Kimley»Horn

City of Tyler

ITS Master Plan

Summary Report

FINAL 10/6/2020

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CITY OF TYLER TEXAS

A Natural Beauty

Table of Contents

Executive Summary

Intelligent Transportation Systems (ITS) are the modern methods by which transportation professionals leverage technology to provide better mobility for the movement of people and goods. For citizens in the City of Tyler, this means a more reliable work commute or better drive down South Broadway on Saturday for shopping. ITS means the City Traffic Engineer can receive near real-time alerts when a traffic signal goes into a flashing state because of a thunderstorm. ITS means many different things to many different 'users' of the transportation system. An effective ITS benefits all users of the transportation system, including citizens, traffic signal technicians, city traffic engineer, fire department, police department, and emergency response vehicles.

In 2019, the City Engineering Services Department authorized a study to investigate the City's core system used to monitor and operate the transportation network and develop an implementation plan to update and modernize the transportation system.

Over a 14-month period of time, the selected consultant team worked with City staff to identify their Concept of Operations, which identifies how the system is currently being used, who depends upon the system, what the future system should do, and who needs to share specific data and information. Based on the Concept of Operations document, the future needs were defined. Based on the needs of the future system, the consultant team worked with City staff to identify and discuss the many possibilities of upgrading communications and systems needed to control the field devices (e.g. traffic signals). The final documents developed were: 1) projects for the Capital Improvement Program (CIP), 2) cost projections, 3) Implementation Plan, and 4) this final report.

The key findings and recommendations of the study include the following:

- The City needs ITS to efficiently manage traffic, promote mobility in keeping pace with the growth of the City, and take advantage of smart technologies that the transportation industry has developed in recent years.

- The City currently uses TACTICS for its Advanced Transportation Management System (ATMS). The City should execute a software maintenance agreement in FY20 for continued use of an up-to-date version of TACTICS. In FY21, the City should evaluate alternative ATMS platforms that have functionality better aligned with City needs.

- There is a need to modernize traffic control cabinets across the city to Advanced Traffic Controller (ATC) Cabinets. This modernization will provide traffic signal technicians with a modern cabinet that has better diagnostics and alerts, which aids in maintenance and operations. The modern traffic signal controllers required for ATC cabinets and others identified for replacement will provide a higher level of intelligence and generate data for performance measurement. It was recommended to begin upgrades and replacements starting in FY21 and complete over a period of 10 years (to FY30).

- The City's legacy school zone flashing beacon system lacks remote monitoring due to the age of the equipment and the lack of communication to the flashing beacon locations. This is a significant limitation because the school day schedule changes frequently and there are unpredictable weather events that cause early or late school schedules. The recommended action is to upgrade the school zone system in FY20 to have communication and remote diagnostic capabilities.

- There are currently eight battery backup units (BBUs) in the City, two of which are operational. BBUs provide power when there is a loss of wired-line power to the traffic control cabinets. The recommended action is to install BBUs at all signalized locations. The BBUs would be installed in FY22-FY30. Per previous discussions with the City, BBUs are required by TxDOT for all signalized locations on the state's highway system.

- There is no emergency vehicle pre-emption system in the City. These systems are required in order to provide a green light to emergency vehicles at a signalized intersection. These vehicles naturally have the right-of-way when their lights and sirens are active. However, it is safer to the public and emergency response teams to provide a pre-emption, or green signal indication, in advance of the emergency vehicle arriving at the intersection. It is recommended to install either a physical/infrared pre-emption system or a centralized emergency vehicle preemption system based entirely upon automated vehicle location (AVL) and global positioning system (GPS). The latter is the modern, more preferred method, and it can be procured with the ATMS system upgrade.

- There are currently no means to remotely observe intersection operations from a central point of command, such as a Traffic Management Center. It is recommended to install closed-circuit television cameras (CCTV) at strategic locations throughout the City, such as downtown and along key travel corridors (South Broadway, Beckham, Front Street, and Loop 323). Other recommended ITS technology would include Dynamic Message Signs and roadway weather sensors.

- The existing communications network is a combination of wired and wireless technologies, and it provides communication to approximately one-half of the existing traffic signals. The existing communications system, while functional, is un-reliable and has significant bandwidth limitations. It is recommended to upgrade the communications network in two phases. First, use a cellular technology at all intersections because of its immediate deployment and relatively low cost. Second, plan to install a high bandwidth secure wireless radio network. The deployment of the cellular modems can be accomplished in late FY20, and throughout FY21. The second phase could be accomplished in later fiscal years.

- The 'central command' center is currently a workstation located at the signal shop. Recently the City's Traffic Engineer has been successful in getting this same data at his office computer located on Locust Street. It is recommended that a secure physical Traffic Management Center (TMC) be constructed. This could be a repurposed office, or a new space constructed in conjunction with a service center. The recommended TMC would be a physically secure office with access to the City's enterprise network (WLAN) and to the future broadband radio communications network. The TMC should be sized to accommodate a minimum of three workstations.

- Final observations and recommendations include continuing to optimize traffic signals for smooth traffic flow and implementing a performance measurement program to measure, monitor, and improve conditions based on data.

Introduction

Incorporated in 1850, Tyler is located 98 miles southeast of Dallas and is the county seat of Smith County. There are several State and US highways that run through and around the City of Tyler, including US-69, US-271, SH-14, SH-31, SH-64, SH-155, and SH-323. These highways, highlighted in Figure 1, provide a network of access to the City of Tyler from the surrounding cities. In addition to these highways, Broadway Avenue and Erwin Street are two major arterials that have seen an increase in traffic over time. Tyler has no interstate highways in the city limits, but IH-20 borders part of the Tyler city limits, connecting the city to other regional hubs such as the Dallas-Fort Worth metroplex.

Figure 1 - State Highways in City of Tyler

As one of the leading cities in East Texas, Tyler has seen steady growth in population over the past decade. The city's current population was estimated to be at 105,729 in July 2018[1] with a total area of 57.2 square miles. Tyler is the principal city in the Tyler metropolitan statistical area, which has an estimated population of 209,714 as of 2010[2].

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[1] https://www.census.gov/quickfacts/tylercitytexas
[2] factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_NSRD_GCTPL2.US24PR

The City of Tyler's Traffic Operations staff provides traffic management and maintenance for 149 signalized intersections. The Traffic Operations staff has the following responsibilities:

- Manufacturing and maintaining City street signs
- Installing and maintaining pavement markings on City streets
- Maintaining traffic signals within the City limits
- Analyzing and implementing traffic signal timing
- Planning for current and future traffic control needs
- Mitigating traffic congestion within the City limits
- Conducting traffic safety studies
- Ensuring street lights are installed and maintained in a timely manner
- Providing oversite of the public school crossing guard program

Project Need

The City operates 149 traffic signals located throughout the city. The Siemens TACTICS system has served the City well, but lack of an ongoing maintenance contract and reliable communication has hindered the City's traffic management capabilities.

Without ongoing upgrades and maintenance, the existing ATMS cannot support many of the advanced functionality available in modern signal controllers. This includes collection of high-resolution data, which can be used to proactively manage the traffic signal system, and integration with performance management tools, adaptive signal control, SPaT data, and third-party software.

Ongoing upgrades are important for a modern ATMS.

Without reliable communication, maintaining traffic signals and school zone flashers has been challenging. There is a significant increase in the demand for an efficiently run transportation system.

The City needs ITS to efficiently manage traffic, promote mobility in keeping pace with the growth of the City, and take advantage of smart technologies that the transportation industry has developed in recent years. It is important that the City take a forward view of becoming a Smart City. This is to say that adjustments made today can better prepare the City for tomorrow. The future ITS will support the City of Tyler tomorrow.

Project Approach

The City embarked upon the first comprehensive study of their existing traffic management systems using a methodical process known as the Systems Engineering Process. This proven process has been used extensively on studies such as this project because it works through a series of steps starting with the identification of the project goals and objectives. Based upon the goals and objectives, the project needs, requirements, and overall implementation plan is developed. This process matches technology to the needs of the community.

As shown in Figure 1, the Systems Engineering "V" Diagram suggests an interdisciplinary approach to developing systems and, through checkpoints back to the starting line, ensures that what is ultimately designed and deployed meets the project intent. The Systems Engineering process is tailored to focus on defining stakeholder needs and required functionality early in the development cycle, documenting requirements, then proceeding with design and system validation while considering the "big picture."

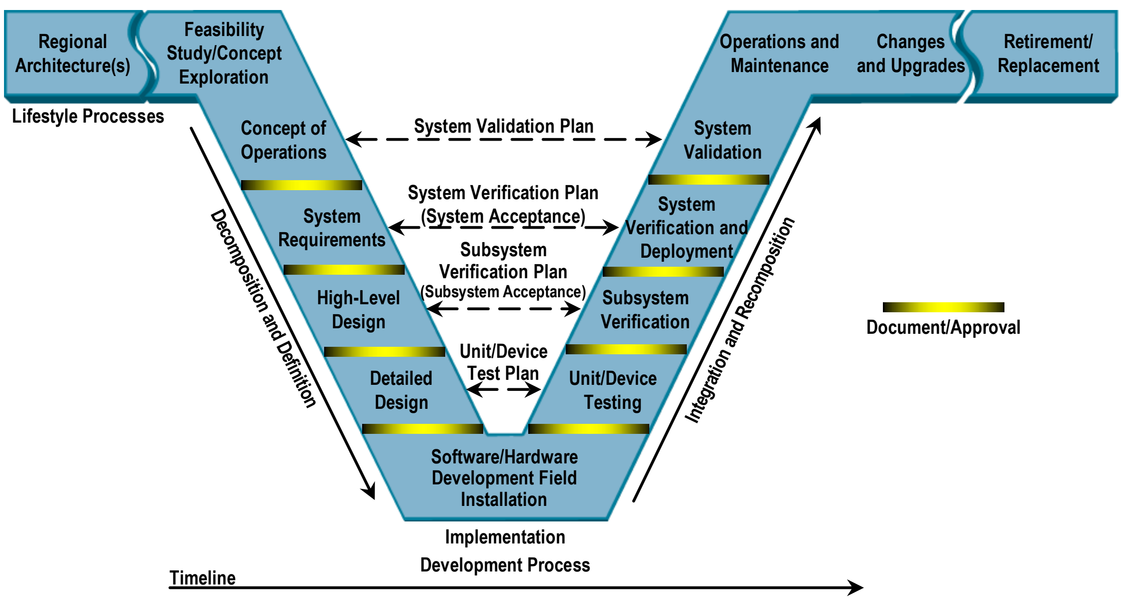

Figure 1 - Systems Engineering "V" Diagram
Source: Systems Engineering for Intelligent Transportation Systems, FHWA, 2007.

It is critical that the planned intelligent transportation system (ITS) reflects a reasonable and comprehensive project that meets the needs of the project stakeholders. The needs identified through the various workshops were used to identify system requirements that guided the design and the development of the implementation plan.

Existing Conditions

This section provides an overview of the existing traffic signal equipment deployed in the City. Further details on the system inventory are contained in the *Existing Conditions* report developed under the ITS Master Plan.

