Texas Department of Transportation
Regional ITS Architectures and Deployment Plans

Austin Region

Regional ITS Deployment Plan

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LIST OF ACRONYMS

AD	Archived Data
APTS	Advanced Public Transportation Systems
ATIS	Advanced Travel Information System
ATMS	Advanced Traffic Management System
AVL	Automated Vehicle Location
CAD	Computer Aided Dispatch
CAMPO	Capital Area Metropolitan Planning Organization
CARTS	Capital Area Rural Transportation System
CCTV	Closed-Circuit Television
CTECC	Combined Transportation and Emergency Communications Center
CTM	Corridor Traffic Management
CTRMA	Central Texas Regional Mobility Authority
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operations
DMS	Dynamic Message Sign
DPS	Department of Public Safety
EM	Emergency Management
EMS	Emergency Medical Services
EOC	Emergency Operations Center
FC	Fare Collection
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HAR	Highway Advisory Radio
HAZMAT	Hazardous Materials
HCRS	Highway Conditions Reporting System
HERO	Highway Emergency Response Operator
HOV	High Occupancy Vehicle
HRI	Highway Rail Intersection
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation System

LIST OF ACRONYMS

MC	Maintenance and Construction
MDT	Mobile Data Terminal
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PIO	Public Information Office
RCN	Radio Communications Network
SH	State Highway
SL	State Loop
STS	Special Transit Services
TIP	Transportation Improvement Plan
TMC	Traffic Management Center
TOC	Traffic Operations Center
TxDOT	Texas Department of Transportation

1. INTRODUCTION

1.1 Project Overview

The Austin Region has developed a Regional Intelligent Transportation System (ITS) Architecture under the direction of the Texas Department of Transportation (TxDOT) Austin District. ITS architectures provide a framework for implementing ITS projects, encourage interoperability and resource sharing among agencies, identify applicable standards to apply to projects, and allow for cohesive long-range planning among regional stakeholders. A regional ITS architecture focuses on the functionality that ITS could provide in the region as well as how those functions could be operated by agencies in and around the region. A regional ITS architecture also satisfies an important requirement from the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) regarding transportation and funding. An FHWA Final Rule and an FTA Final Policy issued in 2001 requires that regions develop an ITS architecture and show how ITS projects conform to that regional ITS architecture in order to receive federal funding.

An ITS deployment plan, while not required by FHWA and FTA, is a useful tool for regions to identify specific projects that are recommended for deployment in order to implement the architecture. The ITS deployment plan builds on the architecture by outlining specific ITS project recommendations and strategies for the Region and identifying deployment timeframes so that the recommended projects and strategies can be implemented over time.

An ITS deployment plan also links each project to the ITS architecture by identifying the market packages that correspond to each project. If projects are identified that do not correspond to market packages, the ITS architecture can be revised easily while still in draft format. The resulting ITS deployment projects from this effort should be clearly supported by the ITS architecture.

The Austin Regional ITS Architecture and ITS Deployment Plan were both developed with significant input from local, state, and federal officials. A series of six workshops were held to solicit input from stakeholders and ensure that the plans reflected the unique needs of the Region. A number of individual interviews were also conducted with stakeholder agencies throughout the Region. Copies of the draft reports were sent to all stakeholders and the project website allowed stakeholders to submit comments directly to the project team. The Regional ITS Architecture and Deployment Plan developed reflects a snapshot of existing ITS deployment and future ITS plans in the Region. Needs and priorities of the Region will change over time, and, in order to remain effective, this plan should be periodically reviewed and updated.

1.2 Document Overview

The Austin Regional ITS Deployment Plan is organized into four key sections:

Section 1 – Introduction

This section provides an overview of the Austin Regional ITS Deployment Plan and the key features and stakeholders in the Austin Region.

Section 2 – Regional ITS Architecture Market Package Implementation

A summary of the market packages selected and prioritized for the Region is provided in this section. Each market package is described and a listing of projects identified for the Austin Region that support implementation of the services contained in the market package is provided.

Section 3 – Project Recommendations

This section contains project recommendations to address stakeholder needs and goals for ITS implementation in the Region. Each project includes a description of the project, stakeholders including the lead agency responsible for implementation, an opinion of probable cost, whether or not funding has been identified, benefits of the project, and a listing of market packages that are associated with the project. Projects are categorized into service areas and recommended for deployment in the short-, mid-, and long-term timeframes.

Section 4 – Maintaining the Regional ITS Deployment Plan

This section contain a description of the maintenance procedure for the Regional ITS Deployment Plan.

Appendix – Communications Media Evaluation

The appendix has been included to provide some general guidance on communications media to consider when implementing an ITS project.

1.3 Austin Region Overview

1.3.1 Geographic Region

The Austin Region is defined by the boundaries of the 11 county TxDOT Austin District. The 11 counties included in the Region are: Bastrop, Blanco, Burnet, Caldwell, Gillespie, Hays, Lee, Llano, Mason, Travis, and Williamson. The Region encompasses 9,489 square miles in central Texas. The largest city in the Region is Austin, which is situated in the center of Travis County. The Austin Region population is approximately 1.5 million.

The Austin Region is served by several State and Federal highways. The primary roadway facilities include I-35, US 183, US 281, US 290, SH 71 and SL 1 (MoPac).

I-35 is the primary highway in the Region and serves as the main north and south route; I-35 extends from Laredo, Texas on the U.S.-Mexico border to Duluth, Minnesota. Construction and incidents along I-35 can have a severe impact on commercial vehicle traffic and motorists traveling through the Region on this significant cross-country facility. SL 1 is the other north and south freeway in the Region.

US 183, US 290, and SH 71 serve several rapidly growing communities north and east of the City of Austin. Most of the traffic along the roadways is daily commuter traffic and this travel pattern is anticipated to continue growing in coming years.

Several toll facilities are planned or under construction for the Region including US 183A, portions of US 183 and US 290, SH 45, portions of SH 71, and SH 130 (MoKan). When complete, SH 130 will provide an alternate route for trucks to avoid I-35 through the Austin metropolitan area. The other toll facilities will improve access to suburbs of Austin and primarily serve daily commuter traffic.

1.3.2 Stakeholders

Due to the fact that ITS often transcends traditional transportation infrastructure, it is important to involve non-traditional stakeholders in the architecture development and visioning process. Input from these stakeholders, both public and private, is a critical part of defining the interfaces, integration needs, and overall vision for ITS in a region.

The following stakeholder agencies have participated in the Austin Region project workshops or provided input to the stakeholders:

- Austin-Travis County Emergency Medical Services (EMS);
- Burnet County;
- Caldwell County;
- Capital Area Metropolitan Planning Organization (CAMPO);
- Capital Area Rural Transportation System (CARTS);
- Capital Metropolitan Transportation Authority (CapMetro);
- Central Texas Regional Mobility Authority (CTRMA);
- City of Austin;
- City of Cedar Park;
- City of Georgetown;
- City of Marble Falls;
- City of Round Rock;
- City of San Marcos;
- Federal Highway Administration Texas Division;
- Hays County;
- National Oceanic and Atmospheric Administration (NOAA) – National Weather Service (NWS);
- Texas Department of Public Safety (DPS) – District 6B;
- Texas State University Transportation Department;
- Travis County;
- TxDOT Austin District;
- TxDOT Public Transportation Division;
- TxDOT Texas Turnpike Authority Division;
- TxDOT Traffic Operations Division;
- University of Texas Center for Transportation Research;
- Village of Bee Cave; and
- Williamson County.

A more detailed list of stakeholders, including the individuals representing each agency, is provided in the ITS Architecture report.

2. REGIONAL ITS ARCHITECTURE MARKET PACKAGE IMPLEMENTATION

Of the 85 market packages available in Version 5.1 of the National ITS Architecture, 50 were selected and customized for deployment in the Austin Region. One additional market package that is not included in the National ITS Architecture was also developed for the Austin Region to cover radio communications. The market packages outline the functions that stakeholders envision ITS to perform in coming years. The ITS Deployment Plan builds on those market packages through the development of project concepts to implement in the Region.

2.1 Market Package Prioritization

Stakeholders were asked to prioritize the market packages into high, medium, and low priorities based on regional needs, feasibility, likelihood of deployment, and overall contribution of the market package to the goals and vision for ITS functionality in the Region. A summary of these prioritized market packages is shown in **Table 1**. More detail on the ITS market packages is provided in the ITS Architecture report.

Table 1 – Austin Market Package Prioritization by Functional Area

High Priority Market Packages	Medium Priority Market Packages	Low Priority Market Packages
Travel and Traffic Management		
ATMS01 Network Surveillance ATMS03 Surface Street Control ATMS04 Freeway Control ATMS06 Traffic Information Dissemination ATMS07 Regional Traffic Control ATMS08 Traffic Incident Management System ATMS10 Electronic Toll Collection ATMS15 Railroad Operations Coordination ATMS16 Parking Facility Management	ATMS02 Probe Surveillance ATMS13 Standard Railroad Grade Crossing ATMS18 Reversible Lane Management ATMS19 Speed Monitoring ATMS21 Roadway Closure Management	ATMS05 HOV Lane Management ATMS11 Emissions Monitoring and Management
Emergency Management		
EM01 Emergency Call Taking and Dispatch EM02 Emergency Routing EM04 Roadway Service Patrols EM06 Wide-Area Alert	EM03 Mayday Support EM08 Disaster Response and Recovery EM09 Evacuation and Reentry Management EM10 Disaster Traveler Information	EM05 Transportation Infrastructure Protection EM07 Early Warning System

Table 1 – Austin Market Package Prioritization by Functional Area (continued)

High Priority Market Packages	Medium Priority Market Packages	Low Priority Market Packages
Maintenance and Construction Management		
MC03 Road Weather Data Collection MC04 Weather Information Processing and Distribution MC08 Work Zone Management MC10 Maintenance and Construction Activity Coordination	MC07 Roadway Maintenance and Construction	MC01 Maintenance and Construction Vehicle and Equipment Tracking MC02 Maintenance and Construction Vehicle Maintenance MC09 Work Zone Safety Monitoring
Public Transportation Management		
APTS1 Transit Vehicle Tracking APTS2 Transit Fixed Route Operations APTS3 Demand Response Transit Operations APTS4 Transit Passenger and Fare Management APTS5 Transit Security APTS7 Multi-modal Coordination	APTS6 Transit Vehicle Maintenance APTS8 Transit Traveler Information	
Commercial Vehicle Operations		
	CVO10 HAZMAT Management	CVO04 CV Administrative Processes
Traveler Information		
ATIS1 Broadcast Traveler Information ATIS2 Interactive Traveler Information		ATIS5 ISP Based Route Coordination
Archived Data Management		
	AD1 ITS Data Mart AD2 ITS Data Warehouse AD3 Virtual ITS Data Warehouse	
User Defined Market Package		
RCN01 Radio Communications Network		

The market package prioritization was a primary factor in developing recommendations for ITS deployment and integration in the Austin Region. These priorities identified the key ITS services that are desired by stakeholders in the Austin Region, as well as the interfaces that need to be established to provide integrated functionality and establish communication between elements. It is important to note that the high, medium, and low prioritization does not necessarily correspond to any specific time frame (such as five, ten, or twenty year deployment horizon). For example, a market package can be a high priority, but because of funding or prerequisite project requirements, it might not be feasible for deployment for several years. Maturity and availability of technology were also considered in prioritizing the market packages. Another consideration included whether or not the market package was better suited for private deployment and operations or public sector deployment.

2.2 Market Packages and Supporting Projects

In order to implement the ITS market package services in the Austin Region, each market package was reviewed to determine what projects should be deployed in order to provide the desired services of that market package. Stakeholders provided a great deal of feedback on these projects at the ITS Deployment Plan Workshop. When identifying projects in the ITS Deployment Plan, stakeholders generally focused on shorter term projects that were more likely to be funded as opposed to projects that extended to the twenty-year timeframe.

Not every market package has an associated ITS project. Several market packages were identified as being important to the Region; however, at this time there are no projects that stakeholders noted were feasible enough to document in the ITS Deployment Plan. In the future, it is likely that additional projects will be added to the ITS Deployment Plan to implement these market packages.

The market packages in the following subsections are organized by service areas in the order they appear in the National ITS Architecture. The service areas that contain market packages selected by stakeholders were the traffic management, emergency management, maintenance and construction management, public transportation management, commercial vehicle operations, traveler information, and archived data management service areas. Each market package includes:

- A brief definition of the market package (which have been modified from the National ITS Architecture definitions);
- Stakeholder priority for the market package (high, medium, or low); and
- Recommended projects that will address some or all of the services that are contained in the market package.

Additional detail regarding each project is provided in Section 3 of this document.

2.2.1 Traffic Management Service Area

The following market packages and related projects, shown in **Table 2**, implement the traffic management service area functions. These traffic management service areas represent some of the most commonly deployed projects, such as closed-circuit television (CCTV) cameras, dynamic message signs (DMS), traffic operations centers (TOCs), and traffic signal systems. It is expected that many of the market packages in this area will be deployed prior to market packages in other areas.

Table 2 – Traffic Management Market Packages and Projects

Network Surveillance (ATMS01)	**High Priority**
Includes traffic detectors, CCTV cameras, other surveillance equipment, supporting field equipment, and fixed point to fixed point communications to transmit the collected data back to a traffic management center (TMC).	
Recommended Projects ▪ City of Austin CCTV Camera Deployment ▪ City of Austin Closed Loop Signal System Upgrades and Expansion ▪ City of Cedar Park Signal System Upgrades ▪ City of Cedar Park Traffic Operations Center ▪ City of Georgetown CCTV Camera Deployment ▪ City of Georgetown ITS Deployments on Southwest Bypass and Inner Loop ▪ City of Georgetown Signal System Upgrades ▪ City of Georgetown Traffic Operations Center ▪ City of San Marcos CCTV Camera Deployment ▪ Hays County Flood Detection System ▪ Travis County Vehicle Detection ▪ TxDOT CTM Maintenance and Upgrades ▪ TxDOT Texas Turnpike Authority Division Toll Enforcement ▪ TxDOT I-35 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 130 (MoKan) CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 45 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 71 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SL 1 (MoPac) CTM Deployment (Phases 1 and 2) ▪ TxDOT US 183 CTM Deployment (Phases 1 and 2) ▪ TxDOT US 290 CTM Deployment (Phases 1 and 2) ▪ TxDOT/CTRMA US 183A CTM Deployments ▪ Village of Bee Cave Speed Detection	

Probe Surveillance (ATMS02)	**Medium Priority**
Provides an alternative approach for surveillance of the roadway network. Probe vehicles are tracked and position and speed information utilized to determine road network conditions such as average speed and congestion conditions.	
Recommended Projects No projects have been identified at this time. Probe surveillance was identified as a potential market package for the Austin Region to consider once toll tags are more common. Probe surveillance could be used on both toll and non-toll roads throughout the Region. Stakeholders will consider implementing probe surveillance projects in the future but did not wish to identify specific projects at this time.	

Table 2 – Traffic Management Market Packages and Projects (continued)

Surface Street Control (ATMS03)	**High Priority**
Provides the central control, monitoring equipment, communication links, and signal control equipment that support local street and/or arterial traffic management. This market package is consistent with typical urban traffic signal control systems.	
Recommended Projects ▪ City of Austin CCTV Camera Deployment ▪ City of Austin Closed Loop Signal System Upgrades and Expansion ▪ City of Cedar Park Emergency Vehicle Signal Preemption ▪ City of Cedar Park Signal System Upgrades ▪ City of Cedar Park Traffic Operations Center ▪ City of Georgetown Emergency Vehicle Signal Preemption ▪ City of Georgetown Signal System Upgrades ▪ City of Georgetown Traffic Operations Center ▪ City of Round Rock Signal System Railroad Coordination ▪ Local Emergency Management Emergency Vehicle Signal Preemption	

Freeway Control (ATMS04)	**High Priority**
Provides the communications and roadside equipment to support ramp control, lane controls, and interchange control for freeways. This market package is consistent with typical urban traffic freeway control systems. Also includes the capability to utilize surveillance information for detection of incidents.	
Recommended Projects ▪ TxDOT CTM Maintenance and Upgrades ▪ TxDOT Ramp Meters ▪ TxDOT I-35 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 130 (MoKan) CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 45 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 71 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SL 1 (MoPac) CTM Deployment (Phases 1 and 2) ▪ TxDOT US 183 CTM Deployment (Phases 1 and 2) ▪ TxDOT US 290 CTM Deployment (Phases 1 and 2) ▪ TxDOT/CTRMA US 183A CTM Deployments	

Table 2 – Traffic Management Market Packages and Projects (continued)

HOV Lane Management (ATMS05)	**Low Priority**
Manages high occupancy vehicle (HOV) lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals.	
Recommended Projects No projects have been identified at this time. Stakeholders identified the HOV Lane Management market package as a future market package to consider for implementation if HOV lanes are added in the Austin Region. Stakeholders did not wish to identify any projects for HOV Lane Management at this time until HOV lanes are more of a reality.	

