Intelligent Transportation System (ITS)
Five-Year Operations Plan

Prepared For

Public Works Department
City of Sugar Land
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Executive Summary

Introduction

Intelligent Transportation Systems (ITS) is a way of improving transportation through advanced technology and information systems that maximize the safety and efficiency of the transportation infrastructure. The two principal ways of improving transportation in the Sugar Land area are through better Traveler Information Systems and Traffic Management Systems.

The Public Works Department of the City of Sugar Land, Texas engaged the services of Naztec ITS, supported by ARINC and Cisco Systems, for the development of the City's Intelligent Transportation System (ITS) Five-Year Operations Plan. The basic goal of this ITS Operations Plan was to identify a series of improvement projects to address the transportation-related functional requirements for the City of Sugar Land, with an objective of providing advanced transportation management system improvements throughout the City.

Meetings were held with City departments and other potential stakeholders. Focus groups provided feedback via a series of questions in an effort to identify key concerns, probable ideas for solutions, and hopes for the future regarding traffic matters. Potential projects were identified for the transportation problems and needs of the City as a series of transportation related functions. Most of these functions are based on the National ITS Architecture and are described as "market packages". The project's technical activities encompassed:

- Documenting the existing conditions of ITS related systems and networks
- Identifying deficiencies in the transportation related systems through an assessment of transportation problems and needs
- Selecting candidate ITS improvements to address problems and needs and establishing an initial priority for each of the projects
- Identifying the Functional Requirements of the ITS Operations Plan and a "High Level" Systems Architecture that will be followed in the implementation of these improvements
- Developing a prioritized ITS Operations Plan to guide the implementation of ITS elements
- Preparing an Implementation Plan for these improvements that conforms to the Code of Federal Regulations Title 23 (23 CFR)

Key Findings

Existing conditions of the ITS related systems and networks in the City were evaluated. The City manages and operates:

- Seventy-four (74) traffic signals
    - The Traffic Management Center (TMC) is connected to signal subsystems via Integrated Services Digital Network (ISDN) lines
        - ISDN lines leased at a current rate of $100/month for each line

    - Eleven subsystems utilizing various communication media
        - Spread spectrum radio equipment (nine systems)
        - Twisted pair copper communications cable (one system)
        - Fiber optic cable (one system)
    - Remote CCTV surveillance cameras are located at 20 intersections
    - Video Image Vehicle Detection system (VIVDS) cameras at 20 intersections
    - Extraterritorial Jurisdiction (ETJ) has approximately 20 signalized intersections

- High-speed single mode fiber optic cable
    - Connects eleven major City facilities
        - Police Station
        - Six Fire Stations
        - City Hall
        - Public Works Department
        - Fire Administration Building
        - FAA Control Tower at the City airport
    - The fiber optic network lease agreement is due to expire in the year 2015

- City website provides transportation-related information
    - Hurricane season and evacuation routes
    - Roadway construction project summaries and updates
    - Traffic updates – construction and weather related alerts
    - City of Sugar Land Highway Hotline Telephone Number
    - Link to the Houston TranStar Real-Time Traffic Map
    - Link to TREK (provides service between Sugar Land and Greenway and Uptown, plus a connection to METRO's Park & Ride facility at West Bellfort)

Improvement Projects

Based on stakeholder input, a number of project types have been developed for achieving Sugar Land's vision, goals and objectives. These projects have been divided into five groups, each representing a particular type of improvement. These groups are:

- Traffic Signal System Improvements
- Safety Enhancement Projects
- Traveler Information and Information Sharing with Regional Agencies
- Transportation Management
- Other Projects

There are four projects that constitute the core of the City's ITS Operations Plan:

- Install Wireless Communications Infrastructure for ITS Field Equipment (2009)
- Upgrade Traffic Controllers to Ethernet-Based Units (2009)
- Expand System Detection Network (2009)
- Expand CCTV Surveillance System (2010)

The core projects listed above will enable additional ITS projects to be implemented. The list below includes the additional projects identified in the ITS Five-Year Operations Plan:

- Citywide Traffic Signal Timing Optimization (Continuing)
- Central Traffic Adaptive Software Module (2009)
- Traveler Information Website Integration (2009)
- Install Permanent Dynamic Message Signs at Selected Locations
- ATMS & Emergency Services Integration
- Install Parking Availability System
- Central Fleet Management Software Module
- Central Traffic Signal Priority Software Module
- Expand Driver Feedback Speed Signs
- Railroad Crossing Monitoring System
- Share Data and Video with TxDOT and Neighboring Cities
- Public Works Vehicle Payload Monitoring System
- Enable System Data Exchange
- Exchange Data with Mobile Command Post for Traffic Incidents

After the core projects have been completed, the additional projects can be pursued based on funding availability and the current City priorities. Funding may be available through the Houston-Galveston Area Council, Texas Department of Transportation, or City funds.

Dedication of adequate resources for operation and maintenance is required to fully realize the capabilities of the ITS devices. Staffing levels should provide for operation, maintenance, video surveillance and network management. The ITS systems being implemented in Sugar Land are complicated and complex which require specific staffing characteristics. The staff will need to be highly specialized and trained for the advanced systems being implemented in Sugar Land. Standard staffing with average training will not be able to utilize or maintain the complex ITS system required to provide the level of service expected. In addition to their current duties, traffic operations personnel will be responsible for tasks associated with new system implementation, scheduling, conflict mitigation, updating timing plans, developing and updating traffic responsive signatures, testing, inspection, and system evaluation. A significant amount of initial training will be required to ensure that the staff is qualified to operate and maintain new equipment. Training will be provided on operation of new central system modules, Ethernet hardware and communications, wireless communications equipment, and new systems hardware and software as they are installed and implemented. Initial training will be provided by the system or equipment provider. A firm commitment to providing both personnel and budgetary resources is critical to the success of the City's overall ITS program.

The City currently operates the TMC five days a week, Monday through Friday. Expanded hours of operation of the TMC could potentially be accommodated by having staff working in two shifts, with a period of operator overlap due to flexible hours. The system should also be operated during scheduled special events and during incidents using comp-time or overtime. The operator would be available to help with other traffic tasks during off-peak

periods. The City plans to operate the TMC on Saturdays in the near future. The extensive retail corridor along SH 6 produces consistently high levels of traffic volumes and congestion on weekends. The traffic activity is more volatile and less predictable than weekday peak traffic traveling to and from work. The operator at the TMC on weekends would modify traffic signal timings to smooth the traffic flow and minimize congestion by observing areas of congestion via the CCTV cameras. As the City grows and the system expands, the City should plan to accommodate a seven days per week operation of the TMC, especially during the holiday shopping season.

In summary, it is recommended that the following staffing/personnel actions be implemented:

- Create and fill a Engineer II, Construction Inspector, and two Traffic Technician II position for system operations and enabling 7-day operation
- Create and fill two Traffic Technician I for signs/markings due to annexation
- Create and fill a Engineer I and two Crew Chiefs
- Combine the functions of the Traffic Operations Supervisor with the Traffic System Operator position

Conclusion

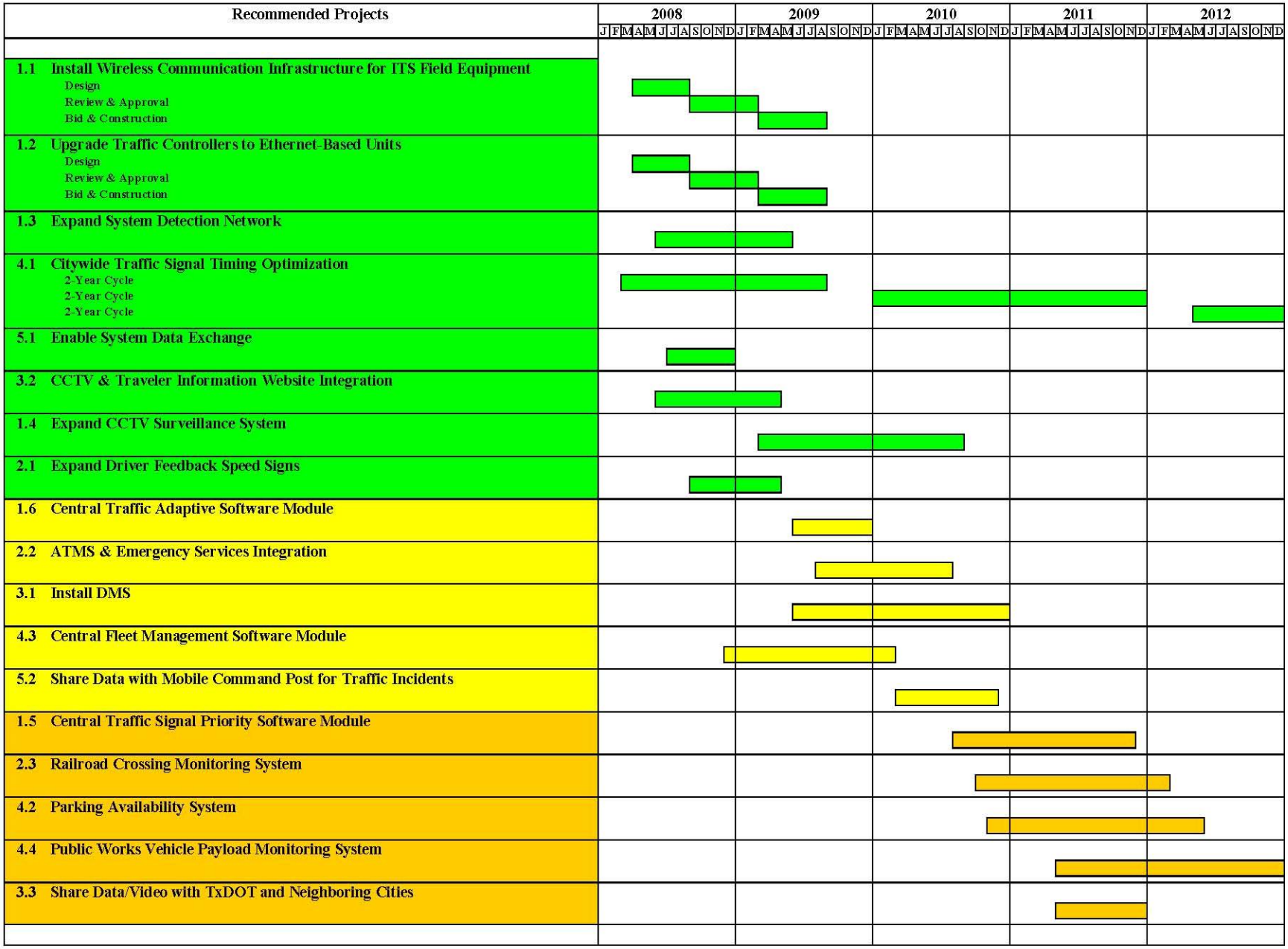
The full text of the ITS Operations Plan and its Appendices provides more information on the various activities associated with the development of the Plan. The Appendices include an expanded description for each project, and a series of spreadsheets showing the derivation of the cost estimates.

The following flow diagram illustrates the proposed implementation of the City's Intelligent Transportation System (ITS) Five-Year Operations Plan and staffing needs. The flow diagram is a roadmap for the implementation but is flexible for change based on funding availability and changing City priorities.

KEY

= High Priority
= Medium Priority
= Low Priority

Prioritized Project Schedule



1 Introduction

The Public Works Department of the City of Sugar Land, Texas engaged the services of Naztec ITS, supported by ARINC and Cisco Systems, for the development of the City's Intelligent Transportation System (ITS) Five-Year Operations Plan. This Operations Plan documents the results of a review of the City of Sugar Land's existing transportation infrastructure and related systems. It summarizes the future needs for citywide ITS projects, as well as signalization and system wide signal control improvements within the City. It identifies and recommends system design features capable of handling the present and future traffic in Sugar Land. These system improvements will produce improvements in traffic flow and air quality throughout the entire Sugar Land area. This is the primary goal of projects sponsored with Congestion Management and Air Quality (CMAQ) funding.

The basic goal of this ITS Operations Plan was to identify a series of improvement projects to address the transportation-related functional requirements for the City of Sugar Land, with an objective of providing advanced transportation management system improvements throughout the City.

1.1 Summary of ITS Operations Plan Project

The Consultant Contract and project was structured into eight general tasks:

- Task 1 – Determine ITS Goals and Objectives
- Task 2 – Document Existing Conditions
- Task 3 – Communication Network Problems and Needs
- Task 4 – Identify Transportation Problems and Needs
- Task 5 – Determine ITS Options
- Task 6 – Define Functional Requirements and System Architecture
- Task 7 – Develop a Prioritized Staffing Plan
- Task 8 – Develop a Prioritized ITS Operations Plan

The technical activities encompassed:

- Documenting the existing conditions of ITS related systems and networks
- Identifying deficiencies in the transportation related systems through an assessment of transportation problems and needs
- Selecting candidate ITS improvements to address problems and needs and establishing an initial priority for each of the projects
- Identifying the Functional Requirements of the ITS Operations Plan and a "High Level" Systems Architecture that will be followed in the implementation of these improvements
- Defining ITS Operations Plan requirements, such as priority, cost, project phasing and staffing
- Preparing an Implementation Plan for these improvements that conforms to the Code of Federal Regulations Title 23 (23 CFR)

Throughout the course of this project, periodic Technical Memoranda were submitted that summarized intermediate findings. The results of the efforts associated with the above

individual tasks are summarized in the chapters of this Operations Plan. A brief summary of each chapter follows.

1.2 Chapter 2 – Existing Conditions

This chapter provides a description of the existing transportation system characteristics, physical needs and data flows and the general system objectives. The data collection activities in this task were geared toward establishing a database for use in the remainder of the project. The data was utilized to evaluate potential system elements and increased functionality, assess communications capabilities and needs, and consider ways of improving transportation through advanced technology and information systems that maximize the safety and efficiency of the transportation infrastructure. Maps were prepared showing existing traffic signals, school zones, communication system, City facilities and other elements of the City's transportation infrastructure.

1.3 Chapter 3 - Communication Network Problems and Needs

This chapter presents a technical memorandum that identifies deficiencies in the City's systems related to ITS communications infrastructure through an assessment of the City's ITS communication problems and needs through comments received from the Stakeholders, and the assessment of existing conditions. This technical memorandum identified the relative priorities for each of the problems and needs. Recommendations were made for a global, city system wide solution of sufficient bandwidth and sustainability to enable the operation of all existing and proposed ITS field equipment on that communications network platform.

Subsequent to the development of this technical memorandum, the City engaged the services of other firms and City departments to expand the scope of the study to assess the feasibility of a wireless broadband network infrastructure to support a wider variety of city government services. On the basis of this further study, the recommendations included in this technical memorandum have been superseded, and preliminary engineering efforts towards the ultimate wireless network have proceeded in parallel to the completion of the remaining chapters of this Operations Plan. This technical memorandum is presented for reference only, and does not reflect the complete set of recommendations and requirements that have guided the preliminary engineering effort.

1.4 Chapter 4 – Transportation Problems and Needs

This chapter presents the results of Steering Committee discussions, questionnaires and consultant summaries. Functionality statements were developed based on the National ITS Architecture. System functional requirements were identified for possible application in Sugar Land. The Committee assigned weights and a list of candidate functions was derived.

1.5 Chapter 5 – Determine ITS Options

This chapter builds on the results obtained from Chapter 4. Based on these results, a list of Project "Groups" has been established. These groups are described as:

- Group 1–Traffic Signal System Improvements
- Group 2–Safety Enhancement Projects
- Group 3–Traveler Information and Information Sharing with Regional Agencies
- Group 4–Transportation Management
- Group 5–Other Projects

Each group is composed of a series of specific projects that are summarized in this chapter. Appendix C contains a complete description of these Projects. These Project Groups may be logically implemented over a period of approximately five years. Details are presented in Chapter 8.

1.6 Chapter 6 – High Level Systems Architecture

A goal of this study was to create a system that would be in compliance with developing National Standards, particularly the National ITS Architecture. This chapter discusses system functions and identifies comparable ITS Market Packages. It then develops the High Level Systems Architecture, using a multi-step process that identifies input and output data flow customized for the City of Sugar Land. Finally, the Architecture was compared to the Regional ITS Architecture developed for the Houston-Galveston Area Council for consistency.

1.7 Chapter 7 – Staffing Plan

This chapter identifies deficiencies in the City's Traffic Operations Division through an assessment of the City's present staffing levels through comments received from the Stakeholders, and the assessment of existing conditions. The findings are summarized and the relative priorities for each of the problems and needs are established.

1.8 Chapter 8 – Prioritized ITS Operations Plan

This chapter presents a prioritized ITS Operations Plan based on the work performed in all of the prior tasks. This ITS Operations Plan summarizes the results of the seven tasks and provides a guide for the implementation of ITS elements over the next five years. This Plan identifies a series of ITS projects that should be implemented by the CITY. An overall schedule for the implementation of the recommended projects is also included in this chapter.

Chapter 8 also presents the Implementation Plan Guidance that has been prepared in accordance with the Federal Code of Regulations (23 CFR 655.409) to guide the City of Sugar Land during the performance and realization of the ITS Operations Plan. The basic structure of this section corresponds to the standard sequence of materials included in a completed Implementation Plan.

1.9 Appendix

Several attachments are included that provide supporting material and tables. There is additional material on Market Packages and ITS Architecture, and a thorough description of the Recommended Projects.

2 Existing Conditions

2.1 Overview

This technical memorandum provides a description of the existing transportation system characteristics, physical needs and data flows and the general system objectives. The data collection activities in this task were geared toward establishing a database for use in the remainder of the project. The data will be utilized to evaluate potential system elements and increased functionality, assess communications capabilities and needs, and consider ways of improving transportation through advanced technology and information systems that maximize the safety and efficiency of the transportation infrastructure. Maps were prepared showing existing traffic signals, school zones, communication system, City facilities and other elements of the City's transportation infrastructure.

As part of this task, Naztec ITS and ARINC met with the Sugar Land Public Works Department and other potential stakeholders, and conducted preliminary data gathering and site visits, to assess existing conditions of the ITS related systems and networks in the City.

2.2 Existing Conditions

2.2.1 Purpose and Introduction

This chapter documents the results of a review of the City of Sugar Land's existing transportation infrastructure and related systems. The Transportation System as a whole is a multifaceted network of components. It incorporates everything that involves moving from one place to another, whether it is people, goods or information. This report encompasses the documentation of the existing roadway network, the existing ITS subsystems and communication between each. A wide variety of subsystems are contained in this review, including:

- Roadway Infrastructure
- Computerized Traffic Signal System
- Local Traffic Signal Controllers
- School Zones with Flashing Warning Signs
- Fire Station Emergency Signals
- High Accident Locations
- Evacuation Routing and Management
- Parking Management
- Transit System
- Traffic Generators
- City's Traffic Signal Communications System

2.2.2 Methodology

Data collection was conducted methodically in cooperation with the City. The data included many agencies and resources to establish a detailed framework of existing subsystems and communications network. The Documentation section of this chapter presents existing

components of the ITS architecture. It provides data that quantifies the magnitude of the Transportation System as it is today and provides some insight into the possibilities of a more sophisticated system that could exist in the future.

2.2.3 Documentation

Roadway Infrastructure

The City of Sugar Land is a suburban community located in Fort Bend County, 20 miles southwest of downtown Houston. The 2000 Census data indicate that Fort Bend County is experiencing continuing growth and development. A comparison between the 1990 Census and 2000 Census shows that Fort Bend moved up to the 10th largest county in Texas from 13th in 1990. The population of the City of Sugar Land increased 158% from 1990 to a level of 63,328. Current population statistics report the City's population to be over 76,000 in 2007, with residents occupying over 22,750 households.

Sugar Land has a land area of approximately 29 square miles. The City is bisected by the Southwest Freeway (US 59), which is a multi-lane, controlled-access highway extending from downtown Houston to southwest of Sugar Land. There are nine interchanges on US 59 in Sugar Land and the City's extraterritorial jurisdiction (ETJ). US 59 has undergone a major widening project in recent years to accommodate the area's commuters.

The roadway infrastructure of the City is made up of several major thoroughfares. US 90A, a major highway running through Sugar Land from west to east, traverses through a historic area of the City known as "Old Sugar Land". US 90A is currently being widened to an eight-lane highway with a 30-foot median between Texas Highway 99 and US 59.

Texas State Highway 6 is a major highway running from north to southeast Sugar Land which traverses through the 10,000 acre master-planned community of First Colony. Texas State Highway 99 is a highway opened in 1994 which traverses through the New Territory and River Park master-planned communities in Sugar Land's extraterritorial jurisdiction (ETJ), west of Sugar Land's current city limits. Eldridge Road is a north-south state highway in north Sugar Land. It traverses through many established areas and acts as the western border of the Sugar Land Business Park. Going north leads into the City of Houston and Harris County. University Boulevard is a proposed major north-south to southeast arterial. It will eventually traverse through the master-planned communities of Sugar Mill, First Crossing, Telfair Avalon, and Riverstone. Currently, a portion is completed from south of U.S. Highway 59 to the Commonwealth Blvd intersection, just west of the Avalon master-planned community. The other completed section is east of State Highway 6 as it traverses through the First Crossing master-planned commercial development and ends just before US 90A.

In addition to the major thoroughfare construction or widening projects, there are numerous efforts underway to improve mobility at City intersections. Current projects include: Williams Trace Boulevard at Lexington Boulevard, State Highway 6 at Town Center Boulevard, and State Highway 6 at Lexington Boulevard.

Roadways are part of the total Transportation System for the City and are the paths used to reach destinations. The goal of deploying a good quality ITS system is to increase efficiency and capacity, enhance mobility, improve safety, reduce energy consumption and environmental costs and increase economic productivity. These goals will be achieved through effective management of the City roadways.

Computerized Traffic Control

The City manages and operates an expanding series of traffic signal controlled intersections. At the time this chapter was prepared, 67 intersections were controlled by traffic signals operated by the City of Sugar Land. That number has subsequently increased to 74. The system will expand with the addition of seven more traffic signals in association with known and approved projects. Further, approximately 20 additional signals could eventually come under City control from within the Extraterritorial Jurisdiction (ETJ).

All of the City's existing 74 signals are currently connected to the **ATMS.now** Advanced Transportation Management System in the Traffic Management Center (TMC). This connection allows the **ATMS.now** system to monitor these signals and determine if some form of traffic signal failure has occurred. The City's proposed intersection upgrade plans will enable **ATMS.now** to monitor the seven additional planned signals.

Traffic Signal Capabilities and Communications

All of the traffic signals the City manages and operates are traffic-actuated installations. In this type of operation traffic detectors located on the approaches to the intersection sense the arrival of vehicles at the signal, and the traffic signal controller at the intersection adjusts the signal timing to respond to these inputs. Figure 2.1 presents the signalized intersections throughout the City.

The City's typical detector configuration at an intersection includes stop bar detection on all approaches and sets of advance detectors on the major street approaches. There is currently no provision for "system" detectors for the collection of signal network free flow traffic speed and volume and volume data. This information could be used to display real-time traffic congestion information via the central system software.

The City's 74 system signals are currently connected to the **ATMS.now** Advanced Transportation Management System. This connection allows **ATMS.now** to monitor these signals and determine if some form of traffic signal failure has occurred, and provides operators the ability to assess current traffic conditions and make intersection timing changes as needed.

Traffic Signal Controller Hardware

All of the existing intersection controllers were manufactured by Naztec, Inc. They are NEMA TS-2 units, capable of communicating at baud rates of up to 19.2K as currently configured. The Naztec, Inc. controllers and system software are easily configurable for all types of telemetry. Naztec provides controllers that are compatible with both RS-232 and Ethernet type connections. The City of Sugar Land currently has a majority of the RS-232 type controllers and a few of the Ethernet variety. Expansion of the system at the traffic management center is as easy as assigning an additional communications channel on a digi-board or Ethernet switch.

Traffic Management Center

The Traffic Management Center (TMC) at Public Works has a main console in a dedicated room using Windows-based control workstations. As mentioned previously, the Naztec NEMA TS-2 intersection controllers are already working with central management software, **ATMS.now**. **ATMS.now** is designed around a cross-platform client-server architecture based upon the TCP/IP architecture, which utilizes IP addresses. The software has a vast

array of features. The design allows for simultaneous NTCIP and/or Naztec devices to attach through a distributed central system. The Naztec ATMS supports any TCIP/IP based network at 10 – 1,000 megabits.

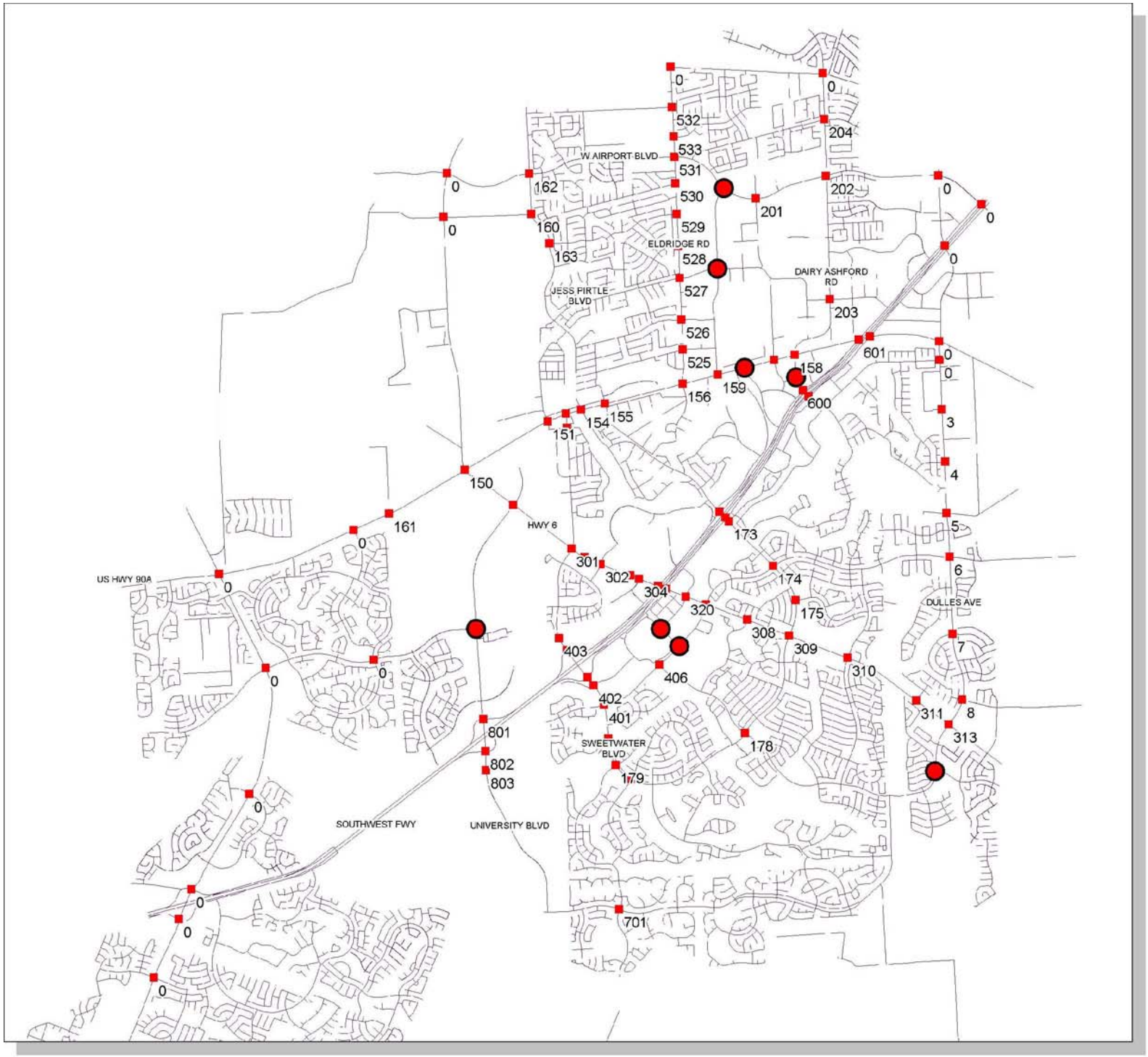


Figure 2.1 Sugar Land Signalized Intersections

The City of Sugar Land would like to upgrade their existing communications network and field hardware to take full advantage of the central software monitoring and control capabilities, and provide a state-of-the-art platform for system growth and expansion. The base communication network being considered would involve the use of Ethernet NTCIP compliant controllers, utilize industrially hardened Ethernet switching hubs (switches) in existing controller cabinets, and provide communications at a range of 10 – 1,000 megabits. This network is addressed in more detail in Chapter 3, Communication Network Problems and Needs.

Naztec's ATMS software has many modules to manage and display real-time traffic conditions. **ATMS.now** offers complete traffic and data management including real-time reporting, integration with Crystal Reports™, XML data exchange, GIS interface and hundreds of other features. **ATMS.now** brings together all of the traffic network data into a single repository for a completely integrated, 360-degree view of the ATMS operation. The application features high-performance parallel database technology, a full suite of data access and management tools, and data mining capabilities.

Pelco remote CCTV surveillance cameras are located at 11 intersections, providing pan, tilt, and zoom traffic monitoring capability at each. Pelco Windows display hardware is used to select and control the cameras. Also, the use of video image processing, or video detection, has been implemented at approximately 20 of the City's intersections. Video detection is a technology that captures and analyzes video images through sophisticated algorithms, providing an economical alternative to inductive loops and other detection technologies for intersection control. The typical configuration entails a camera at each intersection approach, providing a fixed view of traffic arriving at the intersection. This video image and data can be transmitted back to the TMC to provide additional monitoring capability of existing traffic conditions. Figure 2.2 indicates the locations of CCTV cameras and video detection.

The Traffic Management Center has a separate web page displaying railroad activity. Thirty-five trains a day move through the City blocking east west travel. Sometimes all possible major routes are blocked for substantial periods of time. The Doppler Radar Train display reports train speed, position, and road blockage. The system is used to aid emergency responders.

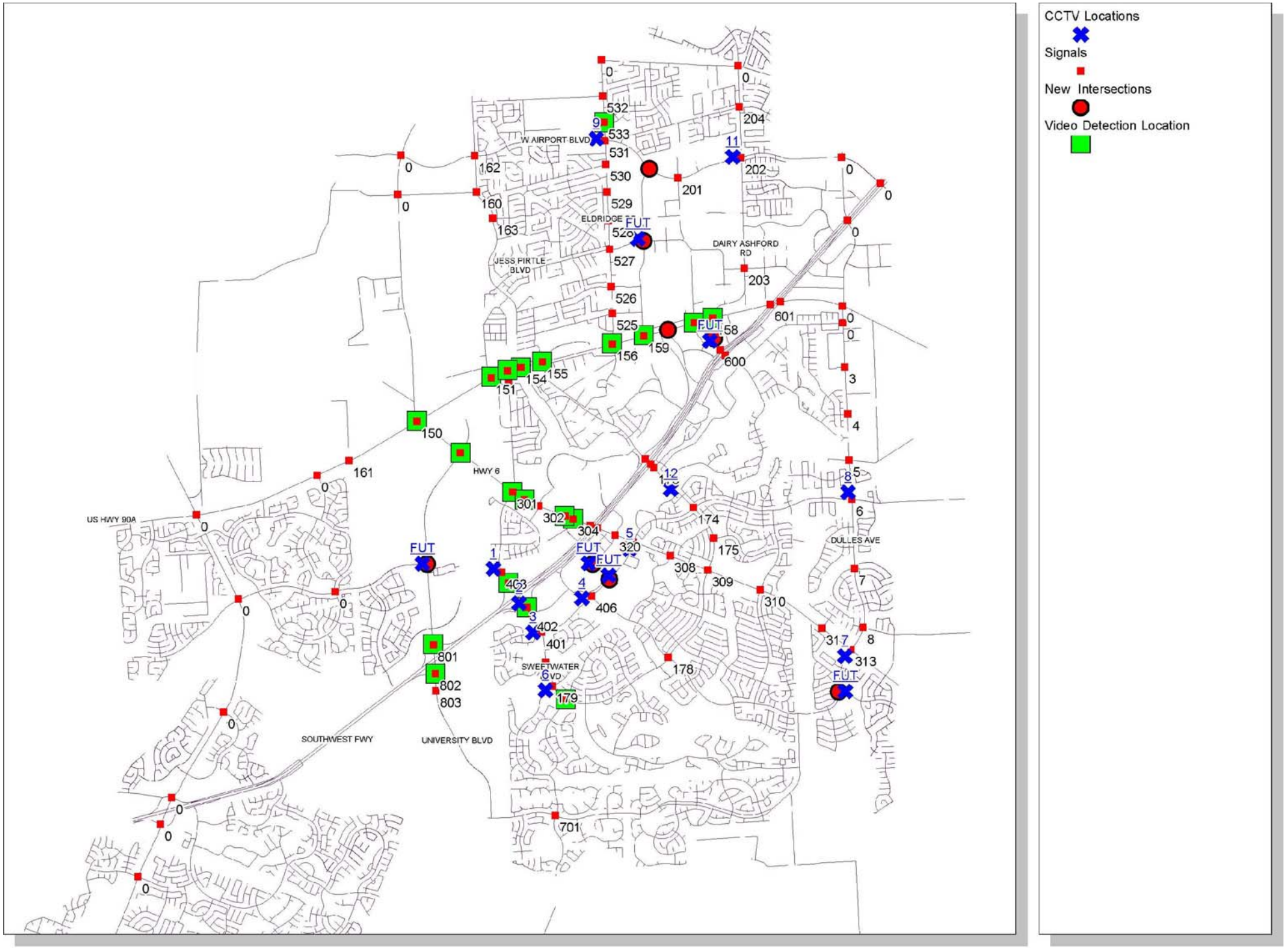


Figure 2.2 Sugar Land CCTV & Video Detection Locations

Emergency Vehicle Priority

The City's Fire Department currently has all of its trucks equipped with either 3M Opticom or Tomar STROBECOM transmitters for in-route traffic signal preemption. All signalized intersections have their major approaches equipped with receivers to be alerted to the arrival of an emergency vehicle as a measure to maximize responsiveness and allow the emergency responders to reach their destination quickly and safely. When a receiver has identified an emergency vehicle, the traffic signal controller transitions to a timing plan in which the signal provides a green indication to the emergency vehicle and a red indication to the other legs of the intersection.

Controller Cabinets

The traffic signal controllers are housed in cabinets that were designed for their installation. All of the controller cabinets are relatively new and in good condition.

Other Roadside Systems

School Zone Flashing Warning Signs

The City of Sugar Land hosts 20 designated signalized school zones with an associated 32 flashing signals. The signs and signals are operated by the Department of Public Works. The existing and proposed zones are presented in Figure 2.3. The signals are operated through Naztec Chronomax programmable time switches that are pre-timed with a standard weekly school schedule. They are currently monitored and controlled via a remote computer and pager service.

Of the school zones, three are currently located directly on traffic signal interconnect cable routes. Most of the other 14 school zones could be connected with short to moderate runs of new cable or via wireless communication.

Any reprogramming effort associated with the beginning and end of school sessions, or changes to school schedules, could be substantially eased if these flashing warning signs were incorporated into an Intelligent Transportation System (ITS) that controlled these units. Interaction with an ITS would also enable these units to be quickly adjusted in response to emergency school cancellations and holidays. Accurate usage of school zones is important for respectful observance by drivers.

The City also maintains six additional flashing warning signs at swimming pools and pedestrian crosswalks.

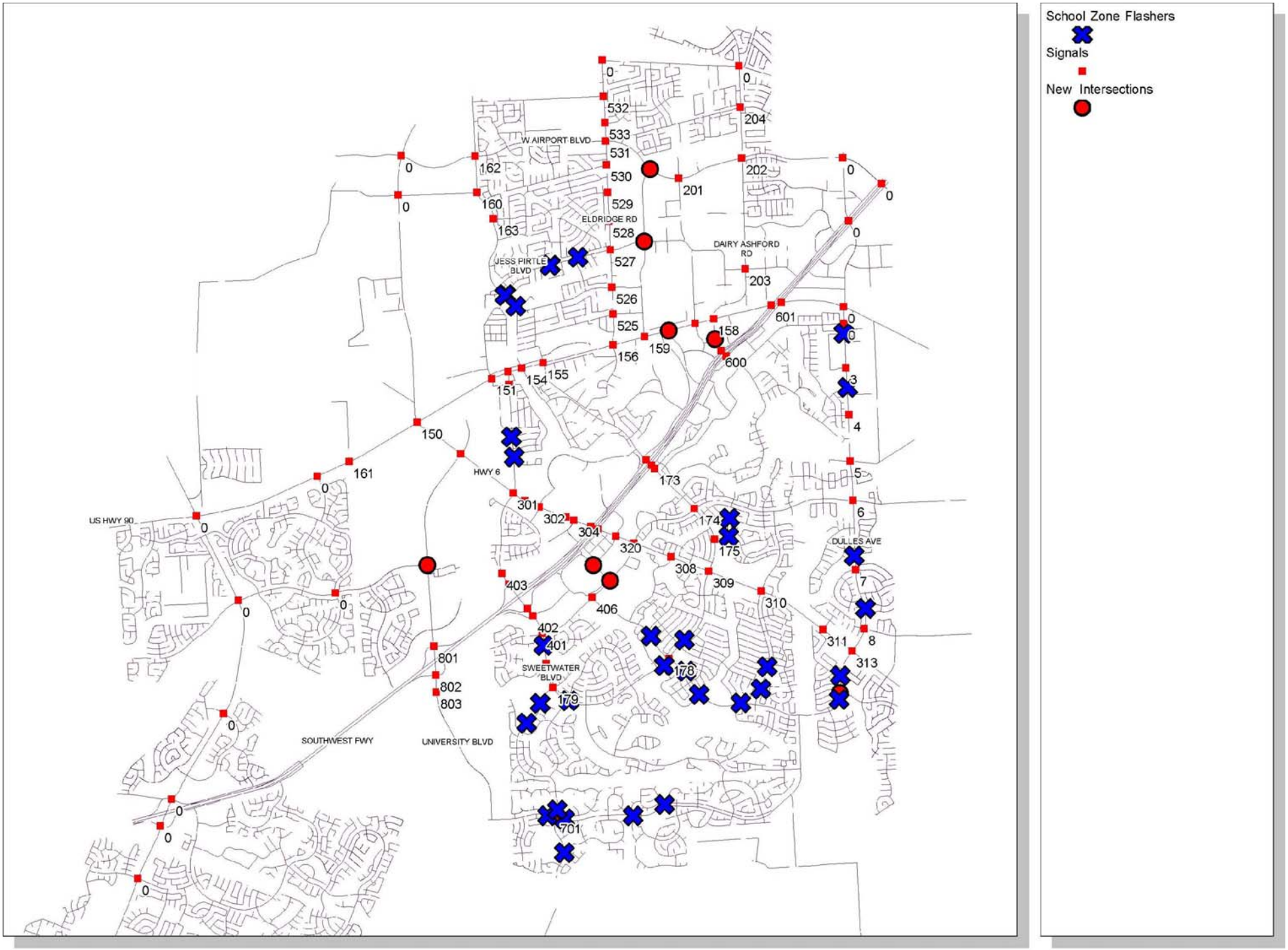


Figure 2.3 Sugar Land School Zone Flashers

Fire Station Emergency Signals

The City Fire Department has six fire stations in Sugar Land. There are no dedicated emergency signals for these stations, and no stations currently have any direct connection to traffic signals or the central signal system software. As presented in Figure 2.4, five of these stations are located along existing interconnect cable routes, or within a short to moderate cable run from the existing cable plant. The remaining station is located in the ETJ of the City. Connection of these stations to the central system could provide an advanced preemption of the nearby signals to clear traffic from the intended route of the fire apparatus.

High Accident Locations

Listings of reported accidents from throughout the City were reviewed for the years 2004, 2005 and 2006. The purpose of this review was to identify those locations with the highest accident frequency. The accident data, provided by the police department, lists only those accidents for which police department resources were dispatched. At the dispatched location, data were recorded identifying the date, time received, accident type (Minor/Major), City District, and an X,Y coordinate reference point, most likely the center point of the roadway or intersection where the accident occurred. With just this single X,Y coordinate reference, it is not possible to ascertain key variables of the accident, such as which approach to an intersection was involved and the direction of travel of the vehicle(s). To summarize the accident information, the 2006 records were tabulated strictly by location of occurrence. This information is presented in Figure 2.5. This figure indicates only the locations of the reported accidents, not the frequency of accidents at a particular location.

As can be seen in Figure 2.5, a large number of the accidents occur on or near US 59, and also State Highway 6. Many of the accidents on US 59 are within close proximity to interchanges. There are seven US 59 interchanges within the city limits of Sugar Land. Each of these interchanges is included in the areas having high-accident frequencies. These are the points of crossing jurisdiction between the City and the Texas Department of Transportation (TxDOT), even though the City of Sugar Land Police Department responds to accidents on the freeway. TxDOT is already operating incident management strategies and ITS initiatives on US 59, including sensors, cameras and dynamic message signs. These components located within the Sugar Land city limits are not yet operational. TxDOT's current practice is to monitor conditions on the freeways and to provide information to the traveling public via the appropriate ITS devices, when requested by the incident commander. TxDOT does not actively monitor the surface streets nor react to incidents off the freeway, unless travel on the freeway is impacted. TxDOT can post notices on message signs on the freeway to notify motorists of incidents on intersecting surface streets, if specifically requested to do so by the City; however, there is no process in place for TxDOT to take such action automatically since TxDOT has no means to identify or verify incidents off the freeway. When the ITS components located within the city limits do become operational, TxDOT has agreed to provide the City with the CCTV camera video feeds and pan, tilt and zoom control of the cameras for viewing purposes.

