Intelligent Transportation System (ITS) 5-Year Operations Plan

Prepared For:

Missouri City, Texas

Prepared By:

Traffic Engineers, Inc.

April 2008

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April 2008

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Executive Summary

The City of Missouri City is located in northeast Fort Bend County, Texas. Missouri City has experienced fast growth over the past several years. The population was approximately 79,500 within the city limits and the extra-territorial jurisdiction (ETJ) in 2006. It is projected to have a population of approximately 131,500 by 2015. The projected 65% increase in population over the next nine years will increase travel times and congestion. Additional capacity has been added in recent years with the expansion of SH 6 and the construction of the Fort Bend Parkway Toll Road. However, the increase in expected population will exceed the ability of the roadway infrastructure to provide additional capacity. It has also been recognized that agencies cannot build their way out of traffic congestion because of limited resources and improved roadway networks lead to more development. Therefore, a more efficient transportation network will need to be provided to handle the additional traffic volumes.

This report concentrates on the use of Intelligent Transportation Systems (ITS) rather than other options that can be used to address congestion. Some of these other options include mass transit, mixed-use developments, or limiting development. This report also concentrates on those elements that are normally under the control of a public or private agency rather than those found in the vehicles themselves. Defining ITS can be difficult; two definitions are shown below.

Intelligent Transportation Systems (ITS) means electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system. ITS project means any project that in whole or in part funds the acquisition of technologies that provide or significantly contribute to the provision of one or more ITS user services as defined in the National ITS Architecture.

Intelligent Transportation Systems, or ITS, encompass a broad range of wireless and wire-line communications-based information, control and electronics technologies. When integrated into the transportation system infrastructure, and in vehicles themselves, these technologies help monitor and manage traffic flow, reduce congestion, provide alternate routes to travelers, enhance productivity, and save lives, time and money.

The purpose of this report is to provide the City of Missouri City a staffing and operation plan for ITS solutions to provide a more efficient transportation system. The ITS plan will provide direction to implement solutions to meet local and regional transportation goals. Improving the efficiency of the roadway infrastructure and providing the traveling public more information will reduce the need to construct new roadways and widen existing roadways. ITS projects improve safety and efficiency of the transportation networks. Some of the benefits provided by ITS projects include:

- Improved travel times
- Reduced vehicle delays
- Reduced fuel consumption
- Improved air quality
- Reduced collisions
- Improved incident response times
- Providing real-time information to travelers

The Goals and Objectives for the ITS 5-year Operations Plan are to develop an organized approach to implementing ITS that is in line with the Houston Regional ITS Architecture and the Houston Regional ITS Strategic Plan. The Goals and Objectives for the ITS Plan are listed below.

- Improve Safety by:
  - Reducing frequency and duration of incidents that impact roadway capacity
  - Reducing emergency response times
  - Reducing first responder injuries
  - Providing remote monitoring of roadway conditions
- Improve Efficiency by:
  - Reducing congestion
  - Improving Capacity
  - Reducing travel time
  - Establishing traffic vehicle data collection procedures
- Reduce Environmental Impacts by:
  - Reducing fuel consumption
  - Reducing air emissions
- Provide Information to Travelers by:
  - Providing real-time travel information to travelers
  - Providing incident information
  - Establishing link with Houston TranStar, Sugar Land Traffic Management Center (TMC) and Fort Bend Emergency Operations Center (EOC)
- Provide Cost Effective ITS Solutions by:
  - Leveraging existing infrastructure
  - Sharing resources between City departments
  - Sharing resources with adjacent local and state agencies

- Provide Plan for ITS Deployment and City Staffing by:
    - Establishing 5-year ITS deployment plan
    - Establishing 5-year staffing needs
    - Identifying funding sources for projects

The Communication Needs for the public works department are:

- Remote access to field devices
- Upgrade signal control software to ATMS.now
- Reliability
- Security
- Sufficient bandwidth for CCTV and VIVDS camera video
- Cost savings
- Reduction in monthly ISDN and T1 costs
- Reduction is staff time for troubleshooting

The Communication Needs for the police and fire department are:

- Replace all non-coded pre-emption emitters with coded emitters
- Reduction in monthly aircard costs
- Implementation of communication frequency rebanding

Multiple ITS options that are available were evaluated for this project. The number and complexity of the ITS options available preclude a comprehensive discussion of each element. The list below shows the primary elements that are included in this report:

- Communication networks
    - Fiber Optics
    - Spread Spectrum
    - Wi-Fi
        - 900 MHz
        - 2.4 GHz
        - 4.9 GHz
        - 5.8 GHz
- Traffic Management Center
- CCTV Cameras
- Traffic Signals
    - Traffic Signal Controllers and Cabinets
    - Traffic Signal Control Software
    - Light Emitting Diode (LED) Signals
    - Vehicle Pre-Emption
    - Vehicle Detection
    - Uninterruptible Power Supply
    - Countdown Pedestrian Signals
    - Traffic-Adaptive or Traffic Responsive Timing
    - Accessible Pedestrian Signals
    - Vehicle Infrastructure Integration

- Automatic Vehicle Identification
- Dissemination of Transportation Related Information
    - Radio
    - Television
    - Highway Advisory Radio
    - City, County and TranStar Websites
    - Dynamic Message Signs
    - Text messages to drivers
- Traffic Incident Management
- School Zone Flashers
- Flashing Crosswalks
- Red Light Cameras
- In-Pavement Lights and LED Backplates

The Transportation Policy Council (TPC) of the Houston-Galveston Area Council (H-GAC) adopted the Houston Region ITS Strategic Plan and Houston Region ITS Architecture in September 2003. These documents provide guidance for the deployment of transportation projects that use ITS technologies. H-GAC adopted these documents to facilitate uniform planning, implementation and operation in the region and to allow interoperability between agencies. Missouri City and Fort Bend County are members of H-GAC. The ITS Architecture defines how major elements of ITS projects should be implemented. The Architecture provides definitions for standardized ITS terms and concepts defined by the United States Department of Transportation. Development of the Regional ITS Architecture was required by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) in order for state and local agencies to qualify for federal funding of ITS projects.

The Houston Region ITS Strategic Plan identified several recommended projects for the Houston area. These projects include:

- Expansion of Surveillance on Arterial Streets
- Expansion of CCTV and sensor equipment on freeways and critical areas (e.g. Hurricane evacuation routes)
- Expansion of the Houston Regional Computerized Traffic Signal System (RCTSS)
- Expansion of Incident Management off freeways
- Deploy and Integrate with other agencies detecting Flood Conditions
- Marketing effort for Traveler Information
- Enhance Emergency Management Operations and Coordination
- Enhance Agency-to-Agency and Agency-to-Public Outreach, Coordination/Communication

The ITS Operation Plan has been set up with short-term (0-2 years), mid-term (3-5 years) and long-term (more than 5 years) goals. Five primary projects have been identified for the short-term and mid-term periods. Additional ITS elements will be implemented as routine maintenance or as funds become available from City budgets or other sources such as TxDOT or H-GAC.

Project #1 – Wi-Fi signal system, Cabinet and Controller Replacement, CCTV cameras and Traffic Management Center

This project would install a Wi-Fi signal communication system, replace cabinets and controllers, install CCTV cameras and construct a TMC at the Missouri City Emergency Operations Center or the Public Safety Headquarters Building, which are both located on Cartwright Road. These improvements would allow the traffic signals to be monitored and adjusted from the TMC or other remote locations. The communication system contained in this report is preliminary and additional work would be required to finalize the design. A separate design project and radio frequency (RF) survey would need to be undertaken which are not a part of this current project.

This project would include replacing all remaining NEMA TS1 controllers and cabinets with NEMA TS2 controllers and cabinets. Also, Ethernet faceplates would be added to all controllers that are not yet equipped with them. The primary advantages of the NEMA TS2 controllers and cabinets are improved standardization of equipment, improved standardization of communications and inclusion of the latest NEMA standards for traffic signal equipment. The NEMA TS2 standard reduces the amount of wiring in the cabinet and also provides for the latest operation and functionality with the ATMS.now communications and operations software system.

CCTV cameras would also be installed at selected intersections with this project. The CCTV cameras would allow City personnel to monitor the primary roadways within Missouri City. Signal timing could be adjusted remotely to accommodate unusual traffic conditions such as lane closures caused by a crash or a stalled car. The CCTV cameras could also be used to determine what equipment needs to be sent to the scene of a crash.

For example, if there was a lot of debris on the roadway, front loaders, dump trucks and street sweepers may be needed. The VIVDS cameras will also be able to transmit video, but the views will be fixed. The CCTV cameras will allow the operator to pan, tilt, and zoom which provides better functionality. The TMC will be the nerve center for the ITS system and will monitor and control all ITS components. The staff at this location will be able to alter traffic signal timings, request equipment or emergency personnel to handle crashes or other issues causing delays and provide information to the public.

This project consists of short-term and mid-term phases to construct the communication system in phases to distribute the cost of the system over several fiscal years. The basic system architecture will provide point-to-multipoint high speed connections. All high speed multipoint communications will connect to the TMC. Local sub-systems connect to one multipoint location. There would also be a few wireless access points, or "hot-spots", where City staff could access the system from the field. The project will require increased security measures because of its use of wireless connectivity. The security measures are needed to prevent unauthorized users from gaining access to the signal timing information or the camera images.

Future additions to the system may add hot-spots for public internet access at certain areas such as City Hall or area parks. UPS systems should be provided for all communications equipment and solar panels for key communications points. Also, implementation of a municipal Wi-Fi network for the entire city by a private third-party provider may be added at a future date. Additional future provisions should be pursued to provide system redundancy. This would include providing a fiber optic backbone or backhaul to provide main communication and increase bandwidth and stability.

The Wi-Fi communication network should utilize either the 4.9 GHz or 5.8 GHz frequency. The City of Sugar Land is currently planning to use the 4.9 GHz frequency, pending FCC approval. The Sugar Land system does not intend to allow any public access. Utilizing the same frequency as Sugar Land would allow for sharing of resources, redundant operation, and interagency cooperation. However, being on the same frequency may result in conflicting network communication and interference.

Utilizing the 5.8 GHz frequency would also allow for future public access at selected hot-spots such as the parks and City Hall.

The estimated construction and design cost for the initial Wi-Fi signal communication system, controller and cabinet replacement, CCTV cameras and TMC has been broken up by phases. The priority for the system installations is shown below and was based on such factors as hurricane evacuation routes, traffic volumes and importance to the City's transportation network. It should be noted that Phase 1 includes startup costs associated with the installation of equipment in the TMC and the purchase of the traffic signal control software. It is also recommended that Missouri City budget for an additional staff member to monitor the system in the TMC and other operational and replacement costs. The added staff member would have additional responsibilities related to the traffic signals during the off-peak time periods of the day.

Phase 1 (SH 6):	$680,225
Phase 2 (Murphy Road):	$183,138
Phase 3 (Texas Parkway/Gessner Road):	$313,203
Phase 4 (Cartwright Road):	$156,826
Phase 5 (Sienna Parkway and all other locations):	$635,674
Total:	$1,969,065

The primary benefits of the Wi-Fi signal communication system, CCTV cameras, and TMC will be realized by the local residents. The improved response time to crashes and reduced time to respond to signal timing issues will reduce congestion and improve travel times. It is estimated that drivers would save approximately $338,644.80 during one year of PM Peak travel periods. Additional benefits would be realized during other time periods of the day. Generally, the PM Peak in the most congested time of the day and has the highest benefit. Additional benefits could be provided during the weekends if the TMC was staffed during those times. Missouri City could staff the TMC during selected weekends such as the peak shopping period between Thanksgiving and Christmas or when other events are occurring.

This project would benefit Missouri City by improving staff time utilization efficiency. Many complaint calls regarding the operation of the traffic signals (e.g. green on a side street with no vehicles) could be checked from the TMC without sending a crew to the field location. Malfunctioning field devices such as VIVDS camera or pedestrian push buttons could be quickly confirmed. The personnel then sent to the field location could be prepared with all the require replacement equipment on the first trip to the intersection. Also, with a NEMA TS2 signal cabinet and an IP addressable power strip, signal equipment can be recycled remotely without sending personnel to the field. This can reduce late night call-outs for emergency service. Also, a technician could make minor timing corrections to the signal that would prevent a late night call-out by providing a short-term fix that would allow the major issue to be addressed during regular business hours which will reduce overtime costs. Between July 1st, 2007 and March 18th, 2008, there were thirty late night call-outs. Based on two employees for a total cost of $51.00 per hour, each four hour call-out costs the City $204.00. Prorated for one complete year, the average late night call-out cost is approximately $7,344.00 per year.

Project #2 – Webpage for TMC

After the CCTV and VIVDS cameras are operational, Missouri City should develop a webpage to disseminate the information to the traveling public. This website would provide images from the cameras on the major commuter routes such as SH 6, Murphy Road and Texas Parkway. This webpage would provide information to the traveling public and draw web traffic to the City's website. The cost of the webpage would depend on whether the City's staff creates it or if an external vendor is hired. The level of functionality would also have an impact on the cost. Provides still images from selected cameras would be considered the minimum necessary functionality for the webpage. A webpage that allows drivers to request e-mail alerts, access images from all CCTV cameras and VIVDS, and a route builder would cost more to develop. Additional data storage capability may also be needed due to increased website traffic. In the future, travel time information and a speed map like the one found on the TranStar website could be added to the Missouri City website. The projected cost for the webpage development is between $20,000 and $100,000.

Project #3 – Add UPS to all signals

This project would add UPS to all the traffic signals in Missouri City. The City has already begun to require UPS on all new traffic signals constructed by private developers. The UPS units improve safety by running the traffic signals during short-term power outages. They also reduce costs to the City by reducing the need for police to control traffic at the intersections during power outages or having public works staff place temporary stop signs. The cost of the UPS is approximately $5,000 per intersection or approximately $195,000 for the entire city.

Project #4 – Install AVI Tag Readers

AVI tag readers provide travel time information that can be used to monitor traffic congestion and delays. Information from the AVI tag readers can be tracked over time to determine the actual impact increased traffic volumes are having on the primary roadways in Missouri City. The information can also be provided to the traveling public through a website to allow drivers to alter the time they leave for work or select another route. For example, if SH 6 has a major incident that is creating heavy delays, a motorist could decide to use the Fort Bend Parkway Toll Road instead. The estimated cost for Project #4 is $261,000.

Project #5–Install Countdown Pedestrian Signals

This project would replace the existing pedestrian signals with countdown pedestrian signals. The countdown pedestrian signals will provide more information to pedestrian crossing the street. There will also be a reduction in electrical costs for the intersections that still have incandescent pedestrian signals. The cost to install the countdown pedestrian signal is approximately $4,000 per intersection assuming eight pedestrian signals per intersection and the intersection is currently equipped with standard pedestrian signals. Installation costs at existing traffic signals without pedestrian signals and push buttons would be higher because of the need to install additional conduit and cable. The estimated cost for Project #5 is $286,000.

Additional short-term and mid-term projects to be pursued as funding is available include:

- Conversion of existing loop detectors to VIVDS (City funding)
- Additional Traffic Incident Management elements (City or TxDOT funding)
- Additional features for the traveler’s information webpage (City funding)
- Links with other regional TMCs (TranStar, Sugar Land TMC, Fort Bend EOC) (City or TxDOT funding)
- Expand Wi-Fi users to other City deparments (City funding)

- Flashing Crosswalks (City or TxDOT funding)
- In-Pavement stop bar LEDs (City or TxDOT funding)
- LED signal backplates (City or TxDOT funding)

Additional long-term projects that may be pursued if funding is available or as the technology matures include:

- Fiber Optic redundant backbone ring (City or TxDOT funding)
- Dynamic Message Signs (TxDOT funding)
- Highway Advisory Radio (TxDOT funding)
- Audible Pedestrian Signals (City Funding)
- Traffic Adaptive or Traffic Responsive Timing System (City or TxDOT funding)
- Municipal Wi-Fi system open to the public (private funding)
- VII technology (Private or TxDOT funding)
- Red-light enforcement cameras (City funding)

An ITS staffing plan was prepared based on the assumption that the five recommended ITS projects are implemented and Missouri City will need to install and maintain additional traffic signals to accommodate continued growth in the area. Missouri City currently has 39 traffic signals with seven more traffic signals expected to be operational in the near future. The job responsibility for the traffic signal technicians is normally general maintenance and trouble shooting. If Missouri City does not maintain sufficient staffing levels as the city continues to grow, needed maintenance will be delayed and response times for trouble calls will increase. As traffic signals and other ITS applications become more sophisticated, the Missouri City staff will require additional training to adequately maintain the systems and maximize use of the systems.

The proposed staffing plan for the next five years is shown below:

- Fiscal year 2008-2009: Add one position for traffic signal operation/maintenance
- Fiscal year 2009-2010: Add one position to operate TMC/coordinate traffic signals
- Fiscal year 2010-2011: Add one position for traffic signal, CCTV and Wi-Fi operation/maintenance

The signal technician staff should have the proper training and certifications. If new staff members have the proper training, their hiring salaries will reflect those credentials. Any additional training for new and existing staff will carry hard costs such as registration and travel and soft costs in lost productivity. The lost productivity will include additional time to troubleshoot and correct problems due to lack of training and the lost time during the training itself. It is usually more cost effective to hire personnel with the proper training if a short learning curve is needed. Training is available through Texas Engineering Extension Service (TEEX) and International Municipal Signals Association (IMSA) as well as other sources. The training plan should include:

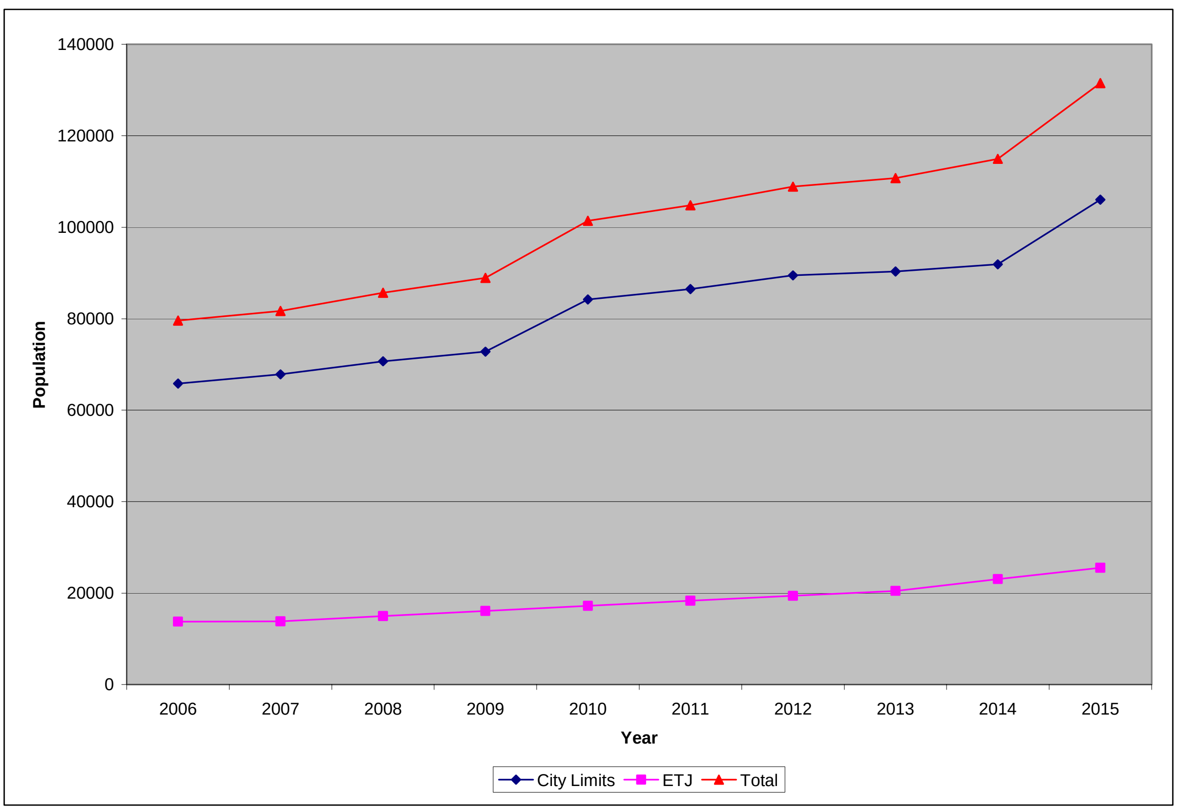
- VIVDS set-up training
- IMSA training
- NEMA TS2 cabinet training
- CCTV training (Yearly review of Policies and Procedures)
- Traffic signal timing training for TMC operators
- Fiber Optic Training
- Wi-Fi Communications operation and maintenance
- Traffic Incident Management training

Chapter 1. Introduction

The City of Missouri City is located in northeast Fort Bend County, Texas. Based on census figures, Fort Bend County grew from 225,421 in 1990 to 354,452 in 2000, a 57.2% increase in population. By 2025, it is estimated that the population of Fort Bend County will be between 793,196[1] and 917,822.[2] Based on the population projections, these two agencies project a growth factor of between 1.97 and 2.10 between 2005 and 2025 for all of Fort Bend County. Certain areas of the county will experience higher growth rates than the average for the entire county.

Missouri City had a population of approximately 79,500 within the city limits and the extra-territorial jurisdiction (ETJ) in 2006. It is projected to have a population of approximately 131,500 by 2015.[3] The projected population is shown in **Figure 1** below.

Figure 1
Projected Population of Missouri City



[1] UH-Center for Public Policy, 2005, website:http://www.uh.edu/cpp/polling.htm
[2] TX State Data Center, 2005 website: http://txsdc.utsa.edu/
[3] City of Missouri City, 2007

The projected 65% increase in population over the next nine years will increase travel times and congestion. Additional capacity has been added in recent years with the expansion of SH 6 and the construction of the Fort Bend Parkway Toll Road. However, the increase in expected population will exceed the ability of the roadway infrastructure to provide additional capacity. It has also been recognized that agencies cannot build their way out of traffic congestion because of limited resources and improved roadway networks lead to more development. Therefore, a more efficient transportation network will need to be provided to handle the additional traffic volumes.

1.1 Definition of ITS

This report concentrates on the use of Intelligent Transportation Systems (ITS) rather than other options that can be used to address congestion. Some of these other options include mass transit, mixed-use developments, or limiting development. This report also concentrates on those elements that are normally under the control of a public or private agency rather than those found in the vehicles themselves. Defining ITS can be difficult; two definitions are shown below.

