★ **Roll Call Number**

Agenda Item Number
9

....

Date November 19, 2018

APPROVING THE INTELLIGENT TRANSPORTATION SYSTEM (ITS) MASTER PLAN AS THE FRAMEWORK FOR THE CITY OF DES MOINES FUTURE TRAFFIC MANAGEMENT AND COMMUNICATION SYSTEMS INFRASTRUCTURE

WHEREAS, on March 20, 2017, under Roll Call No. 17-0461, the City Council authorized a professional services agreement for the City's first ITS Master Plan; and

WHEREAS, the ITS Master Plan addresses major components including signal system hardware and software, work order system, fiber communications infrastructure, video observation cameras, and dynamic message signs; and

WHEREAS, the current ITS infrastructure for the City of Des Moines primarily consists of antiquated technologies, including traffic signal controllers using 1970's technology, video observation cameras that are often not operable, and a central management software that is outdated and will soon be unable to run on City computer systems due to operating system upgrades; and

WHEREAS, due to the limitation of the existing ITS, staff cannot monitor or adjust traffic signal operations during special events, unusual circumstances causing traffic to back up, or other situations when it would be advantageous to quickly make such adjustments; and

WHEREAS, the ITS Master Plan includes an inventory of existing ITS equipment, a needs assessment to determine the City's expectations for the system, concept design and cost estimates of the new systems, and an implementation plan including potential outside funding opportunities to supplement City funding; and

WHEREAS, the plan identifies ITS technologies and staffing necessary to better operate the City's traffic signal system and accommodate the emerging technologies associated with Smart Cities including connected and autonomous vehicles, connected pedestrians and bicyclists, and emergency vehicle preemption systems. The ITS Master Plan provides the framework for a fiber communication system that will be able to handle the data needs associated with connected and autonomous vehicles; and

WHEREAS, the ITS Master Plan was the result of an 18-month process incorporating various City Departments including Engineering/Traffic and Transportation, Public Works, Fire, and Police.

★ **Roll Call Number**

Agenda Item Number
9

Date November 19, 2018

NOW THEREFORE, BE IT RESOLVED by the City Council of the City of Des Moines, Iowa:

That the ITS Master Plan as on file in the office of the City Clerk, is hereby approved as the framework for the City's future traffic management and communication systems infrastructure..
(Council Communication No. 18-624)

Moved by ____________________ to adopt.

APPROVED AS TO FORM:

Kathleen Vanderpool
Deputy City Attorney

Funding Source: 2018-19/2023-24 CIP, TR097, Page 46, Street Improvements - Traffic System Operations Improvements

COUNCIL ACTION	YEAS	NAYS	PASS	ABSENT
COWNIE				
BOESEN				
COLEMAN				
GATTO				
GRAY				
MANDELBAUM				
WESTERGAARD				
TOTAL				

MOTION CARRIED APPROVED

______________________ Mayor

CERTIFICATE

I, DIANE RAUH, City Clerk of said City hereby certify that at a meeting of the City Council of said City of Des Moines, held on the above date, among other proceedings the above was adopted.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal the day and year first above written.

______________________ City Clerk

9

iteris®

CITY OF DES MOINES ITS MASTER PLAN
ITS MASTER PLAN REPORT

FINAL | version 1.0

June 22, 2018

Submitted to:

CITY OF DES MOINES

17J18-0010 | Prepared by **Iteris, Inc.**

Innovating Through Informatics™

DOCUMENT VERSION CONTROL

DOCUMENT NAME	SUBMITTAL DATE	VERSION NO.
City of Des Moines ITS Master Plan Report – Internal Review	March 05, 2018	Draft Version 0.0
City of Des Moines ITS Master Plan Report – Draft Submittal	March 26, 2018	Draft Version 1.0
City of Des Moines ITS Master Plan Report – Final Submittal	May 23, 2018	Final Version 1.0
City of Des Moines ITS Master Plan Report – Final Submittal (City Addressed Comments)	June 22, 2018	Final Version 1.0

TABLE OF CONTENTS

TABLES

FIGURES

APPENDIX

1 INTRODUCTION

The City of Des Moines has initiated the development of a comprehensive Intelligent Transportation Systems (ITS) Master Plan to develop a framework for efficient infrastructure upon which future traffic management and communication systems can be built. The master plan will include phasing and prioritized deployment recommendations and strategies for the system with the objective of providing safe and efficient infrastructure for walking, bicycling, mass transit, and automobiles. The master plan will address major system components including traffic signal system hardware and software, communications infrastructure, and location(s) and functionality of a Traffic Operation Center (TOC). It will also address ITS field devices including cameras, traffic sensors, and arterial Dynamic Message Signs (DMS), data sharing among key stakeholders, and providing key information to the traveling public. A system that is compatible with the needs of multiple jurisdictions that are responsible for traffic management in the Des Moines area will be critical. The system will also need to be scalable and expandable to meet future system needs.

The goal of the ITS Master Plan is **to develop a clear and flexible master plan that results in the right-sized ITS, meets the needs of stakeholders, and provides value, improved safety, and public support well into the future.**

Development of a successful master plan will be essential in helping the City and associated stakeholders in gaining public and political support and securing additional funding for full deployment of the ITS. To that end, a Strategic Communications Plan was developed that will guide City staff in achieving this important goal. A simple outline of the Strategic Communications Plan is included in this master plan.