Central System Software

The central system software allows the City to view signal operations in real-time. The central system software is often also referred to as the Advanced Transportation Management System (ATMS) software. There are differences, but they can be subtle or distinct. For the purposes of this study, they can be used interchangeably. City staff are provided access credentials and thus anyone with the proper credentials can monitor traffic signal status and adjust signal operations from their city workstation or remote laptop when connected to the City network.

The City has been utilizing Siemens traffic control products for decades. They are currently using Siemens TACTICS for their central system software, which exclusively controls only traffic signals. The TACTICS software is Siemens' current offering for controlling and managing traffic signals.

Traffic Management Center

A Traffic Management Center (TMC) serves as a central location for monitoring traffic operations, adjusting timing, responding to incidents, and dispatching personnel to fix field problems. The City's "TMC" is located in the signal shop and consists of 2 workstations with 2 monitors for display. The City's Traffic Engineer has TACTICS installed on his office workstation and can control traffic signals from his office.

Field Devices

Each signalized intersection consists of a variety of equipment to actually detect and control traffic at the intersection. Additional information on the equipment is contained in *Concept of Operations* document. The equipment quantities are based on inventory information provided by the City. More discussion of individual field device by type is further discussed below.

Traffic Signal Cabinet

In Tyler, 51% (76 of 149) of all traffic signal cabinets are NEMA TS-2 cabinets. The remaining cabinets (73 of 149; 49%) are legacy NEMA TS-1 cabinets. The TS-1 cabinets are obsolete, and the TS-2 cabinets are considered mature. Existing cabinets are performing adequately.

Traffic Signal Controllers and Firmware

Four of the City's controllers are the M40 class from Siemens (above)

In Tyler, 75% (112 of 149) of the signal controllers are manufactured by Siemens. Of those, 23 are EPAC. The remaining 89 Siemens controllers are M40, M50, M51, M52, or M60. Four controllers in the City are of the M40 class from Siemens (pictured to the left). For the remaining signal controllers in the city, 30 (20%) are Econolite ASC/3 and 7 (5%) are Econolite Cobalt. The existing traffic signal controllers are controlling intersection operations at an acceptable level.

Vehicular and Pedestrian Detection

Vehicle detection in Tyler is predominantly video based; 113 intersections (76% of total signalized intersections) have video image vehicle detection system (VIVDS) cameras installed. The VIVDS device manufacturers are currently not catalogued. 15 intersections have traditional inductive loops, 8 intersections have Wavetronix radar detection, and 13 intersections are fixed-time/non-actuated. The City identified the video detection as working well.

Source: Iteris

Audible pedestrian push button systems, which provide verbal instructions for visually impaired pedestrians, are installed at 2 intersections (1% of total).

Malfunction Management Units

Source: EDI

The majority of the City of Tyler's MMUs are manufactured by EDI, with the exception of 2 MMUs manufactured by Reno. Of the 147 EDI MMUs, 73% (107 of 147) are in the MMU-16E or MMU-16LE series. 6% (9 of 147) are in the EDI 12LE series. 2% (3 of 147) are in the EDI SSM-12 series, and 3% (5 of 147) are unknown models. The remaining 16% (23 of 147) are in the EDI NSM-12 series, which does not support Flashing Yellow Arrow (FYA) operations.

Battery Backup Units

The City currently has eight Battery Backup Units (BBUs) installed. It has been reported by City staff that only two of the eight existing BBUs are not currently operational because the batteries are beyond useful life and do not carry a load (i.e., dead). Per TxDOT requirements, BBUs are required on City-operated signals on TxDOT roadways.

Pre-Emption Systems

In the City of Tyler, one signal has railroad preemption. Emergency vehicle pre-emption is not currently in place.

School Zone Flasher System

The City operates 72 school zone clocks that do not currently have communications. The times for which the school zone flashers are active are programmed manually for each flasher. Changes in the scheduled time are adjusted annually before the schools are back in session.

Existing Communications Network

The City's existing communication network to the field ITS devices using wireless radios, cable modems, and twisted-pair copper wire were discussed with City staff. The City has constructed a "hybrid" communications network consisting of both wired and wireless communications, which is described below.

Fourteen (9%) of the intersections have cable modems (DSL, from SuddenLink), seven (5%) have City-owned or leased fiber, 38 (26%) have fixed broadband radio (5.8 GHz), two (1%) have both radio and twisted wire pair, and six (4%) have twisted wire pair. Seventy percent of the City's traffic signals have no communication back to the Siemens TACTICS traffic management system.

Concept of Operations

The Consultant team developed a Concept of Operations that accomplished the following:

1. Identified the key roles of the ITS – what it will and will not do.
2. Developed a description of the environment in which the ITS will operate.
3. Developed operational scenarios that were used to describe how the stakeholders would perform under different environmental conditions.
4. Identified high-level functional requirements for the ITS as a whole (based on the operational scenarios).

At the core, the Concept of Operations provided answers to the following questions:

- What is the purpose of the ITS?
- Who will use the ITS?
- What are the roles and responsibilities of each party?
- How will they use the ITS?
- When will the ITS be used?
- In what environments will the ITS be used?
- What support measures are needed?
- What resources will each party contribute?
- What are the communications requirements to support the ITS?

The Consultant team conducted several workshops that identified the system concept, system needs, and ideal responses to operational scenarios. These workshops were conducted on May 8 and July 18, 2019, and included the following City leaders:

- City Engineer
- Stormwater & Traffic Interim Manager
- Traffic Operations Supervisor
- Lead Signal Technician
- Chief Information Officer from the IT Department.
- Police Department
- Fire Department
- Water Utilities Department
- City Manager's Office

Figure 2 illustrates the relationship between stakeholders for which the intelligent transportation system will serve and benefit.

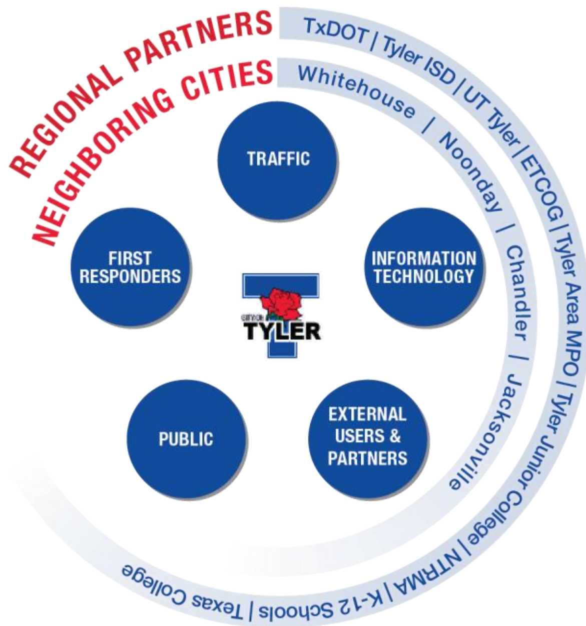

Figure 2 – Stakeholders
Source: Kimley-Horn

Additional information is contained in the *Concept of Operations* document developed under the ITS Master Plan.

Description of the System Needs

This section summarizes the system needs identified in the *Concept of Operations*. A detailed list of high-level and low-level needs is provided in the Appendix.

The City needs ITS to efficiently manage traffic and promote mobility in keeping pace with the growth of the City and take advantage of the smart technologies that the transportation industry has developed in recent years.

Central System Environment

There is a need for the ATMS to integrate the entire traffic signal system and ITS devices on one network to monitor device performance, collect data, and troubleshoot. The environment for the system needs to provide sufficient processing speed, capacity, and expandability. There is a need for the environment configured by the City's IT department to be scalable to support the expansion of the City's signal network over time.

Central System Software and Advanced Transportation Management System

There is a need to maintain and upgrade the City's ATMS

The Siemens TACTICS system has served the City well, but lack of an ongoing maintenance contract and reliable communication has hindered the City's traffic management capabilities. There is a need to keep the version up-to-date for bug fixes and increased functionality. There is also a need to continue having a maintenance contract for operational support and troubleshooting.

The central system software needs to provide access and information (at varying levels) for Traffic Engineering staff, traffic signal technicians (who currently have a laptop to take home), and the Police and Fire Departments (to identify signals on flash).

The central system software needs capabilities to integrate other traffic management functions as part of additional packages or modules. By doing so, the City creates a fully operational Advanced Transportation Management System, or ATMS. For the purpose of this study, the Central System Software is the module that controls traffic signals and operates within the larger ATMS platform, which provides for more comprehensive management and control of all field devices. The central system software shall provide alert capability, including communication status, signals on flash, and email alerts to related personnel. It needs to be adaptable to real-time conditions, and consistent and supportive of City's current process of providing open data. There is a need to support advanced functionality in the controller. The ATMS, which includes the central system software functionality, should include full control of all field devices (e.g. traffic signals, CCTV cameras, DMS) and include the consumption and use of high-resolution data for performance measures.

Traffic Management Center

There was a need identified to expand the existing "TMC" located at the signal shop or construct a "new" facility (could be a repurposed office or training space) so it operates as a central point of command and control for the traffic engineers and signal technicians. There is a need for the TMC to be the central location where information can be shared readily.

Field Devices

This section addresses various types of field devices, including traffic signal controllers, CCTV cameras, and vehicle detection systems.

Traffic Signal Cabinets

A need for upgrading legacy TS-1 cabinets to Advanced Transportation Controller (ATC) cabinets was identified. The ATC cabinet is a modular, serially-interconnected cabinet architecture that is designed to fulfill a variety of transportation applications. There is also a need to upgrade existing TS-2 cabinets to ATC programmatically and at all new signals.

> There is a need to upgrade traffic signal cabinets and controllers

Traffic Signal Controllers

There is a need for state-of-the-art traffic signal controllers to support the City's current traffic operations and provide future capabilities. Upgraded software and hardware will allow the City to manage operations more efficiently. There is a need to standardize traffic signal controllers to be compatible with the full functionality of TACTICS or the City's (future) chosen ATMS. There is a longer-term need to modernize traffic signal controllers and move toward ATC controllers.

Closed Circuit Television Cameras (CCTV) and Control Software

There is a need for the upgraded ATMS to support CCTV cameras with pan-tilt-zoom capabilities. There is a need for the cameras at strategic locations, such as intersections of major roadways, water towers, or high accident locations, to augment vehicle imaging video detection system (VIVDS) camera images. There was a long-term need identified to have 360° video coverage at all signalized intersections.

Detection System

There is a need to upgrade detection equipment to detect all modes of transportation accurately and reliably, including vehicles, bikes, and pedestrians, providing more efficient operations. There was a need identified to standardize the detection equipment used throughout the city and upgrade loops to video detection. There was a need identified to bring video feeds from video detection back to the TMC. Additionally, there was a need identified to have modern detection that meets the needs of adaptive signal control.

Malfunction Management Units (MMU)

There is a need to update malfunction management units (MMUs) as they age out. There is a need for the updated MMUs to support IP communications for remote monitoring. There is a need to upgrade legacy MMUs to support FYA operations.

