
	Maintenance and Construction Management	ODOT District 8 FMC	Planned
	Parking Management	Tulsa International Airport	Planned
	Personal Information Access	User Personal Computing Devices	Planned
	Remote Traveler Support	Tulsa Transit Center_Kiosks	Existing
	Roadway Subsystem	City of Tulsa Operations Center_Roadside Equipment	Existing
		ODOT District 8 FMC_Roadside Equipment	Planned
		Tulsa 911 Center Roadside Equipment	Existing
	Toll Administration	Oklahoma Turnpike	Existing
	Toll Collection	Oklahoma Turnpike_Roadside Equipment	Existing
	Traffic Management	City of Tulsa Traffic Operations Center	Existing
		Local TOC	Planned
		ODOT District 8 FMC	Planned
	Transit Management	Tulsa Transit Center	Existing
	Transit Vehicle Subsystem	Transit Vehicles	Planned

Terminators

Archived Data User Systems
This terminator represents the systems users employ to access archived data. The general interface provided from this terminator allows a broad range of users (e.g. planners, researchers, analysts, operators) and their systems (e.g. databases, models, analytical tools, user interface devices) to acquire data and analyses results from the archive.

Basic Transit Vehicle
This terminator represents a specialized form of the Basic Vehicle used by transit service providers. It supports equipment to collect fares, monitor activities, request priority at signals, and provide information to travelers. It may be a bus, LRT vehicle, or other vehicle specially designed for the carriage of passengers, such as those used by demand responsive transit operators. The monitoring of the Transit Vehicle mechanical condition and mileage provides the major inputs for transit vehicle maintenance scheduling.

Emergency Personnel
This terminator represents personnel that are responsible for police, fire, emergency medical services, towing, service patrols, and other special response team (e.g., hazardous material clean-up) activities at an incident site. These personnel are associated with the Emergency Vehicle Subsystem during dispatch to the incident site, but often work independently of the Emergency Vehicle Subsystem while providing their incident response services. Emergency personnel may include an Officer in Charge (OIC) and a crew. When managing an incident following standard Incident Command System practices, the on-site emergency personnel form an organizational structure under the auspices of an Incident Commander.

ISP Operator
This terminator is the human entity that may be physically present at the ISP to monitor the operational status of the facility and provide human interface capabilities to travelers and other ISP subsystems.

Other Archives
This terminator represents distributed archived data systems or centers whose data can be accessed and shared with a local archive. The interface between the Other Archives Terminator and the Archived Data Management Subsystem allows data from multiple archives to be accessed on demand or imported and consolidated into a single repository.

Other EM
Representing other Emergency Management centers, systems or subsystems, this terminator provides a source and destination for ITS data flows between various communications centers operated by public safety agencies as well as centers operated by other allied agencies and private companies that participate in coordinated management of highway-related incidents. The interface represented by this terminator enables emergency management activities to be coordinated across jurisdictional boundaries and between functional areas. In the Physical Architecture this terminator is a reciprocal Emergency Management Subsystem (EM) implying the requirements for general networks connecting many allied agencies. The interface between this terminator and the EM supports coordination of incident management information between many different centers providing Public Safety Answering Point (both public or private sector implementations), Public Safety Dispatch, Emergency Operations, and other functions that participate in the detection, verification, response, and clearance of highway incidents. This

terminator also supports interface to other allied agencies like utility companies that also participate in the coordinated response to selected highway-related incidents.

Other Parking
Representing another parking facility, system or subsystem, this terminator provides a source and destination for information that may be exchanged between peer parking systems. This terminator enables parking management activities to be coordinated between different parking operators or systems in a region. In the Physical Architecture this terminator is a reciprocal Parking Management Subsystem.

Other Roadway
Representing another roadway system or subsystem, this terminator provides a source and destination for information that may be exchanged between peer roadway subsystems. The interface to this terminator enables direct coordination between field equipment. Examples include the direct interface between sensors and other roadway devices (e.g., Dynamic Message Signs) and the direct interface between roadway devices (e.g., adjacent traffic control equipment).

Other TM
Representing another Traffic Management center, system or subsystem, this terminator is intended to provide a source and destination for ITS data flows between peer (e.g. inter-regional) traffic management functions. It enables traffic management activities to be coordinated across different jurisdictional areas. In the Physical Architecture this terminator is a reciprocal Traffic Management Subsystem (TMS).

Other TRM
Representing another Transit Management center, system or subsystem, this terminator is intended to provide a source and destination for ITS data flows between peer (e.g. inter-regional) transit management functions. It enables traffic management activities to be coordinated across geographic boundaries or different jurisdictional areas. In the Physical Architecture this terminator represents a reciprocal Transit Management Subsystem (TRMS).

Toll Administrator
The Toll Administrator is the human entity that manages the back office payment administration systems for a electronic toll system. This terminator monitors the systems that support the electronic transfer of authenticated funds from the customer to the system operator. The terminator monitors customer enrollment and supports the establishment of escrow accounts depending on the clearinghouse scheme and the type of payments involved. The terminator also establishes and administers the pricing structures and policies.

Traffic
The Traffic terminator represents the collective body of vehicles that travel on surface streets, arterials, highways, expressways, tollways, freeways, or any other vehicle travel surface. Traffic depicts the vehicle population from which traffic flow surveillance information is collected (average occupancy, average speed, total volume, average delay, etc.), and to which traffic control indicators are applied (intersection signals, stop signs, ramp meters, lane control barriers, variable speed limit indicators, etc.). All sensory and control elements that interface to this vehicle population are internal to ITS.

Traffic Operations Personnel

This terminator represents the human entity that directly interfaces with vehicle traffic operations. These personnel interact with traffic control systems, traffic surveillance systems, incident management systems, work zone management systems, and travel demand management systems to accomplish ITS services. They provide operator data and command inputs to direct systems' operations to varying degrees depending on the type of system and the deployment scenario. All functionality associated with these services that might be automated in the course of ITS deployment is modeled as internal to the architecture.

Transit Fleet Manager
This terminator represents the human entity that is responsible for planning the operation of transit fleets, including monitoring and controlling the transit fleet route schedules and the transit fleet maintenance schedules. This comprises planning routes and schedules for either daily use or for special occasions as distinct from making day to day variations to schedules and routes.

Transit System Operators
This terminator represents the human entities that are responsible for all aspects of the Transit subsystem operation including planning and management. They actively monitor, control, and modify the transit fleet routes and schedules on a day to day basis. The modifications will be to take account of abnormal situations such as vehicle breakdown, vehicle delay, etc. These personnel may also be responsible for demand responsive transit operation and for managing emergency situations within the transit network.

Weather Service
This terminator provides weather, hydrologic, and climate information and warnings of hazardous weather including thunderstorms, flooding, hurricanes, tornadoes, winter weather, tsunamis, and climate events. It provides atmospheric weather observations and forecasts that are collected and derived by the National Weather Service, private sector providers, and various research organizations. The interface provides formatted weather data products suitable for on-line processing and integration with other ITS data products as well as Doppler radar images, satellite images, severe storm warnings, and other products that are formatted for presentation to various ITS users.

The table below maps the terminators shown above to their respective architecture elements.

Table 3: Terminator Mapped to Element

Architecture Entity	Terminator Name	Element Name	Element Status
Terminators	Archived Data User Systems	INCOG	Planned
	Basic Transit Vehicle	Tulsa Public School Buses, Tulsa Transit Buses	Existing
	Emergency Personnel	Oklahoma Highway Patrol Center Personnel	Existing
		Tulsa 911 Center Personnel	Existing
	ISP Operator	ODOT District 8 FMC_Personnel	Planned
	Other Archives	INCOG	Planned
	Other EM	Local 911 Center	Planned
		Tulsa 911 Center	Planned
		Tulsa Emergency Management Center	Planned
	Other Parking	Tulsa International Airport	Planned
	Other Roadway	City of Tulsa Operations Center_Roadside Equipment	Existing
		Tulsa 911 Center Roadside Equipment	Existing
	Other TM	City of Tulsa Traffic Operations Center	Existing
		Local TOC	Planned
	Other TRM	Broken Arrow Transit Center	Existing
		Tulsa Transit Center	Existing
	Toll Administrator	Oklahoma Turnpike_Personnel	Existing
	Traffic	Local TOC	Planned
	Traffic Operations Personnel	City of Tulsa Traffic Operations Center_Personnel	Existing
		ODOT District 8 FMC_Personnel	Planned
	Transit Fleet Manager	Tulsa Transit Center_Personnel	Existing
	Transit System Operators	Tulsa Transit Center_Personnel	Existing
	Weather Service	Weather Service	Existing

3.2.2 ***Market Packages***

Market Packages provide an accessible, deployment oriented perspective to the national architecture. They provide the framework that links the subsystems and terminators to ensure a seamless transportation network. Market Packages identify the pieces of the Physical Architecture that are required to implement a particular transportation service. The following table lists the Market Packages that were selected for the Tulsa Region.