The remaining chapters in this master plan address the following topics:

- Strategic Communication Plan
- Systems Engineering
- Existing System Evaluation
- Needs Assessment
- Alternatives Analysis and Recommended Improvements Strategies
- Concept Design and Cost Estimate
- Deployment Strategy

2 STRATEGIC COMMUNICATION PLAN

The purpose of the strategic communication plan is to inform, educate and build awareness with various stakeholders and the public about what the ITS Master Plan is, and why it is needed in our community. At a minimum, the communication plan shall include the following:

1. Stakeholder Identification – Any person who is affected by transportation policy and planning decisions, programs or projects. The following is a list of stakeholders and target groups to be included:
    a. City of Des Moines
        i. Mayor's Office

   ii. City Council
   iii. City Departments
  b. DART Transit
  c. Neighboring Agencies
   i. Iowa DOT
   ii. Urbandale
   iii. Windsor Heights
   iv. West Des Moines
   v. Norwalk
   vi. Pleasant Hill
   vii. Warren County
   viii. Polk County
  d. Federal Highway Administration
  e. General Public
2. Stakeholder Level of Influence
   - Categorize the Stakeholder influence into High, Medium or Low
3. Stakeholder Communication Objectives
   - Inform the Stakeholder what the ITS Master Plan is and what the funding options are. Inform them of the opportunities for their input.
4. Medium/Tools
   - Varied, attempt to target all audiences e.g., newspaper, electronic, in person (public meetings), etc.
5. Frequency
   - Identify communication frequency e.g., On-going, Quarterly, Annually
6. Deliverable
  a. Postcards
  b. Fact Sheets/Brochures
  c. Newsletters
  d. Presentations to Community Groups
  e. Web Page
  f. Social Media accounts and Posts

It is recommended that the City implement the Strategic Communication Plan in order to gain public and political support and secure additional funding for full deployment of the ITS.

3 SYSTEMS ENGINEERING

A Systems Engineering (SE) approach using the "V" model, shown in **Figure 1** was applied to create standard outlines and model documents. Systems Engineering documents were developed for four key deliverables. These include:

- **Project Plan** – This document provides a guide for all stakeholders that clearly define the ITS Master Plan project scope, goals, schedule, and budget.
- **Systems Engineering Management Plan (SEMP)** – This document describes how the SE process will be integrated into the ITS Master Plan and subsequent design and deployment phases.

- **Concept of Operations** - This document communicates overall qualitative system characteristics to the City and other involved stakeholders. This document will define the user needs that will drive the requirements for the ITS Master Plan.
- **High-Level Requirements and Verification Plan** – This document summarizes the system requirements and verification activities that are expected to be completed (as part of future projects). These will be used to demonstrate that the deployment meets the needs of the project stakeholders.

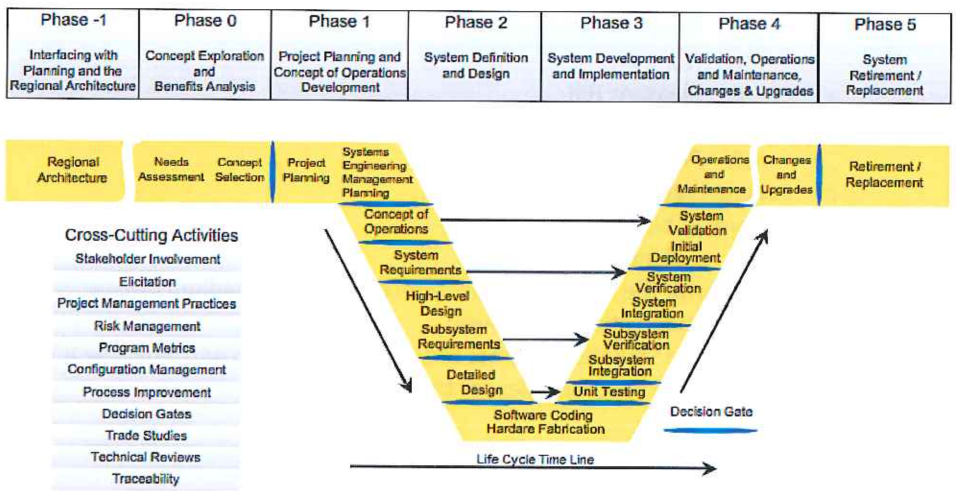


Figure 1 – System Engineering "V" Diagram

Supporting information for the above deliverables will include system diagrams, documentation of ITS project standards, and stakeholder assessments. The goal of the SE effort is twofold:

- Streamline necessary deliverables to meet State requirements and Federal Rule 940.11.
- Provide reference documents for planning, design, and integration of future phases.

Systems Engineering documents described above are provided as part of **Appendix A** and **Appendix B**.

4 EXISTING SYSTEM EVALUATION

One of the initial steps in developing the ITS Master Plan for the City of Des Moines was to conduct a thorough and accurate assessment of the existing system. This step is essential to:

- Understand existing operations,
- Leverage existing traffic signal, communications, and ITS systems to the extent possible,
- Identify existing system deficiencies,
- Establish a foundation for the recommendation of any potential future signal system improvements.

ITS data was compiled from a variety of sources, including Geographic Information Systems (GIS) databases, Traffic Maintenance Information System (TMIS) databases, and meetings and discussions with City engineering, operations, and maintenance staff. The following summarizes the various components of the existing ITS.

4.1 Traffic Signal System

The following subsections present a summary of the City's existing traffic signal system infrastructure. A majority of the signals are owned and operated by City of Des Moines, except for a few that have joint ownership and/or maintenance with Iowa Department of Transportation (DOT), Urbandale, Windsor Heights and West Des Moines.