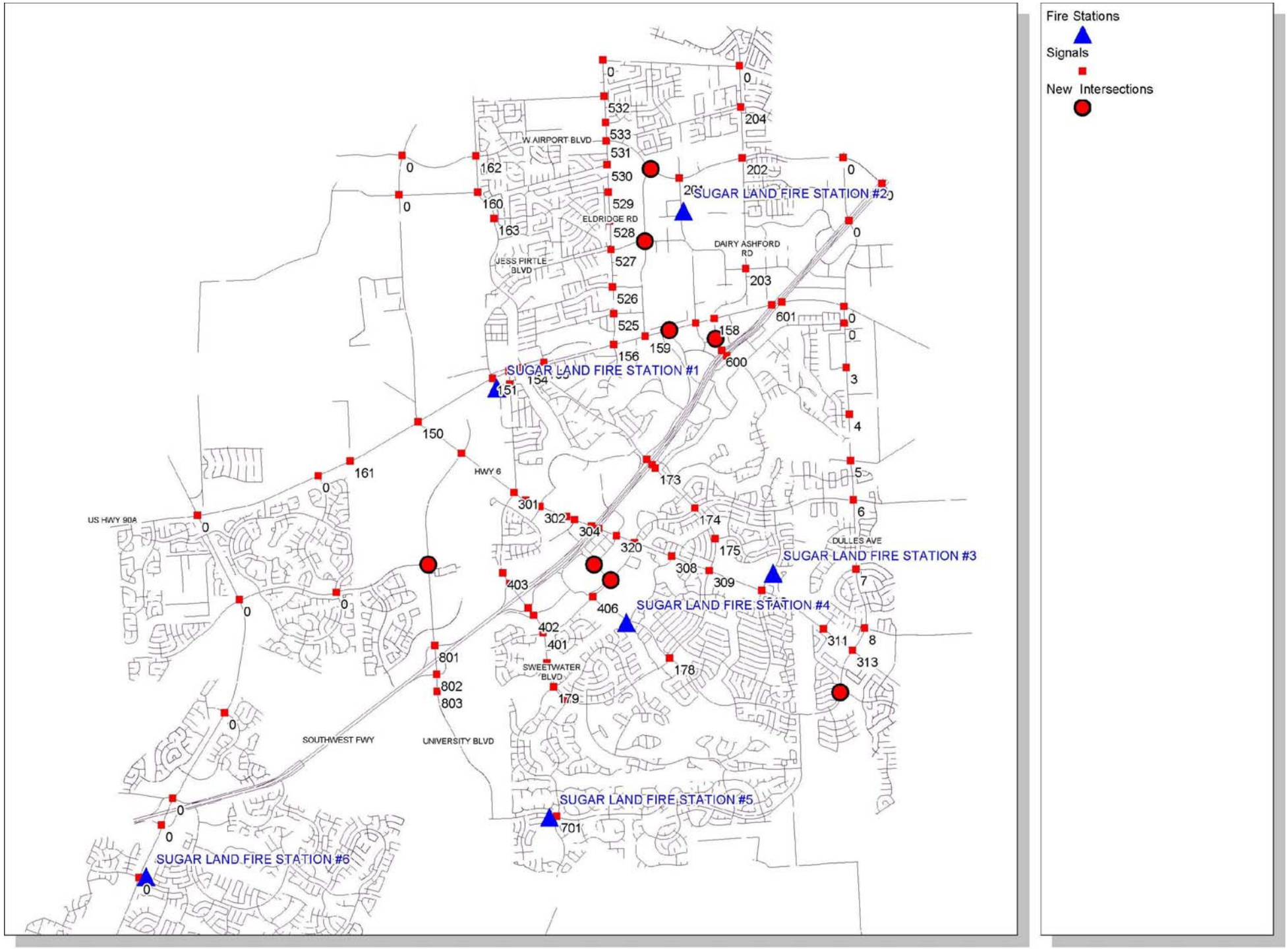


Figure 2.4 Sugar Land Fire Stations

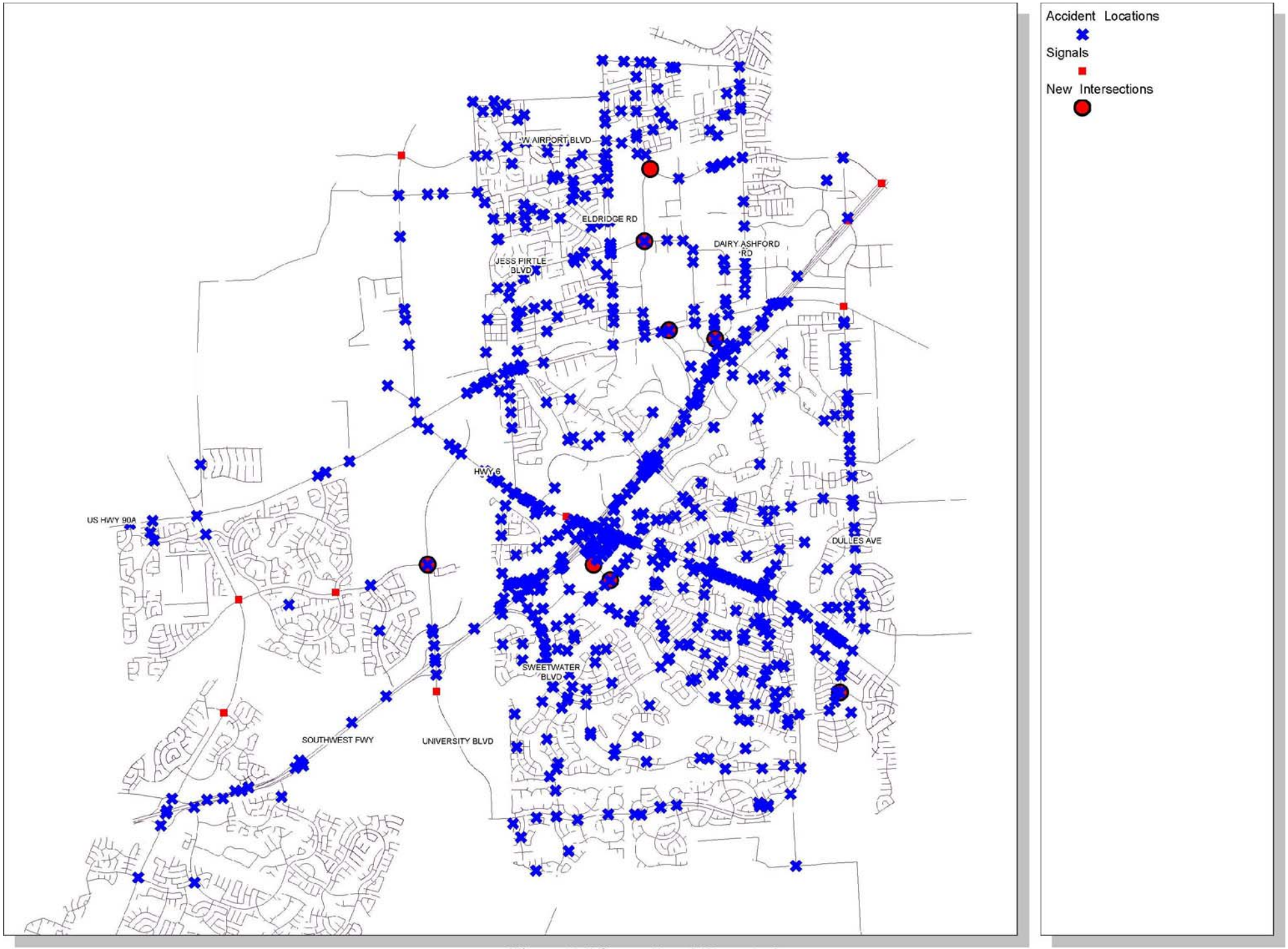


Figure 2.5 Sugar Land Reported Accident Locations - 2006

Thirteen locations were found to have had more than 50 reported incidents in 2006. Eight locations were identified on US 59, and four more were identified on State Highway 6. Table 2.1 lists each of the 13 locations identified.

Table 2.1
High Accident Locations

Major Roadway	Intersecting Roadway	2006 Reported Accidents
US 59/Southwest Freeway	*Entire Length*	1,565
US 59/Southwest Freeway Highest Accident Intersections:		
US 59/Southwest Freeway	State Highway 6	305
US 59/Southwest Freeway	First Colony Blvd / Sweetwater Blvd	169
US 59/Southwest Freeway	Sugar Lakes Dr / Williams Trace Blvd	169
US 59/Southwest Freeway	University Blvd	161
US 59/Southwest Freeway	US 90A	130
US 59/Southwest Freeway	Crabb River Rd / Grand Pkwy	120
US 59/Southwest Freeway	Dairy Ashford Rd / Sugar Creek Blvd	86
US 59/Southwest Freeway	Brazos River Turnaround	82
State Highway 6	*Entire Length*	1,264
State Highway 6 Highest Accident Intersections:		
State Highway 6	US 90A	158
State Highway 6	Williams Trace Blvd	82
State Highway 6	Lexington Blvd	73
State Highway 6	Settlers Way	51
US 90A	*Entire Length*	510
US 90A Highest Accident Intersection:		
US 90A	Dairy Ashford Rd	62

The three major roadways identified in Table 2.1 should be prioritized for receiving ITS initiatives for incident management. Special consideration should also be given to the freeway interchanges, since these locations are already being at least partially equipped for incident management by TxDOT.

Evacuation Routing and Management

As with most coastal communities, the southeastern coast of Texas is highly susceptible to hurricanes and other natural disasters that may require evacuation of the area. While the Sugar Land area is not subject to the affects of storm surge and is not included in an evacuation zone, the threatened landfall of a Category 4 or 5 Hurricane may result in the need to evacuate surrounding communities. In addition, Sugar Land is affected by evacuation routes that have been established for coastal residents. These routes include State Highway 6 and US 59.

Many of the features of TxDOT's Houston TranStar, the Greater Houston Transportation and Emergency Management Center, were designed to enable TxDOT to continue emergency management during an evacuation. As part of its efforts at hurricane preparedness, in conjunction with the Houston-Galveston Area Evacuation and Response Task Force, TxDOT maintains a hurricane evacuation plan to be implemented in the event of a mandatory evacuation of the coastal area.

The Hurricane Evacuation Plan identifies the primary evacuation routes toward the north and the west. The main evacuation routes for the region are indicated in Figure 2.6. The route most directly impacting the City of Sugar Land is State Highway 6. During an evacuation, the Sugar Land Police Department implements special traffic control procedures on State Highway 6 westbound from Dulles Avenue to US 90A. This area, and the traffic signals impacted, is indicated in Figure 2.7. The "Evacuation Routes/Traffic Management Plan" prepared by the Fort Bend County Office of Emergency Management calls for the Police Department to monitor State Highway 6 westbound traffic and assist motorists as needed to ensure a smooth SH6 westbound flow. This is accomplished by placing a patrol car and officer at each of the traffic signals indicated in Figure 2.7, and setting the traffic signal to flashing operation. The signals flash yellow for SH6 westbound traffic and red in all other directions. The police officer provides manual traffic direction as the situation requires.

The City's traffic management responsibilities during an evacuation would benefit from several ITS capabilities. These include: the ability to adjust traffic signal timing plans to optimize traffic flow along the evacuation routes; providing maps and other visual descriptions of the suggested routes to people at home via the Internet or a cable TV channel before they begin their evacuation; and providing en-route information to motorists via a local Highway Advisory Radio station and Variable Message Signs.

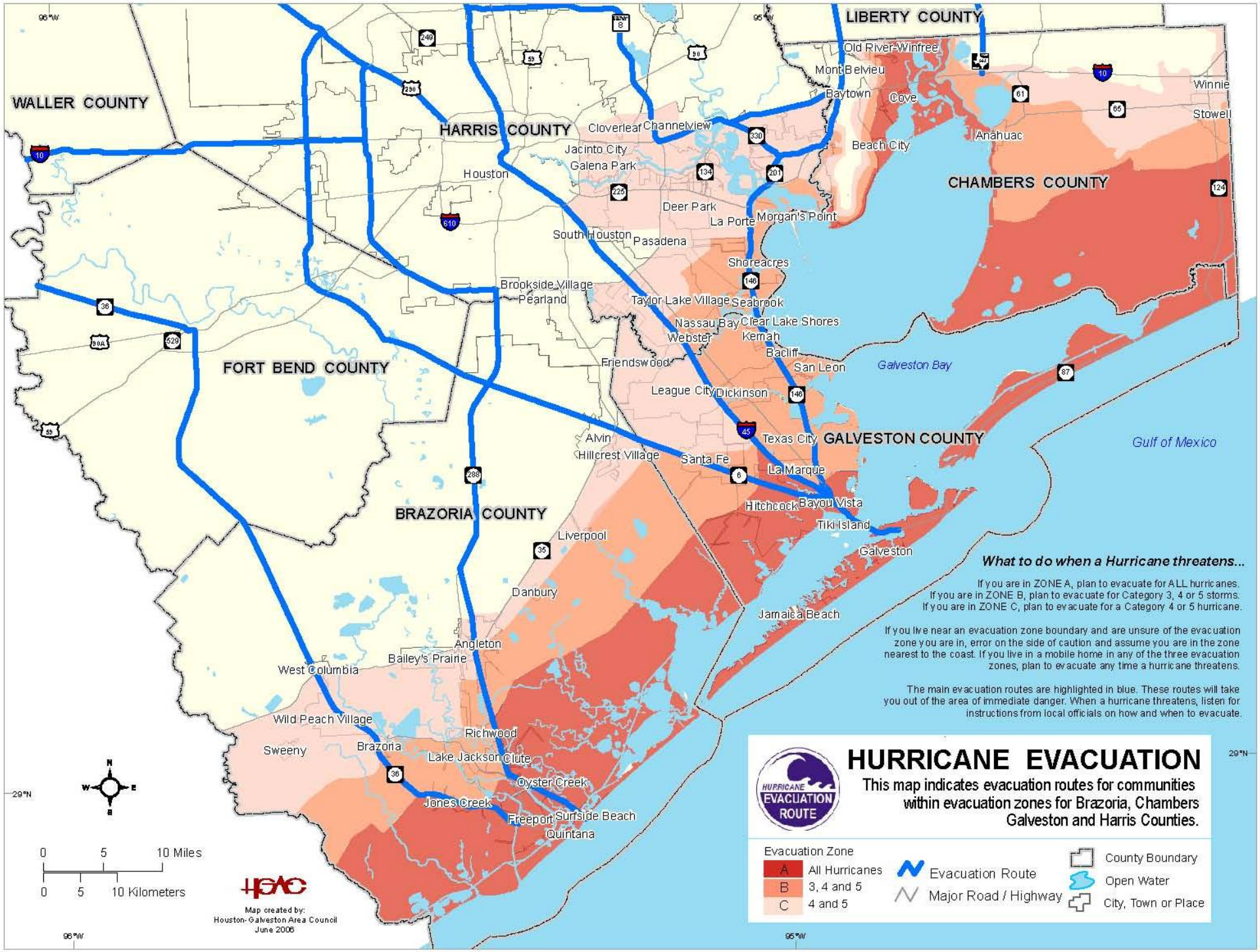


Figure 2.6 Hurricane Evacuation Routes

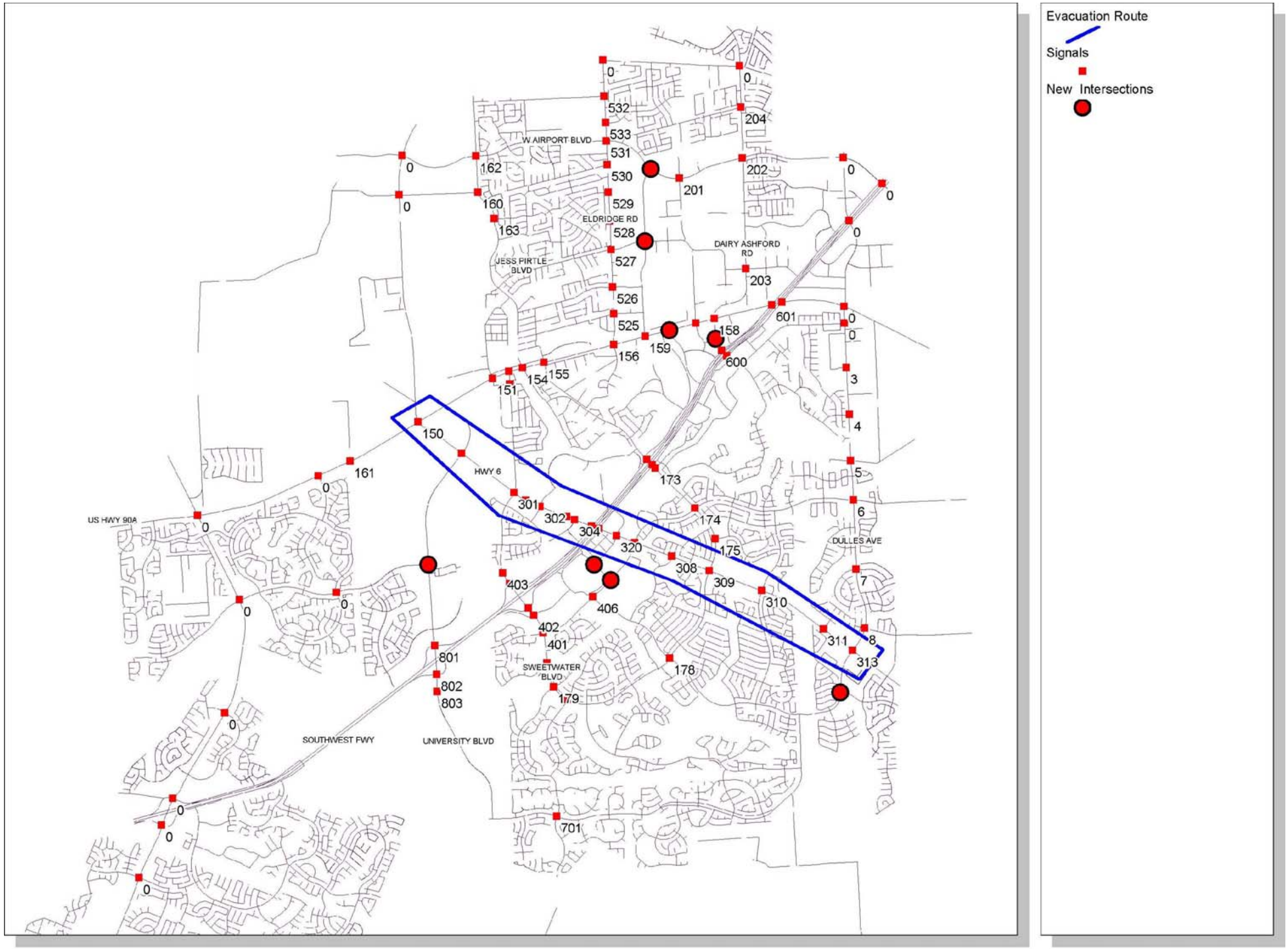


Figure 2.7 Sugar Land Evacuation Route

Parking Management

Sugar Land Town Square and First Colony Mall, discussed in the Section on Retail Centers, occupy the southwest quadrant of the intersection of US 59/Southwest Freeway and State Highway 6. Parking for visitors and businesses located in this area is provided by surface parking spaces at the Mall and three parking structures within Town Square: Lone Star Garage, City Walk Garage, and Texas Garage. Parking is free of charge at all of these facilities. The parking garages are currently equipped with video surveillance cameras.

Parking management can relate to ITS through managing space occupancy and exchange of video images between departments. Some of the newest Intelligent Transportation Systems are designed to direct the driver to areas where parking is available.

Transit System

The City of Sugar Land does not currently have a mass transit system. There have been discussions about possible expansion of Houston's light rail system along the US 90A corridor.

Houston's Metro provides a TREK Express bus service, with routes from the University of Houston – Sugar Land and First Colony Mall to ten stops in Houston on the Uptown/Galleria route and five stops in Houston plus the West Bellfort Park & Ride Lot on the Greenway Plaza route. Both of these routes follow the US 59/Southwest Freeway corridor from Sugar Land into Houston.

Traveler Subsystems

Remote Traveler Support/Personal Information Access

The Traveler Subsystems, as stated by the National ITS Architecture Executive Summary[1], "represent platforms for ITS functions of interest to travelers or carriers in support of multimodal traveling. They may be fixed or portable and may be accessed by the public or by individuals." This report uses this section to identify the travelers who will potentially access the information assembled through the complete system.

There are three key land uses that generate traffic throughout the City: Employment, Retail and Entertainment. Figure 2.8 is a map presenting the locations of these Major Traffic Generators.

[1] The National ITS Architecture; US Department of Transportation; 2002; Washington, D.C.

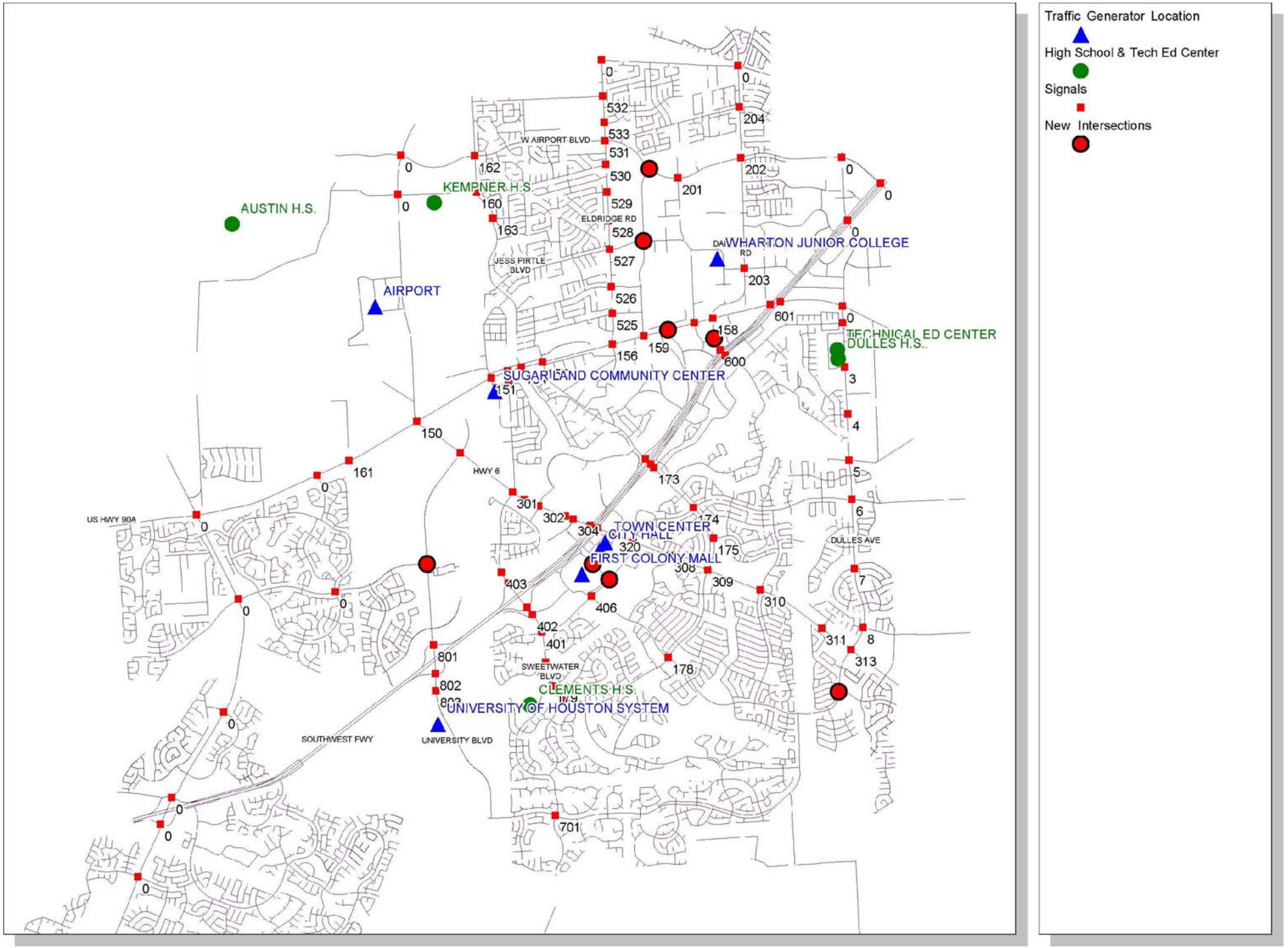


Figure 2.8 Sugar Land Traffic Generator Locations

Major Employment Centers

The traffic patterns throughout the City are in large part a result of the employment destinations within the City and the major employment centers in downtown Houston. Sugar Land industry has grown dramatically over the past 10 years. The City hosts such diverse businesses as engineering, construction, technical services, energy exploration and production, technology and research, electronics and communications.

An abundance of commercial growth, with numerous low-rise office buildings, banks and high-class restaurants can be seen along both US Highway 59 and State Highway 6, two of the main traffic arterials within the City. In an attempt to manage future growth, the City has already placed restrictions on how many levels a building can have, with condominiums only able to reach 10 floors and office buildings having a maximum of 15 floors.

Retail Centers

Retail land uses attract both local and regional trips. Regional shopping malls have a stronger impact on the area's infrastructure than "neighborhood retail." Sugar Land's First Colony Mall is a very large mall that includes outdoor activities, several parking garages, and new signage to blend in with the surrounding area. The mall is anchored by four large department stores and includes over 130 other stores. There are numerous other major retailers located near the mall in various portions of the Town Center area. The mall attracts customers from throughout the southwest Houston area.

Sugar Land Town Square is a pedestrian-oriented, main-street city center and a central business district that is within walking distance of stores, services, mid-rise office buildings, mostly chain restaurants, sidewalk cafes, entertainment and a Marriott Hotel and conference center, and the Sugar Land City Hall.

Entertainment Destinations

Event traffic associated with entertainment facilities is the other major traffic generator identified in this study. The largest economic and entertainment activities are found in the areas of south and southeastern Sugar Land. Most of the population in the city limits is concentrated here. This area is all master-planned communities and it includes nearly all of First Colony, the largest in Sugar Land encompassing 10,000 acres. Other master-planned communities in this area are Sugar Creek, Sugar Lakes, Commonwealth, Avalon, and Riverstone. This area boasts a wide range of recreational activities including three golf courses and country clubs. Another recreational facility in the area is the Sugar Land Ice & Sports Center (formerly Sugar Land Aerodrome), home of the practice facility for the Houston Aeros hockey team.

Other Traffic Generators

Other moderate level traffic generators considered and identified are the regional airport and the schools. Sugar Land Regional Airport is the fourth largest airport within the Houston-Sugar Land-Baytown metropolitan area. The airport handles approximately 250 aircraft operations per day. The airport today serves the area's general aviation (GA) aircraft serving corporate, governmental, and private clientele. A new 20,000 square foot terminal and a 60 acre GA complex opened in 2006. Sugar Land is also home to the Wharton County Junior College and the University of Houston System at Sugar Land, as well as four public high schools and a technical education center.

Communications System

Communication is the core of ITS. It is the information infrastructure that connects the components of the subsystems together and allows coordination and sharing of information among systems and people. The Public Works Department's major communications system is its Traffic Signal System communication network that interconnects the traffic signals throughout the City.

As described earlier, 74 of the City's signals are currently connected to the **ATMS.now** Advanced Transportation Management System in the Traffic Management Center (TMC). This connection allows the **ATMS.now** system to monitor these signals and determine if some form of traffic signal failure has occurred. The City's proposed intersection upgrade plans will enable **ATMS.now** to monitor the seven additional planned signals.

The existing traffic control communications network consists of a combination of media. The TMC is connected to 11 different signal subsystems in the field via ten broadband Integrated Services Digital Network (ISDN) lines. The ISDN lines are leased from the telephone company at a current rate of $100/month for each line. The communication media within each subsystem are owned and maintained by the Public Works Department, necessitating a combination of both skills and equipment. Nine of the eleven subsystems, encompassing a total of 57 signals, utilize Microwave Data Systems (MDS) spread spectrum radio equipment. One subsystem consisting of eight signals utilizes twisted pair copper communications cable, and the final subsystem of two signals is connected to an adjacent spread spectrum subsystem via fiber optic cable.

Figure 2.9 presents the existing and planned signalized intersections throughout the City and ETJ. The communications subsystems are also shown in this figure.

City Website

The City of Sugar Land website, www.sugarlandtx.gov, currently provides several areas of information and interest related to transportation. Depending on the time of the year and current conditions, there are rotating special windows for specific information. These windows include Hurricane Season and Traffic Alert. Hurricane Season provides information and guidance on hurricane preparedness and recommendations to help keep citizens safe during emergencies. Traffic Alert provides notices of roadway construction and related traffic impacts.

Under the Sugar Land Public Works and Utilities banner there is a Traffic Management page that provides static information on projects and operations. In an area titled "Growth and Expansion" there is a page for Highway Construction. The information provided on this page includes:

- Roadway construction project summaries and updates
- Traffic Updates – construction and weather related alerts
- City of Sugar Land Highway Hotline Telephone Number

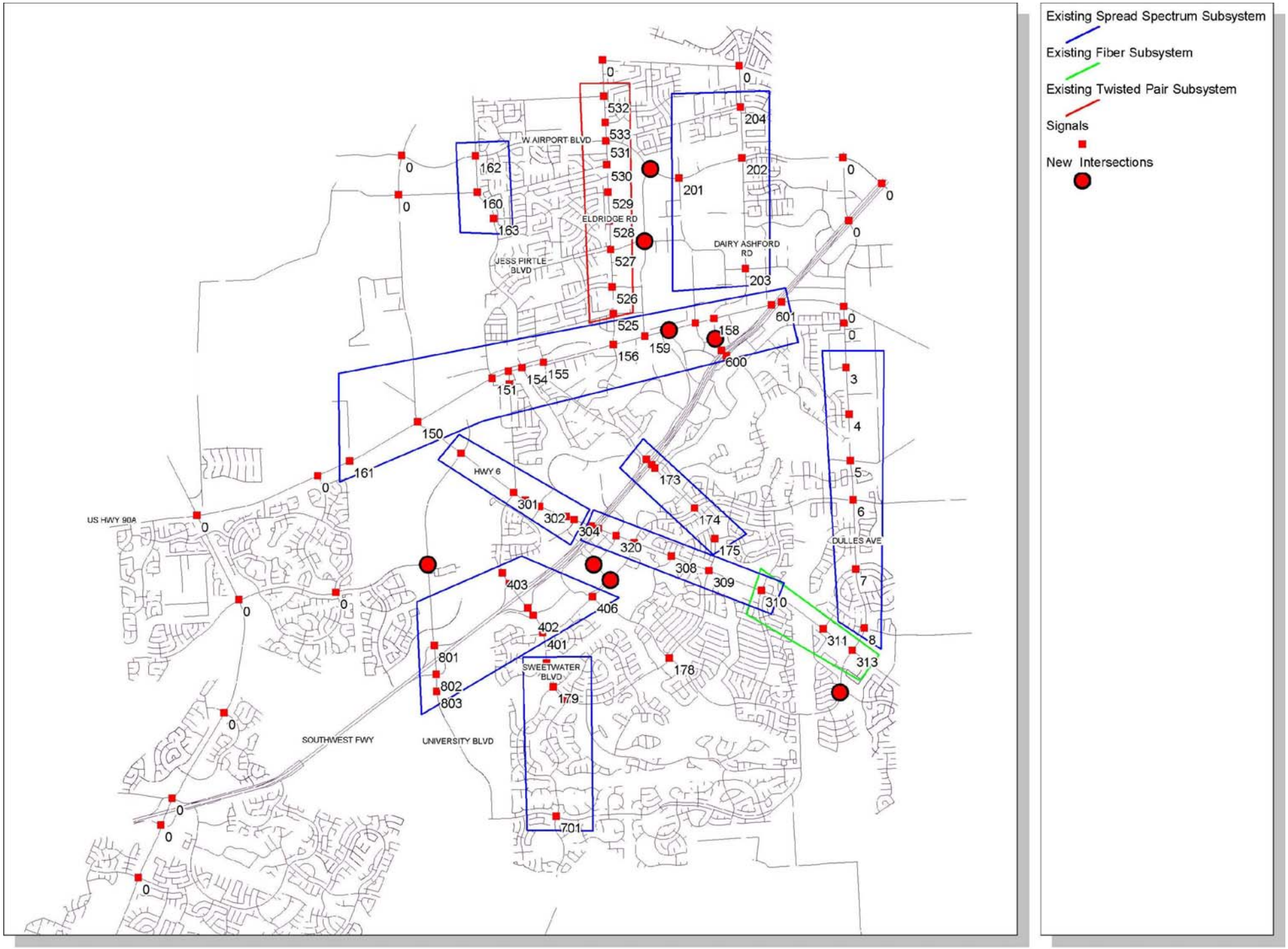


Figure 2.9 Sugar Land Existing Communications Network

Link to the Houston TranStar Real-Time Traffic Map, which provides:

  - Regional current speed data on major TxDOT highways
    - A portion of US 59 in Sugar Land, north of State Highway 6, is currently included
  - CCTV camera views
    - There are currently no active cameras within the city limits of Sugar Land
  - Notices of incidents and road closures

- Link to TREK, the transit operator providing service between Sugar Land and Greenway and Uptown, plus a connection to METRO's Park & Ride facility at West Bellfort

2.2.4 Incident Communications

Various departments within the City, and other organizations, communicate with each other to exchange information and coordinate response during locally managed incidents. The Traffic Management Center at Public Works typically responds to requests for assistance from the Police Department. At the incident scene, either the Police Department or Fire Department will assume the command role for incident response depending on the situation. The Incident Command System (ICS) is put into effect on any scene where the presence of a Supervisor is required. Such incidents include, but are not limited to, major accidents and man-made and natural disasters. The Incident Commander will make a determination of the need to contact TranStar (TxDOT) regarding the incident.

When there is a major incident, assistance may be needed from other jurisdictions, the state and the federal government. Traffic incident management plans are continually reviewed and updated to improve communication between local governments and regional and state agencies. The Public Works Department is currently participating in training on the use of the National Incident Management System (NIMS). NIMS was developed to enable responders from different jurisdictions and disciplines to work together to better respond to natural disasters and emergencies.

The Police Department has a special purpose vehicle outfitted as a Mobile Command Post (MCP). The MCP will be deployed to an emergency/incident location with the approval of the Police Department's Watch Commander. The MCP contains computer, radio, and specialized equipment, and is maintained in a state of operational readiness.

ITS technologies in the area of incident management systems can provide traffic operators with tools to enable quick and efficient response to accidents and other emergencies. Communications systems can link data collection points, transportation management centers, and decision support software into an integrated network that can be operated efficiently and intelligently.

2.2.5 Outreach Activities

On a project of this nature it would be typical to seek input from civic and community leaders, businesses and citizens to determine what pertinent traffic issues are of concern. Surveys and interviews could be conducted to determine stakeholders' perceptions of major transportation problems in the Sugar Land communities. The City of Sugar Land already has

a community outreach program in place whereby a citizen satisfaction survey is conducted every two years to measure sentiments regarding departments' overall efficiency and customer service. The data from these surveys are used to evaluate current City services and make necessary improvements.

A market research firm, Creative Consumer Research (CCR), conducted the most recent survey in November and December 2006. Based on the analysis of results, the City of Sugar Land was interested in further researching residents' opinions on traffic and mobility. CCR was retained by the City to conduct two focus groups with City residents, with mobility and traffic management issues being the primary focus.

Focus Groups

The Project Team prepared a series of questions to be recommended to CCR to utilize in an effort to identify any key concerns, probable ideas for solutions, and hopes for the future regarding traffic matters. Focus group meetings were conducted on April 26, 2007, with Project Team members in attendance to monitor the discussions and receive first-hand feedback. Below are the questions pertaining to Mobility the focus groups were asked during the discussion:

1. What does "traffic mobility" mean to you?
2. What are the biggest challenges relative to traffic in Sugar Land?
3. Describe your commute/your family member's commute to/from work – the positive, the negative aspects.
4. When is your ability to get around town the best?
5. When is your ability to get around town the worst?
6. What has been your very worst experience with traffic in Sugar Land?
7. Describe the traffic in your neighborhood – any concerns, issues, etc.
8. What is your source for information about traffic conditions in your area/on your commute route?
    - How often/when do you seek information about traffic conditions?
    - How reliable is the information?
    - How important is getting better information about traffic conditions?
9. Who should provide information about traffic conditions (the City, TxDOT, County, etc.)?
    - From which of these possible sources, if any, do you receive information about traffic conditions?
    - How do you receive it?
10. How would you like to receive information about traffic conditions?
11. What is your opinion/perception of traffic signs in the community?
12. Have you been to other places where traffic has worked well/better than you feel it is working in Sugar Land? Where was it and describe what made it work well.
13. What areas of the City are you most concerned about for future traffic/mobility?

14. Other comments/suggestions about mobility/traffic management.

The results of the focus group discussions were summarized by Creative Consumer Research in a presentation entitled "City of Sugar Land – Citizens' Concerns Focus Groups". The interested reader is encouraged to review that document for detailed information. The survey questions were effective in determining perceptions of major traffic problems in the Sugar Land communities. It should be noted that the focus group participants were pre-screened in order to assemble groups that met the criteria that they have a negative disposition concerning traffic and mobility in Sugar Land. This was done in order for CCR and the City to understand where the true concerns lie. A partial representation of the findings and responses is provided below.

Key Findings

- "Respondents believe the construction is a reaction to existing population rather than a proactive step to prepare for future growth"
- "Respondents believe when the construction is completed the traffic situation will be the same as it is today because of all the new growth"
- "Respondents understand the traffic inconvenience is unavoidable when there is construction being conducted, but would like to see better planning as far as:
    - Communication of when roads will close or change temporarily
    - Mobility at the major intersections especially when exiting 59 or Highway 6 and 90
    - Controlling the speeds and amount of traffic on through streets of (or close to) residential areas
    - Future development strategies to handle the influx of people new subdivisions, retail, and venues will bring in"

Sample Responses

- **Changes to Sugar Land**
    - "For most, the biggest drawback, or aspect they would like to see changed, is either traffic and construction or overcrowding"
    - "Traffic signals and Volume control"
        - '*The lights. I feel like we're all herded in a huge bunch up to one light, and another one stops in a huge bunch*.'
        - '*I was amazed at how little parking there is there [First Colony Mall]*. '
- **Biggest Issue Sugar Land Faces**
    - "Similar to what respondents want to see changed, they believe the biggest issues facing Sugar Land deal with overcrowding and mobility issues"
        - "Mobility"
            - '*Lack of mobility*'
            - '*I think traffic, especially Highway 6, is certainly the backbone of the community. Sure 59 runs through and that's the path out*

for everybody, but Highway 6 is where an awful lot of the businesses are.'

- '*I would have to go with mobility, but at the same time I can't really see what else can be done to improve the issue*.'

- **Defining Traffic Mobility**
  - "Respondents consider 'traffic mobility' being able to easily get around town; this can be by car or by public transportation"
- **Satisfaction with Mobility**
  - "Respondents give mobility in Sugar Land low ratings (ranging two to seven on a one to ten scale) but they understand it can be a symptom of the current construction and there isn't much that can be done"
- **Biggest Challenge for City of Sugar Land**
  - "Respondents feel traffic volume, construction, and traffic are the biggest things for the City to overcome"
- **Traffic Concerns Within Neighborhood**
  - "While the majority of problems with mobility are at major intersections within Sugar Land, issues can arise within neighborhoods as well"
  - "Issues at the major intersections deal with congestion and lack of mobility, concerns closer to residents' homes involve the through-traffic moving too fast or simply too many cars"
  - "Not only the volume of traffic, but the speed as well, becomes a concern for residents"
- **Sources for Traffic Information**
  - "Residents use various sources to obtain information on traffic and mobility. Web sites, radio, and news are used for daily, quick, updated information as desired."
    - '*I look at the web site for Houston's traffic every day. But there's not really anything on the web, you know, current conditions*.'
    - '*We want the information so we know what to expect, like when they said 90 and 6 was going to be a mess, I've been avoiding that like the plague*.'
  - "Some residents think that updated signs giving estimated drive times would be helpful on the road"
  - "There is a desire to get information on traffic conditions, however most respondents feel they can't change their route, so the information is not a necessity"
  - "Respondents tend to use newspapers (Houston and Fort Bend), the newsletter, the magazine, and the Internet to get information on long-term traffic issues, closures, and construction"
- **Signal Light Synchronizing**

- "Respondents feel that additional signal lights or better synchronized current lights could improve traffic issues"
    - '*Along Lexington and along Highway 6 and some of those kind of thoroughfares, I think [light synching] would help a great deal*.'

- **Post-Construction Traffic Conditions**
    - "Respondents do not feel the traffic and mobility will be better when the current construction is completed. Although the construction might be gone, there will be more people to accommodate so the traffic issues will continue, if not worsen."

- **Future of Mobility**
    - "For the most part, respondents feel the traffic and mobility will get worse in the upcoming years, there are optimists who think it could slightly improve or stay as it is now"

- **Overall**
    - "Respondents realize there is no easy answer. They know if the city is growing to accommodate the amenities and entertainment they want, there will be less space and more traffic."
    - "The realistic ideal seems to be for residents to be informed that the City is expanding with a plan and utilizing a logical strategy, not just trying to keep up or play catch up to accommodate the current situation"

3 Communication Network Problems and Needs

3.1 Preface

This chapter presents a technical memorandum that identified deficiencies in the City's systems related to ITS communications infrastructure through an assessment of the City's ITS communication problems and needs through comments received from the Stakeholders, and the assessment of existing conditions. This technical memorandum identified the relative priorities for each of the problems and needs. Recommendations were made for a global, city system wide solution of sufficient bandwidth and sustainability to enable the operation of all existing and proposed ITS field equipment on that communications network platform.

Subsequent to the development of this technical memorandum, the City engaged the services of other firms and City departments to expand the scope of the study to assess the feasibility of a wireless broadband network infrastructure to support a wider variety of city government services. On the basis of this further study, the recommendations included in this technical memorandum have been superseded, and preliminary engineering efforts towards the ultimate wireless network have proceeded in parallel to the completion of the remaining chapters of this Operations Plan. This technical memorandum is presented for reference only, and does not reflect the complete set of recommendations and requirements that have guided the preliminary engineering effort. The technical memorandum is included in the following sections in its original form.

3.2 Executive Summary

3.2.1 Overview

The Public Works Department of the City of Sugar Land, Texas has engaged the services of Naztec ITS, supported by ARINC and Cisco Systems, for the development of the City's Intelligent Transportation System (ITS) Five-Year Operations Plan. This Technical Memorandum, *Communication Network Problems and Needs*, is somewhat unique to a typical ITS master plan process, yet it is in fact a very key element to the overall success of the City's ITS program.

City, State, and County municipalities are looking for cost-saving ways to improve the efficiencies of roadways without making the actual surface improvements or roadway expansions. The Sugar Land Public Works Department has identified the potential to install Ethernet IP "standards-based" communications to improve traffic signal system management. Wireless IP enabled traffic signal control can be used to improve traffic flow and enable new applications for higher efficiency and cost savings. Advanced Transportation Management Systems (ATMS) provide the ability to connect traffic signal controllers to an intelligent network for enhanced data gathering and analysis and better timing of traffic signals. Connecting signal controllers to an intelligent network with a standards-based wireless IP infrastructure, versus older hard-wired methods, can be cost effective, provide flexibility in design, enable faster deployment, and provide a network infrastructure for future additional applications.

A forward-looking wireless system may ultimately benefit an entire range of City services. Should a wireless network meet other requirements, the level of effort required to implement the network to allow mobile access of Police, Fire, and City Services would be little more than that required to upgrade the traffic control communications system. A well thought out preliminary concept will leverage existing City hardware, personnel expertise, and capabilities to facilitate a wireless communication network as a general purpose enabling technology that is both cost-effective and efficient.

As part of this task, Naztec ITS and ARINC have met with the Sugar Land Public Works Department and other potential stakeholders, and conducted preliminary data gathering and site visits, to realistically define problems, potential, and opportunities for the City's communications network.

3.2.2 Summary and Conclusion

During discussions with Public Works Department staff and other potential stakeholders, the following key aspects of the wireless communication network configuration were highlighted:

- Stakeholders and partners are looking for a long-term relationship providing flexibility and growth for wide-band mobile communications capabilities.
- City inventory and existing infrastructure can be incorporated, allowing expanded capability and cost savings.
- The flexible wireless network preliminary concept perfectly fits a growing area with dynamic needs, allowing re-deployment to meet future needs and applications to match.
- This high-level preliminary concept will cite positive feasibility and show wireless improvement to traffic control as well as usefulness to other City functions.
- The expandability and synergy of a wireless network are important for current and future City services.
- Some of the benefits of a wireless network include flexibility, ease of expansion, lower installation costs, and higher reliability. For example, the wireless approach protects the network from cabling cuts as have been occurring at construction sites where Sugar Land roadway and intersection improvements are taking place.
- Traffic communications may leverage wireless systems with as many expansion capabilities as possible. Wireless today can provide hotspots and service areas around traffic controller cabinets and City buildings with more fill-ins over time.