Battery Backup Units (BBUs)

There was a need identified to install and maintain BBUs. The short-term priority is to install BBUs at signalized intersections on TxDOT roadways, to meet the TxDOT requirement. A long-term need was identified to have operational BBUs at all signalized intersections in the City. For monitoring and alarm purposes, there is a need to add the BBUs to the ATMS. There is a need for the BBUs to support IP communications for remote monitoring.

Pre-Emption Equipment

There are currently no pre-emption systems installed in the City. There is a need to install a pre-emption system across the city, preferably a GPS-based system. There is a need for the pre-emption system to be planned for integration into the ATMS and configured to prevent the potential for unauthorized use.

School Zone Flashers

There was a need identified to install a new school zone flasher system with remote communications, centralized command, and remote monitoring capabilities.

> There is a need for a school zone flasher system with remote communications

Communications

Without reliable communication, maintaining traffic signals and school zone flashers has been challenging. There is a significant increase in the demand for an efficiently run transportation system.

There is a need to provide wireless communications to school zone flashers and traffic signals for remote monitoring capabilities. There is also a need to stream video back to the TMC, which requires a high-bandwidth capability. There is a need for reliable wireless communication in the locations that do not have fiber. There is a need for future upgrades to expand the network and provide redundancy.

Connected Vehicles

There is a need for the City to consider the infrastructure needs of connected vehicles. The most common systems for communication between connected vehicles and surrounding infrastructure are Dedicated Short-Range Communications (DSRC) and 5G. Should DSRC continue to be the dominant communication method, cities (such as Tyler) will be required to invest in DSRC radios at every traffic signal cabinet. From a communications standpoint, the City's network would need to be fast enough and have enough bandwidth to provide Signal Phasing and Timing (SPaT) data to thousands of cars at once, every tenth of a second.

If 5G becomes the dominant communications standard for connected vehicles, the City's network would need to be fast enough and have enough bandwidth to provide SPaT data to thousands of cars at once, every tenth of a second.

Security

There is a need to secure the City's ATMS network from external threats. An unsecured ATMS network can provide an access point to the rest of the City's network, threatening public health and safety, data security, City services, and the overall integrity of the City network.

Data

There is a need to continuously monitor traffic and share travel time conditions with citizens. There is a need for the City of Tyler to become a Waze Connected Citizens Program partner. There is a need to collect high-resolution traffic signal data and integrate Automated Traffic Signal Performance Measures (ATSPM) into traffic signal operations.

Work Orders

A need for an improved work order system was identified at the ConOps workshop. There is a need for a digital inventory and work order system. The work order system needs the ability to query for locations with frequent replacements and calculate response time; these metrics can be further used as performance measures. For staff in the field, there is a need to connect and sync to the work order system, either through cellular coverage or offline synching.

There is a need for a streamlined work order system

Asset Management

A need for a better asset management system was identified at the workshop. For staff in the field, there is a need to connect and sync to the asset management system, either through cellular coverage or offline synching.

Customer Service

An improved customer service process for complaint calls was identified as a need of the upgraded ATMS. A need for a better way of routing complaint calls to the correct personnel and tracking the response was identified.

Public Communications

A need for more communication with the public (i.e. via Twitter, a dedicated web portal, or Waze) was identified. Suggested information to be shared included planned lane closures, signal timing and phase data (SPaT), and various performance metrics. A need to acquire and deploy additional portable changeable message signs (PCMS) and dynamic message signs (DMS) was also identified.

Future Buildout

To anticipate future buildout across the City, known City projects and system needs were incorporated. The future buildout of various device types is summarized below.

Traffic Signals

Two planned traffic signals were identified during the project. The first is at Broadway & Sprouts Driveway (just north of Loop 323), and the second is at Old Omen & McDonald. Battery backup units (BBUs) were proposed citywide, with signals on TxDOT facilities having priority. Pre-emption systems were proposed citywide, which would be achieved through a phased implementation at priority locations.

A citywide upgrade of traffic signal cabinets to ATC cabinets was identified. This would be accomplished in a phased implementation. First, TS-1 cabinets on priority corridors would be upgraded. Next, all other TS-1 cabinets in the City would be replaced. Finally, TS-2 cabinets would be replaced.

Citywide controller upgrades were also identified. These upgrades would occur as cabinets are converted to ATC cabinets and as needed for ATMS compatibility.

School Zone Flashing Beacons

There are not any new school zone beacons planned at this time. However, it is recommended to consider installing school zone beacons at locations that currently only have a school zone sign. These beacons could be installed with the overall system upgrade.

CCTV Cameras

Based on the need for camera coverage, CCTV cameras were planned for installation at 30 major intersections and 3 elevated water storage tanks.

DMS Units

DMS units were proposed at two locations. The first location is on Highway 69, northwest of Loop 323, to provide traveler information to motorists entering and leaving the City. The second location is University Boulevard, southeast of Loop 323, to provide information for people traveling to and from the University of Texas at Tyler.

Weather Sensing Devices

Two weather stations and road weather sensors were proposed. The locations of these devices are flexible and can be identified with a more detailed study of areas with concerns of freezing or high water.

Communication Alternatives

There are a variety of methods used for system communications and communications between intersections and a central location. Methods include:

- Dial up;
- Copper wire;
- Fiber optic cable;
- Spread spectrum radio;
- Licensed channel radio; and
- Cellular networks.

In some cases, the NEMA TS 1 controllers support the more recent communications methods, but the functionality is limited. The TS 2, Type 2070, and ATC controllers support all of the above communication methods. The trend in the industry is towards I.P. Ethernet communications.

The system chosen should utilize the highest communication speed available. The chosen system also needs to support signal phasing and timing data (SPaT), high-resolution traffic signal data, and video streaming back to the TMC.

Additional information related to communication options can be found in the *State of the Practice* and *Communication Alternative Analysis Memorandum*, which are separate technical reports developed under the ITS Master Plan.

Key Considerations

The City of Tyler will need to carefully consider their needs for transmitting data and video. Based upon previous discussions, there is a desire to communicate with each ITS device, such as traffic signal controllers, data collection stations, and CCTV cameras. This comprehensive coverage should be carefully designed using the most appropriate technology. For example, it is assumed that a fiber optic cable will continue to provide the backbone of the communications system. The backbone will be complemented using other communication network mediums, such as wireline and/or wireless equipment. Where CCTV cameras are deployed, a medium that supports high-bandwidth should be constructed.

The key consideration in constructing a private wireless network is the terrain. The rolling terrain and horizontal curvature of roadways in Tyler will dictate the location, frequency, and height of wireless antennas. This would be considered the lowest cost deployment option to support multiple ITS devices along the roadways and can be deployed over time.

In the meantime, cellular communications are another alternative. They support sufficient bandwidth to provide a snapshot and even streaming video during times when roadway conditions are needed.

Cost Considerations for Communication Options

Table 1 provides planning-level cost estimates by communication media, which were effective at this time this report was authored.

Table 1. Communications Costs
Source: Kimley-Horn

Cabinet	Approximate Cost
Copper Wire	$50,000/mile
Fiber Optic Cable	$175,000/mile
Point-to-Multipoint Wireless (low data)	$3,000 to $6,000 per intersection/ITS device
Point-to-Multipoint Wireless (high data)	$12,000 to $30,000 per link
Licensed Wireless	$35,000 per link
Cellular Modem	$50 to 80 per month

Recommended Alternative

Workshops with City staff were conducted on March 5 and June 5, 2020, to discuss the recommended communication alternative, which is detailed in the *Communication Alternative Analysis Memorandum*.

Taking into consideration ownership, network efficiency, network redundancy, and cost, the long-term preferred alternative is a hybrid-type network architecture that consists of both wireless communication technologies and fiber optic cable. This will require staff training, additional staff resources, additional operations and maintenance costs, and capital costs associated with fiber infrastructure.

Considering these factors, a cellular wireless system architecture presents a near term solution to providing quick connectivity throughout the City and should be considered, at a minimum, for priority corridors.

ATMS Alternatives

As part of the ITS Master Plan, Kimley-Horn facilitated workshops presented by vendors of technologies and relevant systems that support the needs identified in the Concept of Operations. The three categories of technologies were the ATC Cabinet, ATMS, and School Zone System.

ATC Cabinet

The ATC Cabinet family is a modular, serially-interconnected cabinet architecture that is designed to fulfill a variety of transportation applications. The ATC cabinet combines concepts from both the NEMA and Model 170 traffic signal cabinets. From the Model 170 cabinet, it takes the concept of rack-mounted sub-assemblies. From the NEMA cabinet, it borrows the basic serial connections between the controller and sub-assemblies.

The ATC cabinet provides support for up to 48 input and 32 output channels, smaller components (and thus more room in similarly sized cabinets), low voltage (48 VDC) operation, voltage and current monitoring of all signal outputs (including ultra-low power LED), advanced diagnostics, enhanced safety, simplified cabinet wiring, and reduced cabinet size. The low voltage ATC cabinet has not been widely adopted because it requires a separate inventory of DC components and a DC power supply.

ATC Cabinets are safer, smarter, and more energy efficient

The ATC cabinet promises many benefits over traditional cabinets, including improved safety, advanced troubleshooting tools, and fail-safer technology. The most prominent benefit is increased available space in a similar sized cabinet, because the individual components are smaller. As the industry moves toward more advanced functionality to support signal performance measurement, connected vehicles, and autonomous vehicles with additional equipment in the cabinet (network switches, DSRC, data collection equipment, etc.) is needed. As equipment needs increase, the extra space afforded in the ATC cabinet becomes more beneficial. ATC cabinets allow twice the equipment in the same space, or the same equipment in half the space[3].

Additional information on the background of the ATC Cabinet is contained in the *State of the Practice* document developed as part of the ITS Master Plan.

Cost Considerations

The cost comparisons of various cabinets are shown below in Table 2.

[3] https://www.editraffic.com/wp-content/uploads/ATC-Cabinet-Overview-3-10-2015.pdf

Table 2. Cabinet Costs
Source: Kimley-Horn

Cabinet	Approximate Cost
TS 2 Type 1	$8,000 to $10,000
TS 2 Type 2	$9,000 to $14,000
Type 2070 (traditional 332 Cabinet)	$8,000 to $11,000
ITS	$13,000 to $21,000
ATC	$8,000 to $13,000
ATC Backpack Cabinet	$6,000 to $8,000

ATC Cabinet Vendor Presentations

Four vendors were contacted to provide demonstrations of their ATC cabinets. The following vendors made presentations on the dates indicated:

- Mobotrex – presented on April 16, 2020
- Econolite Safetran – distributed by Paradigm, presented on April 16, 2020
- McCain – presented on April 17, 2020

Follow-up discussed was conducted with City staff on April 23 and April 28, 2020.

Because the ATC cabinet standard is function-based, there are differences in cabinet equipment between manufacturers. Therefore, it is important to maintain consistency among ATC cabinet procurements (for example, developing a City standard for ATC cabinets).

When moving forward with ATC cabinet procurement, key considerations include:

- Controller upgrades required for cabinet compatibility
- Preferred cabinet configuration and available space
- Backpack cabinet option
- Low-voltage power option

ATMS

The modern-day traffic management system is more commonly referred to as the advanced traffic management system, or ATMS. The City of Tyler currently uses TACTICS as their ATMS, which is an example of a Hybrid Traffic Control System. The ATMS typically monitors, manages, and controls not just traffic signal controllers, but many other ITS elements such as dynamic message signs and closed-circuit television (CCTV) cameras.