4.1.1 Traffic Signals & School Flashers

The City of Des Moines currently operates 389 traffic and 36 pedestrian signals. Several of these signals are under joint ownership and /or maintenance with the Iowa DOT (9), Urbandale (4), Windsor Heights (5), and West Des Moines (3). In addition to traffic and pedestrian signals, the City operates 95 school flashers in a pole mounted 336 cabinet. A school flasher consists of a pole-mounted enclosure, controller, load relay, and termination block to power a set of flashing beacons. The school flashers operate on a time of day plan. School flashers are installed in advance of school zones, and longer school zones include mid-zone flashers. A typical school flasher is shown in **Figure 2**. **Table 1** summarizes the number of traffic signals by type, including full signal installations, pedestrian installations and school flashers. **Figure 3** illustrates the type and location of all traffic signals, pedestrian signals and school flashers.

Table 1 – Number of Traffic Signals by Signal Type

Type of Installation	Number	Color
Full Signal	389	
Pedestrian Signal	36	
School Flashers	95	
Total	520	

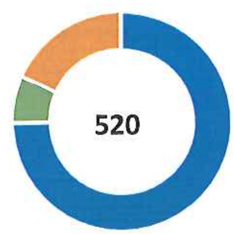


Figure 2 – School Flasher

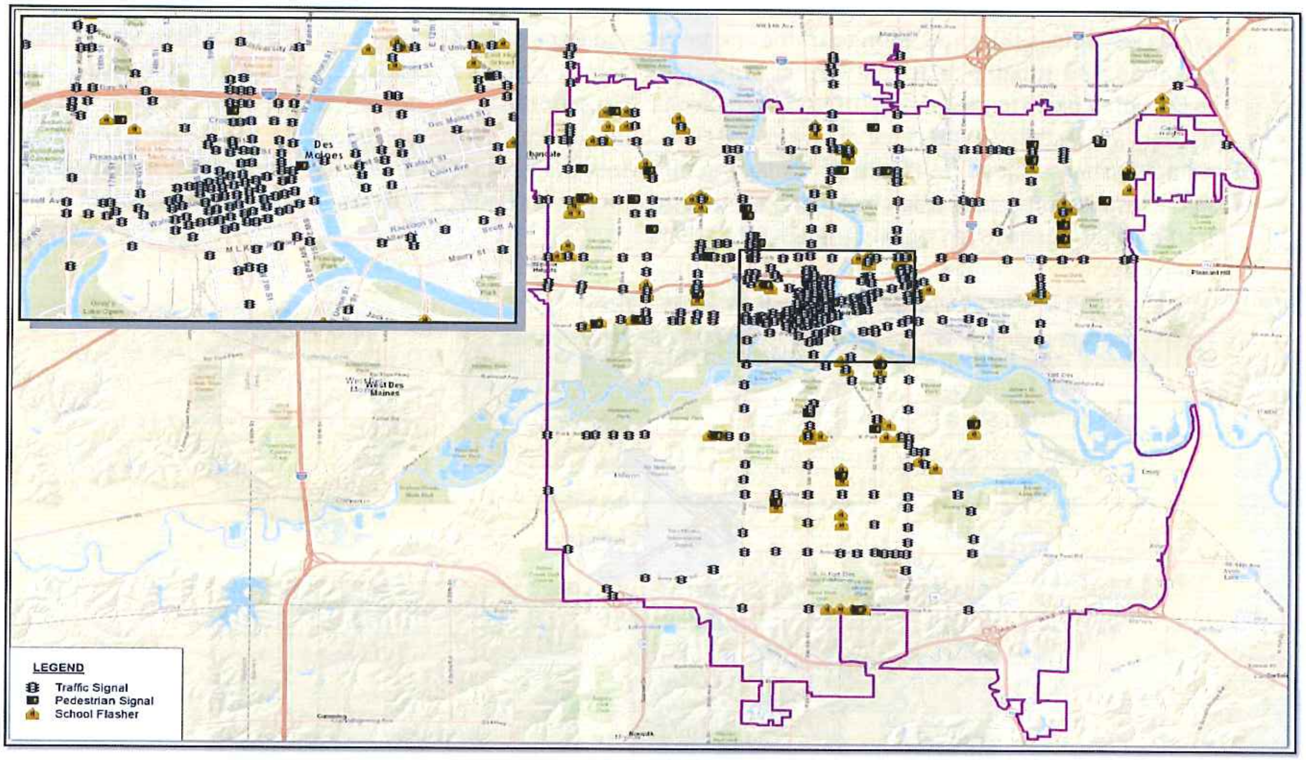


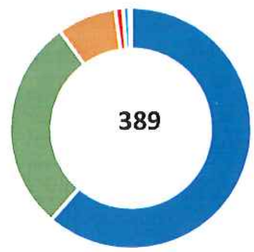
Figure 3 – Existing Traffic Signals

4.1.2 Traffic Signal Cabinets

Signalized intersection traffic controllers are typically housed in a pad-mounted 332 cabinet; while the controllers at pedestrian crossing locations are typically housed in a pole-mounted 336 cabinet. **Figure 4** shows a typical configuration for both pad- and pole-mounted cabinets. **Figure 5** illustrates the type and location of all traffic signal cabinets. The City uses several traffic signal cabinet manufacturers for signalized intersections as summarized in **Table 2**.