Table 4: Selected Market Packages

Market Package Name	Description
AD1: ITS Data Mart	This market package provides a focused archive that houses data collected and owned by a single agency, district, private sector provider, research institution, or other organization. This focused archive typically includes data covering a single transportation mode and one jurisdiction that is collected from an operational data store and archived for future use. It provides the basic data quality, data privacy, and meta data management common to all ITS archives and provides general query and report access to archive data users.
AD3: ITS Virtual Data Warehouse	This market package provides the same broad access to multimodal, multidimensional data from varied data sources as in the ITS Data Warehouse Market Package, but provides this access using enhanced interoperability between physically distributed ITS archives that are each locally managed. Requests for data that are satisfied by access to a single repository in the ITS Data Warehouse Market Package are parsed by the local archive and dynamically translated to requests to remote archives which relay the data necessary to satisfy the request.
APTS1: Transit Vehicle Tracking	This market package monitors current transit vehicle location using an Automated Vehicle Location System. The location data may be used to determine real time schedule adherence and update the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the Transit Management Subsystem is used for relaying vehicle position and control measures. Fixed route transit systems may also employ beacons along the route to enable position determination and facilitate communications with each vehicle at fixed intervals. The Transit Management Subsystem processes this information, updates the transit schedule and makes real-time schedule information available to the Information Service Provider.

Market Package Name	Description
APTS2: Transit Fixed-Route Operations	This market package performs vehicle routing and scheduling, as well as automatic driver assignment and system monitoring for fixed-route transit services. This service determines current schedule performance using AVL data and provides information displays at the Transit Management Subsystem, . Static and real time transit data is exchanged with Information Service Providers where it is integrated with that from other transportation modes (e.g. rail, ferry, air) to provide the public with integrated and personalized dynamic schedules.
APTS4: Transit Passenger and Fare Management	This market package manages passenger loading and fare payments on-board vehicles using electronic means. It allows transit users to use a traveler card or other electronic payment device. Sensors mounted on the vehicle permit the driver and central operations to determine vehicle loads, and readers located either in the infrastructure or on-board the transit vehicle allow electronic fare payment. Data is processed, stored, and displayed on the transit vehicle and communicated as needed to the Transit Management Subsystem.
APTS7: Multi-modal Coordination	This market package establishes two way communications between multiple transit and traffic agencies to improve service coordination. Multimodal coordination between transit agencies can increase traveler convenience at transfer points and also improve operating efficiency. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network. More limited local coordination between the transit vehicle and the individual intersection for signal priority is also supported by this package.
APTS8: Transit Traveler Information	This market package provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services include transit stop annunciation, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this market package.
ATIS1: Broadcast Traveler Information	This market package collects traffic conditions, advisories, general public transportation, toll and parking information, incident information, air quality and weather information, and broadly disseminates this information through existing infrastructures and low cost user equipment (e.g., FM subcarrier, cellular data broadcast). The information may be provided directly to travelers or provided to merchants and other traveler service providers so that they can better inform their customers of travel conditions. Different from the market package ATMS6 - Traffic Information Dissemination, which provides localized HAR and DMS information capabilities, ATIS1 provides a wide area digital broadcast service. Successful deployment of this market package relies on availability of real-time traveler information from roadway instrumentation, probe vehicles or other sources.

Market Package Name	Description
ATMS01: Network Surveillance	This market package includes traffic detectors, other surveillance equipment, the supporting field equipment, and wireline communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.
ATMS02: Probe Surveillance	This market package provides an alternative approach for surveillance of the roadway network. Two general implementation paths are supported by this market package: 1) wide-area wireless communications between the vehicle and Information Service Provider is used to communicate current vehicle location and status, and 2) dedicated short range communications between the vehicle and roadside is used to provide equivalent information directly to the Traffic Management Subsystem. The market package enables traffic managers to monitor road conditions, identify incidents, analyze and reduce the collected data, and make it available to users and private information providers. It requires one of the communications options identified above, roadside beacons and wireline communications for the short range communications option, data reduction software, and utilizes wireline links between the Traffic Management Subsystem and Information Service Provider Subsystem to share the collected information.
AMTS03: Surface Street Control	This market package provides the central control and monitoring equipment, communication links, and the signal control equipment that support local surface street control and/or arterial traffic management. A range of traffic signal control systems are represented by this market package ranging from static pre-timed control systems to fully traffic responsive systems that dynamically adjust control plans and strategies based on current traffic conditions and priority requests. Additionally, general advisory and traffic control information can be provided to the driver while en route. This market package is generally an intra-jurisdictional package that does not rely on real-time communications between separate control systems to achieve area-wide traffic signal coordination. Systems that achieve coordination across jurisdictions by using a common time base or other strategies that do not require real time coordination would be represented by this package. This market package is consistent with typical urban traffic signal control systems.

Market Package Name	Description
ATMS04: Freeway Control	This market package provides the communications and roadside equipment to support ramp control, lane controls, and interchange control for freeways. Coordination and integration of ramp meters are included as part of this market package. This package is consistent with typical urban traffic freeway control systems. This package incorporates the instrumentation included in the Network Surveillance Market Package to support freeway monitoring and adaptive strategies as an option. This market package also includes the capability to utilize surveillance information for detection of incidents. Typically, the processing would be performed at a traffic management center; however, developments might allow for point detection with roadway equipment. For example, a CCTV might include the capability to detect an incident based upon image changes. Additionally, this market package allows general advisory and traffic control information to be provided to the driver while en route.
ATMS06: Traffic Information Dissemination	This market package allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as dynamic message signs or highway advisory radio. This package provides a tool that can be used to notify drivers of incidents; careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information. This package also covers the equipment and interfaces that provide traffic information from a traffic management center to the media (for instance via a direct tie-in between a traffic management center and radio or television station computer systems), Transit Management, Emergency Management, and Information Service Providers. A link to the Maintenance and Construction Management subsystem allows real time information on road/bridge closures due to maintenance and construction activities to be disseminated.
ATMS07: Regional Traffic Control	This market package provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy. This market package advances the Surface Street Control and Freeway Control Market Packages by adding the communications links and integrated control strategies that enable integrated Interjurisdictional traffic control. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. This package relies principally on roadside instrumentation supported by the Surface Street Control and Freeway Control Market Packages and adds hardware, software, and wireline communications capabilities to implement traffic management strategies that are coordinated between allied traffic management centers. Several levels of coordination are supported from sharing of information through sharing of control between traffic management centers.

Market Package Name	Description
ATMS08: Incident Management System	This market package manages both unexpected incidents and planned events so that the impact to the transportation network and traveler safety is minimized. The market package includes incident detection capabilities through roadside surveillance devices (e.g. CCTV) and through regional coordination with other traffic management, maintenance and construction management and emergency management centers as well as weather service entities and event promoters. Information from these diverse sources are collected and correlated by this market package to detect and verify incidents and implement an appropriate response. This market package supports traffic operations personnel in developing an appropriate response in coordination with emergency management, maintenance and construction management, and other incident response personnel to confirmed incidents. The response may include traffic control strategy modifications or resource coordination between center subsystems. Incident response also includes presentation of information to affected travelers using the Traffic Information Dissemination market package and dissemination of incident information to travelers through the Broadcast Traveler Information or Interactive Traveler Information market packages. The roadside equipment used to detect and verify incidents also allows the operator to monitor incident status as the response unfolds. The coordination with emergency management might be through a CAD system or through other communication with emergency field personnel. The coordination can also extend to tow trucks and other allied response agencies and field service personnel.
ATMS10: Electronic Toll Collection	This market package provides toll operators with the ability to collect tolls electronically and detect and process violations. The fees that are collected may be adjusted to implement demand management strategies. Dedicated short range communication between the roadway equipment and the vehicle is required as well as wireline interfaces between the toll collection equipment and transportation authorities and the financial infrastructure that supports fee collection. Vehicle tags of toll violators are read and electronically posted to vehicle owners. Standards, inter-agency coordination, and financial clearinghouse capabilities enable regional, and ultimately national interoperability for these services. The toll tags and roadside readers that these systems utilize can also be used to collect road use statistics for highway authorities. This data can be collected as a natural by-product of the toll collection process or collected by separate readers that are dedicated to probe data collection.