At the conclusion of the preliminary physical site survey and stakeholder meetings our team members concluded that a wireless communication network, with its flexibility and modular expandability, could admirably fit the current and future communications needs of the City of Sugar Land. We recommend a phased approach to implementation, starting with known capabilities for Ethernet traffic signal control and expanding to quick payback smaller projects with other departments to enable controlled growth.

The assessment of existing conditions and the preliminary concept for the wireless communications network are further detailed in the following sections of this Technical

Memorandum. Some examples where other entities and cities have benefited from a common backbone wireless network are provided in the Appendix.

3.3 Existing Conditions

The City of Sugar Land Public Works has taken the lead in coordination with other City stakeholders using experience with GIS and traffic management to inspire ideas and possibilities for time and cost saving mobile data applications. As part of this task effort, meetings were held with representatives of Public Works Traffic Engineering, City Water Utilities, Police Communications, Emergency Services Communications, and City Information Technology.

Information was gathered pertaining to the existing infrastructure and operations of the various departments. Meetings have demonstrated cross department and grassroots support for potential broadband wireless connectivity. Participants have identified useful existing facilities and shown excellent cooperation within the city regarding goals and methods. The section of the Technical Memorandum summarizes the existing conditions.

3.3.1 Traffic Control

Traffic Signal Communications

Communication is the core of ITS. It is the information infrastructure that connects the components of the subsystems together and allows coordination and sharing of information among systems and people. The Public Works Department's major communications system is its Traffic Signal System communication network that interconnects the traffic signals throughout the City.

The City manages and operates an expanding series of traffic signal controlled intersections. At the time this Technical Memorandum was prepared, 67 intersections were controlled by traffic signals operated by the City of Sugar Land. The system will expand with the addition of seven more traffic signals in association with known and approved projects. Further, approximately 20 additional signals could eventually come under City control from within the Extraterritorial Jurisdiction (ETJ).

All of the City's existing 67 signals are currently connected to the **ATMS.now** Advanced Transportation Management System in the Traffic Management Center (TMC). This connection allows the **ATMS.now** system to monitor these signals and determine if some form of traffic signal failure has occurred. The City's proposed intersection upgrade plans will enable **ATMS.now** to monitor the seven additional planned signals.

The existing traffic control communications network consists of a combination of media. The TMC is connected to 11 different signal subsystems in the field via ten broadband Integrated Services Digital Network (ISDN) lines. The ISDN lines are leased from the telephone company at a current rate of $100/month for each line. The communication media within each subsystem are owned and maintained by the Public Works Department, necessitating a combination of both skills and equipment. Nine of the eleven subsystems, encompassing a total of 57 signals, utilize Microwave Data Systems (MDS) spread spectrum radio equipment. One subsystem consisting of eight signals utilizes twisted pair copper communications cable, and the final subsystem of two signals is connected to an adjacent spread spectrum subsystem via fiber optic cable.

Figure 3.1 presents the existing signalized intersections throughout the City and ETJ. The communications subsystems are also shown in this figure.

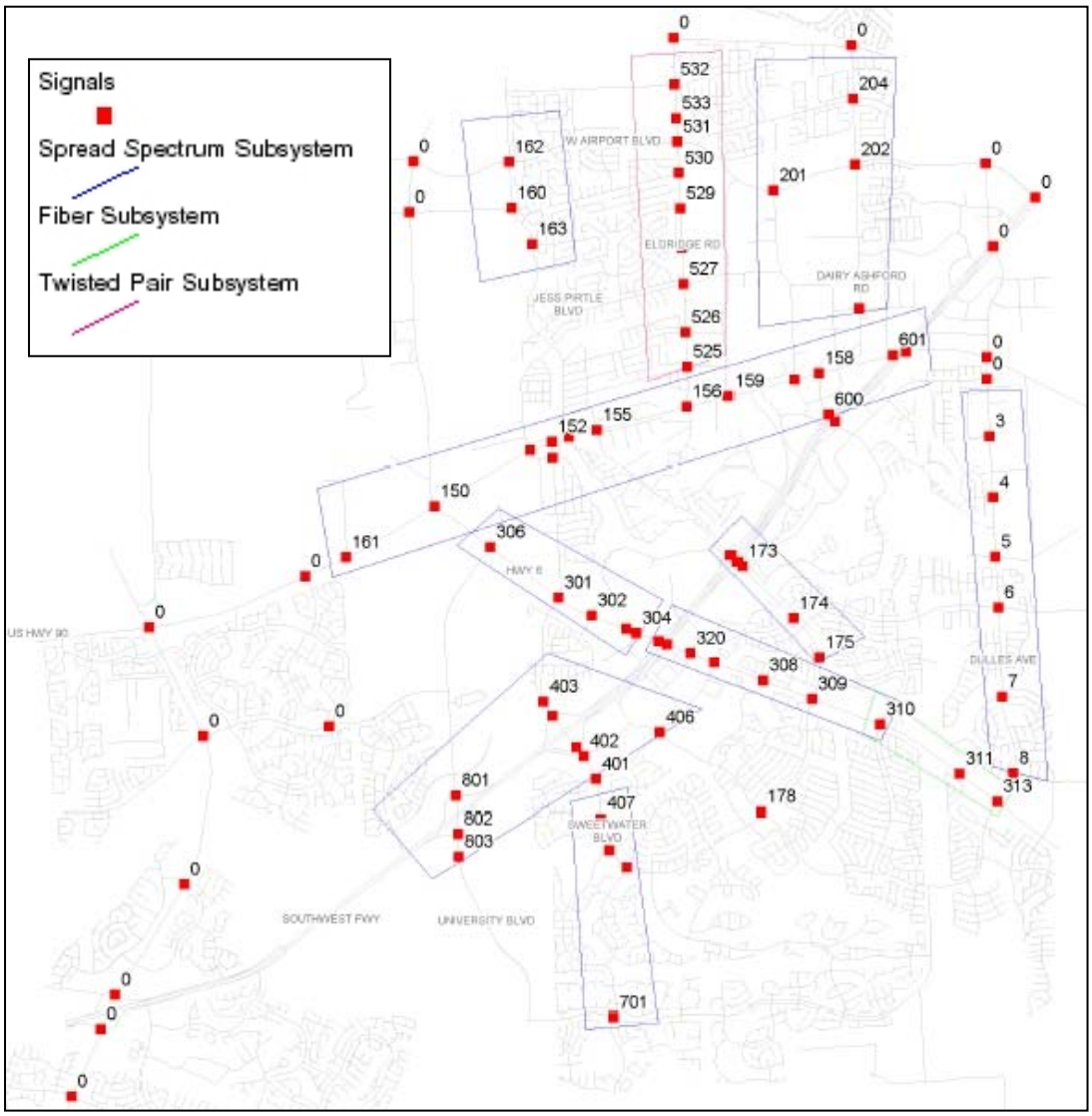


Figure 3.1 Traffic Control Network – Existing Communications

Traffic Signal Controller Hardware

All of the existing intersection controllers were manufactured by Naztec, Inc. They are NEMA TS-2 units, capable of communicating at baud rates of up to 19.2K as currently configured.

Traffic Management Center

The Traffic Management Center (TMC) at Public Works has a main console in a dedicated room using Windows-based control workstations. The Naztec NEMA TS-2 intersection controllers are already working with central management software. Pelco remote CCTV surveillance cameras are located at 11 intersections, providing pan, tilt, and zoom traffic monitoring capability at each. Pelco Windows display software is used to select and control

the cameras. Also, the use of video image processing, or video detection, has been implemented at several intersections. Video detection is a technology that captures and analyzes video images through sophisticated algorithms, providing an economical alternative to inductive loops and other detection technologies for intersection control. The typical configuration entails a camera at each intersection approach, providing a fixed view of traffic arriving at the intersection. This video image and data can be transmitted back to the TMC to provide additional monitoring capability of existing traffic conditions. The Public Works Department may gradually add similar camera clusters at additional signalized intersections. Therefore, the traffic communications backbone may ultimately need to be capable of supporting over 400 potential new cameras.

Adding wideband wireless Ethernet would expand camera capability and increase data feedback from the controllers. Naztec's ATMS software has many modules to manage and display real-time traffic conditions and increased bandwidth would enable advanced features. Extra wireless capacity above that needed for traffic communications may be made available for general City services. The Traffic Management Center has a separate computer displaying railroad activity. Fifteen to 20 trains a day move through the City blocking east west travel. Sometimes all possible major routes are blocked for substantial periods of time. The Doppler Radar Train display reports train speed, position, and road blockage. Trains have a significant effect on emergency response. Making this critical train information available to all mobile and fixed users via browser windows is an important goal.

Existing traffic control cabinets were inspected for mounting space and power. Representative locations deemed to be both easy and difficult to communicate with were surveyed for potential wireless linking solutions. A wireless solution will fit existing intersection controllers and can be sized to support required data volume.

Public Works and Utilities are heavily invested in GIS. The high level of technical sophistication, including trained internal support within Public Works, will make this GIS capability of great use when extended to mobile computers through off-the shelf Internet browser software.

3.3.2 Information Technology

High-speed single mode fiber optic runs from each of eleven major City facilities to a hub at the Police Station. These facilities include six Fire Stations, City Hall, Public Works Department, the Police Station, the Fire Administration Building, and the FAA Control Tower at the City airport.

Existing high-speed fiber has plenty of available capacity and may be exploited in the new system. Wireless mesh backup may be incorporated in case the fiber fails or is cut. Wireless backup capability may be expanded to full capacity later should the existing fiber contract not be renewed in the future. The preliminary concept may include the availability of an all-wireless solution should fiber eventually need to be phased out. The City of may choose to completely own a high-speed microwave backbone capability. Eleven City buildings and two City-owned water towers were surveyed for communications and wireless linking capabilities. A wireless backbone will efficiently interconnect with the existing fiber optic network capacity while providing backup capabilities should any fiber link be cut. The fiber optic network is leased from Time Warner Communications and the current agreement is due to expire in the year 2016. At this time, it is unknown whether the service provider will renew this lease.

3.3.3 Police and Emergency Services

Currently, the City employs an 800 MHz Motorola SmartZone Trunking System and a Proxim 2.4 GHz wireless network. The trunked radio system provides citywide coverage. The Proxim wireless network is installed in the Police Department parking lot and only offers very limited coverage.

Emergency Services and Police currently utilize the Tiburon Computer-Aided Dispatch system, CAD, which does not include an Automatic Vehicle Location (AVL) component in part due to bandwidth limitations of the existing 800 MHz Motorola SmartZone trunking system. Tiburon software modules could be added which would support AVL and facilitate coordination with additional traffic management system modules at the Traffic Management Center. Fleet management software could combine AVL with in-vehicle monitoring systems to enable the City to track the movement and status of fleet vehicles in real-time. By combining GPS-AVL technology with the ATMS system platform, priority service at signalized intersections could be afforded for both emergency and transit vehicles.

At this time there is limited police use of the 2.4 GHz wireless capabilities due to extremely limited coverage. Administrative links are only used in the police building parking lot. Time saving applications and larger coverage areas could provide significant benefits. Existing cards in Police Mobile computers are without external antennas. A requirement for dual-purpose GPS/wireless cards including external antennas would enable both AVL and better wireless range. In-car graphics, cameras, and AVL are not practical now because of limited data capacity of the 800 MHz trunking system. The data channel currently shared with Missouri City sometimes becomes clogged with too much traffic. Emergency Services and Fire personnel are not using communications to mobile computers at this time but are aware of many desirable applications. The City Emergency Operations Center and Main Dispatch Center and Police in-car computers were surveyed. The wireless network concept would substantially improve broadband communications supporting Emergency Services.

It should be noted that there is a current nationwide “800MHz rebanding” effort in which the traditional 800MHz public safety frequencies are being re-assigned to a different part of the spectrum due to radio interference from cellular telephones. ARINC provides rebanding services and has been awarded a contract by the Georgia Technology Authority (GTA) to manage a two-year re-assignment of radio frequencies used by public safety agencies across the entire state.

3.3.4 City Utilities

City water services use AVL vehicle tracking through REDIview, a service contract provider. Current charges are $75 per month per vehicle for service and hardware with web browser access. Approximately eight of 16 utility vehicles have AVL devices installed. Water services staff feels the most important benefit of the AVL system is safety. By knowing where truck is and what its normal movements are, dispatchers are better able to respond to a trouble or emergency signal.

The City has an extensive Water Control SCADA system which uses licensed VHF frequency with EF Johnson radios on the north side of the City and Motorola’s MDS 9810 (spread spectrum) unlicensed radio communication on the south side. A SCADA upgrade project is planned but has not yet been initiated. The SCADA system upgrade is envisioned to implement an open architecture, as opposed to the proprietary technology currently in

place. This upgrade could benefit from wireless communication systems, which are typically developed using accepted standards.

3.3.5 Airport Operations

City fuel trucks at the airport currently use the 800 MHz Motorola trunking data channel for fuel invoicing. A 2.4 GHz wireless system was used in the past but for reasons unknown to the Naztec ITS team, this system was removed. Offloading fuel trucks from critical trunking data services would improve emergency communications. Integration with a citywide wireless data network could be easily achieved, specifically since the current fiber network has a drop in the FAA tower.

The airport terminal supports a large population of business aircraft users. Services such as ARINC Direct are available offering sophisticated dispatch and flight planning services over wireless networks both on-ramp and inside terminals. For more information, please visit www.arinc.com/directweb. Airport coverage and ramp areas were surveyed and we anticipate that wireless communications could be easily improved with the wireless network concept being considered.

3.4 Future Applications

During meetings and discussions with City personnel the following subjects were raised as potential future benefits should wireless mobile Ethernet be available for the City of Sugar Land. These are open-ended subjects requiring future study and development before implementation. Ideas are presented here to illustrate the wide range of potential benefits a high-speed wireless network may bring.

3.4.1 Traffic Control

There are a number of ways in which increased communications capabilities could enable the Public Works Department to operate its traffic signals and related traffic control systems more effectively. These improvements would provide benefits for people that live and work in the City, as well as visitors and other system users. These benefits include:

- Detailed real-time information would enable fine-tuning of traffic flow coordination and provide reduced traffic delays for commuters
- Improved coordination among City Departments during major incidents
- Information to guide visitors to destinations and available parking
- Ability to coordinate traffic plans with neighboring communities
- Enable preferential treatment for buses, high occupancy vehicles, car pools and public transport
- Enable real-time traffic control support of Emergency Management and Operations
- Better warning messages for drivers during major storms
- More efficient use of City personnel managing traffic during normal operations and special events.

Other potential projects could be implemented to take advantage of the increased data gathering and transmission capabilities of the wireless network. Red-light running cameras could monitor and collect information on intersections requiring tighter policing. Automated speed detection and enforcement could monitor traffic flows, and Reckless Driver recognition cameras could discourage risk-taking activities.

3.4.2 Police

Wireless video from police cars and problem areas like parking garages or malls may be reviewed locally and recorded at headquarters. Police or fire vehicles may drive up to buildings and link via the wireless network to in-building private camera systems (in cooperation with private owners). Video and graphics capabilities would be substantially improved with a high-speed secondary non-blocking data channel available. External antennas and built-in GPS using the same external wireless antenna would allow extra bandwidth to support AVL. A wireless network could enable vehicles to receive photos (mug shots) and send mobile camera feeds. Links may relay data and queries from the Texas Data Exchange, the Victim Notification Program, Mutual Aid Task Forces of surrounding counties and jurisdictions, the COBAN license plate recognition system, Bar Code 3D for VIN verification, Mobile AFIS Automated Fingerprint Identification, and AMBER Alert pictures. Audit traceability may be added to camera and data feeds to provide legal evidence and improve prisoner handling and transport.

3.4.3 Emergency Services

Tiburon CAD linked with the central Advanced Transportation Management System software could integrate Automatic Vehicle Location and enable "closest time responder" dispatch and better control of vehicle movement throughout the City. Fire and Emergency personnel could see real-time maps in vehicles showing trains, traffic congestion, and camera views of critical situations. With the implementation of a communication interoperability system, HAZMAT updates, Biological Response Information, Coordination, Incident Command, and Mutual Aid could be available directly at the incident site. A product such as ARINC AWINS could integrate communications systems being used by existing Mobile Command Post and Mobile HAZMAT Response Trucks with all mutual aid services and solve interoperability problems. For more information on AWINS, please refer to relevant information contained in the Appendix. Sugar Land has currently implemented a train Doppler radar system. This system provides a continuous stream of information, allowing train direction and speed to be recorded. Critical information from this Doppler radar system could be made available to expedite real world incident control.

3.4.4 City Utilities

The City has implemented a SunGard HTE Utility System. This product offers a broad, integrated information system to facilitate electric, gas, water, sewer, and other utility services by automating customer service, work orders, and billing tasks and managing utility assets. The Work Order Management module has a wireless integration module, which could potentially save time dispatching workers and collecting results. A substantial increase in efficiency and costs savings could result. GIS browser maps of power, gas lines, water lines, valves, and property owner information could be displayed in real-time to field workers. With the implementation of a wireless communication system, water source and pumping links from SCADA systems could be delivered to mobile workers and as well as support Fire operations. Building floor plans from city planning could be accessed from mobile browsers for Police, Fire, and Building Inspectors. Water Valve surveys are currently a time consuming task. A wireless communication system could be used to send GIS data out workers in the field. City building inspections could be greatly improved with real-time information updated on the spot by field personnel.

3.4.5 Parks and Recreation

Multiple police agencies could monitor camera feeds. Relocatable cameras could be solar powered to increase mobility and decrease electricity costs. “Panic button” and Voice Over IP Emergency 911 calling could also easily be implemented. These types of additions could improve public safety and increase utilization of naturally landscaped or remote public facilities.

3.4.6 City Services

Cameras on school district busses may monitor safety. Building Automation will allow city buildings to heat / cool on intelligent schedules and turn off lights to save energy. City Vehicle Fleet Management Module will integrate with existing HTE Work Order System to increase efficiency and allow long-term work force optimization.

Cameras on school district buses could also be used to monitor safety. Building Automation will allow city buildings to heat / cool on intelligent schedules and turn off lights to save energy. City Vehicle Fleet Management systems could possibly be integrated with the existing HTE Work Order System to increase efficiency and allow long-term work force optimization.

3.5 Sugar Land Wireless Network Preliminary Concept

The traffic control system communication network is at the heart of the City’s Intelligent Transportation System program, and an excellent foundation upon which to add data transmission bandwidth and management and operation capabilities. As stated in the Executive Summary, Public Works Department staff and other potential stakeholders and team members have concluded that a wireless communication network, with its flexibility and modular expandability, could admirably fit the current and future communications needs of the City of Sugar Land.

The Sugar Land Public Works Department has identified the potential to install Ethernet IP “standards-based” communications to improve traffic signal system management. Wireless IP enabled traffic signal control can be used to improve traffic flow and enable new applications for higher efficiency and cost savings. The City’s Advanced Transportation Management System (ATMS) provides the ability to connect traffic signal controllers to an intelligent network for enhanced data gathering and analysis and better timing of traffic signals.

As a first step in the upgrade process, the existing Naztec NEMA TS-2 traffic signal controllers can be easily upgraded to Ethernet-capable devices by the replacement of the controller faceplate and internal communications card, enabling communications at a range of 10 – 1,000 megabits. The preliminary concept of network communications is presented in the following sections.

3.5.1 Preliminary Concept

The Naztec ITS team’s preliminary concept of the Sugar Land ATMS wireless implementation is to deliver a performance-based network. The preliminary concept is based upon knowledge gained from our initial site surveys of the geography and layout of the

intersections to be networked, and selected radio performance with a range of antennas. While reviewing this preliminary concept, it should be kept in mind that the actual network implementation will likely include a wireless optimization phase. During optimization, conclusive RF engineering surveys should be performed to finalize the placement of antenna and radio equipment. It is fully expected that changes to the preliminary concept will occur and may likely result in link layout modifications. The linking layout included is shown in Figure 2 for illustration of the preliminary concept.

3.5.2 Growth and Extraterritorial Jurisdictions

Based on our preliminary site survey conducted as part of this study, it appears that the Sugar Land, Texas ATMS wireless network could consist of approximately forty-one (41) primary intersections and fifty-four (54) secondary intersections (see Figure 3.2). Exact count of intersections is subject to change due to fast growth and added Extraterritorial Jurisdictions (ETJ) responsibilities of this expanding area. The primary and secondary intersections are grouped in a manner so every secondary intersection connects directly to a primary intersection without having to go through multiple hops. This would be done to ensure connectivity and avoid signal or data throughput degradation. The flexibility of the wireless preliminary concept fits this rapid expansion allowing the City to deploy and re-deploy as needed.

3.5.3 Wireless and Link Layout

The preliminary concept of the wireless network utilizes the advantages of a modified mesh technology to attain the best performance. This concept will most likely be built on an architecture that consists of a single central location that provides connectivity to the City's data network, Main Collection Points, Primary Intersections and Secondary Intersections. The single central location, which will most likely be the Police Communications Room, would communicate with Main Collection Points to receive aggregated data from them. The Main Collection Points in turn would connect to Primary Intersections to receive data from them. The Primary Intersections could either be stand-alone, or could be connected to Secondary Intersections. The Main Collection Points will be chosen because of their location with respect to the Primary Intersections as well as their connectivity to the single central location fiber optic hub. The Main Collection Points would typically be located on City-owned water towers, City buildings, and fire stations, etc. The Primary and Secondary Intersections would be co-located with Naztec traffic signal controllers at roadway intersections.

Outlying portions of the City are relatively flat and residential which should allow the primary intersections clear links to the main collection points. Closer to the area of City Hall, tall buildings, highway overpasses along Highway 59, and dense ornamental trees create obstructions which may be accounted for by adding more collection points and mesh connectivity.

Controlled intersections, City building parking lots, and selected building interiors could be fitted for mobile access points working at the economical 2.4 GHz band. The 2.4 GHz connectivity would allow relatively inexpensive high quality mobile computer, PDAs, and SCADA devices to link over Virtual Private Networks to multiple City functions.

3.5.4 Potential Wireless Connectivity Issues

During our site visits, it was noted that there were approximately 15 intersections that could potentially present some problems with establishing wireless connectivity to the rest of the

network. Primarily, this is due to dense foliage. It is anticipated that these issues can be resolved by installing the antennas above the tree height or by implementing Multiple Input, Multiple Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) technology at these locations. MIMO-OFDM is a technology that uses multiple antennas to transmit and receive radio signals. MIMO-OFDM will allow service providers to deploy a Broadband Wireless Access (BWA) system that has Non-Line-of-Sight (NLOS) functionality. Specifically, MIMO-OFDM takes advantage of the multipath properties of environments using base station antennas that do not have line-of-sight.

3.5.5 Next Steps

As a result of this study, it is recommended that the City of Sugar Land proceed with defining/refining the design concept. This effort would require another on-site visit to conduct an in-depth RF survey to accurately determine optimal communication methods. Following the RF survey, an accurate system design could be developed that would enable specific quantities and configurations of components to be determined.

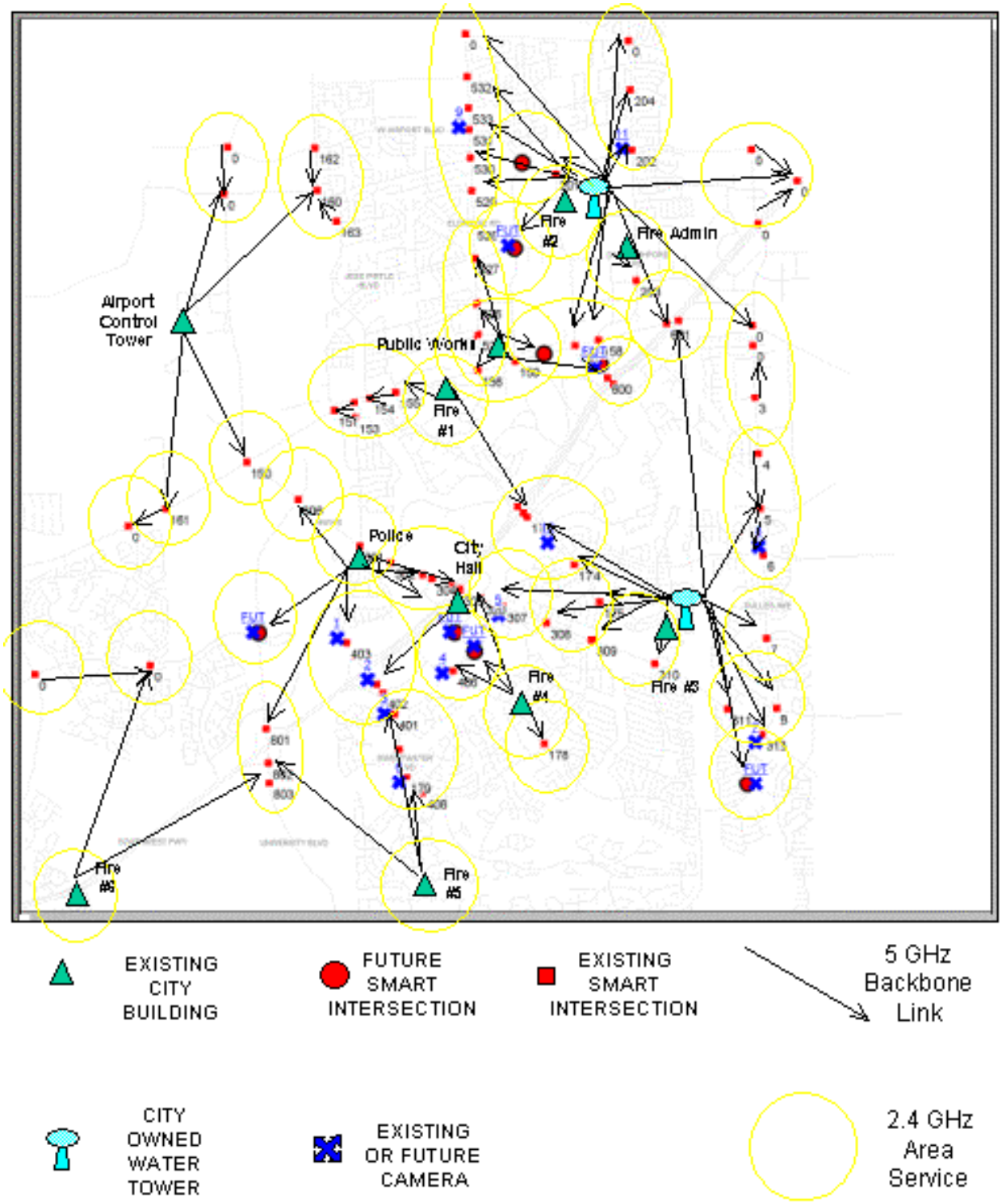


Figure 3.2 Wireless Preliminary Concept

4 Transportation Problems and Needs

4.1 Introduction and Summary

This chapter identifies the transportation problems and needs of the City of Sugar Land as a series of transportation related functions. Most of these functions are based on the National ITS Architecture[2]. This architecture was developed to provide a common framework for, and support the development of, a wide variety of transportation functions and capabilities. These functions and capabilities are described within the National ITS Architecture as "market packages".

Although these market packages cover a wide range of functions, they are not all inclusive. For this reason, the functions that were considered for the City's ITS Operations Plan consisted of functions based on the market packages of the National Architecture and a series of additional functions reflecting the concerns of the project stakeholders. These supplementary functions were derived from the initial meetings of the Project Steering Committee where the project stakeholders described a wide variety of transportation problems and needs in the community.

The Project Steering Committee selected the candidate functions considered for inclusion in the City's ITS Operations Plan using a process with several steps. In one of the most significant steps the Project Steering Committee members rated the importance of each function. In another subsequent step, the Steering Committee determined which of the lower rated functions needed no further consideration. The results of this process are shown in the Listing of Candidate Functions at the end of this chapter.

4.2 Development of Functionality Statements

The candidate functions for inclusion in the City's ITS Architecture were selected by the Project Steering Committee from a larger list of functions drawn from two sources. The first source was a list of functions reflecting the National ITS Architecture, and the second was a supplementary set of functions reflecting the comments and concerns of the Steering Committee

4.2.1 Functions Based on the National ITS Architecture

The vast majority of the functions that could be included in the City's ITS Operations Plan were taken from the market packages associated with the National ITS Architecture. The National ITS Architecture provides a common structure for the design of intelligent transportation systems. It defines the framework around which multiple design approaches can be developed, each one specifically tailored to meet the individual needs of the user, while maintaining the benefits of a common architecture. These benefits include:

[2] _The National ITS Architecture; US Department of Transportation; 2002; Washington, D.C.

- Simplifying integration of Intelligent Transportation Systems by presenting a common structure around which standards can be developed
- Encouraging compatibility that will allow the same equipment to work over the entire country.

Adherence to the National Architecture and its framework allows the establishment of an Intelligent Transportation System with a core group of functions that can be expanded to include additional functions in the future. By establishing the ITS Operations Plan for the City of Sugar Land in conformance with the National ITS Architecture, additional functions are not precluded from being added in the future, even if they are not included in the original set.

Each one of the market packages of the National ITS Architecture identifies pieces of the architecture that implement a particular transportation service. Version 5.0 of the National ITS Architecture identifies 85 market packages. These market packages are divided into eight groups reflecting major ITS applications areas:

- ATMS Advanced Transportation Management Systems
- APTS Advanced Public Transportation Systems
- ATIS Advanced Traveler Information Systems
- AVSS Advanced Vehicle Safety Systems
- CVO Commercial Vehicle Operations
- EM Emergency Management
- AD Archived Data Management
- MC Maintenance and Construction Management

The descriptions of the market packages provided in the National ITS Architecture are occasionally a bit complicated and lengthy. One of the least complex market packages is the National ITS Architecture's description provided for ATMS1 - Network Surveillance:

> This market package includes traffic detectors, other surveillance equipment, the supporting field equipment, and fixed-point to fixed-point communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.

It was not reasonable to expect a Project Steering Committee to read, interpret and evaluate more than 80 statements similar to (and frequently more complex) than this one. For this reason, a series of one sentence "Functionality Statements" were developed and presented to encapsulate the essence of the transportation service at the core of each market package. Where necessary, the market package description was divided into more than one functional statement. For example, the Functionality Statements developed for ATMS01 are:

- ATMS01a - The system should collect traffic volume data for monitoring traffic flow and displaying real-time conditions
- ATMS01b - The system should provide video images of key locations

In several instances market packages from the National ITS Architecture were eliminated because the implementation of these packages is the responsibility of other (non-City) agencies, or of the private sector. These included most market packages associated with the Advanced Public Transportation Systems and Advanced Vehicle Safety Systems.

4.2.2 Supplementary Functions Based on Project Steering Committee Concerns

As previously indicated, several functions were included as a result of the interests and concerns expressed by the members of the Project Steering Committee. In several cases these resulted in a functional statement from the National ITS Architecture being interpreted to address problems and needs of the City. For example: ATMS19 Speed Monitoring was transformed into two functionality statements:

- ATMS19a - The system should monitor vehicle speeds and environmental conditions to recommend a safe driving speed
- ATMS19b - The system should automatically ticket cars that drive at excessive speeds

The inclusion of functionality statement ATMS19b is a direct result of the discussions held with stakeholders during initial project interviews.

Additional new functionality statements were developed to address an interest in expanding the capabilities of the City's Advanced Transportation Management System (i.e., ATMSE02 - The system should support the sharing of parking facility video among City departments). These statements closely parallel market packages developed for Advanced Transportation Management Systems.

A total of 87 functionality statements (market package based functions, plus supplementary functions) were developed in this manner. Table 4.1 shows the list of the functionality statements distributed to the Steering Committee and the instructions for ranking them.

Table 4.1

List of Functionality Statements

Market Package	Statement of Functionality	Importance 0 to 4 (0 not important) (4 very important)
Group 1: ATMS – Advanced Transportation Management Systems		
ATMS01a	The system should collect traffic volume data for monitoring traffic flow and displaying real-time conditions	
ATMS01b	The system should provide video images of key locations	
ATMS02	The system should collect the average speed of traffic on major arterials	
ATMS03a	The system should provide better signal timing and signal coordination	
ATMS03b	The system should adjust signal timing based on real-time traffic data	
ATMS04	The system should support ramp metering at highway on-ramps	
ATMS05	The system should support the control of High Occupancy Vehicle lanes on arterials	
ATMS06a	The system should provide information to drivers using Highway Advisory Radio	
ATMS06b	The system should provide information to drivers using Dynamic Message Signs	
ATMS07	The system should exchange data with TxDOT and other local traffic agencies	
ATMS08a	The system should improve coordination among organizations that respond to accidents	
ATMS08b	The system should improve coordination among organizations dealing with traffic at special events	
ATMS09	The system should help predict future traffic volumes	
ATMS10	The system should support electronic toll collection	
ATMS11	The system should gather emissions and air quality data	
ATMS12	The system should gather data on local roads that do not have signals	
ATMS13	The system should monitor the operation of railroad grade crossings	
ATMS14	The system should monitor the operation of high speed (>80 mph) railroad grade crossings	
ATMS15	The system should coordinate grade crossing operation with the railroad	
ATMS16a	The system should support the operation of on-street parking	

ATMS16b	The system should direct drivers to parking garages where space is available	
ATMS17	The system should provide regional coordination of parking information	
ATMS18	The system should support the operation of reversible traffic flow lanes on major roads	
ATMS19a	The system should monitor vehicle speeds and environmental conditions to recommend a safe driving speed	
ATMS19b	The system should automatically ticket cars that drive at excessive speeds	
ATMS20	The system should monitor the operation of drawbridges	
ATMS21	The system should monitor roads to determine if they are flooded	
Group 2: APTS – Advanced Public Transportation Systems		
The implementation of Public Transit related functions is the responsibility of the transit agency. However, the functions listed below could be supported by the City's ITS Operations Plan.		
APTS5	The system should provide surveillance and/or an emergency call button at selected bus stops	
APTS7	The system should provide buses with a green light when it does not degrade traffic signal operation	
APTS8a	The system should provide transit information using kiosks at selected locations	
APTS8b	The system should provide transit information through City-operated information sources	
Group 3: ATIS – Advanced Traveler Information Systems		
ATIS1	The system should push traffic data to travelers through enhanced pagers, cell phones, etc.	
ATIS2	The system should push customized traffic data to travelers in response to specific requests	
ATIS3	Autonomous in-vehicle route guidance. (Provided by the vehicle manufacturers or after-market suppliers)	**N/A**
ATIS4	The system should provide traffic data for in-vehicle route guidance systems	
ATIS5	The system should provide traffic data and video images to private sector firms	
ATIS6a	The system should adjust signal timing based on real-time event data from major traffic generators	
ATIS6b	The system should optimize the traffic control strategy based on anticipated routes of selected vehicles	
ATIS7	The system should provide “Yellow Pages” and reservation services	
ATIS8	The system should provide real-time ridesharing (carpooling) information	
ATIS9a	The system should provide a low-power radio broadcast at each road sign (Stop, Curve Ahead, etc.)	
ATIS9b	The system should support the display of roadside sign messages on in-vehicle computer screens	

Group 4: AVSS – Advanced Vehicle Safety Systems		
Almost all of the functions in this ITS group must be provided by the motor vehicle manufacturers. However, the functions listed below could be supported by the City's ITS Operations Plan.		
AVSS05	The system should support the warning of drivers when the probability of an intersection collision has been determined	
AVSS10	The system should support automatic vehicle control in support of a collision warning at selected intersections	
AVSS11	The system should support automated ("hands-off") operation of vehicles on selected streets	
Group 5: CVO – Commercial Vehicle Operations		
CVO01a	The system should include an automatic vehicle location system for Public Works Dept. vehicles	
CVO01b	The system should include an automatic vehicle location system for other City-owned vehicles	
CVO02	The system should support the monitoring of material/equipment on Public Works Dept. vehicles	
CVO03	The system should support electronic roadside credential checks of commercial trucks	
CVO04	The system should support the electronic processing of CVO permits, and credentials	
CVO05	The system should support the electronic clearance of cargo from Canada and Mexico	
CVO06	The system should include the electronic weighing of commercial vehicles	
CVO07	The system should provide data for roadside safety checks of commercial trucks	
CVO08	The system should support roadside electronic reading of safety information on commercial trucks	
CVO09	The system should support the automated record keeping of city owned/ Public Works Dept. vehicles	
CVO10	The system should support the response to incidents involving Hazardous Materials (HAZMAT)	
CVO11	The system should support the detection and classification of Hazardous Materials on commercial vehicles	
CVO12	The system should support the detection of unauthorized Public Works Dept. vehicle drivers	
CVO13	The system should support the tracking of freight shipments	
Group 6: EM – Emergency Management		
EM01	The system should support the computer-aided dispatch of emergency vehicles	
EM02a	The system should recommend routes for emergency vehicles based on traffic conditions	

EM02b	The system should provide fire trucks with a green light at traffic signals	
EM02c	The system should provide ambulances with a green light at traffic signals	
EM02d	The system should provide police cars with a green light at traffic signals	
EM03	The system should support the E911 system to identify the location of calls from cell phones	
EM04	The system should provide snapshots of accidents to dispatchers and emergency vehicles	
EM05	The system should provide security monitoring of transportation infrastructure	
EM06	The system should support Amber Alerts and other wide area emergency notifications	
EM07	The system should monitor and detect potential natural and technological disasters	
EM08	The system should support coordination of emergency response plans	
EM09	The system should support coordination of evacuation plans	
EM10	The system should provide disaster-related traveler information	
Group 7: AD – Archived Data Management		
AD1	The system should save City traffic data for future analysis	
AD2	The system should save data on other transportation activities within the City (Transit, Parking, etc.)	
AD3	The system should facilitate the exchange of archived data with other agencies	
Group 8: MC – Maintenance and Construction Management		
MCO1	The system should monitor the location and status of maintenance and construction vehicles	
MCO2	The system should monitor and schedule Public Works Dept. vehicle maintenance activities	
MCO3	The system should monitor roadway environmental conditions such as pavement temperature or flooding	
MCO4	The system should distribute roadway environmental information such as pavement temperature or flooding	
MCO5	The system should automatically treat selected roadways based on environmental conditions	
MCO6	The system should utilize environmental data to schedule winter maintenance activities	
MCO7	The system should support monitoring and scheduling roadway maintenance and construction activities	
MCO8	The system should provide for management and coordination of work zones	
MCO9	The system should provide intrusion detection and alarms to improve safety in work zones	

MC10	The system should provide maintenance and construction activity coordination with other centers of operation	
Group 9: Advanced Transportation Management System Enhancements		
These functions are not necessarily a standard part of the National ITS Architecture, but have been added in response to the Steering Committee's input during the screening process		
ATMSE01	The system should automatically ticket vehicles that run red lights	
ATMSE02	The system should support the sharing of parking facility video among City departments	

4.3 Ranking of Functionality Statements

The basic nature of the functionality statements and ranking process were explained at the August 2007 Project Steering Committee meeting. During this meeting the Functionality Statements and the procedure for ranking them were distributed to the members of the Project Steering Committee.

The table that was distributed to the members of the Steering Committee contained a series of statements about different functions that could be incorporated into the City's ITS Operations Plan. For example: "The system should collect traffic volume data for monitoring traffic flow and displaying real-time conditions." The members of the Steering Committee were requested to review each function and indicate how important they believed the function is.

A column on the right side of the table was provided where the Steering Committee member could enter a number from zero to four to indicate how important he or she believed the function to be. The following instructions were provided to help in assigning the appropriate number to each function.

A four should be entered if you feel that function is very important, and a zero should be entered if you don't think the function is important. In a narrative sense:

- Four indicates the system must have the functionality
- Three indicates that the system should have the functionality
- Two indicates that the system may have the functionality
- One indicates that the system may or may not need the functionality
- Zero indicates that the system doesn't need the functionality

Keep in mind, because of the expandability of the National ITS Architecture, a one or a zero does not mean that a particular function will be prevented from being added in the future.

The importance rating can also be thought of in monetary terms. If you assign a four to a particular function it means you believe that the City should "buy" that functionality. If you assign a zero to a particular function it means that you don't think the City should buy that function. In this interpretation the numbers from zero to four indicate your level of interest in buying that function.

Average rating values were calculated for each of the functional statements based on individual ratings that were returned. These average importance ratings from the members of the Project Steering Committee are a reflection of the needs of the Transportation Stakeholders in the City of Sugar Land. These Functionality Statements were then sorted on the basis of the ratings.

4.4 Review of Statements and Identification of Candidate Functions

The next step in the identification of candidate functions was also conducted at the August 2007 Project Meeting. The Steering Committee reviewed the functionality statements from the bottom up to determine the boundary that divided the functions that should be seriously considered from the remaining functions. This also ensured that there was an opportunity to discuss any functions that were rated low, but that may become significant in the future.

The overall list of ITS functions that should be considered as candidates for inclusion in the City's ITS Operations Plan is shown in Table 4.2. All of these functions are in the top part of the ratings.

4.5 Final Listing of Candidate Functions

Table 4.2 shows the final consolidated list of 30 candidate functions that will be considered for inclusion in the City's ITS Operations Plan. As previously noted, other functions may also be added in the future, as long as the City's ITS system is developed in general conformance with the National ITS Architecture.

Table 4.2

Listing of Candidate Functions

Identifier	Function	Ranking
AD1	The system should save City traffic data for future analysis	4.0
ATMS01a	The system should collect traffic volume data for monitoring traffic flow and displaying real-time conditions	4.0
ATMS01b	The system should provide video images of key locations	4.0
ATMS03a	The system should provide better signal timing and signal	4.0
ATMS03b	The system should adjust signal timing based on real-time traffic	4.0
EM02b	The system should provide fire trucks with a green light at traffic	4.0
EM02C	The system should provide ambulances with a green light at traffic signals	4.0
AD3	The system should facilitate the exchange of archived data with other agencies	3.7
ATIS6a	The system should adjust signal timing based on real-time event data from major traffic generators	3.3
ATMS02	The system should collect the average speed of traffic on major arterials	3.3
ATMS06b	The system should provide information to drivers using Dynamic Message Signs	3.3
ATMS08a	The system should improve coordination among organizations that respond to accidents	3.3
ATMS08b	The system should improve coordination among organizations dealing with traffic at special events	3.3
EM06	The system should support Amber Alerts and other wide area emergency notifications	3.3
AD2	The system should save data on other transportation activities within the City (Transit, Parking, etc.)	3.0
ATIS1	The system should push traffic data to travelers through enhanced pagers, cell phones, etc.	3.0
ATMS09	The system should help predict future traffic volumes	3.0

Identifier	Function	Ranking
ATMS13	The system should monitor the operation of railroad grade crossings	3.0
ATMS16b	The system should direct drivers to parking garages where space is available	3.0
CVO01a	The system should include an automatic vehicle location system for Public Works Dept. vehicles	3.0
CVO01b	The system should include an automatic vehicle location system for other City-owned vehicles	3.0
CVO02	The system should support the monitoring of material/equipment on Public Works Dept. vehicles	3.0
EM02a	The system should recommend routes for emergency vehicles based on traffic conditions	3.0
EM09	The system should support coordination of evacuation plans	3.0
ATMS07	The system should exchange data with TxDOT and other local traffic agencies	2.7
ATMS15	The system should coordinate grade crossing operation with the railroad	2.7
EM01	The system should support the computer-aided dispatch of emergency vehicles	2.7
EM08	The system should support coordination of emergency response plans	2.7
EM10	The system should provide disaster-related traveler information	2.7
ATIS4	The system should provide traffic data for in-vehicle route guidance systems	2.3

5 Determine ITS Options

5.1 Introduction and Summary

Task 4 of this ITS Operations Plan project identified the transportation problems and needs of the City of Sugar Land as a series of transportation related functions. Most of these functions are based on the National ITS Architecture[3]. This architecture was developed to provide a common framework for, and support the development of, a wide variety of transportation functions and capabilities. These functions and capabilities are described within the National ITS Architecture as "market packages".