Table 2 – Traffic Signal Cabinet Summary

Type	Number	Color
Safetran	234	
McCain	109	
Other	30	
PSI	4	
IDC	3	
DTS	1	



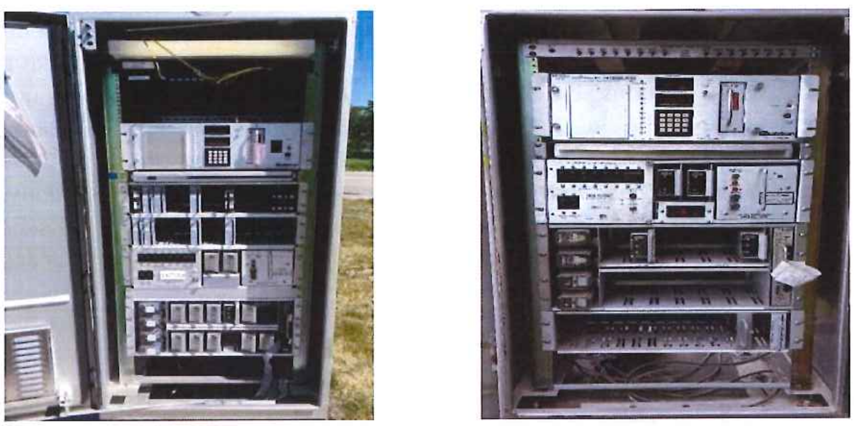


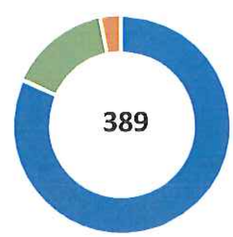
Figure 4 – Traffic Signal Cabinets (Pad-Mounted, left, and Pole-Mounted, right)

4.1.3 Traffic Signal Controllers

A majority of the signals use Type 170, Type 170E and Type 170S controllers which are operated by BI Tran Systems' local controller firmware. A breakdown of the controller types is shown in **Table 3**. **Figure 6** illustrates the type and location of all traffic signal controllers.

Table 3 – Traffic Signal Control Summary

Type	Number	Color
170E	318	
170	59	
170S	12	

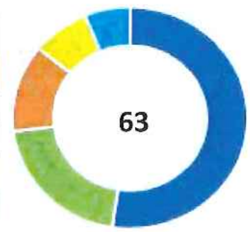


4.1.4 Traffic Management Devices

The City currently uses the following types of traffic management devices: 1) Flashing Pedestrian Sign, 2) Speed Feedback Sign, 3) Rectangular Rapid Flash Beacon (RRFB), 4) HAWK Signal and 5) Railroad Crossing Warning Sign. A summary of the number of locations equipped with these traffic sign types is shown in **Table 4. Figure 7** illustrates the traffic management devices and locations.

Table 4 – Traffic Management Device Summary

Type	Number	Color
Flashing Pedestrian Sign	33	
Speed Feedback Sign	13	
Rectangular Rapid Flash Beacon (RRFB)	8	
HAWK Signal	5	
Railroad Crossing Warning Sign	4	

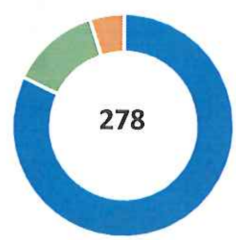


4.1.5 Detection

The City currently uses the following types of detection systems: 1) inductive loops, 2) video detection, 3) microwave radar detection and 4) wireless sensors or pucks. These detection types generally apply to vehicle actuation, but some locations also include bicycle detection. Some intersections utilize a combination of the above detection types. The video detection equipment used are mix of Iteris' Vantage, ITS Plus and Traficon. The City is currently phasing out their use of wireless pucks for vehicle detection. The majority of intersections also provide push-button detection for pedestrian crossing with select intersections operating with Polara or Pelco Accessible Pedestrian Signals (APS). A summary of the number of intersections equipped with these detection types is shown in **Table 5**. **Figure 8** illustrates the types and locations of detection systems.

Table 5 – Detection Summary

Type	Number	Color
Inductive Loops	228	
Video Detection	36	
Radar Detection	13	
Wireless Sensors or Pucks	1	