Intelligent Transportation Systems (ITS) means electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system. ITS project means any project that in whole or in part funds the acquisition of technologies that provide or significantly contribute to the provision of one or more ITS user services as defined in the National ITS Architecture.[4]

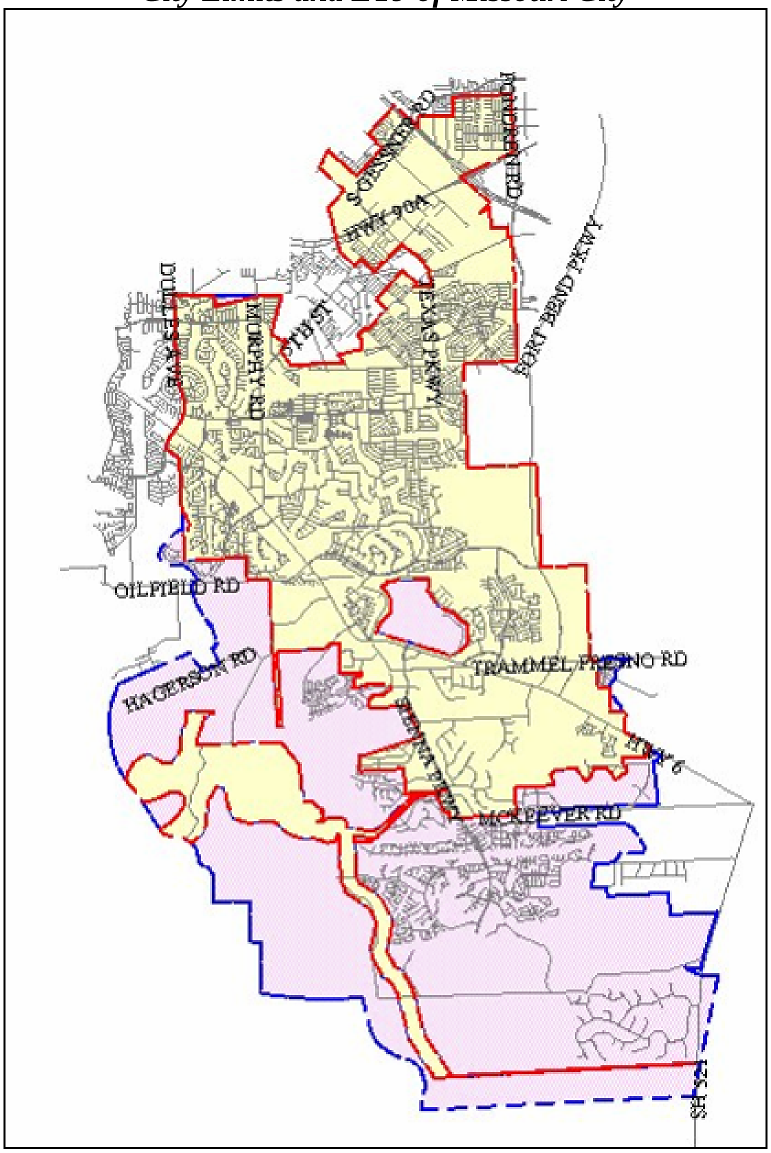
Intelligent Transportation Systems, or ITS, encompass a broad range of wireless and wire-line communications-based information, control and electronics technologies. When integrated into the transportation system infrastructure, and in vehicles themselves, these technologies help monitor and manage traffic flow, reduce congestion, provide alternate routes to travelers, enhance productivity, and save lives, time and money.[5]

[4] Section 940.3 in the FHWA Final Rule, January 2001,
website: http://ops.fhwa.dot.gov/its_arch_imp/archrule_final_1.htm
[5] ITS America website: http://www.itsa.org/what_is_its/c8/What_is_ITS.html

1.2 Purpose of Report

The purpose of this report is to provide the City of Missouri City a staffing and operation plan for ITS solutions to provide a more efficient transportation system. The ITS plan will provide direction to implement solutions to meet local and regional transportation goals. Improving the efficiency of the roadway infrastructure and providing the traveling public more information will reduce the need to construct new roadways and widen existing roadways. **Figure 2**[6] shows the current city limits outlined in red and the ETJ in light purple.

Figure 2
City Limits and ETJ of Missouri City



[6] City of Missouri City website: http://ims.ci.mocity.tx.us/zoning/viewer.

1.3 Expected Benefits

ITS projects improve safety and efficiency of the transportation networks. Some of the benefits provided by ITS projects include:

- Improved travel times
- Reduced vehicle delays
- Reduced fuel consumption
- Improved air quality
- Reduced collisions
- Improved incident response times
- Providing real-time information to travelers

1.4 Structure of Report

This report is comprised of the following chapters:

- Introduction
- Goals and Objectives
- Existing Conditions
- Communication Network Problems and Need
- ITS Options
- System Architecture and Functional Requirements
- ITS Operations Plan
- ITS Staffing Plan

Chapter 2. Goals and Objectives

The Goals and Objectives for the ITS 5-year Operations Plan are to develop an organized approach to implementing ITS that is in line with the Houston Regional ITS Architecture and the Houston Regional ITS Strategic Plan. The Goals and Objectives for the ITS Plan are listed below.

2.1 Improve Safety

Traffic Incident Management (TIM) allows the agencies to identify, respond to, and clear incidents in less time. TIM can reduce incident duration by 65 percent and reduce secondary crashes by 30 to 50 percent.[7] Secondary crashes can account for 20 percent of all crashes on a roadway[8] and the likelihood of a secondary crash increases by 2.8 percent for every second the primary crash remains on the roadway.[9] The reduction in secondary crashes and incident duration provides substantial benefits to the traveling public. The following information regarding the number of reported crashes per year in Missouri City was provided by the Missouri City police department.

January 1 – December 31, 2004 – 885 crashes
January 1 – December 31, 2005 - 853 crashes
January 1 – December 31, 2006 - 847 crashes
January 1 – November 29, 2007 - 849 crashes

Responder deaths and injuries are an increasing concern, as "struck by" secondary incidents seem to be on the rise. According to the U.S. Bureau of Labor Statistics Census of Fatal Occupational Injuries, struck-by vehicle incidents accounted for 336 fatalities across all industries in 2003. More than 20 percent of annual firefighter deaths occur on the roadways. About half of the 300 law enforcement officers killed on duty each year die in vehicle-related incidents.[10] The safety improvement goals and objectives are shown below:

- Reduce frequency and duration of incidents that impact roadway capacity
- Reduce emergency response times
- Reduce first responder injuries
- Provide remote monitoring of roadway conditions

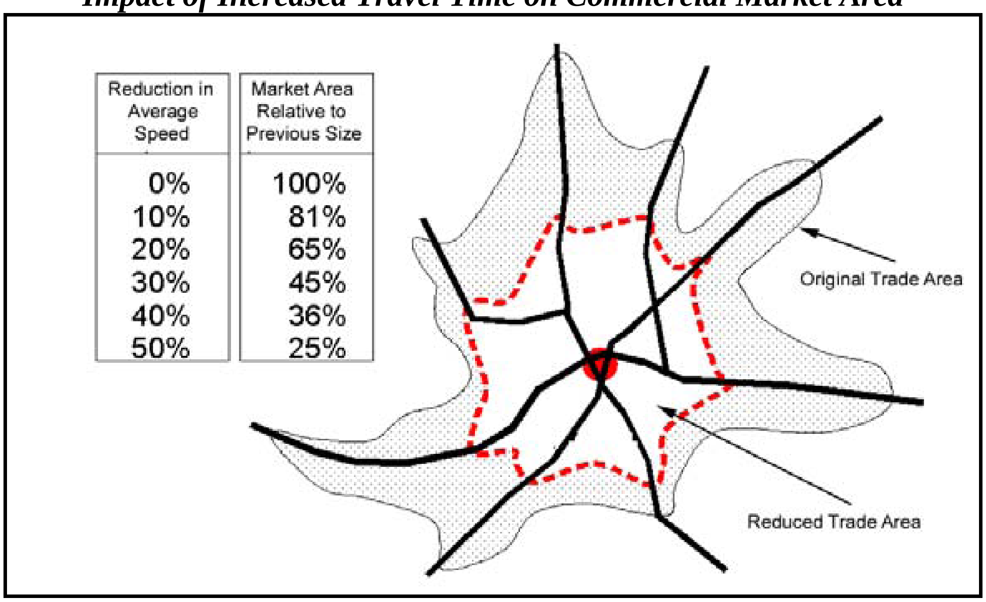
[7] Intelligent Transportation Systems for Traffic Incident Management, US Department of Transportation website: http://www.its.dot.gov/jpodocs/repts_te/14288_files/14288.pdf
[8] Federal Highway Administration Office of Operations Webpage, "Traffic Incident Management"http://www.ops.fhwa.dot.gov/aboutus/one_pagers/tim.htm
[9] Karlaftis, M.G., S.P. Latoski, N.J. Richards, and K.C. Sinha, "ITS Impacts on Safety and Traffic Management: An Investigation of Secondary Crashes," ITS Hournal, Vol. 7, No. 1, 1999, pp.39-52.
[10] National Traffic Incident Management Coalition Website, http://timcoalition.org/?siteid=41&pageid=591

2.2 Improve Efficiency

Vehicle crashes create extensive amounts of traffic congestion. One-quarter of the traffic congestion in the United States is caused by non-recurring traffic incidents. While drivers have learned to function around high levels of recurring congestion during regular peak travel periods, unexpected travel delay is especially destructive to the economy. For every minute that an Interstate lane is blocked, four minutes of travel delay result. Clearing the road quickly requires responders to work together efficiently to accomplish the many tasks involved in traffic incident management: emergency medical services (EMS), fire, law enforcement, transportation, towing and recovery, hazmat and public information.[11]

The average Houston area commuter loses approximately 75 hours each year due to traffic related congestion.[12] In 2004, idled trucks cost the trucking industry 243 million hours, 17,000 work years and $8 billion nationwide. Ultimately, consumers pay when incident-related delay drives up freight costs.[13] In addition to saving drivers time and money, reduced travel times can expand the market area of the City's retail developments. **Figure 3**[14] shows the detrimental effects of congestion on commercial market areas. Reversing the trend by increasing speeds would result in a larger market area.

Figure 3
Impact of Increased Travel Time on Commercial Market Area



[11] National Traffic Incident Management Coalition Website, http://timcoalition.org/?siteid=41&pageid=591
[12] Texas Transportation Institute, Urban Mobility Report
[13] National Traffic Incident Management Coalition Website, http://timcoalition.org/?siteid=41&pageid=591
[14] Transportation and Land Development, ITE, 1988, 2002

By implementing ITS technology, Missouri City intends to improve the transportation network, quality of life and economic health of the region. The ability to easily collect travel time data and vehicle volumes will allow City staff to measure the effectiveness of selected improvements and determine where additional measures are needed. The roadway efficiency goals and objectives are listed below:

- Reduce congestion
- Improve Capacity
- Reduce travel time
- Establish traffic vehicle data collection procedures

2.3 Reduce Environmental Impacts

Approximately 2.3 billion gallons of fuel are lost per year in the US while drivers sit in traffic.[15] Reducing congestion also reduces vehicle emissions that degrade air quality in the region. The greater Houston area is a non-attainment zone for air quality, which can threaten federal funding for roadway projects. Reducing fuel consumption and vehicle emissions improves the quality of life for all area residents. The environmental impacts goals and objectives are listed below:

- Reduce fuel consumption
- Reduce air emissions

2.4 Provide Information to Travelers

ITS can be used to disseminate real-time traveler information via websites, e-mails, text messages, radio or television broadcasts, Dynamic Message Signs (DMS) or other media. Drivers can use this information to select alternate routes to avoid incidents or congestion. Houston TranStar already uses information obtained from Automatic Vehicle Identification (AVI) tags (Harris County Toll Road Authority EZ Tags) to determine travel times on area freeways. Drivers can also have e-mail or text messages sent to them when there are incidents on the normal commute route so they can select alternatives. These concepts are already being utilized on arterial streets. The goals and objectives for providing information to travelers are listed below:

- Provide real-time travel information to travelers
- Provide incident information
- Establish link with Houston TranStar, Sugar Land Traffic Management Center (TMC) and Fort Bend Emergency Operations Center (EOC)

[15] U.S. Department of Transportation, National Strategy to Reduce Congestion on America's Transportation Network, Washington, DC: May 2006. Report: http://www.isddc.dot.gov/OLPFiles/OST/012988.pdf.

2.5 Provide Cost Effective ITS Solutions

Some ITS components result in minimal cost increases over their non-ITS counterparts. Others require substantial investments by the agencies involved. One primary goal of this study is to identify which ITS components can be implemented quickly and in a cost effective manner while maintaining as much of the existing infrastructure as possible. Elements that will require more investment, training, planning or that required technology that has not yet matured will be included in the mid-term or long-term goals.

Another goal is to reduce duplication of effort between the City's departments and improve cooperation and resource sharing with other agencies. The City can save costs if several departments effectively share resources. The ITS plan will aid in coordinating traffic signal timing between adjacent agencies, improving the efficiency of the regional transportation network. The cost effectiveness goals and objectives are listed below:

- Leverage existing infrastructure
- Share resources between City departments
- Share resources with adjacent local and state agencies

2.6 Provide Plan for ITS Deployment and City Staffing

The ultimate goal for this study is to provide a plan for the City of Missouri City to follow over the next five years while implementing ITS technologies. This plan will identify projects for the City to pursue to reduce congestion, increase roadway efficiency and improve the quality of life for the area residents. The study will also identify the staffing needs to properly implement and monitor the ITS components. The study will also identify possible funding sources for the ITS implementation. These funding sources will primarily be the City, Texas Department of Transportation (TxDOT), and Houston-Galveston Area Council (H-GAC) but may also include Fort Bend County, Harris County or METRO. The ITS deployment goals and objectives are shown below:

- Establish 5-year ITS deployment plan
- Establish 5-year staffing needs
- Identify funding sources for projects

Chapter 3. Existing Conditions

Missouri City already incorporates ITS technology into the City's traffic signals and other infrastructure. This chapter documents the existing ITS equipment that is in use or will be in use soon.

3.1 Traffic Signals

The City of Missouri City currently has 39 traffic signals with seven proposed signals to be constructed in the near future. These traffic signals are organized into five existing signal systems as shown below.

- SH 6 from Lake Colony Drive/Colonial Lakes Drive to Fort Bend Parkway Toll Road
- Murphy Road (FM1092) from Lexington Boulevard to Hampton West
- Texas Parkway (FM 2234) from US 90A to Turtle Creek Drive
- Cartwright Road (FM 3345) from Quail Village Drive to Quail Valley East Drive
- Sienna Parkway from SH 6 to Steep Bank Trace

Signals that do not fall within these limits are not currently operating in a signal system. **Appendix A** shows the locations of the existing and proposed traffic signals as well as the existing signal systems.

The existing signal systems have different communications media. Texas Parkway, Cartwright Road and Murphy Road have existing 25-pair, twisted copper cable. US 90A will have 25-pair, twisted copper cable when construction is complete. SH 6 has fiber optic cable (a 24-fiber strand cable which is shared with Sugar Land) from Settlers Way Boulevard to Watts Plantation Road (future signal). The fiber optic cable will be extended to Creekmont Drive with the installation of a traffic signal at that intersection. The traffic signals on Sienna Parkway have a spread spectrum radio system and are fiber optic and Ethernet ready. Fiber optic communications should be operations on Sienna Parkway in 2008. **Appendix B** shows the existing communication types.

Missouri City controls the traffic signals with the Naztec Streetwise Advanced Traffic Management System (ATMS) software, which communicates with the Naztec controllers and cabinet facilities. A new version of the software is available (known as ATMS.now) that provides additional features and functionality. Currently, the SH 6 system master at Lake Colony and the Murphy Road system master at El Dorado are accessed though separate dial-up phone line communication. Access to the secondary signal intersections can be achieved through the system masters.

The existing fiber optic cable on SH 6 within the City of Missouri City limits was installed through a TxDOT contract and has TxDOT, Missouri City and Sugar Land communications. Missouri City has an Interlocal Agreement with Sugar Land to monitor the traffic signals along SH 6 from Sugar Land's TMC facility. Sugar Land provides standard alarm polling services, access to traffic signal timing databases and operational consulting services through this Interlocal Agreement.

Various traffic signal cabinets are in service within the City of Missouri City. The basic cabinet types are National Electrical Manufacturers Association (NEMA) TS1 and TS2. Most of the cabinets are the Naztec NEMA P44 type with some Econolite NEMA P44 type cabinets on Texas Parkway. The remaining cabinets are the Naztec Metro NEMA TS1 type. All NEMA TS1 controllers are currently Naztec brands with various controller versions. The newer and latest types of NEMA TS2 cabinets and signal controllers are also Naztec. Currently, the only signalized intersections with Uninterruptible Power Supply (UPS) are the new signals on Sienna Parkway.

Missouri City has been converting the vehicle detection for the traffic signals from inductive loops in the pavement to Video Imaging Vehicle Detection (VIVDS) cameras. There are three brands of VIVDS in Missouri City: Eagle, Traficon and Econolite. The VIVDS are currently used for vehicle detection and system detection. There is currently no equipment or infrastructure in place for sending video images back to a central location. The signal locations with the current type of vehicle detection are shown in **Appendix C**.

3.2 Driver Feedback Signs/Dynamic Message Signs

Missouri City currently has driver feedback signs (electronic speed signs) on Gessner Road near Cravens and on Sienna Parkway near Watts Plantation. These signs show the drivers their speed and flash if the driver is exceeding the speed limit. Additional driver feedback signs will be added on Lake Olympia Parkway near the marina in 2008. Missouri City does not have any fixed Dynamic Message Signs but does have portable static message signs used for special events or hurricane evacuations.

3.3 School Zones

Missouri City maintains chronomax flashers at the school zones within the city. The solar school zone systems receive power via a solar charged battery system. There are two basic operations for school zone systems. One system lacks communications and must be manually programmed and the other uses a paging system that only receives data from a broadcast paging signal and cannot transmit alerts back to a central location. This does not allow the field units to transmit alerts back to the maintenance staff. The current Naztec Streetwise ATMS system software cannot communicate with the Naztec chronomax pager system. **Appendix D** shows the current schools and school zones. **Appendix E** shows the locations of school flashers.

3.4 Flashing Crosswalks

Missouri City has installed a flashing crosswalk at Grand Park Drive and Pine Hollow Drive to provide access to Hunters Point Park. If this crossing is determined to be a success, additional flashing crosswalks may be added at other locations in the future.

3.5 Police Department

The Missouri City Police Department operates a communications trunk system on the 800 megahertz (MHz) frequency. This system is shared with the City of Sugar Land and the City of Stafford. Fort Bend County operates a separate communications trunk system on the 800 MHz frequency. Interagency communications are possible between the adjacent agencies.

The police department utilizes Computer-Aided Dispatching and Automatic Vehicle Location (AVL) systems. The AVL allows the dispatchers to determine which car is closest to an incident and also allows them to advise officers to adjust their locations to adjust coverage of the City in order to reduce overall response times. The police cars are also outfitted with Mobile Data Terminals (MDTs), which provide information to the police officers in the field to supplement the radio communications and operate through the use of air cards.

The police vehicles also have camera systems that record images in front of the vehicle. The cameras are primarily activated when the emergency lights are activated. The camera system begins recording and maintains the images captured thirty seconds prior to the emergency lights being activated. The current recording system uses Moving Picture Experts Group (MPEG) MPEG-4 recording format. The disk with the recorded images is manually removed from the vehicle, placed in a docking station and uploaded to the system server inside the police station.

The police department vehicles are equipped with emergency pre-emption emitters. These emitters notify the traffic signals that an emergency vehicle is approaching and terminates the green phase that is currently being served and then provides a green indication for the approaching emergency vehicle. The emitter is activated with the emergency lights. The police department is currently not using coded emitters, which prevents Missouri City from enabling certain features of the pre-emption system. The police department should begin to purchase emitters that match the receivers on the traffic signals so that all options of the system could be utilized. The primary feature that this would enable would be the prevention of unauthorized pre-emption by drivers that purchased emitters from the internet.

3.6 Fire Department

The fire department operates on the same 800 MHz trunk system as the police department. The fire department does not have MDTs or cameras on the fire trucks. The fire department vehicles are equipped with emergency pre-emption emitters. These emitters notify the traffic signals that an emergency vehicle is approaching, terminates the green phase that is currently being served and then provides a green indication for the approaching emergency vehicle. The emitter is activated with the emergency lights. The fire department is using coded emitters.

The fire station on Cartwright Road has advance warning flashers that are activated manually by a console in the fire station. These flashers warn approaching motorists that the fire truck is about to leave the station. **Appendix E** shows the location of the fire station flashers.

3.7 High Crash Locations

The Missouri City Police Department supplied information related to the highest twenty crash locations between 1998 and 2007. **Appendix F** shows these locations and lists them by highest number of crashes rather than rates. Rates are considered a better analysis tools but are not available at this time because of the range in the number of years and the changes in traffic volumes that have occurred in the Missouri City area over this time period. The summary also did not provide information regarding the trend of the crashes. The number of crashes may be increasing as the years progress but the crash rate may be decreasing due to the increase in traffic volumes. A yearly analysis of the crash numbers and crash rates would help identify locations that should be evaluated for improved safety measures.

3.8 Traffic Generators

Major traffic generators create traffic and congestion either at specific times of the day or throughout the day. Local traffic generators may have an impact on a specific intersection and usually have a higher percentage of pass-by traffic, which is traffic that decides to enter a business only as it drives past. Examples of this type of generator are fast food restaurants and gas stations. Larger traffic generators draw from a larger area and are usually primary destinations. Examples include large retail establishments, employment centers and office buildings. Major traffic generators in the Missouri City area are identified on the map located in **Appendix G**.

Chapter 4. Communication Network Problems and Needs

There are many gaps in the service provided by the existing Communications Infrastructure of Missouri City. This section discusses the Communication Network Problems and Needs.

4.1 Public Works Department Communications

Not all field devices can be accessed remotely from city buildings. This requires that city personnel travel to the actual field device to determine if the device is operational. It also prevents the field devices other than the traffic signals along SH 6 from sending alarms or notifications to the city staff.

Currently, remote field devices such as traffic signals and water treatment plants are accessed by phone communications such as dial-up modems, Integrated Services Digital Network (ISDN) lines or T1 lines. The T1 access costs are approximately $800 per month per location. Utilizing Missouri City owned fiber optic lines or wireless technology would reduce the recurring fees paid to telecommunications companies. ISDN communications do not provide enough bandwidth to allow the transmission of full motion video from existing traffic signal video or the future traffic closed circuit television (CCTV) cameras.

Having the field devices connected to a central location would provide more functionality and allow the city staff to perform their duties more efficiently. For example, if a resident calls the city to report a traffic signal is malfunctioning, the signal could be accessed from the proposed TMC. The signal technician may be able to verify a malfunction and be able to address the problem from the TMC within minutes of receiving the call of the malfunction.

The Communication Needs for the public works department are:

- Remote access to field devices
- Upgrade signal control software to ATMS.now
- Reliability
- Security
- Sufficient bandwidth for CCTV and VIVDS camera video
- Cost savings
- Reduction in monthly ISDN and T1 costs
- Reduction is staff time for troubleshooting

4.2 Police Department and Fire Department Communications

The communications system for the police department and fire department will be undergoing some changes in the near future. The Federal Communications Commission (FCC) has initiated an effort to make changes to several communication frequencies. Emergency Services are being rebanded from 800 MHz to a different frequency because of interference from other devices operating at 800 MHz such as phones. Missouri City has initiated efforts to modernize equipment to operate at the 700 MHz frequency. Missouri City also has a valid license for the 4.9 MHz public services frequency band, which is reserved for public safety use. This 4.9 MHz license could be used for the transmission of data, including video images, to police cars and other employees using wireless technology.