Traffic Information Dissemination (ATMS06)	**High Priority**
Provides information to drivers using roadway equipment such as DMS or highway advisory radio (HAR). Information can include traffic and road conditions, closure and detour information, incident information, emergency alerts and driver advisories.	
Recommended Projects ▪ City of Austin DMS Deployment ▪ City of Austin HAR Deployment ▪ City of Austin Web-based Information Sharing ▪ City of Cedar Park Traffic Operations Center ▪ City of Georgetown ITS Deployments on Southwest Bypass and Inner Loop ▪ City of Georgetown Portable DMS ▪ City of Georgetown Traffic Operations Center ▪ City of Round Rock Dell Diamond Traffic Management ▪ TxDOT CTM Maintenance and Upgrades ▪ TxDOT Highway Advisory Radio Expansion ▪ TxDOT Portable DMS ▪ TxDOT Portable DMS Upgrades for Remote Communications ▪ TxDOT Travel Time Information ▪ TxDOT I-35 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 130 (MoKan) CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 45 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 71 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SL 1 (MoPac) CTM Deployment (Phases 1 and 2) ▪ TxDOT US 183 CTM Deployment (Phases 1 and 2) ▪ TxDOT US 290 CTM Deployment (Phases 1 and 2) ▪ TxDOT/CTRMA US 183A CTM Deployments ▪ Williamson County Advance Railroad Notification	

Table 2 – Traffic Management Market Packages and Projects (continued)

Regional Traffic Control (ATMS07)	**High Priority**
Facilitates the sharing of traffic information and control among TMCs to support a regional control strategy. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions.	
Recommended Projects ▪ City of Austin Information Sharing Expansion ▪ City of Cedar Park Communications Connection ▪ City of Cedar Park Traffic Operations Center ▪ City of Georgetown Communications Connection ▪ City of Georgetown Traffic Operations Center ▪ City of Round Rock Communications Connection ▪ City of San Marcos Communications Connection ▪ TxDOT Center-to-Center Communications	

Table 2 – Traffic Management Market Packages and Projects (continued)

Traffic Incident Management System (ATMS08)	**High Priority**
Manages both unexpected incidents and planned events so that the impact to the transportation network and traveler safety is minimized. This market package includes incident detection capabilities and coordination with other agencies. It supports traffic operations personnel in developing an appropriate response in coordination with emergency management, maintenance and construction management, and other incident response personnel.	
Recommended Projects ▪ City of Austin CCTV Camera Deployment ▪ City of Austin DMS Deployment ▪ City of Austin HAR Deployment ▪ City of Austin Information Sharing Expansion ▪ City of Cedar Park CAD Integration with TxDOT ATMS Software ▪ City of Cedar Park Communications Connection ▪ City of Cedar Park Traffic Operations Center ▪ City of Georgetown CAD Integration with TxDOT ATMS Software ▪ City of Georgetown CCTV Camera Deployment ▪ City of Georgetown Communications Connection ▪ City of Georgetown ITS Deployments on Southwest Bypass and Inner Loop ▪ City of Georgetown Portable DMS ▪ City of Georgetown Traffic Operations Center ▪ City of Round Rock CAD Integration with TxDOT ATMS Software ▪ City of Round Rock Communications Connection ▪ City of Round Rock Dell Diamond Traffic Management ▪ City of San Marcos CCTV Camera Deployment ▪ City of San Marcos Communications Connection ▪ DPS Local Districts Communications Connection ▪ Hays County CAD Integration with TxDOT ATMS Software ▪ Local Emergency Management CAD Integration with TxDOT ATMS Software ▪ TxDOT Center-to-Center Communications ▪ TxDOT CTM Maintenance and Upgrades ▪ TxDOT Highway Advisory Radio Expansion ▪ TxDOT National Weather Service Connection ▪ TxDOT Real-Time HCRS (Statewide) ▪ TxDOT I-35 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 130 (MoKan) CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 45 CTM Deployment (Phases 1, 2, and 3)	

Table 2 – Traffic Management Market Packages and Projects (continued)

Traffic Incident Management System (ATMS08) (continued)	High Priority
▪ TxDOT SH 71 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SL 1 (MoPac) CTM Deployment (Phases 1 and 2) ▪ TxDOT US 183 CTM Deployment (Phases 1 and 2) ▪ TxDOT US 290 CTM Deployment (Phases 1 and 2) ▪ TxDOT/CTRMA US 183A CTM Deployments ▪ Williamson County CAD Integration with TxDOT ATMS Software ▪ Williamson County Communications Connection	

Electronic Toll Collection (ATMS10)	High Priority
Provides toll operators with the ability to collect tolls electronically and detect and process violations.	
Recommended Projects ▪ TxDOT Texas Turnpike Authority Division Toll Enforcement	

Emissions Monitoring and Management (ATMS11)	Low Priority
Monitors individual vehicle emissions and provides general air quality monitoring using distributed sensors to collect the data.	
Recommended Projects No projects have been identified at this time. Stakeholders felt that emissions monitoring and management in the Region was adequate and did not wish to identify additional projects for implementation at this time.	

Standard Railroad Grade Crossing (ATMS13)	Medium Priority
Manages highway traffic at highway-rail intersections (HRIs) where rail speeds are less than 80 mph.	
Recommended Projects ▪ City of Round Rock Advance Railroad Notification ▪ City of Round Rock Signal System Railroad Coordination ▪ City of San Marcos Advance Railroad Notification ▪ Williamson County Advance Railroad Notification	

Table 2 – Traffic Management Market Packages and Projects (continued)

Railroad Operations Coordination (ATMS15)	**High Priority**
Provides an additional level of strategic coordination between freight rail operations and traffic management centers. Could include train schedules, maintenance schedules or any other anticipated HRI closures.	
Recommended Projects No projects have been identified at this time. Implementation of the Railroad Operations Coordination market package will focus primarily on information sharing between railroads and traffic management agencies. The need for improved communication between railroads and traffic management agencies was seen largely as an institutional issue and not one that stakeholders felt the need to identify projects to address.	

Parking Facility Management (ATMS16)	**High Priority**
Provides enhanced monitoring and management of parking facilities. Market package assists in the management of parking operations, coordinates with transportation authorities, and supports electronic collection of parking fees.	
Recommended Projects ▪ CapMetro Regional Smart Card	

Reversible Lane Management (ATMS18)	**Medium Priority**
Provides for the management of reversible lane facilities and includes the field equipment, physical lane access controls, and associated control electronics.	
Recommended Projects No projects have been identified at this time. Reversible lanes are under consideration by TxDOT and the City of Austin. TxDOT has existing lane control signals on many routes that could be used. Until plans for reversible lanes are more definite, stakeholders did not want to identify specific projects for implementation.	

Speed Monitoring (ATMS19)	**Medium Priority**
Monitors the speed of vehicles traveling through a roadway system. If the speed is determined to be excessive, roadside equipment can suggest a safe driving speed. Environmental conditions may be monitored and factored into the safe speed advisories that are provided to the motorist. This service can also support notifications to an enforcement agency to enforce the speed limit on a roadway system.	
Recommended Projects ▪ Village of Bee Cave Speed Detection	

Table 2 – Traffic Management Market Packages and Projects (continued)

Roadway Closure Management (ATMS21)	**Medium Priority**
Closes roadways to vehicular traffic when driving conditions are unsafe, maintenance must be performed, or during other situations. Market package covers general road closures applications; specific closure systems that are used at railroad grade crossings, drawbridges, reversible lanes, etc. are covered by other market packages.	
Recommended Projects ▪ City of Georgetown Flood Detection and Closure System ▪ City of Round Rock Flood Detection and Closure System ▪ Travis County Flood Detection and Closure System ▪ TxDOT Burnet County Flood Detection System ▪ TxDOT Caldwell County Flood Detection System	

2.2.2 *Emergency Management Service Area*

The following market packages and related projects in **Table 3** implement ITS functions that support emergency management activities. Road weather data collection for low water crossings and flooding, work zone management, and coordination of maintenance and construction activities were identified as priorities for the Region.

Table 3 – Emergency Management Market Packages and Projects

Emergency Call-Taking and Dispatch (EM01)	**High Priority**
Provides basic public safety call-taking and dispatch services. Includes emergency vehicle equipment, equipment used to receive and route emergency calls, wireless communications, and coordination between emergency management agencies.	
Recommended Projects ▪ City of Cedar Park CAD Integration with TxDOT ATMS Software ▪ City of Georgetown CAD Integration with TxDOT ATMS Software ▪ City of Round Rock Advance Railroad Notification ▪ City of Round Rock CAD Integration with TxDOT ATMS Software ▪ City of San Marcos Advance Railroad Notification ▪ DPS Local Districts Communications Connection ▪ Hays County CAD Integration with TxDOT ATMS Software ▪ Local Emergency Management CAD Integration with TxDOT ATMS Software ▪ TxDOT AVL for HERO Vehicles ▪ Williamson County Advance Railroad Notification ▪ Williamson County CAD Integration with TxDOT ATMS Software ▪ Williamson County Communications Connection	

Table 3 – Emergency Management Market Packages and Projects (continued)

Emergency Routing (EM02)	High Priority
Supports automated vehicle location (AVL) and dynamic routing of emergency vehicles. Traffic information, road conditions and suggested routing information are provided to enhance emergency vehicle routing. Includes signal preemption and priority applications.	
Recommended Projects ▪ City of Cedar Park CAD Integration with TxDOT ATMS Software ▪ City of Cedar Park Emergency Vehicle Signal Preemption ▪ City of Georgetown CAD Integration with TxDOT ATMS Software ▪ City of Georgetown Emergency Vehicle Signal Preemption ▪ City of Round Rock Advance Railroad Notification ▪ City of Round Rock CAD Integration with TxDOT ATMS Software ▪ City of San Marcos Advance Railroad Notification ▪ Hays County CAD Integration with TxDOT ATMS Software ▪ Local Emergency Management CAD Integration with TxDOT ATMS Software ▪ Local Emergency Management Emergency Vehicle Signal Preemption ▪ TxDOT AVL for HERO Vehicles ▪ Williamson County Advance Railroad Notification ▪ Williamson County CAD Integration with TxDOT ATMS Software ▪ Williamson County Communications Connection	

Mayday Support (EM03)	Medium Priority
Allows the user to initiate a request for emergency assistance and enables the emergency management subsystem to locate the user, gather information about the incident and determine the appropriate response.	
Recommended Projects No projects have been identified at this time. This market package was seen primarily as a private sector deployment by automobile manufactures and other private sector companies. Coordination with Emergency Management agencies is required but these stakeholders would not be deploying any projects specifically for the Mayday Support market package.	

Roadway Service Patrols (EM04)	High Priority
Supports the roadway service patrol vehicles that aid motorists, offering rapid response to minor incidents (flat tire, accidents, out of gas) to minimize disruption to the traffic stream. This market package monitors service patrol vehicle locations and supports vehicle dispatch.	
Recommended Projects ▪ TxDOT AVL for Hero Vehicles	

Table 3 – Emergency Management Market Packages and Projects (continued)

Transportation Infrastructure Protection (EM05)	**Low Priority**
Includes the monitoring of transportation infrastructure (e.g. bridges, tunnels and management centers) for potential threats using sensors, surveillance equipment, and barriers and safeguard systems to preclude an incident, control access during and after an incident, or to mitigate the impact of an incident. Threats can be acts of nature, terrorist attacks, or other incidents causing damage to the infrastructure.	
Recommended Projects No projects have been identified at this time. Deployment of cameras, detectors, and communications infrastructure to share video and other information will support this market package. However, the primary reason for such deployments by stakeholders in the Austin Region was for traffic and incident management. No deployments of ITS equipment specifically for monitoring transportation infrastructure for security reasons were identified by stakeholders.	

Wide-Area Alert (EM06)	**High Priority**
Uses ITS driver and traveler information systems to alert the public in emergency situations such as child abductions, severe weather, civil emergencies, or other situations that pose a threat to life and property.	
Recommended Projects ▪ City of Austin HAR Deployment ▪ TxDOT Center-to-Center Communications ▪ TxDOT CTM Maintenance and Upgrades ▪ TxDOT National Weather Service Connection ▪ TxDOT I-35 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 130 (MoKan) CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 45 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 71 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SL 1 (MoPac) CTM Deployment (Phases 1 and 2) ▪ TxDOT US 183 CTM Deployment (Phases 1 and 2) ▪ TxDOT US 290 CTM Deployment (Phases 1 and 2) ▪ TxDOT/CTRMA US 183A CTM Deployments	

Early Warning System (EM07)	**Low Priority**
Monitors and detects potential, looming, and actual disasters including natural disasters (hurricanes, earthquakes, floods, winter storms, tsunamis, etc.) and technological and man-made disasters (hazardous materials incidents, nuclear power plant accidents, and acts of terrorism including nuclear, chemical, biological, and radiological weapons attacks).	
Recommended Projects ▪ TxDOT Burnet County Flood Detection System ▪ TxDOT Caldwell County Flood Detection System ▪ TxDOT National Weather Service Connection	

Table 3 – Emergency Management Market Packages and Projects (continued)

Disaster Response and Recovery (EM08)	**Medium Priority**
Enhances the ability of the surface transportation system to respond to and recover from disasters. It addresses the most severe incidents that require an extraordinary response from outside the local community.	
Recommended Projects No projects have been identified at this time. This market package expands on ATMS08 – Incident Management, and requires a high level of coordination between multiple agencies during incidents. The WebEOC software that is currently in use at Combined Transportation and Emergency Communications Center (CTECC) would accomplish much of the coordination required for this market package.	

Evacuation and Reentry Management (EM09)	**Medium Priority**
Supports evacuation of the general public from a disaster area and manages subsequent reentry to the disaster area. This market package supports both anticipated, well-planned, and orderly evacuations such as for a hurricane, as well as sudden evacuations with little or no time for preparation or public warning such as a terrorist act. Employs a number of strategies to maximize capacity along an evacuation route including coordination with transit.	
Recommended Projects ▪ City of Austin HAR Deployment ▪ TxDOT CTM Maintenance and Upgrades ▪ TxDOT Highway Advisory Radio Expansion ▪ TxDOT I-35 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 130 (MoKan) CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 45 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SH 71 CTM Deployment (Phases 1, 2, and 3) ▪ TxDOT SL 1 (MoPac) CTM Deployment (Phases 1 and 2) ▪ TxDOT US 183 CTM Deployment (Phases 1 and 2) ▪ TxDOT US 290 CTM Deployment (Phases 1 and 2) ▪ TxDOT/CTRMA US 183A CTM Deployments	

Disaster Traveler Information (EM10)	**Medium Priority**
Uses ITS to provide disaster-related traveler information to the general public, including evacuation and reentry information and other information concerning the operation of the transportation system during a disaster.	
Recommended Projects No projects have been identified at this time. In the Austin Region this market package was selected by stakeholders as a way to focus on coordination of information between Public Information Offices (PIO) and other entities, such as the media and other public agencies. No specific projects were identified to implement this project.	

2.2.3 Maintenance and Construction Management Service Area

Table 4 implements maintenance and construction management ITS functions for the following market packages and related projects. Maintenance and construction activity coordination, portable DMS for road closures and detour information, and road weather data collection primarily for detection of ice were identified as priorities for the Region.

Table 4 – Maintenance and Construction Management Market Packages and Projects

Maintenance and Construction Vehicle and Equipment Tracking (MC01)	**Low Priority**
Tracks the location of maintenance and construction vehicles and other equipment to ascertain the progress of their activities.	
Recommended Projects No projects have been identified at this time. Maintenance agencies participating in the update did not have any specific projects to identify at this time other than noting that the ability to track maintenance and construction equipment is something they would like to consider for the future.	