The previous chapter described the Project Steering Committee's selection of the most important Functional Requirements. This chapter presents a series of projects that were developed to address these requirements, and shows the relationships of these projects to the functional requirements. These relationships occur at three levels:

- "Enabling" projects implement a particular functionality
- "Prerequisite" projects must be in place or operational for the enabling project to operate
- "Supporting" projects add value to functions that are performed by the enabling projects

Although the relationships between the projects and the functional requirements are easily seen in many instances, there is not a one-to-one relationship between the function and a specific enabling project. In some cases a particular functional requirement is implemented by more than one project. In other cases one project, or a set of projects, implements several of the functional requirements.

The project discussions in this chapter provide brief descriptions of these projects, identify their relationships to the functional requirements, and summarize their benefits.

5.2 Relationships between the Functional Requirements and the Projects

The following sections introduce the projects in terms of their relationships to the functional requirements. These relationships are summarized in Table 5.1, which contains a great deal of information about the relationships between the functional requirements and the projects. Three levels of these relationships are shown:

- Enabling Projects
- Prerequisite Projects
- Supporting Projects

[3] _The National ITS Architecture; US Department of Transportation; 2002; Washington, D.C.

Table 5.1
Relationships Between
Functional Requirements and Projects

KEY
E = Enabling Project
P = Prerequisite Project
S = Supporting Project

		Projects																	
	Functional Requirement	**Install Wireless Communication Infrastructure for ITS Field**	**Upgrade Traffic Controllers to Ethernet-Based Units**	**Expand System Detection Network**	**Expand CCTV Surveillance System**	**Central Traffic Signal Priority Software Module**	**Central Traffic Adaptive Software Module**	**Expand Driver Feedback Speed Signs**	**ATMS & Emergency Services Integration**	**Railroad Crossing Monitoring System**	**Install DMS**	**CCTV & Traveler Information Website**	**Share Data/Video with TxDOT and Neighboring Cities**	**Citywide Traffic Signal Timing Optimization**	**Parking Availability System**	**Central Fleet Management Software Module**	**Public Works Vehicle Payload Monitoring System**	**Enable SystemData Exchange**	**Share Data with Mobile Command Post for Traffic Incidents**
		1.1	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**2.1**	**2.2**	**2.3**	**3.1**	**3.2**	**3.3**	**4.1**	**4.2**	**4.3**	**4.4**	**5.1**	**5.2**
1	Save City traffic data for future analysis	S	S	P														S	
2	Collect traffic volume data for monitoring traffic flow and displaying real-time conditions	S	S	P								S	S		S			S	
3	Provide video images of key locations	S			E							S	S						
4	Provide better signal timing and signal coordination	S	S	E			S							E					
5	Adjust signal timing based on real-time traffic data	S	S	E			P												
6	Provide fire trucks with a green light at traffic signals	S	S			E			S							S			
7	Provide ambulances with a green light at traffic signals	S	S			E			S							S			
8	Facilitate the exchange of archived data with other agencies	S		P								S	E						
9	Adjust signal timing based on real-time event data from major traffic generators	S	S	E															
10	Collect the average speed of traffic on major arterials	S	S	E															
11	Provide information to drivers using Dynamic Message Signs	S		P				E			E				S				
12	Improve coordination among organizations that respond to accidents	S		S	S				E			S				S		E	E
13	Improve coordination among organizations dealing with traffic at special events	S	S	P	S							S						E	E
14	Support Amber Alerts and other wide area emergency notifications	S									E	S	S					S	
15	Save data on other transportation activities within the City (Transit, Parking, etc.)	S								S		S			S	S		S	
16	Push traffic data to travelers through enhanced pagers, cell phones, etc.	S		P								S							
17	Help predict future traffic volumes		S	P															
18	Monitor the operation of railroad grade crossings	S	S							E									
19	Direct drivers to parking garages where space is available	S									S				E				
20	Include an automatic vehicle location system for Public Works Dept. vehicles															E			
21	Include an automatic vehicle location system for other City-owned vehicles															E			
22	Support the monitoring of material/equipment on Public Works Dept. vehicles																E		
23	Recommend routes for emergency vehicles based on traffic conditions	S	S	P	S				E							S			
24	Support coordination of evacuation plans	S		S	S						S	S	E					S	
25	Exchange data with TxDOT and other local traffic agencies			P	S							S	E		S	S		S	
26	Coordinate grade crossing operation with the railroad	S			S					S								S	
27	Support the computer-aided dispatch of emergency vehicles					S										E			
28	Support coordination of emergency response plans	S		S	S	S			S		S	S	S			S		S	S
29	Provide disaster-related traveler information	S			S						E	S	S					S	
30	Provide traffic data for in-vehicle route guidance systems	S	S	P														S	

Enabling projects are at the highest level. These projects directly implement a functional requirement. In several cases more than one project is required to implement a functional requirement. For example: The functional requirement to "Adjust signal timing based on real-time traffic data" is implemented through two separate projects. It is first implemented through Project 1.3–Expand System Detection Network, and is also implemented through Project 1.7–Central Traffic Adaptive Software Module.

Prerequisite projects provide a secondary level of functional requirement implementation. These projects will not directly enable a project by themselves, but the enabling project requires this prerequisite in order to operate. As an illustration, Functional Requirement 23, Recommend Routes for Emergency Vehicles Based on Traffic Conditions is enabled by Project 2.2–ATMS & Emergency Services Integration. Project 1.3 is a prerequisite for this project because it will install system detection equipment on local streets to collect real-time traffic data.

Supporting projects indicate a third level relationship between the functional requirements and an implementation project. These supporting projects are not required for the implementation of the functional requirement, but their existence will improve that functional requirement in some way. An example of this relationship is that Functional Requirement 2, Collect Traffic Volume Data for Monitoring Traffic Flow and Displaying Real-Time Conditions is supported by Project 3.2–CCTV & Traveler Information Website Integration. The website will provide a platform for the display of current traffic conditions.

There are four projects that constitute the core of the City's ITS Operations Plan. As can be seen in Table 5.1, they are related by one of these three levels to a number of functional requirements. These four projects are:

- Project 1.1–Install Wireless Communications Infrastructure for ITS Field Equipment. This project will establish new communications hardware at the Traffic Management Center and at the field cabinets. It is a supporting project for a majority of the functional requirements. The wireless traffic control system communication network is at the heart of the City's Intelligent Transportation System program, and an excellent foundation upon which to add data transmission bandwidth and management and operation capabilities.

- Project 1.2–Upgrade Traffic Controllers to Ethernet-Based Units. This project is not an enabling project for any specific functional requirement, but it is a supporting project for a large number of functional requirements. It is given this special status because Wireless IP-enabled traffic signal control can be used to improve traffic flow and enable new applications for higher efficiency and cost savings. The City's Advanced Transportation Management System (ATMS) provides the ability to connect traffic signal controllers to an intelligent network for enhanced data gathering and analysis and better timing of traffic signals.

- Project 1.3–Expand System Detection Network. The ability of the traffic control software to assess current conditions and optimize traffic flow will be limited if there is partial or inaccurate data coming in from the field. This is also an enabling project for the functional requirements related to signal timing and coordination and is a prerequisite for several of the other functional requirements associated with the analysis and sharing of data.

- Project 1.4–Expand CCTV Surveillance System. Although this project only enables one of the functional requirements, it is a supporting project for every other functional requirement that involves sharing video and improving coordination between groups.

An overview of the relationships between the functional requirements and the projects is provided in the next section along with a basic description of these projects.

5.3 Identification of Projects

Based on stakeholder input, a number of project types have been developed for achieving Sugar Land's vision, goals and objectives. These projects have been divided into five groups, each representing a particular type of improvement. These groups are:

- Group 1–Traffic Signal System Improvements. These improvement projects are related to the functional requirements concerned with various aspects of signal control and other active traffic control devices.
- Group 2–Safety Enhancement Projects. There are three projects in this group that are concerned with the functional requirements that are most directly related to the safe operation of the roadway system.
- Group 3–Traveler Information and Information Sharing with Regional Agencies. As indicated in the title, the projects in this group are concerned with the dissemination of traffic information to the public and other concerned transportation agencies.
- Group 4–Transportation Management. One of the key elements of any ITS Operations Plan involves improving transportation and incident management through better coordination of the transportation and emergency service agencies that deal with accidents and other incidents. The projects in this group address several of the functional requirements related to transportation and incident management.
- Group 5–Other Projects. This last group addresses the overall exchange of data.

5.3.1 Group 1–Traffic Signal System Improvements

These signal system projects include many of the highest priority projects in the Operations Plan. As can be seen in Table 5.1, they directly enable many of the functional requirements that were determined by the Project Steering Committee to be the most important. They also are prerequisite or supporting projects for most of the remaining functional requirements. Although not listed in Table 5.1, initial projects will be required to perform the detailed engineering required for the preparation of the plans and procurement documents for a number of these projects.

Project 1.1: Install Wireless Communication Infrastructure for ITS Field Equipment

As was summarized in the Task 3 Technical Memorandum, *Communications Network Problems and Needs*, Public Works Department staff and other potential stakeholders and team members have concluded that a wireless communication network, with its flexibility and modular expandability, could admirably fit the current and future communications needs of the City of Sugar Land.

The preliminary concept of the wireless network utilizes the advantages of a modified mesh technology to attain the best performance. This concept will most likely be built on an architecture that consists of a single central location that provides connectivity to the City's data network, Main Collection Points, Primary Intersections and Secondary Intersections.

As indicated in Table 5.1 and in the preceding discussion, this is one of the core projects of the City's ITS Operations Plan. It is a supporting project for 24 functional requirements. The major benefits of the new communications infrastructure are:

- Flexibility, ease of expansion, lower installation costs, and higher reliability. For example, the wireless approach protects the network from cabling cuts as have been occurring at construction sites where Sugar Land roadway and intersection improvements are taking place.
- Enhances the ability to monitor the operation of the signal system to identify failures that delay traffic and cause hazardous conditions
- Enhances the ability to help develop, save and implement new timing plans that will minimize the delay to motorists, excessive fuel consumption and vehicle emissions
- Provides flexibility and growth for wide-band mobile communications capabilities.
- City inventory and existing infrastructure can be incorporated, allowing expanded capability and cost savings.
- The flexible wireless network preliminary concept perfectly fits a growing area with dynamic needs, allowing re-deployment to meet future needs and applications to match.
- The expandability and synergy of a wireless network are important for current and future City services.
- Traffic communications may leverage wireless systems with as many expansion capabilities as possible. Wireless today can provide hotspots and service areas around traffic controller cabinets and City buildings with more fill-ins over time.

Project 1.2: Upgrade Traffic Controllers to Ethernet-Based Units

The implementation of Ethernet IP "standards-based" communications will improve traffic signal system management. Wireless IP-enabled traffic signal control can be used to improve traffic flow and enable new applications for higher efficiency and cost savings. The City's Advanced Transportation Management System (ATMS) provides the ability to connect traffic signal controllers to an intelligent network for enhanced data gathering and analysis and better timing of traffic signals.

As a first step in the upgrade process, the existing Naztec NEMA TS-2 traffic signal controllers can be easily upgraded to Ethernet-capable devices by the replacement of the controller faceplate and internal communications card, enabling communications at a range of 10 – 1,000 megabits.

As indicated in Table 5.1 and in the preceding discussion, this is the second of the core projects of the City's ITS Operations Plan. It is a supporting project for 13 of the functional requirements.

The benefits of the Ethernet approach are numerous. They include:

- IP allows sharing of communications. Components sharing the same switching device at each cabinet can include cameras, DMS, and IP phones.
- Because components would share the switching device, there would be only one piece of equipment for the maintenance staff to learn and maintain. With the RS-232 approach, each added component would require the addition of a modem as well.
- Users can connect laptops into remote sites and access all intersections via the IP network.
- Controller database upload/download time would decrease from about one to two minutes to about 20 seconds.

Project 1.3: Expand System Detection Network

System detectors provide current traffic volume, occupancy and speed data on key arterials for implementation of traffic-responsive signal timing plans and real-time display of congestion levels to the motoring public on the traveler information website. This traffic data is also archived for future analysis and forecasting.

The existing detection network needs to be expanded to provide complete and accurate coverage of the major links in the City traffic signal network. This project will provide for new detectors that are installed above the roadway where they will be less likely to be damaged by weather and roadway rehabilitation work than the roadway loop detector configuration. Sensors less prone to failure will improve the operation of signalized intersections reducing the delay, fuel consumption and emissions at these intersections. It will also minimize maintenance efforts by City staff.

Table 5.1 shows the importance of this project. The detectors are an enabling project for the functional requirements of better signal timing (Functional Requirement 4), adjusting signal timing based on real-time traffic data (Functional Requirement 5), adjusting signal timing based on real-time data from major traffic generators (Functional Requirement 9), and collecting the average speed of traffic on major arterials (Functional Requirement 10). It is also a prerequisite project for ten other projects related to data collection, data sharing and traveler information.

Some of the benefits of the expansion of the system detection network include:

- Timing Plan Aids – The ATMS will have the capability to archive traffic signal detector data for use in traffic signal timing and analysis programs. The system will also facilitate the transfer of the output of the signal timing programs into new signal timing plans. Automating the data collection process and the import of these data into signal timing programs will enable the cost-effective production of new timing plans.
- Traffic Responsive Capability – The ATMS will include traffic responsive operation providing the automatic selection of the timing plan best suited to the traffic demand.

This capability is particularly useful near special event venues and other major traffic generators where it will reduce delay, fuel consumption and emissions and will return the system to normal traffic flow more quickly. Traffic responsive capabilities will also reduce the duration that Police Officers are needed to perform traffic control duties.

- Congestion Status Maps – The ATMS will have the capability to generate a congestion map based on detector data from the field. This map will help Traffic Management Center (TMC) personnel prioritize future improvement activities. It is also a prerequisite for many other projects that will share traffic congestion data for other City and regional transportation agencies.
- Traffic Volume Forecasts – The ATMS will have the capability to predict future traffic volumes through an extrapolation of past volumes, or through software programs that "model" traffic volumes from roadway and community characteristics. This capability will allow the City's engineers to better prepare for the traffic associated with special events that are held on an annual basis, and the design of major roadway improvements.

Project 1.4: Expand CCTV Surveillance System

The City has a number of traffic surveillance cameras already in place. Under this project additional cameras will be installed at locations most likely to experience congestion. These include locations that experience daily traffic congestion because of commuting patterns and locations near parks, stadiums and other venues where special events take place on a periodic basis.

This project enables Functional Requirement 3 that requests video images. It is also a supporting project for implementation of eight other requirements. These cameras will enable the engineers at the TMC to adjust traffic signal timing in response to real-time events. These could be accidents or special events that cause anomalies in the normal patterns of traffic flow. The cameras would also enable operations and maintenance staff to respond more quickly to calls from citizens reporting problems.

Project 1.5: Central Traffic Signal Priority Software Module

Emergency vehicles must respond quickly to incidents under all traffic conditions. Studies have shown that emergency vehicle priority systems can reduce response times[4] and improve emergency vehicle safety[5]. This project would integrate the Naztec PRIORITY.now software module with the existing ATMS.now platform to implement an Emergency Vehicle Priority System, integrating automatic vehicle location tracking with the City's proven Advanced Transportation Management System (ATMS) technology. The result will enable reduced emergency response time and greater emergency vehicle safety, with minimal

[4] Emergency Response Management Study. Houston Metropolitan Transit Authority.
[5] Emergency Vehicle Accident Study. Department of Fire and Safety Services, St. Paul, MN.

impact to surrounding traffic, at a lower cost of implementation than other available solutions[6].

This project enables Functional Requirements 6 and 7 that request the provision of green signal indications at traffic signals for fire trucks and ambulances. It is also a supporting project for the functional requirement to support the computer-aided dispatch of emergency vehicles (Functional Requirement 27), and for coordination of emergency response plans (Functional Requirement 28).

The City's Fire Department currently has all of its trucks equipped with either 3M Opticom or Tomar STROBECOM transmitters for in-route traffic signal preemption. All signalized intersections have their major approaches equipped with receivers to be alerted to the arrival of an emergency vehicle as a measure to maximize responsiveness and allow the emergency responders to reach their destination quickly and safely. When a receiver has identified an emergency vehicle, the traffic signal controller transitions to a timing plan in which the signal provides a green indication to the emergency vehicle and a red indication to the other legs of the intersection.

The signal preemption described above, that gives the green signal to emergency vehicles and a red signal to traffic on other approaches, has two distinct safety-related benefits. First, it helps expedite the arrival of the emergency vehicle at the scene and can reduce the severity of the damage to people and property. Second, it reduces the potential for intersection accidents involving emergency vehicles going to the emergency scene.

Traffic Signal Preemption is defined by NEMA TS2-2003 and NTCIP 1202 – "Object Definitions for Actuated Traffic Signal Controllers". When a preempt request is received, the controller terminates the active phase to service any track clearance intervals associated with the preempt. The controller then moves to the dwell state in flash, free or coordinated operation to service the programmed dwell phase(s) until the preempt input is released.

Priority service differs from preemption in that the controller never leaves coordination and phase skipping is optional based on a user-defined strategy used to service the priority request. In addition, the City's Naztec controllers go beyond the operation described in the NTCIP by providing priority service in free operation as well as during coordination.

Through the addition of this central priority software module, integrating the City's existing ATMS, this project would maximize the potential power that can be utilized by both the on-street software as well as the central software. Utilizing the full capacity of the controller's software features and functions, and optimizing both software packages (field and central), would provide numerous unique benefits to the City. These would include:

- Achieve Faster Emergency Response Time - The Emergency Vehicle Priority System will provide traffic flow priority to vehicles traversing a route between an origin and an incident. Traffic flow priority enables vehicles to move through signalized intersections under a green signal indication, thus eliminating delay time and safety hazards caused by moving through intersections under a red light.
- Maximize Emergency Vehicle Safety - The Emergency Vehicle Priority System creates a natural-feeling green signal indication for emergency vehicles. A green

[6] Department of Transportation, Unit Costs (Adjusted) of Equipment for Roadside Control.

indication for emergency vehicles that appears normal and natural to all other traffic reduces the risk of accidents for all concerned.

- Minimize Impact to Surrounding Traffic - The Emergency Vehicle Priority System works with the City's ATMS technology to maintain coordinated traffic flow on roadways adjacent to the emergency route. Coordinated traffic flow will minimize impact to cross streets even as emergency vehicles experience green signals en route to an incident. As the ATMS system dynamically adjusts traffic signal timing, drivers on adjacent and oncoming roadways operate normally without disruption. Since the Emergency Vehicle Priority System will maintain non-disruptive roadway conditions, drivers will be less likely to interfere with emergency vehicles.

This project would enable priority operation throughout an entire corridor. The Naztec Emergency Vehicle Priority System (PRIORITY.now) integrates the capabilities of the Naztec ATMS, vehicle-based GPS units, and the emergency dispatch application. GPS units installed on emergency vehicles send vehicle location data back to a central office. Dispatchers work with the dispatch application to record incidents and generate routes for emergency vehicles to reach the scene. The ATMS communicates with both the GPS units and the dispatch application to coordinate traffic along the selected emergency route to the scene. Using route information and the vehicle locations, the ATMS will adjust the signal coordination in favor of the emergency vehicles. The result is fluid traffic movement for the emergency vehicles and a natural flow for all other traffic in the area.

Project 1.6: Central Traffic Adaptive Software Module

A significant portion of traffic delays on arterial routes is the result of outdated or poor traffic signal timing. ITS technology enables the process of traffic signal timing to be performed more efficiently by enhancing data collection and system monitoring capabilities and, in traffic adaptive applications, automating the process entirely. ITS tools such as automated traffic data collection, centrally controlled or monitored traffic signal systems, interconnected traffic signals, and traffic adaptive signal control help make the traffic signal timing process efficient and cost effective, and responsive to real-time conditions. This project would enable the integration of a traffic adaptive module to the existing ATMS platform.

This project is a prerequisite project for Functional Requirement 5 to adjust signal timing based on real-time traffic data. It is also a supporting project for the functional requirement to provide better signal timing and signal coordination (Functional Requirement 4).

Naztec's ADAPTIVE.now module has been developed to provide fully adaptive traffic signal control system operation within the ATMS.now application. The ADAPTIVE.now philosophy is to:

- Provide a module to calculate or select appropriate cycle length, phase split and offset for each coordinated intersection;
- Maintain consistency with the emerging National Transportation Communications ITS Protocol (NTCIP) standards for System Masters;
- Minimize the need for additional detection, and avoid the need for additional conduits, especially at intersections:

- Provide automation and self-calibration features so that staff will become more efficient, not have an increased workload;
- Provide facilities for operators to modify or override the adaptive system at any time; and
- Provide for real-time signal timing plan preparation, in response to current traffic conditions.

5.3.2 Group 2–Safety Enhancement Projects

The projects in this group focus on safety improvements that can help reduce the occurrence of accidents, expedite the response to 911 calls from travelers with cellular telephones, and improve the response to accidents. These projects generally fall into the second tier of priority in the Operations Plan.

Project 2.1: Expand Driver Feedback Speed Signs

In December 2006 the City's Public Works Department implemented a pilot project designed to promote motorist compliance with posted speed limits on the City's arterials, and thereby increase safety. The project implemented pole-mounted radar speed displays to advise drivers of their actual speed compared to the posted speed limit. Feedback from the public regarding these signs has been very positive, and results have indicated speed reductions on selected roadways. This project would provide for the expansion of this system through the procurement and implementation of additional equipment.

This project is an enabling project for Functional Requirement 11 to provide information to drivers using Dynamic Message Signs. The benefits of the project would include increased monitoring and reduction of vehicle speeds, and heightened awareness of posted speed limits.

Project 2.2: ATMS & Emergency Services Integration

This project will enable emergency services integration with the existing Advanced Transportation Management System (ATMS) and would provide, on one consistent GIS background, a display of all the traffic condition data available at the traffic management center, and with the implementation of the fleet management module the status tracking data for priority vehicles. Having one application to monitor these intertwined operations would serve to greatly enhance the productivity and effectiveness of management and operations staff of all affected departments.

Depending on the degree of integration desired, through coordination with other departments, this system would enable reduced emergency response time and greater emergency vehicle safety, with minimal impact to surrounding traffic.

This is the enabling project for the following functional requirements: Functional Requirement 12, Improve coordination among organizations responding to accidents, and Functional Requirement 23, Recommend Routes for Emergency Vehicles Based on Traffic Conditions. It is a supporting project for three other functional requirements.

This project will export the data and video from the TMC to the emergency service agency, as well as the congestion map and data from system sensors. The Emergency service agency personnel will use the roadway information to identify the fastest route to the scene of the emergency. Future upgrades to this project will implement a software program that will automatically identify the fastest route from the congestion data. Viewing a video image of an incident can help emergency personnel determine the appropriate type and number of response vehicles that are required. Giving the staff information on congestion will help them select and dispatch the vehicle that can get to the emergency the fastest. Public Works dispatchers can use the images in a similar manner.

Project 2.3: Railroad Crossing Monitoring System

ITS provides for the basic management of highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate more advanced features (e.g., where rail operational speeds are less than 80 miles per hour). Both passive (e.g., the crossbuck sign) and active warning systems (e.g., flashing lights and gates) are supported. Whereas the passive systems exercise only the single interface between the roadway system and the driver, these traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems can be activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Condition monitoring of the HRI equipment and interfaces can be performed, and detected abnormalities can be reported to both highway and railroad officials through wayside interfaces and interfaces to the traffic management system.

This project is an enabling project for Functional Requirement 18 to monitor the operation of railroad grade crossings. It is also a supporting project for the functional requirement to save data on other transportation activities within the City (Functional Requirement 15), and for coordination of grade crossing operation with the railroad (Functional Requirement 26).

Through implementation of this project the system will monitor the operation of railroad grade crossings. With this capability the system will be able to determine when preemption is requested by a train, the operation of crossing gates and the time that the crossing is occupied by a railroad car. The system could provide an additional level of strategic coordination between freight rail operations and the traffic management center. Rail operations could provide train schedules, maintenance schedules, and any other forecast events that will result in highway-rail intersection closures. This information could be used to develop forecast HRI closure times and durations that may be used in advanced traffic control strategies or to enhance the quality of traveler information.

5.3.3 Group 3–Traveler Information and Information Sharing with Regional Agencies

This group contains a series of information dissemination and information sharing projects that will increase knowledge of roadway conditions for travelers and agencies. These projects constitute a third set of priorities. These projects also require an engineering effort before they can be implemented. However, in this case the traditional engineering disciplines must be supplemented with personnel with Information Technology expertise.

Project 3.1: Install Permanent Dynamic Message Signs at Selected Locations

This project is one of two projects that will enable the functionality identified in Functional Requirement 11. It will install a series of permanently mounted dynamic message signs (DMS) at selected non-residential locations in the community. These signs would provide routing information for visitors entering the community, provide parking availability information and warn residents and employees of delays that can be avoided by using alternate routes. The overall project benefits to area residents, employees and visitors are reduced delay, fuel consumption and vehicle emissions.

Ideally, the control of these DMS units should be integrated into the workstations of the Advanced Transportation Management System and any remote laptops that can operate the ATMS. Furthermore, the software for the control of these units could allow authorized users outside the City (i.e., at TxDOT's TranStar Center) to place messages on these signs and for authorized Sugar Land personnel to place messages on the DMS operated by these other jurisdictions.

Dynamic message signs can change the message they display to reflect conditions or inform motorists of important information. The signs can convey information about roadway conditions, alternate routes, construction activities, or any information that may assist motorists in making decisions. Signs will initially be placed at select key locations.

Project 3.2: CCTV & Traveler Information Website Integration

This project will support Functional Requirement 2, Collect Traffic Volume Data for Monitoring Traffic Flow and Displaying Real-Time Conditions. It will also support the provision of video images of key locations (Functional Requirement 3). It further supports dissemination of information to the traveling public and other agencies that is the underlying intent of ten other functional requirements that also provide information, coordination and data exchange.

Through further integration with the City's existing ATMS, the traffic information website would be a mechanism to deliver to the public real-time condition data collected by the system. The website and background GIS map would be configurable, designed to display data such as traffic signal status, congestion level, traffic volumes, incident locations and details, and construction information. The site would be integrated with video streaming technology to provide links to the existing and planned CCTV surveillance cameras. Any supplementary hardware and software required to support this integration will be provided by this project.

Information from the City's cameras made available for viewing in the home will reduce delay, fuel consumption and emissions by enabling travelers to assess the extent of traffic congestion and make appropriate decisions about their departure times and routes. Similar delay, fuel consumption and emissions reductions on trips headed home after work will be made possible for people that view the web site on PCs at their offices.

Project 3.3: Share Data and Video with TxDOT and Neighboring Cities

This project is the enabling project for Functional Requirement 25, Exchange Data with TxDOT and Other Local Traffic Agencies, Functional Requirement 8, Facilitate the Exchange of Archived Transportation Data with Other Agencies, and Functional Requirement 24, Support Coordination of Evacuation Plans. The project consists of several parts, which establish communications links between the TMC and TxDOT's TranStar Center and establish communications links between the TMC and neighboring cities, such as Missouri City. It also includes the purchase of any hardware (such as file servers) and software (such as firewall protection programs) required to exchange video and current and archived data through these communications links.

Coordination with neighboring cities such as Missouri City will enable the development of improved timing plans for arterials that cross these jurisdictional boundaries. Improved timings will result in reduced delay, fuel consumption, and emissions.

Coordination with TxDOT will make video and data from the City of Sugar Land available to the TxDOT TranStar Center where it can be viewed by the TranStar staff at the consoles. The data and views from these cameras will allow TxDOT to post appropriate messages on TxDOT's Dynamic Message Signs. Similarly, video from TranStar will be made available to the City's TMC staff. The images from the TxDOT cameras located at the interchanges with the City's arterials will enable the City's TMC staff to assess traffic problems and develop new signal timing plans for the signalized intersections located at the ramps for the interchanges.

This connection to TxDOT will enable the TMC to exchange transportation-related data with many other organizations in the region. This ability to easily exchange archived data with other organizations will provide City and regional planners and engineers with the information needed to analyze the current use of the transportation infrastructure and forecast its future use.

5.3.4 Group 4–Transportation Management

This group of projects is aimed at improving the operation, monitoring and management of the overall City transportation network. The projects included have a range of implementation priority. Once again, there will be an engineering effort needed to convert some of these concepts into implementation projects that can be put out for bid.

Project 4.1: Citywide Traffic Signal Timing Optimization

Optimized signal timing is considered to be a very effective low-cost approach to reducing congestion. Benefit-cost ratios as high as 40 to 1 can be realized after traffic signal retiming is performed. This project will include interjurisdictional and extraterritorial jurisdiction (ETJ) signal coordination, as well as evacuation route timing plans.

Updated signal timing plans will be prepared for the complete city signal network as well as ETJ signals and coordination with adjacent jurisdictions. Studies will include inventory and operational assessment of traffic control devices as well as recommendations for geometric and safety improvements. Specialized timing plans could be developed for special events that

are known in advance and detour routes that can be used when there is a major incident on US 59 and major arterials in the City. These timing plans would minimize delay, fuel consumption and emissions that occur when these activities take place.

This project is the enabling project for Functional Requirement 4, Provide Better Signal Timing and Signal Coordination. Its effectiveness will be enhanced by the implementation of several of the other recommended projects, but optimization efforts can begin on key City corridors at any time.

The *National Traffic Signal Report Card* published by the National Transportation Operations Coalition indicates the following:

> *Improper traffic signal timing accounts for 5 to 10 percent of all traffic delay, or 295 million vehicle-hours of delay, on major roadways alone.*
>
> Traffic signals affect the traveling public in many ways:
>
> - Drivers pass through a green light at one intersection only to be stopped by a red light at the next intersection. Inconsistent travel on surface streets causes frequent stops and unnecessary delays. *Intersections should be coordinated and traffic signal timing plans updated based on changing travel patterns*.
> - Drivers must stop at a red light when there are no vehicles or pedestrians at the cross street. Incorrectly functioning traffic sensors do not serve all vehicles and pedestrians equitably. *The sensor in the roadway may be broken and the agency either hasn't been informed about it or lacks the resources to fix it*.
> - Drivers must wait through more than one green signal at an intersection, causing long queues and clogged intersections. *Traffic signal timing should be adjusted to handle traffic diverted from a work zone, crash, or special event.*
>
> In addition to driver impacts, signal-related congestion has broader economic, social and environmental impacts. Congestion not only wastes fuel, time and money, but is also a significant factor in shaping the quality of life for individuals and families. The real impact of congestion is felt in how and where people choose to live, how they commute and how much they pay for things resulting from the additional costs congestion imposes on society.
>
> ***Congestion causes the average peak-period traveler an extra 38 hours of travel time and an additional 26 gallons of fuel, amounting to a cost of $710 per traveler per year.***
>
> As the consumers of the transportation system, everyday travelers observe these inefficiencies and know that something more can be done. Improving traffic signal operations must be a priority.

Project 4.2: Install Parking Availability System

This project will enable the functionality identified in Functional Requirement 19 by installing a sign system to direct drivers to City-owned parking facilities where parking spaces are available. It is anticipated that this would include the facilities located at Town Square. The TMC would learn when one or more of these facilities are full through connections to the existing parking monitoring systems or through contact with the personnel working there. Information regarding available parking would be placed on large dynamic

message signs and smaller wireless automated parking advisory signs strategically deployed to help motorists find open facilities.

Directing drivers to available spaces will reduce unnecessary circulation by vehicles looking for parking spaces. It will help increase the utilization of City-owned facilities that are less frequently used. It will also provide a more positive perception of the City by visitors that would otherwise become frustrated while they are looking for a place to park.

Project 4.3: Central Fleet Management Software Module

The central fleet management software module integrates Global Positioning Systems (GPS) and wireless communications to provide a method for remote vehicle tracking and monitoring. Data can be stored for later retrieval and analysis or transmitted to the traffic management center for real-time display. The system would be initially implemented on select Public Works vehicles, with possible expansion to fire and police departments.

This project will establish a contract for an Automatic Vehicle Location (AVL) system that may be used by all City agencies. This may also be linked to a city-wide contract for a Computer Aided Dispatch (CAD) system that will be used by the emergency service agencies, the Public Works Department and other interested City organizations. The same central software will be used by all organizations. The system will primarily limit the information seen on each agency's workstation to its own vehicles. Emergency dispatchers may permit the TMC to view traffic related incidents. The TMC will permit the emergency dispatchers to view intersections with signal failures, flooded roads and other roadway system incidents identified by the Public Works Department.

This project is an enabling project for Functional Requirements 20 and 21 that will provide an automatic vehicle location system for Public Works Department and selected other City vehicles, and also for Functional Requirement 27 that will support the computer-aided dispatch of emergency vehicles. It is a supporting project for seven additional functional requirements.

This project has several benefits:

- It allows the Department of Public Works and other City agencies to monitor the locations of its vehicles and if desired, dispatch the closest available vehicle to deal with traffic and signal system problems
- It allows the Department of Public Works to monitor the location of its construction vehicles and other high value mobile assets
- It will further facilitate the coordination of Public Works and Emergency units at traffic and roadway related incidents
- It improves the ability of the emergency dispatchers to quickly identify the availability of the vehicle closest to the emergency.

Project 4.4: Public Works Vehicle Payload Monitoring System

This project is the enabling project for Functional Requirement 22, Support the Monitoring of Material/Equipment on Public Works Department Vehicles. It would be a subsequent or follow-on project to the fleet management project described above.

The Freight Administration market package in the ITS National Architecture provides for the tracking of movements of cargo and monitoring the cargo condition. Interconnections are provided to intermodal freight shippers and intermodal freight depots for tracking of cargo from source to destination. In addition to the usual cargo monitoring required to insure that cargo gets from origin to destination, the Fleet and Freight Management subsystem monitors shipments to make sure that no tampering or breach of security occurs to the cargo on commercial vehicles.

For the Public Works Department, the fleet management software module will allow the monitoring of a vehicle's performance, its speed, its location and its daily starting and stopping times. With equipment and machinery, the Vehicle Payload Monitoring System will potentially allow the Department to locate abandoned, lost or stolen equipment, monitor equipment hours, verify equipment utilization, and decrease equipment downtime. This type of monitoring system could enable better management of productivity, resulting in a return on the investment (ROI) far exceeding the cost of the system.

5.3.5 Group 5–Other Projects

Project 5.1: Enable System Data Exchange

This project is important to all of the functional requirements that call for the exchange, archiving, and analysis of system data, as well as those providing for coordination amongst various departments or agencies. It is an enabling project for Functional Requirements 12 and 13, Improve Coordination among Organizations that Respond to Accidents and that Deal with Traffic at Special Events. It is a supporting project for ten other functional requirements.

An example of the implementation of this project would be the exporting of data and video from the TMC to the emergency service agencies, Public Works personnel and to the City's management staff that may be interested in knowing about traffic incidents and roadway conditions. These data could include the congestion map and data from sensors. The video would include the CCTV surveillance cameras and could also include images from the TxDOT cameras on US 59.

The concept of this project is to provide a focused archive that houses data collected and managed by the system. It provides the basic data quality, data privacy, and meta data management common to all ITS archives and provides general query and report access to archive data users.

This project includes all the data collection and management capabilities provided by the ITS Data Mart market package, and adds the functionality and interface definitions that allow collection of data from multiple agencies and data sources spanning across modal and jurisdictional boundaries. It performs the additional transformations and provides the additional meta data management features that are necessary so that all this data can be managed in a single repository with consistent formats. The potential for large volumes of varied data suggests additional on-line analysis and data mining features that are also

included in this market package in addition to the basic query and reporting user access features.

Project 5.2: Exchange Data with Mobile Command Post for Traffic Incidents

This project is an enabling project for Functional Requirements 12 and 13 that will improve coordination among organizations dealing with traffic problems at accidents and special events. It is also a supporting project for Functional Requirement 28, which provides coordination for emergency response plans. This project will enhance the on-scene coordination of organizations by providing a system interface to the mobile command post from which they may operate during incidents or emergencies. The recommended equipment for this vehicle includes:

- Communications and workstations for monitoring data from the traffic detectors showing congestion
- Communications equipment and monitors for receiving CCTV images of traffic
- It may also include portable CCTV cameras and variable message signs that can be controlled from the command post

Overall the data exchange interface will help minimize the congestion experienced by motorists and other travelers. Through the proper coordination of traffic signals and personnel, it may also reduce the level of staffing needed to handle traffic at these events.

6 High Level Systems Architecture

6.1 Introduction and Summary

The "big picture" of the City's ITS Operations Plan is presented in this chapter. One of the fundamental ITS objectives is to provide travelers and system managers with information they can use to make effective decisions. For drivers, this may be information telling them that a road they expected to use is closed. It may be information that will enable an emergency agency dispatcher to dispatch the right number and type of emergency vehicles to an accident. Better information (knowledge) gives these dispatchers the power to do a better job. The high level systems architecture identifies the organizational entities that are sending and receiving information to each other through improvements identified in the City's ITS Operations Plan.

In a sense, this architecture provides the overview of how the various projects in the ITS Operations Plan will work together to enable the exchange of information to offices within the City and to agencies and organizations outside of the City.

It provides the City of Sugar Land with an overview of the organizational entities that will be linked together through the City's ITS Operations Plan and the information exchanged between these entities. It also indicates the communication links to be implemented by the Public Works Department and those to be implemented by other City Departments and other agencies.

6.2 Functions and Market Packages

The high-level system architecture for the City is based on the ITS functions that were selected by the Project Steering Committee and modified to reflect the comments and discussions of these functions that took place in subsequent meetings of the committee. These functions and the relative weights assigned by the committee are shown in Table 6.1.

The last column of this table identifies the Market Package from the National ITS Architecture that is most closely related to the function. The National ITS Architecture contains a total of 85 market packages divided into eight groups:

- ATMS Advanced Transportation Management Systems (21 market packages)
- APTS Advanced Public Transportation Systems (8 market packages)
- ATIS Advanced Traveler Information Systems (9 market packages)
- AVSS Advanced Vehicle Safety Systems (11 market packages)
- CVO Commercial Vehicle Operations (13 market packages)
- EM Emergency Management (10 market packages)
- AD Archived Data Management (3 market packages)
- MC Maintenance and Construction Management (10 market packages)

The original list of functions reviewed and evaluated by the Steering Committee was based on functions discussed during the initial Steering Committee meetings and on the market packages in the National ITS Architecture. By using this approach, the Steering Committee was presented with the widest possible range of functionality and given the opportunity to include these functions in the City's ITS Architecture.

Table 6.1

Ranking of Functions by the Steering Committee

	Market Package	Function	Ranking
1	AD1	The system should save City traffic data for future analysis	4.0
2	ATMS01a	The system should collect traffic volume data for monitoring traffic flow and displaying real-time conditions	4.0
3	ATMS01b	The system should provide video images of key locations	4.0
4	ATMS03a	The system should provide better signal timing and signal coordination	4.0
5	ATMS03b	The system should adjust signal timing based on real-time traffic data	4.0
6	EM02b	The system should provide fire trucks with a green light at traffic signals	4.0
7	EM02c	The system should provide ambulances with a green light at traffic signals	4.0
8	AD3	The system should facilitate the exchange of archived data with other agencies	3.7
9	ATIS6a	The system should adjust signal timing based on real-time event data from major traffic generators	3.3
10	ATMS02	The system should collect the average speed of traffic on major arterials	3.3
11	ATMS06b	The system should provide information to drivers using Dynamic Message Signs	3.3
12	ATMS08a	The system should improve coordination among organizations that respond to accidents	3.3
13	ATMS08b	The system should improve coordination among organizations dealing with traffic at special events	3.3
14	EM06	The system should support Amber Alerts and other wide area emergency notifications	3.3
15	AD2	The system should save data on other transportation activities within the City (Transit, Parking, etc.)	3.0
16	ATIS1	The system should push traffic data to travelers through enhanced pagers, cell phones, etc.	3.0
17	ATMS09	The system should help predict future traffic volumes	3.0

	Market Package	Function	Ranking
18	ATMS13	The system should monitor the operation of railroad grade crossings	3.0
19	ATMS16b	The system should direct drivers to parking garages where space is available	3.0
20	CVO01a	The system should include an automatic vehicle location system for Public Works Dept. vehicles	3.0
21	CVO01b	The system should include an automatic vehicle location system for other City-owned vehicles	3.0
22	CVO02	The system should support the monitoring of material/equipment on Public Works Dept. vehicles	3.0
23	EM02a	The system should recommend routes for emergency vehicles based on traffic conditions	3.0
24	EM09	The system should support coordination of evacuation plans	3.0
25	ATMS07	The system should exchange data with TxDOT and other local traffic agencies	2.7
26	ATMS15	The system should coordinate grade crossing operation with the railroad	2.7
27	EM01	The system should support the computer-aided dispatch of emergency vehicles	2.7
28	EM08	The system should support coordination of emergency response plans	2.7
29	EM10	The system should provide disaster-related traveler information	2.7
30	ATIS4	The system should provide traffic data for in-vehicle route guidance systems	2.3

The market packages that are not included in the list of functions desired by the City were excluded because they were functions that would not be provided by the City or because they received such a low ranking they were not seriously considered for implementation. For example: implementation responsibility for most of the Commercial Vehicle Operations (CVO) market packages rests with the private sector carriers and shippers. The two CVO market packages that are included deal with the tracking of City vehicles and monitoring of equipment. Similarly, the public transit market packages were excluded because the transit agency is not a regional entity operated by the City.

Because the list of functions also included functions that arose from the Steering Committee discussions, there are several cases where more than one function on the list is associated with the same market package. For example, the "Incident Management" market package (ATMS08) will support the function 12, "Improve coordination among organizations that respond to accidents;" the function 13, "Improve coordination among organizations dealing with traffic at special events;" and function number 9, " Adjust signal timing based on real-time event data from major traffic generators."

Similarly, function 6, "Provide fire trucks with a green light at traffic signals", function 7, "Provide ambulances with a green light at traffic signals", and function 23, "Recommend routes for emergency vehicles based on traffic conditions" are all part of the National ITS Architecture's Emergency Routing Market Package (EM02).

In total, the functions of interest to the City are related to 24 of the 85 market packages in the architecture. Definitions of all of the market packages will be provided in an Appendix to the final ITS 5-Year Operations Plan. The market packages associated with the Sugar Land ITS Operations Plan are shown in Table 6.2.