The Police Department has MDTs with aircards to provide supplemental information to the police cars. Missouri City pays a monthly fee for the use of the aircards, which is approximately $50 per card per month. The cost of aircards could be decreased by the implementation of a municipal Wi-Fi service. For example, the City of Corpus Christi has implemented a municipal Wi-Fi network that covers approximately 90% of the City. The Corpus Christi MDTs are still equipped with aircards which only become active if the police car is not in range of the Wi-Fi network. This has reduced the cost of the aircards for Corpus Christi because the contract was negotiated to be on a usage basis rather than per month. The aircards also become active if an officer travels outside the jurisdiction of Corpus Christi to provide support for another police agency.

The Communication Needs for the police and fire department are:

- Replace all non-coded pre-emption emitters with coded emitters
- Reduction in monthly aircard costs
- Implementation of communication frequency rebanding

Chapter 5. ITS Options

This chapter provides a brief summary of some of the ITS options that are available and were evaluated. The number and complexity of the ITS options available preclude a comprehensive discussion of each element.

5.1 Communication Network

This project evaluated communication networks and current technology capable of providing a global, citywide system solution with sufficient bandwidth and sustainability to enable the operation of all existing and proposed ITS field equipment. The primary communication mediums available are fiber optic cable, Wi-Fi systems, spread spectrum systems, communication cable like hardwire Ethernet or twisted pair cable. Due to the current limits on communication cable, Ethernet cable and hardwire cable, those mediums were not considered compatible with the future needs of the City. The remaining three options with their key advantages and disadvantages are shown below.

- Fiber Optics
    - Advantages
        - Virtually unlimited bandwidth (colors)
        - Minimum 100,000 times faster than copper
        - Better stability
        - Better video quality
        - High security
        - No electrical noise or interference
        - Most reliable signal path
        - Preferred backbone or backhaul media
        - Most cost effective for high speed, high volume needs (megabits per second)
    - Disadvantages
        - Initial construction cost is high
        - Susceptible to being cut by nearby construction projects
        - Higher repair costs when damaged
        - Less flexible (not easily relocated)
        - Difficult signal switching technology
        - Most expensive “Last Mile” connection
- Spread Spectrum
    - Advantages
        - Low installation cost
        - Fast installation
        - High security
        - Easy to expand

    - Disadvantages
        - Line of sight required
        - Noise and interference issues
        - Electrical issues
        - Lower bandwidth
- Wi-Fi
    - Advantages
        - Low installation cost
        - Low expansion costs
        - Can provide access to mobile users (Police, etc.)
        - Better interoperability
        - More flexible
        - Best signal switching technology
        - Cheapest "Last Mile" connection
    - Disadvantages
        - Lower security
        - Noise and interference issues
        - Electrical issues
        - City competing with private business if open to public access

Wi-Fi networks can be set up to operate at different frequencies. Each frequency has its own advantages and disadvantages. The primary frequencies for Wi-Fi networks are 900 MHz, 2.4 gigahertz (GHz), 4.9 GHz (reserved for public safety), and 5.8 GHz. The advantages and disadvantages of the different frequencies are shown below.

- 900 MHz
    - Advantages
        - Mature technology
        - Penetrates foliage and buildings better
        - Private users migrating to other frequencies
    - Disadvantages
        - Lower bandwidth
        - Lower speed
        - May become hard to find replacement parts as industry moves ahead
- 2.4 GHz
    - Advantages
        - Mature technology
        - Higher bandwidth than 900 MHz
        - Common usage among private users
        - Easy to find compatible equipment
        - Some users migrating to other frequencies

- Disadvantages
    - Less secure because many users have equipment for this frequency
    - Interference with other users on same frequency (Note: High broadcast strength of the City system may cause interference with private users. This may cause legal or public opinion problems)
    - Replacement parts may become hard to find as industry moves ahead
- 4.9 GHz
  - Advantages
    - Few other users
    - More secure since few users would operate on same frequency
    - Higher bandwidth than 900 MHz and 2.4 GHz
  - Disadvantages
    - Requires special modems (not available through many retailers)
    - Less foliage and building penetration
- 5.8 GHz
  - Advantages
    - Higher bandwidth than 900 MHz, 2.4 GHz, and 4.9 GHz
    - Becoming more common among private users
  - Disadvantages
    - Less secure since many users will have equipment for this frequency
    - Interference with other users on same frequency (Note: High broadcast strength of the City system may cause interference with private users. This may cause legal or public opinion problems. This issue would be less pronounced if the City is an early user of the frequency)
    - Less foliage and building penetration

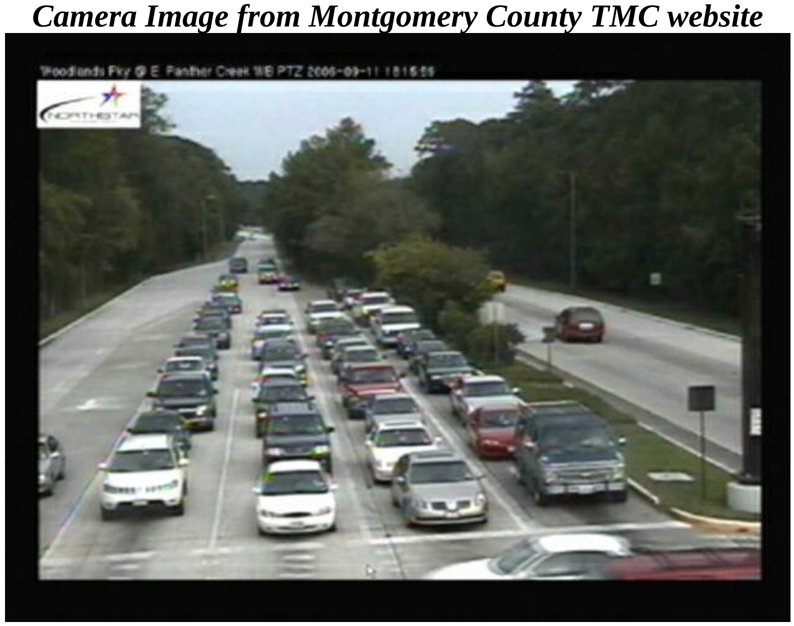
Other cities have already installed municipal Wi-Fi networks similar to what could be installed in Missouri City. The City of Corpus Christi has developed a municipal Wi-Fi network. The wireless network currently covers approximately 90% of the city. This system has recently been sold to Earthlink. There are approximately five wireless access points per square mile. Earthlink plans to triple the number of wireless access points per square mile. The Corpus Christi network has a fiber optic backbone that connects to 80% of the traffic signals and provides the primary backhaul for the Wi-Fi network.

5.2 Traffic Management Center

Missouri City intends to build and operate a Traffic Management Center (TMC). The TMC would allow staff to manage ITS components, observe traffic issues and remotely adjust traffic signal timing. Area roadways would be monitored through the use of CCTV or VIVDS cameras. If an incident occurs, staff could request emergency vehicles as needed and adjust the traffic signal timing to reduce congestion. At the agency's discretion, the images from the cameras could be made available to the public through a website to allow drivers to check area roadway conditions prior to leaving home or work and select an appropriate route. **Figure 4** below shows the Sugar Land TMC located at 111 Gillingham Lane. **Figure 5** shows an image available from the Montgomery County TMC website (http://mctraffic.org/mctraffic.html).

Figure 4
Sugar Land TMC

Figure 5
Camera Image from Montgomery County TMC website



The TMC will be located in the Emergency Operations Center (EOC) or the Public Safety Headquarters Building that are both located on Cartwright Road. Due to limited space, it is expected that the TMC will be approximately ten feet by ten feet. The recommended minimum dimensions for the TMC are sixteen feet by twenty five feet, which excludes room for the majority of the computer and video hardware. A room of this size will provide space for two workstation locations, a conference table, multiple video screens and additional seating for observers. **Appendix H** shows potential layout option for both sizes of the TMC.

The TMC will require a significant investment in computer equipment and furniture. The list of equipment below will be needed to make the TMC functional.

- Computer requirements
  - Workstations (2)
  - Servers (3) – File server, Communication server, Administration server, TMC server, video server (spread across the 3 servers)
- Video Screens (2 minimum)
- Hardware and software for CCTV camera control (must be expandable, ability to control multiple camera brands)
- Digital video recording (Latest video format)
- Furniture (desks, chairs, conference table)
- Power requirements
- Uninterruptible Power Supply
- Graphics cards
- Connectivity to the existing Missouri City Local Area Network

A long-term goal for the Missouri City TMC is coordination with other TMCs within the region. These include Houston TranStar, Sugar Land TMC and the Fort Bend Emergency Operations Center located in Richmond. This would allow for coordinating responses and sharing information during regional events such as hurricanes. SH 6 is a major hurricane evacuation route which crosses through the jurisdiction of multiple agencies (TxDOT, Missouri City, Sugar Land, Fort Bend County and others).

5.3 CCTV Cameras

Closed Circuit Television (CCTV) cameras with pan, tilt, and zoom (PTZ) capabilities are recommended at strategic locations. The cameras would be primarily located on key traffic signals along the major arterials in Missouri City. Additional cameras could be added to allow City staff to monitor areas of frequent flooding, area parks or other areas of traffic congestion or concern. The CCTV cameras would be used to observe the arterial street system or area traffic generators to allow staff to adjust signal timing as needed or to verify a crash and deploy needed personnel to clear a crash quickly. Two styles of CCTV cameras are show in the photos below.

The initial installation of the CCTV cameras should be on SH 6 because it is the primary hurricane evacuation route through Missouri City and has existing fiber optic cable available between the traffic signals. The priority for installation of CCTV cameras would be:

1) SH 6
2) Murphy Road
3) Texas Parkway/Gessner Road
4) Cartwright Road
5) US 90A
6) Drainage areas and City Parks
7) Sienna Parkway

The CCTV cameras should have the following characteristics:

- Pan, tilt, zoom
- Color
- Internet protocol (IP) addressable
- Presets to preferred locations
- Blackout-capable for privacy issues (with overrides)
- Security status (requires password)
- Department use priority (signal staff have priority over Parks and Recreation staff checking on event)

A policy and procedures manual will need to be developed for the CCTV camera use. Training of personnel is essential for proper use. This training includes awareness of camera view location if accessible to public for viewing, proper use (i.e. cameras near pools or parks) and supervision of camera use and audits to insure the staff are using the cameras properly. A sample policy from Houston TranStar can be found in **Appendix I**.

5.4 Traffic Signals

A multitude of ITS components are available for traffic signals. Some of these elements are described below.

5.4.1 Traffic Signal Controllers and Cabinets

Missouri City plans to convert all existing NEMA TS1 traffic signal controllers and cabinets to the NEMA TS2 standard. The NEMA TS2 standard provides standardized equipment, improved standardized communications and latest NEMA standards for traffic signal equipment. The NEMA TS2 standard reduces the amount of wiring in the cabinet and also provides for the latest operation and functionality with ATMS.now communications and operations software system. The ATMS.now system can provide increased functionality for the City of Missouri City's signal system.

The existing Naztec NEMA P44 TS2 cabinets are limited in cabinet and shelf space. The need for increased cabinet space suggests the need for an enlarged NEMA P rack type cabinet. It is recommended that the outer communications loop (in the long-term) uses the enlarged NEMA P rack type currently produced by Naztec to provide the space needed for additional equipment.

The Missouri City ITS plan calls for increased equipment and infrastructure. The communication plan also calls for creation of a communications system and a long-term redundant communications loop.

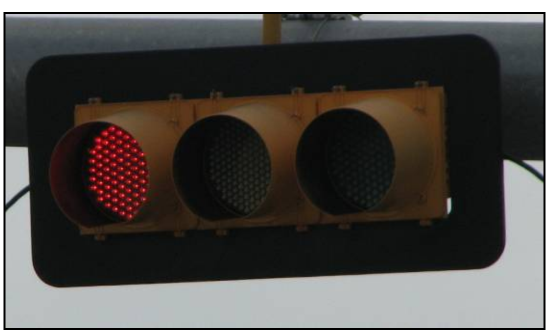
The Missouri City ITS plan provides for higher traffic signal security, reliability and efficiency. The plan's traffic signal operations ensure time and date updating and monitoring. Additional intersection communications allows for the real time monitoring of cabinet issues of intrusion, current failures and operations, and traffic signal timing database integrity. Additional communications with traffic signals can include an auto paging system that can give instant paging messages, email or voice messages to alert staff of critical issues.

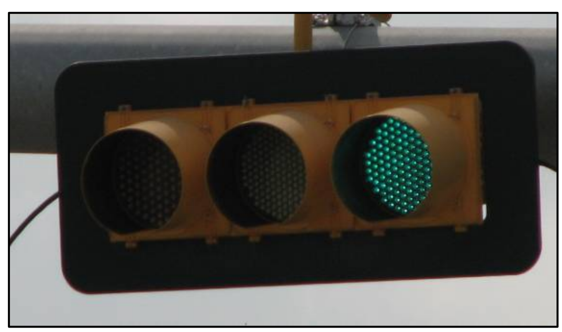
5.4.2 Traffic Signal Control Software

Traffic signal control software allows City staff to monitor, troubleshoot and adjust traffic signal timing from a remote location such as the TMC or a computer laptop in the field. Currently, Missouri City uses Naztec NEMA TS1 and NEMA TS2 traffic signal controllers. The latest control software for Naztec controllers is ATMS.now. This software provides the ability to adjust cycle lengths, phase splits, and other changes to the signal timing. The software can also generate time-space diagrams for the current timing plans and provides a graphical interface for the City staff to watch while monitoring the signal timing changes. Vehicle counts, alarms and other information are also available.

5.4.3 Light Emitting Diode Signals

Missouri City already uses Light Emitting Diode (LED) traffic signals at most locations and is in the process of updating the remaining signals. LED signals reduce energy consumption by as much as 80%. The Energy Policy Act of 2005 requires that all traffic signal and pedestrian modules manufactured after January 1, 2006 be LED. Therefore, finding incandescent replacements for the older traffic signals will become difficult. Although energy conservation is the motivation for the legislation, LED signals also reduce maintenance because they do not require the replacement of bulbs as often as the incandescent signals. Although LEDs have proven to be susceptible to lightning storms, it may be possible to reduce the impact of lightning storms by installing UPS systems in the traffic signal controller cabinets to reduce power spikes and clean the power supply.





5.4.4 Vehicle Pre-Emption

Vehicle pre-emption[16] interrupts the normal signal sequence to give a green light to an approaching emergency vehicle which improves response times. Some entities equip all their emergency vehicles (fire, police and EMS) with the pre-emption devices. Other entities restrict which services are equipped with the pre-emption capability. Pre-emption capabilities can also be given to mass-transit buses with a lower priority than emergency vehicles. Missouri City requires pre-emption devices on all traffic signals. The existing equipment on the Missouri City traffic signals has the ability to code the signal to prevent unauthorized use, track which units use the system and manage usage. These features are not currently enabled because the emitters used by the Missouri City Police Department are not matched to the receivers on the traffic signals. Enabling the features would prevent the police cars from pre-empting the traffic signal. It is recommended that the police department begin to purchase emitters that match the receivers.

5.4.5 Vehicle Detection

Vehicle detection allows the traffic signals to allocate green time based on traffic demand. Vehicle detection is normally provided by the following options:

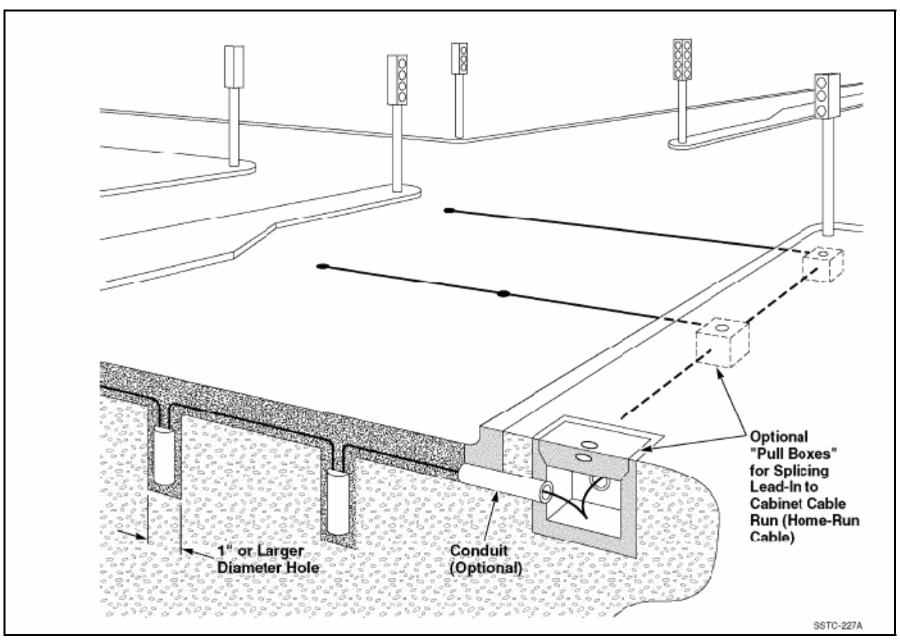
- Loop Detectors

[16] Image courtesy of 3M website: http://multimedia.3m.com/mws/mediawebserver?66666UuZjcFSLXTtN8TE4xz6EV76EbHSHVs6EVs6E666666--

- Video Imaging Vehicle Detection (VIVDS) cameras

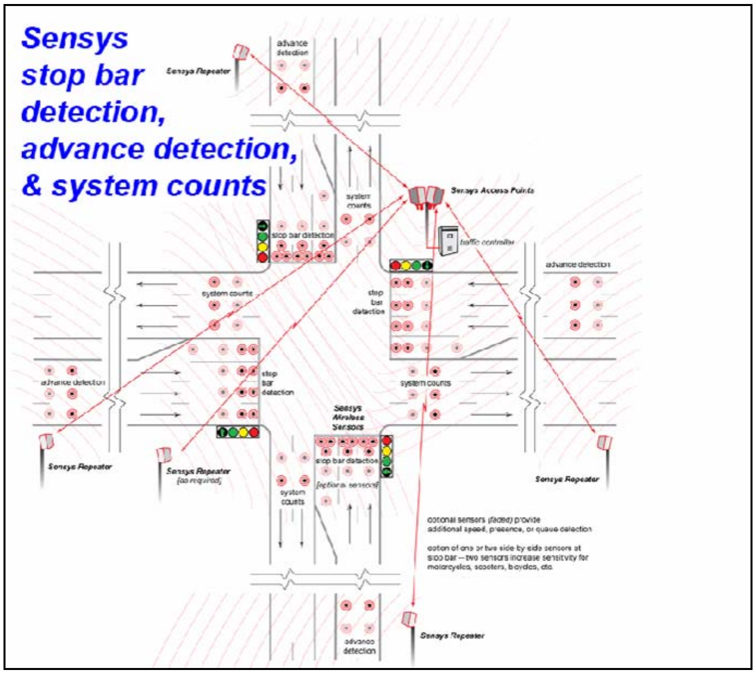
- Microwave Detectors

- Microloop Probes[17]



[17] Image courtesy of 3M website: http://multimedia.3m.com/mws/mediawebserver?66666UuZjcFSLXTt5XfXoX46EVuQEcuZgVs6EVs6E666666--

- SENSYS wireless system[18]



Missouri City is currently converting all traffic signals to VIVDS detection. Loop detectors are cut into the pavement and are susceptible to malfunctions caused by shifting pavement and contractors working nearby that may cut the loop leads. Also, loop detectors are cut into the pavement which may cause pavement damage and reduce the service life if not installed correctly. The primary advantage of VIVDS is that the detection zones can be adjusted as needed during the life of the traffic signal. If additional detection is needed on an approach, additional zones can be provided easily. VIVDS also allow zones to be adjusted during construction activities. Newer technologies allow the VIVDS to collect vehicle counts and the images to be viewed from the TMC, providing supplemental information to the CCTV cameras.

[18] Image courtesy of SENSYS Networks http://www.sensysnetworks.com/images/full_intersection_v0.4.png

5.4.6 Uninterruptible Power Supply

Uninterruptible Power Supply (UPS) systems (also known as battery back-up) provide power during localized or widespread outages. This prevents or reduces crashes while the traffic signals are "dark" and are supposed to be treated as all-way stop signs. The duration that the UPS will operate a traffic signal depends on the size of the batteries selected and the power drain from the affected signal and can be determined by Missouri City.

Missouri City will begin to require UPS systems on all new traffic signals. The existing traffic signals will be upgraded as funds become available. The batteries will be able to operate an LED equipped typical traffic signal for a minimum of two hours for most locations.

5.4.7 Countdown Pedestrian Signals

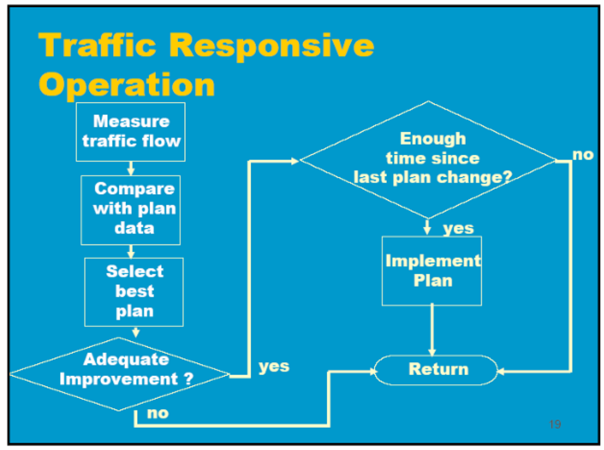
Standard pedestrian signal heads provide two indications: a "walk" indication and a "don't walk" indication. The indications usually take the form of text or symbols. A flashing "don't walk" symbol informs pedestrians to continue walking if they have started to cross the street and to not enter the crosswalk if they have not started. Therefore, the signal is trying to provide three functions with two signs. Many pedestrians do not understand what the flashing "don't walk" symbol means.

A newer technology utilizes a numbered countdown symbol display to tell pedestrians how much time they have to complete crossing the street.[19] This reduces pedestrian confusion and anxiety while crossing the street by providing them with more information. Missouri City requires countdown pedestrian signals on all new traffic signals. The existing pedestrian signals will be replaced as funds are available.