Maintenance and Construction Vehicle Maintenance (MC02)	**Low Priority**
Performs vehicle maintenance scheduling and manages both routine and corrective maintenance activities. Includes on-board sensors capable of automatically performing diagnostics.	
Recommended Projects No projects have been identified at this time. Maintenance agencies participating in the update did not have any specific projects to identify at this time other than noting, similar to Maintenance and Construction Vehicle and Equipment Tracking, that maintenance and construction vehicle maintenance services are something they would like to consider for the future.	

Road Weather Data Collection (MC03)	**High Priority**
Collects current road weather conditions using data collected from environmental sensors deployed on and about the roadway.	
Recommended Projects ▪ City of Georgetown Flood Detection and Closure System ▪ City of Round Rock Flood Detection and Closure System ▪ City of San Marcos Flood Detection System ▪ Hays County Flood Detection System ▪ Travis County Flood Detection and Closure System ▪ TxDOT Burnet County Flood Detection System ▪ TxDOT Caldwell County Flood Detection System	

Table 4 – Maintenance and Construction Management Market Packages and Projects (continued)

Weather Information Processing and Distribution (MC04)	**High Priority**
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 can make decisions on corrective actions to take.	
Recommended Projects ▪ City of Georgetown Flood Detection and Closure System ▪ City of Round Rock Flood Detection and Closure System ▪ City of San Marcos Flood Detection System ▪ Hays County Flood Detection System ▪ Travis County Flood Detection and Closure System ▪ TxDOT Burnet County Flood Detection System ▪ TxDOT Caldwell County Flood Detection System ▪ TxDOT National Weather Service Connection	

Roadway Maintenance and Construction (MC07)	**Medium Priority**
Supports numerous services for scheduled and unscheduled maintenance and construction on a roadway system or right-of-way. Environmental conditions information is also received from various weather sources to aid in scheduling maintenance and construction activities.	
Recommended Projects No projects have been identified at this time. This market package looks at ways to automate scheduling of maintenance and construction based on information brought into the scheduling system from roadside devices such as weather stations. The stakeholders wanted to consider the Roadway Maintenance and Construction market package for future implementation but did not want to add any projects at this time.	

Work Zone Management (MC08)	**High Priority**
Directs activity in work zones, controlling traffic through portable DMS and informing other groups of activity for better coordination management. Also provides speed and delay information to motorists prior to the work zone.	
Recommended Projects ▪ City of Georgetown Portable DMS ▪ TxDOT Portable DMS ▪ TxDOT Portable DMS Upgrades for Remote Communications	

Table 4 – Maintenance and Construction Management Market Packages and Projects (continued)

Work Zone Safety Monitoring (MC09)	Low Priority
Includes systems that improve work crew safety and reduce collisions between the motoring public and maintenance and construction vehicles. Detects vehicle intrusions in work zones and warns workers and drivers of safety hazards when encroachment occurs.	
Recommended Projects No projects have been identified at this time. Stakeholders wanted to consider this market package for future implementations but did not want to identify any projects at this time.	

Maintenance and Construction Activity Coordination (MC10)	High Priority
Supports the dissemination of maintenance and construction activity information to centers that can utilize it as part of their operations. (i.e., traffic management, transit, emergency management).	
Recommended Projects ▪ TxDOT Real-Time HCRS (Statewide)	

2.2.4 Public Transportation Management Service Area

The following ITS market packages and related projects, as detailed in **Table 5**, implement public transportation management ITS functions. Public transportation projects for both the Capital Metropolitan Transportation Authority and Capital Area Rural Transportation System were identified for nearly all of the ITS market packages. Most of these market packages were considered high priority and will likely be implemented or expanded in the near future.

Table 5 – Public Transportation Management Market Packages and Projects

Transit Vehicle Tracking (APTS1)	**High Priority**
Monitors current transit vehicle location using an AVL system. Location data may be used to determine real time schedule adherence and update the transit system's schedule in real time.	
Recommended Projects ▪ CapMetro ITS Implementation for Rail ▪ CapMetro ITS Implementation for RAPID Bus ▪ CapMetro ITS Implementation for Special Transit Services (STS) ▪ CARTS Real-time Bus Arrival Information ▪ Texas State University Transportation Department AVL	

Transit Fixed-Route Operations (APTS2)	**High Priority**
Performs vehicle routing and scheduling, as well as operator assignment and system monitoring for fixed-route and flexible-route transit services.	
Recommended Projects ▪ CapMetro Centralized Rail Control Center ▪ CapMetro ITS Implementation for Fixed Route Buses ▪ CapMetro ITS Implementation for Rail ▪ CapMetro ITS Implementation for RAPID Bus ▪ City of San Marcos Advance Railroad Notification (Note: This project was identified as a priority to improve service provided by Texas State University)	

Table 5 – Public Transportation Management Market Packages and Projects (continued)

Demand Response Transit Operations (APTS3)	**High Priority**
Performs vehicle routing and scheduling, as well as operator assignment and system monitoring for demand responsive transit services.	
Recommended Projects ▪ CapMetro ITS Implementation for Special Transit Services (STS) ▪ CapMetro Web-based STS Reservation System ▪ CARTS Intercity Bus Flag Stops ▪ CARTS Web-based Reservation System for Paratransit ▪ City of San Marcos Advance Railroad Notification (Note: This project was identified as a priority to improve service provided by Texas State University)	

Transit Passenger and Fare Management (APTS4)	**High Priority**
Manages passenger loading and fare payments on transit vehicles using electronic means.	
Recommended Projects ▪ CapMetro ITS Implementation for Fixed Route Buses ▪ CapMetro ITS Implementation for Rail ▪ CapMetro ITS Implementation for RAPID Bus ▪ CapMetro Regional Smart Card ▪ CapMetro Smart Card Payment System ▪ CapMetro Ticket Vending Kiosks ▪ CapMetro Web-based STS Reservation System ▪ CARTS Passenger Counters ▪ CARTS RideCARTS Card Electronic Fare Payment System ▪ CARTS Web-based Reservation System for Paratransit ▪ RideCARTS Card Service Kiosks ▪ Texas State University Transportation Department Passenger Counters	

Table 5 – Public Transportation Management Market Packages and Projects (continued)

Transit Security (APTS5)	High Priority
Provides for the physical security of transit passengers and transit vehicle operators. Includes on-board security cameras and panic buttons.	
Recommended Projects ▪ CapMetro ITS Implementation for Rail ▪ CapMetro ITS Implementation for RAPID Bus ▪ CapMetro Security Monitoring ▪ CapMetro Security Monitoring Enhancements ▪ CARTS Security Monitoring	

Transit Maintenance Management (APTS6)	Medium Priority
Supports automatic transit maintenance scheduling and monitoring for both routine and corrective maintenance.	
Recommended Projects ▪ CapMetro Asset Management System	

Multi-Modal Coordination (APTS7)	High Priority
Establishes two way communications between multiple transit and traffic agencies to improve service coordination.	
Recommended Projects ▪ CapMetro/CARTS CAD Coordination ▪ CapMetro Centralized Rail Control Center ▪ CapMetro ITS Implementation for Rail ▪ CapMetro ITS Implementation for RAPID Bus	

Table 5 – Public Transportation Management Market Packages and Projects (continued)

Transit Traveler Information (APTS8)	**Medium Priority**
Provides transit users at transit stops and on board transit vehicles with ready access to transit information. Services include stop annunciation, imminent arrival signs, and real-time transit schedule displays. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this market package.	
Recommended Projects ▪ CapMetro ITS Implementation for Fixed Route Buses ▪ CapMetro ITS Implementation for Rail ▪ CapMetro ITS Implementation for RAPID Bus ▪ CapMetro ITS Implementation for Special Transit Services (STS) ▪ CapMetro Web-based STS Reservation System ▪ CARTS Real-time Bus Arrival Information ▪ CARTS Web-based Reservation System for Paratransit	

2.2.5 Commercial Vehicle Operations Service Area

There were two market packages, Commercial Vehicle Administrative Processes and HAZMAT Management, that were identified that related to commercial vehicle operations in the Region. Planning for commercial vehicle operations is also being done on a statewide level as part of the Commercial Vehicle Information Systems and Networks (CVISN) program. As part of this program projects are being developed on a statewide basis rather than a regional basis. **Table 6** shows that although two market packages were identified by stakeholders for local deployment, no projects were currently identified for implementation of these market packages.

Table 6 – Commercial Vehicle Operations Market Packages and Projects

CV Administrative Processes (CVO04)	**Low Priority**
Provides for electronic application, processing, fee collection, issuance, and distribution of commercial vehicle operations (CVO) credentials and tax filing.	
Recommended Projects No projects have been identified at this time. This market package was identified to possibly provide for automated permitting for commercial vehicles in the future.	

HAZMAT Management (CVO10)	**Medium Priority**
Integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of hazardous materials (HAZMAT) material and incidents.	
Recommended Projects No projects have been identified at this time. This market package would rely on commercial vehicles and rail putting systems in place to automate the notification of emergency responders in case of an incident. Private sector commercial vehicle and rail operators would likely drive the implementation of this market package.	

2.2.6 Traveler Information Service Area

The following market packages and related projects implement traveler information ITS functions, as seen in **Table 7**. Traveler information service area projects address market packages that broadcast traveler information over a wide area. The future 511 traveler information phone number, updates to add real time information to TxDOT's Highway Condition Reporting System (HCRS), and website features and improvement were identified as projects to facilitate broadcast traveler information. Traveler information provided at a specific location on the roadway, such as DMS, is addressed in the ATMS06 – Traffic Information Dissemination market package in Section 2.2.1.

Table 7 – Traveler Information Market Packages and Projects

Broadcast Traveler Information (ATIS1)	**High Priority**
Collects traffic conditions, advisories, general public transportation, toll and parking information, incident information, roadway maintenance and construction information, air quality and weather information, and broadly disseminates this information through existing infrastructures (radio, cell phones, etc.).	
Recommended Projects ▪ City of Austin Web-based Information Sharing ▪ TxDOT 511 Traveler Information ▪ TxDOT Real-Time HCRS (Statewide) ▪ TxDOT Traveler Information Website with Speed Maps	

Interactive Traveler Information (ATIS2)	**High Priority**
Provides tailored information in response to a traveler request. Both real-time interactive request/response systems and information systems that "push" a tailored stream of information to the traveler based on a submitted profile are supported. The traveler can obtain current information regarding traffic conditions, roadway maintenance and construction, transit services, ride share/ride match, parking management, detours and pricing information.	
Recommended Projects ▪ TxDOT 511 Traveler Information	

ISP Based Route Coordination (ATIS5)	**Low Priority**
Offers the user pre-trip route planning and turn-by-turn route guidance services. Routes may be based on static or real time network conditions.	
Recommended Projects No projects have been identified at this time. This market package could use the TxDOT motor carrier routing information system to provide trip plans to commercial vehicles through a kiosk or website.	

2.2.7 *Archived Data Management Service Area*

The archived data management service area market packages and related projects implement archived data management ITS functions. Data collected through ITS deployments can be housed in several different formats. The market packages selected by stakeholders will allow data for a specific agency to be housed by that agency, or data from throughout the Region can be sent to a site to be housed together. Data housed by an agency as part of an ITS data mart would likely be part of another project deployment and are not called out separately in this section. For example, DMS implementation might include software to archive all of the messages placed on the DMS over a period of time.

Table 8 – Archived Data Management Market Packages and Projects

ITS Data Mart (AD1)	**Medium Priority**
Provides a focused archive that houses data collected and owned by a single agency or other organization. Focused archive typically covers a single transportation mode and one jurisdiction.	
Recommended Projects No projects have been identified at this time. The ITS Data Mart market package was identified primarily to note the importance of archiving data through automated systems that ITS can offer. The need to archive data and ultimately make that data available to the entire Region through a data warehouse was identified as important to stakeholders.	

ITS Data Warehouse (AD2)	**Medium Priority**
Includes all the data collection and management capabilities of the ITS Data Mart. Adds the functionality to allow collection of data from multiple agencies and data sources across modal and jurisdictional boundaries.	
Recommended Projects ▪ CAMPO Data Warehouse	

Virtual ITS Data Warehouse (AD3)	**Medium Priority**
Provides the same broad access to multimodal, multidimensional data from varied 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.	
Recommended Projects ▪ CAMPO Data Warehouse	

2.2.8 User Defined Service Area

In addition to the 50 market packages customized from the National ITS Architecture, a user defined market package, displayed in **Table 9**, was also developed for the Austin Regional ITS Architecture to address the need for improved radio communications. Radio communications are essential to many of the incident management, emergency management, maintenance, and transit operations in the Region. In addition to voice, stakeholders also envisioned the use of radio for data transmittal throughout the Region. The Regional Radio Interoperability project identified in the ITS Deployment Plan would seek to bring all of the agencies in the Region onto a radio system that is interoperable.

Table 9 – User Defined Market Packages and Projects

Radio Communications Network (RCN01)	**High Priority**
Customized market package developed for the Austin Region to show the need for traffic, emergency management, maintenance, and transit agencies to be able to communicate through radios within the Austin Region. Radio communications allows for both voice and data transfer between agencies.	
Recommended Projects ▪ Regional Radio Interoperability	

3. PROJECT RECOMMENDATIONS

In order to achieve the vision of the Regional ITS Architecture, a region must deploy carefully developed projects that provide the functionality and interoperability identified in the architecture. A key step toward that vision is the development of an ITS Deployment Plan that identifies specific projects, timeframes, and responsible agencies.

Input from the stakeholders is required in order for the stakeholders to have ownership of the ITS Deployment Plan and to ensure that the plan has realistically identified projects and timeframes for the Region. Cost is another important factor. Cost can vary a great deal for many ITS elements, depending on the level of deployment, maturity of the technology, type of communications, etc. For example, network surveillance could be adequately achieved for one agency by the deployment of still frame CCTV cameras at key intersections or interchanges; however, for another agency there may be a desire for full motion cameras deployed at half mile intervals to provide complete coverage of the arterial or freeway system. The infrastructure and telecommunications costs for these two projects would vary a great deal, yet either one could be suitable for a particular stakeholder.

In order to gather input from stakeholders, a workshop was held in the Austin Region on July 18, 2006 to discuss potential projects. Each project recommended for the Regional ITS Deployment Plan was discussed, and consensus was reached by the stakeholders on the project description and the timeframe for implementation. Separate discussions were also held with many stakeholders to gather additional input on their projects.

In the following section, projects are categorized into functional areas: Traffic Management, Emergency Management, Maintenance and Construction Management, Public Transportation Management, Traveler Information, and Archived Data Management. For each functional area, stakeholders grouped projects into timeframes for deployment based on priority, dependence on other projects, technology, and feasibility. The timeframes have been categorized as follows:

- Short-term deployments – Deployments in the next 5 years from 2007 – 2011;
- Mid-term deployments – Deployments in the next 10 years from 2012 – 2016; and
- Long-term deployments – Deployment in the next 20 years from 2017 – 2026.

Actual deployment timeframes for the projects will be dependent on inclusion in the Regional Transportation Improvement Plan (TIP) and identification of funding sources.

For each project, the tables include a project description, cost and benefits, stakeholders, and the applicable market packages in the Austin Regional ITS Architecture.

- Project Description – The project description provides a brief overview of the project. The level of detail of the project is dependent on the stakeholder agency. In some cases projects were in the planning or design stage and the level of detail of the project description can be increased. In other cases projects have been identified as a result of the ITS Architecture process and no real detail beyond a very basic project concept is available.
- Cost and Benefits – An opinion of probable cost has been provided for each project. No design has been done as part of the ITS Deployment Plan and costs are included only for planning purposes. Many of the projects have not been developed to the point where stakeholders were comfortable identifying quantities or magnitudes of the project, so often unit costs have been included to serve as guidance in planning and budgeting for the project. This section also identifies if funding currently exists for the project as well as some potential benefits of deployment.
- Stakeholders – A lead agency for the project has been identified where appropriate and other agencies that will have a role in some or all of the planning, implementation, operations, and maintenance of the projects have also been included.
- Applicable Market Packages – Each project identified will assist stakeholders in implementing one or more of the ITS market packages identified for the Region. Projects often just implement one piece of a market package, and, to fully implement a market package, multiple projects will need to be implemented. Due to funding constraints, it is unlikely that all market packages will ever be fully implemented in the Region. Rather, stakeholders will need to focus on implementing the most important pieces of each market package so that ITS investments in the Region are maximized.