Market Package Name	Description
CVO10: HAZMAT Management	This market package integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents. HAZMAT tracking is performed by the Fleet and Freight Management Subsystem. The Emergency Management subsystem is notified by the Commercial Vehicle if an incident occurs and coordinates the response. The response is tailored based on information that is provided as part of the original incident notification or derived from supplemental information provided by the Fleet and Freight Management Subsystem. The latter information can be provided prior to the beginning of the trip or gathered following the incident depending on the selected policy and implementation.
EM1: Emergency Response	This market package includes emergency vehicle equipment, equipment used to receive and route emergency calls, and wireless communications that enable safe and rapid deployment of appropriate resources to an emergency. Coordination between Emergency Management Subsystems supports emergency notification and coordinated response between agencies. Existing wide area wireless communications would be utilized between the Emergency Management Subsystem and an Emergency Vehicle to enable an incident command system to be established and supported at the emergency location. Public safety, traffic management, and many other allied agencies may each participate in the coordinated response managed by this package.
MC01: Maintenance and Construction Vehicle Tracking	This market package will track the location of maintenance and construction vehicles and other equipment to ascertain the progress of their activities. These activities can include ensuring the correct roads are being plowed and work activity is being performed at the correct locations.
MC04: Weather Information Processing and Distribution	This market package processes and distributes the environmental information collected from the Road Weather Data Collection market package. This market package uses the environmental data to detect environmental hazards such as icy road conditions, high winds, dense fog, etc. so system operators and decision support systems can make decision on corrective actions to take. The continuing updates of road condition information and current temperatures can be used by system operators to more effectively deploy road maintenance resources, issue general traveler advisories, issue location specific warnings to drivers using the Traffic Information Dissemination market package, and aid operators in scheduling work activity.

3.2.3 *Physical Architecture Layers*

The Physical Architecture is composed of three layers: the Institutional Layer, the Transportation Layer, and the Communications Layer. The Institutional Layer represents the existing and emerging institutional constraints and arrangements that are the context for all ITS deployments. The Transportation Layer shows the relationships among the transportation-related elements. It is composed of subsystems for travelers, vehicles, transportation management centers, and field devices, as well as external system interfaces (terminators) at the boundaries. The Communications Layer shows the different methods of relaying information between subsystems and with terminators.

The Transportation Layer and Communications Layer together provide the technical framework within which interoperable systems may be implemented. The Institutional Layer introduces the policies, funding incentives, working arrangements, and jurisdictional structure that support the technical layers of the architecture. This Institutional Layer provides the basis for understanding who the implementers will be and the roles these implementers could take in implementing architecture-based ITS systems.

The Communications Layer includes all of the communications equipment (e.g., wireline and wireless transmitters and receivers) and the information management and transport capabilities necessary to transfer information among entities in the Transportation Layer. The application data content and the transportation application requirements are generally transparent to the Communications Layer. The Communication Layer's view of ITS is that of many distributed users, some of them mobile, which require communication services.

3.2.3.1 Transportation Layer

The transportation layer is comprised of the information flows within various interconnected subsystems and terminators. These information flows make up the interfaces between the agencies that manage the transportation system.

There are five major components that constitute an advanced transportation management system (ATMS). These components were created based on the foundation provided in the National ITS Architecture. The five components: Regional Traffic Management System (RTMS), Local Traffic Operations System (LTOS), Local Emergency Response System (LERS), Transit Management System (TRMS) and Information Service Provider (ISP) are described in terms of the several subsystems. A diagram is also given for each component displaying the relationships between the participating agencies. The information that is exchanged between these agencies are described as architecture flows. Every architecture flow is defined in the National ITS Architecture CD-ROM Version 4 documentation in Table 2.3-6 Architecture Flow Descriptions.

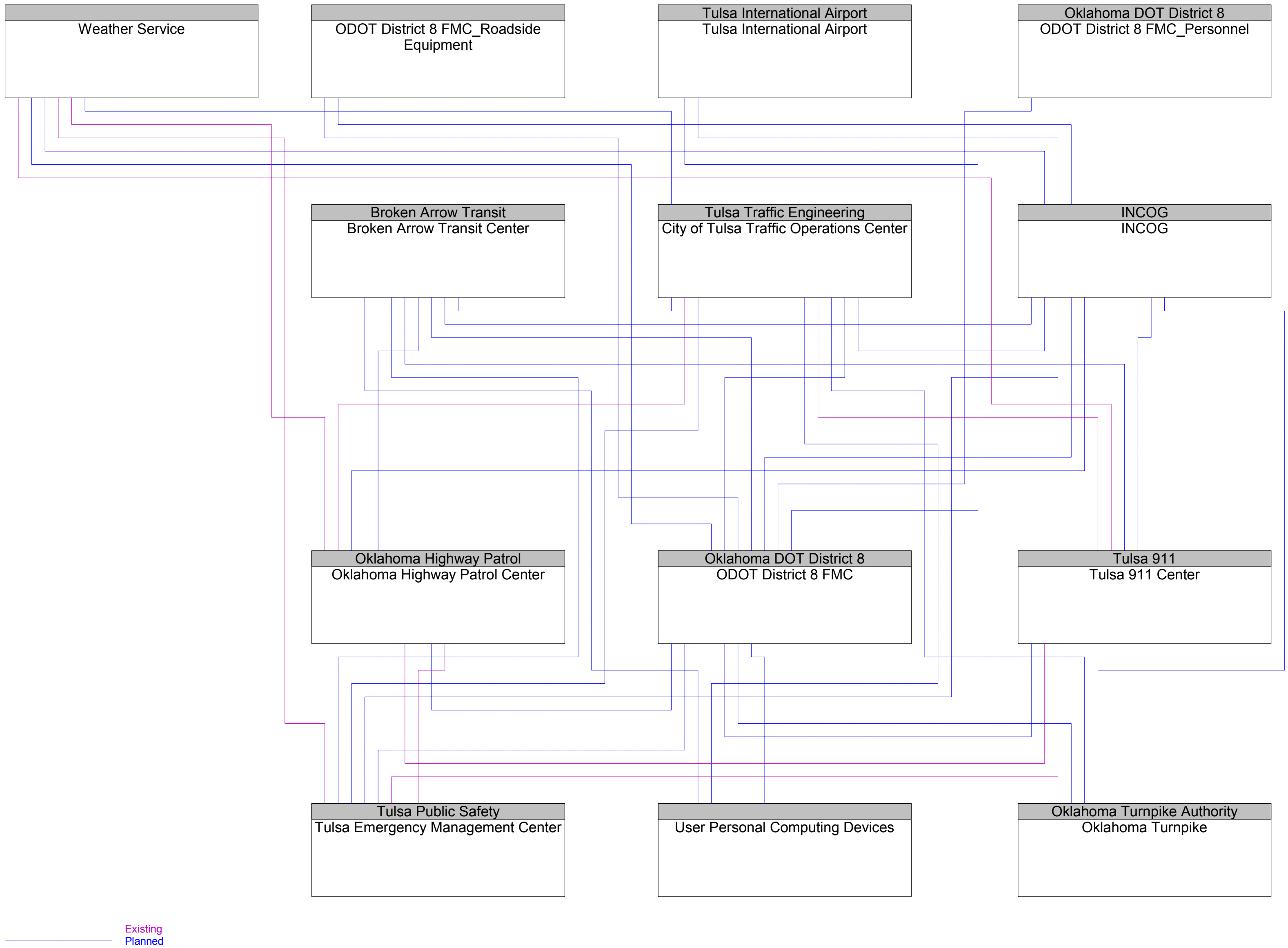
Regional Traffic Management System (RTMS)