[19] Image courtesy of Advanced Traffic Products http://www.advancedtraffic.com/tassimco-p2-2.jpg

5.4.8 Traffic-Adaptive or Traffic Responsive Timing

Traffic Adaptive systems change the cycle length, phase split and offset on a cycle by cycle basis based on the traffic demand.[20] Traffic Adaptive systems improve the responsiveness of signal timings in rapidly changing traffic conditions. Various Traffic Adaptive systems have demonstrated network performance enhancement from five percent to over thirty percent.[21] ITS communication and sensor networks allow the use of Traffic Adaptive ssytems to be deployed. Traffic Adaptive systems are useful under the following conditions:



- Arterials with variable traffic flow
- Near regional shopping areas
- Near educational facilities
- Near entertainment venues (stadiums, etc.)
- Seasonal routes
- Incident corridors that run parallel to freeways

Traffic Responsive Plan Matrix

Directional Distribution/ Cycle Length	Average	Inbound	Outbound
Level 1 "Free"	Pattern 1	Pattern 1	Pattern 1
Level 2 90 sec	Pattern 2	Pattern 3	Pattern 4
Level 3 120 sec	Pattern 5	Pattern 6	Pattern 7
Level 4 150 sec	Pattern 8	Pattern 9	Pattern 10

Traffic Adaptive systems require an extensive data collection system. Volume and occupancy data is collected from vehicle detectors, grouped, and compared to user defined criteria. Difficulties with Traffic Adaptive systems include:

- Must be monitored and adjusted to prevent frequent plan changes
- Requires significant user defined change in traffic before new plan is selected
- Can be slow to react if traffic builds quickly
- Will not operate if there are too many detector failures
- Can impair coordination with crossing systems unless cross systems are set to match changes on primary arterial

[20] Images courtesy of the Institute of Transportation Engineers Professional Development Series, Advanced Signal Timing Concepts http://www.ite.org/education/advancedsignal/Advanced%20Signal%20Concepts%20(color).pdf

[21] U.S. Department of Tranportation, Turner-Fairbank Highway Research Center, "Adaptive Control Software," Turner-Fairbank Highway Research Center Report No. FHWA-HRT-04-037, Washington, DC: December 2003) (Abdel-Rahim, A. et. Al., "The Impact of SCATS on Travel Time and Delay," paper presented at the 8th ITS America Annual Meeting, Detroit Michigan, May 4-7, 1998. ITS Benefits Database Entry: www.itsbenefits.its.dot.gov/its/benecost.nsf/0/AF

Primary benefits of Traffic Adaptive systems include:

- Reduced need for timing plan updates
- More appropriate timing for incidents and special conditions

Primary disadvantages of Traffic Adaptive systems include:

- Increased cost of installation and maintenance
- Loss of control over timing plans

5.4.9 Accessible Pedestrian Signals

Accessible Pedestrian Signals (APS) assist blind pedestrians (which include those with very limited vision) that cannot see the standard pedestrian signals or locate the push buttons that call the pedestrian phase. There are products on the market that emit a locator tone for the push button and sounds to inform the blind pedestrian when the pedestrian signals are active. The sounds for the walk signal can be a human voice that tells the pedestrian which signal is green or a combination of chirps and whistles. The direction for the chirp and the whistle is standardized throughout the country.

The proposed *Guidelines for Accessible Public Rights-of-Way*[22] would require that any new or modified traffic signal have APS technology. However, it is not currently known when these guidelines will be officially adopted and become mandatory. Missouri City will begin to require this type of equipment on all new traffic signals. The existing equipment will be replaced as funds are available.

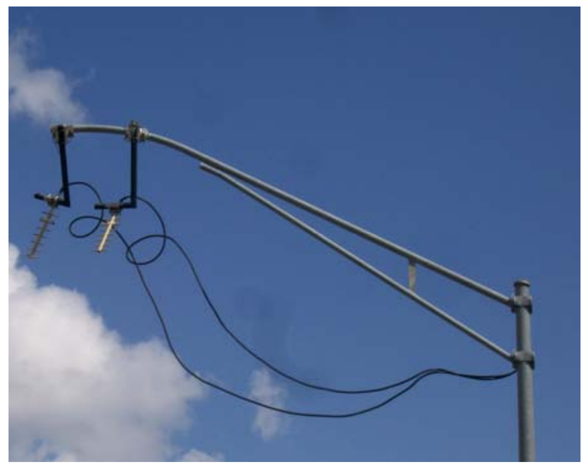
5.4.10 Vehicle Infrastructure Integration

ITS America and its associates are currently working on a pilot program for future technology called Vehicle Infrastructure Integration (VII).[23] A specially equipped van receives information from specially equipped traffic signals or construction zones. The information is transmitted to the drivers with visual displays and audible announcements. The type of information transmitted include informing the driver they are entering a construction zone, the traffic signal ahead will turn red before they reach the intersection or that they are approaching a red light at too high of a speed. This technology is still relatively new and the equipment required in the vehicles is not currently available on the market.

[22] Access Board website: http://www.access-board.gov/prowac/draft.htm
[23] National VII Coalition website: http://www.vehicle-infrastructure.org/

5.5 Automatic Vehicle Identification

Automatic Vehicle Identification (AVI) is used to collect information related to travel times between two points. AVI deployment includes antennas and tag readers that monitor the passage of vehicles that are equipped with transponder tags. In the Houston region, these tags are supplied by the Harris County Toll Road Authority and are known as EZ Tags. The information collected from the AVI tags can be used to determine the actual speeds and congestion levels on the roadways. The information can then be displayed on a travel time map and posted on a webpage. The Texas Transportation Institute (TTI) provides the data analysis and supplies the speed information displayed on the TranStar website.

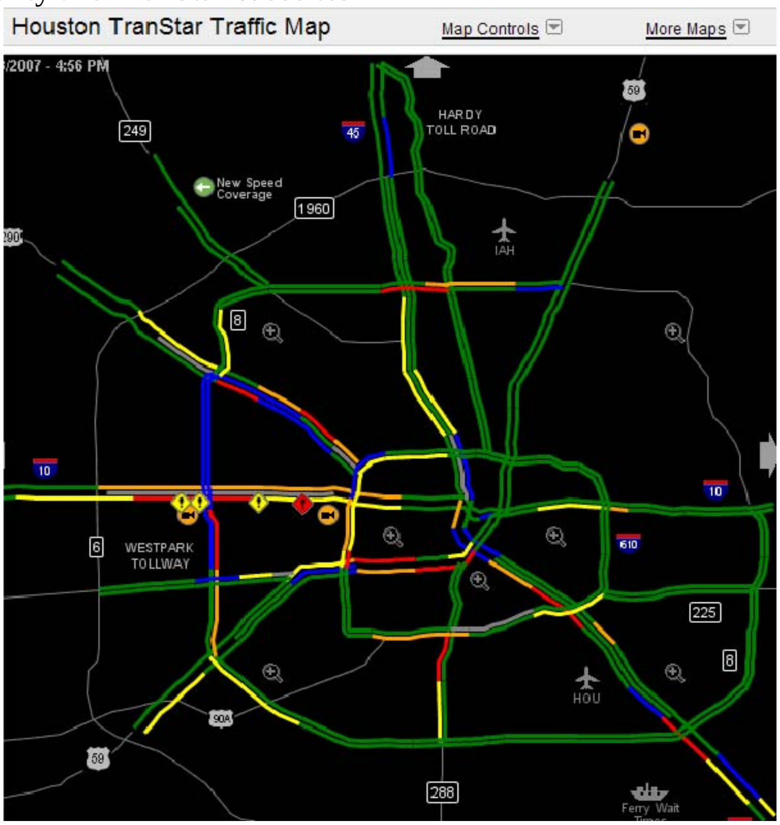


5.6 Dissemination of Transportation Related Information

If transportation related information is not transmitted to the public, drivers have no way of avoiding congestion or delays. The information collected can be made available to commercial broadcasters which can relay the information on the radio or television. Providing information on websites would allow the public to view a map showing travel times and congestion which would allow them to choose alternate routes. TranStar provides a service that sends e-mails or text messages to drivers if their normal commute routes have abnormal events or delays. DMS signs can provide travel times or alert drivers to congestion or crashes ahead. Highway Advisory Radio (HAR) would normally be reserved for severe events such as a major crash or a hurricane evacuation.

Several ways to provide this information to the public are shown below:

- Radio
- Television
- Highway Advisory Radio
- City, County and TranStar Websites[24]



Dynamic Message Signs[25]

[24] Image courtesy of TranStar website: http://traffic.houstontranstar.org/layers/
[25] Image courtesy of atom.smasher.org http://atom.smasher.org/highway/

- Text messages to drivers[26]

> *IH-610 WEST LOOP Southbound At OLD KATY RD Accident - Verified at 11:17 AM, 5 Mainlane(s), 1 Shoulder Lane(s) blocked*
>
> *IH-610 WEST LOOP Southbound At OLD KATY RD Accident - Cleared at 12:51 PM*

5.7 Traffic Incident Management

Traffic Incident Management (TIM) is a systematic, planned and coordinated effort to detect, respond to and remove traffic incidents that restrict traffic flow and create congestion. TIM reduces delays, fuel consumption and secondary crashes, which are estimated to represent 20 percent of all crashes.[27]

Detection of incidents can be obtained by CCTV cameras, citizens calls to dedicated numbers or police, service patrols or automated incident detection systems. Due to the number of AVI tags in the region, a system could be installed that provides automated incident detection and vehicle travel times over the City's roadway network.

Once an incident is detected, CCTV cameras can be used to verify the incident and determine what personnel and equipment will be needed to clear the obstruction. A small incident may require police, fire and a tow truck. A major incident may require hazardous materials (HAZMAT) crews, Homeland Security or heavy equipment.[28]

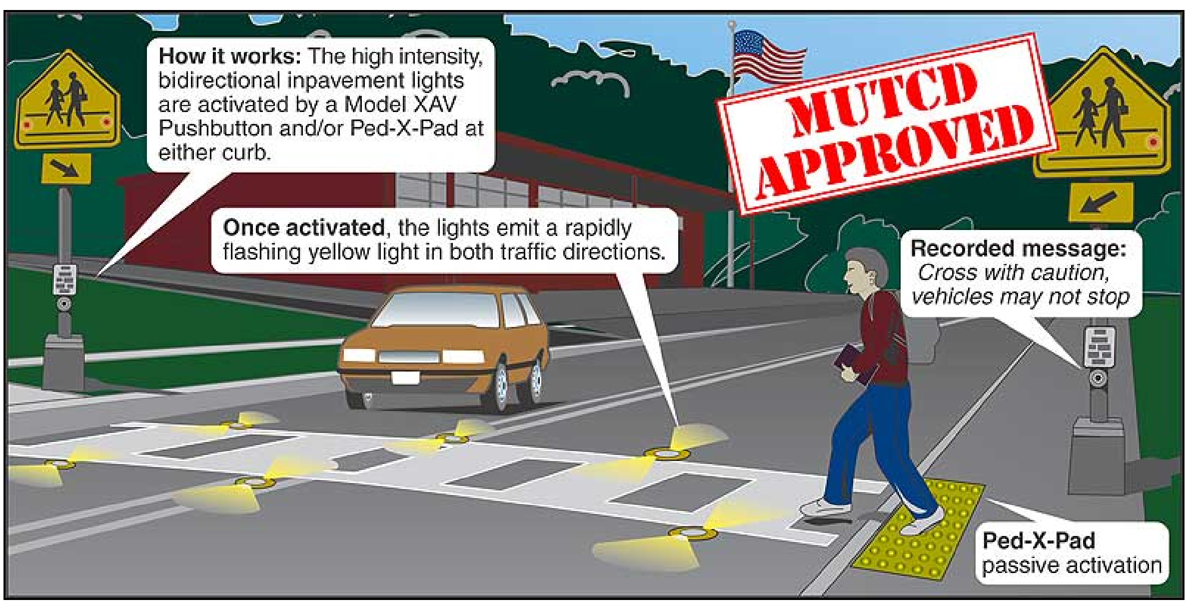
[26] Messages generated from TranStar website
[27] Federal Highway Administration Office of Operations Webpage, "Traffic Incident Management," www.ops.fhwa.dot.gov/aboutus/one_pagers/tim/htm
[28] Image courtesy of Government of Andhra Pradesh – Directorate of Medical Education website: http://dme.ap.nic.in/traffic_accident.jpg

5.8 School Zone Flashers

School zone flashers[29] can be controlled from the TMC if the necessary equipment and software is installed. Such a setup would allow the City staff to monitor and modify the flashers remotely. The calendar for the school year, including partial attendance days, could be broadcast to all locations at once with the school zone software. Newer technology allows two-way communication which allows the field equipment to send alarms to City staff.

5.9 Flashing Crosswalks

LED lights can be installed on the pavement with raised pavement markers. The flashing crosswalks[30] can be activated by push buttons (active system) or remote sensors (passive system). The flashing crosswalks can provide additional information for the approaching driver. However, due to the additional cost, these types of crosswalks cannot be installed at all locations. Therefore, they should be reserved for areas of high pedestrian use such as schools and parks, crosswalks in non-standard locations, or areas that have a documented crash record.



[29] Image courtesy of Solar San Antonio website: http://www.solarsanantonio.org/images/schoolcrossing.jpg
[30] Image courtesy of Traffic Safety Corp website: http://www.xwalk.com/Main-graphic-5_HR3.jpg

5.10 Red Light Cameras

Senate Bill (SB) 1184, enacted in 2003, included a provision granting cities additional powers to regulate traffic on their roads and issue civil citations for violations that previously had been punishable only as criminal offenses. SB 1119, enacted in 2007, specifically allows red-light cameras but directs that fifty percent of the fines collected be sent to the State Comptroller for deposit to the credit of the regional trauma account. The remainder that the local agency collects can only be spent on traffic safety programs including pedestrian safety, public safety, intersection improvements and traffic enforcement.

A recent federal study found economic benefits associated with red-light camera use and many cities in Texas and nationally that use cameras have seen reductions in crashes and violations. But a number of studies suggest that the use of red-light cameras may actually increase the number of car crashes, especially rear-end crashes.[31]

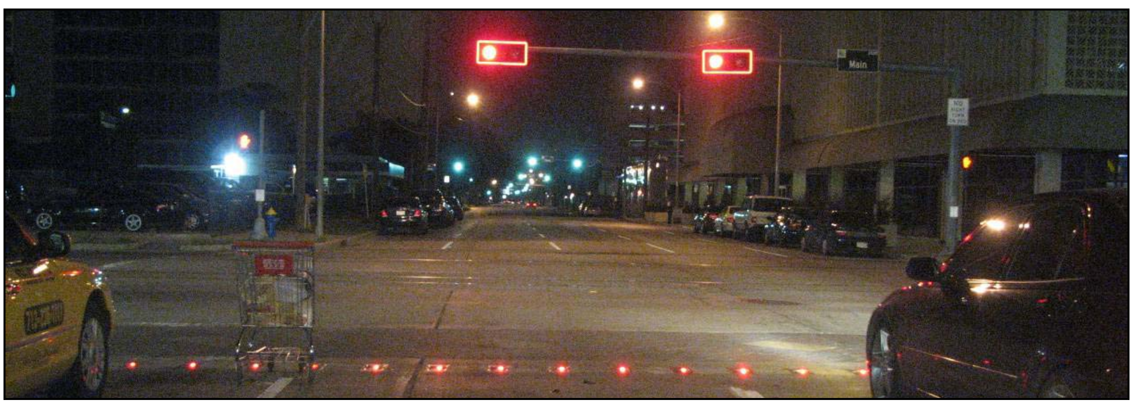
Although red-light cameras have the potential to increase safety and revenue, they also have generated a number of ethical and legal dilemmas. Opponents of the cameras express concerns about privacy and the rise of a surveillance state along with other complaints about the unfairness of punishments issued by for-profit companies in lieu of law enforcement agencies.

Some opponents of red-light cameras claim that cities may be more interested in raising revenue than in promoting public safety. They point to San Diego where the vendor operating the red-light camera program had access to the traffic signal timing and where yellow clearance intervals were set shorter than the national standard.[32]

[31, 32] House Research Organization, Texas House of Representatives "Red-light Cameras in Texas: A Status Report", July 31, 2006.

5.11 In-Pavement Lights and LED Backplates

Two other options to improve visibility of red lights and reduce red-light running are red in-pavement LEDs at the stop bar and red LED lights on the signal backplates. These two options can be used together or separately and are being studied by the Federal Highway Administration. The photos below show these applications in use on Main Street in Houston, Texas.



Chapter 6. System Architecture and Functional Requirements

This section of the report will explain and describe the terms System Architecture and Functional Requirements. The proposed Missouri City System Architecture will be presented. Five proposed projects will be described and Functional Requirements will also be provided.

6.1 System Architecture

The Transportation Policy Council (TPC) of the Houston-Galveston Area Council (H-GAC) adopted the Houston Region ITS Strategic Plan[33] and Houston Region ITS Architecture[34] in September 2003. These documents provide guidance for the deployment of transportation projects that use ITS technologies. H-GAC adopted these documents to facilitate uniform planning, implementation and operation in the region and to allow interoperability between agencies. Missouri City and Fort Bend County are members of H-GAC.

The ITS Architecture defines how major elements of ITS projects should be implemented. The Architecture provides definitions for standardized ITS terms and concepts defined by the United States Department of Transportation. Development of the Regional ITS Architecture was required by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) in order for state and local agencies to qualify for federal funding of ITS projects.

The Houston Region ITS Strategic Plan documents a program to implement projects outlined in the Houston Region ITS Architecture. The Houston Region ITS Strategic Plan documented the mission and vision for ITS in the region, existing ITS systems, needs and requirements for the region, agency roles and responsibilities and a set of ITS projects to be phased in over time. Both the Houston Region ITS Architecture and the Houston Region ITS Strategic Plan recognize that the area has Legacy Systems. A Legacy System is an existing transportation system, communication system or institutional process.

[33, 34] Available on Houston Galveston Areas Council website: http://www.h-gac.com

The primary Legacy Systems for Missouri City are listed below:

- Existing roadway system
- Existing signal network
- Naztec NEMA TS2 controllers and cabinets
- Naztec Streetwise traffic signal control software
- Existing twisted pair and fiber optic communication systems
- Loop and VIVDS detectors
- Emergency Vehicle Preemption (Opticom)

The Houston Region ITS Strategic Plan identified several recommended projects for the Houston area. These projects include:

- Expansion of Surveillance on Arterial Streets
- Expansion of CCTV and sensor equipment on freeways and critical areas (e.g. Hurricane evacuation routes)
- Expansion of the Houston Regional Computerized Traffic Signal System (RCTSS)
- Expansion of Incident Management off freeways
- Deploy and Integrate with other agencies detecting Flood Conditions
- Marketing effort for Traveler Information
- Enhance Emergency Management Operations and Coordination
- Enhance Agency-to-Agency and Agency-to-Public Outreach, Coordination/Communication

A System Architecture for Missouri City has been developed and is shown in **Appendix J**. This System Architecture presents a roadmap for system design and implementation for Missouri City's ITS projects.

6.2 Functional requirements

Functional requirements are the capabilities that an ITS system or project must have in order to address the needs that the ITS system or project must satisfy. The needs are normally mission oriented objectives of the agency for which the system is built. Functional requirements should not specify implementation details but remain broad. The organization seeking an ITS system should describe what is to be done and the implementer of the system or project should decide how to implement the project, given the time and budget constraints.

Functional requirements should have the following characteristics:[35]

- Necessary – Something that must be included or an important element of the system is missing and other system components can't compensate for its absence.
- Concise – Stated in language that is easy to read, yet conveys the essence of what is needed.
- Attainable – A realistic capability that can be implemented for the available money, with the available resources, in the available time.
- Complete – Described in a manner that does not force the reader to look at additional text to know what the requirement means.
- Consistent – Does not contradict other stated requirements nor is it contradicted by other requirements. In addition, uses terms and language that means the same from one requirement statement to the next.
- Unambiguous – Open to only one interpretation.
- Verifiable – Must be able to determine that the requirement has been met through one of four possible methods: inspection, analysis, demonstration, or test.

Providing adequate functional requirements is essential to creating a project or system that meets the needs and expectations of the end user. Incomplete functional requirements can result in an under-designed project. Correcting this issue carries a low cost at the requirement phase but can be 1,000 times greater to correct once the system is in operation.

Functional Requirements for Missouri City ITS projects

Project #1- Wi-Fi system, controller and cabinet replacement, CCTV cameras and TMC

A Wi-Fi communications system shall be provided to communicate between the proposed Traffic Management Center (TMC) and all traffic signals under the jurisdiction of Missouri City. This communications system will be capable of providing monitoring and control of the traffic signal timing from the TMC and transmitting video images from CCTV and VIVDS cameras. The remaining existing NEMA TS1 traffic signal controllers and cabinets shall be converted to NEMA TS2 controllers and cabinets. Ethernet faceplates shall be installed on all NEMA TS2 controllers not currently equipped with them. Each backhaul connection shall be capable of 60 megabits per second. The video transmission shall provide a minimum of 15 frames per second from all CCTV and VIVDS cameras connected to the system simultaneously. The system shall be operational within two years of the design consultant being selected by the City of Missouri City. The TMC design shall conform to the latest NTCIP center-to-center ITS standards

[35] Developing Functional Requirements for ITS Projects, US Department of Transportation website: http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/13621.html

Project #2 - Webpage for TMC

A webpage for the Missouri City web site shall be developed to disseminate travel information to the public. This information shall include images from the CCTV and VIVDS cameras refreshed at a minimum rate of once every ten seconds. A speed display map for SH 6, Murphy Road and Texas Parkway shall be provided and updated every ten minutes once AVI tag readers are installed and operational. A link to the Houston TranStar website shall be provided. This webpage shall be accessible to the public within six months after Project #1 is completed.

Project #3 – Add UPS to all signals

UPS shall be provided at all new traffic signals under Missouri City control. UPS shall be provided at all existing traffic signals under Missouri City control within five years. The UPS shall provide a minimum of two hours of continuous standard operation during a power outage. The priority for installation of the UPS units is: SH 6, Murphy Road, Texas Parkway/Gessner Road, Cartwright Road, all other locations.

Project #4 – Install AVI Tag Readers

AVI tag readers shall be installed on SH 6, Murphy Road and Texas Parkway. Travel time data shall be collected from the AVI tag readers and transmitted to the TMC. This information will then be displayed on the TMC webpage to inform drivers of the travel time between specific points on the selected roadways. This installation shall be completed within five years.

Project #5 – Install Countdown Pedestrian Signals

Countdown pedestrian signals shall be provided at all new traffic signals under Missouri City control. Countdown pedestrian signals shall be provided at all existing traffic signals under Missouri City control within ten years.

Chapter 7. ITS Operations Plan

The ITS Operation Plan has been set up with short-term (0-2 years), mid-term (3-5 years) and long-term (more than 5 years) goals. Five primary projects have been identified for the short-term and mid-term periods. Additional ITS elements will be implemented as routine maintenance or as funds become available from City budgets or other sources such as TxDOT or H-GAC.

7.1 Project #1 – Wi-Fi signal system, Cabinet and Controller Replacement, CCTV cameras and Traffic Management Center

This project would install a Wi-Fi signal communication system, replace cabinets and controllers, install CCTV cameras and construct a TMC at the Missouri City Emergency Operations Center or the Public Safety Headquarters Building, which are both located on Cartwright Road. These improvements would allow the traffic signals to be monitored and adjusted from the TMC or other remote locations. **Appendix K** shows the proposed communication system. This communication system is preliminary and additional work would be required to finalize the design. A separate design project and radio frequency (RF) survey would need to be undertaken which are not a part of this current project.

This project would include replacing all remaining NEMA TS1 controllers and cabinets with NEMA TS2 controllers and cabinets. Also, Ethernet faceplates would be added to all controllers that are not yet equipped with them. Currently, 12 of the 39 traffic signals still have a NEMA TS1 signal controller and cabinet. Seven of the traffic signals have a NEMA TS2 controller in a NEMA TS1 cabinet. The primary advantages of the NEMA TS2 controllers and cabinets are improved standardization of equipment, improved standardization of communications and inclusion of the latest NEMA standards for traffic signal equipment. The NEMA TS2 standard reduces the amount of wiring in the cabinet and also provides for the latest operation and functionality with the ATMS.now communications and operations software system.