Additional information on ATMS is contained in the *State of the Practice* document developed as part of the ITS Master Plan.

ATMS Vendor Presentations

Five vendors were contacted to provide demonstrations of their ATMS, detection, and Connected Vehicle systems. The following vendors made presentations on the dates indicated:

- Econolite Centracs – distributed by Paradigm, presented on April 8, 2020
- Kimley-Horn KITS – presented on April 9, 2020
- Intelight/Q-Free MaxView – distributed by Texas Highway Products, presented on April 9, 2020
- Siemens TACTICS – distributed by Iteris in Texas, presented on April 14, 2020
- Trafficware ATMS.now – presented on April 15, 2020

Follow-up discussed was conducted with City staff on April 23 and April 28, 2020. Table 3 summarizes key differentiators between ATMS options.

Table 3: Summary of ATMS Differentiators

	Centracs	TACTICS	ATMS.now	MaxView	KITS
Developer	Econolite	Siemens	Cubic	Q-Free	Kimley-Horn
Controller	ASC3/EOS	Siemens	Cubic	Intelight, Siemens, Econolite	Intelight, Siemens, Econolite, many others
Architecture	C-S	C-S	C-S	Cloud	C-S, Cloud
Support ITS Devices	Simple module	CONCERT	Simple module	None	Simple module
Support CAV	Yes (AI)	Yes (Siemens)	Yes (TTS)	Yes (CV)	Yes (TTS)
SPM	Yes	Yes (Iteris)	Yes	Yes	Yes (Traction)
Purchase	BuyBoard	No Co-Op	No Co-Op	BuyBoard	No Co-Op

When moving forward with an ATMS, key considerations include:

- Ease of use
- Maintenance/support
- Controller upgrades required

School Zone System Vendors

Cellular-based school zone flasher systems offer more functionality and diagnostics than their legacy processors. New school zone systems also allow users to change schedules remotely, store multiple plans, monitor radar speed of vehicles, monitor energy use and batter performance, provide analytical and performance metric tools, and allow remote firmware updates.

Additional information on School Zone Systems is contained in the *State of the Practice* document developed as part of the ITS Master Plan.

School Zone Vendor Presentations

Five vendors were contacted to provide demonstrations of their school zone flasher systems. The following vendors made presentations on the dates indicated:

- ENCOM – distributed by Texas Highway Products, presented on April 6, 2020
- Applied Information – distributed by Paradigm, presented on April 6, 2020
- ELTEC – presented on April 7, 2020
- RTC – distributed by CTC, presented on April 7, 2020
- TAPCO – presented on April 8, 2020

Follow-up discussed was conducted with City staff on April 23 and April 28, 2020.

When moving forward with a school zone flasher system, key considerations include:

- Turnkey solution
- Warranty
- Connectivity guarantee
- Ease of use

Four of the vendors provided cost data for their school zone flasher system. Cost data is summarized in Table 4, with total costs for various contract lengths. The total costs were calculated for 75 school zone flashers, and the total costs include equipment costs and recurring cell service charges for all locations.

Table 4: School Zone Flasher Cost Data

Vendor	Total Costs				Notes
	1 Year	3 Years	5 Years	10 Years	
ENCOM	-	-	-	-	Pricing not provided
AI	$120,000	-	$187,500	$225,000	Did not include cost of retrofitting base plates
ELTEC	$39,000	-	$75,000	$120,000	$400 per device and $10/month for cell service
CTC	-	-	$166,275	$220,275	10-year cost includes cellular renewal fee
TAPCO	$142,125	$158,419	-	-	3-year cost includes discount for contract extension

Future Technologies

The following subjects were identified as areas of interest. Presentations on the subjects are forthcoming.

Smart City

While "Smart Cities" is an increasingly popular topic, the term itself has been applied in a variety of ways. The term is typically understood as using data provided by sensors and other technology to improve, enhance, make more efficient, and/or automate the operations of a city.

FHWA describes a smart city as "a system of interconnected systems, including employment, health care, retail/entertainment, public services, residences, energy distribution, and not least, transportation. The system of systems is tied together by information and communications technologies (ICT) that transmit and process data about all sorts of activities within the city."[4]

Connected and Autonomous Vehicles (CAV)

Connected vehicles communicate with each other, with other devices, and with the surrounding infrastructure. This is generally known as Vehicle-to-X or V2X. This communication enables vehicles to be aware of where other nearby vehicles are, and where they are headed[5]. Drivers receive notifications and alerts, such as an impending red-light runner.

The development and deployment of autonomous vehicles is accelerating. While the concept is far from being accepted for full-scale deployment due to enormous technological, funding, and social hurdles, it is within the realm of possibility that dense urban settings may begin to support autonomous vehicles within the next 20 years. As testing and research move forward, the industry will begin to understand the infrastructure requirements. As with the connected vehicles, it is expected that autonomous vehicle infrastructure may need to be capable of huge amounts of data transfer. Although, whether these network services will be provided by public or private agencies remains to be seen.

Autonomous vehicles are also being tested both in the US and throughout the world. Texas is among the leaders in testing autonomous vehicles. The Texas Automated Vehicle (AV) Proving Ground Partnership consists of cities, regions, and research agencies throughout Texas that have partnered together to make Texas the nation's first "Smart State[6]".

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[4] https://www.its.dot.gov/itspac/Dec2014/Smart_Connected_City_FINAL_111314.pdf
[5] https://www.its.dot.gov/cv_basics/index.htm
[6] http://smartmobilitytexas.org/#regulations

Outside of the Texas Automated Vehicle (AV) Proving Ground Partnership, at least two autonomous services have started in the DFW Metroplex. The Milo system in Arlington uses low speed autonomous shuttles operating on sidewalks to move passengers between parking lots in the entertainment district to Texas Rangers and Dallas Cowboys games and events at Globe Life Field and AT&T Stadium.

Figure 3. Milo Autonomous Vehicle in Arlington
Source: https://www.usnews.com/news/best-states/articles/2018-02-21/driverless-vehicles-hit-the-road-in-texas

Drive.ai operated a pilot program in Frisco, Texas to provide autonomous ride-hailing service between the Hall Office Park and the Star Complex. The Drive.ai vehicle does not require any V2I communications. The routes and pick up points are fixed. Drive.ai was acquired by Apple in June 2019[7].

[7] https://www.theverge.com/2019/6/25/18758820/drive-ai-self-driving-startup-shutting-down-apple

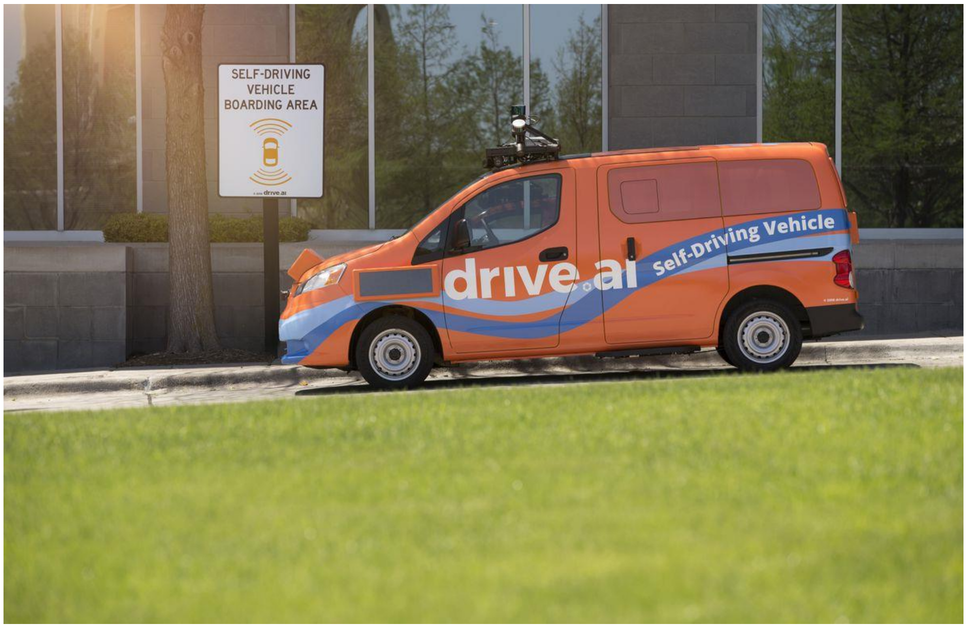


Figure 4. Drive.ai Autonomous Vehicle in Frisco, TX
Source: https://www.vox.com/energy-and-environment/2018/5/8/17330112/self-driving-cars-autonomous-vehicles-texas-drive-ai

Starting October 19, 2018[8], Drive.ai deployed 3 autonomous vehicles for a one-year pilot project in the City of Arlington's entertainment district, the same area served by the Milo shuttle system which includes the Dallas Cowboys and Texas Rangers stadia. Unlike the Milo system, which operates on the sidewalk at walking speed, the Drive.ai vans will travel up to 35 miles per hour on city streets. The $435,000 project is being funded mostly ($343,000) by the federal government through the Congestion Mitigation Air Quality Improvement Grant.

Adaptive Traffic Control Systems (ATCS)

An adaptive traffic control system (ATCS) uses detection data and algorithms to dynamically adjust signal timing parameters to accommodate changing traffic patterns and demand. The dynamic changes to traffic signal timing are predictive in nature; adjustments are implemented in anticipation of changing traffic demand.

Characteristics of an ATCS include the following:

- A central system processes data based on the adaptive algorithm
- The system is dependent on field detection of vehicles. Preference is detection by lane on each approach and sometimes departure of a signalized intersection

[8] https://www.dallasnews.com/business/technology/2018/08/22/arlington-youcan-soon-request-autonomous-vehicle-demand

- Coordination is performed with "near real time" signal timing adjustments typically using one of the following:
  - A traffic model that may be focused on optimizing multiple objective functions
  - Algorithms that seek to optimize degree of saturation
  - Algorithms that seek the minimization of queues, delays and stops
- Cycle and Non-Cycle based operations
- Variable adjustments to splits, cycle length, offsets, and groupings in near real time
- Adjustments are based on prediction of arriving traffic
  - Queues, size and approach of platoon, turn percentages, arrival time

While on-going ATCS operations do not require active input from engineers and technicians, adaptive systems are not "set-and-forget" systems. They require on-going monitoring and fine-tuning of critical detection and communications infrastructure to maintain a high level of performance. The level of maintenance often exceeds that of traditional time-based actuated-coordinated signal operations.

The following are the commercially available ATCS that have existing deployments in the United States. The developers and/or system integrators are also shown in the list.