3.1 Regional Projects

Regional projects are identified in **Table 10** through **Table 15**. The tables are broken out as follows:

- **Table 10** – Traffic Management Project Recommendations;
- **Table 11** – Emergency Management Project Recommendations;
- **Table 12** – Maintenance and Construction Management Project Recommendations;
- **Table 13** – Public Transportation Project Recommendations;
- **Table 14** – Traveler Information Project Recommendations; and
- **Table 15** – Archived Data Management Project Recommendations.

Many of the TxDOT projects in the Traffic Management Project Recommendations section reference Corridor Traffic Management (CTM) projects. CTM projects may include DMS, CCTV cameras, lane control signals, and vehicle detection. **Figure 1** identifies the roadways where CTM will be deployed and summarizes the project phases and time frames for CTM deployment.

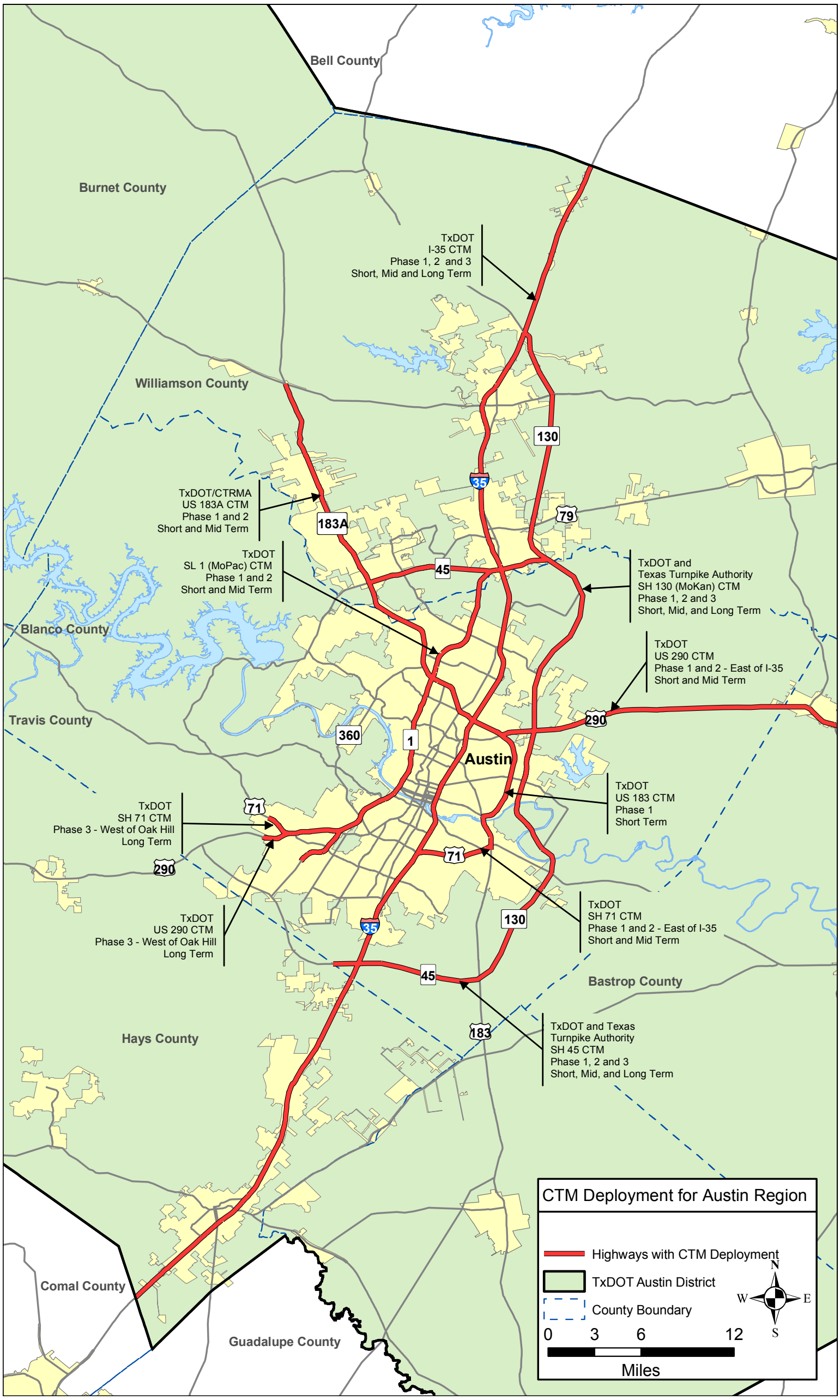

Figure 1 – Corridor Traffic Management Projects for the Austin Region

3.1.1 *Traffic Management Project Recommendations*

Table 10 – Traffic Management Project Recommendations

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Traffic Management Projects: 2007 – 2011				
TxDOT Center-to-Center Communications	Communications between TxDOT traffic management centers (TMCs), especially the San Antonio TMC, TransGuide. Cost will vary based on communications method selected.	Cost: Unknown Funding Identified: No Benefits: Improved coordination between districts to provide traveler information on interstate corridors	Lead: TxDOT	ATMS07 ATMS08 EM06
TxDOT CTM Maintenance and Upgrades	Maintain and upgrade existing corridor traffic management (CTM) deployments on TxDOT roadways in the Austin District. Cost will vary based on the types of upgrades and maintenance that are needed.	Cost: Unknown Funding Identified: No Benefits: Maintain and improve the operations of the CTM deployments	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT Highway Advisory Radio Expansion	Expand highway advisory radio (HAR) coverage on I-35 to provide coverage of the corridor through Hays, Travis, and Williamson Counties. This project involves the deployment of three transmitters and should include compatibility with the City of Austin HAR system.	Cost: $25,000 per transmitter Funding Identified: No Benefits: Provide improved traveler information	Lead: TxDOT Others: City of Austin, Hays County, Travis County, Williamson County	ATMS06 ATMS08 EM09
TxDOT National Weather Service Connection	Communications between the TxDOT Austin TMC (Combined Transportation and Emergency Communications Center [CTECC]) and National Weather Service (NWS) to get weather and flood gauge information. Cost will vary based on communications method selected.	Cost: Unknown Funding Identified: No Benefits: Provide additional real-time information to TxDOT on weather conditions that can affect roadways	Lead: TxDOT Others: National Weather Service	ATMS08 EM06 EM07 MC04
TxDOT I-35 CTM Deployment (Phase 1)	Implement additional CTM deployments on I-35. CTM deployments will include dynamic message signs (DMS), closed-circuit television (CCTV) cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Traffic Management Projects (continued)				
TxDOT SH 45 CTM Deployment (Phase 1)	Implement CTM deployments on SH 45. CTM deployment will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT Others: TxDOT Texas Turnpike Authority Division	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT SH 71 CTM Deployment (Phase 1 – East of I-35)	Implement additional CTM deployments on SH 71. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT SH 130 (MoKan) CTM Deployment (Phase 1)	Implement CTM deployments on SH 130. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT Others: TxDOT Texas Turnpike Authority Division	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT SL 1 (MoPac) CTM Deployment (Phase 1)	Implement additional CTM deployments on State Loop 1. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT US 183 CTM Deployment (Phase 1)	Implement additional CTM deployments on US 183. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Traffic Management Projects (continued)				
TxDOT US 290 CTM Deployment (Phase 1 – East of I-35)	Implement additional CTM deployments on US 290. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT Texas Turnpike Authority Division Toll Enforcement	Implement video surveillance and violation processing technologies for the operation of Texas Turnpike Authority Division facilities. The software will coordinate with local and national database for violations.	Cost: $7,000 per high speed camera (each camera covers two lanes) and $30,000 for toll administration software Funding Identified: Yes Benefits: Toll collection enforcement	Lead: TxDOT Texas Turnpike Authority Division	ATMS01 ATMS10
TxDOT/CTRMA US 183A CTM Deployments	Implement CCTV cameras and vehicle detection for traffic management and incident detection as well as DMS for traveler information. The cost shown is for implementation at a level similar to TxDOT's typical CTM deployments. Costs could vary greatly depending on the level of coverage desired.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Improved traffic management and traveler information	Lead: CTRMA Others: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
City of Austin CCTV Camera Deployment	Deploy additional CCTV cameras to monitor traffic conditions and aid in incident detection and emergency response.	Cost: $20,000 per camera Funding Identified: No Benefits: Improved traffic management	Lead: City of Austin Others: TxDOT	ATMS01 ATMS03 ATMS08
City of Austin Closed Loop Signal System Upgrades and Expansion	Continue to upgrade and expand the closed loop signal system. Cost represents an average cost per intersection for upgrading and coordinating an existing signalized intersection.	Cost: Approximately $20,000 per intersection Funding Identified: No Benefits: Improved traffic signal coordination	Lead: City of Austin	ATMS01 ATMS03

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Traffic Management Projects (continued)				
City of Austin HAR Deployment	Implement HAR for information dissemination. In addition to use for traffic information dissemination, the transmitters will also be used by the Austin Police Department and Austin Bergstrom International Airport. When deploying this project, opportunities for interoperability with TxDOT HAR transmitters should be explored.	Cost: $20,000 per transmitter Funding Identified: No Benefits: Improved traffic management, traveler information, and emergency information	Lead: City of Austin Others: TxDOT	ATMS06 ATMS08 EM06 EM09
City of Austin Information Sharing Expansion	Expand information sharing arrangement with TxDOT Austin District TMC (CTECC) to include detector information and increase video sharing capabilities. Cost will depend on whether additional communications capacity must be added and whether any software modifications are required.	Cost: Unknown Funding Identified: No Benefits: Facilitate traffic management	Lead: City of Austin Others: TxDOT	ATMS07 ATMS08
City of Austin Web-based Information Sharing	Implement a system (i.e. SmartNET, etc.) to allow the sharing of information with other agencies and the public through the internet.	Cost: Unknown Funding Identified: No Benefits: Facilitate traffic management and provide traveler information	Lead: City of Austin Others: TxDOT, City of Round Rock	ATMS06 ATIS1
City of Cedar Park Signal System Upgrades	Joint project between the City and TxDOT to upgrade state owned traffic signals in preparation for transfer to City maintenance and control. Cost represents an average cost per intersection for upgrading and coordinating an existing signalized intersection.	Cost: Approximately $20,000 per intersection Funding Identified: No Benefits: Improved traffic signal coordination. Upgrades will also reduce initial City maintenance responsibilities	Lead: City of Cedar Park Others: TxDOT	ATMS01 ATMS03
City of Cedar Park Traffic Operations Center	Implement a traffic operations center (TOC) for control of signal systems and other ITS equipment in the City. Approximate cost for equipment and those costs associated with modifying available space in an existing facility for use as a TOC.	Cost: $100,000 Funding Identified: No Benefits: Improved traffic signal coordination and incident management	Lead: City of Cedar Park Others: TxDOT	ATMS01 ATMS03 ATMS06 ATMS07 ATMS08

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Traffic Management Projects (continued)				
City of Georgetown Portable DMS	Procure additional portable DMS for use in the TxDOT Austin District for maintenance and construction management. Portable DMS will have cellular communications capability.	Cost: $20,000 Funding Identified: No Benefits: Improved work zone management	Lead: City of Georgetown	ATMS06 ATMS08 MC08
City of Georgetown Signal System Upgrades	Joint project between the City and TxDOT to upgrade state owned traffic signals in preparation for transfer to City maintenance and control. Cost represents an average cost per intersection for upgrading and coordinating an existing signalized intersection.	Cost: Approximately $20,000 per intersection Funding Identified: No Benefits: Improved traffic signal coordination. Upgrades will also reduce initial City maintenance responsibilities.	Lead: City of Georgetown Others: TxDOT	ATMS01 ATMS03
City of Georgetown Traffic Operations Center	Implement a TOC for control of signal systems and other ITS equipment in the City. Approximate cost for equipment and those costs associated with modifying available space in an existing facility for use as a TOC.	Cost: $100,000 Funding Identified: No Benefits: Improved traffic signal coordination and incident management	Lead: City of Georgetown Others: TxDOT	ATMS01 ATMS03 ATMS06 ATMS07 ATMS08
City of Round Rock Communications Connection	Implement high bandwidth communications connection between the City of Round Rock and TxDOT Austin District TMC (CTECC) for sharing of video and other traffic information. Cost will depend on communications method chosen.	Cost: Unknown Funding Identified: No Benefits: Improved coordination between the City and TxDOT for traffic management	Lead: City of Round Rock, TxDOT	ATMS07 ATMS08
City of San Marcos Communications Connection	Implement high bandwidth communications connection between the City of San Marcos and TxDOT Austin District TMC (CTECC) for sharing of video and other traffic information. Cost will depend on communications method chosen.	Cost: Unknown Funding Identified: No Benefits: Improved coordination between the City and TxDOT for traffic management	Lead: City of San Marcos, TxDOT	ATMS07 ATMS08

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Traffic Management Projects (continued)				
Austin Regional ITS Architecture and Deployment Plan Update	Update the Austin Regional ITS Architecture to incorporate additional stakeholders and elements, changes in regional plans for ITS, and any changes to the National ITS Architecture. The update will involve all stakeholders in the Region and completely update both the Regional ITS Architecture and ITS Deployment Plan. The cost of this project will vary based on the level of changes required and should be completed in preparation for the 2011-2014 Transportation Improvement Plan (TIP) due in May 2010.	Cost: $200,000 Funding Identified: No Benefits: Continued conformance with the National ITS Architecture and eligibility to use federal funds on ITS related projects	Lead: TxDOT Others: CAMPO, Other stakeholder agencies represented in the Regional ITS Architecture	Not Applicable
Mid-Term Traffic Management Projects: 2012 – 2016				
TxDOT CTM Maintenance and Upgrades	Maintain and upgrade existing CTM deployments on TxDOT roadways in the Austin District. Cost will vary based on the types of upgrades and maintenance that are needed.	Cost: Unknown Funding Identified: No Benefits: Maintain and improve the operations of the CTM deployments	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT I-35 CTM Deployment (Phase 2)	Implement additional CTM deployments on I-35. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT SH 45 CTM Deployment (Phase 2)	Implement CTM deployments on SH 45. CTM deployment will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT Others: TxDOT Texas Turnpike Authority Division	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Mid-Term Traffic Management Projects (continued)				
TxDOT SH 71 CTM Deployment (Phase 2 – East of I-35)	Implement additional CTM deployments on SH 71. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT SH 130 (MoKan) CTM Deployment (Phase 2)	Implement CTM deployments on SH 130. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT Others: TxDOT Texas Turnpike Authority Division	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT SL 1 (MoPac) CTM Deployment (Phase 2)	Implement additional CTM deployments on State Loop 1. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT/CTRMA US 183 CTM Deployment (Phase 2)	Implement CTM deployments on US 183. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: CTRMA Others: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
City of Austin DMS Deployment	Deploy DMS on major arterials for dissemination of traveler information. Cost represents approximate cost for an arterial-sized DMS.	Cost: $100,000 per sign Funding Identified: No Benefits: Provide traveler information	Lead: City of Austin Others: TxDOT	ATMS06 ATMS08
City of Cedar Park Communications Connection	Implement high bandwidth communications connection between the City of Cedar Park and TxDOT Austin District TMC (CTECC) for sharing of video and other traffic information. Cost will vary based on communications method chosen.	Cost: Unknown Funding Identified: No Benefits: Improved coordination between the City and TxDOT for traffic management	Lead: City of Cedar Park, TxDOT	ATMS07 ATMS08