The primary reason to accelerate the replacement of the controllers and cabinets is to prevent duplicating effort in the future. If the additional equipment for the Wi-Fi system and CCTV camera system is installed in an existing NEMA TS1 cabinet, it would need to be removed and reinstalled when the controller cabinet is upgraded to a NEMA TS2. This may occur within months of the initial installation of the Wi-Fi and CCTV equipment.

CCTV cameras would also be installed at selected intersections with this project, as shown in **Appendix K**. The CCTV cameras would allow City personnel to monitor the primary roadways within Missouri City. Signal timing could be adjusted remotely to accommodate unusual traffic conditions such as lane closures caused by a crash or a stalled car. The CCTV cameras could also be used to determine what equipment needs to be sent to the scene of a crash. For example, if there was a lot of debris on the roadway, front loaders, dump trucks and street sweepers may be needed. The VIVDS cameras will also be able to transmit video, but the views will be fixed. The CCTV cameras will allow the operator to pan, tilt, and zoom which provides better functionality.

The TMC will be the nerve center for the ITS system and will monitor and control all ITS components. The staff at this location will be able to alter traffic signal timings, request equipment or emergency personnel to handle crashes or other issues causing delays and provide information to the traveling public.

System Design Requirements

The design of the Wi-Fi communication network will require close attention to multiple details. Line-of-sight for the antennas influences the amount of bandwidth and dependability of the connection. Standard antennas have a ten degree radius but special antennas with broader ranges can be used for certain applications. The signal data and images from the traffic signals, CCTV and VIVDS cameras are then transmitted to the TMC. The same radio can be configured to operate as a local access point, multipoint radio or for backhaul communications. Repeaters may be necessary for difficult areas where line-of-sight cannot be provided. The Wi-Fi communications network would be constructed in several phases.

This project consists of short-term and mid-term phases to construct the communication system in phases to distribute the cost of the system over several fiscal years. The basic system architecture will provide point-to-multipoint high speed connections. All high speed multipoint communications will connect to the TMC. Local sub-systems connect to one multipoint location. There would also be a few wireless access points, or "hot-spots", where City staff could access the system from the field. The project will require increased security measures because of its use of wireless connectivity. The security measures are needed to prevent unauthorized users from gaining access to the signal timing information or the camera images.

Future additions to the system may add hot-spots for public internet access at certain areas such as City Hall or area parks. UPS systems should be provided for all communications equipment and solar panels for key communications points. Also, implementation of a municipal Wi-Fi network for the entire city by a private third-party provider may be added at a future date. Additional future provisions should be pursued to provide system redundancy. This would include providing a fiber optic backbone or backhaul to provide main communication and increase bandwidth and stability.

The Wi-Fi communication network should utilize either the 4.9 GHz or 5.8 GHz frequency. The City of Sugar Land is currently planning to use the 4.9 GHz frequency, pending FCC approval. The Sugar Land system does not intend to allow any public access. Utilizing the same frequency as Sugar Land would allow for sharing of resources, redundant operation, and interagency cooperation. However, being on the same frequency may result in conflicting network communication and interference. Utilizing the 5.8 GHz frequency would also allow for future public access at selected hot-spots such as the parks and City Hall.

The estimated construction and design cost for the initial Wi-Fi signal communication system, controller and cabinet replacement, CCTV cameras and TMC has been broken up by phases. The priority for the system installations is shown below and was based on such factors as hurricane evacuation routes, traffic volumes and importance to the City's transportation network. The cost estimates can be found in **Appendix L**. It should be noted that Phase 1 includes startup costs associated with the installation of equipment in the TMC and the purchase of the traffic signal control software. It is also recommended that Missouri

City budget for an additional staff member to monitor the system in the TMC and other operational and replacement costs. The added staff member would have additional responsibilities related to the traffic signals during the off-peak time periods of the day.

Phase 1 (SH 6):	$680,225
Phase 2 (Murphy Road):	$183,138
Phase 3 (Texas Parkway/Gessner Road):	$313,203
Phase 4 (Cartwright Road):	$156,826
Phase 5 (Sienna Parkway and all other locations):	$635,674
Total:	$1,969,065

The primary benefits of the Wi-Fi signal communication system, CCTV cameras, and TMC will be realized by the local residents. The improved response time to crashes and reduced time to respond to signal timing issues will reduce congestion and improve travel times. The corridors of SH 6, Murphy Road and Texas Parkway were evaluated for existing conditions to determine the total delay experienced by drivers and the fuel consumed during a typical PM Peak period using the signal timing software Synchro. **Table 1** shows the results of the analysis and the Syncho output can be found in **Appendix M**.

Table 1
Total Delay and Fuel Consumed during the PM Peak

	Total Delay (Hr)	Fuel Consumed (gal)
SH 6 Existing Conditions	252	955
Murphy Road Existing Conditions	143	522
Texas Parkway Existing Conditions	364	742

The Total Delay value is the combined delay experienced by all users on the roadway during the PM Peak period. Long roadway segments with high traffic volumes will typically have higher Total Delay values than shorter segments or corridors with lighter traffic. However, corridors that are near capacity and have high levels of congestion will show high Total Delay values. The Fuel Consumed value is the combined fuel for all the roadway users.

The benefits that may be realized by the citizens of Missouri City if the Wi-Fi signal communication system, CCTV cameras and TMC project were completed would be a reduction in travel time, primarily during the peak driving periods. The value for time was obtained from the Texas Transportation Institute. The estimation of benefits is shown in **Table 2** based on the following assumptions:

- Value of time – private vehicles ($19.30 per hour)
- Value of time – commercial vehicles ($81.80 per hour)
- Value of fuel – ($3.00 per gallon)
- Existing conditions govern for a standard weekday
- 5% reduction in delay and fuel consumption per day through the use of the ITS equipment provided by this project
- Traffic stream consists of 90% passenger vehicles and 10% commercial vehicles

Table 2
Estimated Cost Savings for Traveling Public from Project #1

Line	Description	SH 6	Murphy Road	Texas Parkway
1	Reduction in Total Delay (Hr) = Total Delay x 5% =	12.60	7.15	18.20
2	Reduction in Total Delay (Private Vehicles) (Hr) = Line 1 x 90% =	11.34	6.435	16.38
3	Reduction in Total Delay (Commercial Vehicles) (Hr) = Line 1 x 10% =	1.26	0.715	1.82
4	Cost Savings (Private Vehicles) ($) = Line 2 x $19.30/hr =	$218.86	$124.20	$316.13
5	Cost Savings (Commercial Vehicles) ($) = Line 3 x $81.80/hr =	$103.07	$58.49	$148.88
6	Cost Savings from reduced delay ($) = Line 4 + Line 5 =	$321.93	$182.69	$465.01
7	Reduction in Fuel Consumed (gal) = Fuel Consumed x 5% =	47.75	26.10	37.10
8	Cost Savings from reduced Fuel Consumption ($) = Line 7 x $3.00/gal =	$143.25	$78.30	$111.30
9	Total Cost Savings per PM Peak Hour = Line 6 + Line 8 =	$465.18	$260.99	$576.31
10	Total number of working days per year =	260	260	260
11	Total Cost Savings per Year = Line 9 x Line 10 =	$120,946.80	$67,857.40	$149,840.60
12	**Total Cost Savings per Year during PM Peak**	**$338,644.80**		

The $338,644.80 cost savings shown in **Table 2** only considers the savings obtained during the PM Peak travel period. Additional benefits would be realized by the traveling public during other time periods of the day. Generally, the PM Peak in the most congested time of the day and has the highest benefit. Additional benefits could be provided during the weekends if the TMC was staffed during those times. Missouri City could staff the TMC during selected weekends such as the peak shopping period between Thanksgiving and Christmas or when other events are occurring.

This project would benefit Missouri City by improving staff time utilization efficiency. Many complaint calls regarding the operation of the traffic signals (e.g. green on a side street with no vehicles) could be checked from the TMC without sending a crew to the field location. Malfunctioning field devices such as VIVDS camera or pedestrian push buttons could be quickly confirmed. The personnel then sent to the field location could be prepared with all the require replacement equipment on the first trip to the intersection. Also, with a NEMA TS2 signal cabinet and an IP addressable power strip, signal equipment can be recycled remotely without sending personnel to the field. This can reduce late night call-outs for emergency service. Also, a technician could make minor timing corrections to the signal that would prevent a late night call-out by providing a short-term fix that would allow the major issue to be addressed during regular business hours which will reduce overtime costs. Between July 1st, 2007 and March 18th, 2008, there were thirty late night call-outs. Based on two employees for a total cost of $51.00 per hour, each four hour call-out costs the City $204.00. Prorated for one complete year, the average late night call-out cost is approximately $7,344.00 per year.

7.2 Project #2 – Webpage for TMC

After the CCTV and VIVDS cameras are operational, Missouri City should develop a webpage to disseminate the information to the traveling public. This website would provide images from the cameras on the major commuter routes such as SH 6, Murphy Road and Texas Parkway. This webpage would provide information to the traveling public and draw web traffic to the City's website. The cost of the webpage would depend on whether the City's staff creates it or if an external vendor is hired. The level of functionality would also have an impact on the cost. Provides still images from selected cameras would be considered the minimum necessary functionality for the webpage. A webpage that allows drivers to request e-mail alerts, access images from all CCTV cameras and VIVDS, and a route builder would cost more to develop. Additional data storage capability may also be needed due to increased website traffic. In the future, travel time information and a speed map like the one found on the TranStar website could be added to the Missouri City website. The projected cost for the webpage development is between $20,000 and $100,000. The cost estimate can be found in **Appendix L.**

7.3 Project #3 – Add UPS to all signals

This project would add UPS to all the traffic signals in Missouri City. The City has already begun to require UPS on all new traffic signals constructed by private developers. The UPS units improve safety by running the traffic signals during short-term power outages. They also reduce costs to the City by reducing the need for police to control traffic at the intersections during power outages or having public works staff place temporary stop signs. Between July 1st, 2007 and March 18th, 2008, there were ten call-outs that required police control of the intersection until the traffic signal was operational. Based on $28.00 per hour, each four hour call-out costs the City $112.00. Prorated for one complete year, the average call-out cost for police control of intersections is approximately $1,344.00 per year. This cost does not account for the true cost of having the police officers diverted from their normal duties.

The cost of the UPS is approximately $5,000 per intersection or approximately $195,000 for the entire city. The cost estimate can be found in **Appendix L.** The installation of the UPS could be completed in one large project or phased in over several years. If a phased approach is used, it is recommended that the UPS be installed in the following order of priority for the major roadways.

1. SH 6
2. Murphy Road
3. Texas Parkway/Gessner Road
4. Cartwright Road
5. All other locations

7.4 Project #4 – Install AVI Tag Readers

AVI tag readers provide travel time information that can be used to monitor traffic congestion and delays. The proposed locations for the AVI tag readers are shown on the figure in **Appendix K**. Information from the AVI tag readers can be tracked over time to determine the actual impact increased traffic volumes are having on the primary roadways in Missouri City. The information can also be provided to the traveling public through a website to allow drivers to alter the time they leave for work or select another route. For example, if SH 6 has a major incident that is creating heavy delays, a motorist could decide to use the Fort Bend Parkway Toll Road instead. The estimated cost for Project #4 is $261,000. The cost estimate can be found in **Appendix L.**

7.5 Project #5–Install Countdown Pedestrian Signals

This project would replace the existing pedestrian signals with countdown pedestrian signals. The countdown pedestrian signals will provide more information to pedestrian crossing the street. There will also be a reduction in electrical costs for the intersections that still have incandescent pedestrian signals. The cost to install the countdown pedestrian signal is approximately $4,000 per intersection assuming eight pedestrian signals per intersection and the intersection is currently equipped with standard pedestrian signals. Installation costs at existing traffic signals without pedestrian signals and push buttons would be higher because of the need to install additional conduit and cable. The estimated cost for Project #5 is $286,000. The cost estimate can be found in **Appendix L.**

Projects #1 through #5 provide a guideline for implementation of ITS projects over the next five years. Additional projects may be undertaken if funds are available from Missouri City or other agencies such as TxDOT or METRO. Table 3 shows a summary of the costs for Projects #1 through #5.

Table 3
Fiscal Year Cost Summary

	Fiscal Year				
Description	**'08-'09**	**'09-'10**	**'10-'11**	**'11-'12**	**'12-'13**
Project #1: Wi-Fi Communication System, Controller and Cabinet Upgrades, CCTV Cameras, and Traffic Management Center	$680,225	$183,138	$313,203	$156,826	$635,674
Project #2: Traffic Website		$30,000			
Project #3: UPS for signals	$60,000	$30,000	$50,000	$30,000	$25,000
Project #4: AVI Tag Readers				$269,100	
Project #5: Countdown Pedestrian Signals		$44,000	$70,000	$34,000	$138,000
Fiscal Year Total	**$740,225**	**$287,138**	**$433,203**	**$489,926**	**$798,674**

Additional short-term and mid-term projects to be pursued as funding is available include:

- Conversion of existing loop detectors to VIVDS (City funding)
- Additional Traffic Incident Management elements (City or TxDOT funding)
- Additional features for the traveler's information webpage (City funding)
- Links with other regional TMCs (TranStar, Sugar Land TMC, Fort Bend EOC) (City or TxDOT funding)
- Expand Wi-Fi users to other City deparments (City funding)
- Flashing Crosswalks (City or TxDOT funding)
- In-Pavement stop bar LEDs (City or TxDOT funding)
- LED signal backplates (City or TxDOT funding)

Additional long-term projects that may be pursued if funding is available or as the technology matures include:

- Fiber Optic redundant backbone ring (City or TxDOT funding)
- Dynamic Message Signs (TxDOT funding)
- Highway Advisory Radio (TxDOT funding)
- Audible Pedestrian Signals (City Funding)
- Traffic Adaptive or Traffic Responsive Timing System (City or TxDOT funding)
- Municipal Wi-Fi system open to the public (private funding)
- VII technology (Private or TxDOT funding)
- Red-light enforcement cameras (City funding)

Funding sources from the Federal Government or H-GAC would be administered through TxDOT. The TxDOT designations above may include funds earmarked through Congress, Federal funds or funds from H-GAC supplied through the Texas Department of Transportation.

The tables below show the User Service Bundles and Market Package Categories from the Houston Region ITS Strategic Plan. The five primary projects discussed above fulfill several aspects of the Strategic Plan. Therefore, funding through H-GAC and TxDOT may be available for some of the project costs.

Table 4
User Service Bundles for Proposed Missouri City ITS Projects

User Service Bundle	User Service	Project				
		#1-Wi-Fi system	#2-Webpage	#3-UPS	#4-AVI Readers	#5-Ped Signals
Travel and Traffic Management	1.1 Pre-trip Travel Information		X		X	
	1.2 Enroute Driver Information		X		X	
	1.3 Route Guidance		X			
	1.4 Ridematching and Reservation					
	1.5 Traveler Services Information		X			
	1.6 Traffic Control	X	X	X	X	X
	1.7 Incident Management	X				
	1.8 Travel Demand Management		X		X	
	1.9 Emissions Testing and Mitigation					
	1.10 Highway-rail Intersection					
Public Transportation Management	2.1 Public Transportation Management					
	2.2 Enroute Transit Information					
	2.3 Personalized Public Transit					
	2.4 Public Travel Security	X				
Electronic Payment	3.1 Electronic Payment Services					
Commercial Vehicle Operations	4.1 Commercial Vehicle Electronic Clearance					
	4.3 On-board Safety Monitoring					
	4.5 Hazardous Material Incident Response					
	4.6 Commercial Fleet Management					
Emergency Services	5.1 Emergency Notification and Personal Security	X	X		X	
	5.2 Emergency Vehicle Management	X				
Advanced Vehicle Safety Systems	6.1 Longitudinal Collision Avoidance					
	6.2 Lateral Collision Avoidance					
	6.7 Automated Vehicle Operation					
Information Management	7.1 Archived Data Function	X			X	
Maintenance and Construction Management	8.1 Maintenance and Construction Operations	X				

Table 5
Market Package Category for Proposed Missouri City ITS Projects

Market Package Category	Market Packages	Project				
		#1-Wi-Fi system	#2-Webpage	#3-UPS	#4-AVI Readers	#5-Ped signals
Advanced Traffic Management Systems (ATMS)	ATMS01 Network Survillance	X				
	ATMS02 Probe Surveillance				X	
	ATMS03 Surface Street Control	X		X		X
	ATMS04 Freeway Control					
	ATMS05 HOV Lane Management					
	ATMS06 Traffic Information Dissemination	X	X		X	
	ATMS07 Regional Traffic Control	X				
	ATMS08 Incident Management System	X				
	ATMS09 Traffic Forecast and Demand Management	X	X		X	
	ATMS10 Electronic Toll Collection					
	ATMS11 Emissions Monitoring and Management					
	ATMS13 Standard Railroad Grade Crossing					
	ATMS14 Advanced Railroad Grade Crossing					
	ATMS18 Reversible Lane Management					
Advanced Public Transportation Systems (APTS)	APTS1 Transit Vehicle Tracking					
	APTS2 Fixed Route Transit Operations					
	APTS3 Demand Responsive Transit Operations					
	APTS4 Transit Passenger and Fare Management					
	APTS5 Transit Security					
	APTS6 Transit Maintenance					
	APTS7 Multi-Modal Coordination					
	APTS8 Transit Traveler Information					
Advanced Traveler Information Systems (ATIS)	ATIS1 Broadcast Traveler Information	X	X		X	
	ATIS2 Interactive Traveler Information	X	X		X	
	ATIS5 ISP Route Guidance					
	ATIS7 Yellow Pages and Reservations					
	ATIS8 Dynamic Ridesharing					
Advanced Vehicle Safety Systems (AVSS)	AVSS01 Vehicle Safety Monitoring					
	AVSS04 Lateral Safety Warning					
	AVSS08 Advanced Vehicle Longitudinal Control					
	AVSS09 Advanced Vehicle Lateral Control					
Commercial Vehicle Operations (CVO)	CVO03 Electronic Clearance					
	CVO06 Weigh in Motion					
	CVO08 On board CVO Safety					
	CVO10 HAZMAT Management					
Emergency Management (EM)	EM1 Emergency Response					
	EM2 Emergency Routing	X				
Archived Data (AD)	AD1 ITS Data Mart	X			X	
	AD2 ITS Data Warehouse	X			X	
Maintenance and Construction Management (MC)	MC03 Road Weather Data Collection	X				
	MC04 Weather Information Processing and Distribution	X				
	MC07 Roadway Maintenance and Construction	X				
	MC08 Work Zone Management					
	MC09 Work Zone Safety Monitoring					
	MC10 Maintenance and Construction Activity Coordination	X				
Houston TranStar Auxiliary Market Packets (MP)	MP1 Evacuation Transportation					
	MP2 Evacuation Monitoring	X			X	
	MP3 Evacuation Information Dissemination	X			X	
	MP4 Flood Level Reporting	X			X	
	MP5 Use of Transit Vehicle as Shelter					
	MP6 Truck Rollover Warning System					

Chapter 8. ITS Staffing Plan

An ITS staffing plan was prepared based on the assumption that the five recommended ITS projects are implemented and Missouri City will need to install and maintain additional traffic signals to accommodate continued growth in the area. Missouri City currently has 39 traffic signals with seven more traffic signals expected to be operational in the near future. The job responsibility for the traffic signal technicians is normally general maintenance and trouble shooting. If Missouri City does not maintain sufficient staffing levels as the city continues to grow, needed maintenance will be delayed and response times for trouble calls will increase. As traffic signals and other ITS applications become more sophisticated, the Missouri City staff will require additional training to adequately maintain the systems and maximize use of the systems.

The proposed staffing plan for the next five years is shown below:

- Fiscal year 2008-2009
  - Add one position for traffic signal operation/maintenance
- Fiscal year 2009-2010
  - Add one position to operate TMC/coordinate traffic signals
- Fiscal year 2010-2011
  - Add one position for traffic signal, CCTV and Wi-Fi operation/maintenance

The signal technician staff should have the proper training and certifications. If new staff members have the proper training, their hiring salaries will reflect those credentials. Any additional training for new and existing staff will carry hard costs such as registration and travel and soft costs in lost productivity. The lost productivity will include additional time to troubleshoot and correct problems due to lack of training and the lost time during the training itself. It is usually more cost effective to hire personnel with the proper training if a short learning curve is needed. Training is available through Texas Engineering Extension Service (TEEX) and International Municipal Signals Association (IMSA) as well as other sources.