The Regional Traffic Management System, which is operated by ODOT District 8, operates within a freeway management center (FMC). The FMC communicates with the Tulsa traffic operations center (TOC) to coordinate traffic information and control strategies in neighboring jurisdictions. The information from incidents that are detected and verified is provided to the Oklahoma Highway Patrol, travelers and to ISP's. The FMC also monitors and manages maintenance work and disseminates maintenance work schedules and road closures. The FMC is the primary source of traffic information that is distributed to the public and the following agencies:

- Tulsa Transit
- Weather Service
- Tulsa International Airport
- Broken Arrow Transit
- Tulsa TOC
- INCOG
- Tulsa 911
- Oklahoma Highway Patrol
- Oklahoma Turnpike Authority
- Tulsa Emergency Management Center

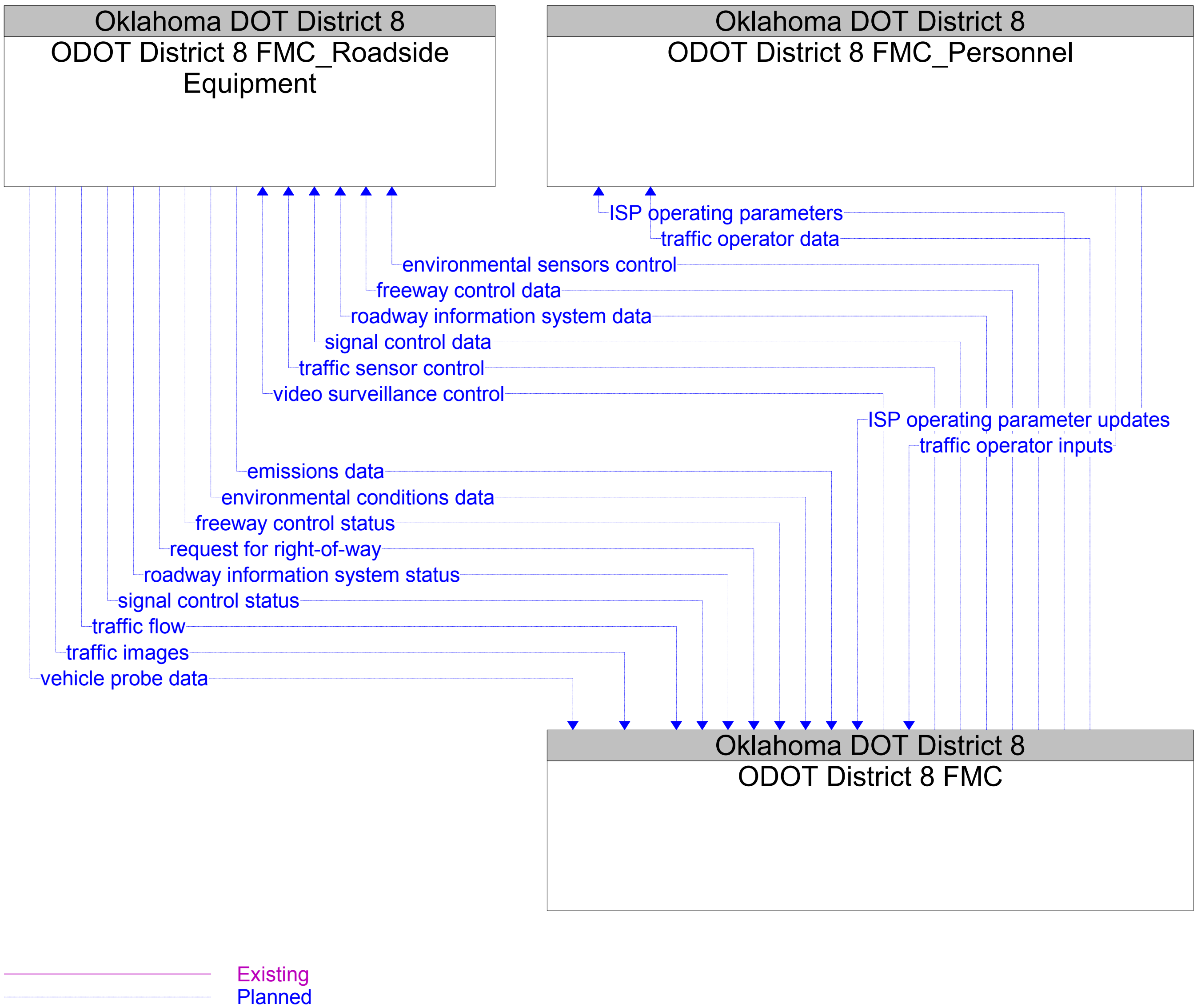
Figure 2 shows the interconnects between the participating agencies.

Figure 2: Oklahoma DOT Interconnect Diagram



Data is also exchanged among the elements that compose the FMC. The figure below identifies the data flows that are internally exchanged at ODOT. A complete listing of the data flows for the Tulsa regional architecture is located in Appendix 2.

Figure 3: Oklahoma DOT Internal Data Flows



Local Traffic Operations System (LTOS)

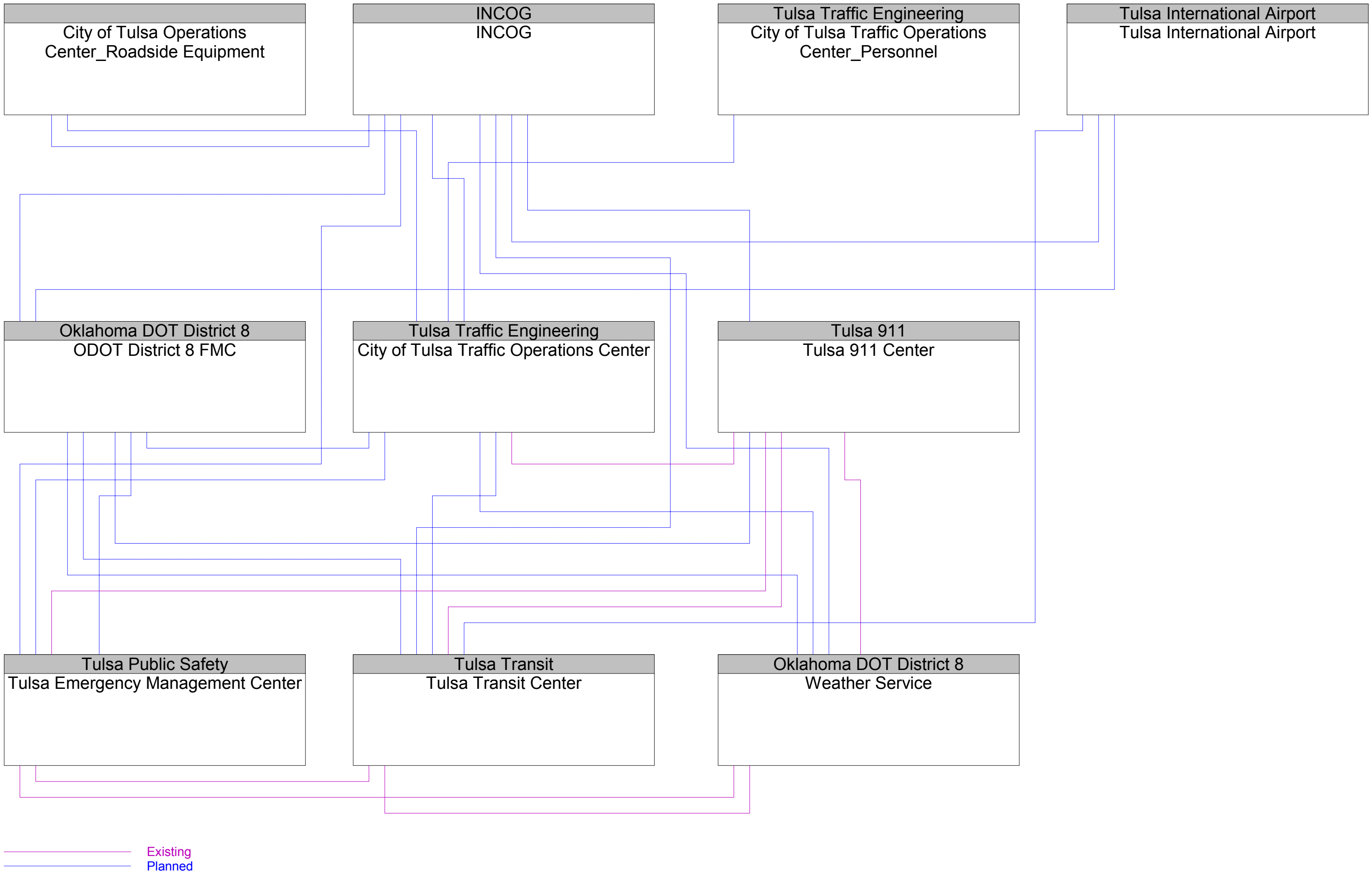
The Local Traffic Operations System, which is operated by Tulsa Traffic Engineering, provides the capabilities to collect, process, and store traffic information on local streets. It also coordinates with the FMC as well as disseminates traveler information to travelers and the public at large. The local traffic operations centers (TOC) will focus on local surface traffic control, traffic data collection on surface streets, parking management and coordination with the FMC and other centers. Information provided may include basic advisories, real time traffic condition and transit schedule information.