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Mid-Term Traffic Management Projects (continued)				
City of Georgetown CCTV Camera Deployment	Deploy CCTV cameras to monitor traffic conditions and aid in incident detection and emergency response.	Cost: $20,000 per camera Funding Identified: No Benefits: Improved traffic management	Lead: City of Georgetown Others: TxDOT	ATMS01 ATMS08
City of Georgetown Communications Connection	Implement high bandwidth communications connection between the City of Georgetown and TxDOT Austin District TMC (CTECC) for sharing of video and other traffic information. Cost will vary based on communications method chosen.	Cost: Unknown Funding Identified: No Benefits: Improved coordination between the City and TxDOT for traffic management	Lead: City of Georgetown, TxDOT	ATMS07 ATMS08
City of Round Rock Dell Diamond Traffic Management	Implement DMS in the vicinity of the Dell Diamond. This will be a joint project with TxDOT. Cost represents approximate cost for an arterial-sized DMS.	Cost: $100,000 per sign Funding Identified: No Benefits: Provide traveler information	Lead: City of Round Rock, TxDOT	ATMS06 ATMS08
City of San Marcos CCTV Camera Deployment	Deploy CCTV cameras to monitor traffic conditions and aid in incident detection and emergency response.	Cost: $20,000 per camera Funding Identified: No Benefits: Improved traffic management	Lead: City of San Marcos Others: TxDOT	ATMS01 ATMS08
Travis County Vehicle Detection	Implement vehicle detection to gather traffic count, classification and speed data. Cost will vary based on detection method chosen.	Cost: Unknown Funding Identified: No Benefits: Gather improved traffic volume information	Lead: Travis County Others: TxDOT	ATMS01
Village of Bee Cave Speed Detection	Implement speed detection and driver speed feedback at the entrances to the Village on SH 71. This will be a joint project with TxDOT.	Cost: Unknown Funding Identified: No Benefits: Reduced speeds within the Village	Lead: Village of Bee Cave Others: TxDOT	ATMS01 ATMS19

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Long-Term Traffic Management Projects: 2017 – 2026				
TxDOT CTM Maintenance and Upgrades	Maintain and upgrade existing CTM deployments on TxDOT roadways in the Austin District. Cost will vary based on the types of upgrades and maintenance that are needed.	Cost: Unknown Funding Identified: No Benefits: Maintain and improve the operations of the CTM deployments	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT Ramp Meters	If determined appropriate for the District, implement ramp metering on area freeway facilities (currently being studied).	Cost: Unknown Funding Identified: No Benefits: Improved traffic flow on area freeways	Lead: TxDOT Others: City of Austin, City of Cedar Park, City of Round Rock	ATMS04
TxDOT I-35 CTM Deployment (Phase 3)	Implement additional CTM deployments on I-35. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT SH 45 CTM Deployment (Phase 3)	Implement CTM deployments on SH 45. CTM deployment will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT SH 71 CTM Deployment (Phase 3 – West of Oak Hill)	Implement additional CTM deployments on SH 71. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09

Table 10 – Traffic Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Long-Term Traffic Management Projects (continued)				
TxDOT SH 130 (MoKan) CTM Deployment (Phase 3)	Implement CTM deployments on SH 130. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
TxDOT US 290 CTM Deployment (Phase 2 – West of Oak Hill)	Implement additional CTM deployments on US 290. CTM deployments will include DMS, CCTV cameras, lane control signals, and vehicle detection.	Cost: Approximately $500,000 per mile Funding Identified: No Benefits: Provide improved incident management capabilities and traveler information	Lead: TxDOT	ATMS01 ATMS04 ATMS06 ATMS08 EM06 EM09
City of Georgetown ITS Deployments on Southwest Bypass and Inner Loop	Implement CCTV cameras and vehicle detection for traffic management and incident detection as well as DMS for traveler information. Cost for DMS is approximate cost for an arterial sized DMS.	Cost: $20,000 per camera, $100,000 per DMS Funding Identified: No Benefits: Improved traffic management and traveler information	Lead: City of Georgetown Others: TxDOT	ATMS01 ATMS06 ATMS08

[1]The design has not been undertaken and thus this is only an opinion of probable cost for planning purposes.

[2]Agency or agencies listed will play a role the planning, implementation, operations, and/or maintenance. The lead agency and any other agencies that have a stake in the project are identified.

[3]Partial implementation of market package as it applies to the identified project.

3.1.2 *Emergency Management Project Recommendations*

Table 11 – Emergency Management Project Recommendations

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Emergency Management Projects: 2007 – 2011				
TxDOT AVL for HERO Vehicles	Implement automated vehicle location (AVL) on Highway Emergency Response Operator (HERO) vehicles. This project will most likely be integrated with the Austin/Travis County AVL system. Cost represents in-vehicle equipment as well as supporting software.	Cost: $3,000 per vehicle Funding Identified: No Benefits: Improved incident response capabilities through ability dispatch HERO vehicles taking in to account their location	Lead: TxDOT Others: Austin/Travis County Emergency Services	EM01 EM02 EM04
Regional Radio Interoperability	Integrate radios systems for emergency and transportation agencies throughout the Region. The City of Austin currently has a Homeland Security Grant to integrate Williamson County Radios. Integration with all agencies at the city, county, state, and feral level is eventually desired. Radio system should be interoperable for both voice and data sharing among agencies in the Region.	Cost: Unknown Funding Identified: No Benefits: Improved incident management and traffic coordination capability. Radio may also be able to serve as a communications media for data sharing as well as voice.	Lead: A lead agency for this project has not been identified. The project will be a joint effort of transportation and emergency management agencies.	RCN01
City of Cedar Park Emergency Vehicle Signal Preemption	Implement emergency vehicle signal preemption for City of Cedar Park Fire Department and Williamson and Travis County EMS within the City.	Cost: $6,000 per intersection, $1,500 per vehicle Funding Identified: No Benefits: Faster emergency response times	Lead: City of Cedar Park	ATMS03 EM02
City of Georgetown Emergency Vehicle Signal Preemption	Implement emergency vehicle signal preemption for City of Georgetown Fire Department and Williamson County Emergency Medical Services (EMS) within the City.	Cost: $6,000 per intersection, $1,500 per vehicle Funding Identified: No Benefits: Faster emergency response times.	Lead: City of Georgetown	ATMS03 EM02
City of Round Rock Advance Railroad Notification	Implement system to detect when railroad crossings are blocked and notify emergency dispatchers as well as motorists (especially I-35 near RR 620).	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic management	Lead: City of Round Rock, TxDOT	ATMS13 EM01 EM02

Table 11 – Emergency Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Emergency Management Projects (continued)				
City of Round Rock CAD Integration with TxDOT ATMS Software	Integrate TxDOT traffic management software with City emergency services computer aided dispatch (CAD) system. Emergency dispatch can utilize real-time traffic information to determine dispatch routes and traffic management can have timely information about incidents that might impact the roadway network.	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic management during an incident	Lead: City of Round Rock, TxDOT	ATMS08 EM01 EM02
City of Round Rock Signal System Railroad Coordination	Improve signal timing in corridors with rail crossings to reduce the amount of time required to achieve synchronization after railroad preemption.	Cost: Unknown Funding Identified: No Benefits: Improved signal coordination and traffic flow	Lead: City of Round Rock	ATMS03 ATMS13
Williamson County CAD Integration with TxDOT ATMS Software	Integrate TxDOT traffic management software with County emergency services CAD system. Emergency dispatch can utilize real-time traffic information to determine dispatch routes and traffic management can have timely information about incidents that might impact the roadway network.	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic management during an incident	Lead: Williamson County, TxDOT	ATMS08 EM01 EM02
Mid-Term Emergency Management Projects: 2012 – 2016				
City of Cedar Park CAD Integration with TxDOT ATMS Software	Integrate TxDOT traffic management software with City emergency services CAD system. Emergency dispatch can utilize real-time traffic information to determine dispatch routes and traffic management can have timely information about incidents that might impact the roadway network.	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic management during an incident	Lead: City of Cedar Park, TxDOT	ATMS08 EM01 EM02

Table 11 – Emergency Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Mid-Term Emergency Management Projects (continued)				
City of Georgetown CAD Integration with TxDOT ATMS Software	Integrate TxDOT traffic management software with City emergency services CAD system. Emergency dispatch can utilize real-time traffic information to determine dispatch routes and traffic management can have timely information about incidents that might impact the roadway network.	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic management during an incident	Lead: City of Georgetown, TxDOT	ATMS08 EM01 EM02
City of San Marcos Advance Railroad Notification	Implement system to detect when railroad crossings are blocked and notify emergency dispatchers as well as motorists. This information will also be shared with the Texas State University Transportation Department and Capital Area Rural Transportation System (CARTS).	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic and transit management	Lead: City of San Marcos, TxDOT	ATMS13 APTS2 APTS3 EM01 EM02
DPS Local Districts Communications Connection	Implement high bandwidth communications connection between DPS and TxDOT Austin District TMC (CTECC) for sharing of video and other traffic information. Cost will depend on communications method chosen.	Cost: Unknown Funding Identified: No Benefits: Improved coordination with traffic management for incident management	Lead: DPS Local Districts Others: TxDOT, Austin/Travis County Emergency Services	ATMS08 EM01
Hays County CAD Integration with TxDOT ATMS Software	Integrate TxDOT traffic management software with County emergency services CAD system. Emergency dispatch can utilize real-time traffic information to determine dispatch routes and traffic management can have timely information about incidents that might impact the roadway network.	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic management during an incident	Lead: Hays County, TxDOT	ATMS08 EM01 EM02
Local Emergency Management Emergency Vehicle Signal Preemption	Implement emergency vehicle signal preemption. This will be a joint project between the local emergency management and TxDOT. (Includes Marble Falls).	Cost: $6,000 per intersection, $1,500 per vehicle Funding Identified: No Benefits: Faster emergency response times	Lead: Local Emergency Management	ATMS03 EM02

Table 11 – Emergency Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Mid-Term Emergency Management Projects (continued)				
Williamson County Communications Connection	Implement high bandwidth communications connection between the future Williamson County Emergency Services Combined Dispatch and TxDOT Austin District TMC (CTECC) for sharing of video and other traffic information. Cost will vary based on communications method chosen.	Cost: Unknown Funding Identified: No Benefits: Improved coordination with traffic management for incident management	Lead: Williamson County, TxDOT	ATMS08 EM01 EM02
Williamson County Advance Railroad Notification	Implement system to detect when railroad crossings are blocked and notify emergency dispatchers as well as motorists.	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic and transit management	Lead: Williamson County	ATMS06 ATMS13 EM01 EM02
Long-Term Emergency Management Projects: 2017 – 2026				
Local Emergency Management CAD Integration with TxDOT ATMS Software	Integrate TxDOT traffic management software with local emergency services CAD systems. Emergency dispatch can utilize real-time traffic information to determine dispatch routes and traffic management can have timely information about incidents that might impact the roadway network.	Cost: Unknown Funding Identified: No Benefits: Faster emergency response times and improved traffic management during an incident	Lead: Local Emergency Management, TxDOT	ATMS08 EM01 EM02

[1]The design has not been undertaken and thus this is only an opinion of probable cost for planning purposes.

[2]Agency or agencies listed will play a role the planning, implementation, operations, and/or maintenance. The lead agency and any other agencies that have a stake in the project are identified.

[3]Partial implementation of market package as it applies to the identified project.

3.1.3 *Maintenance and Construction Management Project Recommendations*

Table 12 – Maintenance and Construction Management Project Recommendations

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Maintenance and Construction Management Projects: 2007 – 2011				
TxDOT Burnet County Flood Detection System	Implement flood detection equipment at low water crossings on state routes within Burnet County. May also include automated road closure gates.	Cost: $10,000 per station, gates approximately $10,000 Funding Identified: No Benefits: Provide real-time road condition data and improve safety of travelers	Lead: TxDOT, Burnet County	ATMS21 EM07 MC03 MC04
TxDOT Caldwell County Flood Detection System	Implement flood detection equipment at low water crossings on state routes within Caldwell County. May also include automated road closure gates. Locations for deployment include US 183 and SH 80.	Cost: $10,000 per station, gates approximately $10,000 Funding Identified: No Benefits: Provide real-time road condition data and improve safety of travelers	Lead: TxDOT, Caldwell County	ATMS21 EM07 MC03 MC04
TxDOT Portable DMS	Procure additional portable DMS for use in the TxDOT Austin District for maintenance and construction management. Portable DMS will have cellular communications capability.	Cost: $20,000 per sign Funding Identified: No Benefits: Improved work zone management	Lead: TxDOT	ATMS06 MC08
TxDOT Portable DMS Upgrades for Remote Communications	Upgrade existing portable DMS signs with cellular modems to allow remote communications.	Cost: $1,000 per sign Funding Identified: No Benefits: Improved work zone management	Lead: TxDOT	ATMS06 MC08
TxDOT Real-Time HCRS (Statewide)	Integrate Highway Condition Reporting System (HCRS) with District TMCs to get real-time incident information into from ATMS into HCRS. This information would include incidents and lane closures.	Cost: Unknown Funding Identified: No Benefits: Provide up to date road closure and restriction information	Lead: TxDOT Travel Division (Statewide)	ATMS08 MC10 ATIS1
City of Georgetown Flood Detection and Closure System	Implement flood detection equipment at low water crossings on roadways within the City. May also include automated road closure gates.	Cost: $10,000 per station, gates approximately $10,000 Funding Identified: No Benefits: Provide real-time road condition data and improve safety of travelers	Lead: City of Georgetown	ATMS21 MC03 MC04

Table 12 – Maintenance and Construction Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Maintenance and Construction Management Projects (continued)				
City of San Marcos Flood Detection System	Implement flood detection equipment at low water crossings on roadways within the City.	Cost: $10,000 per station Funding Identified: No Benefits: Provide real-time road condition data and improve safety of travelers	Lead: City of San Marcos	MC03 MC04
Hays County Flood Detection System	Implement flood detection equipment at low water crossings on state routes within the Region. May also include CCTV cameras and flashing beacon signs. The Federal Emergency Management Agency funding allows basic deployment at 182 sites and limited CCTV camera deployment. Cameras at additional sites are desired.	Cost: $10,000 per station, $20,000 per camera Funding Identified: Partial Benefits: Provide real-time road condition data and improve safety of travelers	Lead: Hays County	ATMS01 MC03 MC04
Mid-Term Maintenance and Construction Management Projects: 2012 – 2016				
City of Round Rock Flood Detection and Closure System	Implement flood detection equipment at low water crossings on roadways within the City. May also include automated road closure gates.	Cost: $10,000 per station, gates approximately $10,000 Funding Identified: No Benefits: Provide real-time road condition data and improve safety of travelers	Lead: City of Round Rock	ATMS21 MC03 MC04
Travis County Flood Detection and Closure System	Implement flood detection equipment at low water crossings on roadways within the City. May also include automated road closure gates.	Cost: $10,000 per station, gates approximately $10,000 Funding Identified: No Benefits: Provide real-time road condition data and improve safety of travelers	Lead: Travis County	ATMS21 MC03 MC04

[1]The design has not been undertaken and thus this is only an opinion of probable cost for planning purposes.

[2]Agency or agencies listed will play a role the planning, implementation, operations, and/or maintenance. The lead agency and any other agencies that have a stake in the project are identified.

[3]Partial implementation of market package as it applies to the identified project.