- ACDSS (Adaptive Control Decision Support System) by KLD Associates (in conjunction with TransCore)
- Centracs Edaptive by Econolite
- InSync by Rhythm Engineering
- Kadence by Kimley-Horn
- MAXTIME by Q-Free/Intelight (local adaptive control)
- QuicTrac by McCain
- SCATS (Sydney Coordinated Adaptive Traffic System) by New South Wales Provincial (distributed in North America by TransCore)
- SCOOT (Split Cycle Offset Optimization Technique) co-owned by Imtech, Siemens Traffic Controls Ltd., and TRL Ltd.
- Synchro Green by Trafficware
- Transparity Adaptive by McCain

The City of Tyler previously deployed ACS-Lite (Adaptive Control System Lite) by FHWA at multiple locations across the city. ACS-Lite relies on pre-determined signal timing plans and adjusts splits and offsets every few minutes, within the programmed cycle lengths. None of the previous ACS-Lite deployments are currently operational, for reasons unknown due to departures of prior City staff.

Automated Traffic Signal Performance Measures (ATSPM)

Automated Traffic Signal Performance Measures (ATSPMs) are transforming traffic signal operations and management by harnessing the power of big data. ATSPMs use high-resolution controller data to provide detailed, real-time signal operation information, such as phase utilization, sufficiency of splits, arrivals on red/green, and turning movement counts. Compatible traffic signal controllers log signal event data across 255 enumerations every 100 milliseconds.

ATSPMs can be used to prioritize retiming efforts and directly measure signal performance, instead of relying on modeling techniques. They also can be used to support goals and objectives defined by an agency. Benefits of ATSPMs include increased safety, targeted maintenance, and improved operations.

The FHWA featured ATSPMs in the fourth round of Every Day Counts (EDC-4). As a result, agencies across the country are using ATSPMs to monitor and manage their traffic signals. ATSPM software solutions include an open-source platform developed by the Utah DOT and various vendor software packages.

Mobility as a Service

Mobility as a Service (MaaS) encompasses transportation options that are accessible on-demand, such as car- and bike-sharing[9]. MaaS also includes Transportation Network Companies (TNCs) such as Uber and Lyft. While MaaS has been viewed by some as a disruptor or replacement of transit services, it can also be used as first/last mile solution. In order to make this successful, it is key for agencies to partner with MaaS providers in their areas to serve unmet demand and set operating guidelines.

MaaS also intends to provide alternatives to private car usage. This can help communities reduce their carbon footprint and utilize more sustainable transportation options.

[9] https://maas-alliance.eu/homepage/what-is-maas/

Cost Projections

Cost data was analyzed to create cost projections for the implementation plan. Cost data was collected from TxDOT Low Bid data and vendor quotes. This section provides an overview of the cost data used for the major implementation plan components. The cost data is used for planning-level purposes only, and actual costs may vary.

Cost projections completed for this study also incorporated a 15% contingency and engineering costs, which were assumed to be 10%. Recurring maintenance costs for cellular modems and ATMS were also included for appropriate years.

ITS Communication Infrastructure

The communication infrastructure considered for this project was cellular modems. Table 5 details the cost data of cellular modems used in this study. A hardened ethernet switch is required for each modem. At the network level, a Layer 3 ethernet switch and network firewall are required.

Table 5: Planning-Level Costs for ITS Communication Infrastructure

Equipment	Unit	Approximate Cost
Cellular Modem	EA	$ 750
Field Ethernet Switch	EA	$ 2,500
TMC Ethernet Switch (Layer 3)	EA	$ 4,500
Network Firewall	EA	$ 2,600

CCTV Network

Table 6 lists planning-level costs for the CCTV network. The cost of assorted field equipment includes 300 feet of ethernet cable, a mounting bracket, a pole extension, a flash memory card, and a 2-year extended warranty.

Table 6: Planning-Level Costs for CCTV Network

Equipment	Unit	Approximate Cost
CCTV Camera	EA	$ 5,500
Assorted Field Equipment	EA	$ 1,050
CCTV Camera (at Water Tower)	EA	$ 7,500

ITS Devices

Table 7 shows cost data of the ITS devices included in this study. The cost of the arterial DMS sign also includes new electrical services for those locations. Additionally, the cost of the video server is per field location with video being brought back.

Table 7: Planning-Level Costs for ITS Devices

Equipment	Unit	Approximate Cost
Arterial DMS Sign	EA	$ 67,000
Video Server (per location)	EA	$ 3,100
Weather Station	EA	$ 8,500
Road Weather Sensors	EA	$ 8,500

School Zone System

Table 8 details the planning-level costs for a cellular based school zone system. This unit cost corresponds to the highest cost presented by school zone vendors during meetings with the City (discussed above). This cost allows for a 10-year connectivity plan.

Table 8: Planning-Level Costs for School Zone System

Equipment	Unit	Approximate Cost
Cellular Based School Zone (per beacon)	EA	$ 3,500

Traffic Signal Controller/Cabinet Upgrades

Table 9 shows approximate costs for traffic signal controller and cabinet upgrades. These costs are consistent with data presented in the *State of the Practice* document, but final costs may vary depending on the selected manufacturers and models.

Table 9: Planning-Level Costs for Traffic Signal Controller & Cabinet Upgrades

Equipment	Unit	Approximate Cost
Traffic Signal Controller	EA	$ 2,700
Traffic Signal Cabinet	EA	$ 15,000
Battery Backup System	EA	$ 6,000

Advanced Traffic Management System

Table 10 details planning-level costs for an ATMS and associated modules. The ATMS cost includes licenses for 50 locations. The additional modules would be implemented during various years of the implementation plan.

Table 10: Planning-Level Costs for ATMS

Equipment	Unit	Approximate Cost
Advanced Traffic Management System	LS	$ 200,000
CCTV Module	LS	$ 21,000
DMS Module	LS	$ 21,000
Adaptive Signal Control Module	LS	$ 105,000
Travel Time Module	LS	$ 37,000
Performance Metrics Module	LS	$ 21,000
Dedicated Website Dashboard	LS	$ 52,000

Detection Systems

Table 11 contains approximate cost data for detection systems anticipated to be used in Tyler. The final costs may vary depending on detection vendor and ongoing developments in detection technology.

Table 11: Planning-Level Costs for Detection Systems

Equipment	Unit	Approximate Cost
Radar Detection System (4 Leg Approach)	EA	$ 21,000
Video Detection System (4 Leg Approach)	EA	$ 15,000
Third Party Data Source for Travel Time	EA	$ 70,000
GPS Opticom Detection (Per Intersection)	EA	$ 8,000

Traffic Management Center and Video Management System

Table 12 lists approximate costs of implementing a TMC and Video Management System. The furniture upgrades and TMC remodel include two workstation consoles, operator chairs, a simple round meeting table, white board, electronic overhead projectors, and network gear. A conceptual TMC layout is provided in the Appendix.

Table 12: Planning-Level Costs for Traffic Management Center and Video Management System

Equipment	Unit	Approximate Cost
TMC LED Monitors	EA	$ 2,500
Misc. Upgrades to TMC Furniture	LS	$ 2,000
Video Management System	EA	$ 11,000
TMC Remodel	LS	$ 25,000

Recommended Implementation Plan

A workshop focused on ATMS Alternatives was conducted on May 12, 2020, with multiple City staff. The discussion below documents the decisions made on 12 possible ITS elements. It should be noted that the core ITS elements are proceeding forward. There are some elements identified that can add value and benefit to the City but require other elements to be deployed first. For those elements, the final decision will be made in the future, which is the appropriate strategy.

From these elements, the recommended implementation plan identified staged implementation of the key projects selected to address the needs and future buildout identified throughout the project. The plan also considered project priorities and an annual budget of $1 million.

The implementation plan summary table is provided in the Appendix. Complete details of each project are included in the *CIP Recommended Projects* document, which was developed as part of the ITS Master Plan.

School Zone Flasher System Upgrade

Project Description

The School Zone Flasher System Upgrade Project will upgrade to a new school zone beacon control system with remote communications, centralized command, and remote monitoring capabilities.

Estimated Cost

Upgraded school zone flashers are estimated to cost $3,500 per location, including necessary management software. Total estimated budget is $240,000.

Locations

Upgrade 36 school zones that include 72 individual school clocks.

Recommended Deployment Date

Deploy in FY 2021.

Traffic Signal Cabinet Modernization

Project Description

The Traffic Signal Cabinet Modernization project will upgrade outdated NEMA TS-1 and TS-2 traffic signal cabinets to modern ATC traffic signal cabinets.

Estimated Cost

ATC traffic signal cabinet costs are consistent with NEMA TS-2 cabinets, at approximately $15,000 each. One cabinet is required per signalized intersection. The total cost is estimated to be $2,250,000.

Locations

Installation of ATC cabinets will replace all existing NEMA TS-1 and/or TS-2 traffic signal cabinets in a phased implementation. First, TS-1 cabinets on priority corridors will be replaced. Next, remaining TS-1 cabinets across the City will be replaced. Finally, TS-2 cabinets across the City will be replaced.

Recommended Deployment Date

FY 2022-2025 for TS-1 cabinets on priority corridors, FY 2026-2027 for remaining TS-1 cabinets, and FY 2027-2030 for TS-2 cabinets.

Communications Upgrade

Project Description

The Communications Upgrade project will procure, install, and configure communications equipment at signalized intersections on priority corridors in support of traffic signal operations. The communications network is expected to include leased line communications via SuddenLink, fixed wireless communications owned by the City, and cellular communications. The final communication architecture will be determined after pilot study of cellular communications.

Estimated Cost

Communications unit costs vary widely depending on the ultimate solution, in a range of $6,000 - $10,000 per intersection. Total cost is estimated to be $1,000,000 - $2,000,000 over 2 years.

Locations

Initial rollout of communications will install cellular modems at 77 intersections that are currently on TACTICS. Then, cellular modems will be installed at the remaining 66 locations.

Recommended Deployment Date

FY 2021 and 2022.

Traffic Signal Controller Modernization and Standardization

Project Description

The Traffic Signal Controller Modernization and Standardization project will upgrade priority locations to state-of-the-art Advanced Traffic Controller (ATC) traffic signal controllers to support the City's current traffic operations and provide future capabilities.

Estimated Cost

ATC traffic signal controllers cost approximately $2,700 each. One controller is required per signalized intersection. For planning purposes, it is estimated that all legacy controllers (approximately one-quarter) are replaced due to age, and all incompatible controllers (approximately one-quarter) are replaced. The estimated budget for controller replacement is $205,000.

Locations

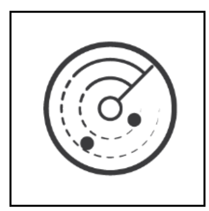
Initial rollout of ATC controllers will replace existing traffic signal controllers that are incompatible with TACTICS. Next, ATC controllers will be upgraded for compatibility with the upgraded Advanced Traffic Management System (ATMS). Throughout the 10-year implementation plan, ATC controllers will be deployed on priority corridors as needed for ATC cabinet compatibility.

Recommended Deployment Date

Controller upgrades will begin in fiscal year 2021 and continue to fiscal year 2030, as needed on priority corridors and for compatibility with ATC cabinets and ATMS. .

Detection Upgrade

Project Description



The Detection Upgrade project will procure, install, and configure detection equipment at signalized intersections on priority corridors to detect all modes of transportation accurately and reliably, including vehicles, bikes, and pedestrians.