The training plan for the next five years is shown below:

- FY ’07-’08
    - VIVDS set-up training
    - IMSA training
    - NEMA TS2 cabinet training
    - CCTV training (Yearly review of Policies and Procedures)

- FY ’08-‘09
    - VIVDS set-up training
    - IMSA training
    - NEMA TS2 cabinet training
    - CCTV training (Yearly review of Policies and Procedures)
    - Traffic signal timing training for TMC operators
    - Fiber Optic Training
    - Wi-Fi Communications operation and maintenance

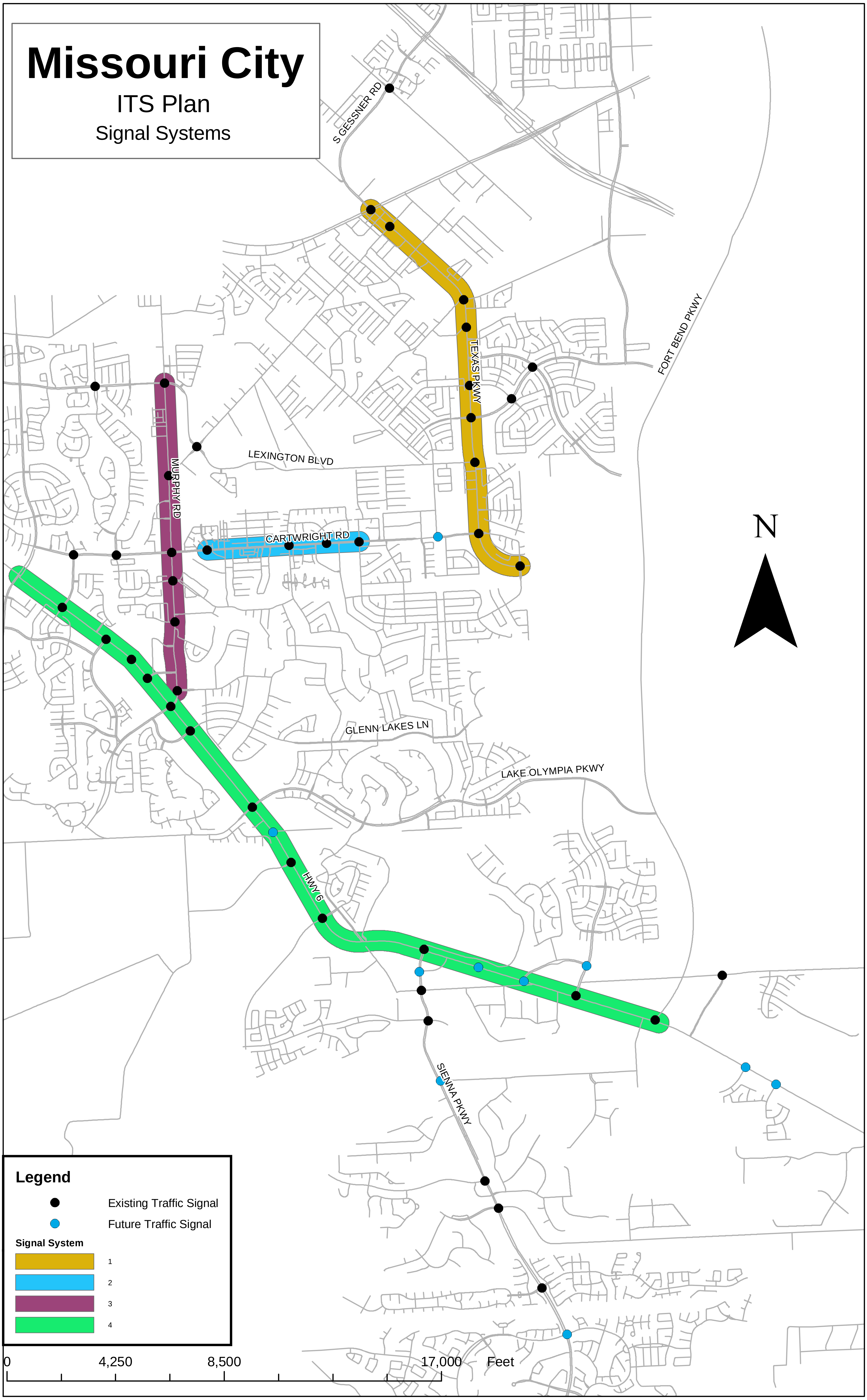
- FY ’09-‘10
    - VIVDS set-up training
    - IMSA training
    - NEMA TS2 cabinet training
    - CCTV training (Yearly review of Policies and Procedures)
    - Traffic signal timing training for TMC operators
    - Traffic Incident Management training
    - Fiber Optic Training
    - Wi-Fi Communications operation and maintenance

- FY ’10-‘11
    - VIVDS set-up training
    - IMSA training
    - NEMA TS2 cabinet training
    - CCTV training (Yearly review of Policies and Procedures)
    - Traffic signal timing training for TMC operators
    - Traffic Incident Management training
    - Fiber Optic Training
    - Wi-Fi Communications operation and maintenance

- FY ’11-12
    - VIVDS set-up training
    - IMSA training
    - NEMA TS2 cabinet training
    - CCTV training (Yearly review of Policies and Procedures)
    - Traffic signal timing training for TMC operators
    - Traffic Incident Management training
    - Fiber Optic Training
    - Wi-Fi Communications operation and maintenance

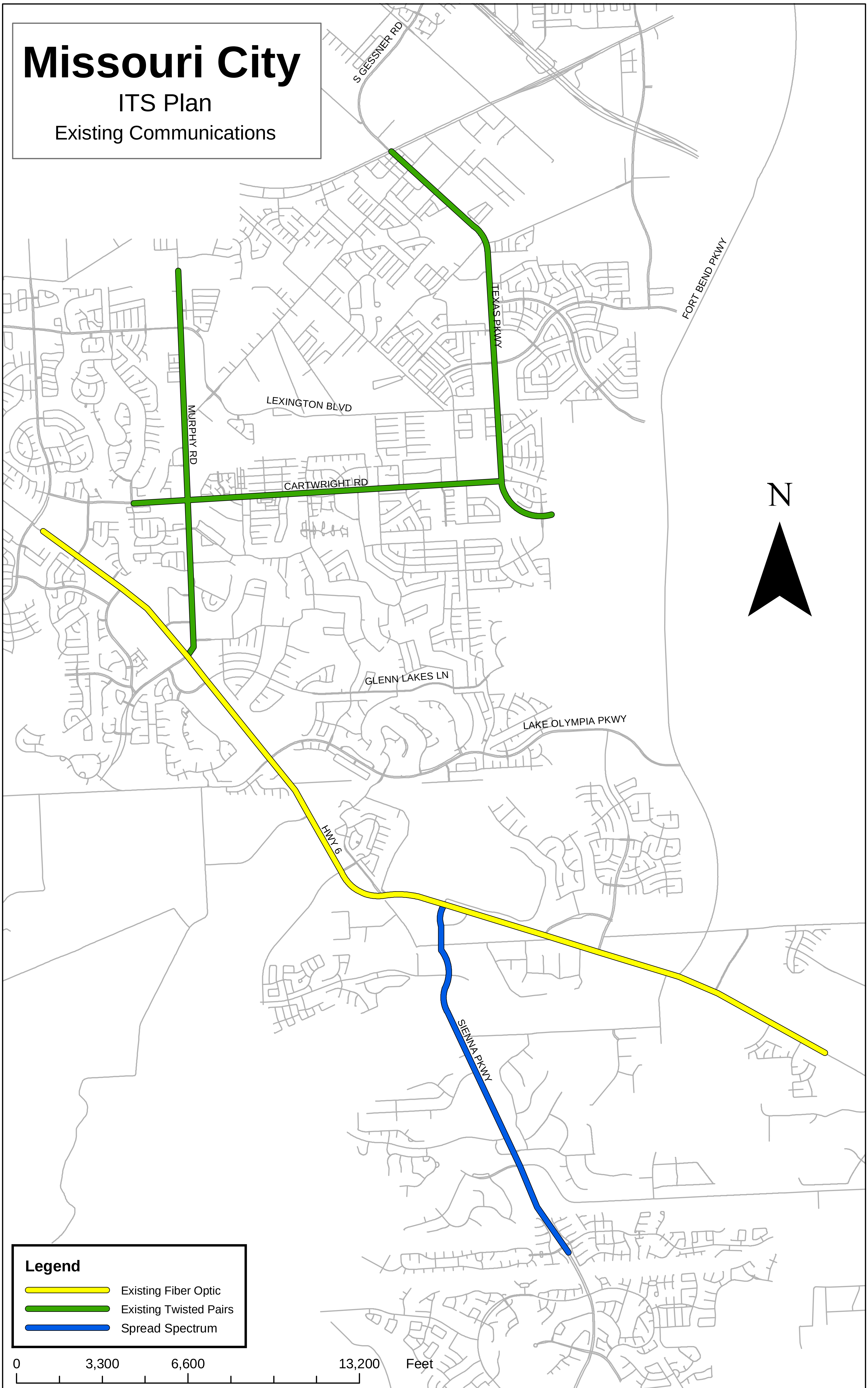
APPENDICES

A. Traffic Signal Systems



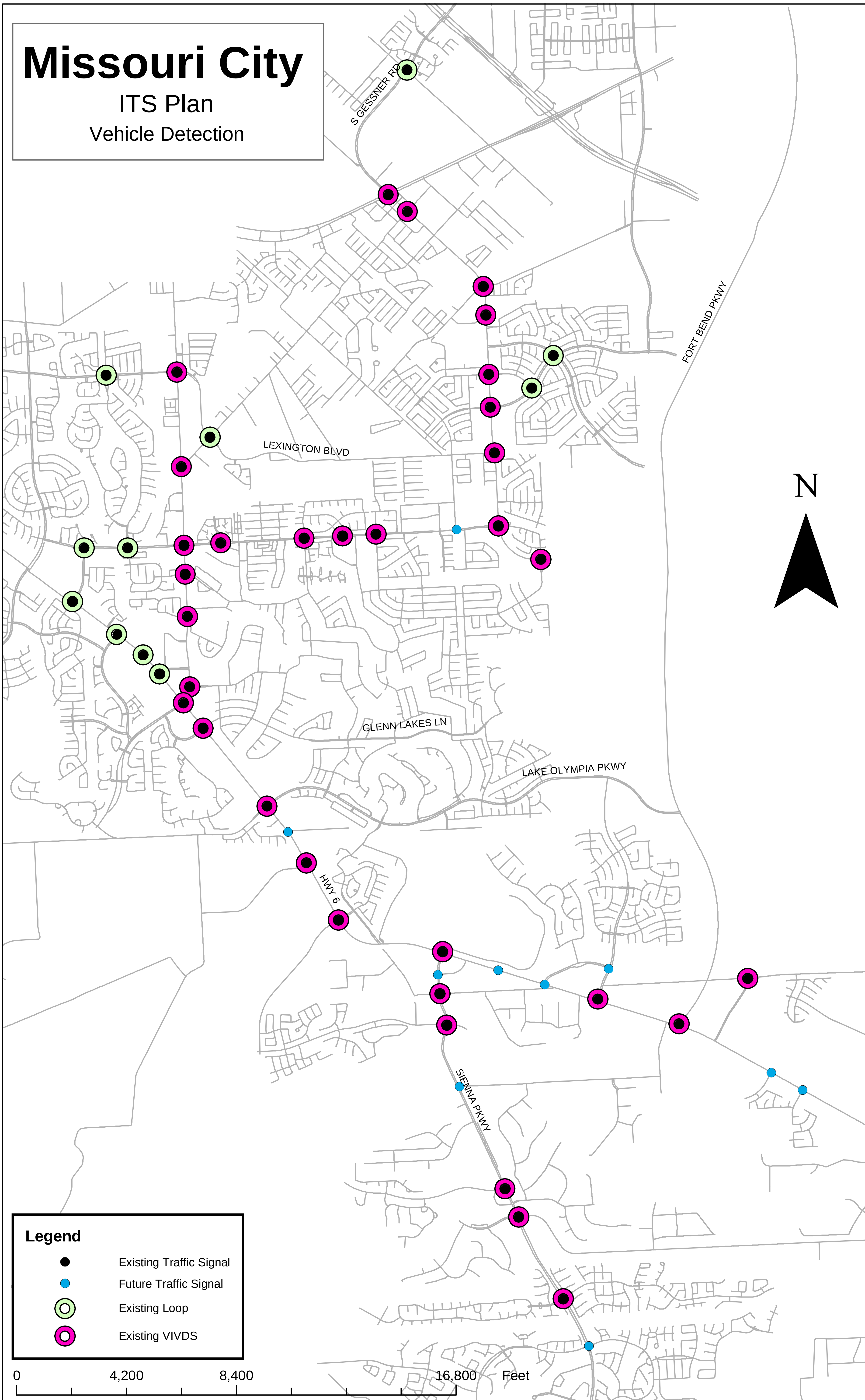
Date Printed: October 1, 2007

B. Existing Traffic Signal Communication



Date Printed: October 1, 2007

C. Traffic Signal Vehicle Detection



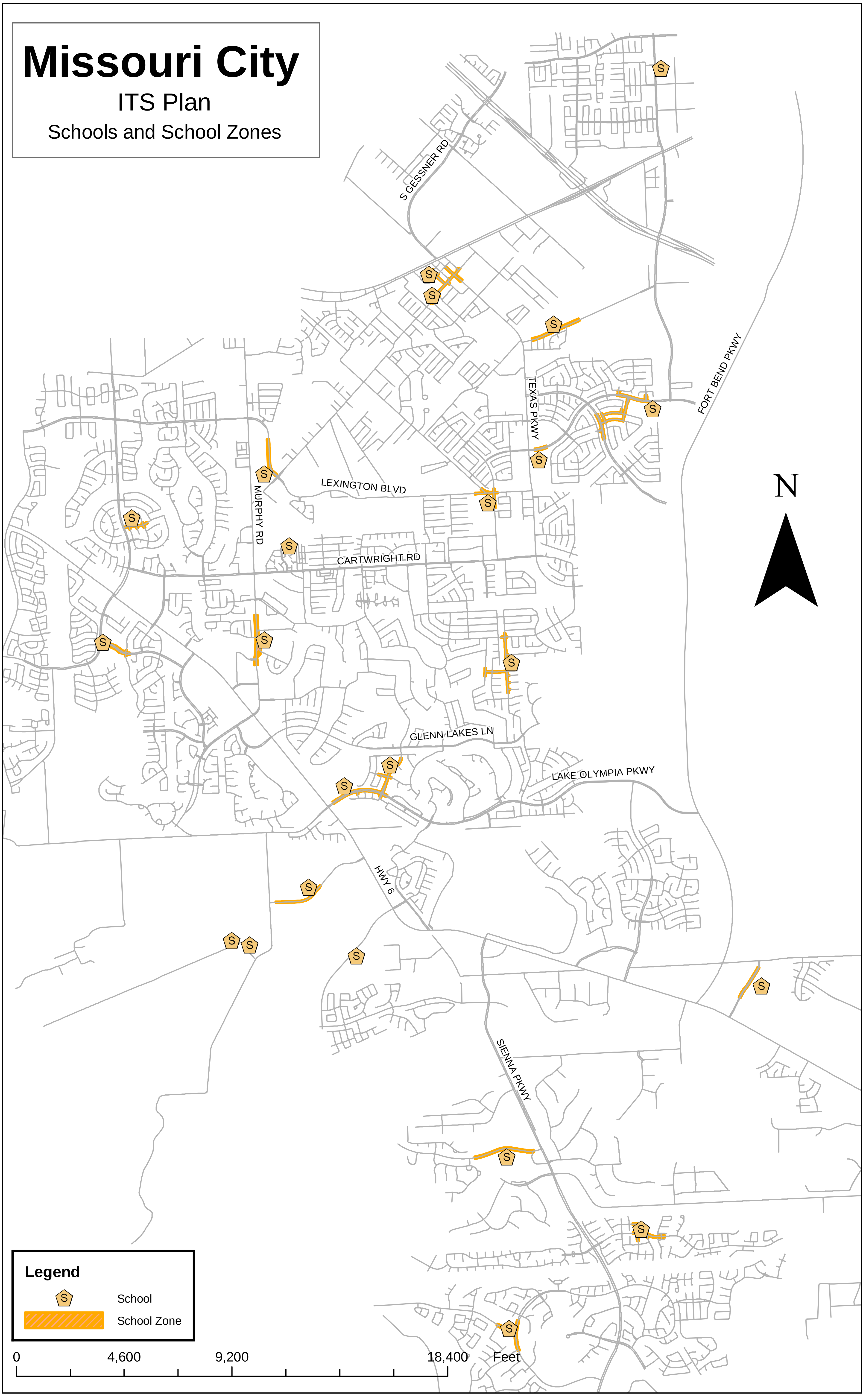
Date Printed: October 1, 2007

D. Schools and School Zones

Missouri City

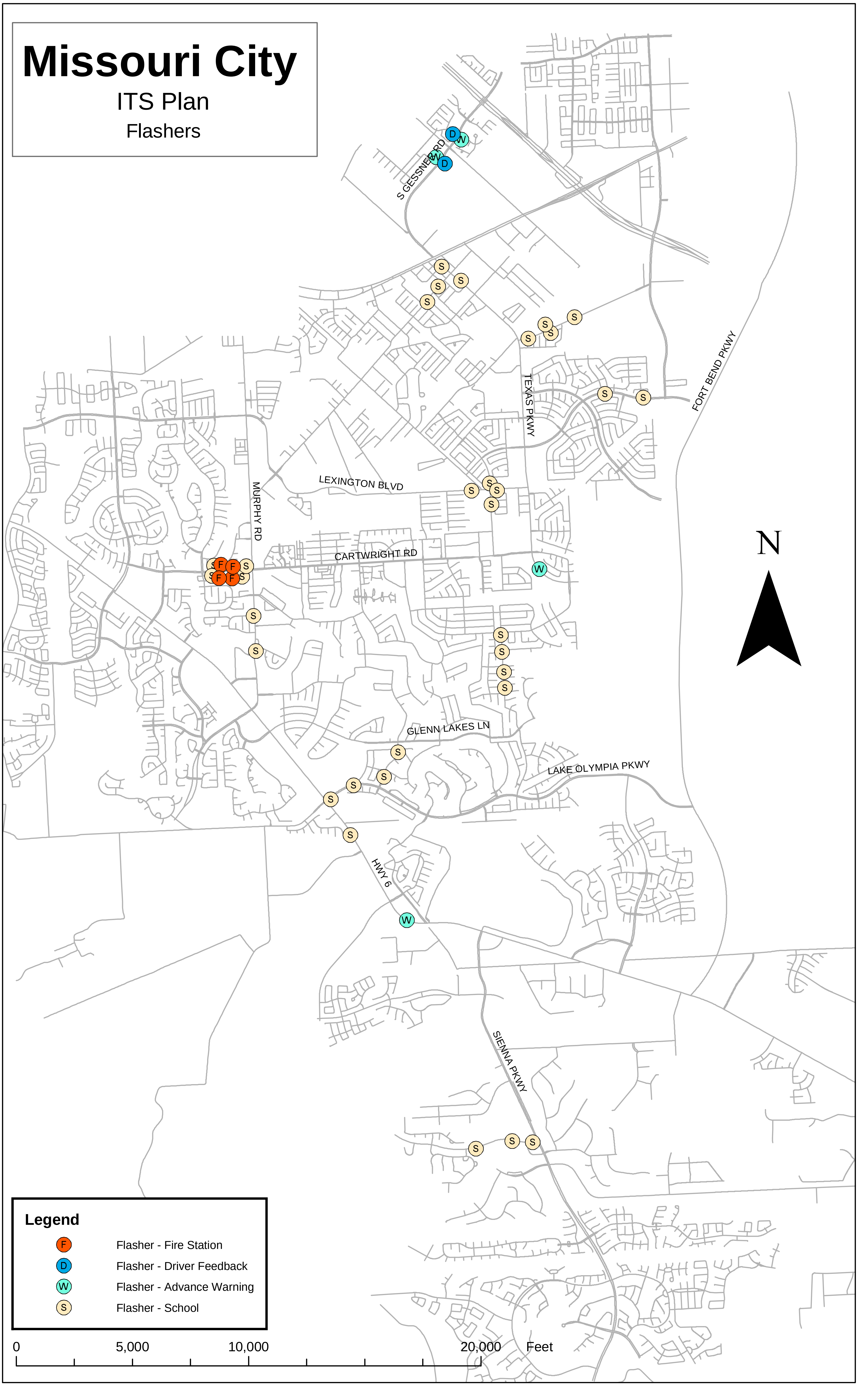
ITS Plan

Schools and School Zones



Date Printed: October 1, 2007

E. Existing Flashers



Date Printed: October 1, 2007

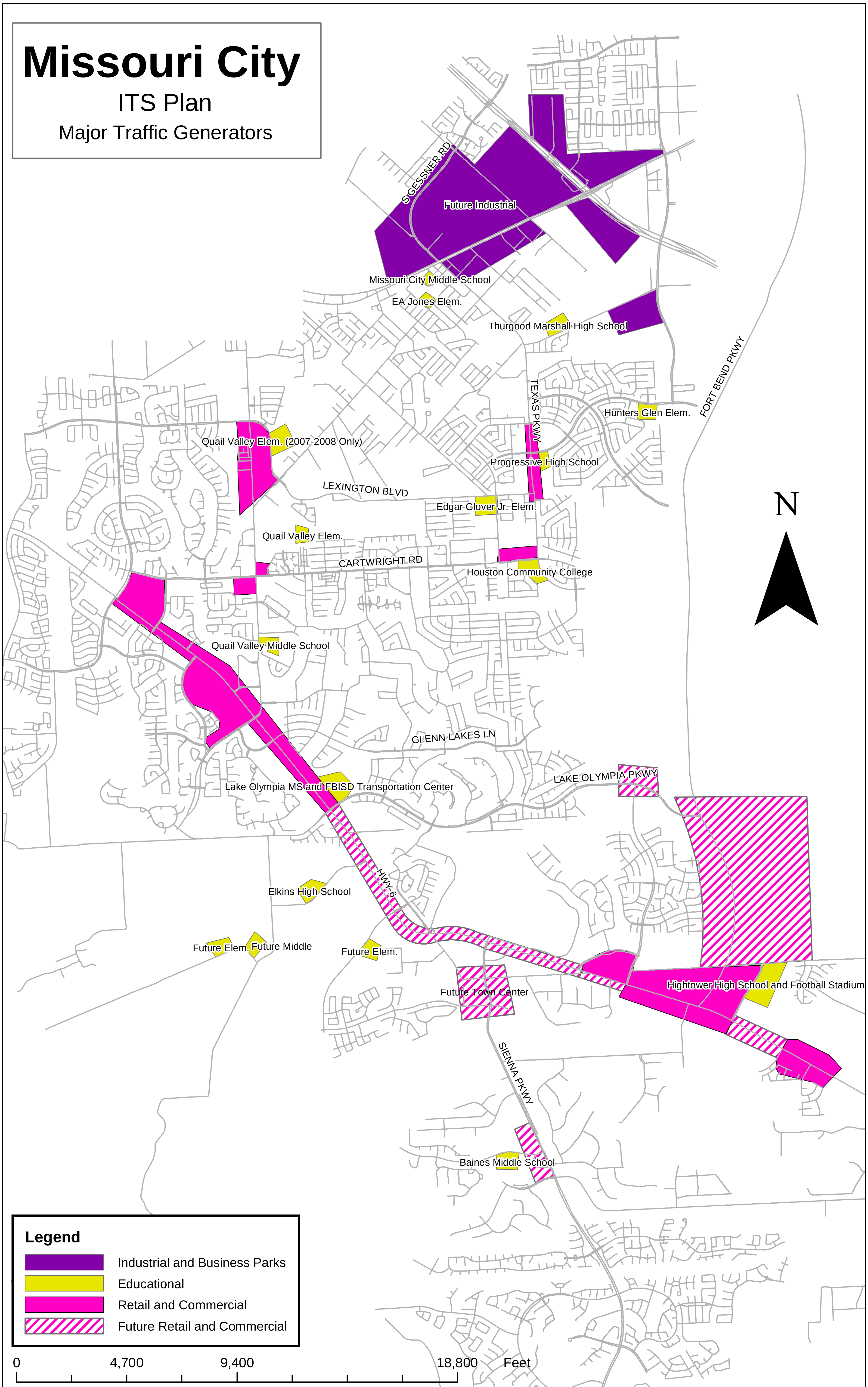
F. High Crash Locations

High Crash Locations in Missouri City, Texas
Years: January 1998 - July 2007
Source: Missouri City Police Department

Rank	Location	# of Crashes
1	1500 Texas Parkway	263
2	1600 Independence Boulevard	237
3	2400 Murphy Road	221
4	2100 Texas Parkway	156
5	10200 Beltway 8	153
6	1900 Plumb Creek	150
7	2200 Lake Olympia	150
8	6200 State Highway 6	150
9	1200 Texas Parkway	137
10	3000 Murphy Road	137
11	3700 Cartwright Road	135
12	1300 Murphy Road	125
13	3400 Texas Parkway	124
14	2900 Cartwright Road	122
15	4700 State Highway 6	117
16	1400 Sheffield	115
17	1800 Court Road	114
18	2000 Murphy Road	110
19	1700 Glenn Lakes Lane (Parking Lot)	108
20	2500 Cartwright Road	104
21	9400 State Highway 6	104