Table 6.2

Market Packages in the Sugar Land ITS Operations Plan

AD1	ITS Data Mart
AD2	ITS Data Warehouse
AD3	ITS Virtual Data Warehouse
ATIS1	Broadcast Traveler Information
ATIS4	Dynamic Route Guidance
ATIS6	Transportation Operations Data Sharing
ATMS01	Network Surveillance
ATMS02	Traffic Probe Surveillance
ATMS03	Surface Street Control
ATMS06	Traffic Information Dissemination
ATMS07	Regional Traffic Control
ATMS08	Traffic Incident Management System
ATMS09	Traffic Forecast and Demand Management
ATMS13	Standard Railroad Grade Crossing
ATMS15	Railroad Operations Coordination
ATMS16	Parking Facility Management
CVO1	Fleet Administration
CVO2	Freight Administration
EM01	Emergency Call-Taking and Dispatch
EM02	Emergency Routing
EM06	Wide-Area Alert

EM08 Disaster Response and Recovery

EM09 Evacuation and Reentry Management

EM10 Disaster Traveler Information

6.3 Development of High Level Architecture Drawings

The High Level Architecture and its associated diagrams were assembled with the aid of the "Turbo Architecture" software tool (version 4.0). This software tool, developed by the National ITS Architecture Team, "… is a high level, interactive software program that aids transportation planners and systems integrators…in the development of a Regional and/or Project ITS Architecture…The application will utilize user inputs and information from the National ITS Architecture databases to provide users with tabular and graphical outputs comprising a high level representation of their Regional or Project Architecture." A glossary of ITS terms used throughout this program is included in Appendix B.

The development of the high level architecture for the City of Sugar Land was performed in the four-step sequence built into the program:

6.3.1 Step 1 – Input Data

The first step was performed with the aid of Turbo Architecture's "Interview Dialog." This dialog prompts the user to input data in response to a series of questions about the capabilities and functions of the system and whether these capabilities are existing or planned[7]. For example:

"Does your Arterial or Traffic Management Center control (or plan to control) signalized intersections?

Indicate what types of technologies are used:

Closed Loop or Centralized Control

Real-time traffic adaptive control such as SCOOT/SCATS or similar

Signal Preemption for emergency vehicles

Signal Priority for Transit Vehicles"

Through this type of dialog the basic characteristics of the Sugar Land ITS Operations Plan were entered into the program for the organizational "entities" listed below:

- Sugar Land Traffic Management Center
- Sugar Land Emergency Management Center
- Sugar Land Public Works Department
- TxDOT TranStar Center
- Missouri City Traffic Management Center

[7] For purposes of developing outputs (graphics and documents), the terms "existing" and "planned" were adapted to aid in understanding the implementation of the system. Items were identified as "Existing" if they exist or if the City's Public Works Department is primarily responsible for their implementation. Items were identified as "Planned" if their primary implementation responsibility rests with other City Departments or other agencies.

The program uses the nature of the entity (traffic management center, emergency management center, transit management center, etc.) and the responses to the questions in the dialog to make an initial determination of the market packages that are included in the architecture.

Although the dialog is extensive, it does not cover all of the market packages and the functionality included in the National ITS Architecture. A supplementary data input procedure in the software was used to add the additional market packages selected by the Project Steering Committee that were not already selected through the dialog.

6.3.2 Step 2 – Build an Uncustomized Architecture

Naztec ITS used the software to create a database of the flows within the architecture. These provide a brief description of the information exchanged within the architecture, identifying the source of the information and the destination of the information. At this step the program identifies all the flows that are included in the architecture on the basis of the inputs from Step 1.

In the final Architecture for the City of Sugar Land ITS Operations Plan, there were 32 possible interconnections between entities. (These are based on the initial entities previously identified and other associated entities identified by the program.) These interconnections are the links between two entities transmitting one or more pieces of information from one entity to the other in either direction. There were also a total of 344 possible architecture flows, which are one-way flows of a specific piece of information from a source entity to a destination entity.

6.3.3 Step 3 – Customize the Architecture

This is the most intensive step. The Architecture was customized through an iterative process in which the interconnections between the entities, and the architecture flows, were reviewed to determine if they could be eliminated from the City's ITS Architecture or if additional entities, interconnections, or architecture flows were needed.

One of the customizations done for the Sugar Land ITS Operations Plan was to incorporate the functionality to "Coordinate grade crossing operation with the railroad" (function 26 in Table 6.1). A review of the outputs from the initial architecture revealed that there was no architecture flow corresponding to this function. In order to show this flow a new entity "Railroad Management" was defined as being an element within the region. Most of the activity in the customization of the Architecture involved deleting interconnections and architecture flows that were included by the program because they are part of the full implementation of a market package. However, they are not part of the more limited implementations of these market packages envisioned in the City's Architecture.

6.3.4 Step 4 – Generate Outputs

In this step the results of these activities are documented. As indicated in the prior paragraph, there was actually a series of iterations involving Step 2, Step 3 and iterations, such as the one that deleted the links between TranStar and Railroad Management, which were performed for purposes of clarifying the output graphics. The results of these efforts are shown with the aid of a series of diagrams that were produced by the Turbo Architecture Program.

Figure 6.1 shows the Interconnect Diagram for the Sugar Land ITS Operations Plan. Each of the boxes on this figure represents an "entity" that is either a data source or a destination to which data is sent. Where appropriate the responsible "stakeholder" for the entity is identified in the heading above each box. Fifteen entities are identified representing five stakeholders as indicated in Table 6.3 below:

Table 6.3

Entities and Stakeholders in the

Sugar Land ITS Architecture

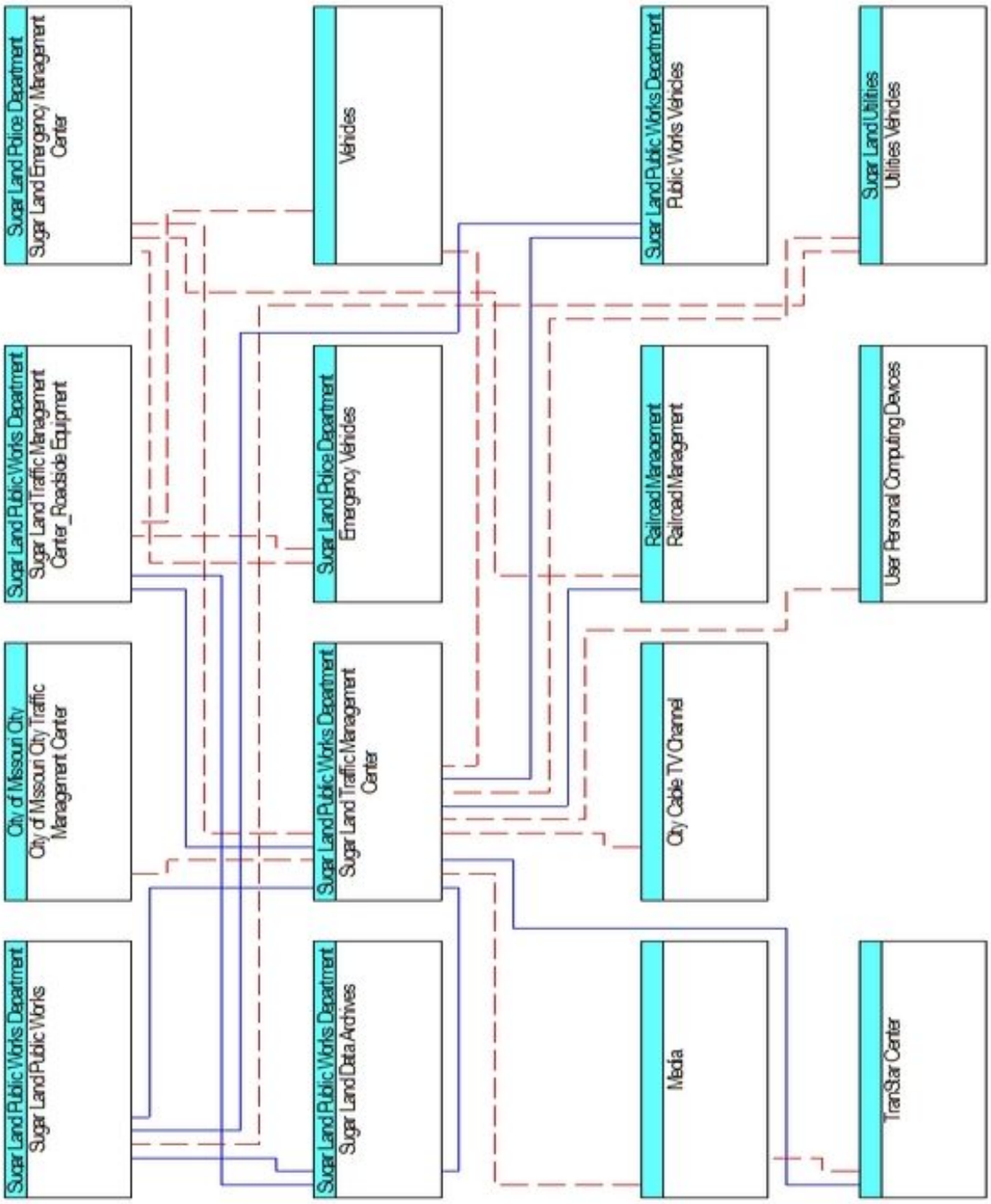
Entity	Stakeholder
Sugar Land TMC	CoSL – Public Works Department
Sugar Land TMC Roadside Equipment	CoSL – Public Works Department
Public Works	CoSL – Public Works Department
Public Works Vehicles	CoSL – Public Works Department
Utilities Vehicles	CoSL – Utilities Department
Sugar Land Parking Management	CoSL – Public Works Department
Sugar Land Data Archives	CoSL – Public Works Department
Emergency Management Center	CoSL – Emergency Services
Emergency Vehicles	CoSL – Emergency Services
TranStar Center	TxDOT, METRO, City of Houston, Harris County
Missouri City TMC	City of Missouri City
Railroad Management	Railroad Management
City Cable TV Channel	(No stakeholder shown)
Media	(No stakeholder shown)
User Personal Computing Devices (PCs)	(No stakeholder shown)

The lines in Figure 6.1 identify the entities that are linked together. For example: The Sugar Land TMC shows links to six other entities: the Emergency Management Center, Roadside Equipment, Public Works, the TranStar Center, the Missouri City TMC, and Railroad Management.

The solid lines in this diagram identify the links that are the responsibility of the Public Works Department. Implementation responsibility for the dashed lines rests with others.

Figure 6.1

Sugar Land ITS Operations Plan Interconnection Diagram



The final exhibit in this series is the "Flow Diagram" in Figure 6.2. This figure is similar to the Interconnect figure previously presented, but provides an additional level of detail. The entities in the Interconnect Diagram and the Flow Diagram are the same. The difference is that the flow diagram shows the actual information that is transmitted from one entity to another. In some instances these flows are specific, like the "traffic images" going from the TMC Roadside Equipment to the Sugar Land TMC. In other cases these flows are more generic and representative of a set of specific information or data flows, for example the "traffic information coordination" sent from the Sugar Land TMC to the TranStar Center. Once again the solid lines and dashed lines are used to indicate the flows that are the responsibility of the Public Works Department and other agencies, respectively.

6.4 Consistency with the Regional Architecture

The Regional Architecture previously developed for the Houston-Galveston Area Council is shown in Figure 6.3. In this figure the City of Sugar Land would be a City Traffic Management Center Subsystem. The four major systems identified in this Regional Architecture are:

- Center Subsystems
- Traveler Subsystems
- Vehicle Subsystems
- Roadside Subsystems

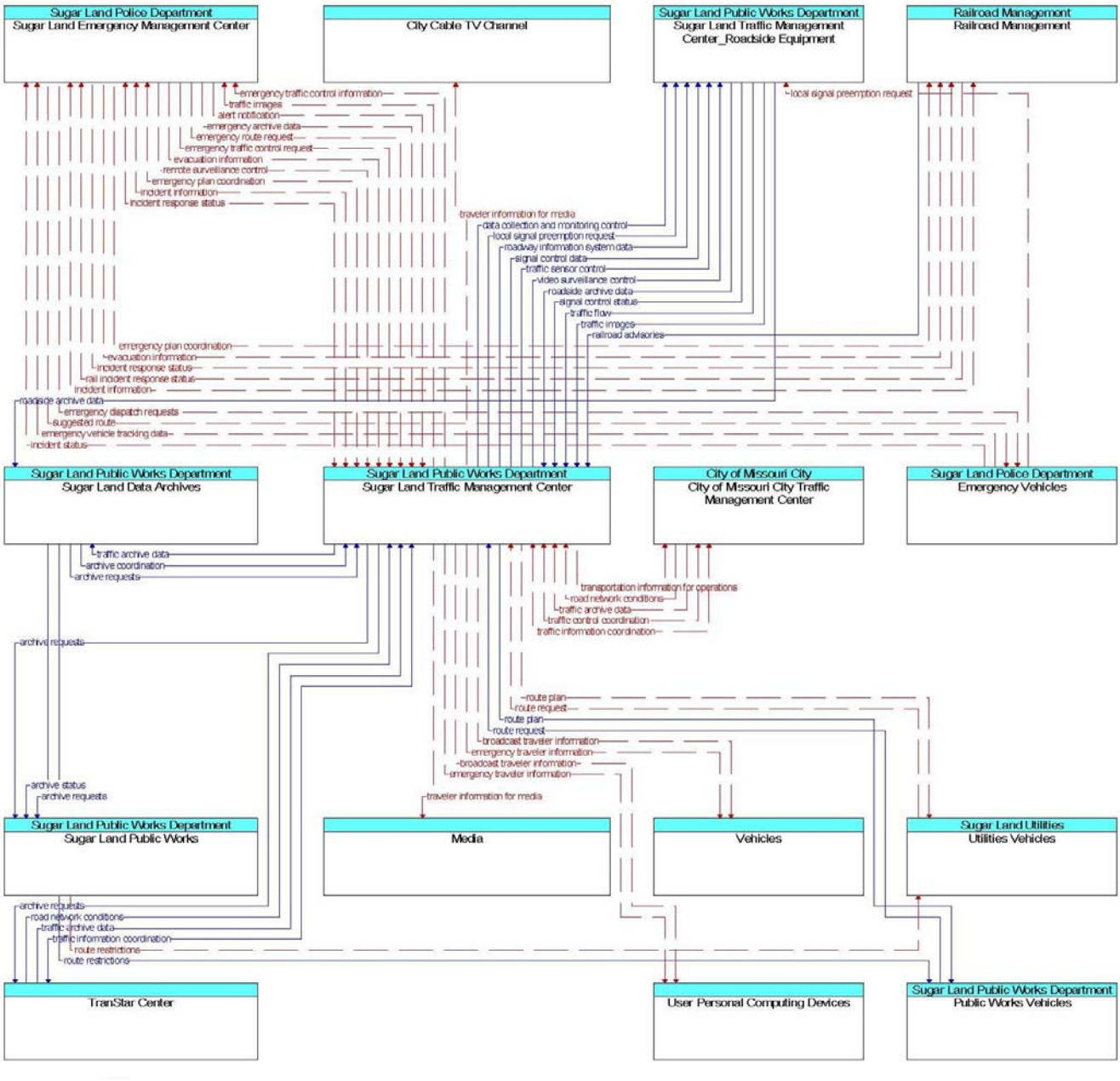
The Houston TranStar Center is shown at the center of the Traffic Management Subsystem. TranStar is envisioned to be the primary transportation management center in the Houston region, supplemented by surrounding regional city and county TMC's. The architecture flows to and from the City are listed in Table 6.4.

The City's High Level Architecture is generally consistent with this Regional Architecture in most ways. Although all of these data flows are not explicitly identified in the City's Architecture, the linkage to the TranStar Center is identified, along with a two-way flow of traffic information.

Within an area of the Regional Architecture described as "Regional Cities Traffic Departments", the City's High Level Architecture shows a linkage to the Missouri City TMC. This linkage is intended to facilitate the operation of traffic signal timing plans on major arterials that link the communities together. Although this linkage could be established through the TranStar Center, the direct linkage lessens the opportunity for hardware and software errors to interfere with the joint operation of traffic signals and other shared devices.

Figure 6.2

Sugar Land ITS Operations Plan Flow Diagram



Implementation Keys

Department of Public Works

Other

Figure 6.3

Houston Regional ITS Architecture Framework

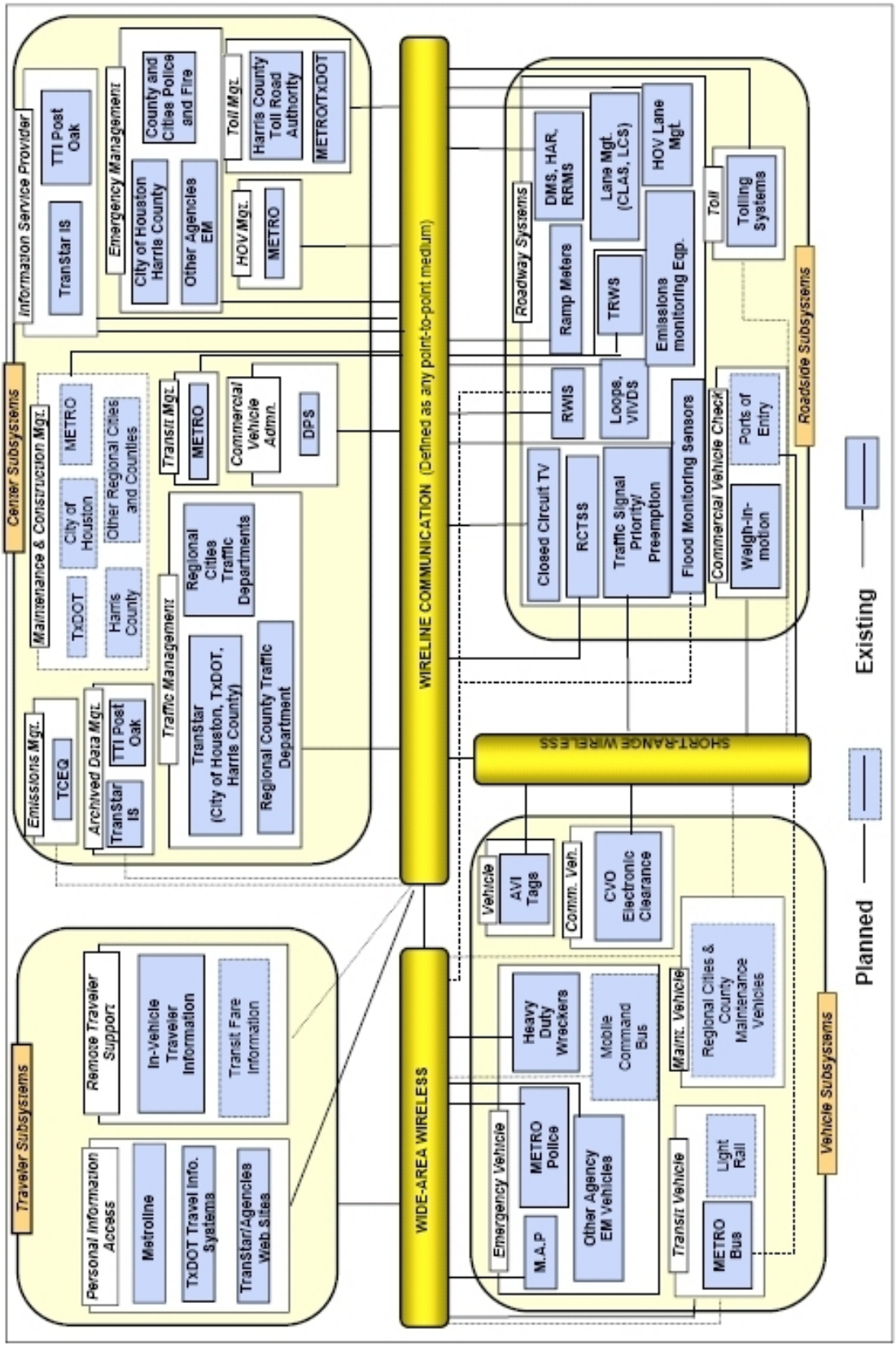


Table 6. 4

Architecture Flows to and from
the City Traffic Management Center
In HGAC's Regional ITS Architecture

Architecture Flows	
From the City of Sugar Land	**To the City of Sugar Land**
Incident Data **Graphical Data** **Traffic Flow Data** **Road Closure Data** **CCTV Control Data** **CCTV Images/Status** **Diversion Data/Status** **Signal Coordination Data**	**Incident Data** **Graphical Data** **Traffic Flow Data** **Road Closure Data** **CCTV Control Data** **CCTV Images/Status** **Diversion Data/Status** **Diversion Control Data** **Signal Coordination Data**

7 Staffing Plan

7.1 Introduction and Summary

This chapter documents the results of a review of the City of Sugar Land's existing staffing levels within the Traffic Operations Division. Dedication of adequate resources for operation and maintenance is required to fully realize the capabilities of the Advanced Transportation Management System and other ITS devices. A firm commitment to providing both personnel and budgetary resources is critical to the success of the City's overall ITS program.

7.2 Requirements for Staffing

The existing City staff available to operate and maintain the traffic signal system is identified in the figures on the following pages. Figure 7.1 is the Organization Chart for the Public Works Department (April 2008). Figure 7.2 represents the portion of the Public Works Organization Chart that relates to the Traffic Operations Division.

To determine the adequacy of the present staff to operate and maintain the City's existing ATMS and planned ITS components, an evaluation was made of the City's traffic operations staff. Consideration of the requirements for staffing should include:

- Staffing for Operation
- Staffing for Maintenance
- Staffing for Wireless Communications
- Staffing for ITS Network
- Staffing for Video Surveillance System
- Staffing for Network Management

Figure 7.1

Organization Chart for Public Works Department

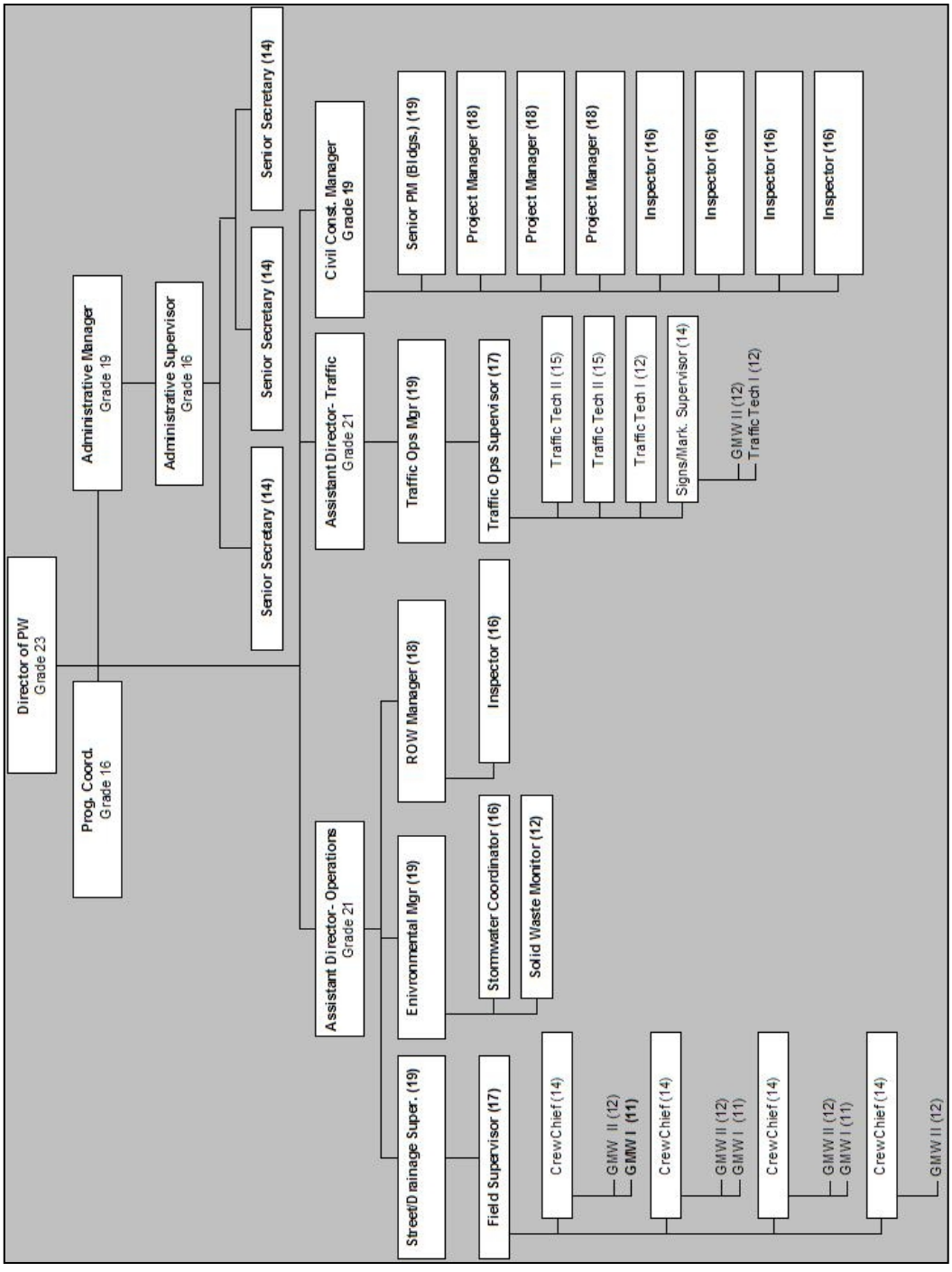
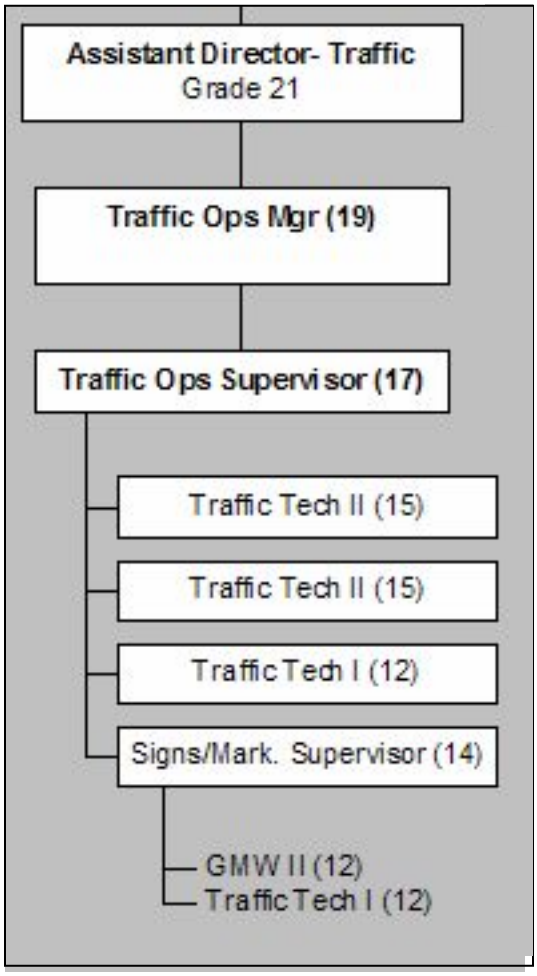


Figure 7.2

Organization Chart – Traffic Operations



7.2.1 Staffing for Operation

The existing table of organization for the Traffic Operations Division of the Department of Public Works currently provides staffed operations positions within the following categories: Traffic Engineer – Assistant Public Works Director, Traffic Operations Manager, Traffic Operations Supervisor, and three Traffic Technicians. The staff also includes a Signs/Marking Supervisor supported by two Traffic Technicians. At present, these personnel are responsible for engineering and traffic systems operations. In addition to their current duties, traffic operations personnel will be responsible for tasks associated with new system implementation: contract administration, scheduling, conflict mitigation, updating timing plans, developing and updating traffic responsive signatures, testing, inspection, and system evaluation.

System operations personnel will be responsible for daily system monitoring; observation of intersection operation; control of system access; and maintenance of files and documentation.

Assuming the Traffic Operations Manager devotes 50% of his time to administration, and the Traffic Operations Supervisor devotes 50% of his time to administration and/or maintenance, there would be the equivalent of one system engineer/manager personnel position for approximately 67 intersections. This does not take into consideration the effects of migrating to a wireless communication infrastructure. A survey of several cities revealed the following information on the number of personnel required for the operation of their systems:

Table 7.1

Staffing for Operation in Other Cities

	Number of City Signals		
Staff Position	**50 Signals or ITS Devices**	**200 Signals or ITS Devices**	**1000 Signals or ITS Devices**
Signal Systems Manager	1 Manager/Engineer	1 Manager	1 Manager
Signal System/ITS Engineer	0	1 to 3	3 to 6
System Technicians	1	2 to 4	4 to 8
System Analysts	1	2 to 4	4 to 8
System Operators	1	2 to 4	4 to 8
Field Technicians and Workers	2 to 4	4 to 10	20 to 50

Sugar Land has experienced rapid growth in the last decade, with expectations for that trend to continue. On the basis of the population of an urban area, 12 cities which were surveyed averaged 1.86 engineers per 100,000 population. The population of Sugar Land was 79,943 (2006). This equates to about 1.5 engineers for Sugar Land. The City has 74 signals, which puts it slightly to the right of the 50 signal column in Table 7.1. Sugar Land should have a moderate to high level of ITS devices. If we add a wireless communication device and integrate it with a video surveillance camera at each intersection, the number of devices may increase by more than threefold. Based on these data, the recommended staffing for the operation of the ATMS and new ITS components is shown in Table 7.2.

Table 7.2

Recommended Staffing for

Operations and Maintenance

Staff Position	Number of City Signals 74 plus ITS Devices
Traffic Operations Manager	1
Traffic Operations Supervisor	1
Traffic System Technicians Traffic System Operators	1 to 3 1 to 2
Field Technicians	3 to 6
Engineer II (including network management & video surveillance)	1
Wireless Engineer/Technician	1 to 2

The System Technician, System Operator, Engineer II and Wireless Engineer/Technician positions should be filled as this ITS Operations Plan is approved and implemented. These staff members should be assigned to follow new system upgrade and development closely through installation, testing, system operation, and maintenance. Field Technician positions can be added as additional devices are installed.

Staffing Duties

Though each jurisdiction may have a unique way of referring to each employee or classifying their duties, the categories below are quite typical:

Traffic Operations Manager – The Traffic Operations Manager (TOM) is the designated person in charge of the ITS and its wireless component. The manager and staff evaluate and provide information about the ITS program to upper management, and communicate requirements and concerns to the organization. The TOM ensures Operational Procedures are developed, reviewed, implemented, and revised. Technical capabilities and training needs are assessed by the TOM, then appropriate training plans are developed and presented.

Traffic Operations Supervisor – The Traffic Operations Supervisor ensures that the technicians, operators and wireless engineers are aware of the operational requirements of the ITS. The Supervisor must monitor employee activities to ensure compliance with all job

requirements and report any non-compliance and the reasons therefor to the Traffic Operations Manager.

System Technician / Construction Inspector – A System Technician would report to the Operations Supervisor and is usually less advanced in terms of theoretical signal timing knowledge and traffic engineering experience. The System Technician would provide support in the areas of changing timing, invoking patterns, directing field personnel to repair equipment and designing new facilities. Additionally, the System Technician could provide support for additional timing plan development, updating the computer database and continually evaluating the system's performance.

This staff member would also support the operation of the advanced transportation management system and its technical components and should be made available to assist with the design, installation and testing of the new system components at the outset, and assist with the supervision and inspection of system construction and integration as project schedules demand.

System Operator – A System Operator sits at the TMC console and monitors the system and makes changes at the direction of the Operations Supervisor or System Technician. This person should be present for all technical training required of any system contractor. The System Operator should function to maintain the effective operation of the ATMS and new ITS components through day-to-day interface with them and should have the additional role of providing technical support to field personnel on the actual maintenance of the on-street hardware. In addition, this staff member should be made available to assist with the supervision and inspection of construction activities.

Field Technician – The Field Technician is certified to perform and/or direct signal and equipment repair and may assist with signal timing.

Engineer II - This staff member would support the operation of the network management and video surveillance components of the ITS network and should be made available to assist with the design, installation and testing of the network at the outset, and assist with the supervision, inspection and maintenance of the network when field visits to the individual sites are required. This Engineer would also be responsible for the development of signal timing plans and maintenance of signal coordination.

Wireless Engineer/Technician – The Wireless Engineer/Technician is a person who is an individual contributor who will work under general direction. He/she monitors the operation of the wireless communication network including the operations of the wireless network management system and the wireless video surveillance component. This engineer would be responsible for ensuring the wireless network operates in an optimum manner, continually monitoring RF interference and taking necessary corrective actions when appropriate.

7.2.2 Staffing for Maintenance

In addition to the engineering and operation staff analysis presented in Table 7.1 and Table 7.2, an additional assessment was made of the adequacy of the existing staff to support an on-going field equipment maintenance program. The installation of the recommended ITS projects is expected to have the following effect:

- Increased maintenance requirements due to the installation of new higher tech ITS equipment, additional system detectors and more sophisticated communications equipment
- Decreased maintenance requirements due to the upgrade of traffic signal controllers to Ethernet-capable units, replacement of the current mix of aging system communications with modern wireless technology, etc.

Decreased maintenance requirements for system communications should moderately offset increased maintenance requirements for system detectors, ITS devices and system functionality. When the wireless communication network is installed, it should require training for City staff to properly maintain the system. A literature search revealed the following levels of maintenance staffing:

Table 7.3

Maintenance Staffing

in Other Cities

Survey Source	Number of Signals per Technician
NCHRP Synthesis 371 – Managing Selected Transportation Assets	30 to 40 signals per technician
Hampton, Virginia, Survey	76 signals per technician
Menlo Park, California, Survey	50 signals per technician
FHWA Computerized Traffic Signal System Training Class	40 to 50 signals per technician
2007 National Traffic Signal Report Card, average of six case study cities (Average City grade = C+)	50 signals per technician
ITE Operations Handbook	17 to 27 signals per technician
National Average	40 signals per technician

Where intersections are complex eight-phased locations, the ITE survey drops to 17 signals per technician. It is seen that for the Sugar Land 74 signals plus ITS devices, approximately 3 to 6 technicians would be required, which is shown in the Recommended Staffing table (Table 7.2).

The Signs/Markings Supervisor and staff are responsible for the maintenance of traffic control signs and pavement markings. With the City's rapid growth, the number of roadway signs and lane miles has increased dramatically. The public demand for increased vehicular, pedestrian and bicycle safety has expanded the need for better and more signage and pavement markings. The ability of staff to efficiently provide prompt, thorough and effective traffic-related services is on the decline due to an increase in development and annexation. In order to meet the high level of service expected by the citizens of Sugar Land, it is recommended that the signs and markings staff be supplemented by an additional two to three technicians or workers.

7.2.3 Staffing for IT/System Network Functions

In an ideal wireless communication program, the job functions most wireless managers and staff are required to perform do not change; rather more personnel are added that are dedicated solely to wireless. What has been found is that in most organizations, wireless personnel have ancillary duties. There is simply not enough time to complete non-wireless tasks and wireless tasks. Often the wireless functions that are not an immediate need such as audit reviews and contingency planning are put on hold. The time-sensitive wireless tasks such as restoration of wireless components that are inoperative are completed as quickly as possible with no time to review or revise procedures if needed.

Wireless Engineering Staff Functions

This section describes the many functions the wireless engineering staff should perform and the amount of staffing suggested to effectively carry out the function. The wireless engineering staff must understand and implement management, operational, and technical controls. The full implementation of all the controls requires the wireless engineering staff to wear many hats. On any given day the wireless team may serve as a procurement specialist reviewing a detailed specification for a system upgrade or as a training specialist presenting a class on wireless engineering practices and procedures. The reality in many organizations is that the multi-faceted duties of a wireless team that is sorely lacking personnel resources requires prioritization of the work load in order to accomplish just the critical tasks. Each function described below contains the ideal amount of staff required to perform the function as well as the minimum level. The levels are described as the percentage of one staff year.

Audit - Wireless engineers are responsible for examining the system to see whether the system is meeting stated functional and performance requirements, including system and organization policies. The wireless engineering staff should annually perform a detailed review of wireless operations in order to reauthorize the system for processing.

Staffing levels: Ideal – 50%

Minimum – 35%

Network Security - The wireless engineering staff should work closely with the physical security office to address the physical security of the wireless network against computer viruses, rogue access point intrusion, hacking attacks, etc. Ideally, the security team would research new security products, evaluate products, threats, and vulnerabilities to the wireless

component of the ITS and compare the threats against the features of security products. Following these types of efforts the wireless engineering staff would make recommendations to upper management regarding security upgrades.

Staffing levels: Ideal – 10%

Minimum - 5%

Disaster Recovery/ Contingency Planning - The wireless engineering staff should be part of a Traffic Operations disaster recovery and contingency planning team. The team is responsible for contingency planning for the wireless ITS and would assist in the disaster and contingency planning of the overall ITS network.

Staffing levels: Ideal – 15%

Minimum – 5%

Procurement - Although the procurement office is responsible for ensuring that organizational procurements have been adequately reviewed, the wireless engineering staff is responsible for ensuring that goods and services for their part of the ITS meet stated functional requirements and expectations. The staff would be responsible for developing Bills of Materials (BOMs) for all wireless procurements. The staff should be knowledgeable about current wireless communication industry standards such as 802.11 a/b/g and should bring them to the attention of the procurement office where appropriate.

Staffing levels: Ideal – 15%

Minimum - 5%

Training - Wireless engineering training and awareness is a requirement for the continuing functional operation of the wireless component of the ITS. The wireless engineering staff is responsible for communicating with the wireless hardware/software vendors to identify training needs and requirements of the staff and working to ensure the staff receives adequate training which oftentimes leads to levels of certification from the perspective of the wireless equipment vendor. The wireless engineering staff also has primary responsibility for cross training users, operators, and managers in the operation and maintenance of the wireless network. The staff develops training classes for Engineers, System Technicians, System Operators and Field Technicians, as well as the Traffic Operations Supervisor and Traffic Operations Manager where appropriate. The staff also briefs IT requirements at intra-departmental and inter-departmental conferences and meetings.

Staffing levels: Ideal – 25%

Minimum – 15%

Network Management/Video Operations Center Management - These personnel are the engineers and technicians who design and operate the wireless network management systems and the video operation and video data storage components of the wireless network and the video surveillance portion of the network. They are responsible for operating the network management system and implementing the video storage requirements that relate to their system.

Network Management

The Gartner Group, a leading research and consulting organization, reports that the need for wireless management is one of the top two barriers to wireless adoption in the enterprise. Wireless management solutions today must do far more than simply configure the access points and controllers – they need to provide a full range of operational capabilities, from real-time user and device monitoring to compliance management. The core components of a wireless management suite should include software for configuration, monitoring, and reporting; a visual-RF module for location tracking and RF mapping, and a module for automated rogue access point detection. Optimally the wireless engineering staff should be able to view their entire WLAN from a single web-based console.

The components of a Wireless Management Suite should deliver the following functionality:

- Manageability to reduce operational costs through efficient automation of routine tasks
- Visibility to every user and device
- Security through automated compliance audits and rogue AP detection
- Usability for the entire IT staff, enabling a Help Desk to handle most end-user support
- Flexibility to manage multiple WLAN architectures and vendors from a single console
- Scalability to easily grow as the entire wireless network grows.

Traffic Video Surveillance

Traffic video surveillance is a major component of an integrated transportation management system. The video surveillance system provides transportation engineering and operations personnel with invaluable information on traffic conditions throughout their metropolitan area. A comprehensive video surveillance system achieves this goal by supporting the following activities:

- **Identification and resolution of non-recurring traffic incidents**

  The traffic video surveillance system allows operations personnel to quickly identify non-recurring traffic incidents caused by unscheduled or unplanned incidents such as traffic accidents, vehicle breakdowns, etc. The traffic video surveillance system also allows ITS personnel to mobilize appropriate resources to respond to incidents and to resolve them quickly.

- **Identification and Management of Recurring Traffic Events**

  Recurring traffic events are those that appear with some degree of regularity and predictability. An example of a recurring traffic event is daily congestion that occurs on some routes that run near capacity during the morning and

evening rush hours. The traffic video surveillance subsystem allows traffic engineering personnel to detect areas that are subject to recurring traffic events, to analyze the causes of the problems, and to monitor the effectiveness of any short term or long term measures that have been applied to mitigate the problems. The video surveillance system provides the information needed for operations professionals to become aware of relevant traffic conditions and to develop effective solutions.

- **Coordination of Regional Transportation Operations with Local Government Partners**

  Sugar Land's video surveillance system could be integrally connected with the transportation networks of neighboring cities and towns. Regional traffic video surveillance data could allow neighboring cities and towns to be aware of conditions in the district, reducing delays for all users of the regional transportation system.

To be effective, traffic video surveillance data needs to be readily available to transportation professionals who manage the various facilities who can then communicate with emergency responder agencies such as police, fire, and emergency medical services, etc.

Staffing levels: Ideal – 100%

Minimum – 50%

Preventive Maintenance - Preventive maintenance is a schedule of planned maintenance actions aimed at the prevention of breakdowns and failures. The primary goal of preventive maintenance is to prevent the failure of equipment before it actually occurs. It is designed to preserve and enhance equipment reliability by replacing worn components before they actually fail. Preventive maintenance activities include equipment checks, partial or complete overhauls at specified periods, re-tightening mounting brackets, lubrication and so on. The ideal preventive maintenance program would prevent all equipment failure before it occurs.

Staffing levels: Ideal – 25%

Minimum – 15%

Remedial or Corrective Maintenance - The maintenance performed as required, on an unscheduled basis, by the engineer following equipment failure. This includes repairing components or equipment as necessary either by on-site repair or by replacing individual elements in order to keep the system in proper operating condition.

Staffing levels: Ideal – 10%

Minimum – 5%

The minimum personnel resources needed to maintain a "bare bones" wireless engineering team is roughly 1.15 staff years. Ideally, however, to effectively perform the functions described above 1.95 staff years is needed. The table below summarizes the staffing resources required to perform typical wireless engineering functions.

Table 7.4

Summary of Functions and Staffing

Wireless Engineering Staff Functions	Ideal Percentage of Time	Minimum Percentage of Time
Audit	35%	15%
Network Security	10%	5%
Disaster Recovery & Contingency Planning	10%	5%
Procurement	5%	5%
Training	15%	5%
Network Mgt/Video Operations Center Mgt	75%	50%
Preventive Maintenance	35%	25%
Remedial Maintenance	10%	5%
Totals	1.95 staff years	1.15 staff years

The numbers do not take into account whether line-management is required to perform some of the duties listed resulting in less tasking of the wireless engineering team. These numbers could be further reduced by cross training the Traffic System Technician or Traffic System Operator to perform some of the functions listed in the table above. Of course, a determination would have to be made to determine which of these individuals has the most available time that could be reallocated to wireless engineering activities. The break down by function will enable ITS management to determine which duties require ideal levels of staffing and which functions should remain at a minimum level or delegated to other ITS organizational entities.

Upon review and consideration of these requirements, it was determined by the City of Sugar Land that the Wireless Engineer/Technician position(s) will be filled by the City's IT Department. This will help ensure the rapid response to operational issues that a real-time traffic management system requires.

7.2.4 Shift Schedule and Persons per Shift

The City should plan to have a trained operator at the TMC six days a week, Monday through Saturday. This could potentially be accommodated by having staff working in two shifts, with a period of operator overlap due to flexible hours. Staff will continue to provide coverage from 7 AM to 7 PM. The system should also be operated during scheduled special events and during "incidents" using "comp-time" or overtime. The operator would be available to help with other traffic tasks during "lulls" in activity.