Estimated Cost

Appropriate detection technologies are tailored to the need of each individual intersection. A planning-level cost is estimated at $20,000 per intersection. The total cost is estimated to be $1,000,000.

Locations

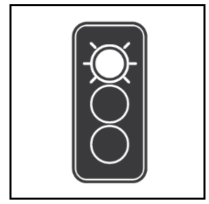
Initial rollout of improved detection will upgrade equipment at 50 locations on priority corridors with consideration of providing the most operational benefits.

Recommended Deployment Date

FY 2022-2025 for priority corridors, and FY 2026-2030 for remaining locations.

Synchronized Traffic Signal Timing

Project Description



The Synchronized Traffic Signal Timing project includes developing, implementing, and fine-tuning synchronized traffic signal timing. Traffic signals should be retimed every 3 years. For areas of the City with little traffic pattern change, the frequency of update can be every 5 years.

Estimated Cost

Development, implementation, and fine-tuning of synchronized traffic signal timing is estimated at $6,000 per intersection. It is recommended to allocate approximately $90,000 - $180,000 per year for signal timing; which retimes 15 to 30 traffic signals per year.

Locations

For the next several fiscal years, the City should retime approximately 15 intersections per year. By Year 2027, the number of intersections increases to 30 per year, and that number of intersections should be retimed annually in perpetuity.

Recommended Deployment Date

FY 2021-2030 and thereafter.

Advanced Traffic Management System Upgrade

Project Description

The Advanced Traffic Management System (ATMS) project includes procurement, installation, and configuration of a central system software to monitor, command, and control all connected signalized intersections and other ITS devices in the City.

Estimated Cost

For budgetary purposes, this CIP project assumes a full replacement of the current ATMS. Full replacement will include the procurement, installation, and configuration of the ATMS. The budgetary cost estimate for fiscal planning is $200,000.

Locations

The upgraded ATMS will control all connected field devices.

Recommended Deployment Date

FY 2021.

Traffic Management Center

Project Description

The Traffic Management Center (TMC) project includes creation of a dedicated central location for monitoring traffic operations, adjusting timing, responding to incidents, and dispatching personnel to fix field problems. The TMC is expected to include a modest video wall and three dedicated workstations. A conceptual TMC layout is provided in the Appendix.

Estimated Cost

For a similar facility for a similar size city, the construction build-out cost was $65,000 (in year 2015). The equipment needed to make the TMC operational is approximately $50,000 and includes two workstation consoles, operator chairs, video displays, a simple round meeting table, white board, electronic overhead projectors, and network gear.

Recommended Deployment Date

It is recommended to deploy the TMC after the City has constructed a reliable communication network to at least 75% of all field devices, installed a reliable ATMS central system software, and deployed CCTV cameras at key high-traffic locations around the city.

Approximate FY 2024.

Closed-Circuit Television (CCTV) Installation

Project Description

The Closed-Circuit Television (CCTV) Installation project will install CCTV cameras with pan-tilt-zoom capabilities at priority locations across the City.

Estimated Cost

CCTV has a planning level cost between $5,000 - $10,000 per installation. The total cost is estimated to be $175,000 - $350,000.

Locations

Initial rollout of CCTV will upgrade equipment at 30 locations at priority locations that provide the most operational benefits.

Recommended Deployment Date

FY 2024-2026.

Automated Traffic Signal Performance Measures

Project Description

This project includes installation and configuration of Automated Traffic Signal Performance Measures (ATSPM).

Estimated Cost

Installation and configuration of Automated Traffic Signal Performance Measures is estimated as a lump sum of $100,000.

Locations

ATSPM will be configured at the TMC for all signalized intersections with capable equipment (controller, detection, communications).

Recommended Deployment Date

This project can start as early FY 2023 when there are several upgraded components in the ITS system. ATSPM can be expanded with increased deployment of necessary equipment throughout the City.

Adaptive Traffic Control System

Project Description

This project includes procurement, installation and calibration of an Adaptive Traffic Control System (ATCS).

Estimated Cost

Procurement, installation, and configuration of the ATCS is estimated as $6,000 - $40,000 per intersection. The total is estimated to be $150,000 - $1,000,000. Given that the City has deployed ATCS in the past, it is possible that previously purchased licenses are transferable, which will reduce deployment cost.

Locations

ATCS will be configured at 25 locations on priority corridors with consideration of providing the most operational benefits.

Recommended Deployment Date

This project could be deployed as early as FY 2024.

Emergency Vehicle Pre-Emption

Project Description

This project includes procurement and installation of an Emergency Vehicle Pre-Emption system.

Estimated Cost

Procurement and installation of the emergency vehicle pre-emption system falls into two categories: equipment on the traffic signal and equipment on the emergency vehicle. Equipment on the traffic signal is estimated at $8,000 per intersection, for an approximate total of $1,200,000. Equipment on the emergency vehicle is estimated at $2,500 per vehicle. Per the Tyler Fire Department, 26 vehicles would need to be outfitted with necessary equipment. This results in a total of approximately $65,000.

Locations

GPS pre-emption will be deployed at all intersections across the City, in order of priority.

Recommended Deployment Date

FY 2023-2028.

CIP Funding Recommendation

The Capital Improvement Projects (CIP) projects identified in the Implementation Plan are a combination of expenses a municipality should expect as part of rolling equipment replacements and new items such as build out of the communication system, upgrades to the central Advanced Traffic Management System, and the implementation of signal performance measures. The current plan focuses on critical components to help get the City back on track with operating a safe, functional, and efficient traffic and ITS system.

The City's CIP budget is based on the City's Half Cent Sales Tax. Understanding there are funding limitations with the Half-Cent Sales Tax program, the current Implementation Plan does not include costs for replacing older traffic signal structures. If funds are available, additional effort should be directed to replacing older traffic signal structures during this 10-year implementation plan.

Beyond this initial 10-year horizon, approximately $2,489,000 should be allocated annually for Capital Improvements. This budget represents funds for programmatic replacement of existing traffic signal equipment allowing for on-going, rolling replacement of equipment as it reaches the end of its lifecycle. This will help keep the City from falling behind while still providing budget flexibility for new installations to accommodate future growth. Table 13 details the replacement costs for various ITS elements and total annual CIP cost.

Table 13: Annual Capital Improvement Budget – ITS System

Item	Life Cycle (Years)	Yearly Installs	Unit Cost	Total Cost
Full Signal Replacement	25	6 (of 149, 4.0%)	$300,000	$1,800,000
Cabinet Replacement	25	6 (of 149, 4.0%)	$16,000	$96,000
Controllers	10	15 (of 149, 10.1%)	$2,700	$40,500
Detection	10	15 (of 149, 10.1%)	$20,000	$300,000
Power Supply	20	8 (of 149, 5.4%)	$500	$4,000
BBU	10	15 (of 150, 10.0%)	$5,000	$75,000
BBU - Batteries	5	30 (of 149, 20.1%)	$1,000	$30,000
MMU	10	16 (of 151, 10.6%)	$1,000	$16,000
Switches	10	15 (of 149, 10.1%)	$2,500	$37,500
Communications	10	15 (of 149, 10.1%)	$6,000	$90,000
Total Annual CIP Cost				**$2,489,000**

Maintenance Funding Recommendations

Maintenance includes upkeep and replacement as necessary of all traffic and ITS components throughout the City, including traffic signals, communications infrastructure, school zone flashers, and operational upgrades.

Some key criteria to determine maintenance needs are:

- Number of signals and changes in number of signals, and other field devices.
- Organizational structure of the responsible agency (sharing of resources with other functions) and budgeting structures.
- Congestion levels.
- Type of signal system (e.g., distributed or centrally controlled); distribution of signals on the network and need for interconnection.
- Development of signal timing plans (City personnel vs. consultants).
- Frequency of equipment maintenance
- Complexity of signal operation at the intersection

In Tyler's case, the age of the system and the reliability of the system or the information provided by the system may not provide the efficiencies that might otherwise help keep staff levels to a minimum.

The City currently budgets around $160,000 annually for Traffic Operations Division maintenance between preventative maintenance ($98,000) and response maintenance ($62,000), an average of $1,074 per intersection.

To maintain functionality and efficiency of the City of Tyler's Traffic Signal and ITS system, $450,000 should be allocated annually for maintenance. This amount equates to approximately $3,020 per year per signalized intersection, a conservative estimate based on national data points.

Staffing Recommendations

Past approaches to the development of staffing criteria for operation and maintenance of traffic signals and ITS devices have often provided guidelines in terms of the number of traffic signals that can be maintained and operated per number of personnel performing these tasks. These approaches should also consider other operations objectives and desired level or needs for traffic signal management operations and maintenance. Some of key criteria to determine staff needs are:

- Required response time.
- Number of signals and changes in number of signals, and other field devices.
- Variations in knowledge, skills and abilities of maintenance and engineering personnel.
- Differences in functions that the systems and agencies must perform.
- Organizational structure of the responsible agency (sharing of resources with other functions) and budgeting structures.
- Geographic configuration of traffic flow network (i.e., grid, arterial) and the overall number and size of other facilities in the transportation network (freeways, interstate, transit, freight, land use etc.).
- Density of traffic signal network relative to population density.
- Congestion levels.
- Type of signal system (e.g., distributed or centrally controlled); distribution of signals on the network and need for interconnection.
- Development of signal timing plans (City personnel vs. consultants).
- Frequency of equipment maintenance
- Complexity of signal operation at the intersection

Various examples provide rules of thumb for Traffic Operations staffing, such as one technician per 30 to 40 traffic signals. However, caution should be exercised in using general guidelines because such "rule of thumb" criteria do not specifically address complicating factors such as age of the system or approach to preventative maintenance. In Tyler's case, the age and reliability of the system may not provide the efficiencies that might otherwise help keep staff levels to a minimum.

Using a conservative estimate on the low-end of examples provided, and based on the City of Tyler's current needs, information from other agencies, and general guidelines, the following positions are needed:

- One (1) Traffic Engineer;
- One (1) Engineer-in-Training (EIT);
- One (1) Signal Supervisor;
- One (1) Advanced Traffic Signal Technician; and

- Two (2) Traffic Signal Technicians.

The EIT position would report to the City Traffic Engineer, while the Advanced Traffic Signal Technician would report to the Signal System Supervisor. The EIT position should support the City Traffic Engineer on engineering and management duties, while learning and becoming a licensed professional engineer.

External resources such as contractors, technicians for hire, and consultants will still be needed to fill gaps in workload capacity and expertise.

To successfully fill these positions, competitive salaries should be offered. To be competitive with TxDOT, the City of Tyler should at least match the salaries listed for TxDOT's open Traffic Systems Technician I or II positions in Tyler. The standard Traffic Signal Technician salary range should be \$15.00 – \$26.50 hourly (\$31,200 – \$55,130 annually). The Advanced Traffic Signal Technician salary range should be \$26.50 – \$32.50 hourly (\$55,130 – \$67,600 annually). Salary expectations for the Traffic Operations Supervisor would be around \$60,000 – \$75,000 annually. Again, to be competitive in the Tyler region, the City of Tyler should at least match the salary range for a Traffic EIT position (\$37,000 – \$65,000 annually).