Date Printed: April 28, 2008

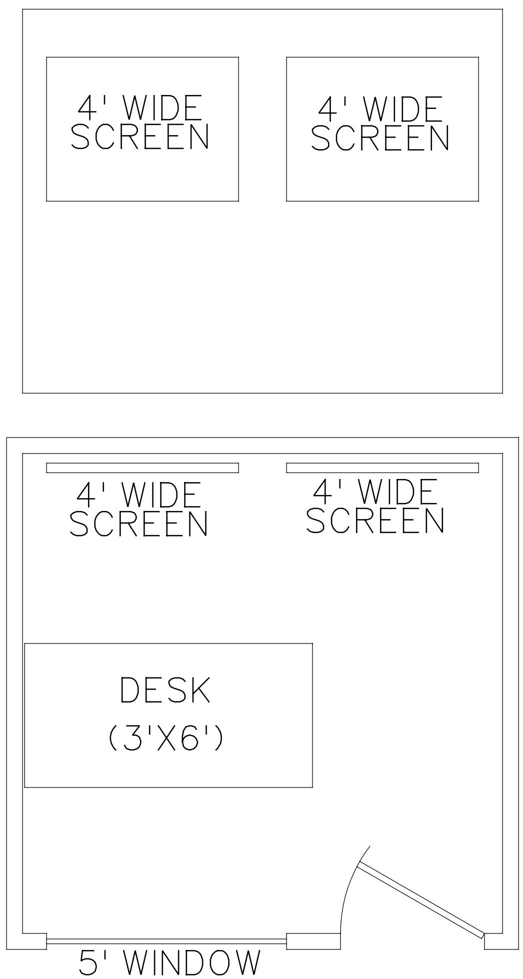
G. Traffic Generators



Date Printed: October 1, 2007

H. TMC Layout Options

OPTION 1
10'X10'



OPTION 2
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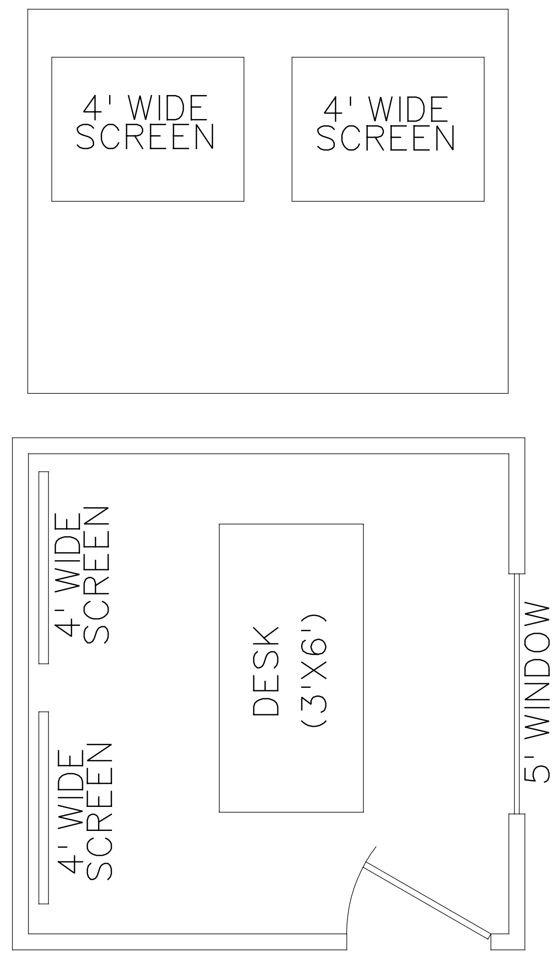
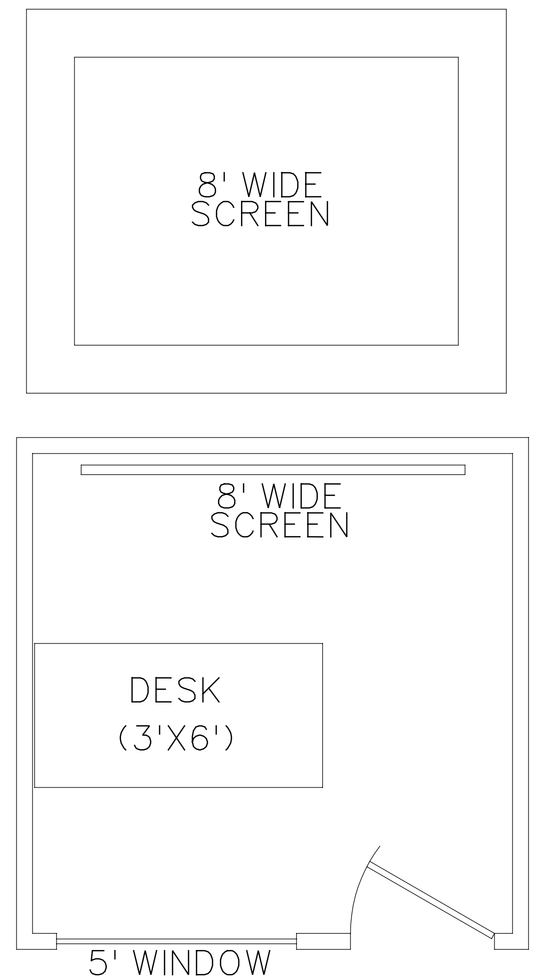


OPTION 3
10'X10'



OPTION 4
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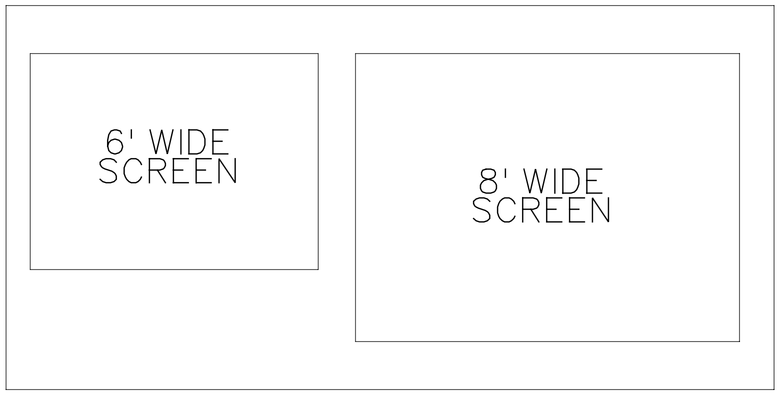

OPTION 5
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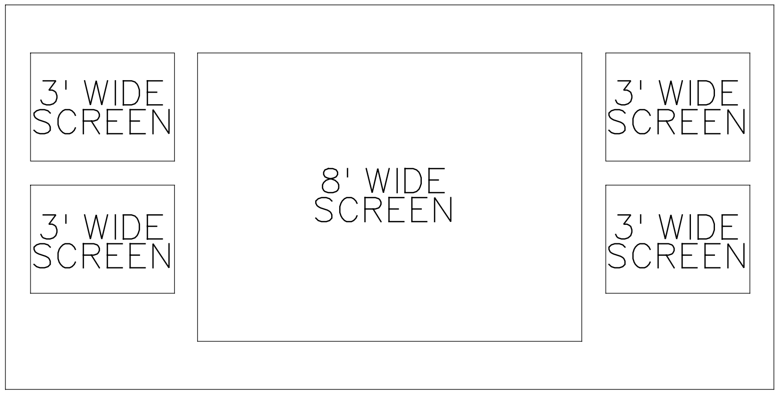
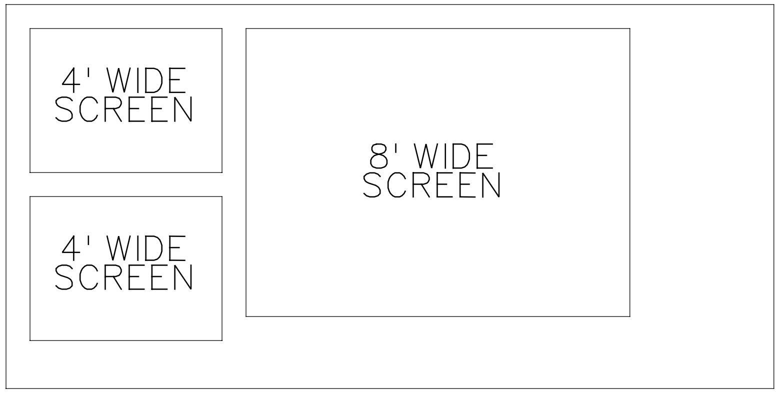
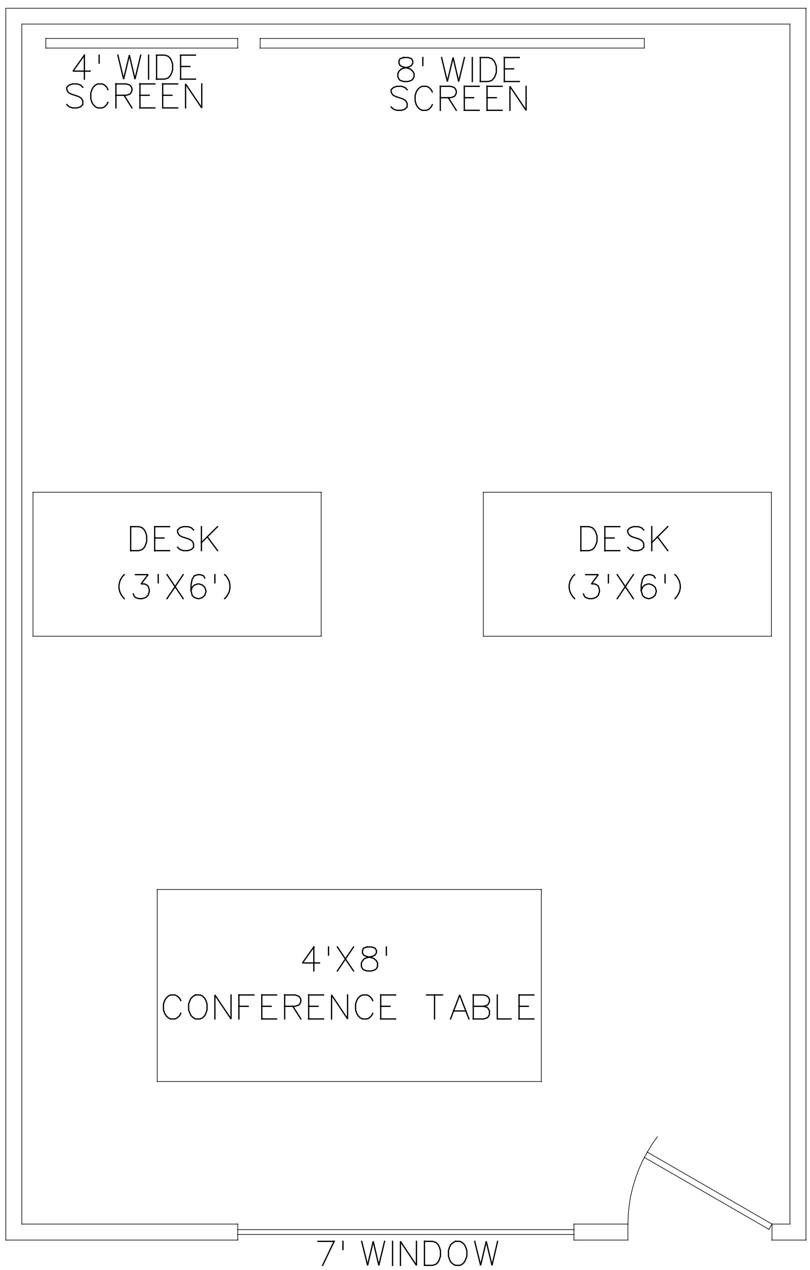


OPTION 6
16'X25'





I. Houston Transtar CCTV Policy

POLICY & PROCEDURE

SUBJECT:	**Closed Circuit Television (CCTV) Operations**		
		ISSUE DATE:	**06/19/02**
PPM NUMBER	**706**	**REVISION DATE:**	**09/08/03**

PURPOSE: To establish a policy for anyone operating cameras in the consortium closed circuit television system.

POLICY: The CCTV system has been installed to support transportation management and emergency management activities across several jurisdictions and is to be used for those purposes only. Respect for the privacy of the public is to be maintained at all times. To that end, the guidelines to implement this policy will be followed at all times.

PROCEDURES: The following guidelines are to be used when operating any closed circuit television camera connected to the Houston TranStar network.

A. General Use: Typically, cameras are intended for the purposes of viewing public rights-of-way. Therefore, cameras are to be turned such that they view the travel lanes (freeways, frontage roads, surface streets, and HOV lanes). Cameras may only be moved to view objects off of the rights-of-way in response to an Emergency Management situation as approved by a Shift Supervisor or Operations Manager.

Cameras are not intended to view the interiors of vehicles. Thus they are to be zoomed out to a practical extent so as to see as much of the right-of-way while minimizing the viewing of private property adjacent to the right-of-way.

In order to prevent, the undue and unauthorized viewing of property not on the rights-of-way and to prevent close up viewing of vehicles, the cameras are to be checked at least once each work shift to assure the cameras are turned to view the rights-of-way and are zoomed out to a proper perspective. Each operating agency is responsible to make this check of the cameras on their rights-of-way. This can be done in conjunction with the standard CTMS maintenance check. If an operator finds a particular camera is consistently found to be viewing any unauthorized area, the operator is to report this to his shift supervisor.

When viewing an incident, the operator should have the adjacent cameras placed so that they view both directions of travel on the roadway when practical. The view should include the resultant traffic queue upstream of the incident. Close up views of the vehicular damage or injuries caused by an accident are to be avoided. However, close up views of damaged agency property in order to assess the need for repair or of the incident scene to evaluate the resources needed for proper response are authorized for the shortest amount of time required to make the evaluation.

When rotating camera-viewing direction, the camera is to be placed in a wide-angle view and the roadway is to be kept in view as the camera is turned. Under no circumstances is the camera to be rotated away from the roadway without the approval of a supervisor.

B. Recording and Outside Use: Videotape recordings of incidents are not a general practice. Only a Supervisor may initiate the videotaping of the recovery process after an incident.

Requests by outside agencies or organizations to view areas not on the rights-of-way are to be referred to a Shift Supervisor or Operations Manager. Requests made from outside agencies or organizations to videotape from the CCTV system must be referred to a manager with jurisdiction over the rights-of-way where the cameras are located.

C. Use of Images from Outside Resources: Images placed upon the four main viewing screens are immediately viewable by all media outlets with closed circuit television use agreements. Some discretion must be used prior to placing an image on any of the main viewing screens so that no contractual agreements are violated. Supervisors have the right to restrict what is viewed on the screens.

Video feed from helicopters is available on the system. This includes police helicopters as well as media helicopters. The video feed from a Metro Networks helicopter camera can be viewed on the four main viewing screens from 6 am to 8 am and from 4 pm to 6 pm without infringing on any agreement. The viewing of a Metro Network helicopter video feed at any other time is subject to the conditions of the agreements made by Metro Networks with the local media outlets. During these times and prior to placing the helicopter video feed on the main screens, Metro Networks must be notified. If the feed is from their helicopter, permission must be given by a Metro Networks operator to place it on the main screen.

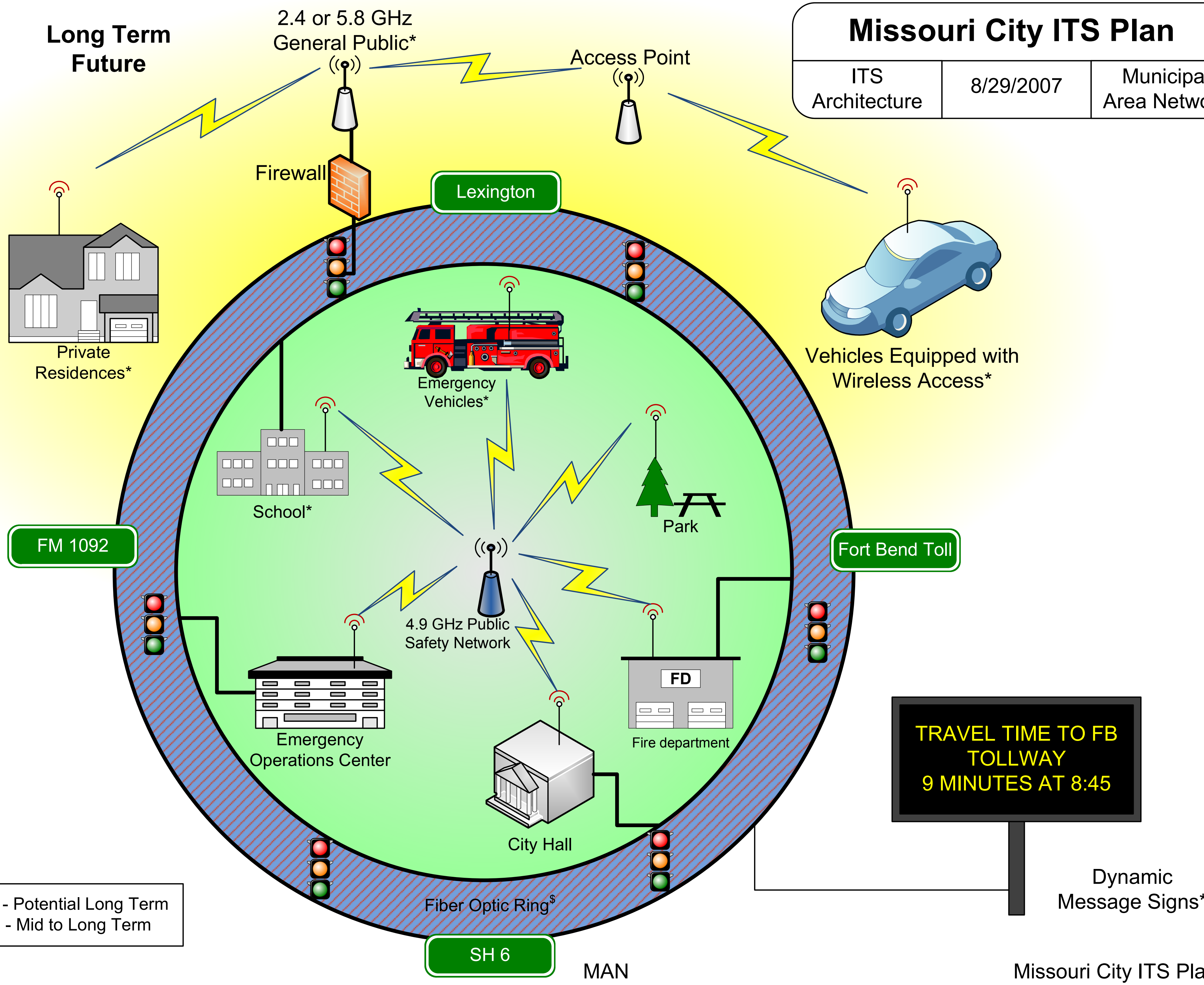
D. Helicopter Video Priority: The video downlink system for helicopter video can only receive video from one helicopter source at a time. The use of the Center’s video system to view video from police helicopter sources will always take priority over viewing video from helicopters of private companies.