As the City grows and the system expands, the Traffic Operations Division should plan to accommodate a 7 days per week operation. This will be particularly valuable for field equipment maintenance and installation activities, and can be implemented as the new Field Technician positions are filled.

7.2.5 Training for New Staff

A significant amount of initial training will be required to ensure that the staff is qualified to operate and maintain new equipment. Training will be provided on operation of new central system modules, Ethernet hardware and communications, wireless communications equipment, and new systems hardware and software as they are installed and implemented.

Initial training will be provided by the system or equipment provider. If turnover or retirement in City personnel is expected, then the Contract Documents could require additional system and controller training by the manufacturer, perhaps one year after acceptance.

There is a rapidly growing tendency of software vendors to provide professionally created training (step-by-step) on-line or on CD-ROM. Most jurisdictions promote operators "from within," finding intelligent, eager engineers or technicians. They are then brought "up through the system," by increasingly more difficult assignments. In addition to the above training methods, the new operator can sit side by side and be "talked-through" various system activities. Modern software with easy-to-use graphical user interfaces (GUIs) makes this much easier.

Unless Sugar Land hires wireless engineers with very specific experience, training will be required for them as well as for newly hired wireless engineering staff. With this in mind, Traffic Operations and IT management should endeavor to employ people with specific experience or provide training to their wireless group. If other system vendors are selected, the equivalent of the training described below should be provided. All of the wireless engineers should possess the following certifications or their equivalent:

- **Certified Network Professional** - Certified Network Professional is an intermediate-level certification for IT professionals who can install, configure, and troubleshoot local and wide area networks for enterprise organizations with networks from 100 to more than 500 nodes. The CNP Certification has as its prerequisite the CNA (Certified Network Associate), and covers content such as: security, converged networks, quality of service (QoS), virtual private networks (VPN) and broadband technologies.

- **CNA Network Associate** - The CNA Network Associate certification validates the ability to install, configure, operate, and troubleshoot medium-size routed and switched networks, including implementation and verification of connections to remote sites in a WAN. This new curriculum includes basic mitigation of security threats, introduction to wireless networking concepts and terminology, and performance-based skills. This new curriculum also includes (but is not limited to) the use of these protocols: IP, Enhanced Interior Gateway Routing Protocol (EIGRP), Serial Line Interface Protocol Frame Relay, Routing Information Protocol Version 2 (RIPv2), VLANs, Ethernet, access control lists (ACLs).

Assuming that there will be wireless field workers and wireless office workers, or people who work in both environments, there should be at least one Wireless Engineer with the Advanced Wireless LAN Design Specialist Certification and one with the Advanced Wireless LAN Field Specialist Certification.

- **Advanced Wireless LAN Design Specialist** - The Advanced Wireless LAN Design Specialist will demonstrate the ability to successfully design solutions using the advanced feature set of wireless products and based on a validated understanding of radio frequency and antenna theory, 802.11a/b/g standards, site survey and configuration of controllers and APs. Solutions may include voice over WLAN, outdoor mesh and secure wireless.

- **Advanced Wireless LAN Field Specialist** - The Advanced Wireless LAN Field Specialist will demonstrate the ability to successfully install, configure and support solutions using the advanced feature set of wireless products and based on a validated understanding of radio frequency and antenna theory, 802.11a/b/g standards and support of controllers and APs.

The following table summarizes some of the key aspects of operations and maintenance functions, as well as training, related to the ITS projects recommended as part of the ITS 5-Year Operations Plan.

Table 7.5

Project O&M and Training Matrix

	Recommended Projects	Operations & Maintenance and Training Requirements
	Group 1 - Traffic Signal System Improvements	
1.1	Install Wireless Communication Infrastructure for ITS Field Equipment	Staff will require training on the installation, configuration and routine troubleshooting of wireless network equipment… a private contractor will most likely be required to assist in system design and antenna selection.
1.2	Upgrade Traffic Controllers to Ethernet-Based Units	Maintenance skills for Ethernet controller and switching equipment will be required. Minimal training is needed to maintain the Ethernet controllers and switches to be deployed in the field. The Ethernet switch equipment envisioned for the TMC is more sophisticated and may require assistance from the City's IT Department or a private contractor.
1.3	Expand System Detection Network	Staff will require training on any new detection technology introduced. Ongoing operations & maintenance will require increased level of effort as hardware deployment expands.
1.4	Expand CCTV Surveillance System	City staff may require training on the configuration and routine troubleshooting of video encoder/decoder equipment. If new server equipment is installed at the TMC, assistance from the IT Department or a private contractor will most likely be required.
1.5	Central Traffic Signal Priority Software Module	Staff will require training on new hardware and software. Ongoing operations & maintenance should require approximately the same level of effort from City staff.
1.6	Central Traffic Adaptive Software Module	Staff will require training on new software. Staff time devoted to traffic signal synchronization will be reduced.
	Group 2 - Safety Enhancement Projects	
2.1	Expand Driver Feedback Speed Signs	Staff operations & maintenance requirements will expand as additional units are deployed.
2.2	ATMS & Emergency Services Integration	Staff will require training on new hardware and software.
2.3	Railroad Crossing Monitoring System	Staff will require training on new hardware and software. Depending on the terms of the MOU with the railroad, City staff may assume O&M responsibility for system components on railroad right-of-way.
	Group 3 - Traveler Information and Information Sharing with Regional Agencies	
3.1	Install DMS	Staff will require training on new hardware and software. Staff will require training on routine DMS maintenance and troubleshooting.
3.2	CCTV & Traveler Information Website Integration	Staff will require training on new hardware and software. Public Works Department may need assistance from IT Department with routine server backups and administration. A private contractor may be required to maintain the "look and feel" of the website as well as the content.

	Recommended Projects	Operations & Maintenance and Training Requirements
3.3	Share Data/Video with TxDOT and Neighboring Cities	City staff will need to ensure compatibility of data/video with all sharing agencies
	Group 4 - Transportation Management	
4.1	Citywide Traffic Signal Timing Optimization	City staff should consider training on the latest signal timing optimization software. Staff can support and/or manage private contractor efforts and assume responsibility for updating optimization models as needed.
4.2	Parking Availability System	Staff will require training on new hardware and software. Staff will require training on routine system equipment maintenance and troubleshooting.
4.3	Central Fleet Management Software Module	Staff will require training on new hardware and software. Installation of vehicle equipment will be the responsibility of the owning department.
4.4	Public Works Vehicle Payload Monitoring System	Staff will require training on new hardware and software. Staff will require training on routine system equipment maintenance and troubleshooting.
	Group 5 - Other Projects	
5.1	Enable System Data Exchange	City staff will need to ensure compatibility of data with all sharing agencies
5.2	Share Data with Mobile Command Post for Traffic Incidents	Staff will require training on new hardware and software.

7.2.6 Summary

In summary, it is recommended that the following staffing/personnel actions be implemented by the Traffic Operations Division:

- Create and fill an Engineer II, Traffic System Technician /Construction Inspector, and two Traffic Technician II positions for system operations and enabling 7-day operation
- Cross train the Engineer II, Traffic System Technician and Traffic Technicians as system operators
- Create and fill two Traffic Technician I positions for signs/markings due to annexation
- Create and fill an Engineer I and two Crew Chief positions
- Combine the functions of the Traffic Operations Supervisor with the Traffic System Operator position

It must be recognized by the City that full utilization of ATMS and ITS capabilities requires a firm commitment of adequate personnel for the maintenance and operation of all systems and components. It must also be recognized that adequate training in Operations and Maintenance is absolutely critical to the success of the ATMS and Intelligent Transportation Systems.

In cooperation with Traffic Operations Division staff, the recommendations listed above have been combined with some desirable modifications and upgrades to existing staff positions. The resultant recommended Traffic Operations Division Organization Charts for 2009 and 2010 are provided in Figures 7.3 and 7.4.

Implementation of these staffing recommendations will reduce the current dependence on overtime activities of existing staff, and also enable 7 days per week, 24 hours per day operation starting in 2009. The mechanism for implementing this operation is depicted in Table 7.6.

Figure 7.3

Recommended Organization Chart – Traffic Operations Division

2009

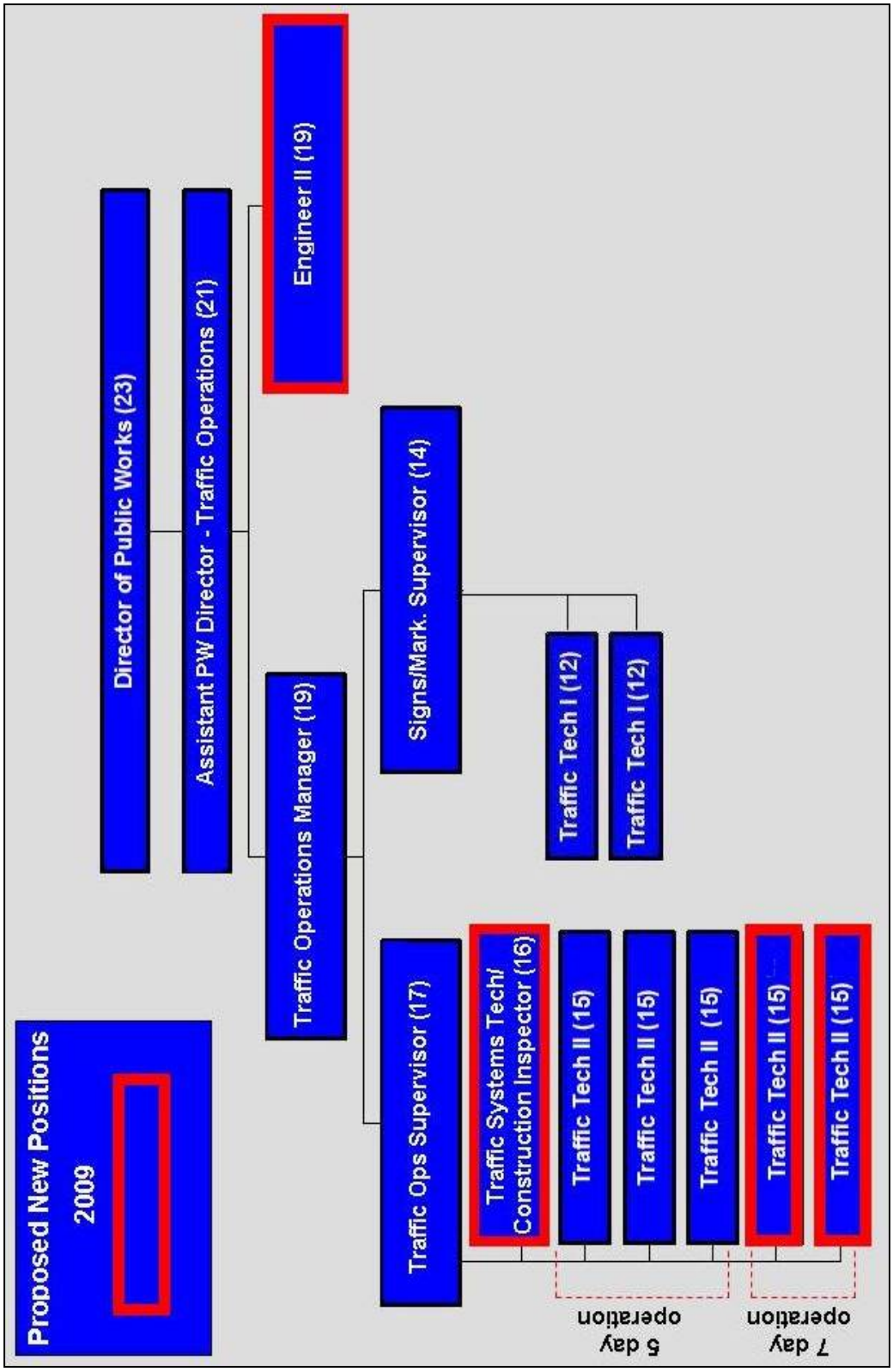


Figure 7.4

Recommended Organization Chart – Traffic Operations Division

2010

Table 7.6

Anticipated Work Schedule by Staff Position

Staff Position	Work Schedule	Work Hours	4/10 Days Off	9/80 Days Off	8-5 Days Off
Traffic Eng. Assistant Director	5/8	8 AM-5 PM			S,S
Traffic Operations Manager	5/8	8 AM-5 PM			S,S
Traffic Operations Supervisor	4/10	8 AM-7 PM*	W,S,S		
Engineer II	4/10	8 AM-7 PM*	M,S,S		
Traffic System Technician/Construction Inspector	9/80	7 AM-5 PM*		FRI S,S	
Traffic Technician II	9/80	7 AM-5 PM*		FRI S,S	
Traffic Technician II	9/80	7 AM-5 PM*		FRI S,S	
Traffic Technician II	9/80	9 AM-7 PM*		TUE S,M	
Traffic Technician II	9/80	9 AM-7 PM*		TUE S,M	
Traffic Technician II	9/80	9 AM-7 PM*		FRI S,S	
Signs/Markings Supervisor	9/80	8 AM-6 PM		FRI S,S	
Traffic Technician I	9/80	8 AM-6 PM		FRI S,S	
Traffic Technician I	5/8	7 AM-4 PM			S,S

* Available via ATMS.now Paging System during After Hours

8 Prioritized ITS Operations Plan

8.1 Introduction and Summary

This chapter presents a prioritized ITS Operations Plan based on the work performed in all of the prior tasks. This ITS Operations Plan summarizes the results of the seven tasks and provides a guide for the implementation of ITS elements over the next five years. This Plan identifies a series of ITS projects that should be implemented by the CITY. These projects are summarized in detail in Appendix C, Recommended Projects, which provides an assessment for each project that includes the following information:

- Project Description
- Benefits
- Assumptions
- Relationship of Projects to the System Architecture
- Cost Estimate

This chapter also provides Implementation Plan guidance in keeping with the requirements of the Code of Federal Regulations Title 23 (23 CFR) and with the HGAC Regional ITS Architecture.

8.2 Project Prioritization

The list of recommended projects was identified in Chapter 5, Determine ITS Options. In that chapter the projects were described in terms of their relationships to the functional requirements. These relationships are summarized in Table 5.1, which contains a great deal of information about the relationships between the functional requirements and the projects. That table is duplicated here as Table 8.1 as the first step in the project prioritization process.

The projects in Table 8.1 were then evaluated in terms of the following considerations:

- Does the Project have a Precursor Project?
    - Meaning, does another recommended project need to be completed before this project can be effectively implemented?
- Does the Project have a Dependent Project?
    - Meaning, does another recommended project require the completion of this project before can be effectively implemented?
- Rating of Functional Requirement(s) it Satisfies
    - Meaning, what was the ranking of importance, determined by the project Steering Committee, of the functional requirements satisfied by the subject project?
- Was the Project previously identified in the City's Capital Improvement Project (CIP) list or Advanced Funding Agreement (AFA)?
- The Project's relative ease of implementation.

Table 8.1
Relationships Between
Functional Requirements and Projects

KEY
E = Enabling Project
P = Prerequisite Project
S = Supporting Project

		Projects																	
	Functional Requirement	**Install Wireless Communication Infrastructure for ITS Field**	**Upgrade Traffic Controllers to Ethernet-Based Units**	**Expand System Detection Network**	**Expand CCTV Surveillance System**	**Central Traffic Signal Priority Software Module**	**Central Traffic Adaptive Software Module**	**Expand Driver Feedback Speed Signs**	**ATMS & Emergency Services Integration**	**Railroad Crossing Monitoring System**	**Install DMS**	**CCTV & Traveler Information Website Integration**	**Share Data/Video with TxDOT and Neighboring Cities**	**Citywide Traffic Signal Timing Optimization**	**Parking Availability System**	**Central Fleet Management Software Module**	**Public Works Vehicle Payload Monitoring System**	**Enable SystemData Exchange**	**Share Data with Mobile Command Post for Traffic Incidents**
		1.1	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**2.1**	**2.2**	**2.3**	**3.1**	**3.2**	**3.3**	**4.1**	**4.2**	**4.3**	**4.4**	**5.1**	**5.2**
1	Save City traffic data for future analysis	S	S	P														S	
2	Collect traffic volume data for monitoring traffic flow and displaying real-time conditions	S	S	P								S	S		S			S	
3	Provide video images of key locations	S			E							S	S						
4	Provide better signal timing and signal coordination	S	S	E			S							E					
5	Adjust signal timing based on real-time traffic data	S	S	E			P												
6	Provide fire trucks with a green light at traffic signals	S	S			E			S							S			
7	Provide ambulances with a green light at traffic signals	S	S			E			S							S			
8	Facilitate the exchange of archived data with other agencies	S		P								S	E						
9	Adjust signal timing based on real-time event data from major traffic generators	S	S	E															
10	Collect the average speed of traffic on major arterials	S	S	E															
11	Provide information to drivers using Dynamic Message Signs	S		P				E			E				S				
12	Improve coordination among organizations that respond to accidents	S		S	S				E			S				S		E	E
13	Improve coordination among organizations dealing with traffic at special events	S	S	P	S							S						E	E
14	Support Amber Alerts and other wide area emergency notifications	S									E	S	S					S	
15	Save data on other transportation activities within the City (Transit, Parking, etc.)	S								S		S			S	S		S	
16	Push traffic data to travelers through enhanced pagers, cell phones, etc.	S		P								S							
17	Help predict future traffic volumes		S	P															
18	Monitor the operation of railroad grade crossings	S	S							E									
19	Direct drivers to parking garages where space is available	S									S				E				
20	Include an automatic vehicle location system for Public Works Dept. vehicles															E			
21	Include an automatic vehicle location system for other City-owned vehicles															E			
22	Support the monitoring of material/equipment on Public Works Dept. vehicles																E		
23	Recommend routes for emergency vehicles based on traffic conditions	S	S	P	S				E							S			
24	Support coordination of evacuation plans	S		S	S						S	S	E					S	
25	Exchange data with TxDOT and other local traffic agencies			P	S							S	E		S	S		S	
26	Coordinate grade crossing operation with the railroad	S			S					S								S	
27	Support the computer-aided dispatch of emergency vehicles					S										E			
28	Support coordination of emergency response plans	S		S	S	S			S		S	S	S			S		S	S
29	Provide disaster-related traveler information	S			S						E	S	S					S	
30	Provide traffic data for in-vehicle route guidance systems	S	S	P														S	

Table 8.2 reflects the first step in the prioritization process. Each of the Recommended Projects is presented, with the Precursor and Dependent Projects identified. Table 8.3 then takes the next step, identifying projects as high, medium and low priority. The highest priority projects were those that had no Precursor Projects. That is, they could be implemented immediately without the need to wait for the completion of another recommended project. The medium priority projects all have Precursor Projects that fall into the high priority category, meaning that they are dependent upon the completion of a prior project before they can be fully implemented. Finally, the low priority projects are dependent upon the completion of a project or projects in the high and medium priority categories.

The high, medium and low priority projects were then assembled together by project number. This result is reflected in Table 8.4. Finally, these Recommended Projects were compared to the rankings of the Functional Requirement(s) it satisfies. These rankings were presented in Table 6.1. The Recommended Projects were then sorted by these rankings to establish the prioritization of projects, reflected in Table 8.5.

8.3 Project Schedule

The anticipated sequence of project implementation, and a preliminary estimate of project duration, is presented in Table 8.6, Prioritized Project Schedule. Much of this schedule is dependent on the design and implementation of the ongoing project to implement the wireless communications network and upgrade the traffic signal controllers (Projects 1.1 and 1.2). This schedule reflects the latest available schedule estimate from that project. It can be seen, however, that the City may embark on several high priority projects in parallel to Projects 1.1 and 1.2 so as to continue making progress toward achieving the goals of this ITS Operations Plan, and increase the capabilities and functionality of the overall advanced transportation management system that will be available when the implementation of the wireless network and Ethernet control capability is complete.

Table 8.2
Identification of Precursor Projects

Recommended Projects		Precursor Project																		Has Dependent Project(s)
		None	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	4.4	5.1	5.2	
1.1	Install Wireless Communication Infrastructure for ITS Field Equipmen	X																			YES
1.2	Upgrade Traffic Controllers to Ethernet-Based Units	X																			
1.3	Expand System Detection Network	X																			YES
1.4	Expand CCTV Surveillance System	X																			
1.5	Central Traffic Signal Priority Software Module		X		X					X			X				X		X		
1.6	Central Traffic Adaptive Software Module		X		X																
2.1	Expand Driver Feedback Speed Signs	X																			
2.2	ATMS & Emergency Services Integration		X		X								X						X		YES
2.3	Railroad Crossing Monitoring System																		X		
3.1	Install DMS	X																			YES
3.2	CCTV & Traveler Information Website Integration	X																			YES
3.3	Share Data/Video with TxDOT and Neighboring Cities																		X		
4.1	Citywide Traffic Signal Timing Optimization	X																			
4.2	Parking Availability System											X							X		
4.3	Central Fleet Management Software Module	X																			YES
4.4	Public Works Vehicle Payload Monitoring System																X				
5.1	Enable System Data Exchange	X																			YES
5.2	Share Data with Mobile Command Post for Traffic Incidents																		X		

Table 8.3
Prioritization of Projects

KEY

= High Priority
= Medium Priority
= Low Priority

	Recommended Projects	Precursor Project																		Has Dependent Project(s)	In 2008 CIP or AFA
		None	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	4.4	5.1	5.2	
1.1	Install Wireless Communication Infrastructure for ITS Field Equipment	X																			YES	YES
1.2	Upgrade Traffic Controllers to Ethernet-Based Units	X																				YES
1.3	Expand System Detection Network	X																			YES	YES
1.4	Expand CCTV Surveillance System	X																				
1.5	Central Traffic Signal Priority Software Module		X		X					X			X				X		X			
1.6	Central Traffic Adaptive Software Module		X		X																	
2.1	Expand Driver Feedback Speed Signs	X																				YES
2.2	ATMS & Emergency Services Integration		X		X								X						X		YES	YES
2.3	Railroad Crossing Monitoring System																		X			
3.1	Install DMS		X																		YES	YES
3.2	CCTV & Traveler Information Website Integration	X																			YES	YES
3.3	Share Data/Video with TxDOT and Neighboring Cities																		X			
4.1	Citywide Traffic Signal Timing Optimization	X																				YES
4.2	Parking Availability System											X							X			YES
4.3	Central Fleet Management Software Module												X								YES	YES
4.4	Public Works Vehicle Payload Monitoring System																X					
5.1	Enable System Data Exchange	X																			YES	
5.2	Share Data with Mobile Command Post for Traffic Incidents																		X			

Table 8.4
Prioritized Projects, By Number

KEY

= High Priority
= Medium Priority
= Low Priority

	Recommended Projects	Precursor Project																		Has Dependent Project(s)	In 2008 CIP or AFA
		None	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	4.4	5.1	5.2	
1.1	Install Wireless Communication Infrastructure for ITS Field Equipment	X																			YES	YES
1.2	Upgrade Traffic Controllers to Ethernet-Based Units	X																				YES
1.3	Expand System Detection Network	X																			YES	YES
1.4	Expand CCTV Surveillance System	X																				
2.1	Expand Driver Feedback Speed Signs	X																				YES
3.2	CCTV & Traveler Information Website Integration	X																			YES	YES
4.1	Citywide Traffic Signal Timing Optimization	X																				YES
5.1	Enable System Data Exchange	X																			YES	
1.6	Central Traffic Adaptive Software Module		X		X																	
2.2	ATMS & Emergency Services Integration		X		X								X						X		YES	YES
3.1	Install DMS		X																		YES	YES
4.3	Central Fleet Management Software Module												X								YES	YES
5.2	Share Data with Mobile Command Post for Traffic Incidents																		X			
1.5	Central Traffic Signal Priority Software Module		X		X					X			X				X		X			
2.3	Railroad Crossing Monitoring System																		X			
3.3	Share Data/Video with TxDOT and Neighboring Cities																		X			
4.2	Parking Availability System											X							X			YES
4.4	Public Works Vehicle Payload Monitoring System																X					

Table 8.5
Prioritized Projects, By Project Ranking

KEY

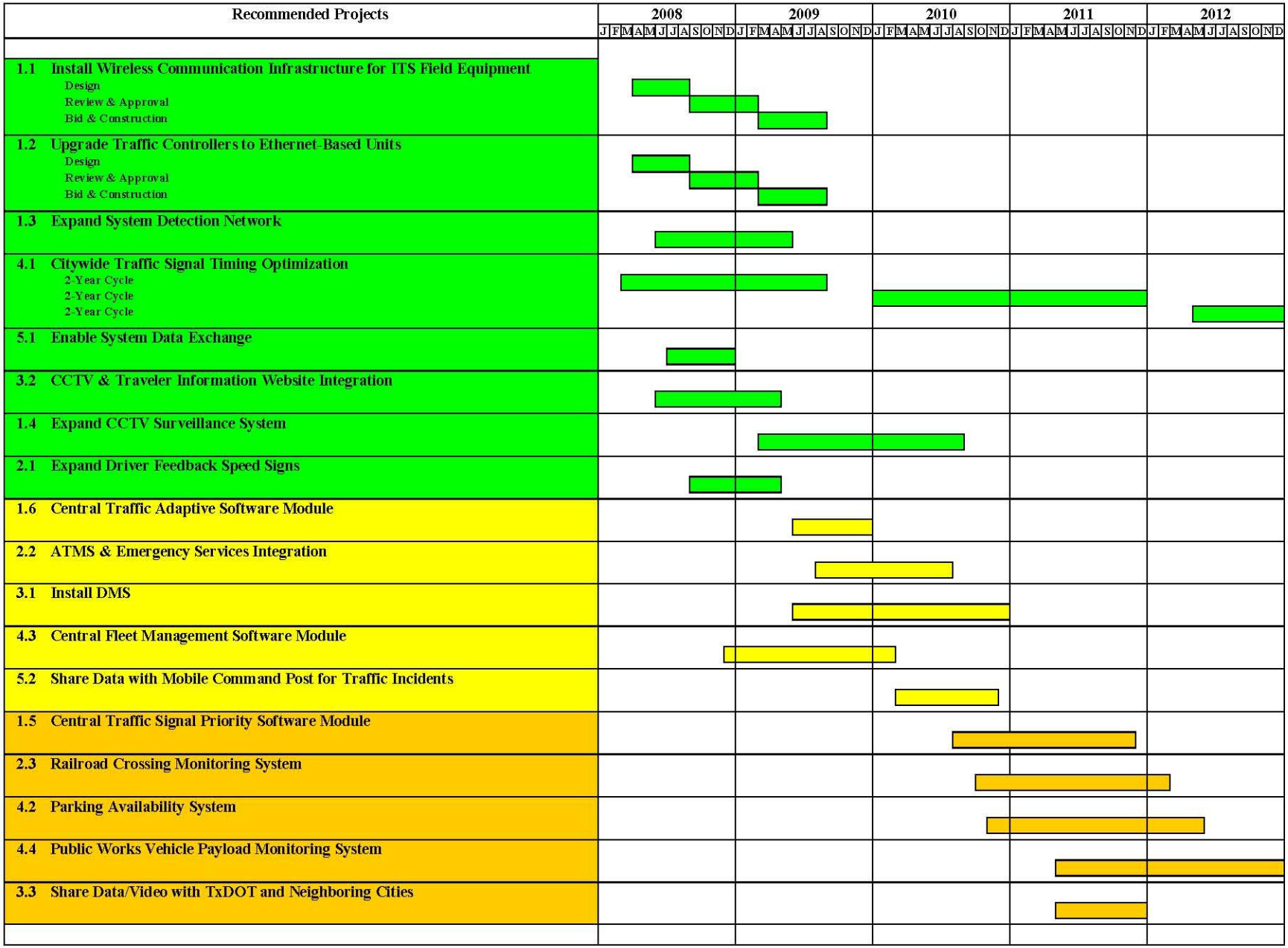
= High Priority
= Medium Priority
= Low Priority

Recommended Projects		Precursor Project																		Has Dependent Project(s)	In 2008 CIP or AFA
		None	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	4.4	5.1	5.2	
1.1	Install Wireless Communication Infrastructure for ITS Field Equipment	X																			YES	YES
1.2	Upgrade Traffic Controllers to Ethernet-Based Units	X																				YES
1.3	Expand System Detection Network	X																			YES	YES
4.1	Citywide Traffic Signal Timing Optimization	X																				YES
5.1	Enable System Data Exchange	X																			YES	
3.2	CCTV & Traveler Information Website Integration	X																			YES	YES
1.4	Expand CCTV Surveillance System	X																				
2.1	Expand Driver Feedback Speed Signs	X																				YES
1.6	Central Traffic Adaptive Software Module		X		X																	
2.2	ATMS & Emergency Services Integration		X		X								X						X		YES	YES
3.1	Install DMS		X																		YES	YES
4.3	Central Fleet Management Software Module												X								YES	YES
5.2	Share Data with Mobile Command Post for Traffic Incidents																		X			
1.5	Central Traffic Signal Priority Software Module		X		X					X			X				X		X			
2.3	Railroad Crossing Monitoring System																		X			
4.2	Parking Availability System											X							X			YES
4.4	Public Works Vehicle Payload Monitoring System																X					
3.3	Share Data/Video with TxDOT and Neighboring Cities																		X			

KEY

= High Priority
= Medium Priority
= Low Priority

Table 8.6
Prioritized Project Schedule



8.4 Implementation Plan Guidance

8.4.1 Overview

This Implementation Plan guidance has been prepared in accordance with the Code of Federal Regulations (23 CFR 655.409) to guide the City of Sugar Land during the performance and realization of the ITS Operations Plan. An Implementation Plan is required for both new traffic control systems, as well as expansions of existing systems, which use Federal funds and are encouraged for those systems which do not use Federal funds

The basic structure of this section corresponds to the standard sequence of materials included in a completed Implementation Plan, and most subsections are written as they should appear in the Plan. Several subsections require policy and engineering decisions by the City that are being made under parallel projects, have not yet been made, or materials that are unavailable. For example, the method for proceeding with the Design and Procurement Phase of the wireless network projects has not yet been completely determined. As these and other decisions are made, this section should be updated to form an Implementation Plan that can be approved by all parties. This section provides guidance for the completion of the subsections that must be finalized by the City.

When finalized, this Implementation Plan should be considered contractual in nature and "signed-off" by City, State and Federal officials, indicating their commitment to it. However, even the final Implementation Plan should not be considered undeviating, fixed or rigid. As circumstances change, the Plan should evolve to reflect those changes.

Overall, this Implementation Plan demonstrates a serious commitment from the City and the stakeholders to implement, fund, construct and perpetually operate and maintain the ITS system for the City of Sugar Land.

8.4.2 Legislation

If any features of a project conflict with existing laws, conventions, rules or regulations, it may be necessary to generate legislative amendments or "enabling legislation" to facilitate construction and operation of that project. No hurdles of this type have been identified for any of the projects in the Sugar Land ITS Operations Plan.

8.4.3 System Design

Systems Designer

The Systems Designer is to be determined by the City. There are several ways the City can design the projects and prepare the necessary Plans, Specifications and Cost Estimates. They include:

- The City can design the system
- The City can select an experienced ITS System Consultant to prepare the design
- The City can select a Design/Build Contractor
- The City can justify a sole-source purchase and installation of an "off-the-shelf" system, which is a variation of the first three items

The City has entered into an agreement with a consultant team to prepare construction design plans for the wireless communications network and the upgrade of the traffic signal controllers.

System Design Life

It is generally acknowledged that the design life of ITS and traffic signal systems is about 10 years. However, some relatively expendable items begin to fail at five to seven years; some control equipment may last 12 to 15 years; while heavy hardware (signal poles) may last 20 to 30 years. It is generally advised that the City begin thinking about the next generation (system upgrade or replacement) system after about eight years of operation.

System Coverage

All of the signals under the control of the City of Sugar Land are included.

System Design and Operations/Maintenance Philosophies

Chapter 5, Determine ITS Options, and Appendix C, Recommended Projects, discuss Functional Requirements and list features of the control system upgrades that should be included in the Specifications. The enhanced system should be improved by using traffic responsive operation where timing plans are automatically changed in accordance with the increase or decrease in traffic volume. Volume data should be collected by the System from new or added system detectors.

The System itself should continue to monitor proper operation of on-street components, log failures and generate maintenance reports and work orders. The use of off-the-shelf computers, controllers and other devices, simplifies the maintenance and upkeep of the System. If something breaks, it is relatively easy to make a direct replacement. The failed component should be returned for factory service or repaired off-line by City personnel. City personnel should also perform routine maintenance.

System Architecture

The projects recommended in this Operations Plan expand on the foundation of the existing traffic control system, which is an off-the-shelf central system with on-street traffic signal control equipment provided by the same manufacturer. The central system and software are modular so ITS features can be added as necessary.

Integration with Other Functions

ITS features should be an integral part of the System. The central system is modular so that the ITS features desired by the City can be added with minimal disruption. System upgrades should be designed to be consistent with the HGAC Regional ITS Architecture. Specifications should be based as far as possible on the National ITS Architecture. Being modular in nature, the system should be easily updated and upgraded through the design life. The upgraded system should be designed to provide for information sharing and even some control with TxDOT, surrounding cities, other agencies and the public. National Standards have been addressed by using NEMA Standard controllers and by consideration of NTCIP.

System Components and Functions

The heart of the System is a networked, PC-based arrangement that forms the "Central Computer" that is connected via a communications server to the communications network and thence to the local on-street controllers. Using LAN, WAN and the Internet, various degrees of access can be provided to other agencies, adjacent cities and the public. The primary purpose of the System is to control traffic signals, and software modules should be added to the System to operate other desired functions.

Communication Subsystem Design Approach

The City's existing traffic control communications network consists of a combination of media. The TMC is connected to 11 different signal subsystems in the field via ten broadband Integrated Services Digital Network (ISDN) lines. The communication media within each subsystem are owned and maintained by the Public Works Department. Nine of the eleven subsystems, encompassing a total of 57 signals, utilize Microwave Data Systems (MDS) spread spectrum radio equipment. One subsystem consisting of eight signals utilizes twisted pair copper communications cable, and the final subsystem of two signals is connected to an adjacent spread spectrum subsystem via fiber optic cable. An ongoing design project is preparing to replace this entire network with a three tier wireless network for the existing traffic signal and CCTV systems.

Traffic Operations Center Design Features

The existing Traffic Management Center will continue to provide monitoring and control of the advanced transportation management system and ITS components.

Project Phasing/ Scheduling

Previous sections of this document provided general descriptions of the features and location associated with each ITS Project Group and the recommended construction phasing of the projects. Detailed write-ups and cost estimates have been provided for each group elsewhere in this Plan.

Design Review

Plans, Specifications and the Cost Estimates should be reviewed, revised as required, and finally approved.

8.4.4 Procurement

Method

A consultant team is preparing design documents for procurement of the wireless communications network and the upgrade of the traffic signal controllers following Texas Department of Transportation (TxDOT) procedures.

Schedule

Following the procurement process described above, it is anticipated that the advertisement date for the project will be approximately in April, 2009. Bid openings would then occur approximately 30 days later, and construction would start in the 3rd Quarter of 2009.

8.4.5 Construction Management Procedures

Division of Responsibilities

Following development, review and approval of the Plans, Specifications and Estimates (PS&E), bid letting and contract award, the City's responsibilities in the implementation phase should include participation in tests of all equipment and software. The City should play an active role in inspection of equipment installations and the coordination of the contractor's activities with utilities. The City's inspection activities should include any system software as well as the hardware, and the City should provide advice and guidance to the Contractor as requested.

Scheduling and Establishment of Mileposts

The Contract Documents should state the Contract Time for completion. In the Specifications, the Contractor should be required to submit a detailed milestone/calendar schedule using an industry standard software package that is based upon critical path analysis or PERT. A licensed copy of the software should be provided to the City to track accomplishments and changes. The City (as well as the CEI Consultant if used) should approve the schedule.

Conflict Mitigation

The City's Project Engineer has the ultimate responsibility for strict but fair enforcement of the Contract Documents. City or State inspectors (or contract inspectors) should report to the Project Engineer. If the City has retained the Design Consultant into the construction phase, then that Consultant should assist with problems, decisions and disputes. The most common problems involve errors in quantities, overlooked items or inappropriate installation techniques. The solution of these problems is what "field engineering" is all about. Frequent meetings of the construction partners are important, particularly during the early stages.

Coordination with Other Projects

This project is largely stand-alone and can proceed without influencing or conflicting with other projects. The Contractor should be required to cooperate with other contractors in the vicinity. The City should provide a list of potentially conflicting projects.

8.4.6 System Start-Up Plan

Software Acceptance Tests

As stated in the System Specifications that should be developed, the Contractor should be required to submit for approval, complete *Software and System Acceptance Test Procedures*. These tests should be performed in the presence of City personnel and an inspector (either TxDOT or a CEI consultant). All aspects of ATMS field and central firmware and software should be confirmed to still operate properly through Acceptance Testing, including:

- Local Intersection Program
- Upload/Download
- Central System Software Features

Again every specification requirement should be verified. When failures or "action items" occur, the Contractor should have some period of time, usually about 30 days, to perform a "fix," and re-testing should be at the Contractor's expense, including CEI consultant expenses, if one is used.

System Acceptance Tests

As stated in the System Specifications that should be developed, the Contractor should be required to submit for approval, complete *Software and System Acceptance Test Procedures*. These tests should be performed in the presence of City personnel and an inspector. The System Specification should require the provision of system startup equipment, which includes high-tech Test Equipment that should be used by the Contractor during installation and the Acceptance Tests, but which become the property of the City.

The Acceptance Test Procedure should verify the operation of every feature of the operational requirements. With regard to Hardware System Acceptance, each feature of the entire network should be tested during the Acceptance Test.

Partial Acceptance

As permitted by City ordinance and TxDOT in the State's Standard Specifications, the Contractor may request Partial Acceptance and payment for permitted equipment, installation and software. Payments should be structured so that a substantial Final Payment is not made until Final Acceptance has been successfully completed. Final Acceptance should only occur after the following:

- All field and central equipment has been installed and tested
- All documentation has been completed, including manuals, warranties, wiring diagrams, redlined plans, etc.
- All training has been received
- All spare parts have been received
- All "punch-list" items have been corrected

Documentation

The Contract Documents should state the documentation requirements. It is recognized that in an effort to be more "green," paper documentation is giving way to "On-line" manuals and drop-down help screens. Nevertheless, some form of documentation should be required for all software, controllers and other equipment. Documentation should include backup software on CD's or disk.

Transition from Old to New Control

The Contractor should be required to submit for approval a "Transition Plan," as part of their schedule. Continuity of operation and maintenance of traffic flow should be stressed.

New communications connections should be established between the signal controllers and the Traffic Management Center, and then each channel should be connected to the central communications server. During the communications switchover, the existing controllers can run time-of-day plans. As soon as new communications are available, the controllers on that channel should be upgraded to Ethernet-capable units and immediately operated from the Central Computer. Timing plans and database parameters should have been previously programmed and stored in the Central Database. Upon connection, the Central Computer should download the parameters to the upgraded controllers.

Operational Support and Warranty Period

With the entire system operating, the project should enter an Observation Period, typically 30 to 45 days. During this time, the Contractor must correct anything that malfunctions, at which time the Observation Period is restarted. After the Observation Period, the project moves toward "Final Acceptance."

Contract Documents should establish a strong warranty for two years to get the project through the start-up period and into the Maintenance Phase.

For computer equipment, the City should purchase a renewable On-Site Service Contract in the name of the City. Most vendors have several different options available.

Training

The System Specification, covering communications equipment and software, should require several training sessions. Training can be expensive; therefore, it is important that it be based on actual functions to be performed by the staff, as well as the deficiencies the staff may have in terms of the technical understanding of the system. Operator training should use the system documentation provided by the Contractor and should familiarize the City staff with all aspects of system operation. Maintenance training should be conducted prior to System Acceptance and should emphasize hands-on troubleshooting and the repair of central hardware and on-street communications equipment.

Coordination with the Media

Using the City's Director of Public Affairs or a Media Consultant, press releases should be made at the start of construction and periodically thereafter. Television coverage and interviews may be conducted with City personnel. As the Contractor submits a list of intersections to be changed over, that list with dates may be published in a local newspaper. Postings should be made to the City website. A completion announcement should be released.

8.4.7 Operations and Maintenance Plan

The City has for years been operating and maintaining the existing system and has proven very capable and dedicated to this task. It is expected that their dedication should continue. By approving this Implementation Plan, the City is expressing its commitment to operate and maintain the upgraded System aggressively and perpetually.

Evaluation

About six months after the System has been upgraded, the City (or a Consultant) should perform an evaluation of the System, including its features, operability and maintainability. Basically this would be a "How well did we do?" report. Changes could be made to the project before proceeding with other phases of the project.

Maintenance Plans

City personnel should perform maintenance procedures. As stated earlier, by using off-the-shelf computers and other devices, the maintenance and upkeep of the System becomes much easier. If something breaks, it is relatively easy to make a direct replacement. To expedite direct replacement, Contract Documents should require "system support equipment," which are basically spares of every type of device furnished for the System.

The Maintenance Program should encompass Field Maintenance and Central (TMC) Maintenance. For Field Maintenance the City has a program, a written policy and schedule for routine Preventative Maintenance (PM). Remedial Maintenance (RM) is the repair or replacement of a problem in a field device that is known but is not critical. The City should develop and update a priority list for Remedial Maintenance, with public safety as the most important consideration.

The last aspect of fieldwork is Emergency Maintenance (EM). The City keeps a list of on-call personnel with critical telephone and pager numbers. A list of 24-hour emergency numbers for utility companies is also available. Upon reaching the EM site, personnel have been instructed to secure the site by making it safe, perform interim repairs and log the activities.

The next aspect is Central (TMC) Maintenance for which the City should develop updated procedures. The same types of maintenance occur at the TMC; namely PM, RM and EM. The two primary areas to be emphasized are Facilities Maintenance (housekeeping) and Software Maintenance. Facilities Maintenance refers to the actual equipment in the room, such as computers, displays, test equipment, routers, switching gear, etc. It also involves keeping the room neat and clean. Software Maintenance will entail the communications network management and monitoring software, as well as the traffic control software and other software modules. The Contract Documents should contain provisions for upgrading the central software by the manufacturer.

8.4.8 Institutional Arrangements

Contact Persons and Liaisons

The Director of Public Works for the City of Sugar Land is Mike Hobbs, with Mike Leech as the Assistant Public Works Director. The primary project contact person is David Worley, Assistant Public Works Director – Traffic, 281/275-2450, e-mail dworley@sugarlandtx.gov. The contact for the System Operation is the Traffic Operations Manager, Chris Cameron, 281/275-2490, e-mail ccameron@sugarlandtx.gov.

Delineation of Organizational Responsibilities

The Project Engineer, who should be assigned by David Worley, should have the primary responsibility for this project. City Inspectors should be assigned from a pool of Department of Public Works personnel.

Provisions for Project Updates to Upper Management

The Contractor, and any Consultant selected by the City to assist in this effort, should provide monthly reports, summarizing recent activity. These may be distributed to Stakeholders or to City management. The Contractor should provide updates to the schedule.

Utility Arrangements

As far as economically feasible, utility locations should be shown on the Plans. Very little interference with existing utilities should occur, except for some communications conduit or overhead cables. A utility location service should be provided prior to any field installations.