The Tulsa TOC will exchange information with the following agencies:

- Tulsa Transit
- ODOT FMC
- INCOG
- Tulsa 911
- Tulsa Emergency Management Agency
- Weather Service

Figure 4 displays the interconnects between the participating agencies.

Figure 4: Tulsa Interconnect Diagram



The Tulsa TOC exchanges data flows among its agencies within the community. The figure below displays the information that is exchanged among participating agencies.

Figure 5: Tulsa Data Flows

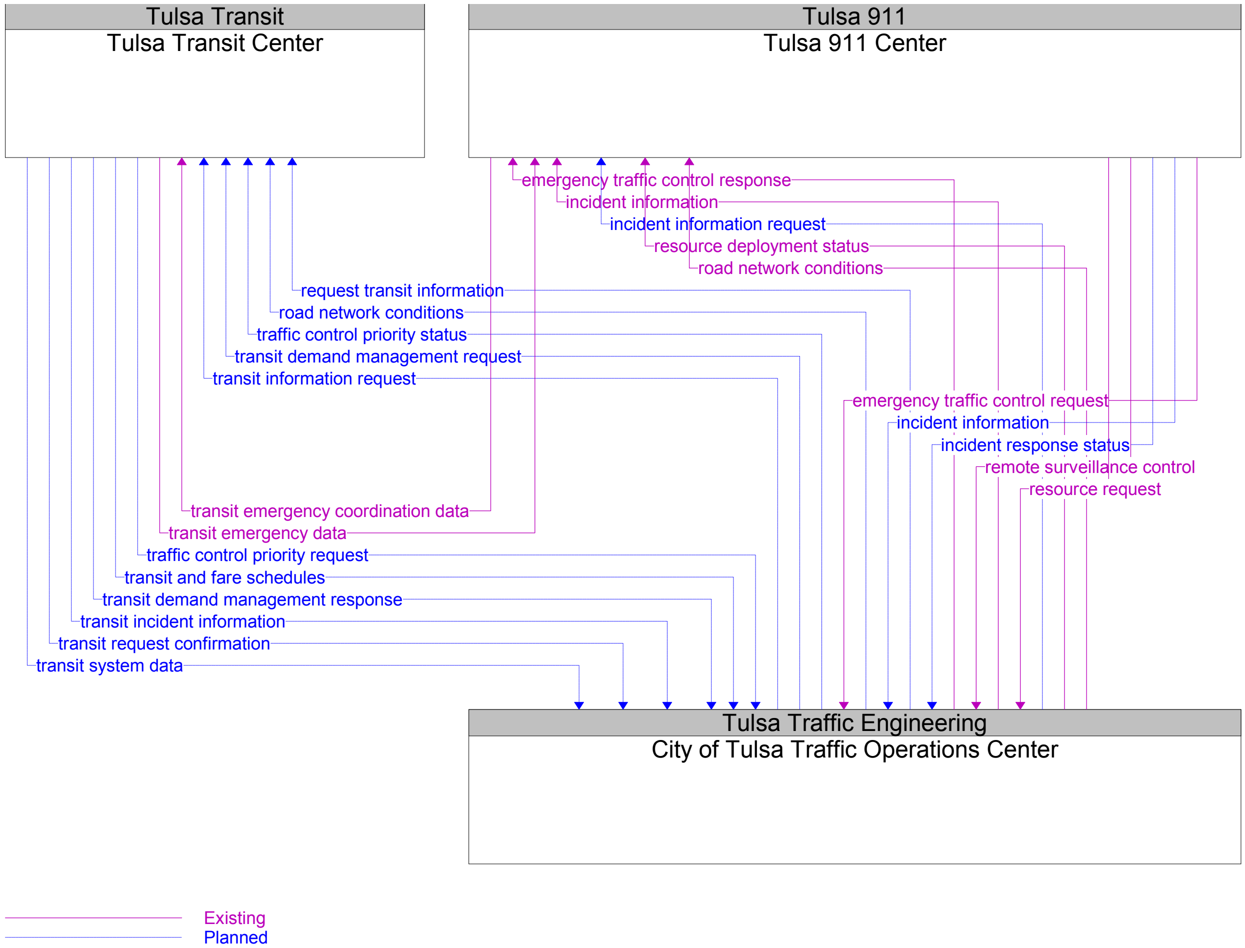
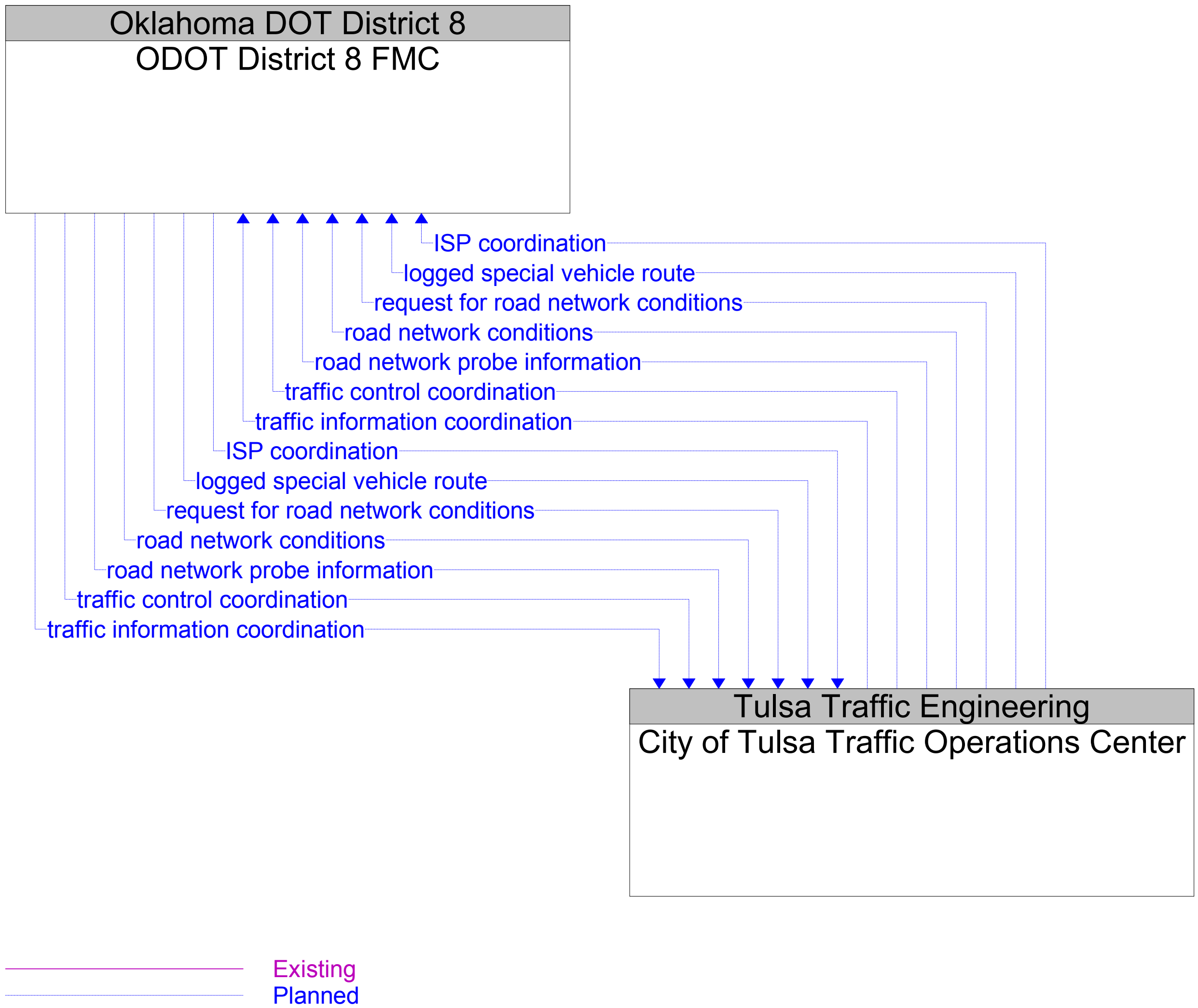