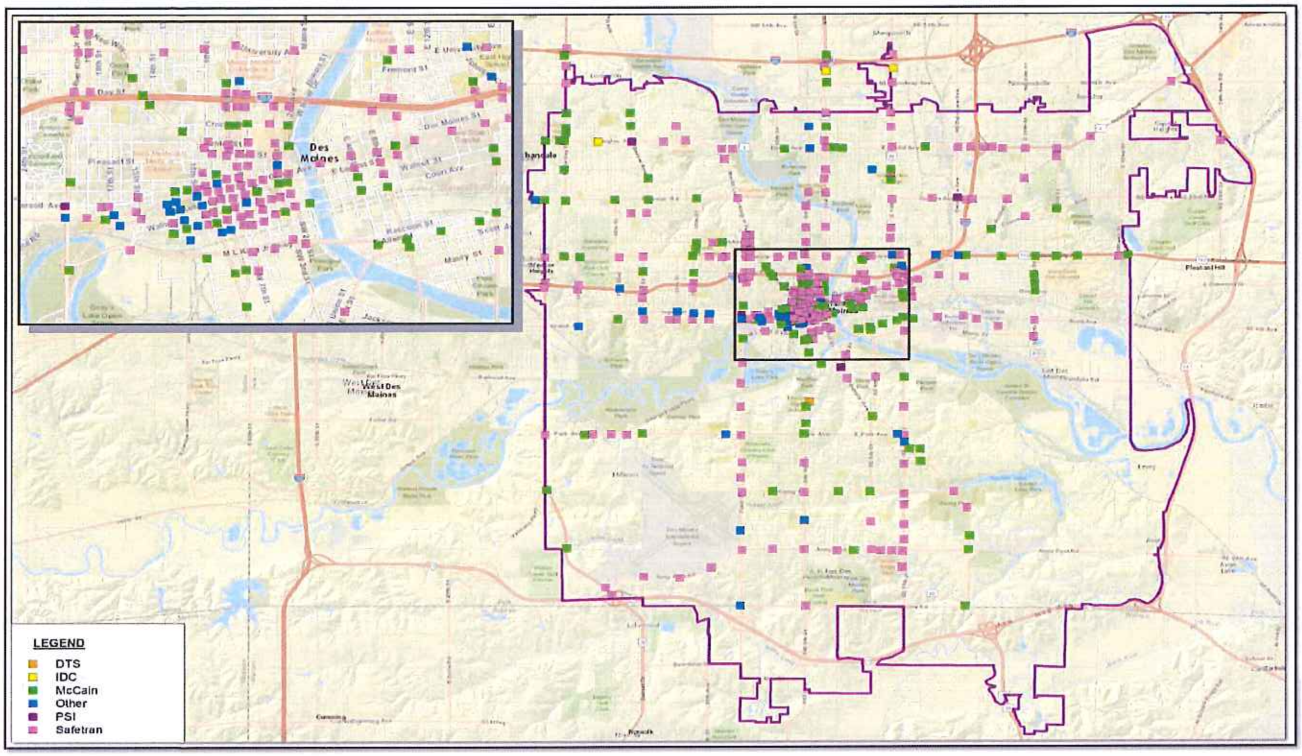


Figure 5 – Traffic Signal Cabinets

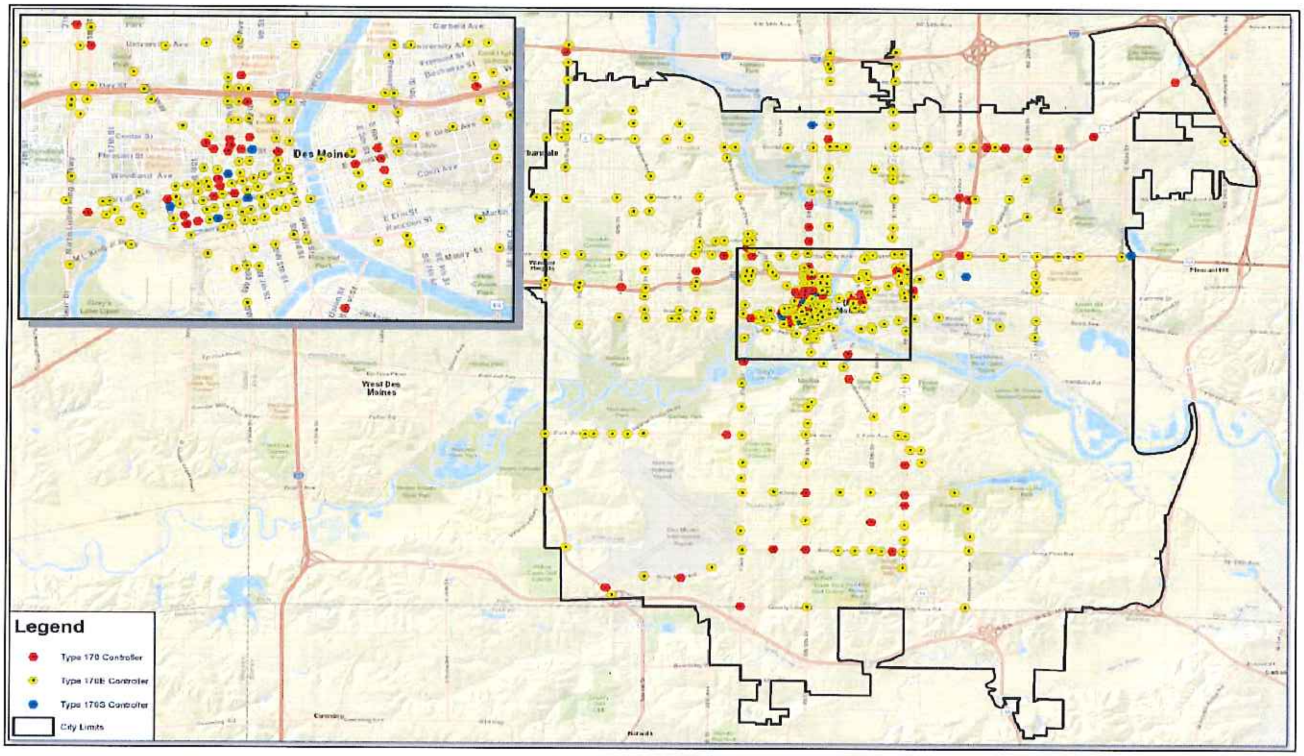


Figure 6 – Traffic Signal Controllers

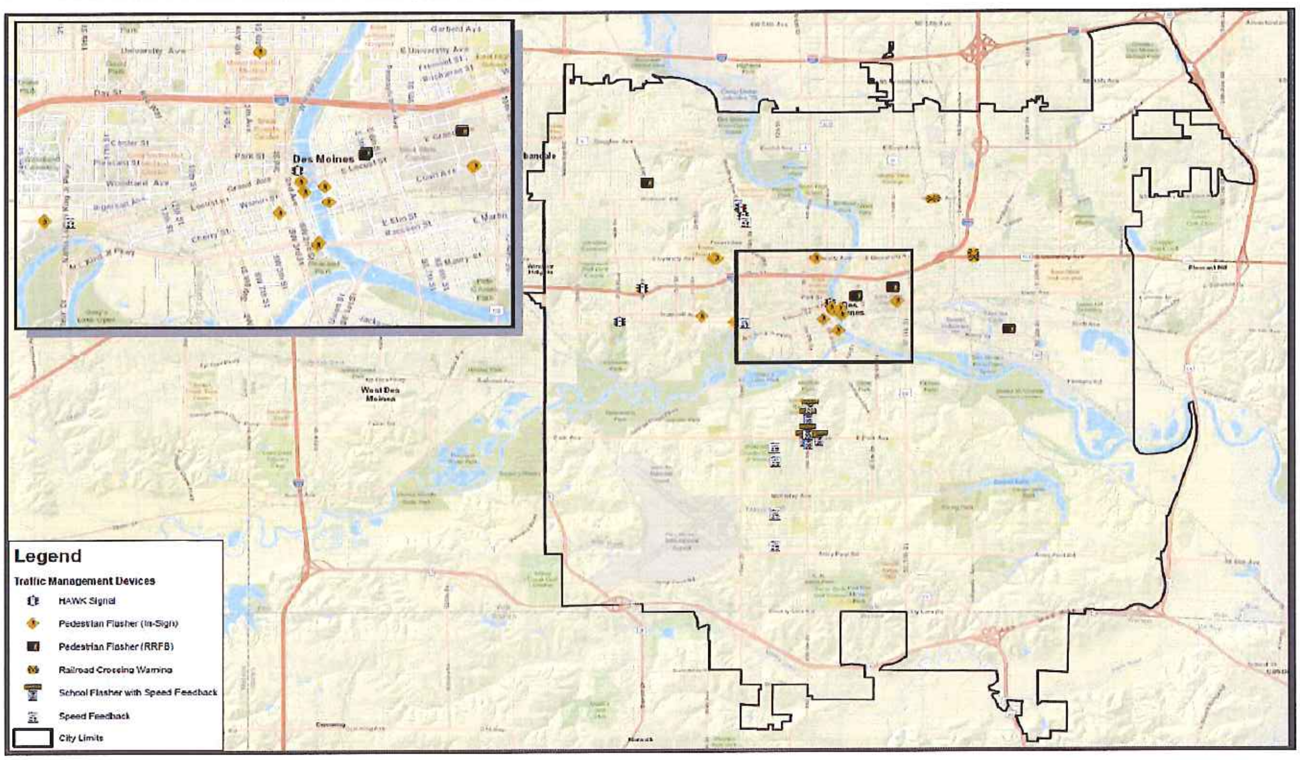


Figure 7 – Traffic Management Devices

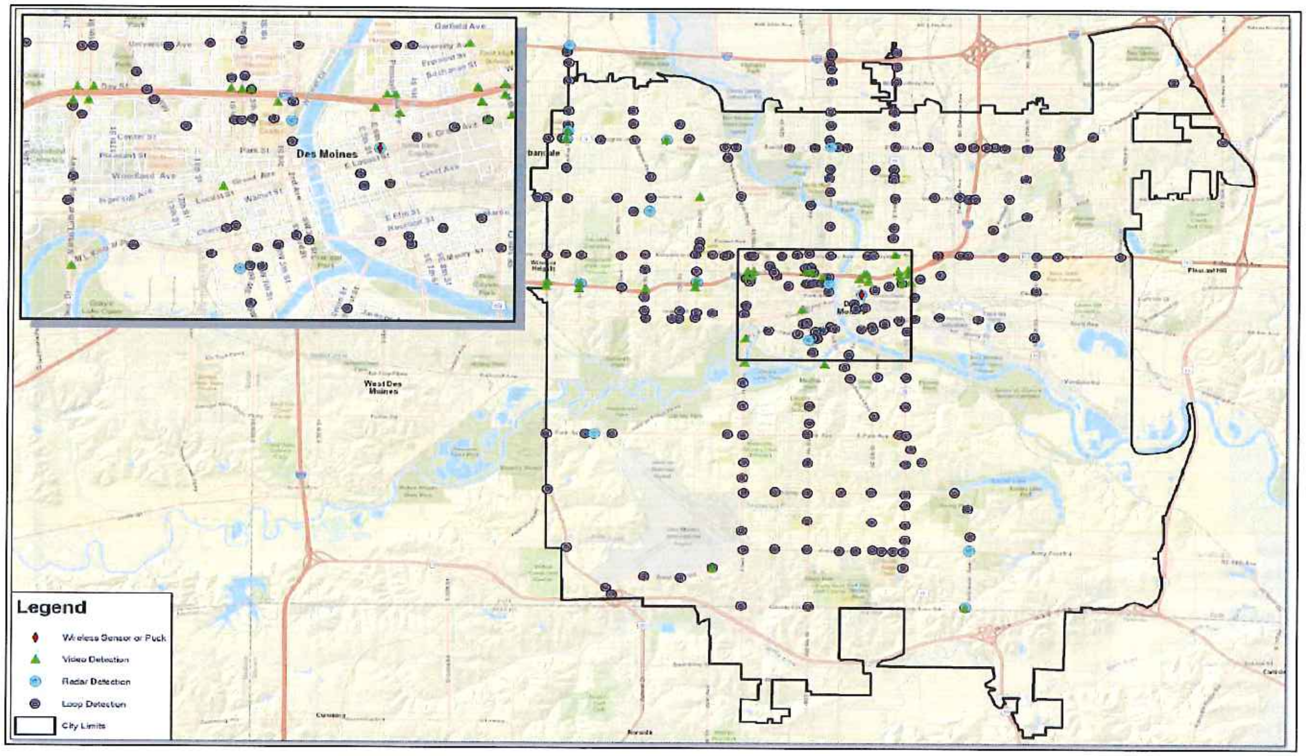


Figure 8 – Detection Types and Location

4.2 Communications Systems

The following subsections present a summary of the City's existing communication infrastructure.

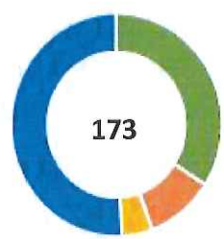
The City's wide-area communication network is comprised of a variety of media types and technologies. The current network is IP based and generally conforms to the NTCIP standards for field device connection and communication, utilizing IPv4 routing and addressing protocols. Fiber optic cables, both Single Mode and Multimode, are the primary physical medium that the City uses for communication with traffic signal controllers, CCTV cameras, and other existing ITS elements. Some signal groups are currently connected using twisted copper pairs (TWP) for signal interconnect. The TWP cables consist mostly of 12-pair, 25-pair, and 50-pair copper conductors. The City also utilizes IP based point-to-point broad band radios for 'last mile' connections to traffic signals located at the end of fiber cable circuits.