3.1.4 *Public Transportation Management Project Recommendations*

Table 13 – Public Transportation Management Project Recommendations

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Public Transportation Management Projects: 2007 – 2011				
CapMetro Asset Management System	Implement an asset management system to track routine maintenance and repair requests for vehicles, rail cars, stations and other facilities or equipment. Vehicle diagnostic equipment will be utilized to monitor the status of transit vehicles.	Cost: Unknown Funding Identified: Yes Benefits: Provide centralized asset management system to more efficiently manage preventative maintenance and repairs	Lead: CapMetro	APTS6
CapMetro Centralized Rail Control Center	Establish an operations center for scheduling of freight and commuter rail.	Cost: Unknown Funding Identified: Yes Benefits: Provide operations coordination services	Lead: CapMetro	APTS2 APTS7
CapMetro ITS Implementation for Fixed Route Buses	Mobile data terminals (MDTs) with covert alarm, next bus arrival/departure prediction and traveler information at select bus stops via DMS as well through the website and phone response systems.	Cost: $6.3 M Funding Identified: Yes Benefits: Provide real-time information to transit patrons and improved operations and security	Lead: CapMetro	APTS2 APTS4 APTS8
CapMetro ITS Implementation for RAPID Bus	MDTs with covert alarm, CAD, AVL, passenger counters, next bus arrival/departure prediction and traveler information via DMS at RAPID bus stops.	Cost: $5.7 M Funding Identified: Yes Benefits: Provide real-time information to transit patrons and improved operations and security	Lead: CapMetro	APTS1 APTS2 APTS4 APTS5 APTS7 APTS8
CapMetro ITS Implementation for Rail	MDTs with covert alarm, expansion of CAD and AVL implemented for RAPID, passenger counters, next train arrival/departure prediction and traveler information via DMS.	Cost: $926,000 Funding Identified: Yes Benefits: Provide real-time information to transit patrons and improved operations and security	Lead: CapMetro	APTS1 APTS2 APTS4 APTS5 APTS7 APTS8

Table 13 – Public Transportation Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Public Transportation Management Projects (continued)				
CapMetro ITS Implementation for Special Transit Services (STS)	MDTs, CAD upgrade to incorporate AVL, and paratransit scheduling and communications software upgrade to include dial out notification of arrival times as well as customer retrieval of trip schedules and status.	Cost: $1.6 M Funding Identified: Yes Benefits: Facilitate paratransit operations and provide real-time information to travelers	Lead: CapMetro	APTS1 APTS3 APTS8
CapMetro Security Monitoring	Implement video surveillance on CapMetro transit vehicles to improve patron and driver safety.	Cost: Unknown Funding Identified: No Benefits: Improved passenger and driver safety	Lead: CapMetro	APTS5
CapMetro Smart Card Payment System	Implement Smart Card electronic fare collection system. Smart Card system should be coordinated with CARTS to ensure future interoperability opportunities.	Cost: Unknown Funding Identified: No Benefits: Improved fare collection and patron convenience	Lead: CapMetro Others: CARTS	APTS4
CapMetro Ticket Vending Kiosks	Implement ticket vending kiosks at rail stations, RAPID stations, and larger park and rides to sell and add fund to the fare payment smart card.	Cost: Unknown Funding Identified: Yes Benefits: Improved fare collection and patron convenience	Lead: CapMetro	APTS4
CapMetro Web-based STS Reservation System	Implement web-based program to allow paratransit users to make trip requests and retrieve trip information online.	Cost: Unknown Funding Identified: No Benefits: Improved STS scheduling and patron convenience	Lead: CapMetro	APTS3 APTS4 APTS8
CARTS Passenger Counters	Implement passenger counters on CARTS transit vehicles to record boarding and alightings.	Cost: Unknown Funding Identified: No Benefits: Improved data collection	Lead: CARTS	APTS4
CARTS Real-time Bus Arrival Information	Implement AVL and tracking software as well provide next bus arrival and departure information at transfer stations.	Cost: Project is fully funded and in progress. Funding Identified: Yes Benefits: Provide real-time information to transit patrons	Lead: CARTS	APTS1 APTS8

Table 13 – Public Transportation Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Public Transportation Management Projects (continued)				
CARTS RideCARTS Card Electronic Fare Payment System	Implement electronic fare collection system. CARTS is planning on using a magnetic-stripe card technology for their system. The cards can be recharged via internet or phone.	Cost: Unknown Funding Identified: Yes Benefits: Improved fare collection and patron convenience	Lead: CARTS Others: CapMetro	APTS4
RideCARTS Card Service Kiosks	Implement kiosks at CARTS transfer stations where patrons can purchase and recharge RideCARTS fare payment cards. In addition to CARTS transfer stations, a kiosk will be installed in the San Marcos AMTRAK station.	Cost: Unknown Funding Identified: No Benefits: Improved fare collection and patron convenience	Lead: CARTS Others: AMTRAK	APTS4
CARTS Web-based Reservation System for Paratransit	Implement web-based program to allow paratransit users to make trip requests and retrieve trip information online – tied in to Smart Card project.	Cost: Unknown Funding Identified: Yes Benefits: Improved scheduling and patron convenience	Lead: CARTS	APTS3 APTS4 APTS8
CARTS Intercity Bus Flag Stops	Implement technology at low-density stops on intercity routes to alert the driver that a passenger requiring pickup is waiting at the stop. The system will utilize the existing AVL network.	Cost: Unknown Funding Identified: No Benefits: Improved fixed route operations	Lead: CARTS	APTS3
CapMetro/CARTS CAD Coordination	Implement communications connections and software modifications necessary to link the CapMetro and CARTS CAD systems. Having CARTS vehicle locations in the CapMetro CAD system will support passenger transfers between transit providers	Cost: Unknown Funding Identified: No Benefits: Improved passenger transfers between transit agencies	Lead: CapMetro, CARTS	APTS7
Texas State University Transportation Department AVL	Implement AVL on Texas State University Transportation Department vehicles. AVL would enable dispatch to track bus locations. This real-time information could be shared with system patrons and also used in case of an incident. Cost represents an average cost per bus and includes some built in cost for software.	Cost: $5,000 per bus Funding Identified: Yes Benefits: Improved operations	Lead: Texas State University Transportation Department	APTS1

Table 13 – Public Transportation Management Project Recommendations (continued)

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Public Transportation Management Projects (continued)				
Texas State University Transportation Department Passenger Counters	Implement passenger counters on Texas State University Transportation Department vehicles to record boarding and alightings.	Cost: Unknown Funding Identified: Yes Benefits: Improved data collection	Lead: Texas State University Transportation Department	APTS4
Mid-Term Public Transportation Management Projects: 2012 – 2016				
CapMetro Regional Smart Card	Establish a regional Smart Card for payment of transit fares on CapMetro vehicles as well as other area transit agencies and parking facilities.	Cost: Unknown Funding Identified: Yes Benefits: Improved fare collection and patron convenience	Lead: CapMetro Others: CARTS	APTS4 ATMS16
CapMetro Security Monitoring Enhancements	Implement CCTV cameras at bus stops, transfer stations, park and rides and commuter rail stations – CCTV also used for operations with rail.	Cost: Unknown Funding Identified: No Benefits: Improved passenger and driver safety	Lead: CapMetro	APTS5
CARTS Security Monitoring	Implement CCTV cameras on buses and at transfer stations.	Cost: $5,000 per vehicle Funding Identified: Yes Benefits: Improved passenger and driver safety	Lead: CARTS	APTS5

[1]The design has not been undertaken and thus this is only an opinion of probable cost for planning purposes.

[2]Agency or agencies listed will play a role the planning, implementation, operations, and/or maintenance. The lead agency and any other agencies that have a stake in the project are identified.

[3]Partial implementation of market package as it applies to the identified project.

3.1.5 *Traveler Information Project Recommendations*

Table 14 – Traveler Information Project Recommendations

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Short-Term Traveler Information Management Projects: 2007 – 2011				
TxDOT 511 Traveler Information	Implement traveler information 511 phone service to make transportation information available to the public both pre-trip and real-time during their trip. The TxDOT Traffic Operations is leading this effort statewide. Real-time information will be needed from the TxDOT Austin District in order to provide 511 users information on travel conditions in the Austin Region.	Cost: Not yet determined Funding Identified: No Benefits: Provide pre-trip travel information and improved real-time traveler information	Lead: TxDOT Traffic Operations Division Others: TxDOT Austin District	ATIS1 ATIS2
TxDOT Travel Time Information	Provide travel time information on DMS within the Region. The TxDOT Traffic Operations Division is leading this effort with a projected implementation in early in 2008. The project is being completed with in-house staff but will require upgrades of some TxDOT Austin District field equipment.	Cost: TxDOT Traffic Operations Division is completing with in-house staff. Funding Identified: Yes Benefits: Improved traveler information	Lead: TxDOT Traffic Operations Division Others: TxDOT Austin District	ATMS06
TxDOT Traveler Information Website with Speed Maps	Implement a website to provide speed maps for advance traveler planning. The TxDOT Traffic Operations Division is leading this effort with a projected implementation in late 2008. The project will require the TxDOT Austin District to migrate to the Statewide Development and Integration Program developed software for Advanced Traffic Management Systems (ATMS).	Cost: TxDOT Traffic Operations Division is completing with in-house staff. Funding Identified: Yes Benefits: Provide pre-trip travel information	Lead: TxDOT Traffic Operations Division Others: TxDOT Austin District	ATIS1

[1]The design has not been undertaken and thus this is only an opinion of probable cost for planning purposes.

[2]Agency or agencies listed will play a role the planning, implementation, operations, and/or maintenance. The lead agency and any other agencies that have a stake in the project are identified.

[3]Partial implementation of market package as it applies to the identified project.

3.1.6 *Archived Data Management Project Recommendations*

Table 15 – Archived Data Management Project Recommendations

Program Area/Project	Description	Cost[1] and Benefits	Stakeholders[2]	Applicable Market Packages[3]
Long-term Archived Data Management Projects: 2017 – 2026				
CAMPO Data Warehouse	Establish a data warehouse to store transportation information from Capital Area Metropolitan Planning Organization (CAMPO) member agencies for use in transportation planning. Cost will depend on the level of functionality desired.	Cost: Unknown Funding Identified: No Benefits: Improved access to transportation statistics for use in planning	Lead: CAMPO Others: City of Austin, City of Round Rock, City of Cedar Park, City of Georgetown, CapMetro, CARTS, TxDOT	AD2 AD3

[1]The design has not been undertaken and thus this is only an opinion of probable cost for planning purposes.

[2]Agency or agencies listed will play a role the planning, implementation, operations, and/or maintenance. The lead agency and any other agencies that have a stake in the project are identified.

[3]Partial implementation of market package as it applies to the identified project.

3.2 Regional Communications

3.2.1 Communications Media Evaluation

Communications play a critical role in any ITS deployment. One of the primary purposes of an ITS architecture is to identify the data that needs to flow between agencies. Much of this data, such as video from CCTV cameras and real time traffic information, can require high bandwidth communication. Reliability of communications is also a concern. ITS functions are often most needed during major incidents, severe weather, or other emergencies. These are the same times that communications systems are often most stressed due to high call volumes and potential damage from severe weather events; therefore, no ITS deployment is complete without addressing the communications component of the project.

A robust and reliable communication system requires a substantial financial investment. Fiber systems may require miles of underground conduit, environmentally controlled hub buildings, and right-of-way acquisition. Wireless systems often require multiple repeater stations and may be subject to interference from other systems. New technologies are continually being introduced and often offer increased bandwidth and flexibility. It is important to evaluate the available options when deploying a project.

Maintenance of any communication system must also be carefully considered. Redundancy in the system adds reliability but also adds cost. If redundancy is not built into the communication system then an agency must be prepared with enough resources to quickly diagnose and repair problems. Even with redundancy, failures can happen and require that skilled maintenance personnel be available with the necessary parts to make a repair.

Resource sharing between agencies is often a very cost effective way to deploy communications. Resource sharing may be as simple as two departments within a municipality sharing the cost of a fiber installation, or it may be much more complicated, such as all of the partners at a regional TMC determining their share of the deployment cost of the communication system. Resource sharing can also apply to maintenance where multiple agencies establish a maintenance contract with a contractor or share maintenance personnel.

Several of the market packages identified in the Regional ITS Architecture will rely heavily on the communications systems in the Austin Region. These include:

- ATMS01 – Network Surveillance;
- ATMS03 – Surface Street Control;
- ATMS04 – Freeway Control;
- ATMS06 – Traffic Information Dissemination;
- ATMS07 – Regional Traffic Control;
- ATMS08 – Incident Management;
- ATMS21 – Roadway Closure Management;
- EM01 – Emergency Call-Taking and Dispatch;
- EM02 – Emergency Routing;
- EM06 – Wide Area Alerts;
- EM09 – Evacuation and Reentry Management;
- MC03 – Road Weather Data Collection;

- APTS1 – Transit Vehicle Tracking;
- APTS2 – Transit Fixed-Route Operations;
- APTS3 – Demand Response Transit Operations; and
- APTS7 – Multi-modal Coordination.

In addition to the above list of market packages, nearly every market package will rely on communications to some extent in order to be fully functional.

In the **Appendix**, a detailed discussion has been included that evaluates communication media that may be considered for implementation in the Austin Region. Leased lines, wireless, and fiber optic communications systems are discussed.

3.2.2 Radio Communications

In the Austin Region a user defined market package called Radio Communications Network (RCN01) was developed to address the need for improved radio communications. Radio communications are essential to many of the incident management, emergency management, maintenance, and transit operations in the Region. In addition to voice communications, stakeholders also envisioned the use of radio for data transmission in the Region. The technology used to transmit data, whether it is radio, fiber or microwave, is not generally shown in a regional ITS architecture; however, due to the importance of radio and the need for interoperability, stakeholders concluded it was important to clearly demonstrate the desired interoperability in the Region by creating a market package specific to radio communications.

In Texas, a Statewide Interagency Radio Working Group has been striving to identify solutions to the radio interoperability challenge. The group adopted the Association of Public Safety Communications Officials International Project 25 standards. Project 25 is not a single standard but rather a number of individual protocols that can be customized to meet the individual needs of an agency. The key is that any radios using the Project 25 standards should be able communicate with any other Project 25 radio regardless of the manufacturer. The Texas legislature has required that future radio equipment purchased by the state meet Project 25 standards.

Local governments are not required to use the Project 25 radios; however, all of the local agencies interviewed as part of the Regional ITS Architecture process expressed a desire for regional radio system interoperability. The greatest obstacles in achieving interoperability between all agencies are the costs involved in upgrading systems and purchasing Project 25 compliant digital radios for every vehicle.

A project was added to the ITS Deployment Plan to support the Radio Communications Network market package. The project, Regional Radio Interoperability, was added as a short-term Emergency Management project. The goal of the project will be to integrate radio systems for emergency and transportation agencies throughout the Region. Interoperability should include the ability to share both voice and data among all agencies in the Region.

4. MAINTAINING THE REGIONAL ITS DEPLOYMENT PLAN

Just as the ITS Architecture developed for the Austin Region documents the Region's goals for ITS implementation at the time it was prepared, the ITS Deployment Plan addresses the projects that stakeholders agreed were necessary to implement at the time the plan was developed in order to reach their ITS deployment goals. As the Region grows, needs will change, and, as technology progresses new ITS opportunities will arise. Shifts in regional focus as well as changes in the National ITS Architecture will necessitate the Austin Regional ITS Architecture be updated to remain a useful resource for the Region. These same changes will create new project opportunities and revisions to the projects in this ITS Deployment Plan.

Stakeholders agreed upon a procedure for updating the Regional ITS Architecture and Deployment Plan. The procedure, documented in the Austin Regional ITS Architecture, outlines how to document architecture changes for inclusion in the next plan update. While complete plan updates are scheduled to occur every four years, stakeholders agreed that it would be beneficial to review the projects identified in the ITS Deployment Plan once a year. The CAMPO Congestion Management Program and ITS Working Group will lead the annual project reviews. The purpose of the discussion would be to update the project status, remove projects that were completed, add project detail when available, and add new projects. Any corresponding architecture changes would be documented and retained by CAMPO for inclusion during the next complete update as outlined in the Regional ITS Architecture.

APPENDIX

A.1 Communications Media Evaluation

There are three primary candidate communication modes for use in transportation applications: leased telephone lines, wireless media, and fiber optic cables. Fiber optic cables are recognized industry-wide to provide the highest capacity along with the most flexibility to deploy multiple ITS applications or devices; however, fiber deployments, particularly underground installations, can sometimes be cost prohibitive. This section reviews the technical and cost implications of these communication media options. Each media is evaluated based upon attributes such as scalability, interoperability, security, and cost.

A.1.1 Leased Telephone Lines

The use of existing public telephone networks to carry traffic control information results in low initial capital costs, but there are recurring monthly charges for this service. Accordingly, the installation of a leased telephone line consists of both non-recurring and recurring costs. Non-recurring costs include the one-time charge for installing the service. Recurring costs consist of termination charges, long distance charges, and optional charges such as line conditioning. These recurring costs must be accounted for in an agency's operating budget. The fact that a third party is responsible for operating and maintaining the network is both an advantage and a disadvantage. On the positive side, the telephone service provider provides technical staff, spare equipment, and continuous monitoring. However, agencies are constrained by their contract agreement with the service provider when problems do occur. If it is a long-term contract, this means that an agency cannot terminate service without paying a penalty for early withdrawal from a contract. If the contract does not stipulate the response times during outages, then an agency may go without service for an extended period if the service provider has a higher priority. The monthly costs of leased line telephone services can increase unpredictably. Accordingly, long-term contracts can be structured to control the escalation of monthly costs. Member agencies may also be able to use State contracts and negotiate better rates than currently available through standard public tariffs.