Figure 6: Tulsa and Oklahoma DOT Data Flows

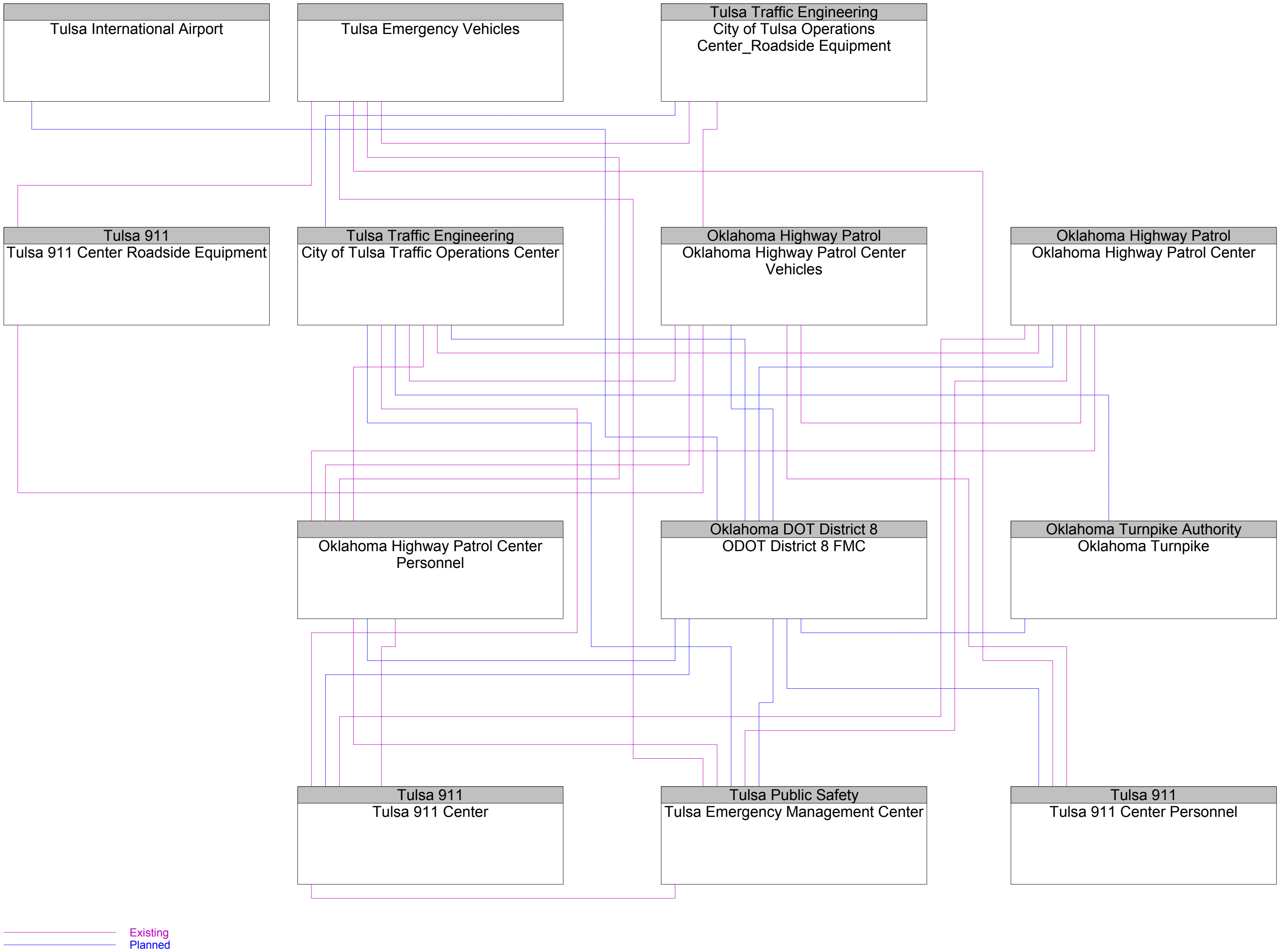


Local Emergency Response System (LERS)

The Local Emergency Response System operates in various local emergency response centers (LERC) supporting public safety including police and fire stations, search and rescue special detachments, and HAZMAT response teams. This system interfaces with other emergency management subsystems to support coordinated emergency response involving multiple agencies. The subsystem creates, stores and utilizes emergency response plans to facilitate coordinated response. It tracks and manages emergency vehicle fleets. Real-time traffic information received from the other center subsystems is used to further aid the emergency dispatcher in selecting the emergency vehicle(s) and routes that will provide the most timely response. Interface with the Traffic Management subsystem (RTMS & LTOS) allows strategic coordination in tailoring traffic control to support en-route emergency vehicles. Interface with the Transit Management subsystem allows coordinated use of transit vehicles to facilitate response to major emergencies. Figure 7 shows the interconnect diagram for participating agencies which includes:

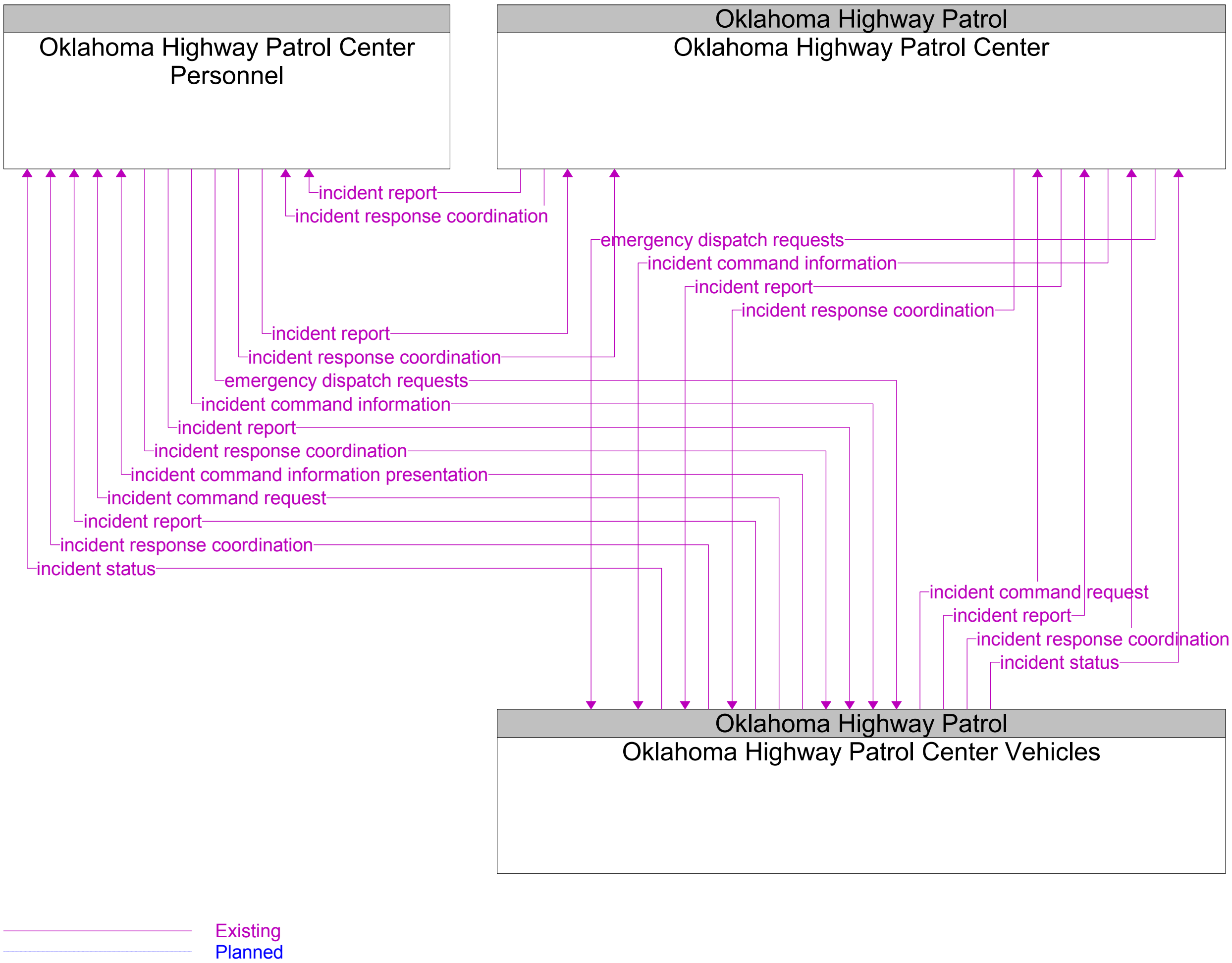
- Tulsa 911
- Tulsa TOC
- Oklahoma Highway Patrol
- Oklahoma Turnpike Authority
- Oklahoma FMC
- Tulsa Emergency Management Center
- Tulsa International Airport