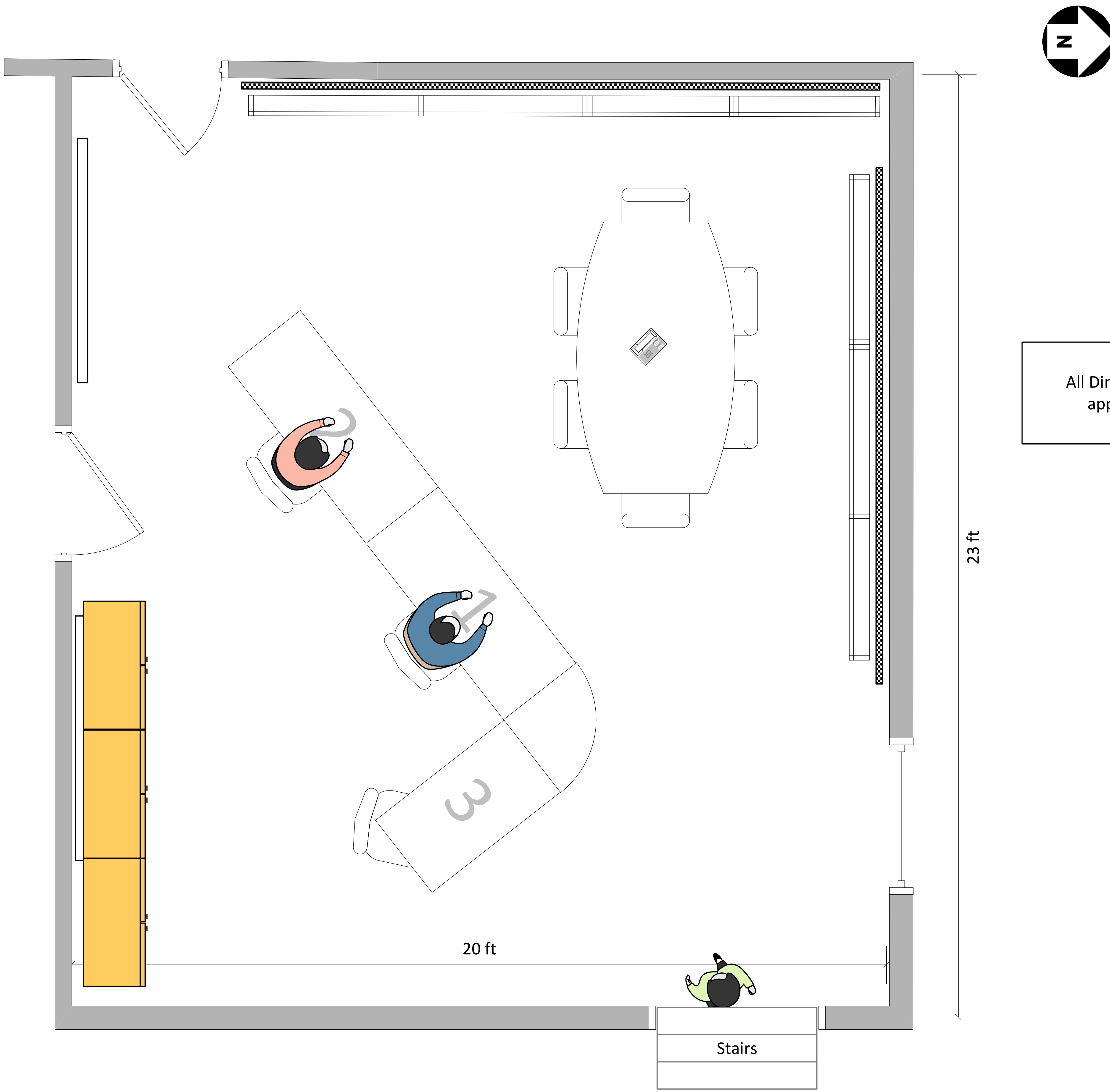
Appendix

Implementation Plan Summary Table

Year	1	2	3	4	5
Objective(s)	- Replace school zone flasher system - Install communications at key intersections - Upgrade ATMS - Implement optimized signal timing for priority intersections	- Install communications at remaining intersections - Upgrade signal control equipment on priority corridors - Implement optimized timing for priority intersections	- Upgrade signal control equipment on priority corridors - Implement performance measures - Implement optimized timing for priority intersections	- Upgrade signal control equipment on priority corridors - Upgrade TMC equipment - Install CCTVs at critical locations - Implement optimized timing for priority intersections	- Upgrade signal control equipment on priority corridors - Install CCTVs at critical locations - Implement optimized timing for priority intersections
Funding Needed	$1,060,000	$1,162,000	$1,246,000	$1,181,000	$1,412,000
High Priority Locations	- School zones - Intersections on TACTICS	- Broadway - Beckham	- Loop 323 - Front	- 5th - 4th	- Gentry - Glenwood - Old Jacksonville
School Zone Beacons	- All 36 school zones across the city	- Maintenance only	- Maintenance only	- Maintenance only	- Maintenance only
Traffic Signal Cabinets	- Maintenance only	- 9 cabinets & BBUs on Broadway - 5 cabinets & BBUs on Beckham	- 9 cabinets & BBUs on Loop 323 - 5 cabinets & BBUs on Front	- 4 cabinets & BBUs on 5th - 3 cabinets & BBUs on 4th	- 8 cabinets & BBUs on Gentry - 4 cabinets & BBUs on Glenwood - 3 cabinets & BBUs on Old Jacksonville
Comm Upgrade	- Cellular modems at 77 intersections currently on TACTICS	- Cellular modems at remaining 66 intersections	- Recurring cellular modem costs	- Recurring cellular modem costs	- Recurring cellular modem costs
Traffic Signal Controllers	- 5 controllers as needed for TACTICS compatibility	- 9 controllers on Broadway - 5 controllers on Beckham - 25 additional controllers for ATMS compatibility	- 9 controllers on Loop 323 - 5 controllers on Front - 15 additional controllers for ATMS compatibility	- 4 controllers on 5th - 3 controllers on 4th - 10 additional controllers for ATMS compatibility	- 8 controllers on Gentry - 4 controllers on Glenwood - 3 controllers on Old Jacksonville
Detection	- Maintenance only	- 2 vehicle detection systems on Broadway - 10 GPS opticom detection systems at critical locations	- 1 vehicle detection system on Loop 323 - 30 GPS opticom detection systems at critical locations	- 25 GPS opticom detection systems at critical locations	- 5 vehicle detection systems on Gentry - 2 vehicle detection systems on Glenwood - 25 GPS opticom detection systems at critical locations
Traffic Signal Synchronization	- 15 priority locations	- 15 priority locations	- 15 priority locations	- 15 priority locations	- 15 priority locations
ATMS	- Upgrade ATMS	- Maintenance only	- Performance metrics module - Travel time module - Maintenance	- CCTV module - Maintenance	- Maintenance only
TMC/ITS Devices				- TMC remodel - LED monitors - Furniture upgrades - Video management system	- Maintenance only
CCTV				- 10 CCTV cameras at priority locations - 3 CCTV cameras on water towers	- 10 CCTV cameras at priority locations - Video server for 50 VIVDS locations
Performance Measures			3rd party data source for travel time	- Dedicated website dashboard	- Maintenance only
Adaptive Signal Control				- Adaptive signal control system	- Maintenance only

Year	6	7	8	9	10
Objective(s)	- Upgrade signal control equipment at priority locations - Install CCTVs at critical locations - Install various weather sensors - Implement optimized signal timing for priority intersections	- Upgrade signal control equipment at priority locations - Install DMS - Implement optimized timing for priority intersections	- Upgrade signal control equipment at priority locations - Implement optimized timing for priority intersections	- Upgrade signal control equipment at priority locations - Implement optimized timing for priority intersections	- Upgrade signal control equipment at priority locations - Implement optimized timing for priority intersections
Funding Needed	$1,381,000	$1,316,000	$1,314,000	$1,294,000	$1,312,000
High Priority Locations	- Locations with TS-1 cabinets - Locations with controllers incompatible with ATMS	- Remaining locations with TS-1 cabinets - Locations with TS-2 cabinets	- Locations with TS-2 cabinets	- Locations with TS-2 cabinets	- Locations with TS-2 cabinets
School Zone Beacons	- Maintenance only	- Maintenance only	- Maintenance only	- Maintenance only	- Maintenance only
Traffic Signal Cabinets	- 15 cabinets & BBUs at priority locations	- 15 cabinets & BBUs at priority locations	- 20 cabinets & BBUs at priority locations	- 25 cabinets & BBUs at priority locations	- 25 cabinets & BBUs at priority locations
Comm Upgrade	- Recurring cellular modem costs	- Recurring cellular modem costs	- Recurring cellular modem costs	- Recurring cellular modem costs	- Recurring cellular modem costs
Traffic Signal Controllers	- 5 controllers at priority locations	- 5 controllers at priority locations	- 10 controllers at priority locations	- 10 controllers at priority locations	- 15 controllers at priority locations
Detection	- 5 vehicle detection systems at critical locations - 25 GPS opticom detection systems at critical locations	- 5 vehicle detection systems at critical locations - 20 GPS opticom detection systems at critical locations	- 10 vehicle detection systems at critical locations - 10 GPS opticom detection systems at remaining locations	- 10 vehicle detection systems at critical locations	- 10 vehicle detection systems at critical locations
Traffic Signal Synchronization	- 15 priority locations	- 30 priority locations	- 30 priority locations	- 30 priority locations	- 30 priority locations
ATMS	- Maintenance only	- DMS module - Maintenance	- Maintenance only	- Maintenance only	- Maintenance only
TMC/ITS Devices	- 2 weather stations - 2 road weather sensors	- 2 DMS	- Maintenance only	- Maintenance only	- Maintenance only
CCTV	- 10 CCTV cameras at priority locations - Video server for 50 VIVDS locations	- Maintenance only	- Maintenance only	- Maintenance only	- Maintenance only
Performance Measures	- Maintenance only	- Maintenance only	- Maintenance only	- Maintenance only	- Maintenance only
Adaptive Signal Control	- Maintenance only	- Maintenance only	- Maintenance only	- Maintenance only	- Maintenance only

Traffic Management Center Conceptual Layout



All Dimensions are approximate

General Notes:

Main Entry Door
Standard 3-0 size door, metal frame.
See through clear glass vertical rectangle.

Secondary Door
Standard 3-0 size door, metal frame.
See through clear glass upper half.

Canister Lighting
Canister lighting should be installed on a separate power circuit from the existing room lighting.

Wall Covering
Walls should be painted with the “accent” color, which is paint color #3. This covering can be applied to all walls. Paint finish should be satin or flat.
As an option, the north wall can be covered with the lighter color.

Floor Covering
The floor covering will be carpet. The color will be the “accent” color (darker of the two).

Window treatment
The window on the north wall should have full blinds. The color is at the option of the City, but it is recommended to be wall color.

Structural Reinforcement
The west and north walls will have display equipment attached. These walls should be covered from floor to ceiling with plywood, min, thickness of ¾ inch. The plywood is between the metal studs and sheetrock.