Written Cooperative Agreements

Letters of Agreement should be created and promulgated to TxDOT and the City of Missouri City. As necessary, Memoranda of Agreement should be negotiated between the Public Works Department and other City agencies.

A Steering Committee of involved "stakeholders" was formed at the onset of the development of the ITS Operations Plan. Public hearings and presentations have been conducted. The intended project reflects the thoughts of the public and the Committee. If the City believes that continued public input is still important, it could reactivate this Steering Committee and continue the Public Involvement Process.

8.4.9 Personnel and Budget Resources

The recommended staffing for operations and maintenance of the advanced transportation management system and ITS components was discussed in detail in Chapter 7, Staffing Plan. In summary, it was recommended that the following staffing/personnel actions be implemented:

- Create and fill an Engineer II, Traffic System Technician /Construction Inspector, and two Traffic Technician II positions for system operations and enabling 7-day operation
- Cross train traffic system technician and traffic technicians as system operators
- Create and fill two Traffic Technician I positions for signs/markings due to annexation
- Create and fill an Engineer I and two Crew Chief positions
- Combine the functions of the Traffic Operations Supervisor with the Traffic System Operator position

Appendix

Appendix A – Definitions of the ITS Market Packages
Appendix B – ITS Architecture Glossary of Terms
Appendix C – Recommended Projects

Appendix A. Definitions of the ITS Market Packages

Network Surveillance (ATMS01)

This market package includes traffic detectors, other surveillance equipment, the supporting field equipment, and fixed-point to fixed-point communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.

Probe Surveillance (ATMS02)

This market package provides an alternative approach for surveillance of the roadway network. Two general implementation paths are supported by this market package: 1) wide-area wireless communications between the vehicle and Information Service Provider is used to communicate current vehicle location and status, and 2) dedicated short range communications between the vehicle and roadside is used to provide equivalent information directly to the Traffic Management Subsystem. The first approach leverages wide area communications equipment that may already be in the vehicle to support personal safety and advanced traveler information services. The second approach utilizes vehicle equipment that supports toll collection, in-vehicle signing, and other short range communications applications identified within the architecture. The market package enables traffic managers to monitor road conditions, identify incidents, analyze and reduce the collected data, and make it available to users and private information providers. It requires one of the communications options identified above, roadside beacons and fixed-point to fixed-point communications for the short range communications option, data reduction software, and utilizes fixed-point to fixed-point links between the Traffic Management Subsystem and Information Service Provider Subsystem to share the collected information. Both “Opt out” and “Opt in” strategies are available to ensure the user has the ability to turn off the probe functions to ensure individual privacy. Due to the large volume of data collected by probes, data reduction techniques are required, such as the ability to identify and filter out-of-bounds or extreme data reports.

Surface Street Control (ATMS03)

This market package provides the central control and monitoring equipment, communication links, and the signal control equipment that support local surface street control and/or arterial traffic management. A range of traffic signal control systems are represented by this market package ranging from fixed-schedule control systems to fully traffic responsive systems that

dynamically adjust control plans and strategies based on current traffic conditions and priority requests. Additionally, general advisory and traffic control information can be provided to the driver while en route. This market package is generally an intra-jurisdictional package that does not rely on real-time communications between separate control systems to achieve area-wide traffic signal coordination. Systems that achieve coordination across jurisdictions by using a common time base or other strategies that do not require real time coordination would be represented by this package. This market package is consistent with typical urban traffic signal control systems

Freeway Control (ATMS04)

This market package provides the communications and roadside equipment to support ramp control, lane controls, and interchange control for freeways. Coordination and integration of ramp meters are included as part of this market package. This package is consistent with typical urban traffic freeway control systems. This package incorporates the instrumentation included in the Network Surveillance Market Package to support freeway monitoring and adaptive strategies as an option.

This market package also includes the capability to utilize surveillance information for detection of incidents. Typically, the processing would be performed at a traffic management center; however, developments might allow for point detection with roadway equipment. For example, a CCTV might include the capability to detect an incident based upon image changes. Additionally, this market package allows general advisory and traffic control information to be provided to the driver while en-route.

HOV Lane Management (ATMS05)

This market package manages HOV lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals. Preferential treatment is given to HOV lanes using special bypasses, reserved lanes, and exclusive rights-of-way that may vary by time of day. Vehicle occupancy detectors may be installed to verify HOV compliance and to notify enforcement agencies of violations.

Traffic Information Dissemination (ATMS06)

This market package provides driver information using roadway equipment such as dynamic message signs or highway advisory radio. A wide range of information can be disseminated including traffic and road conditions, closure and detour information, incident information, and emergency alerts and driver advisories. This package provides information to drivers at specific equipped locations on the road network. Careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information. This package also covers the equipment and interfaces that provide traffic information from a traffic management center to the media (for instance via a direct tie-in between a traffic management center and radio or television station computer systems), Transit Management, Emergency Management, and Information Service Providers. A link to the Maintenance and Construction Management

subsystem allows real time information on road/bridge closures due to maintenance and construction activities to be disseminated.

Regional Traffic Control (ATMS07)

This market package provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy. This market package advances the Surface Street Control and Freeway Control Market Packages by adding the communications links and integrated control strategies that enable integrated interjurisdictional traffic control. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. This package relies principally on roadside instrumentation supported by the Surface Street Control and Freeway Control Market Packages and adds hardware, software, and fixed-point to fixed-point communications capabilities to implement traffic management strategies that are coordinated between allied traffic management centers. Several levels of coordination are supported from sharing of information through sharing of control between traffic management centers.

Traffic Incident Management System (ATMS08)

This market package manages both unexpected incidents and planned events so that the impact to the transportation network and traveler safety is minimized. The market package includes incident detection capabilities through roadside surveillance devices (e.g. CCTV) and through regional coordination with other traffic management, maintenance and construction management and emergency management centers as well as rail operations and event promoters. Information from these diverse sources is collected and correlated by this market package to detect and verify incidents and implement an appropriate response. This market package supports traffic operations personnel in developing an appropriate response in coordination with emergency management, maintenance and construction management, and other incident response personnel to confirmed incidents. The response may include traffic control strategy modifications or resource coordination between center subsystems. Incident response also includes presentation of information to affected travelers using the Traffic Information Dissemination market package and dissemination of incident information to travelers through the Broadcast Traveler Information or Interactive Traveler Information market packages. The roadside equipment used to detect and verify incidents also allows the operator to monitor incident status as the response unfolds. The coordination with emergency management might be through a CAD system or through other communication with emergency field personnel. The coordination can also extend to tow trucks and other allied response agencies and field service personnel.

Traffic Forecast and Demand Management (ATMS09)

This market package includes advanced algorithms, processing, and mass storage capabilities that support historical evaluation, real-time assessment, and forecast of the roadway network performance. This includes the prediction of travel demand patterns to support better link travel time forecasts. The source data would come from the Traffic Management Subsystem itself as well as other traffic management centers and forecasted traffic loads derived from route plans supplied by the Information Service Provider Subsystem. This market package provides data that supports the implementation of TDM programs, and policies managing

both traffic and the environment. The package collects information on vehicle pollution levels, parking availability, usage levels, and vehicle occupancy to support these functions. Demand management requests can also be made to Toll Administration, Transit Management, and Parking Management Subsystems.

Electronic Toll Collection (ATMS10)

This market package provides toll operators with the ability to collect tolls electronically and detect and process violations. The fees that are collected may be adjusted to implement demand management strategies. Dedicated short range communication between the roadway equipment and the vehicle is required as well as fixed-point to fixed-point interfaces between the toll collection equipment and transportation authorities and the financial infrastructure that supports fee collection. Vehicle tags of toll violators are read and electronically posted to vehicle owners. Standards, inter-agency coordination, and financial clearinghouse capabilities enable regional, and ultimately national interoperability for these services. Two other market packages, APTS4: Transit Passenger and Fare Management and ATMS16: Parking Facility Management also provide electronic payment services. These three market packages in combination provide an integrated electronic payment system for transportation services.

The toll tags and roadside readers that these systems utilize can also be used to collect road use statistics for highway authorities. This data can be collected as a natural by-product of the toll collection process or collected by separate readers that are dedicated to probe data collection.

Emissions Monitoring and Management (ATMS11)

This market package monitors individual vehicle emissions and provides general air quality monitoring using distributed sensors to collect the data. The collected information is transmitted to the emissions management subsystem for processing. Both area wide air quality monitoring and point emissions monitoring are supported by this market package. For area wide monitoring, this market package measures air quality, identifies sectors that are non-compliant with air quality standards, and collects, stores and reports supporting statistical data. For point emissions monitoring, this market package measures tail pipe emissions and identifies vehicles that exceed emissions standards. Summary emissions information or warnings can also be displayed to drivers. The gathered information can be used to implement environmentally sensitive TDM programs, policies, and regulations.

Virtual TMC and Smart Probe Data (ATMS12)

This market package provides for special requirements of rural road systems. Instead of a central TMC, the traffic management is distributed over a very wide area (e.g., a whole state or collection of states). Each locality has the capability of accessing available information for assessment of road conditions. The package uses vehicles as smart probes that are capable of measuring road conditions and providing this information to the roadway for relay to the Traffic Management Subsystem and potentially direct relay to following vehicles (i.e., the

automated road signing equipment is capable of autonomous operation). In-vehicle signing is used to inform drivers of detected road conditions.

Standard Railroad Grade Crossing (ATMS13)

This market package manages highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate more advanced features (e.g., where rail operational speeds are less than 80 miles per hour). Both passive (e.g., the crossbuck sign) and active warning systems (e.g., flashing lights and gates) are supported. (Note that passive systems exercise only the single interface between the roadway subsystem and the driver in the architecture definition.) These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Health monitoring of the HRI equipment and interfaces is performed; detected abnormalities are reported to both highway and railroad officials through wayside interfaces and interfaces to the traffic management subsystem.

Advanced Railroad Grade Crossing (ATMS14)

This market package manages highway traffic at highway-rail intersections (HRIs) where operational requirements demand advanced features (e.g., where rail operational speeds are greater than 80 miles per hour). This market package includes all capabilities from the Standard Railroad Grade Crossing Market Package and augments these with additional safety features to mitigate the risks associated with higher rail speeds. The active warning systems supported by this market package include positive barrier systems that preclude entrance into the intersection when the barriers are activated. Like the Standard Package, the HRI equipment is activated on notification by wayside interface equipment which detects, or communicates with the approaching train. In this market package, the wayside equipment provides additional information about the arriving train so that the train's direction of travel, estimated time of arrival, and estimated duration of closure may be derived. This enhanced information may be conveyed to the driver prior to, or in context with, warning system activation. This market package also includes additional detection capabilities that enable it to detect an entrapped or otherwise immobilized vehicle within the HRI and provide an immediate notification to highway and railroad officials.

Railroad Operations Coordination (ATMS15)

This market package provides an additional level of strategic coordination between freight rail operations and traffic management centers. Rail operations provides train schedules, maintenance schedules, and any other forecast events that will result in highway-rail intersection (HRI) closures. This information is used to develop forecast HRI closure times and durations that may be used in advanced traffic control strategies or to enhance the quality of traveler information.

Parking Facility Management (ATMS16)

This market package provides enhanced monitoring and management of parking facilities. It assists in the management of parking operations, coordinates with transportation authorities, and supports electronic collection of parking fees. This market package collects current parking status, shares this data with Information Service Providers and Traffic Management, and collects parking fees using the same in-vehicle equipment utilized for electronic toll collection or contact or proximity traveler cards used for electronic payment. Two other market packages, APTS4: Transit Passenger and Fare Management and ATMS10: Electronic Toll Collection also provide electronic payment services. These three market packages in combination provide an integrated electronic payment system for transportation services.

Regional Parking Management (ATMS17)

This market package supports coordination between parking facilities to enable regional parking management strategies.

Reversible Lane Management (ATMS18)

This market package provides for the management of reversible lane facilities. In addition to standard surveillance capabilities, this market package includes sensory functions that detect wrong-way vehicles and other special surveillance capabilities that mitigate safety hazards associated with reversible lanes. The package includes the field equipment, physical lane access controls, and associated control electronics that manage and control these special lanes. This market package also includes the equipment used to electronically reconfigure intersections and manage right-of-way to address dynamic demand changes and special events.

Speed Monitoring (ATMS19)

This market package monitors the speeds of vehicles traveling through a roadway system. If the speed is determine 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.

Drawbridge Management (ATMS20)

This market package supports systems that manage drawbridges at rivers and canals and other multimodal crossings (other than railroad grade crossings which are specifically covered by other market packages). The equipment managed by this market package includes control devices (e.g., gates, warning lights, dynamic message signs) at the drawbridge as well as the information systems that are used to keep travelers apprised of current and forecasted drawbridge status.

Roadway Closure Management (ATMS21)

This market package closes roadways to vehicular traffic when driving conditions are unsafe, maintenance must be performed, and other scenarios where access to the roadway must be prohibited. The market package includes automatic or remotely controlled gates or barriers that control access to roadway segments including ramps and traffic lanes. Remote control systems allow the gates to be controlled from a central location, improving system efficiency and reducing personnel exposure to unsafe conditions during severe weather and other situations where roads must be closed. Surveillance systems allow operating personnel to visually verify the safe activation of the closure system and driver information systems (e.g., DMS) provide closure information to motorists in the vicinity of the closure. The equipment managed by this market package includes the control and monitoring systems, the field devices (e.g., gates, warning lights, DMS, CCTV cameras) at the closure location(s), and the information systems that notify other systems of a closure. This market package covers general road closure applications; specific closure systems that are used at railroad grade crossings, drawbridges, reversible lanes, etc. are covered by other ATMS market packages.

Transit Vehicle Tracking (APTS1)

This market package monitors current transit vehicle location using an Automated Vehicle Location System. The location data may be used to determine real time schedule adherence and update the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the Transit Management Subsystem is used for relaying vehicle position and control measures. Fixed route transit systems may also employ beacons along the route to enable position determination and facilitate communications with each vehicle at fixed intervals. The Transit Management Subsystem processes this information, updates the transit schedule and makes real-time schedule information available to the Information Service Provider.

Transit Fixed-Route Operations (APTS2)

This market package performs vehicle routing and scheduling, as well as automatic operator assignment and system monitoring for fixed-route and flexible-route transit services. This service determines current schedule performance using AVL data and provides information displays at the Transit Management Subsystem. Static and real time transit data is exchanged with Information Service Providers where it is integrated with that from other transportation modes (e.g. rail, ferry, air) to provide the public with integrated and personalized dynamic schedules.

Demand Response Transit Operations (APTS3)

This market package performs vehicle routing and scheduling as well as automatic operator assignment and monitoring for demand responsive transit services. In addition, this market package performs similar functions to support dynamic features of flexible-route transit services. This package monitors the current status of the transit fleet and supports allocation of these fleet resources to service incoming requests for transit service while also considering traffic conditions. The Transit Management Subsystem provides the necessary data processing and information display to assist the transit operator in making optimal use of the

transit fleet. This service includes the capability for a traveler request for personalized transit services to be made through the Information Service Provider (ISP) Subsystem. The ISP may either be operated by a transit management center or be independently owned and operated by a separate service provider. In the first scenario, the traveler makes a direct request to a specific paratransit service. In the second scenario, a third party service provider determines that the paratransit service is a viable means of satisfying a traveler request and makes a reservation for the traveler.

Transit Passenger and Fare Management (APTS4)

This market package manages passenger loading and fare payments on-board transit vehicles using electronic means. It allows transit users to use a traveler card or other electronic payment device. Sensors mounted on the vehicle permit the operator and central operations to determine vehicle loads, and readers located either in the infrastructure or on-board the transit vehicle allow electronic fare payment. Data is processed, stored, and displayed on the transit vehicle and communicated as needed to the Transit Management Subsystem. Two other market packages, ATMS10: Electronic Toll Collection and ATMS16: Parking Facility Management also provide electronic payment services. These three market packages in combination provide an integrated electronic payment system for transportation services.

Transit Security (APTS5)

This market package provides for the physical security of transit passengers and transit vehicle operators. On-board equipment is deployed to perform surveillance and sensor monitoring in order to warn of potentially hazardous situations. The surveillance equipment includes video (e.g., CCTV cameras), audio systems and/or event recorder systems. The sensor equipment includes threat sensors (e.g., chemical agent, toxic industrial chemical, biological, explosives, and radiological sensors) and object detection sensors (e.g., metal detectors). Transit user or transit vehicle operator activated alarms are provided on-board. Public areas (e.g., transit stops, park and ride lots, stations) are also monitored with similar surveillance and sensor equipment and provided with transit user activated alarms. In addition this market package provides surveillance and sensor monitoring of non-public areas of transit facilities (e.g., transit yards) and transit infrastructure such as bridges, tunnels, and transit railways or bus rapid transit (BRT) guideways. The surveillance equipment includes video and/or audio systems. The sensor equipment includes threat sensors and object detection sensors as described above as well as, intrusion or motion detection sensors and infrastructure integrity monitoring (e.g., rail track continuity checking or bridge structural integrity monitoring).

The surveillance and sensor information is transmitted to the Emergency Management Subsystem, as are transit user activated alarms in public secure areas. On-board alarms, activated by transit users or transit vehicle operators are transmitted to both the Emergency Management Subsystem and the Transit Management Subsystem, indicating two possible approaches to implementing this market package.

In addition the market package supports remote transit vehicle disabling by the Transit Management Subsystem and transit

Transit Maintenance (APTS6)

This market package supports automatic transit maintenance scheduling and monitoring. On-board condition sensors monitor system status and transmit critical status information to the Transit Management Subsystem. Hardware and software in the Transit Management Subsystem processes this data and schedules preventative and corrective maintenance.

Multi-modal Coordination (APTS7)

This market package establishes two way communications between multiple transit and traffic agencies to improve service coordination. Multimodal coordination between transit agencies can increase traveler convenience at transit transfer points and clusters (a collection of stops, stations, or terminals where transfers can be made conveniently) and also improve operating efficiency. Transit transfer information is shared between Multimodal Transportation Service Providers, Transit Agencies, and ISPs. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network. More limited local coordination between the transit vehicle and the individual intersection for signal priority is also supported by this package.

Transit Traveler Information (APTS8)

This market package provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services include transit stop annunciation, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this market package.

Broadcast Traveler Information (ATIS1)

This market package 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 and low cost user equipment (e.g., FM subcarrier, cellular data broadcast). The information may be provided directly to travelers or provided to merchants and other traveler service providers so that they can better inform their customers of travel conditions. Different from the market package ATMS6 - Traffic Information Dissemination, which provides localized HAR and DMS information capabilities, ATIS1 provides a wide area digital broadcast service. Successful deployment of this market package relies on availability of real-time traveler information from roadway instrumentation, probe vehicles or other sources.

Interactive Traveler Information (ATIS2)

This market package 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. A range of two-way wide-area wireless and fixed-point to fixed-point communications systems may be used to support the required data communications between the traveler and Information Service Provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en route including phone via a 511-like portal, kiosk, Personal Digital Assistant, personal computer, and a variety of in-vehicle devices. This market package also allows value-added resellers to collect transportation information that can be aggregated and be available to their personal devices or remote traveler systems to better inform their customers of transportation conditions. Successful deployment of this market package relies on availability of real-time transportation data from roadway instrumentation, transit, probe vehicles or other means. A traveler may also input personal preferences and identification information via a "traveler card" that can convey information to the system about the traveler as well as receive updates from the system so the card can be updated over time.

Autonomous Route Guidance (ATIS3)

This market package relies on in-vehicle sensory, location determination, computational, map database, and interactive driver interface equipment to enable route planning and detailed route guidance based on static, stored information. No communication with the infrastructure is assumed or required. Identical capabilities are available to the traveler outside the vehicle by integrating a similar suite of equipment into portable devices.

Dynamic Route Guidance (ATIS4)

This market package offers advanced route planning and guidance that is responsive to current conditions. The package combines the autonomous route guidance user equipment with a digital receiver capable of receiving real-time traffic, transit, and road condition information, which is considered by the user equipment in provision of route guidance.

ISP-Based Route Guidance (ATIS5)

This market package offers the user pre-trip route planning and turn-by-turn route guidance services. Routes may be based on static information or reflect real time network conditions. Unlike ATIS3 and ATIS4, where the user equipment determines the route, the route determination functions are performed in the Information Service Provider Subsystem in this market package. This approach simplifies the user equipment requirements and can provide the infrastructure better information on which to predict future traffic. The package includes two way data communications and optionally also equips the vehicle with the databases, location determination capability, and display technology to support turn by turn route guidance.

Integrated Transportation Management/Route Guidance (ATIS6)

This market package provides advanced route planning and guidance which is responsive to current conditions, and supports collection of near-real time information on intended routes for a proportion of the vehicles in the network. This comprehensive road network probe

information can be used by the Traffic Management Subsystem to optimize the traffic control strategy based on anticipated vehicle routes. The Traffic Management Subsystem would utilize the individual and ISP route planning information to optimize signal timing while at the same time providing updated signal timing information to allow optimized route plans. The predictive link times used by this market package are provided by the market package ATMS9--Traffic Forecast and Demand Management--at the traffic management center.

Yellow Pages and Reservation (ATIS7)

This market package provides yellow pages and reservation services to the user. These additional traveler services may be provided using the same basic user equipment used for Interactive Traveler Information. This market package provides multiple ways for accessing information either while en route in a vehicle using wide-area wireless communications or pre-trip via fixed-point to fixed-point connections.

Dynamic Ridesharing (ATIS8)

This market package provides dynamic ridesharing/ride matching services to travelers. This service could allow near real time ridesharing reservations to be made through the same basic user equipment used for Interactive Traveler Information. This ridesharing/ride matching capability also includes arranging connections to transit or other multimodal services.

In Vehicle Signing (ATIS9)

This market package supports distribution of traffic and travel advisory information to drivers through in-vehicle devices. It includes short range communications between roadside equipment and the vehicle and wireline connections to the Traffic Management Subsystem for coordination and control. This market package also informs the driver of both highway-highway and highway-rail intersection status.

Vehicle Safety Monitoring (AVSS01)

This market package will diagnose critical components of the vehicle and warn the driver of potential dangers. On-board sensors will determine the vehicle's condition, performance, on-board safety data, and display information.

Driver Safety Monitoring (AVSS02)

This market package will determine the driver's condition, and warn the driver of potential dangers. On-board sensors will determine the driver's condition, performance, on-board safety data, and display information.

Longitudinal Safety Warning (AVSS03)

This market package allows for longitudinal warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas in front of and behind the vehicle and present warnings to the driver about potential hazards.

Lateral Safety Warning (AVSS04)

This market package allows for lateral warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas to the sides of the vehicle and present warnings to the driver about potential hazards.

Intersection Safety Warning (AVSS05)

This market package will determine the probability of a collision in an equipped intersection (either highway-highway or highway-rail) and provide timely warnings to drivers in response to hazardous conditions. Monitors in the roadway infrastructure assess vehicle locations and speeds near an intersection. Using this information, a warning is determined and communicated to the approaching vehicle using a short range communications system. Information can be provided to the driver through the market package ATIS9--In-Vehicle Signing.

Pre-Crash Restraint Deployment (AVSS06)

This market package provides in-vehicle sensors to monitor the vehicle's local environment, determine collision probability and deploy a pre-crash safety system. It will include on-board sensors to measure lateral and longitudinal gaps and together with weather and roadway conditions will determine lateral and longitudinal collision probability. It will have the mechanism to deploy a pre-crash safety system.

Driver Visibility Improvement (AVSS07)

This market package will enhance driver visibility using an enhanced vision system. On-board display hardware is needed.

Advanced Vehicle Longitudinal Control (AVSS08)

This market package automates the speed and headway control functions on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the throttle and brakes. It requires on-board sensors to measure longitudinal gaps and a processor for controlling the vehicle speed.

Advanced Vehicle Lateral Control (AVSS09)

This market package automates the steering control on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the steering. It requires on-board sensors to measure lane position and lateral deviations and a processor for controlling the vehicle steering.

Intersection Collision Avoidance (AVSS10)

This market package will determine the probability of an intersection collision and provide timely warnings to approaching vehicles so that avoidance actions can be taken. This market package builds on the Intersection Collision Warning infrastructure and in-vehicle equipment and adds equipment in the vehicle that can take control of the vehicle in emergency situations. The same monitors in the roadway infrastructure are needed to assess vehicle locations and speeds near an intersection. This information is determined and communicated to the approaching vehicle using a short range communications system. The vehicle uses this information to develop control actions which alter the vehicle's speed and steering control and potentially activate its pre-crash safety system.

Automated Highway System (AVSS11)

This market package enables "hands-off" operation of the vehicle on the automated portion of the highway system. Implementation requires lateral lane holding, vehicle speed and steering control, and Automated Highway System check-in and checkout. This market package currently supports a balance in intelligence allocation between infrastructure and the vehicle pending selection of a single operational concept by the AHS consortium.

Fleet Administration (CVO01)

This market package provides the capabilities to manage a fleet of commercial vehicles. The Fleet and Freight Management subsystem provides the route for a commercial vehicle by either utilizing an in-house routing software package or an Information Service Provider. Routes generated by either approach are constrained by hazardous materials and other restrictions (such as height or weight). Any such restricted areas are determined by the Commercial Vehicle Administration. A route would be electronically sent to the Commercial Vehicle with any appropriate dispatch instructions. The location of the Commercial Vehicle can be monitored by the Fleet and Freight Management subsystem and routing changes can be made depending on current road network conditions. Once a route has been assigned, changes must be coordinated between the Fleet and Freight Management subsystem and the Commercial Vehicle. Commercial Vehicle Drivers would be alerted to any changes in route from the planned route and given an opportunity to justify a rerouting. Any unauthorized or unexpected route changes by the Commercial Vehicle will register a route deviation alert with the Fleet and Freight Management subsystem. The Fleet and Freight Management subsystem can also notify local public safety agencies of the route deviation when appropriate (e.g., if there is safety sensitive HAZMAT being carried), by sending an alarm to the Emergency Management subsystem.

Freight Administration (CVO02) This market package tracks the movement of cargo and monitors the cargo condition. Interconnections are provided to intermodal freight shippers and intermodal freight depots for tracking of cargo from source to destination. In addition to the usual cargo monitoring required to insure that cargo gets from origin to destination, the Fleet and Freight Management subsystem monitors shipments to make sure that no tampering or breach of security occurs to the cargo on commercial vehicles. Any such

tampering will be reported to the Fleet and Freight Management subsystem. In addition to exceptions (e.g., alerts) that are reported, on-going indications of the state of the various freight equipment are reported to the Fleet and Freight Management subsystem. The commercial vehicle driver is also alerted of any tampering or breach of cargo security. Freight managers may decide to take further action on the alerts and/or provide responses that explain that the alerts are false alarms. If no explanation is received, the Fleet and Freight Management subsystem may notify the Emergency Management subsystem.

Electronic Clearance (CVO03)

This market package provides for automated clearance at roadside check facilities. The roadside check facility communicates with the Commercial Vehicle Administration subsystem to retrieve infrastructure snapshots of critical carrier, vehicle, and driver data to be used to sort passing vehicles. This allows a good driver/vehicle/carrier to pass roadside facilities at highway speeds using transponders and dedicated short range communications to the roadside. Results of roadside clearance activities will be passed on to the Commercial Vehicle Administration. The roadside check facility may be equipped with Automated Vehicle Identification (AVI), weighing sensors, transponder read/write devices and computer workstations.

CV Administrative Processes (CVO04)

This market package provides for electronic application, processing, fee collection, issuance, and distribution of CVO credential and tax filing. Through this process, carriers, drivers, and vehicles may be enrolled in the electronic clearance program provided by a separate market package which allows commercial vehicles to be screened at mainline speeds at roadside check facilities. Through this enrollment process, current profile databases are maintained in the Commercial Vehicle Administration subsystem and snapshots of this database are made available to the roadside check facilities at the roadside to support the electronic clearance process.

Commercial Vehicle Administration subsystems can share credential information with other Commercial Vehicle Administration subsystems, so that it is possible for any Commercial Vehicle Administration subsystem to have access to all credentials, credential fees, credentials status and safety status information. In addition, it is possible for one Commercial Vehicle Administration subsystem to collect HAZMAT route restrictions information from other Commercial Vehicle Administration subsystems and then act as a clearinghouse for this route restrictions information for Information Service Providers, Map Update Providers, and Fleet and Freight Management subsystems.

International Border Electronic Clearance (CVO05)

This market package provides for automated clearance at international border crossings. This package augments the electronic clearance package by allowing interface with customs related functions.

Weigh-In-Motion (CVO06)

This market package provides for high speed weigh-in-motion with or without Automated Vehicle Identification (AVI) capabilities. This market package provides the roadside equipment that could be used as a stand-alone system or to augment the Electronic Clearance (CVO03) market package.

Roadside CVO Safety (CVO07)

This market package provides for automated roadside safety monitoring and reporting. It automates commercial vehicle safety inspections at the roadside check facilities. The capabilities for performing the safety inspection are shared between this market package and the On-board CVO and Freight Safety & Security (CVO08) Market Package which enables a variety of implementation options. The basic option, directly supported by this market package, facilitates safety inspection of vehicles that have been pulled in, perhaps as a result of the automated screening process provided by the Electronic Clearance (CVO03) Market Package. In this scenario, only basic identification data and status information is read from the electronic tag on the commercial vehicle. The identification data from the tag enables access to additional safety data maintained in the infrastructure which is used to support the safety inspection, and may also inform the pull-in decision if system timing requirements can be met. More advanced implementations, supported by the On-board CVO and Freight Safety & Security (CVO08) market package, utilize additional on-board vehicle safety monitoring and reporting capabilities in the commercial vehicle to augment the roadside safety check.

On-board CVO and Freight Safety & Security (CVO08)

This market package provides for on-board commercial vehicle safety monitoring and reporting. It is an enhancement of the Roadside CVO Safety Market Package and includes roadside support for reading on-board safety data via tags. Safety warnings are provided to the driver as a priority with secondary requirements to notify the Commercial Vehicle Check roadside elements. This market package allows for the Fleet and Freight Management subsystem to have access to the on-board safety data. In addition to safety data, this market package provides a means for monitoring the security of the Commercial Vehicle along with the cargo, containers, trailers, and other equipment that are being hauled. Commercial Vehicle on-board tamper and breach sensors provide an indication of any security irregularities and the sensor data is provided to the Fleet and Freight Management subsystem along with particular notification of any breach alerts. Commercial Vehicle Drivers may be aware of the sensor readings and can provide an explanation back to the Fleet and Freight Management subsystem via the Commercial Vehicle. Commercial vehicle and freight security breaches are also sent to the commercial vehicle check.

CVO Fleet Maintenance (CVO09)

This market package supports maintenance of CVO fleet vehicles with on-board monitoring equipment and Automated Vehicle Location (AVL) capabilities within the Fleet and Freight Management Subsystem. Records of vehicle mileage, repairs, and safety violations are maintained to assure safe vehicles on the highway.

HAZMAT Management (CVO10)

This market package integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents. HAZMAT tracking is performed by the Fleet and Freight Management Subsystem. The Emergency Management subsystem is notified by the Commercial Vehicle if an incident occurs and coordinates the response. The response is tailored based on information that is provided as part of the original incident notification or derived from supplemental information provided by the Fleet and Freight Management Subsystem. The latter information can be provided prior to the beginning of the trip or gathered following the incident depending on the selected policy and implementation.

Roadside HAZMAT Security Detection and Mitigation (CVO11)

This market package provides the capability to detect and classify security sensitive HAZMAT on commercial vehicles using roadside sensing and imaging technology. Credentials information can be accessed to verify if the commercial driver, vehicle and carrier are permitted to transport the identified HAZMAT. If the credentials analysis and sensed HAZMAT information do not agree, the vehicle can be signaled to pull in, and if required, an alarm can be sent to Emergency Management to request they monitor, traffic stop or disable the vehicle.

CV Driver Security Authentication (CVO12)

This market package provides the ability for Fleet and Freight Management to detect when an unauthorized commercial vehicle driver attempts to drive their vehicle based on stored driver identity information. If an unauthorized driver has been detected, Fleet and Freight Management can activate commands to safely disable the commercial vehicle. Alarms can also be sent to emergency management to inform them of a potential commercial vehicle hijacking or theft and potential hazardous situation. In addition, Emergency Management can request Fleet and Freight Management to disable a specific vehicle in their fleet.

Freight Assignment Tracking (CVO13)

This market package provides for the planning and tracking of three aspects of commercial vehicle shipments. For each shipment, the commercial vehicle, the freight equipment, and the commercial vehicle driver are monitored for consistency with the planned assignment. Any unauthorized changes are determined by the Fleet and Freight Management subsystem and then the appropriate people and subsystems are notified. Data collected by the On-board CV and Freight Safety & Security and the On-board Driver Authentication equipment packages used in other market packages are also used to monitor the three aspects of assignment for this market package. In addition to this market package, Fleet and Freight Managers may also monitor routes and itineraries and this capability is included in Fleet Administration.

Emergency Call-Taking and Dispatch (EM01)

This market package provides basic public safety call-taking and dispatch services. It includes emergency vehicle equipment, equipment used to receive and route emergency calls, and wireless communications that enable safe and rapid deployment of appropriate resources to an emergency. Coordination between Emergency Management Subsystems supports emergency notification between agencies. Wide area wireless communications between the Emergency Management Subsystem and an Emergency Vehicle supports dispatch and provision of information to responding personnel.

Emergency Routing (EM02)

This market package supports automated vehicle location and dynamic routing of emergency vehicles. Traffic information, road conditions, and suggested routing information are provided to enhance emergency vehicle routing. Special priority or other specific emergency traffic control strategies can be coordinated to improve the safety and time-efficiency of responding vehicle travel on the selected route(s). The Emergency Management Subsystem provides the routing for the emergency fleet based on real-time conditions and has the option of requesting a route from the Traffic Management subsystem. The Emergency Vehicle may also be equipped with dedicated short range communications for local signal preemption. The service provides for information exchange between care facilities and both the Emergency Management Subsystem and emergency vehicles.

Mayday Support (EM03)

This market package allows the user (driver or non-driver) 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. The request for assistance may be manually initiated or automated and linked to vehicle sensors. This market package also includes general surveillance capabilities that enable the Emergency Management Subsystem to remotely monitor public areas (e.g., rest stops, parking lots) to improve security in these areas. The Emergency Management Subsystem may be operated by the public sector or by a private sector telematics service provider.

Roadway Service Patrols (EM04)

This market package supports roadway service patrol vehicles that monitor roads that aid motorists, offering rapid response to minor incidents (flat tire, accidents, out of gas) to minimize disruption to the traffic stream. If problems are detected, the roadway service patrol vehicles will provide assistance to the motorist (e.g., push a vehicle to the shoulder or median). The market package monitors service patrol vehicle locations and supports vehicle dispatch to identified incident locations. Incident information collected by the service patrol is shared with traffic, maintenance and construction, and traveler information systems.

Transportation Infrastructure Protection (EM05)

This market package includes the monitoring of transportation infrastructure (e.g., bridges, tunnels and management centers) for potential threats using sensors and surveillance

equipment and barrier and safeguard systems to preclude an incident, control access during and after an incident or mitigate impact of an incident. Threats can result from acts of nature (e.g., hurricanes, earthquakes), terrorist attacks or other incidents causing damage to the infrastructure (e.g., stray barge hitting a bridge support). Infrastructure may be monitored with acoustic, environmental threat (such as nuclear, biological, chemical, and explosives), infrastructure condition and integrity, motion and object sensors and video and audio surveillance equipment. Data from such sensors and surveillance equipment may be processed in the field or sent to a center for processing. The data enables operators at the center to detect and verify threats. When a threat is detected, agencies are notified. Detected threats or advisories received from other agencies result in an increased level of system preparedness. In response to threats, barrier and safeguard systems may be activated by Traffic Management Subsystems to deter an incident, control access to an area or mitigate the impact of an incident. Barrier systems include gates, barriers and other automated and remotely controlled systems that manage entry to transportation infrastructure. Safeguard systems include blast shields, exhaust systems and other automated and remotely controlled systems that mitigate impact of an incident.

Wide-Area Alert (EM06)

This market package uses ITS driver and traveler information systems to alert the public in emergency situations such as child abductions, severe weather events, civil emergencies, and other situations that pose a threat to life and property. The alert includes information and instructions for transportation system operators and the traveling public, improving public safety and enlisting the public's help in some scenarios. The ITS technologies will supplement and support other emergency and homeland security alert systems such as the Emergency Alert System (EAS). When an emergency situation is reported and verified and the terms and conditions for system activation are satisfied, a designated agency broadcasts emergency information to traffic agencies, transit agencies, information service providers, toll operators, and others that operate ITS systems. The ITS systems, in turn, provide the alert information to transportation system operators and the traveling public using ITS technologies such as dynamic message signs, highway advisory radios, in-vehicle displays, transit displays, 511 traveler information systems, and traveler information web sites.

Early Warning System (EM07)

This market package 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). The market package monitors alerting and advisory systems, ITS sensors and surveillance systems, field reports, and emergency call-taking systems to identify emergencies and notifies all responding agencies of detected emergencies.

Disaster Response and Recovery (EM08)

This market package 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. All types of disasters are

addressed including natural disasters (hurricanes, earthquakes, floods, winter storms, tsunamis, etc.) and technological and man-made disasters (hazardous materials incidents, nuclear power plant accidents, and national security emergencies such as nuclear, chemical, biological, and radiological weapons attacks).

The market package supports coordination of emergency response plans, including general plans developed before a disaster as well as specific tactical plans with short time horizon that are developed as part of a disaster response. The market package provides enhanced access to the scene for response personnel and resources, provides better information about the transportation system in the vicinity of the disaster, and maintains situation awareness regarding the disaster itself. In addition, this market package tracks and coordinates the transportation resources - the transportation professionals, equipment, and materials - that constitute a portion of the disaster response.

The market package identifies the key points of integration between transportation systems and the public safety, emergency management, and other allied organizations that form the overall disaster response. In this market package, the Emergency Management subsystem represents the federal, regional, state, and local Emergency Operations Centers and the Incident Commands that are established to respond to the disaster. The interface between the Emergency Management Subsystem and the other center subsystems provides situation awareness and resource coordination among transportation and other allied response agencies. In its role, traffic management implements special traffic control strategies and detours and restrictions to effectively manage traffic in and around the disaster. Maintenance and construction provides damage assessment of road network facilities and manages service restoration. Transit management provides a similar assessment of status for transit facilities and modifies transit operations to meet the special demands of the disaster. As immediate public safety concerns are addressed and disaster response transitions into recovery, this market package supports transition back to normal transportation system operation, recovering resources, managing on-going transportation facility repair, supporting data collection and revised plan coordination, and other recovery activities.

This market package builds on the basic traffic incident response service that is provided by ATMS08, the Traffic Incident Management market package. This market package addresses the additional complexities and coordination requirements that are associated with the most severe incidents that warrant an extraordinary response from outside the local jurisdictions and require special measures such as the activation of one or more emergency operations centers. Many users of the National ITS Architecture will want to consider both ATMS08 and this market package since every region is concerned with both day-to-day management of traffic-related incidents and occasional management of disasters that require extraordinary response.

Disaster Response and Recovery is also supported by EM10, the "Disaster Traveler Information" market package that keeps the public informed during a disaster response. See that market package for more information.

Evacuation and Reentry Management (EM09)

This market package supports evacuation of the general public from a disaster area and manages subsequent reentry to the disaster area. The market package addresses evacuations for all types of disasters, including disasters like hurricanes that are anticipated and occur slowly, allowing a well-planned orderly evacuation, as well as disasters like terrorist acts that occur rapidly, without warning, and allow little or no time for preparation or public warning.

This market package supports coordination of evacuation plans among the federal, state, and local transportation, emergency, and law enforcement agencies that may be involved in a large-scale evacuation. All affected jurisdictions (e.g., states and counties) at the evacuation origin, evacuation destination, and along the evacuation route are informed of the plan. Information is shared with traffic management agencies to implement special traffic control strategies and to control evacuation traffic, including traffic on local streets and arterials as well as the major evacuation routes. Reversible lanes, shoulder use, closures, special signal control strategies, and other special strategies may be implemented to maximize capacity along the evacuation routes. Transit resources play an important role in an evacuation, removing many people from an evacuated area while making efficient use of limited capacity. Additional shared transit resources may be added and managed in evacuation scenarios. Resource requirements are forecast based on the evacuation plans, and the necessary resources are located, shared between agencies if necessary, and deployed at the right locations at the appropriate times.

Evacuations are also supported by EM10, the "Disaster Traveler Information" market package, which keeps the public informed during evacuations. See that market package for more information.

Disaster Traveler Information (EM10)

This market package 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. This market package collects information from multiple sources including traffic, transit, public safety, emergency management, shelter provider, and travel service provider organizations. The collected information is processed and the public is provided with real-time disaster and evacuation information using ITS traveler information systems.

A disaster will stress the surface transportation system since it may damage transportation facilities at the same time that it places unique demands on these facilities to support public evacuation and provide access for emergency responders. Similarly, a disaster may interrupt or degrade the operation of many traveler information systems at the same time that safety-critical information must be provided to the traveling public. This market package keeps the public informed in these scenarios, using all available means to provide information about the disaster area including damage to the transportation system, detours and closures in effect, special traffic restrictions and allowances, special transit schedules, and real-time information on traffic conditions and transit system performance in and around the disaster.

This market package also provides emergency information to assist the public with evacuations when necessary. Information on mandatory and voluntary evacuation zones, evacuation times, and instructions are provided. Available evacuation routes and destinations and current and anticipated travel conditions along those routes are provided so evacuees are prepared and know their destination and preferred evacuation route. Information on available transit services and traveler services (shelters, medical services, hotels, restaurants, gas stations, etc.) is also provided. In addition to general evacuation information, this market package provides specific evacuation trip planning information that is tailored for the evacuee based on origin, selected destination, and evacuee-specified evacuation requirements and route parameters.

This market package augments the ATIS market packages that provide traveler information on a day-to-day basis for the surface transportation system. This market package provides focus on the special requirements for traveler information dissemination in disaster situations.

ITS Data Mart (AD1)

This market package provides a focused archive that houses data collected and owned by a single agency, district, private sector provider, research institution, or other organization. This focused archive typically includes data covering a single transportation mode and one jurisdiction that is collected from an operational data store and archived for future use. It provides the basic data quality, data privacy, and meta data management common to all ITS archives and provides general query and report access to archive data users.

ITS Data Warehouse (AD2)

This market package includes all the data collection and management capabilities provided by the ITS Data Mart, and adds the functionality and interface definitions that allow collection of data from multiple agencies and data sources spanning across modal and jurisdictional boundaries. It performs the additional transformations and provides the additional meta data management features that are necessary so that all this data can be managed in a single repository with consistent formats. The potential for large volumes of varied data suggests additional on-line analysis and data mining features that are also included in this market package in addition to the basic query and reporting user access features offered by the ITS Data Mart.

ITS Virtual Data Warehouse (AD3)

This market package provides the same broad access to multimodal, multidimensional data from varied data sources as in the ITS Data Warehouse Market Package, but provides this access using enhanced interoperability between physically distributed ITS archives that are each locally managed. Requests for data that are satisfied by access to a single repository in the ITS Data Warehouse Market Package are parsed by the local archive and dynamically translated to requests to remote archives which relay the data necessary to satisfy the request.