Currently, traffic signals communicate using City owned fibers or twisted pairs of copper wire in signal groups that connect between on-street traffic signal controllers. These signal-to-signal field circuits generally have maximum communication speeds of either 100 megabits/second or 1 gigabit/second between individual signal controllers, depending upon if the signals are connected using multimode or single mode fiber. The signal controllers are connected to the central signal management software using the shared City/MetroNet single mode fiber network backbone that exists across much of the Des Moines metropolitan area. Traffic signal communication is logically segregated from other network traffic within the IT network with the use of VLANS and unique IP addressing.

Table 6, below, summarizes the overall total lengths of the different communication media and conduit systems in miles that available for use by the City. Please note, the Multimode and Single Mode items quantify the City owned fiber cables which are separate from the MetroNet quantity used as City's communication medium.

Table 6 – Type of Communications Media and Amount in Use

Communications Media	Mileage	
Twisted Copper (SIC)	unknown	
Multimode Fiber Optic	59	
Single Mode Fiber Optic (12 ct or less)	18	
Single Mode Fiber Optic (24 ct or more)	8	
MetroNet (Shared SM – 12 ct for City use)	88	



4.2.1 Fiber Optic Cable

Both Single Mode and Multimode fiber optic cables are currently being utilized at, and between, many of the signalized intersections. The City owns all Multimode fiber cables in use, solely owns many low count (i.e. 2-6 fibers) Single Mode branch cables between signal installations, and has access to significant segments of Single Mode cables as part of the MetroNet system. Any 36 or larger count Single Mode fiber cable that has shared usage by at least two members of MetroNet (i.e. the City or other partner public entity) result in each member automatically being allocated 12 of the 36 fibers for their use. Fiber cables installed with counts larger than 36 fibers follow the same allocation for the first 36 fibers but the remaining fibers of the cable are owned and allocated for use by the installing member of MetroNet.

From City provided information, fiber is currently present at 308 intersections, and the City connects signal controllers to the fiber network in the following ways: 1) direct fiber connection, 2) fiber modem (media converter), and 3) Ethernet switch. The City is currently planning to replace all its Multimode fiber with Single Mode fiber as part of this ITS Master Plan.

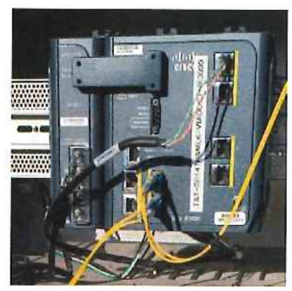
Figure 9 and **Figure 10** illustrates the location and extent of all the single and multimode fiber installations throughout the City.

4.2.2 Signal Interconnect Cable (SIC)

Besides fiber optics, the City also utilizes copper twisted pair cable (TWP) for signal interconnect. The SIC consists of 12-pair, 25-pair, and 50-pair copper cables. The majority of SIC installed is 12-pair cable and is installed within a dedicated SIC conduit and pull boxes network. The dedicated SIC conduit varies between two and three inches in diameter. All conduits are constructed of Polyvinyl chloride (PVC), a common type of material used for communications conduit. The City has TWP SIC along several corridors that could be upgraded to single mode fiber as part of this overall improvement project.

4.2.3 Ethernet Switch

The City uses the Cisco Industrial Ethernet 3000 Series (IE-3000-4TC) switch to remotely communicate with the traffic signal system directly from the City's individual workstations. The Cisco IE-3000-4TC is a family of Layer 2 and Layer 3 switches with innovative features, robust security, and superior ease of use. This Cisco IE-3000-4TC switch provides the following ports for connection:



- 4 Ethernet 10/100 ports and two dual-purpose uplinks (each dual-purpose uplink port has one active port either 10/100/1000 copper or SFP fiber1 RJ45 10/100/1000 Port)
- Support up to two expansion modules with various combinations
- DC input range 18VDC-60VDC
- Layer 2 LAN Base Image

4.2.4 Conduit System

Currently, the City has access to conduits that have been installed for the SIC, the conduits for the City owned Multimode and Single Mode fiber cables, and conduits utilized by the MetroNet system. From available information, the City has access to approximately 123 miles of conduit across the metropolitan area. It has been noted by the City that the majority of the conduit system has either SIC or fiber cables already installed and in use for signal communications, but there are some short segments around the City that may be empty and available for future use.

Figure 11 illustrates the locations of all existing conduit installations throughout the City.