Figure 7: Emergency Management Interconnect Diagram



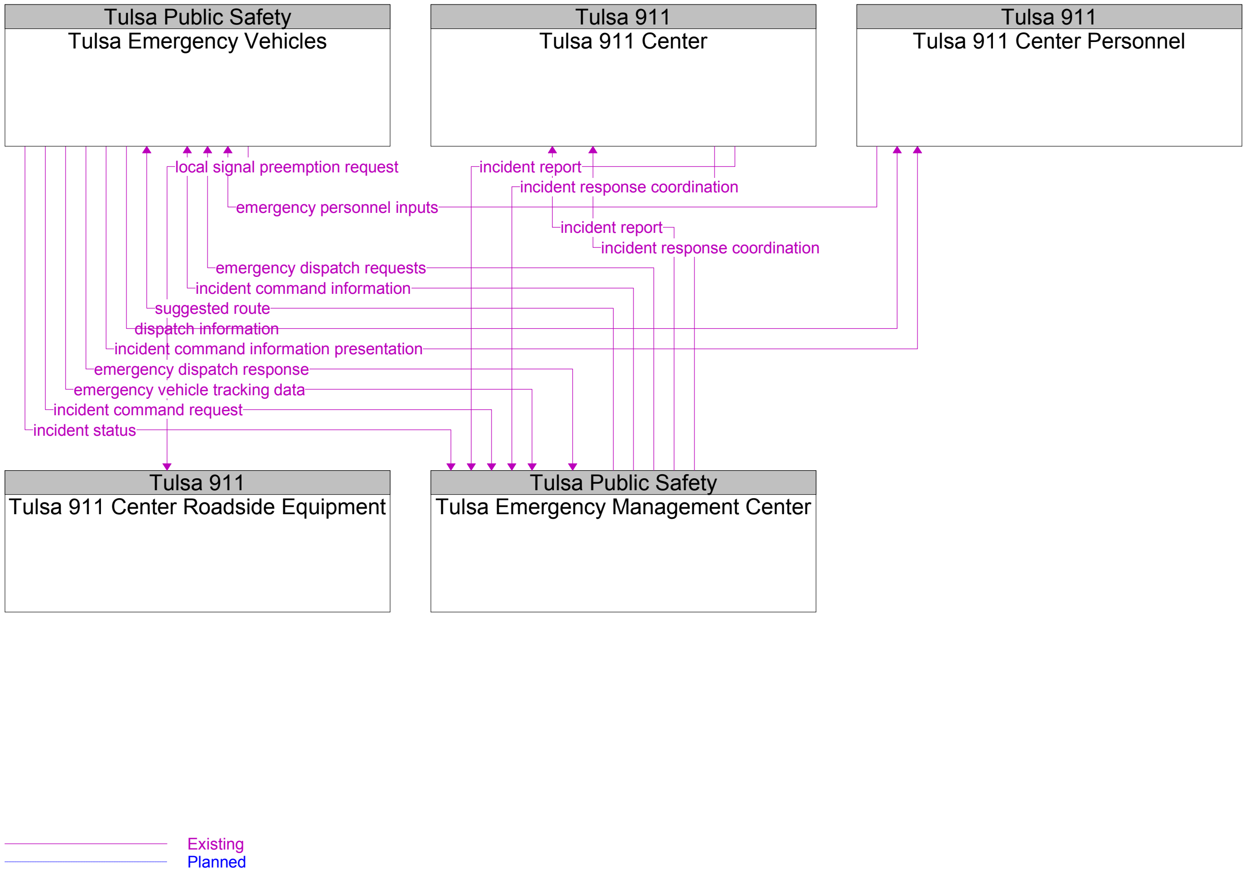
Oklahoma Highway Patrol will also need to exchange data among its own elements. Figure 8 depicts the data that will be exchanged internally.

Figure 8: OHP Data Flows



It is also important to display the data that will be exchanged specifically among the Tulsa public safety agencies.