	City of Tyler **Intelligent Transportation System** **Traffic Management Center Layout** Current Layout – Conceptual
SIZE	FSCM NO / DWG NO / REV
SCALE N.T.S.	SHEET

Summary of Needs

Needs were developed as part of the Concept of Operations. The needs listed below are highlighted based on how they were addressed in the Implementation Plan, as follows:

- Green = Addressed in Implementation Plan
- Yellow = Partially addressed in Implementation Plan
- Red = Not addressed in Implementation Plan
- No color = Not applicable to Implementation Plan

Traffic Operations

TO - 1. There is a need for state-of-the-art traffic signal controllers.

TO - 2. There is a need to install, at select locations within the City, CCTV cameras with pan-tilt-zoom capabilities.

TO - 3. There is a need to store and manage support documentation in a central location that has hyperlinks to personal workstations.

TO - 4. There is a need for the ATMS to collect signal status data.

TO - 5. There is a need for the ATMS to collect turning movement count data.

TO - 6. There is a need for the ATMS to collect volume data.

TO - 7. There is a need for the ATMS to collect speed data.

TO - 8. There is a need for the ATMS to collect video data.

TO - 9. There is a need for the ATMS to collect occupancy data.

TO - 10. There is a need for the ATMS to collect detection data (vehicle and preemption).

TO - 11. There is a need for the ATMS to collect weather data.

TO - 12. There is a need for the ATMS to collect roadway condition data.

TO - 13. There is a need for the ATMS to collect communications data.

TO - 14. There is a need for the ATMS to log all performance measure and communication data.

TO - 15. There is a need for the ATMS to support adaptive control of traffic signals.

Central System Software

CS - 1. There is a need for the City to implement a modern central system software to support command and control of all ATMS devices.

CS - 2. There is a need for the City's future ATMS software to be based on a proven software and hardware architecture.

CS - 3. There is a need for the City's future ATMS software to provide useful, current, and accurate information on system health and status of field devices.

CS - 4. There is a need for ATMS software to support the development and maintenance of optimized traffic signal timing plans.

CS - 5. There is a need for the ATMS software to provide real-time information.

CS - 6. There is a need for the ATMS software to provide a robust selection of reports.

CS - 7. There is a need for the ATMS software to provide alarms and alerts.

CS - 8. There is a need for the ATMS software to be accessible from remote locations.

CS - 9. There is a need for the ATMS software to be able to monitor detector state of operation.

CS - 10. The ATMS software and local controller software needs to be able to execute and respond respectively to a pre-empt call issued from the TMC.

CS - 11. There is a need for the ATMS software to be able to manage time-of-day schedules.

CS - 12. There is a need for the ATMS software to manage ATMS devices as groups.

CS - 13. There is a need for the ATMS software to support multiple communication media to field devices.

CS - 14. There is a need for the ATMS software to provide controlled access and only allow specific rights by individual users.

CS - 15. There is a need for the ATMS software to log specific actions by the system and user.

CS - 16. There is a need for the ATMS software to incorporate aerial imagery of intersections.

CS - 17. There is a need for the ATMS software to display maps of the intersection.

CS - 18. There is a need for the ATMS software to display intersection information on a map.

CS - 19. There is a need for the ATMS software to share data at varying levels with various stakeholders.

CS - 20. There is a need to have special signal timing plans on hand and available for implementation.

CS - 21. There is a need to use performance data to adjust signal timing plans for future incidents.

CS - 22. There is a need to use signal performance measures to adjust signal timing plans for future incidents.

CS - 23. There is a need for automatically generated alerts for heavy delays and volumes.

CS - 24. There is a need for increased alerts for fiber outages through management software.

CS - 25. There is a need for work order software.

CS - 26. There is a need to query locations with frequent replacements in the work order software.

CS - 27. There is a need to calculate response times in the work order software.

CS - 28. There is a need for asset management software.

CS - 29. There is a need for software to diagnose different failure points within the communications system (e.g. ports on switches).

CS - 30. There is a need for the ATMS software to employ a distributed client/server interconnection to accommodate current needs and future expansion.

CS - 31. There is a need to secure the City's ATMS network from external threats.

CS - 32. There is a need for the ATMS software to manage controller firmware upgrades.

CS - 33. There is a need for the ATMS software to be module-based, to allow future functionality such as CV/AV technologies.

System Support

SY - 1. There is a need for the ATMS software application and database to be backed up automatically.

SY - 2. There is a need for the ATMS software to support a modern server platform, such as Windows Server 2016.

SY - 3. There is a need for the ATMS software to support a secure desktop operating system, such as Windows 10.

SY - 4. There is a need for the ATMS software to support Microsoft SQL Server database either as a stand-alone instance or within a virtualized environment.

SY - 5. There is a need for the ATMS software to have internet access.

SY - 6. There is a need for the ATMS to support mobile devices, including iOS and Android.

Regional Traffic Management

RE - 1. There is a need to support regional transportation operations.

RE - 2. There is a need for the ATMS to have the capability to support regional data sharing.

RE - 3. There is a need for the ATMS to support regional video sharing with neighboring cities and agencies for incident management and emergency response coordination.

RE - 4. There is a need for the ATMS to support major reporting of major construction activities.

Devices

DEV - 1. There is a need to install CCTV cameras with PTZ at select locations.

DEV - 2. There is a need to support CCTV cameras with no noticeable delay in providing full-motion broadcast quality video images.

DEV - 3. There is a need to support CCTV cameras with no noticeable jitter in providing full-motion broadcast quality video images.

DEV - 4. There is a need to support CCTV cameras with no noticeable lag in providing full-motion broadcast quality video images.

DEV - 5. There is a need for better remote management of ITS devices, such as communications diagnostics and remotely managing traffic signals.

DEV - 6. There is a need to upgrade TS-1 cabinets to modern cabinets (such as TS-2 and ATC cabinets) citywide.

DEV - 7. There is a need for state-of-the-art traffic signal controllers to support the City's current traffic operations and provide future capabilities.

DEV - 8. There is a need to incorporate additional CCTV cameras to provide observation and proactive management capabilities.

DEV - 9. There is a need to upgrade vehicle detection equipment to detect all modes of transportation accurately and reliably, including vehicles, bikes, and pedestrians, providing more efficient operations.

DEV - 10. There is a need to update MMUs to support the flashing yellow arrow operation.

DEV - 11. There is a need for MMUs to support IP communications for remote monitoring.

DEV - 12. There is a need to install BBUs across the city.

DEV - 13. There is a need to integrate BBUs into the ATMS for monitoring.

DEV - 14. There is a need for BBUs to support IP communications for remote monitoring.

DEV - 15. There is a need to install a pre-emption system.

DEV - 16. There is a need to integrate the pre-emption system into the ATMS.

DEV - 17. There is a need to configure the pre-emption system to prevent the potential for unauthorized use.

DEV - 18. There is a need to integrate low water crossing sensors into the ATMS and the TMC operations and capabilities.

DEV - 19. There is a need to integrate RWIS sensors into the ATMS.

DEV - 20. There is a need for advanced traveler information systems (ATIS).

DEV - 21. There is a need for a radio in the TMC to coordinate with dispatch.

Communications

CO - 1. There is a need for the ATMS communications network to communicate with NCTCIP-compliant ITS and ATMS devices.

CO - 2. There is a need for the communications network to be based on Ethernet and support IP communications.
CO - 3. There is a need for the future ATMS system to support national communication protocols.
CO - 4. There is a need for an expandable and scalable communications network.
CO - 5. There is a need for a communications network that supports high-bandwidth for video operations.
CO - 6. There is a need for a simple wireless communications network to support remote ITS and ATMS device locations.
CO - 7. There is a need for a communications network to support network engineering principles such as system redundancy, system reliability, system scalability, and system security.
CO - 8. There is a need for wireless radios to reach some planned signals and other ITS devices.
CO - 9. There is a need for staff in the field to connect and sync to the work order system, either through cellular coverage or offline syncing.
CO - 10. There is a need for staff in the field to connect and sync to the asset management system, either through cellular coverage or offline syncing.
CO - 11. There is a need for the capability to remotely change the start time of school zone flashers.

Connected/Autonomous Vehicles

CAV - 1. There is a need to collect data from autonomous vehicles.
CAV - 2. There is a need to provide data to autonomous vehicles.
CAV - 3. There is a need to collect data from connected vehicles.
CAV - 4. There is a need to provide data to connected vehicles.
CAV - 5. There is a need to broadcast SPaT (Signal Phase and Timing) data to connected vehicles.
CAV - 6. There is a need to disseminate information regarding construction activities to connected vehicles.
CAV - 7. There is a need to maintain signing and striping during construction, especially for autonomous vehicles.

Documentation

DOC - 1. There is a need to document Standard Operating Procedures for traffic operations and the ATMS in general.
DOC - 2. There is a need to document Standard Operating Procedures for inclement weather.
DOC - 3. There is a need for pre-planned response plans for incident corridor management (ICM).
DOC - 4. There is a need to document Standard Operating Procedures for contacts, response plans, and after-action reviews of large-scale, unanticipated events.
DOC - 5. There is a need to document Standard Operating Procedures for long-term construction.
DOC - 6. There is a need to document Standard Operating Procedures for work zones.

High Resolution Data

HRD - 1. There is a need to collect high-resolution data.
HRD - 2. There is a need to analyze high resolution data.
HRD - 3. There is a need to use high resolution data for proactive management of the ATMS system.

Crowd-Sourced Data

CSD - 1. There is a need to integrate crowd-sourced data into the City's operations.
CSD - 2. There is a need to leverage crowd-sourced data to detect incidents in real time.
CSD - 3. There is a need to leverage crowd-sourced data to assess the performance of arterials and signals
CSD - 4. There is a need to leverage crowd-sourced data to monitor and respond in real-time to non-recurring congestion.

Public Information

PI - 1. There is a need to share information with the public.
PI - 2. There is a need to stream video to the public and/or media.
PI - 3. There is a need for a customer service process for complaint calls.
PI - 4. There is a need to route complaint calls to the correct department.
PI - 5. There is a need for more communication with the public (i.e. via Twitter or a dedicated web portal).
PI - 6. There is a need to share data with school districts.
PI - 7. There is a need for public outreach and information, to ensure citizens are aware of special events.
PI - 8. There is a need to provide traffic control plans online.
PI - 9. There is a need to expand social media outreach.
PI - 10. There is a need to enter into the Waze Connected Citizens program.
PI - 11. There is a need to use the ATMS map to show lane closures and share that data with Waze (via the Connected Citizens program) automatically.
PI - 12. There is a need for the ATMS to provide low water crossing information to Waze (via the Connected Citizens program) automatically.
PI - 13. There is a need for consistent coordination with the contractor during long-term construction.

Training and Staff

TS - 1. There is a need for full staffing of signal technicians.
TS - 2. There is a need for additional staff in the TMC.
TS - 3. There is a need for signal technician training.
TS - 4. There is a need to decrease response time for signals on flash, through remote diagnostics and stocking all trucks with spare parts.
TS - 5. There is a need for traffic incident management (TIM) training.
TS - 6. There is a need for a dedicated Traffic Engineer to operate the ATMS and support TMC operations.