E. Enforcement: Violators of this policy will be subject to disciplinary action as prescribed by their home agency.

J. Missouri City System Architecture

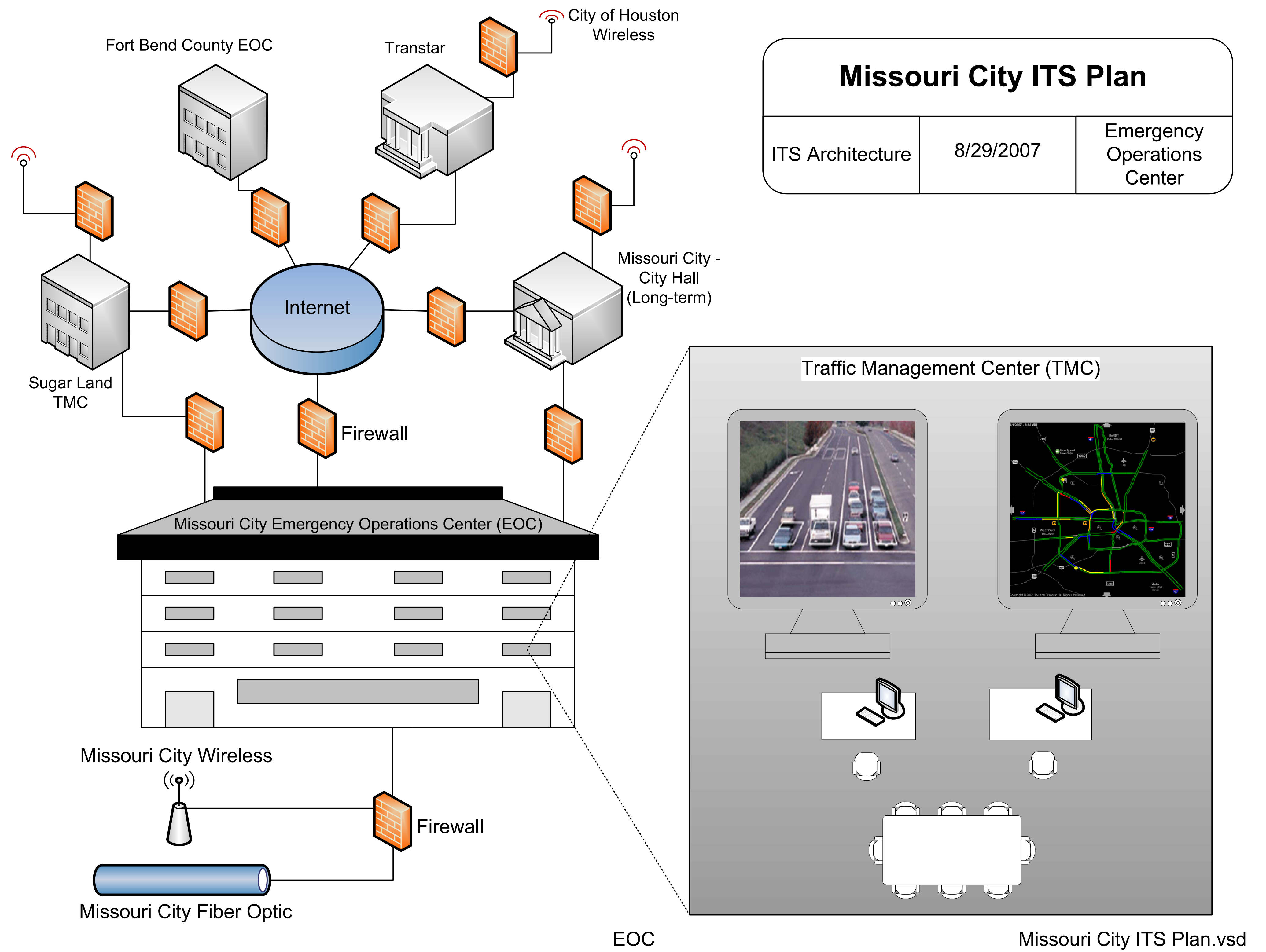
Missouri City ITS Plan

ITS Architecture	8/29/2007	Municipal Area Network



* - Potential Long Term
$ - Mid to Long Term

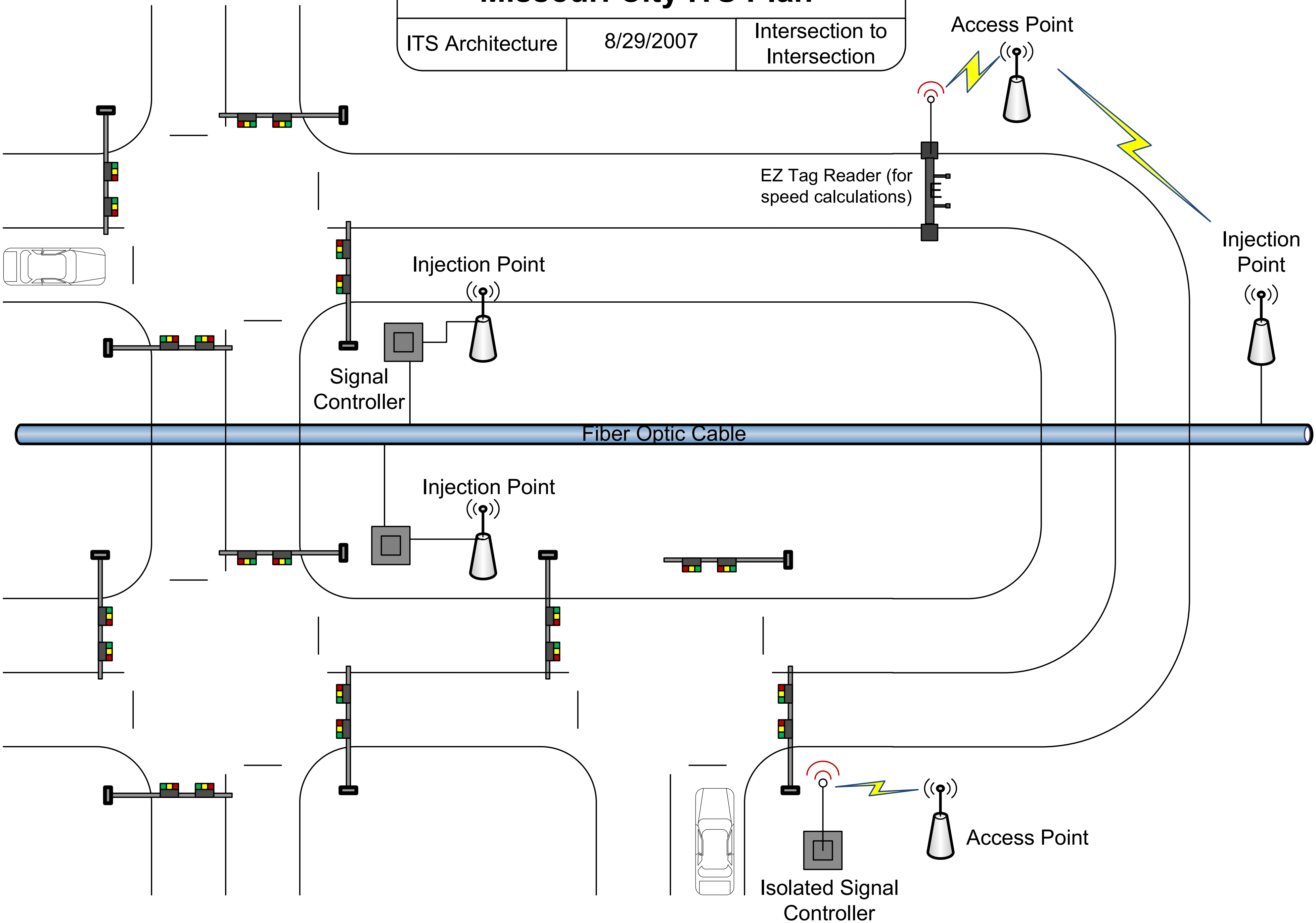
Missouri City ITS Plan.vsd



Missouri City ITS Plan
ITS Architecture
8/29/2007
Emergency Operations Center
Fort Bend County EOC
Transtar
City of Houston Wireless
Sugar Land TMC
Internet
Missouri City - City Hall (Long-term)
Firewall
Missouri City Emergency Operations Center (EOC)
Traffic Management Center (TMC)
Missouri City Wireless
Firewall
Missouri City Fiber Optic
EOC
Missouri City ITS Plan.vsd

Missouri City ITS Plan

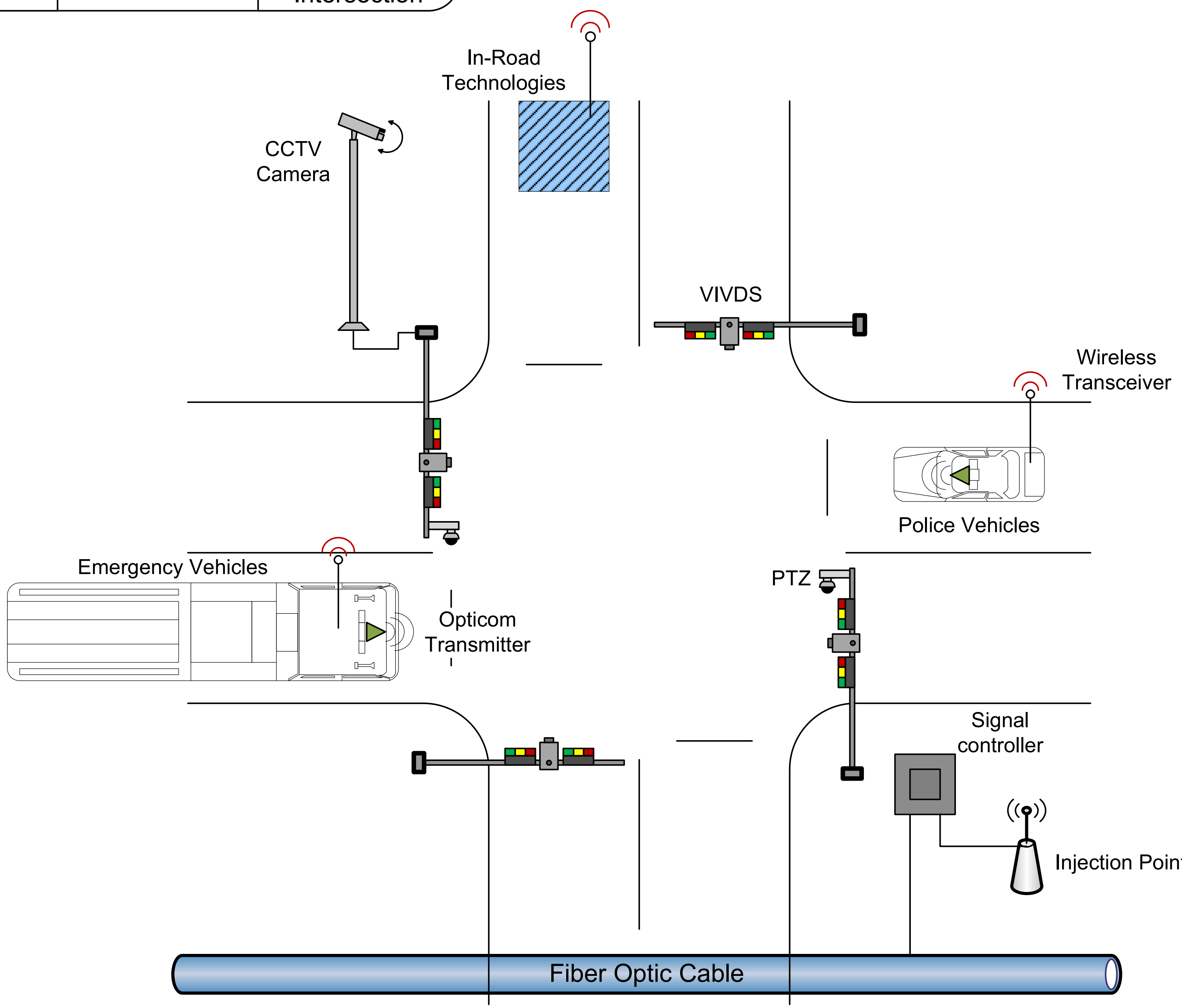
ITS Architecture	8/29/2007	Intersection to Intersection



Intersections

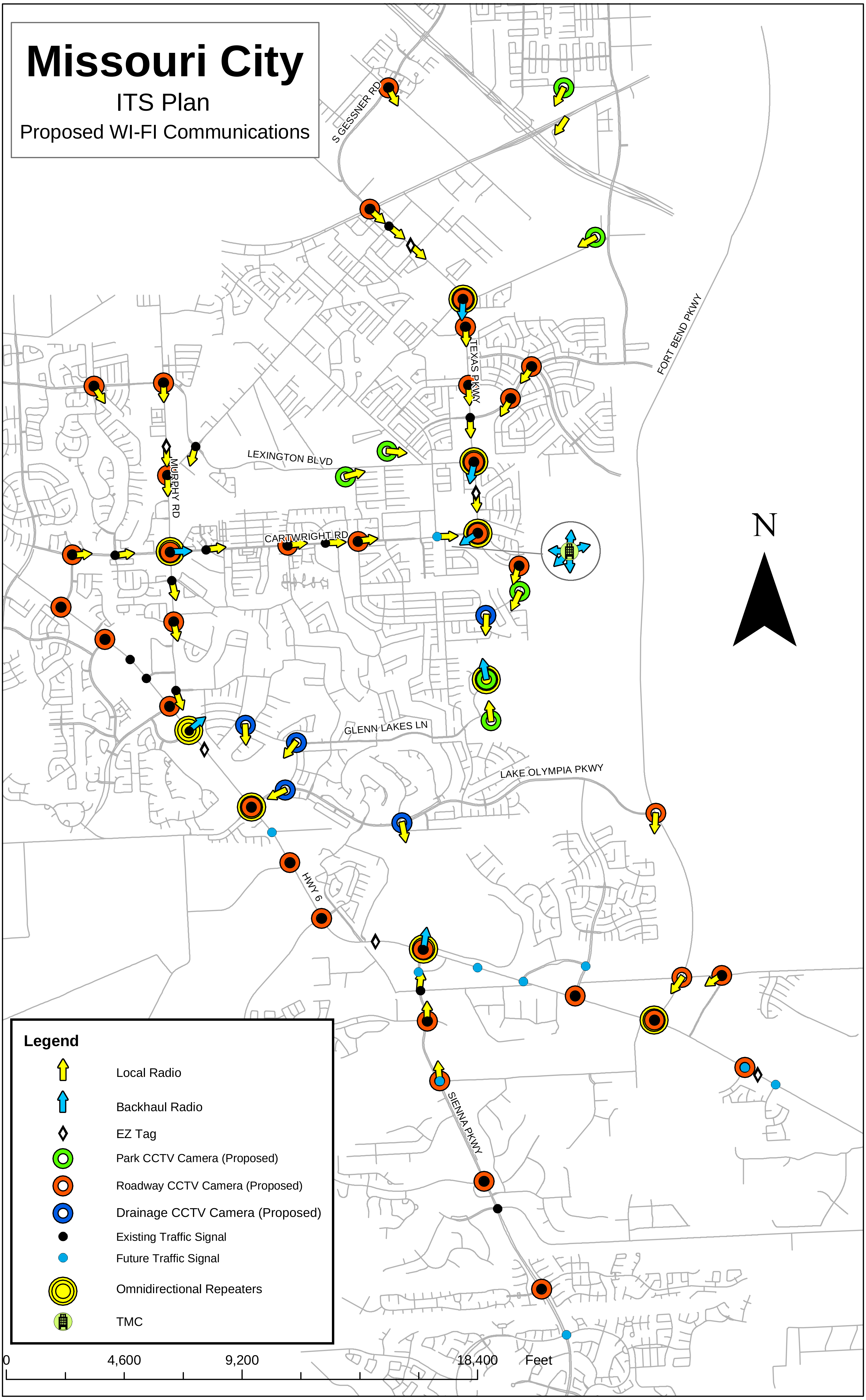
Missouri City ITS Plan.vsd

Missouri City ITS Plan		
ITS Architecture	8/29/2007	Local Intersection



Local Intersection

K. Proposed Communication System



Date Printed: October 1, 2007

L. Project Cost Estimates

Project #1 - Install Wi-Fi communication system, TS2 Controllers and Cabinets, CCTV cameras and Traffic Management Center

Item	Description	Quantity	Unit	Unit Price	Phase 1 FY '08-'09	Phase 2 FY '09-'10	Phase 3 FY '10-'11	Phase 4 FY '11-'12	Phase 5 FY '12-'13
TS 2 Cabinets and Ethernet Controller (complete)	SH 6	3	Each	$6,000	$18,000				
	Murphy Road	3	Each	$6,000		$18,000			
	Texas Parkway/Gessner Road	6	Each	$6,000			$36,000		
	Cartwright Road	1	Each	$6,000				$6,000	
	Sienna Parkway	0	Each	$6,000					
	All other locations	4	Each	$6,000					$24,000
TS 2 Ethernet Controllers (Replace faceplate on existing TS2 controllers)	SH 6	9	Each	$3,000	$27,000				
	Murphy Road	3	Each	$3,000		$9,000			
	Texas Parkway/Gessner Road	3	Each	$3,000			$9,000		
	Cartwright Road	5	Each	$3,000				$15,000	
	Sienna Parkway	0	Each	$3,000					
	All other locations	1	Each	$3,000					$3,000
Signal Timing Conversions	SH 6	12	Each	$1,200	$14,400				
	Murphy Road	6	Each	$1,200		$7,200			
	Texas Parkway/Gessner Road	9	Each	$1,200			$10,800		
	Cartwright Road	6	Each	$1,200				$7,200	
	Sienna Parkway	0	Each	$1,200					
	All other locations	5	Each	$1,200					$6,000
Ethernet/Fiber Optic Switch	SH 6	16	Each	$2,100	$33,600				
	Murphy Road	8	Each	$2,100		$16,800			
	Texas Parkway/Gessner Road	12	Each	$2,100			$25,200		
	Cartwright Road	7	Each	$2,100				$14,700	
	Sienna Parkway	0	Each	$2,100					
	All other locations	17	Each	$2,100					$35,700
Fiber Splicing	SH 6	14	Each	$2,000	$28,000				
	Murphy Road	0	Each	$2,000					
	Texas Parkway/Gessner Road	0	Each	$2,000					
	Cartwright Road	0	Each	$2,000					
	Sienna Parkway	0	Each	$2,000					
	All other locations	0	Each	$2,000					
Wireless Survey	SH 6	1	Lump Sum	$10,000	$10,000				
	Murphy Road	1	Lump Sum	$7,000		$7,000			
	Texas Parkway/Gessner Road	1	Lump Sum	$7,000			$7,000		
	Cartwright Road	1	Lump Sum	$5,000				$5,000	
	Sienna Parkway	1	Lump Sum	$7,000					$7,000
	All other locations	1	Lump Sum	$7,000					$7,000
Standard Radio (single radio, dual band)	SH 6	4	Each	$4,000	$16,000				
	Murphy Road	7	Each	$4,000		$28,000			
	Texas Parkway/Gessner Road	12	Each	$4,000			$48,000		
	Cartwright Road	7	Each	$4,000				$28,000	
	Sienna Parkway	8	Each	$4,000					$32,000
	All other locations	22	Each	$4,000					$88,000
Backhaul radio (Intersection)	SH 6	2	Each	$4,000	$8,000				
	Murphy Road	1	Each	$4,000		$4,000			
	Texas Parkway/Gessner Road	2	Each	$4,000			$8,000		
	Cartwright Road	1	Each	$4,000				$4,000	
	Sienna Parkway	0	Each	$4,000					$0
	All other locations	1	Each	$4,000					$4,000
Backhaul radio (TMC)	SH 6	2	Each	$4,000	$8,000				
	Murphy Road	1	Each	$4,000		$4,000			
	Texas Parkway/Gessner Road	2	Each	$4,000			$8,000		
	Cartwright Road	1	Each	$4,000				$4,000	
	Sienna Parkway	0	Each	$4,000					$0
	All other locations	1	Each	$4,000					$4,000
Omni antenna	SH 6	4	Each	$500	$2,000				
	Murphy Road	1	Each	$500		$500			
	Texas Parkway/Gessner Road	3	Each	$500			$1,500		
	Cartwright Road	0	Each	$500				$0	
	Sienna Parkway	0	Each	$500					$0
	All other locations	1	Each	$500					$500
CCTV camera and equipment	SH 6	10	Each	$5,000	$50,000				
	Murphy Road	4	Each	$5,000		$20,000			
	Texas Parkway/Gessner Road	8	Each	$5,000			$40,000		
	Cartwright Road	3	Each	$5,000				$15,000	
	Sienna Parkway	4	Each	$5,000					$20,000
	All other locations	18	Each	$5,000					$90,000
Video Encoder	SH 6	10	Each	$2,000	$20,000				
	Murphy Road	4	Each	$2,000		$8,000			
	Texas Parkway/Gessner Road	8	Each	$2,000			$16,000		
	Cartwright Road	3	Each	$2,000				$6,000	
	Sienna Parkway	4	Each	$2,000					$8,000
	All other locations	18	Each	$2,000					$36,000
Electrical Service	SH 6	0	Each	$2,000	$0				
	Murphy Road	0	Each	$2,000		$0			
	Texas Parkway/Gessner Road	0	Each	$2,000			$0		
	Cartwright Road	0	Each	$2,000				$0	
	Sienna Parkway	0	Each	$2,000					$0
	All other locations	10	Each	$2,000					$20,000
Pole and Foundation	SH 6	0	Each	$4,000	$0				
	Murphy Road	0	Each	$4,000		$0			
	Texas Parkway/Gessner Road	0	Each	$4,000			$0		
	Cartwright Road	0	Each	$4,000				$0	
	Sienna Parkway	0	Each	$4,000					$0
	All other locations	10	Each	$4,000					$40,000
Signal Control Software	ATMS.now	1	Each	$100,000	$100,000				
TMC operations center	Computer hardware, software, etc.	1	Lump Sum	$120,000	$120,000				
	Phase Sub Total:				**$455,000**	**$122,500**	**$209,500**	**$104,900**	**$425,200**
	Design at 15%:				**$68,250**	**$18,375**	**$31,425**	**$15,735**	**$63,780**
	Contingencies (30%):				**$156,975**	**$42,263**	**$72,278**	**$36,191**	**$146,694**
	Phase Total:				**$680,225**	**$183,138**	**$313,203**	**$156,826**	**$635,674**
	Grand Total for all Phases:				**$1,969,065**				

Note: Phase 1 includes startup costs associated with installation of TMC equipment and purchase of signal control software.
Note: Actual installation costs will vary.

Project #2 - Develop Traffic Website

Item	Description	Quantity	Unit	Unit Price	Phase 1 FY '08-'09	Phase 2 FY '09-'10	Phase 3 FY '10-'11	Phase 4 FY '11-'12	Phase 5 FY '12-'13
Website	Web Page Development	1	Lump Sum	$30,000		$30,000			

NOTE: Actual costs will vary depending on using in-house staff or outside consultant, features of website and additional equipment that may be needed.

Project #3 - Add UPS to all existing traffic signals

Item	Description	Quantity	Unit	Unit Price	Phase 1 FY '08-'09	Phase 2 FY '09-'10	Phase 3 FY '10-'11	Phase 4 FY '11-'12	Phase 5 FY '12-'13
UPS	SH 6	12	Each	$5,000	$60,000				
	Murphy Road	6	Each	$5,000		$30,000			
	Texas Parkway/Gessner Road	10	Each	$5,000			$50,000		
	Cartwright Road	6	Each	$5,000				$30,000	
	Sienna Parkway	0	Each	$5,000					
	All other locations	5	Each	$5,000					$25,000
				Phase Sub Total:	**$60,000**	**$30,000**	**$50,000**	**$30,000**	**$25,000**
				Grand Total for all Phases:	**$195,000**				

NOTE: Actual installation costs will vary.

Project #4 - Install AVI Tag Readers

Item	Description	Quantity	Unit	Unit Price	Phase 1 FY '08-'09	Phase 2 FY '09-'10	Phase 3 FY '10-'11	Phase 4 FY '11-'12	Phase 5 FY '12-'13
AVI Tag Reader system	SH 6	12	Each	$7,500				$90,000	
	Murphy Road	6	Each	$7,500				$45,000	
	Texas Parkway/Gessner Road	6	Each	$7,500				$45,000	
	Cartwright Road	0	Each	$7,500				$0	
	Sienna Parkway	0	Each	$7,500				$0	
	All other locations	0	Each	$7,500				$0	$0
				Phase Sub Total:				**$180,000**	
				Design at 15%:				**$27,000**	
				Contingencies (30%):				**$62,100**	
				Phase Total:				**$269,100**	
				Grand Total for all Phases:	**$269,100**				

NOTE: Actual installation costs will vary.

Project #5 - Install Countdown Pedestrian Signals

Item	Description	Quantity	Unit	Unit Price	Phase 1 FY '08-'09	Phase 2 FY '09-'10	Phase 3 FY '10-'11	Phase 4 FY '11-'12	Phase 5 FY '12-'13
Countdown Pedestrian Signals	SH 6	12	Each	$4,000					$48,000
	Murphy Road	6	Each	$4,000				$24,000	
	Texas Parkway/Gessner Road	10	Each	$4,000			$40,000		
	Cartwright Road	6	Each	$4,000		$24,000			
	Sienna Parkway	5	Each	$4,000					$20,000
	All other locations	5	Each	$4,000		$20,000			
Additional Signal Hardware for intersections without existing pedestrian items	SH 6	7	Each	$10,000					$70,000
	Murphy Road	1	Each	$10,000				$10,000	
	Texas Parkway/Gessner Road	3	Each	$10,000			$30,000		
	Cartwright Road	0	Each	$10,000					
	Sienna Parkway	0	Each	$10,000					
	All other locations	0	Each	$10,000					
			Phase Sub Total:		**$0**	**$44,000**	**$70,000**	**$34,000**	**$138,000**
			Grand Total for all Phases:		**$286,000**				

NOTE: Actual installation costs will vary.

M. Synchro Output

Zone 3 Totals

Number of Intersections	11
Total Delay / Veh (s/v)	24
Total Delay (hr)	252
Stops / Veh	0.44
Stops (#)	16268
Average Speed (mph)	27
Total Travel Time (hr)	638
Distance Traveled (mi)	16944
Fuel Consumed (gal)	955
Fuel Economy (mpg)	17.7
CO Emissions (kg)	66.77
NOx Emissions (kg)	12.99
VOC Emissions (kg)	15.47
Performance Index	297.6

Zone 2 Totals

Number of Intersections	6
Total Delay / Veh (s/v)	26
Total Delay (hr)	143
Stops / Veh	0.52
Stops (#)	10231
Average Speed (mph)	26
Total Travel Time (hr)	311
Distance Traveled (mi)	8047
Fuel Consumed (gal)	522
Fuel Economy (mpg)	15.4
CO Emissions (kg)	36.49
NOx Emissions (kg)	7.10
VOC Emissions (kg)	8.46
Performance Index	171.4

Zone 1 Totals

Number of Intersections	10
Total Delay / Veh (s/v)	49
Total Delay (hr)	364
Stops / Veh	0.57
Stops (#)	15367
Average Speed (mph)	15
Total Travel Time (hr)	565
Distance Traveled (mi)	8550
Fuel Consumed (gal)	742
Fuel Economy (mpg)	11.5
CO Emissions (kg)	51.89
NOx Emissions (kg)	10.10
VOC Emissions (kg)	12.03
Performance Index	407.2