Figure 9: Tulsa Public Safety Data Flows

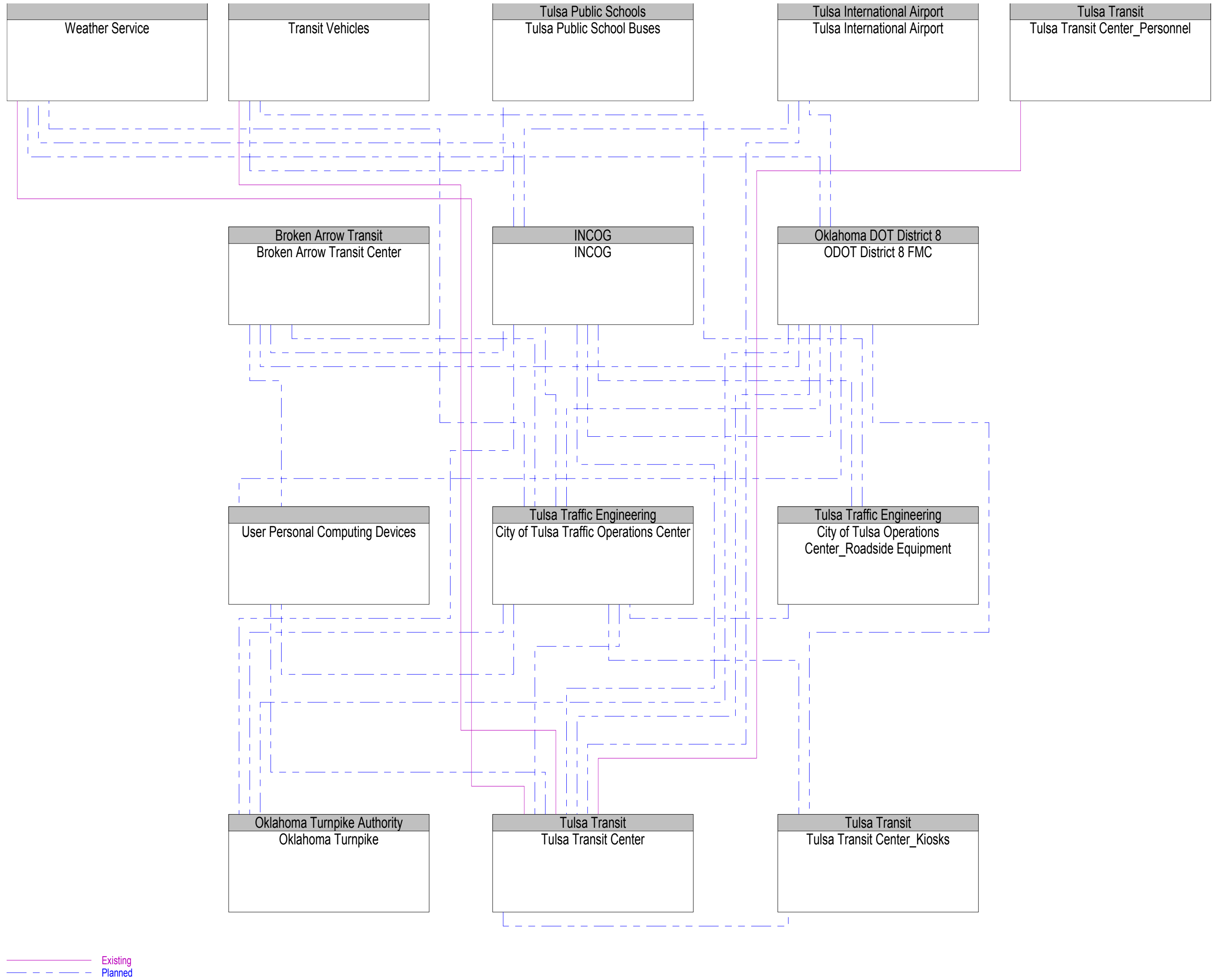


Transit Management System (TRMS)

The transit management subsystem manages transit vehicle fleets and coordinates with other modes and transportation services. It provides operations, maintenance, customer information, planning and management functions for the transit property. It spans distinct central dispatch and garage management systems and supports the spectrum of fixed route, flexible route, paratransit services, and bus rapid transit (BRT) service. The subsystem's interfaces allow for communication between transit departments and with other operating entities such as emergency response services and traffic management systems. This subsystem receives special event and real-time incident data from the traffic management subsystem. It provides current transit operations data to other center subsystems. The Transit Management Subsystem collects and stores accurate ridership levels and implements corresponding fare structures. It collects operational and maintenance data from transit vehicles, manages vehicle service histories, and assigns drivers and maintenance personnel to vehicles and routes. The Transit Management Subsystem also provides the capability for automated planning and scheduling of public transit operations. It furnishes travelers with real-time travel information, continuously updated schedules, schedule adherence information, transfer options, and transit routes and fares. In addition, the monitoring of key transit locations with both video and audio systems is provided with automatic alerting of operators and police of potential incidents including support for traveler activated alarms. The following agencies are included in the TRMS:

- Tulsa Transit
- Weather Service
- Broken Arrow Transit
- INCOG
- Oklahoma FMC
- Tulsa International Airport
- Oklahoma Turnpike Authority

Figure 10: Transit Interconnect Diagram



3.3 Institutional Layer

The institution layer of the physical architecture defines the relationships among agencies participating in ITS and the operational responsibilities of those agencies. A description of the basic role of agencies participating in the Tulsa Regional systems is in the following paragraphs.

3.3.1 *Oklahoma DOT*

The Oklahoma Department of Transportation District 8 is the lead organization responsible for operating and maintaining highway facilities and managing traffic and incidents on the Tulsa metropolitan Interstate Highway System. By managing, operating and maintaining a regional traffic management center in Tulsa, ODOT will be able to do this more efficiently.

ODOT, through the FMCs, will provide transportation information to travelers on the condition of the region's roadways. The type of information that may be provided includes incidents, traffic speeds, and roadway construction. Information could be provided to travelers through private information service providers or via roadside subsystems such as Dynamic Message Signs (DMS) and Highway Advisory Radio (HAR), and traveler information subsystems such as kiosks and an Internet web site.

Via ITS, ODOT District 8 can share transportation information electronically with other jurisdictions and agencies. The automatic exchange of information helps coordinate activities and services better, and thus improves rescue operations, increases safety, and provides travelers an improved, seamless transportation system.

3.3.2 *City/County Public Works Departments*

ODOT will not be responsible for managing the local streets; it will be up to the respective cities or counties to operate and manage the LTOC's and the LERC's. The local Public Works Departments, which may include a Traffic Engineering Department, are responsible for managing traffic and incidents on the surface street network including the principal arterials that are part of the State Highway System. The cities and counties will collect traffic data from their roadway network, process it, and use the information to manage their transportation system. ITS functions such as Traffic Signal Control and Network Surveillance will help local governments control and manage the flow of traffic on the surface street system. The LTOCs will coordinate and communicate with the FMC in order to facilitate regional traffic management.

Local governments will provide transportation information to travelers on the condition of surface streets. The type of information that may be provided includes incidents, traffic speeds, and roadway construction. Information could be provided to travelers via roadside subsystems such as DMS and HAR, and traveler subsystems such as kiosks and an Internet web site.

It is recommended that each city and county Public Works Department share transportation information electronically with other agencies – other local agencies and neighboring jurisdictions. The automatic exchange of information will help agencies coordinate their activities and services better, and thus improve rescue operations and increase safety, and provide travelers an improved, seamless transportation system.

3.3.3 *Emergency Service Responders*

In the Tulsa region, there are many emergency service providers. With ITS implementation, each emergency service would communicate and coordinate electronically with the FMC in detecting, verifying and responding to incidents. The FMC would also communicate and coordinate electronically with transit agencies and freight carriers about such incidents.

3.3.4 *Transportation Planning Agencies*

One of the functions performed by the Metropolitan Planning Organization (MPO) is the continued planning of the transportation system. The MPO in the Tulsa region is the Indian National Council of Governments (INCOG). INCOG can be supported by ITS functions that electronically exchange transportation data with the FMC. Access to both real-time and archived electronic data, and the increased amount of data with which to work, will greatly improve the ability of ODOT and INCOG to plan for the current and future demand of transportation services.

Other participating agencies including ODOT, the cities and counties and the transit agencies have transportation planning functions that will benefit from the data generated by ITS. The implementation of a virtual data warehouse will provide access to useful data for all participating agencies.

3.3.5 *Transit Agencies*

Transit agencies provide route, schedule, fare, and other transit service information to their customers. Information would be provided to travelers via a number of ITS elements, including an Internet website, a semi-automated telephone system, traveler information systems on-board transit vehicles, and information kiosks. Currently Broken Arrow Transit and Tulsa Transit both provide fixed route bus service in the Tulsa metropolitan region.

3.3.6 *Interagency Agreements*

It will be necessary for each operating agency to sign agreements defining the types of information to be shared, system control hierarchy, capital, operating and maintenance costs of facilities shared with ODOT District 8 or other agencies. Protocol for information exchange within each jurisdiction is to be defined and formalized in an inter-agency memorandum of understanding (MOU) or joint project agreement (JPA). The following information should be defined in MOUs:

1. Information and operating requirements pertaining to various ITS elements such as freeway or arterial (signal) control, dispatch information for emergency management, and transit management,
2. Uses of broadcast and interactive traveler/tourism information,
3. Sharing of responsibilities and costs,
4. Sharing of hardware, communications media, and data, and
5. Standardization.

3.4 Communications Layer

3.4.1 *NITSA Communications Guidelines*

As defined in the National ITS Architecture, the communications layer is the information transmission infrastructure that connects elements of the transportation layer and allows coordination and sharing of information among systems and people. The National ITS Architecture has identified four communications types for coordination and sharing information among systems. These include wireline communications, wide-area wireless communications, dedicated short-range communications (DSRC), and vehicle to vehicle communications.

Wireline communications addresses information transfer between two fixed entities. Physically, this communications type includes wireline (e.g. fiber optic or twisted pair copper) as well as point-to-point wireless (e.g. microwave) infrastructure.

Wide area wireless communications addresses information transfer between fixed and mobile entities and includes cellular and radio frequency technologies. It supports wide-area communications between mobile users or between mobile and fixed network-connected users (e.g., those connected to the telephone network). This communications type also includes one-way broadcast wireless voice and data communications systems used to provide basic traveler information across a wide-area.

Dedicated short-range communications (DSRC) is used to communicate short distances (<100 feet) between a vehicle and a roadside device. Examples of DSRC applications are toll tags for electronic toll collection and transponders for commercial vehicles such as used in the PrePass program by the Georgia Department of Safety.

Vehicle to vehicle communications has yet to be deployed in the United States.