Leased Telephone Line Technologies

There are a host of services available through service providers in the Austin Region. Some of these services and typical monthly costs (without government discounted rates) are described below:

- *Analog Plain Old Telephone Service (POTS)*: Low bandwidth analog services for standard voice telecommunications and dial-up modem circuits. These services are the same as typical residential telephone service, which provide support for analog dial-up modem throughput up to a maximum of 56 kbps provided the end-user equipment, such as a traffic controller, can also support that data rate. Typical dial-up phone service in the region is approximately $30 per month.

- *Digital Subscriber Line (DSL)*: There are different variations of DSL such as Asynchronous DSL (ADSL), Synchronous DSL (SDSL), and Rate Adaptive DSL (RADSL). As a service category, these will be collectively referred to as DSL. DSL provides medium bandwidth data services, which are typically offered for Internet access with relatively high download data rates (768 kbps) and a moderate upload rate (384 kbps). DSL circuits are generally less expensive than T-1 lines but are limited to a three-mile range from the nearest telecommunications provider central office. Typical

business class DSL circuits rated for 768 kbps bi-directional throughput average approximately $150 per month.

- *T-1/DS-1*: Medium bandwidth services offered for point-to-point telecommunications up to 1.544 Mbps. T-1s can be constructed to deliver 24 voice channels, all data, or a mixture of voice and data between two or more facilities. Unlike DSL, T-1s are not distance limited, but providers charge users for extended mileage. The average cost for a typical T-1 circuit for local use is approximately $500 to $700 per month. The disadvantage with point-to-point circuits is that redundancy can only be achieved by procuring a second T-1 circuit to an alternate location, which becomes very expensive to maintain across multiple sites. For this reason, point-to-point T-1s are not a likely communications choice for traffic management system deployments.

- *T-3/DS-3*: High bandwidth services for up to 44.736 Mbps, the equivalent of 28 T-1 circuits. Service providers generally combine multiple T-1 circuits from several locations into a single T-3 for delivery to a headquarters location instead of terminating multiple sets of T-1s. The average cost for a typical frame-relay T-3 circuit for local use is approximately $3,000 to $4,000 per month depending on the desired bandwidth from the service provider.

- *Frame Relay*: A packet technology designed specifically for delivering data services between multiple locations over a common circuit. Frame Relay services generally use T-1, T-3, or fractions thereof, to provide WAN connectivity between routers on a private network. Unlike point-to-point T-1s, frame-relay circuits can have "virtual circuit" connections to multiple destinations thereby increasing the reliability and redundancy without paying for additional circuits to alternate destinations. Frame Relay circuits are generally less expensive than conventional T-1/T-3 circuits. The average cost for a typical frame-relay T-1 circuit (768 kbps to 1.5 Mbps) for use in a local area is approximately $450 to $600 per month. Frame relay services can be provided with a private network Internet Protocol (IP) address accessible only by the owning agency or with a public IP address accessible over the Internet.

- *Asynchronous Transfer Mode (ATM)*: This is similar to Frame Relay in that it relies upon T-1 and T-3 circuits for physical transport. ATM uses much smaller packets called cells and has quality of service standards that create a real-time environment for voice and video telecommunications. While data transmissions do not have the same real-time requirements as voice and video, quality of service can also, for example, be applied to protect mission-critical applications from Internet traffic. ATM circuits are generally more expensive than Frame Relay and conventional T-1/T-3 circuits. The average cost for a typical ATM T-1 circuit (768 kbps to 1.5 Mbps) is approximately $600 to $800 per month.

Attributes of Leased Telephone Line Technologies

Table A1 provides a comparative summary of advantages and disadvantages for leased line communications. Leased-line technologies share the following attributes:

- *Scalability and Backward Compatibility*: This is an advantage of leased line networks because additional telephone lines can always be added. The public telephone network is designed for scalability from analog telephone line channels. As new telephone standards have been established, such as SONET, they have typically maintained the ability to interconnect with previous telephone standards such as T-1 or T-3. With leased lines, agencies operate with a pay-as-you-go communications structure.

Agencies can use analog dial-up lines for a few years until a need for higher bandwidth warrants upgrading to a T-1/DS-1 or above.

- *Interoperability*: Historically, this is an advantage of the public telephone network since different carriers must work together.
- *Security*: The traditional T-3, T-1, and standard telephone line offerings are highly secure because they are dedicated to, and only accessible by, the leasing agency. However, other types of services like frame relay and dial-up analog lines can potentially be intercepted or breached, particularly the latter where an errant telephone connection by a would-be hacker could potentially endanger a portion of the system.
- *Cost*: Initial installation cost of leased lines is low. As discussed above, the recurring operating costs are high and would need to be accounted for in the operating budget.

Table A1 – Advantages and Disadvantages of Leased Lines

Advantages	Disadvantages
▪ Low capital cost to deploy ▪ Limited obligation; use for temporary installations and disconnect when done ▪ Low maintenance because it is maintained by the telephone company ▪ Extensive trenching is not required ▪ Line-of-sight is not required	▪ Recurring monthly operating fees ▪ Available bandwidth usually limited ▪ Dependent upon telephone company for maintaining service (longer time to repair than for agency-owned system) ▪ High-bandwidth services not available in all locations

A.1.2 Wireless Modes

Wireless telecommunications are an alternate option for the design of a regional telecommunications network. Wireless data transmission does not require trenching, attaching, or boring to install conduit for fiber optic or twisted-pair cable. This can be advantageous in rugged terrain, over bodies of water, in environmentally sensitive areas, where the cost of right-of-way acquisition is high or there is a lack of right-of-way, or in temporary installations. Wireless telecommunications can be described in terms of low bandwidth multi-point systems and high bandwidth point-to-point systems. Multi-point systems have the ability to communicate with multiple locations/devices from a single master modem, similar to the fiber ring topology. Point-to-point systems can only communicate with one device from a signal modem.

Regional data networks often demand high bandwidth and bi-directional telecommunications, which places limits on the wireless telecommunications format selected. For instance, low-frequency radio systems cannot effectively carry full-motion video over extended distances. Such a wireless signal would not be expected to be sent more than a few miles over a low-power, unlicensed medium without a reduction in bandwidth capacity and an increase in potential interference.

In cases where security, exclusivity, and long-term reliability are an issue, a licensed radio system is the preferred type of radio system. The owner acquires a specific frequency from the Federal Communications Commission (FCC) and theoretically should not experience problems with radio emissions from other systems. The downside of the licensed format is acquisition and study costs, as well as a lengthy licensing process. Frequency searches must be performed, and preliminary notices filed before the FCC license is issued. However, licensed wireless systems have a long history of success. For years, point-to-point

microwave systems have been the medium of choice for phone companies, cable TV companies, utilities, railways, paging companies and public sector agencies, and they will continue to be an important part of the national telecommunications infrastructure.

Wireless Technologies

There are several key wireless technologies available. They include:

- *Microwave*: Microwave systems offer capacity up to 622 Mbps, though systems above 155 Mbps are generally much more costly. The largest expense of wireless systems has traditionally been the network of towers required to establish a line-of-sight between the various destinations. Microwave range is dependent upon radio frequency and signal strength and typically varies from approximately 1 to 25 miles under ideal conditions. Adverse weather conditions can have a significant affect on system performance, particularly if the system was designed for ideal conditions. Microwave network architectures include daisy-chain/repeater, ring, and central hub/relay configurations. Microwave equipment is available in both licensed and unlicensed frequency bands.

- *Spread-Spectrum Radio (SSR) for Low-Speed Data*: Several unlicensed frequency bands (902-928 MHz, 2.4-2.4835 Gigahertz (GHz), and 5.725-5.85 GHz) are available in the United States for general public usage. Many of these frequencies have become overcrowded, making them unsuitable for high-capacity connections. SSR applications are commonly used in remote areas to minimize the potential for interference, but experience has shown that even in remote areas interference can still be a problem with antennas in close proximity with one another. The advantage of the SSR system is that no license is required and there are no fees; therefore the system may go online immediately. Lower bands of SSR are less susceptible to weather attenuation than the higher bands. When designing an SSR system, conservative distance limits should be used in order to compensate for adverse weather.

- *Wireless LAN*: Institute of Electrical and Electronic Engineers (IEEE) standards 802.11a, 802.11b, and 802.11g (Wi-Fi), address wireless LAN technologies over the 915 MHz, 2.4 GHz and 5.8 GHz license-free bands.

  Table A2 shows the available bandwidth and relative transmission range comparisons between the three bands. The 5.8 GHz band generally experiences less interference.

Table A2 – Wireless Local Area Networks

	915-MHz Band	2.4-GHz Band	5.8-GHz Band
Available Frequency Range	26 MHz	83.5 MHz	125 MHz
Approximate Throughput (Bandwidth)	11 Mbps	36 Mbps	54 Mbps
Transmission Range	Longest (power dependent)	95% of 915 MHz	80% of 915 MHz (with antenna gain)

Although the distance from the access point at which wireless networks can operate is limited, wireless signals can be received at distances of several hundred feet beyond the physical perimeter of a facility. This presents a security concern because unauthorized users outside of the facility have the opportunity to compromise network security and

gain access to the network, which warrants additional measures to secure wireless LANs (WLANs). One key issue when developing a WLAN is the difficulty presented by the wired equivalency protocol (WEP). To overcome this issue, security standards were developed by IEEE giving detailed specifications to enhance the security features provided in WLAN systems.

The original 802.11 specification was developed using Service Set Identifier (SSID), Media Access Control (MAC) Address Filtering, and WEP to protect the WLAN. The SSID is a broadcast that identifies/distinguishes each WLAN. Once the network is configured, the SSID broadcast can be turned off to prevent its presences from being widely known. MAC is the technology that restricts WLAN access to only specified computers. WEP is an encryption scheme, with known security flaws, that provides minimal protection of WLAN data streams between clients and access points specified by the 802.11 standards.

Because Wi-Fi/WLAN uses the same frequency bands as unlicensed spread-spectrum radios, the same susceptibility to weather attenuation and interference from other systems applies.

Worldwide Interoperability for Microwave Access (WiMAX) is the IEEE standard for wireless broadband access for both mobile and fixed point-to-point and point-to-multipoint applications. IEEE 802.16 was originally specified for the frequency range between 10 to 60 GHz, but was later modified to support frequencies from 2 to 11 GHz in version 802.16a. WiMAX provides better security and increased bandwidth in comparison with Wi-Fi standards. While the standards also call for provisions for non-line-of-sight conditions, particularly for the 5 to 6 GHz band, the performance of links under those conditions is not yet well known.

- *Millimeter Band:* The existing 60 GHz band as well as the pending bands in the 71-76, 81-85, and 92-95 GHz ranges support applications such as high-speed LAN connections, broadband Internet access, point-to-point telecommunications, and point-to-multipoint telecommunications. These bands allow many broadband users to establish MANs with little risk of interference due to the narrow beam width of this spectrum. Millimeter band transceivers have a nominal range from 0.6 miles up to one mile with a clear line-of-sight, which already compensates for weather attenuation. Due to this distance limit between transceivers, millimeter equipment is generally not as cost effective as microwave for establishing a WAN over long distances, nor is it cost effective for distribution.

Wireless Technology Licensing Requirements

While some of the wireless technologies discussed in this section are licensed, others are not. Unlicensed bands have a greater potential for interference from other sources at the time of installation or in the future, and there is no recourse for interference in the unlicensed bands.

Table A3 summarizes which of the discussed technologies are licensed and which are not. As projects near the design phase, the FCC coordinator for the area will be able to indicate which frequencies are available at that time.

Table A3 – Wireless Technology Licensing Requirements

Technology	Typical Use	Licensed or Unlicensed
Microwave	Moderate distance, line of sight, point to point transmission	Licensed and unlicensed bands available, contact FCC Coordinator for availability
Spread Spectrum Radio	Moderate distance, point to point transmission, most effective in rural areas with minimal interference due to crowded nature of these bands	902-928 MHz – unlicensed 2.4-2.4835 GHz – unlicensed 5.725-5.85 GHz – unlicensed
Wireless LAN	Short distance, point to point and point to multi-point transmission, unlicensed bands are most effective in rural areas with minimal interference due to crowded nature of these bands	Licensed and unlicensed bands available, contact FCC Coordinator for availability 700 MHz – licensed 902-928 MHz – unlicensed 928-960 MHz – licensed 2.3 GHz – licensed 2.4-2.4835 GHz – unlicensed 2.5 GHz – licensed 4.9 GHz – licensed for public safety uses 5.725-5.85 GHz – unlicensed
Millimeter Band	Short distance, point to point and point to multi-point transmission	60 GHz – unlicensed 71-76 GHz – licensed 81-85 GHz – licensed 92-95 GHz – licensed, contact FCC Coordinator for availability

Attributes of Wireless Technologies

Table A4 provides a comparative summary of advantages and disadvantages for wireless communications. Wireless technologies share the following attributes:

- *Scalability and Backward Compatibility*: Wireless networks are not generally scalable. The equipment/transceivers are configured for a specific bandwidth capacity and application and rarely allow for upgrades other than replacement. Capacity-wise, the allocated spectrum in the unlicensed bands varies dramatically, which heavily impacts the scalability of a wireless network. The 2.4 GHz band can realistically provide 10Mbps capacity on most links, for 5.8 GHz and 24 GHz it is closer to 100 Mbps, whereas the 60 GHz band can provide upwards of 1.25 Gbps. Any consideration for wireless as a backbone should be focused on using the 60 GHz band.

- *Interoperability*: Interoperability in the WLAN environment is well established through IEEE standards-based equipment. However, in the backbone environment, microwave and millimeter band equipment is largely proprietary over the wireless interface, which currently requires each link to be configured with matching equipment. This situation is anticipated to be addressed by the Wi-Max standards.

- *Security*: WLAN wireless telecommunications is not very secure due to the wide availability of Ethernet monitoring tools and wireless WLAN transceivers. On the other hand, security of microwave and millimeter band transmissions is high because they are much more directional, require sophisticated equipment, and require a direct line-of-sight to intercept transmissions.

- *Cost*: Initial installation cost of spread-spectrum low-speed data networks is fairly low in comparison to fiber and leased lines, averaging about $3,000 to $5,000 per link. Installation cost of microwave and millimeter links are high and largely depend upon the associated cost of towers in specific locations to achieve line-of-sight. Millimeter equipment (without poles or towers) is currently ranging between $20,000 and $30,000 per pair. Recurring costs for wireless networks are moderate, as they require more frequent maintenance than fiber optics.

Table A4 – Advantages and Disadvantages of Wireless

Advantages	Disadvantages
▪ Can transmit data and a limited number of full motion video channels ▪ Can use both analog and digital transmission standards ▪ More economical than underground infrastructure for rural/remote applications ▪ Rapid deployment ▪ No land line interconnect required ▪ Potential for short-range connections of traffic control system applications to a backbone (i.e. fiber, leased line) ▪ May prove effective for temporary or interim installations	▪ Higher lifecycle cost to deploy ▪ Requires line-of-sight for millimeter and microwave backbone ▪ Some jurisdictions may have difficulty gaining approval for new towers where line-of-sight is limited by vertical obstructions (i.e. trees, buildings, etc.) ▪ Susceptibility to security breaches, particularly for omni-directional Wi-Fi systems ▪ Susceptibility to weather and EMI/RFI interference ▪ Backbone would require 60 GHz equipment to serve the video bandwidth needs of the City ▪ Backbone is not scalable without significant equipment replacement ▪ Unprotected channel space/shared with other users ▪ Requires more sophisticated equipment and specialized technicians to operate and maintain the system

A.1.3 Fiber Optic Communications Systems

Fiber optic cables coupled with fiber optic transceivers provide digital high-speed capability for voice, data, and video transmission. There are two primary factors to consider when choosing fiber optic systems: 1) the type of cable (single-mode vs. multi-mode) and 2) the technology/optical equipment that will be used with the cable.