Maintenance and Construction Vehicle and Equipment Tracking (MCO1)

This market package will track the location of maintenance and construction vehicles and other equipment to ascertain the progress of their activities. These activities can include ensuring the correct roads are being plowed and work activity is being performed at the correct locations.

Maintenance and Construction Vehicle Maintenance (MCO2)

This market package performs vehicle maintenance scheduling and manages both routine and corrective maintenance activities on vehicles and other maintenance and construction equipment. It includes on-board sensors capable of automatically performing diagnostics for maintenance and construction vehicles, and the systems that collect this diagnostic information and use it to schedule and manage vehicle maintenance.

Road Weather Data Collection (MCO3)

This market package collects current road and weather conditions using data collected from environmental sensors deployed on and about the roadway (or guideway in the case of transit related rail systems). In addition to fixed sensor stations at the roadside, sensing of the roadway environment can also occur from sensor systems located on Maintenance and Construction Vehicles and on-board sensors provided by auto manufacturers. The collected environmental data is used by the Weather Information Processing and Distribution Market Package to process the information and make decisions on operations.

Weather Information Processing and Distribution (MCO4)

This market package processes and distributes the environmental information collected from the Road Weather Data Collection market package. This market package uses the environmental data to detect environmental hazards such as icy road conditions, high winds, dense fog, etc. so system operators and decision support systems can make decision on corrective actions to take. The continuing updates of road condition information and current temperatures can be used by system operators to more effectively deploy road maintenance resources, issue general traveler advisories, issue location specific warnings to drivers using the Traffic Information Dissemination market package, and aid operators in scheduling work activity.

Roadway Automated Treatment (MCO5)

This market package automatically treats a roadway section based on environmental or atmospheric conditions. Treatments include fog dispersion, anti-icing chemicals, etc. The market package includes the environmental sensors that detect adverse conditions, the automated treatment system itself, and driver information systems (e.g., dynamic message signs) that warn drivers when the treatment system is activated.

Winter Maintenance (MCO6)

This market package supports winter road maintenance including snow plow operations, roadway treatments (e.g., salt spraying and other anti-icing material applications), and other snow and ice control activities. This package monitors environmental conditions and weather forecasts and uses the information to schedule winter maintenance activities, determine the appropriate snow and ice control response, and track and manage response operations.

Roadway Maintenance and Construction (MCO7)

This market package supports numerous services for scheduled and unscheduled maintenance and construction on a roadway system or right-of-way. Maintenance services would include landscape maintenance, hazard removal (roadway debris, dead animals), routine maintenance activities (roadway cleaning, grass cutting), and repair and maintenance of both ITS and non-ITS equipment on the roadway (e.g., signs, traffic controllers, traffic detectors, dynamic message signs, traffic signals, CCTV, etc.). Environmental conditions information is also received from various weather sources to aid in scheduling maintenance and construction activities.

Work Zone Management (MCO8)

This market package directs activity in work zones, controlling traffic through portable dynamic message signs (DMS) and informing other groups of activity (e.g., ISP, traffic management, other maintenance and construction centers) for better coordination management. Work zone speeds and delays are provided to the motorist prior to the work zones.

Work Zone Safety Monitoring (MCO9)

This market package includes systems that improve work crew safety and reduce collisions between the motoring public and maintenance and construction vehicles. This market package detects vehicle intrusions in work zones and warns crew workers and drivers of imminent encroachment or other potential safety hazards. Crew movements are also monitored so that the crew can be warned of movement beyond the designated safe zone. The market package supports both stationary and mobile work zones. The intrusion detection and alarm systems may be co-located or distributed, allowing systems that detect safety issues far upstream from a work zone (e.g., detection of over dimension vehicles before they enter the work zone).

Maintenance and Construction Activity Coordination (MC10)

This market package supports the dissemination of maintenance and construction activity to centers that can utilize it as part of their operations, or to the Information Service Providers who can provide the information to travelers.

Appendix B. ITS Architecture Glossary of Terms

Term	Description
Architecture, Uncustomized	An uncustomized architecture is one which has been built via the "Build" option on the Interfaces tab in Turbo Architecture, but no changes to element or architecture flow selections have been made, i.e., no tailoring of the architecture has been done yet.
Architecture, Customized	A customized architecture is one in which element and architecture flow associations have been modified on the Interfaces tab in Turbo Architecture. The flow status may be changed or the project association for a flow or interconnect may be deselected (i.e., in order not to display this flow or interconnect on the diagrams).
Center	Center is a term used in the Turbo Architecture Interview Dialog and represents the primary Administration or Management "Element". This may often be a physical building (such as the Marinara County Freeway Management Center). The centers defined during the Interview will also appear as elements on the Inventory tab.
Element	This is the basic building block of a local regional or project ITS architecture. It is the name used by the stakeholders to describe an instance of one or more ITS entities. An element is defined by the name that a user gives to an instance of an ITS entity (e.g.,Caltrans/California Highway Patrol District 12 Traffic Management Center). An element is also assigned to a stakeholder.
Entity	An entity represents a National ITS Architecture subsystem or terminator from the Physical Architecture, or a user defined (locally defined) entity (similar to a subsystemor terminator). Each "element" should be associated with one or more "entities".
File	The definition of an architecture is saved in a file. Within a single Turbo Architecture "file" (or database), the user may define zero or one Regional Architecture and/or zero to many Project Architectures. A file is also referred to within this document as: A database file; Turbo Architecture database file; Turbo Architecture file
Interfaces, Interconnect	Communications paths that carry information between entities (subsystems and terminators) of the National ITS Architecture and between elements of a Regional or Project ITS Architecture. Interconnects are directionless and contain one or more architecture flows.
Interfaces, Architecture Flows	Architecture flows define direction-specific information flow between entities of the National ITS Architecture and between elements of a Regional or Project ITS Architecture – such as "road network conditions" from a traffic management center to an emergency center. Forms the basis for the standardization of ITS interfaces.
Project	A project is a set of ITS deployment activities grouped together (usually within a single procurement) for planning, deployment, and/or operational purposes. A project has defined boundaries within the context of a region.
Project Architecture	This term defines the elements and information exchanges of a single ITS project.
Region	A region is a geographical area spanning one or more jurisdictions. A region is a local decision. It is not necessarily bounded politically. It could be a state or multiple states, a metropolitan area or multiple metropolitan areas, one MPO or multiple MPO's, a corridor (e.g., I-95 corridor), counties, rural towns or areas.
Regional Architecture	The elements and information exchanges of the many ITS projects existing or planned within a region. It should be a comprehensive organization of the region's ITS.
Stakeholder	A stakeholder defines an organization that owns, operates, or interfaces with the ITS elements in a region.
Subsystem	There are 22 subsystems that make up the National ITS Architecture and encompass all the functionality of the ITS User Services and are grouped into four classes: Centers, Field, Vehicles, and Travelers. Examples include the Traffic Management Subsystem (TMS), the Vehicle Subsystem (VS), and the Roadway Subsystem (RS), corresponding to traffic operations centers, automobiles, and roadside signal controllers.
System	A system is a collection of hardware, software, data, processes, and people that work together to achieve a common goal (definition from the NHI System Engineering Course). NOTE that "system" is a relative term since many different types of systems fit this definition. To a sign manufacturer, a dynamic message sign is a "system". To a state DOT, the same sign is only a component of a larger Freeway Management System. In the National ITS Architecture, a Freeway Management System is a part of the overall surface transportation system for the region.
Terminators	Terminators are physical entities that define the boundary of an architecture. The National ITS Architecture terminators represent the people, systems, and general environment that interface to ITS. The interfaces between terminators and the subsystems and processes within the National ITS Architecture are defined, but no functional requirements are allocated to terminators.

Appendix C. Recommended Projects

The Improvement Projects recommended in this ITS Operations Plan have been divided into five groups with each group representing a particular type of improvement. These groups and the projects associated in each group are identified below:

Group 1 Traffic Signal System Improvements

Project 1.1: Install Wireless Communication Infrastructure for ITS Field Equipment
Project 1.2: Upgrade Traffic Controllers to Ethernet-Based Units
Project 1.3: Expand System Detection Network
Project 1.4: Expand CCTV Surveillance System
Project 1.5: Central Traffic Signal Priority Software Module
Project 1.6: Central Traffic Adaptive Software Module

Group 2 Safety Enhancement Projects

Project 2.1: Expand Driver Feedback Speed Signs
Project 2.2: ATMS & Emergency Services Integration
Project 2.3: Railroad Crossing Monitoring System

Group 3 Traveler Information and Information Sharing with Regional Agencies

Project 3.1: Install DMS
Project 3.2: CCTV & Traveler Information Website Integration
Project 3.3: Share Data/Video with TxDOT and Neighboring Cities

Group 4 Transportation Management

Project 4.1: Citywide Traffic Signal Timing Optimization
Project 4.2: Parking Availability System
Project 4.3: Central Fleet Management Software Module
Project 4.4: Public Works Vehicle Payload Monitoring System

Group 5 Other Projects

Project 5.1: Enable System Data Exchange
Project 5.2: Share Data with Mobile Command Post for Traffic Incidents

GROUP 1 TRAFFIC SIGNAL SYSTEM IMPROVEMENTS

These signal system projects include many of the highest priority projects in the Operations Plan. They directly enable many of the functional requirements that were determined by the Project Steering Committee to be the most important. They also are prerequisite or supporting projects for most of the remaining functional requirements. Initial projects will be required to perform the detailed engineering required for the preparation of the plans and procurement documents for a number of these projects.

Project 1.1: Install Wireless Communication Infrastructure for ITS Field Equipment

Project Description:

This project will install the hardware and software to enable Ethernet IP "standards-based" communications to improve traffic signal system management. Wireless IP enabled traffic signal control will be used to improve traffic flow and enable new applications for higher efficiency and cost savings. Advanced Transportation Management Systems (ATMS) provide the ability to connect traffic signal controllers to an intelligent network for enhanced data gathering and analysis and better timing of traffic signals. Connecting signal controllers to an intelligent network with a standards-based wireless IP infrastructure, versus older hard-wired methods, will be cost effective, provide flexibility in design, enable faster deployment, and provide a network infrastructure for future additional applications.

Project Benefits:

The major benefits of the new communications infrastructure are:

- Flexibility, ease of expansion, lower installation costs, and higher reliability. For example, the wireless approach protects the network from cabling cuts as have been occurring at construction sites where Sugar Land roadway and intersection improvements are taking place.
- Enhances the ability to monitor the operation of the signal system to identify failures that delay traffic and cause hazardous conditions
- Enhances the ability to help develop, save and implement new timing plans that will minimize the delay to motorists, excessive fuel consumption and vehicle emissions
- Provides flexibility and growth for wide-band mobile communications capabilities.
- City inventory and existing infrastructure can be incorporated, allowing expanded capability and cost savings.
- The flexible wireless network preliminary concept perfectly fits a growing area with dynamic needs, allowing re-deployment to meet future needs and applications to match.
- The expandability and synergy of a wireless network are important for current and future City services.
- Traffic communications may leverage wireless systems with as many expansion capabilities as possible. Wireless today can provide hotspots and service areas around traffic controller cabinets and City buildings with more fill-ins over time.

Related Functions:

1 Save City traffic data for future analysis ..... Supporting
2 Collect traffic volume data for monitoring traffic flow and displaying real-time conditions…. ..... Supporting
3 Provide video images of key locations… ..... Supporting
4 Provide better signal timing and signal coordination ..... Supporting
5 Adjust signal timing based on real-time traffic data ..... Supporting
6 Provide fire trucks with a green light at traffic signals ..... Supporting

7	Provide ambulances with a green light at traffic signals	Supporting
8	Facilitate the exchange of archived data with other agencies	Supporting
9	Adjust signal timing based on real-time event data from major traffic generators	Supporting
10	Collect the average speed of traffic on major arterials	Supporting
11	Provide information to drivers using Dynamic Message Signs	Supporting
12	Improve coordination among organizations that respond to accidents	Supporting
13	Improve coordination among organizations dealing with traffic at special events	Supporting
14	Support Amber Alerts and other wide area emergency notifications	Supporting
15	Save data on other transportation activities within the City	Supporting
16	Push traffic data to travelers through enhanced pagers, cell phones, etc.	Supporting
18	Monitor the operation of railroad grade crossings.	Supporting
19	Direct drivers to parking garages where space is available.	Supporting
23	Recommend routes for emergency vehicles based on traffic conditions	Supporting
24	Support coordination of evacuation plans	Supporting
26	Coordinate grade crossing operation with the railroad	Supporting
28	Support coordination of emergency response plans	Supporting
29	Support coordination of emergency response plans	Supporting
30	Provide traffic data for in-vehicle route guidance systems	Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Wireless Communication Infrastructure			
Head End Equipment	$115,000	$11,500	$126,500
Tower Infrastructure	$592,500	$59,300	$651,800
Field Infrastructure	$145,400	$14,500	$159,900
Ethernet Switches			
51 locations @ $2,100	$107,100	$10,700	$117,800
Detailed Design and Implementation Support	$192,000	$19,200	$211,200
Totals for Project 1.1:	$1,152,000	$115,200	$1,267,200

Lead Implementation Organization:

Department of Public Works

Project 1.2: Upgrade Traffic Controllers to Ethernet-Based Units

Project Description:

The implementation of Ethernet IP "standards-based" communications will improve traffic signal system management. Wireless IP-enabled traffic signal control can be used to improve traffic flow and enable new applications for higher efficiency and cost savings. The City's Advanced Transportation Management System (ATMS) provides the ability to connect traffic signal controllers to an intelligent network for enhanced data gathering and analysis and better timing of traffic signals.

As a first step in the upgrade process, the existing Naztec NEMA TS-2 traffic signal controllers can be easily upgraded to Ethernet-capable devices by the replacement of the controller faceplate and internal communications card, enabling communications at a range of 10 – 1,000 megabits.

Project Benefits:

The benefits of the Ethernet approach are numerous. They include:

- IP allows sharing of communications. Components sharing the same switching device at each cabinet can include cameras, DMS, and IP phones.
- Because components would share the switching device, there would be only one piece of equipment for the maintenance staff to learn and maintain. With the RS-232 approach, each added component would require the addition of a modem as well.
- Users can connect laptops into remote sites and access all intersections via the IP network.
- Controller database upload/download time would decrease from about one to two minutes to about 20 seconds.

Related Functions:

1	Save City traffic data for future analysis	Supporting
2	Collect traffic volume data for monitoring traffic flow and displaying real-time conditions…	Supporting
4	Provide better signal timing and signal coordination	Supporting
5	Adjust signal timing based on real-time traffic data	Supporting
6	Provide fire trucks with a green light at traffic signals	Supporting
7	Provide ambulances with a green light at traffic signals	Supporting
9	Adjust signal timing based on real-time event data from major traffic generators	Supporting
10	Collect the average speed of traffic on major arterials	Supporting
13	Improve coordination among organizations dealing with traffic at special events	Supporting
17	Help predict future traffic volumes	Supporting
18	Monitor the operation of railroad grade crossings.	Supporting
23	Recommend routes for emergency vehicles based on traffic conditions	Supporting
30	Provide traffic data for in-vehicle route guidance systems	Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Upgrade Traffic Controllers to Ethernet-Based Units			
TS2 Ethernet Faceplate Upgrade			
37 locations @ $3,000	$111,000	$11,100	$122,100
Replace TS2 Cabinets & Controllers (Includes Database Conversion and IP Set-up)			
14 locations @ $17,900	$250,600	$25,000	$275,600
Controller Database Conversion/IP Set-up			
37 locations @ $1,200	$44,400	$4,400	$48,800
Detailed Design and Implementation Support	$101,500	$10,200	$111,700
Totals for Project 1.2:	$507,500	$50,700	$558,200

Lead Implementation Organization:

Department of Public Works

Project 1.3: Expand System Detection Network

Project Description:

The existing detection network needs to be expanded to provide complete and accurate coverage of the major links in the City traffic signal network. This project will provide for new detectors that are installed above the roadway where they will be less likely to be damaged by weather and roadway rehabilitation work than the roadway loop detector configuration.

Project Benefits:

System detectors provide current traffic volume, occupancy and speed data on key arterials for implementation of traffic-responsive signal timing plans and real-time display of congestion levels to the motoring public on the traveler information website. This traffic data is also archived for future analysis and forecasting.

Sensors less prone to failure will improve the operation of signalized intersections reducing the delay, fuel consumption and emissions at these intersections. It will also minimize maintenance efforts by City staff.

Some of the benefits of the expansion of the system detection network include:

- Timing Plan Aids – The ATMS will have the capability to archive traffic signal detector data for use in traffic signal timing and analysis programs. The system will also facilitate the transfer of the output of the signal timing programs into new signal timing plans. Automating the data collection process and the import of these data into signal timing programs will enable the cost-effective production of new timing plans.

- Traffic Responsive Capability – The ATMS will include traffic responsive operation providing the automatic selection of the timing plan best suited to the traffic demand. This capability is particularly useful near special event venues and other major traffic generators where it will reduce delay, fuel consumption and emissions and will return the system to normal traffic flow more quickly. Traffic responsive capabilities will also reduce the duration that Police Officers are needed to perform traffic control duties.

- Congestion Status Maps – The ATMS will have the capability to generate a congestion map based on detector data from the field. This map will help Traffic Management Center (TMC) personnel prioritize future improvement activities. It is also a prerequisite for many other projects that will share traffic congestion data for other City and regional transportation agencies.

- Traffic Volume Forecasts – The ATMS will have the capability to predict future traffic volumes through an extrapolation of past volumes, or through software programs that "model" traffic volumes from roadway and community characteristics. This capability will allow the City's engineers to better prepare for the traffic associated with special events that are held on an annual basis, and the design of major roadway improvements.

Related Functions:

1 Save City traffic data for future analysis ..... Prerequisite

2 Collect traffic volume data for monitoring traffic flow and displaying real-time conditions… ..... Prerequisite
4 Provide better signal timing and signal coordination ..... Enabling
5 Adjust signal timing based on real-time traffic data ..... Enabling
8 Facilitate the exchange of archived data with other agencies ..... Prerequisite
9 Adjust signal timing based on real-time event data from major traffic generators ... Enabling
10 Collect the average speed of traffic on major arterials ..... Enabling
11 Provide information to drivers using Dynamic Message Signs ..... Prerequisite
12 Improve coordination among organizations that respond to accidents ..... Supporting
13 Improve coordination among organizations dealing with traffic at special events Prerequisite
16 Push traffic data to travelers through enhanced pagers, cell phones, etc. ..... Prerequisite
17 Help predict future traffic volumes. ..... Prerequisite
23 Recommend routes for emergency vehicles based on traffic conditions ..... Prerequisite
24 Support coordination of evacuation plans ..... Supporting
25 Exchange data with TxDOT and other local traffic agencies ..... Prerequisite
28 Support coordination of emergency response plans ..... Supporting
30 Provide traffic data for in-vehicle route guidance systems ..... Prerequisite

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Expand System Detection Network			
130 Intersection Approaches at $3,000	$390,000	$39,000	$429,000
Detailed Design and Implementation Support	$58,500	$5,900	$64,400
Totals for Project 1.3:	$448,500	$44,900	$493,400

Lead Implementation Organization:

Department of Public Works

Project 1.4: Expand CCTV Surveillance System

Project Description:

The City has a number of traffic surveillance cameras already in place. Under this project additional cameras will be installed at locations most likely to experience congestion. These include locations that experience daily traffic congestion because of commuting patterns and locations near parks, stadiums and other venues where special events take place on a periodic basis.

Project Benefits:

These cameras will enable the engineers at the TMC to adjust traffic signal timing in response to real-time events. These could be accidents or special events that cause anomalies in the normal patterns of traffic flow. The cameras would also enable operations and maintenance staff to respond more quickly to calls from citizens reporting problems.

Related Functions:

3	Provide video images of key locations…	Enabling
12	Improve coordination among organizations that respond to accidents	Supporting
13	Improve coordination among organizations dealing with traffic at special events	Supporting
23	Recommend routes for emergency vehicles based on traffic conditions	Supporting
24	Support coordination of evacuation plans	Supporting
25	Exchange data with TxDOT and other local traffic agencies	Supporting
26	Coordinate grade crossing operation with the railroad	Supporting
28	Support coordination of emergency response plans	Supporting
29	Support coordination of emergency response plans	Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Expand CCTV Surveillance System			
51 locations @ $4,100	$209,100	$20,900	$230,000
Video Encoder			
51 locations @ $2,000	$102,000	$10,200	$112,200
TMC Servers and Equipment	$50,000	$5,000	$55,000
Detailed Design and Implementation Support	$90,300	$9,000	$99,300

Totals for Project 1.4:	$451,400	$45,100	$496,500

Lead Implementation Organization:

Department of Public Works

Project 1.5: Central Traffic Signal Priority Software Module

Project Description:

This project would integrate the Naztec PRIORITY.now software module with the existing ATMS.now platform to implement an Emergency Vehicle Priority System, integrating automatic vehicle location tracking with the City's proven Advanced Transportation Management System (ATMS) technology. The result will enable reduced emergency response time and greater emergency vehicle safety, with minimal impact to surrounding traffic, at a lower cost of implementation than other available solutions.

Project Benefits:

Through the addition of this central priority software module, integrating the City's existing ATMS, this project would maximize the potential power that can be utilized by both the on-street software as well as the central software. Utilizing the full capacity of the controller's software features and functions, and optimizing both software packages (field and central), would provide numerous unique benefits to the City. These would include:

- Achieve Faster Emergency Response Time - The Emergency Vehicle Priority System will provide traffic flow priority to vehicles traversing a route between an origin and an incident. Traffic flow priority enables vehicles to move through signalized intersections under a green signal indication, thus eliminating delay time and safety hazards caused by moving through intersections under a red light.

- Maximize Emergency Vehicle Safety - The Emergency Vehicle Priority System creates a natural-feeling green signal indication for emergency vehicles. A green indication for emergency vehicles that appears normal and natural to all other traffic reduces the risk of accidents for all concerned.

- Minimize Impact to Surrounding Traffic - The Emergency Vehicle Priority System works with the City's ATMS technology to maintain coordinated traffic flow on roadways adjacent to the emergency route. Coordinated traffic flow will minimize impact to cross streets even as emergency vehicles experience green signals en route to an incident. As the ATMS system dynamically adjusts traffic signal timing, drivers on adjacent and oncoming roadways operate normally without disruption. Since the Emergency Vehicle Priority System will maintain non-disruptive roadway conditions, drivers will be less likely to interfere with emergency vehicles.

Related Functions:

6	Provide fire trucks with a green light at traffic signals	Enabling
7	Provide ambulances with a green light at traffic signals	Enabling
27	Support the computer-aided dispatch of emergency vehicles	Supporting
28	Support coordination of emergency response plans	Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Central Traffic Signal Priority Software			
Central Priority Software Module	$750,000	$75,000	$825,000
Controller Firmware Upgrade	$75,000	$7,500	$82,500
Detailed Design and Implementation Support	$82,500	$8,300	$90,800
Totals for Project 1.5:	$907,500	$90,800	$998,300

Lead Implementation Organization:

Department of Public Works

Project 1.6: Central Traffic Adaptive Software Module

Project Description:

This project would enable the integration of a traffic adaptive module to the existing ATMS platform. Fully adaptive traffic signal control system operation within the ATMS will:

- Provide a module to calculate or select appropriate cycle length, phase split and offset for each coordinated intersection;
- Provide automation and self-calibration features so that staff will become more efficient, not have an increased workload;
- Provide facilities for operators to modify or override the adaptive system at any time; and
- Provide for real-time signal timing plan preparation, in response to current traffic conditions.

Project Benefits:

ITS technology enables the process of traffic signal timing to be performed more efficiently by enhancing data collection and system monitoring capabilities and, in traffic adaptive applications, automating the process entirely. ITS tools such as automated traffic data collection, centrally controlled or monitored traffic signal systems, interconnected traffic signals, and traffic adaptive signal control help make the traffic signal timing process efficient and cost effective, and responsive to real-time conditions.

Related Functions:

4 Provide better signal timing and signal coordination ..... Supporting
5 Adjust signal timing based on real-time traffic data ..... Prerequisite

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Central Traffic Adaptive Software			
Central Traffic Adaptive Software Module	$175,000	$17,500	$192,500
Detailed Design and Implementation Support	$17,500	$1,800	$19,300
Totals for Project 1.6:	$192,500	$19,300	$211,800

Lead Implementation Organization:

Department of Public Works

GROUP 2 SAFETY ENHANCEMENT PROJECTS

The projects in this group focus on safety improvements that can help reduce the occurrence of accidents, expedite the response to 911 calls from travelers with cellular telephones, and improve the response to accidents. These projects generally fall into the second tier of priority in the Operations Plan.

Project 2.1: Expand Driver Feedback Speed Signs

Project Description:

In December 2006 the City's Public Works Department implemented a pilot project designed to promote motorist compliance with posted speed limits on the City's arterials, and thereby increase safety. The project implemented pole-mounted radar speed displays to advise drivers of their actual speed compared to the posted speed limit. Feedback from the public regarding these signs has been very positive, and results have indicated speed reductions on selected roadways. This project would provide for the expansion of this system through the procurement and implementation of additional equipment.

Project Benefits:

The benefits of the project would include increased monitoring and reduction of vehicle speeds, and heightened awareness of posted speed limits.

Related Functions:

11 Provide information to drivers using Dynamic Message Signs ..... Prerequisite

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Expand Driver Feedback Speed Signs			
7 locations @ $11,000	$77,000	$7,700	$84,700
Totals for Project 2.1:	$77,000	$7,700	$84,700

Lead Implementation Organization:

Department of Public Works

Project 2.2: ATMS & Emergency Services Integration

Project Description:

This project will enable emergency services integration with the existing Advanced Transportation Management System (ATMS) and would provide, on one consistent GIS background, a display of all the traffic condition data available at the traffic management center, and with the implementation of the fleet management module the status tracking data for priority vehicles.

Project Benefits:

Having one application to monitor these intertwined operations would serve to greatly enhance the productivity and effectiveness of management and operations staff of all affected departments. This project will export the data and video from the TMC to the emergency service agency, as well as the congestion map and data from system sensors. The Emergency service agency personnel will use the roadway information to identify the fastest route to the scene of the emergency. Future upgrades to this project will implement a software program that will automatically identify the fastest route from the congestion data. Viewing a video image of an incident can help emergency personnel determine the appropriate type and number of response vehicles that are required. Giving the staff information on congestion will help them select and dispatch the vehicle that can get to the emergency the fastest. Public Works dispatchers can use the images in a similar manner.

Related Functions:

6 Provide fire trucks with a green light at traffic signals ..... Supporting
7 Provide ambulances with a green light at traffic signals ..... Supporting
12 Improve coordination among organizations that respond to accidents..... Enabling
23 Recommend routes for emergency vehicles based on traffic conditions..... Enabling
28 Support coordination of emergency response plans ..... Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
ATMS & Emergency Services Integration			
System Hardware, Software and Integration	$50,000	$5,000	$55,000
In-Vehicle GPS Device Integration			
100 vehicles @ $250	$25,000	$2,500	$27,500
Detailed Design and Implementation Support	$7,500	$1,000	$8,500

Totals for Project 2.2:	$82,500	$8,500	$91,000

Lead Implementation Organization:

Department of Public Works

Emergency Services

Project 2.3: Railroad Crossing Monitoring System

Project Description:

Through implementation of this project the system will monitor the operation of railroad grade crossings. With this capability the system will be able to determine when preemption is requested by a train, the operation of crossing gates and the time that the crossing is occupied by a railroad car.

Project Benefits:

The system could provide an additional level of strategic coordination between freight rail operations and the traffic management center. Rail operations could provide train schedules, maintenance schedules, and any other forecast events that will result in highway-rail intersection closures. This information could be used to develop forecast highway-rail intersection closure times and durations that may be used in advanced traffic control strategies or to enhance the quality of traveler information.

Related Functions:

15 Save data on other transportation activities within the City ..... Supporting
18 Monitor the operation of railroad grade crossings. ..... Enabling
26 Coordinate grade crossing operation with the railroad ..... Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Railroad Crossing Monitoring System			
Railroad Crossing Detection & Control Equipment			
8 locations @ $44,000	$352,000	$35,200	$387,200
System Software and Integration	$120,000	$12,000	$132,000
Detailed Design and Implementation Support	$70,800	$7,100	$77,900
Totals for Project 2.3:	$542,800	$54,300	$597,100

Lead Implementation Organization:

Department of Public Works

GROUP 3 TRAVELER INFORMATION AND INFORMATION SHARING WITH REGIONAL AGENCIES

This group contains a series of information dissemination and information sharing projects that will increase knowledge of roadway conditions for travelers and agencies. These projects constitute a third set of priorities. These projects also require an engineering effort before they can be implemented. However, in some cases the traditional engineering disciplines must be supplemented with personnel with Information Technology expertise.

Project 3.1: Install DMS

Project Description:

This project will install a series of permanently mounted dynamic message signs (DMS) at selected non-residential locations in the community. These signs would provide routing information for visitors entering the community, provide parking availability information and warn residents and employees of delays that can be avoided by using alternate routes.

Project Benefits:

Dynamic message signs can change the message they display to reflect conditions or inform motorists of important information. The signs can convey information about roadway conditions, alternate routes, construction activities, or any information that may assist motorists in making decisions. Signs will initially be placed at select key locations. The overall project benefits to area residents, employees and visitors are reduced delay, fuel consumption and vehicle emissions.

Related Functions:

11	Provide information to drivers using Dynamic Message Signs	Enabling
14	Support Amber Alerts and other wide area emergency notifications	Enabling
19	Direct drivers to parking garages where space is available.	Supporting
24	Support coordination of evacuation plans	Supporting
28	Support coordination of emergency response plans	Supporting
29	Support coordination of emergency response plans	Enabling

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Dynamic Message Signs			
5 locations @ $150,000	$750,000	$75,000	$825,000
Detailed Design and Implementation Support	$112,500	$11,300	$123,800
Totals for Project 3.1:	$862,500	$86,300	$948,800

Lead Implementation Organization:

Department of Public Works

Project 3.2: CCTV & Traveler Information Website Integration

Project Description:

This project will implement a website to provide real-time traffic condition data and CCTV images. Through further integration with the City's existing ATMS, the website will be a mechanism to deliver to the public real-time condition data collected by the system. The website and background GIS map will be configurable, designed to display data such as traffic signal status, congestion level, traffic volumes, incident locations and details, and construction information. The site will be integrated with video streaming technology to provide links to the existing and planned CCTV surveillance cameras. Any supplementary hardware and software required to support this integration will be provided by this project.

Project Benefits:

Information from the City's cameras made available for viewing in the home will reduce delay, fuel consumption and emissions by enabling travelers to assess the extent of traffic congestion and make appropriate decisions about their departure times and routes. Similar delay, fuel consumption and emissions reductions on trips headed home after work will be made possible for people that view the web site on PCs at their offices.

Related Functions:

2	Collect traffic volume data for monitoring traffic flow and displaying real-time conditions…	Supporting
3	Provide video images of key locations…	Supporting
8	Facilitate the exchange of archived data with other agencies	Supporting
12	Improve coordination among organizations that respond to accidents	Supporting
13	Improve coordination among organizations dealing with traffic at special events	Supporting
14	Support Amber Alerts and other wide area emergency notifications	Supporting
15	Save data on other transportation activities within the City	Supporting
16	Push traffic data to travelers through enhanced pagers, cell phones, etc.	Supporting
24	Support coordination of evacuation plans	Supporting
25	Exchange data with TxDOT and other local traffic agencies	Supporting
28	Support coordination of emergency response plans	Supporting
29	Support coordination of emergency response plans	Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
CCTV & Traveler Information Website Integration			
Website Development and Integration	$35,000	$3,500	$38,500
TMC Servers and Equipment	$25,000	$2,500	$27,500

Totals for Project 3.2:	$60,000	$6,000	$66,000

Lead Implementation Organization:

Department of Public Works

Project 3.3: Share Data/Video with TxDOT and Neighboring Cities

Project Description:

This project consists of several parts, which establish communications links between the TMC and TxDOT's TranStar Center and establish communications links between the TMC and neighboring cities, such as Missouri City. It also includes the purchase of any hardware (such as file servers) and software (such as firewall protection programs) required to exchange video and current and archived data through these communications links.

Project Benefits:

Coordination with neighboring cities such as Missouri City will enable the development of improved timing plans for arterials that cross these jurisdictional boundaries. Improved timings will result in reduced delay, fuel consumption, and emissions.

Coordination with TxDOT will make video and data from the City of Sugar Land available to the TxDOT TranStar Center where it can be viewed by the TranStar staff at the consoles. The data and views from these cameras will allow TxDOT to post appropriate messages on TxDOT's Dynamic Message Signs. Similarly, video from TranStar will be made available to the City's TMC staff. The images from the TxDOT cameras located at the interchanges with the City's arterials will enable the City's TMC staff to assess traffic problems and develop new signal timing plans for the signalized intersections located at the ramps for the interchanges.

Related Functions:

2	Collect traffic volume data for monitoring traffic flow and displaying real-time conditions…	Supporting
3	Provide video images of key locations…	Supporting
8	Facilitate the exchange of archived data with other agencies	Enabling
14	Support Amber Alerts and other wide area emergency notifications	Supporting
24	Support coordination of evacuation plans	Enabling
25	Exchange data with TxDOT and other local traffic agencies	Enabling
28	Support coordination of emergency response plans	Supporting
29	Support coordination of emergency response plans	Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Share Data/Video			
	$80,000	$8,000	$88,000
Detailed Design and Implementation Support	$8,000	$1,000	$9,000

Totals for Project 3.3:	$88,000	$9,000	$97,000

Lead Implementation Organization:

Department of Public Works

GROUP 4 TRANSPORTATION MANAGEMENT

This group of projects is aimed at improving the operation, monitoring and management of the overall City transportation network. The projects included have a range of implementation priority. Once again, there will be an engineering effort needed to convert some of these concepts into implementation projects that can be put out for bid.

Project 4.1: Citywide Traffic Signal Timing Optimization

Project Description:

This project will be enhanced by the implementation of several of the other recommended projects, but optimization efforts can begin on key City corridors at any time. Updated signal timing plans will be prepared for the complete city signal network as well as ETJ signals and coordination with adjacent jurisdictions. Studies will include inventory and operational assessment of traffic control devices as well as recommendations for geometric and safety improvements. Specialized timing plans could be developed for special events that are known in advance and detour routes that can be used when there is a major incident on US 59 and major arterials in the City.

Project Benefits:

Optimized signal timing is considered to be a very effective low-cost approach to reducing congestion. Benefit-cost ratios as high as 40 to 1 can be realized after traffic signal retiming is performed. This project will include interjurisdictional and extraterritorial jurisdiction (ETJ) signal coordination, as well as evacuation route timing plans. These timing plans would minimize delay, fuel consumption and emissions that occur when these activities take place.

Related Functions:

4 Provide better signal timing and signal coordination .....Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Citywide Traffic Signal Timing Optimization			
	$325,000	$32,500	$357,500
Totals for Project 4.1:	$325,000	$32,500	$357,500

Lead Implementation Organization:

Department of Public Works

Project 4.2: Parking Availability System

Project Description:

This project will install a sign system to direct drivers to City-owned parking facilities where parking spaces are available. It is anticipated that this would include the facilities located at Town Square. The TMC would learn when one or more of these facilities are full through connections to the existing parking monitoring systems or through contact with the personnel working there. Information regarding available parking would be placed on large dynamic message signs and smaller wireless automated parking advisory signs strategically deployed to help motorists find open facilities.

Project Benefits:

Directing drivers to available spaces will reduce unnecessary circulation by vehicles looking for parking spaces. It will help increase the utilization of City-owned facilities that are less frequently used. It will also provide a more positive perception of the City by visitors that would otherwise become frustrated while they are looking for a place to park.

Related Functions:

2 Collect traffic volume data for monitoring traffic flow and displaying real-time conditions…. ..... Supporting
11 Provide information to drivers using Dynamic Message Signs ..... Supporting
15 Save data on other transportation activities within the City ..... Supporting
19 Direct drivers to parking garages where space is available. ..... Enabling
25 Exchange data with TxDOT and other local traffic agencies ..... Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Parking Availability System			
System Development, Communications, Testing			
5 locations @ $10,000	$50,000	$5,000	$55,000
Dynamic Message Signs			
5 locations @ $90,000	$450,000	$45,000	$495,000
Static Message Signs			
15 locations @ $2,600	$39,000	$3,900	$42,900
Parking Facility Equipment			
5 locations @ $7,000	$35,000	$3,500	$38,500

System Hardware and Software	$50,000	$5,000	$55,000
Detailed Design and Implementation Support	$62,400	$6,200	$68,600
Totals for Project 4.2:	$686,400	$68,600	$755,000

Lead Implementation Organization:

Department of Public Works

Project 4.3: Central Fleet Management Software Module

Project Description:

This project will establish a contract for an Automatic Vehicle Location (AVL) system that may be used by all City agencies. This may also be linked to a city-wide contract for a Computer Aided Dispatch (CAD) system that will be used by the emergency service agencies, the Public Works Department and other interested City organizations. The same central software will be used by all organizations. The central fleet management software module integrates Global Positioning Systems (GPS) and wireless communications to provide a method for remote vehicle tracking and monitoring. Data can be stored for later retrieval and analysis or transmitted to the traffic management center for real-time display. The system would be initially implemented on select Public Works vehicles, with possible expansion to fire and police departments.

Project Benefits:

This project has several benefits:

- It allows the Department of Public Works and other City agencies to monitor the locations of its vehicles and if desired, dispatch the closest available vehicle to deal with traffic and signal system problems
- It allows the Department of Public Works to monitor the location of its construction vehicles and other high value mobile assets
- It will further facilitate the coordination of Public Works and Emergency units at traffic and roadway related incidents
- It improves the ability of the emergency dispatchers to quickly identify the availability of the vehicle closest to the emergency.

Related Functions:

6	Provide fire trucks with a green light at traffic signals	Supporting
7	Provide ambulances with a green light at traffic signals	Supporting
12	Improve coordination among organizations that respond to accidents	Supporting
15	Save data on other transportation activities within the City	Supporting
20	Include an automatic vehicle location system for Public Works Dept. vehicles	Enabling
21	Include an automatic vehicle location system for other City-owned vehicles	Enabling
23	Recommend routes for emergency vehicles based on traffic conditions	Supporting
25	Exchange data with TxDOT and other local traffic agencies	Supporting
27	Support the computer-aided dispatch of emergency vehicles	Enabling
28	Support coordination of emergency response plans	Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Central Fleet Management Software Module			
Central Fleet Management Software Module	$200,000	$20,000	$220,000
In-Vehicle GPS Device			
50 vehicles @ $1,200	$60,000	$6,000	$66,000
Totals for Project 4.3:	$260,000	$26,000	$286,000

Lead Implementation Organization:

Department of Public Works

Project 4.4: Public Works Vehicle Payload Monitoring System

Project Description:

With the implementation of the Central Fleet Management Software Module, this project will install the additional hardware and software, including Global Positioning Systems (GPS) devices on field equipment, to enable tracking and condition monitoring of construction and maintenance equipment and trailers.

Project Benefits:

For the Public Works Department, the fleet management software module will allow the monitoring of a vehicle's performance, its speed, its location and its daily starting and stopping times. With equipment and machinery, the Vehicle Payload Monitoring System will potentially allow the Department to locate abandoned, lost or stolen equipment, monitor equipment hours, verify equipment utilization, and decrease equipment downtime. This type of monitoring system could enable better management of productivity, resulting in a return on the investment (ROI) far exceeding the cost of the system.

Related Functions:

22 Support the monitoring of material/equipment on Public Works Dept. vehicles ..... Enabling

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Public Works Vehicle Payload Monitoring System			
System Hardware and Software	$60,000	$6,000	$66,000
Equipment GPS Device			
100 units @ $1,200	$120,000	$12,000	$132,000
Totals for Project 4.4:	$180,000	$18,000	$198,000

Lead Implementation Organization:

Department of Public Works

GROUP 5 OTHER PROJECTS

This group contains a series of information dissemination and information sharing projects that will increase knowledge of roadway conditions for travelers and agencies. These projects also require an engineering effort before they can be implemented. However, in this case the traditional engineering disciplines must be supplemented with personnel with Information Technology expertise.

Project 5.1: Enable System Data Exchange

Project Description:

The concept of this project is to provide a focused archive that houses data collected and managed by the system. It provides the basic data quality, data privacy, and meta data management common to all ITS archives and provides general query and report access to archive data users.

This project includes all the data collection and management capabilities provided by the ITS Data Mart market package, and adds the functionality and interface definitions that allow collection of data from multiple agencies and data sources spanning across modal and jurisdictional boundaries. It performs the additional transformations and provides the additional meta data management features that are necessary so that all this data can be managed in a single repository with consistent formats.

Project Benefits:

This project is important to all of the functional requirements that call for the exchange, archiving, and analysis of system data, as well as those providing for coordination amongst various departments or agencies. An example of the implementation of this project would be the exporting of data and video from the TMC to the emergency service agencies, Public Works personnel and to the City's management staff that may be interested in knowing about traffic incidents and roadway conditions. These data could include the congestion map and data from sensors. The video would include the CCTV surveillance cameras and could also include images from the TxDOT cameras on US 59.

Related Functions:

1	Save City traffic data for future analysis	Supporting
2	Collect traffic volume data for monitoring traffic flow and displaying real-time conditions…	Supporting
12	Improve coordination among organizations that respond to accidents	Enabling
13	Improve coordination among organizations dealing with traffic at special events	Enabling
14	Support Amber Alerts and other wide area emergency notifications	Supporting
15	Save data on other transportation activities within the City	Supporting
24	Support coordination of evacuation plans	Supporting
25	Exchange data with TxDOT and other local traffic agencies	Supporting
26	Coordinate grade crossing operation with the railroad	Supporting
28	Support coordination of emergency response plans	Supporting
29	Support coordination of emergency response plans	Supporting
30	Provide traffic data for in-vehicle route guidance systems	Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Enable System Data Exchange			
	$70,000	$7,000	$77,000
Detailed Design and Implementation Support	$7,000	$1,000	$8,000
Totals for Project 5.1:	$77,000	$8,000	$85,000

Lead Implementation Organization:

Department of Public Works

Project 5.2: Share Data with Mobile Command Post for Traffic Incidents

Project Description:

This project will enhance the on-scene coordination of organizations by providing a system interface to the mobile command post from which they may operate during incidents or emergencies. The recommended equipment for this vehicle includes:

- Communications and workstations for monitoring data from the traffic detectors showing congestion
- Communications equipment and monitors for receiving CCTV images of traffic
- It may also include portable CCTV cameras and variable message signs that can be controlled from the command post

Project Benefits:

Overall the data exchange interface will help minimize the congestion experienced by motorists and other travelers. Through the proper coordination of traffic signals and personnel, it may also reduce the level of staffing needed to handle traffic at these events.

Related Functions:

12 Improve coordination among organizations that respond to accidents..... Enabling
13 Improve coordination among organizations dealing with traffic at special events ... Enabling
28 Support coordination of emergency response plans .....Supporting

Estimated Costs:

Description and Calculation	Cost	Communication and Contingency	Total Element Cost
Share Data with Mobile Command Post			
System Hardware, Software and Integration	$80,000	$8,000	$88,000
Detailed Design and Implementation Support	$12,000	$1,200	$13,200
Totals for Project 5.2:	$92,000	$9,200	$101,200

Lead Implementation Organization:

Department of Public Works

Police Department