Fiber Optic Cables

Two types of cables are generally used for fiber optic applications: single-mode and multi-mode. While multi-mode fiber has a bandwidth distance attenuation characteristic that causes the bandwidth to decrease the farther it is transmitted, single mode fiber has significantly less signal attenuation. This characteristic permits transmission over greater distances, providing a greater opportunity for expansion. Another benefit of single-mode fiber versus multi-mode fiber is that it is two to five times less expensive. The optical modems and fiber connections are more expensive for single-mode, but the fiber cable cost savings generally negate this difference. For example, over a two-mile span of 12-fiber cable, a single-mode cable costs approximately $0.60/foot plus $2,500 for each optical modem (spaced one mile apart), totaling approximately $11,500. In comparison, a multi-

mode cable costs approximately $1.80/foot and $1,500 for each optical modem, totaling approximately $22,000 for the same two-mile installation. The capacity (both bandwidth and distance) and flexibility provided by fiber optic cables far exceeds the slightly higher cost of installing fiber optic cable versus other media (e.g. copper twisted-pair).

Fiber Optic Technologies

Once the physical cable is installed, there are several fiber optic technologies suitable to manage information transfers over the cable. These technologies vary in the way they manage the use of the cable, as well as the method for packaging/transferring the information between the field cabinet and the management center. These technologies include Synchronous Optical Networks (SONET), Wave Division Multiplexing (WDM), Gigabit/10 Gigabit Ethernet (GigE and 10GigE), and Passive Optical Networks (PONs).

- *SONET:* SONET defines interface standards at the physical layer of the Open System Interconnection (OSI) seven-layer model. SONET was designed to replace its twisted-pair predecessors with much more capacity, increased flexibility to administer changes, and increased capability to manage the network from one location. SONET standards provide both forward-compatibility with future equipment as well as backward-compatibility with existing telephone carrier equipment, protecting long-term capital investment. The standard defines a hierarchy of interface rates that allow data streams at different rates to be multiplexed. SONET establishes Optical Carrier (OC) levels from 51.8 Mbps (about the same as a T-3 line) to 10 Gbps. SONET architectures are capable of efficiently handling large amounts of bandwidth for multiple carriers and customers. SONET's bandwidth characteristics are described in terms of optical carriers (e.g. OC-X) with capacities as shown in **Table A4**. When higher capacity SONET equipment is introduced to the market, the opportunity to upgrade is always available by either swapping out modules or adding new optical shelves to increase the system capacity. The increased availability of WDM further protects fiber investment by providing virtually unlimited capacity if utilized in a regional network. WDMs provide the ability to multiplex multiple optical signals across one fiber without degrading the transported data.

Table A4 – Bandwidth Table

Digital/Optical Signaling Level	Line Rate (Transmission Speed) in Mbps
DS-0	0.064
DS-1/T-1	1.544
OC-1 (equivalent to DS-3/T-3)	51.84
OC-3 (equiv. to 3 DS-3s)	155.52
OC-12 (equiv. to 12 DS-3s)	622.08
OC-48 (equiv. to 48 DS-3s)	2488.32
OC-192 (equiv. to 192 DS-3s)	9953.28

SONET establishes fixed bandwidth channels (e.g. DS-0s and DS-1s) that can be terminated anywhere around the ring. Because each channel is dedicated for a specific purpose, when it is not in use other channels cannot take advantage of the unused capacity. SONET was designed to accommodate all of the prevalent legacy telecommunications circuits such as analog voice circuits (DS-0s) and digital T-1 circuits (DS-1s).

The use of T-1/DS-1 interfaces allows agencies to communicate between legacy voice telecommunications equipment such as between two private branch exchange (PBX) telephone systems. However, if a small remote office location only has conventional analog telephone lines, ISDN, or something less than T-1 speed capabilities, a T-1 channel bank would be required in order to provide 56 kbps/64 kbps voice telecommunications circuits for up to 24 simultaneous users.

Even with the evolution of lower cost technologies such as Gigabit Ethernet, backbone providers still install SONET for four primary reasons: reliability, interoperability, compatibility with legacy communication standards, and network management. Reliability of SONET networks provides the ability to restore or re-route around a failed component or fiber in less than 200 milliseconds. Industry interoperability standards allow owners and providers to interconnect with other owners and providers without requiring the use of the same vendor's equipment and without sacrificing security within their network. SONET network management is well defined, extending beyond alarm and failure monitoring into network provisioning (setting up and removing circuits from one location to another). However, network provisioning for SONET and ATM equipment is much more complex than the Ethernet networks that most Information Technology departments are accustomed to operating.

- *Coarse or Dense WDM (CWDM or DWDM)*: In a WDM system, each wavelength operates as an entirely separate carrier channel. Wavelength is the inverse of frequency, and WDM is, in essence, the optical equivalent to Frequency Division Multiplexing (FDM). Each wavelength can run at a different rate than the others. In the recent past, there were two primary ways to increase backbone capacity. The first was to replace the optical carrier equipment with higher capacity equipment or optical transceivers (e.g. OC-12 to OC-48). The second involved using more fibers to run a separate ring and distribute the load across two or more networks. CWDM and DWDM allow the latter to occur without any additional fiber strands on the backbone.

  WDM systems can transmit SONET OC-48 on some wavelengths, while others are simultaneously transmitting one or ten Gigabit Ethernet or even proprietary multiplexers without interference between channels or wavelengths.

  WDM uses tunable lasers that emit light at different wavelengths. Each wavelength is transmitted through a separate window onto a single optical fiber. Light detectors at the receiving end detect their respective wavelength. International Telegraphic Union (ITU) has adopted a standard set of grid wavelengths to allow the industry to produce standard optical amplifiers instead of proprietary amplifiers specific to each WDM manufacturer. ITU Grid-compliance also enables the use of small-form factor optical add/drop filters to be inserted into the network without requiring a complete multiplexer if only one type of service (i.e. data) is required at a given drop location.

  DWDM contains a dense amount of wavelengths and therefore requires precise temperature control of transmitter lasers to prevent "drift" off a very narrow center wavelength. CWDM systems require less precision in regards to the transmitter lasers due to a less dense amount of wavelengths on the fiber. CWDM devices have dropped in price to the point where they are similar in price to end-user equipment such as Ethernet switches. DWDM systems are significantly more expensive than CWDM because the laser transmitters need to be significantly more stable than those needed for CWDM. DWDM systems are better suited for applications needing a fast connection over longer distances (i.e. long-distance telephone carriers).

WDM can be deployed in a star, mesh, or even a ring-based topology. Star and mesh configurations generally require a separate pair of WDMs for each link. If one site needs to communicate with three others, three separate WDM pairs would be required. On the other hand, in a ring configuration, it is necessary to introduce an additional function known as optical add/drop multiplexing (OADM) commonly found in SONET equipment. This functionality allows the optical network to use a single multiplexer to receive from one path and transmit/forward to the next path without dropping all wavelengths and regenerating every carrier signal.

- *Passive Optical Network* (PON): A PON is an optical system that has active electronics only at the endpoints, such as an office, traffic management center (TMC) or field cabinet/device. Between endpoints, the network consists only of passive components including fiber optic cabling, optical splitters/combiners, and splice enclosures. There are no active electronics or metal connectors to corrode, degrade from heat, or weaken and fail over time.

  A PON generally consists of one or two shared optical fibers connecting a service provider (or head-end) to a fan-out device located near customers or field devices, along with dedicated optical fibers between the fan-out device and each field device. For a PON serving N field devices or drop locations, the fan-out device is either a 1-to-N optical power splitter or a 1-to-N wavelength-division de-multiplexer (or a combination of both). This results in a 1-to-N (or N-to-1 for the return path) topology over an optical path. It is "transparent" to bit rate, modulation format (e.g., digital or analog), and protocol (e.g., SONET, ATM, Ethernet), which allows services to be mixed or economically upgraded in the future as needed. New services and field devices can be added by changing equipment only at the ends of the network and only for the affected field devices rather than visiting all cabinets on a daisy-chain or fiber ring. Such flexibility is not generally the case in most of today's other network architectures.

  The PON technology uses a passive splitter between the head-end's optical line terminal (OLT) and the optical network units (ONU) at the remote end. The splitter divides the downstream signal from the OLT into several identical signals that are broadcast to the ONUs. Each ONU is responsible for determining what data is intended for it and ignoring everything else. Upstream signals are handled by time-division multiplexing (TDM) in which ONU transmitters operate in burst mode. The main obstacle for reducing the deployment cost is the ONU at the remote end, which typically would be associated with a residence or business. Industry analysts have targeted ONU costs of $1,000 per ONU for wide-scale deployment. ONU manufacturers are developing efficiencies within the production environment and working with researchers to lower the ONU costs over the next several years.

  There are currently three prominent varieties of PON: ATM PON (APON), Ethernet PON (EPON), and Gigabit PON (GPON). A downside of this technology is that the connections between the OLT and ONU are not compatible with equipment compliant with the IEEE 802.3 Ethernet standard and few vendors currently offer products supporting Gigabit PON.

- *Gigabit and 10-Gig Ethernet (GigE)*: Gigabit Ethernet is an extension of the 10 Mbps (10Base-T) Ethernet and 100 Mbps (100Base-T) Fast Ethernet standards for network connectivity. Ethernet itself is a local area network (LAN) protocol standardized to allow multiple users to access a common logical bus structure. IEEE approved the Gigabit version of the Ethernet standard, 802.3z, in June 1998.

In the past, one potential issue in dealing with Ethernet has been the deployment of video and other multimedia applications, whereby few guarantees could be made for the quality of image transmission because it was treated the same way as any other Ethernet data connection. Standards bodies have since addressed these concerns and issues by adapting quality of service priorities for use in managing voice and video traffic. Video and voice services are classified with the highest quality of service priority since they require real-time transmission characteristics. Data, on the other hand, can be characterized to obtain the remaining available bandwidth as the network permits. Video and voice traffic require encoding devices to convert analog inputs to digital streams for transmission across the network. A typical MPEG2/MPEG4 video codec would cost approximately $2,000 to $4,000 each for a standalone device that can be remotely managed. For a typical signal system application, each field cabinet's communication equipment would be comprised of an Ethernet switch with optical and copper connections, an Ethernet video codec (only at camera locations), and a serial port terminal server (only for signal controllers or other devices that do not currently support Ethernet communications).

Gigabit Ethernet has a transmission range of 5 km (3.1 miles) over single-mode fibers using standard transceivers although some manufacturers have managed to exceed the standard by an increased transmission range of 10 km (6.2 miles). Extended range transceivers are available from most manufacturers upwards of 70 km (43.5 miles). However, they must be closely matched to ensure both ends maintain equivalent optical link characteristics. The distance that single-mode transceivers can obtain is equivalent to Gigabit Ethernet (GigE) at 5 km (3.1 miles). In June of 2002, 10 Gigabit Ethernet (10GigE) was ratified as the IEEE 802.3 standard. 10GigE combines multi-gigabit bandwidth and intelligent services to achieve scaled, intelligent, multi-gigabit networks with network links that range from 10 Mbps to 10,000 Mbps. With this technology, Ethernet will run at 10 Gigabits per second, serve as a LAN connection, work in metropolitan-area networks (MANs) and wide-area networks (WANs). One big advantage to 10GigE is that it can fit neatly within a SONET OC-192 channel with little waste, whereas GigE wastes 60 percent of an OC-48 channel and is 40 percent larger than an OC-12.

With both GigE and 10GigE standards, ring-based, mesh-based, or star topologies can be deployed, provided that some form of Equal Cost Multipath Routing (ECMR) is used to effectively manage the redundant links. Ethernet is a well-known standard among Information Technology departments and companies. Therefore, it is easier to identify resources equipped to configure, administer, and troubleshoot networks designed around Ethernet standards.

Gigabit Ethernet backbone solutions are much less expensive for data applications than SONET or WDM. A typical Open System Interconnect (OSI) layer 3 router/switch with redundant power, 32 ports of 10/100 Ethernet, and 2 Gigabit Ethernet fiber ports, can range from $10,000 for a fixed configuration up to $60,000 for a modular configuration. Two fibers are required for each Gigabit Ethernet backbone link unless WDM technologies are used in conjunction with the Ethernet platform. WDM adds approximately $80,000 per network link that provides 8 wavelengths of additional capacity (e.g. 8 Gbps).

Other Networking Technologies

The following technologies may have future value as a system expands and these standards mature:

- *IEEE 802.17 Resilient Packet Ring (RPR) over Gigabit and 10 Gigabit Ethernet*: RPR and the earlier proprietary Cisco implementation Spatial Reuse Protocol (SRP) provide metropolitan area networks with the reliability, management, and real-time voice and video benefits of SONET, with the lower overhead and provisioning flexibility of Ethernet. Future upgrades to the standard include different physical layers and elegant ways of bridging between rings. Due to rings not being multivendor, interoperability is not currently a key issue with RPR. However, in the future it is possible interoperability will enable service providers to extend functionality from one ring to another. RPR appears to be a technology worth following for future implementation, but in its current form this technology is not an ideal solution for the intentions of this project due to the proprietary nature of the currently available equipment.

- *Hot Standby Router Protocol (HSRP)*: This proprietary protocol is designed for use over a Cisco-based multi-access, multicast or broadcast capable LANs (e.g., Ethernet). Using HSRP, a set of routers work in concert to present the illusion of a single virtual router to the hosts on the LAN. This set is known as an HSRP group or a standby group. A single router elected from the group is responsible for forwarding the packets that hosts send to the virtual router. This router is known as the active router. Another router is elected as the standby router. In the event that the active router fails, the standby assumes the packet forwarding duties of the active router. Although an arbitrary number of routers may run HSRP, only the active router forwards the packets sent to the virtual router. To minimize network traffic, only the active and the standby routers send periodic HSRP messages once the protocol has completed the election process. If the active router fails, the standby router takes over as the active router. If the standby router becomes the active router, another router is elected as the standby router. This reduces the impact of a single component failure dramatically affecting the rest of the network/system.

- *Virtual Router Redundancy Protocol (VRRP)*: This open standard protocol eliminates the single point of failure inherent in the static default LAN/WAN/MAN routed environments by specifying an election protocol that dynamically assigns responsibility for a virtual router to one of the VPN (Virtual Private Network) concentrators on a network. The functionality is equivalent to Cisco's proprietary HSRP. The concentrator that controls the IP address(es) associated with a virtual router is called the Master, and forwards packets sent to those IP addresses. When the Master becomes unavailable, a backup concentrator takes the place of the Master. The advantage gained from using VRRP is a higher availability default path without requiring configuration of dynamic routing or router discovery protocols on every end-host.

Attributes of Fiber Optic Technologies

Fiber optic technologies share the following attributes:

- *Scalability and Backward Compatibility*: These are salient features of fiber optic networks because single mode fibers have yet to reach a quantifiable limit in bandwidth capacity. Standards such as SONET and Ethernet continue to migrate to higher bandwidths while maintaining backward compatibility. Likewise, CWDM and DWDM

manufacturers continue to increase the number of wavelengths that can be carried over a single pair of fibers.

- *Interoperability*: The backbone environment is available for fiber optic networking equipment. Multi-manufacturer interoperability tests have been performed in independent labs for SONET and Ethernet equipment. Basic network management is accommodated between multiple vendors, but configuration and circuit provisioning generally must be performed using each vendor's proprietary tools.

- *Security*: In general, fiber optic telecommunications is highly secure; however, the level of security depends largely upon the technologies deployed on the fiber optic cable network (i.e. SONET is inherently more secure than Ethernet due to the dedicated bandwidth/channels allocated to each user group, as well as the out-of-band administration of those channel assignments).

- *Cost*: Initial installation cost of agency-owned fiber networks is moderate, but the recurring operating costs are relatively low. Typical fiber optic cable deployments range from $100,000 per mile for aerial cable routes, to $150,000 per mile for suburban underground conduit installations. Urban environments with concrete encased duct banks are even higher.

  New installation techniques such as micro-tubing are providing additional options to agencies to re-use existing conduit by "jetting" micro-tube innerducts within spare capacity of existing conduits. These micro-tubes can then be used to jet new fiber optic cables into the micro-tubes at a cost much less than installing all new conduit systems.

Table A5 lists the advantages and disadvantages of the fiber optic medium.

Table A5 – Advantages and Disadvantages of an Agency-Owned Fiber Optic Network

Advantages	Disadvantages
▪ Ability to carry full-motion video, high-speed data, and voice telecommunications ▪ Fault tolerance capabilities ▪ High bandwidth capacity ▪ Not susceptible to EMI/RFI interference ▪ Long distances supported ▪ No monthly operational fees ▪ Low maintenance costs	▪ Higher cost to deploy infrastructure ▪ Longer time to deploy ▪ Requires physical path to all elements