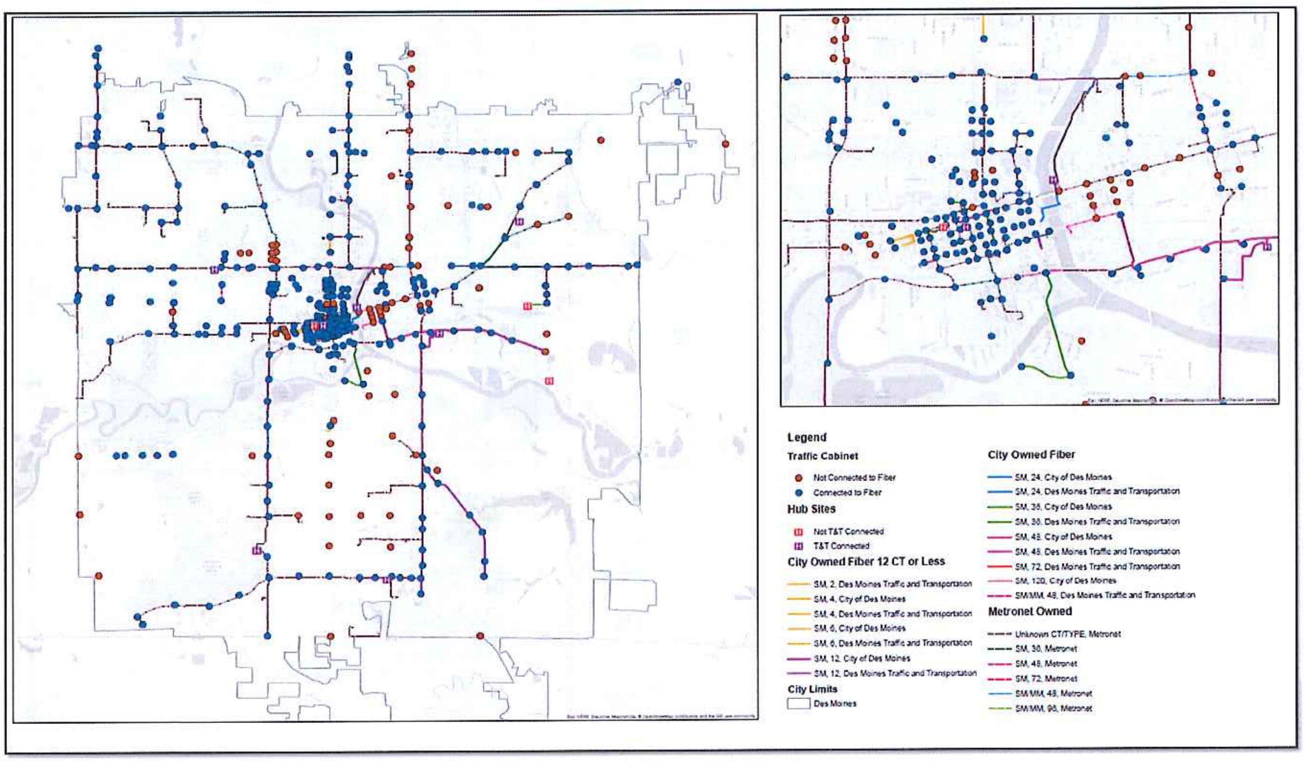


Figure 9 –Existing Single Mode Fiber Communication

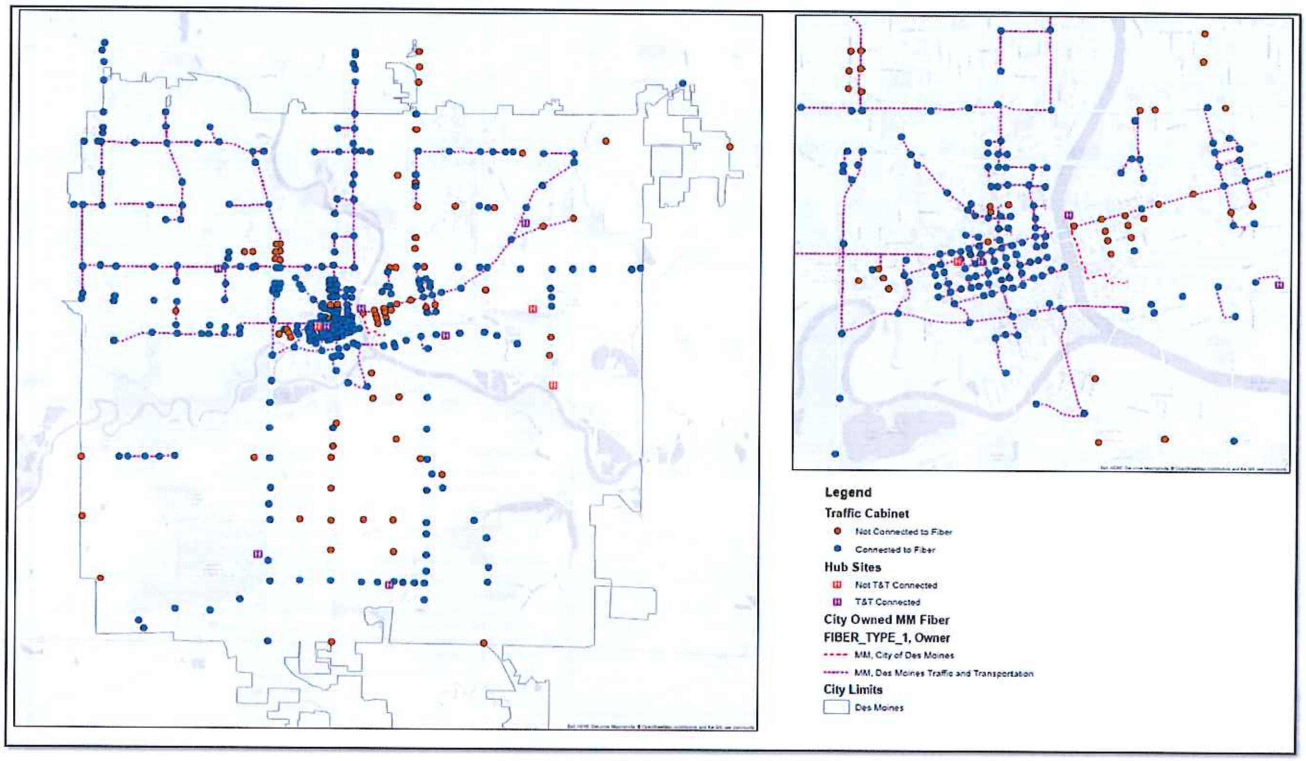


Figure 10 –Existing Multimode Fiber Communication

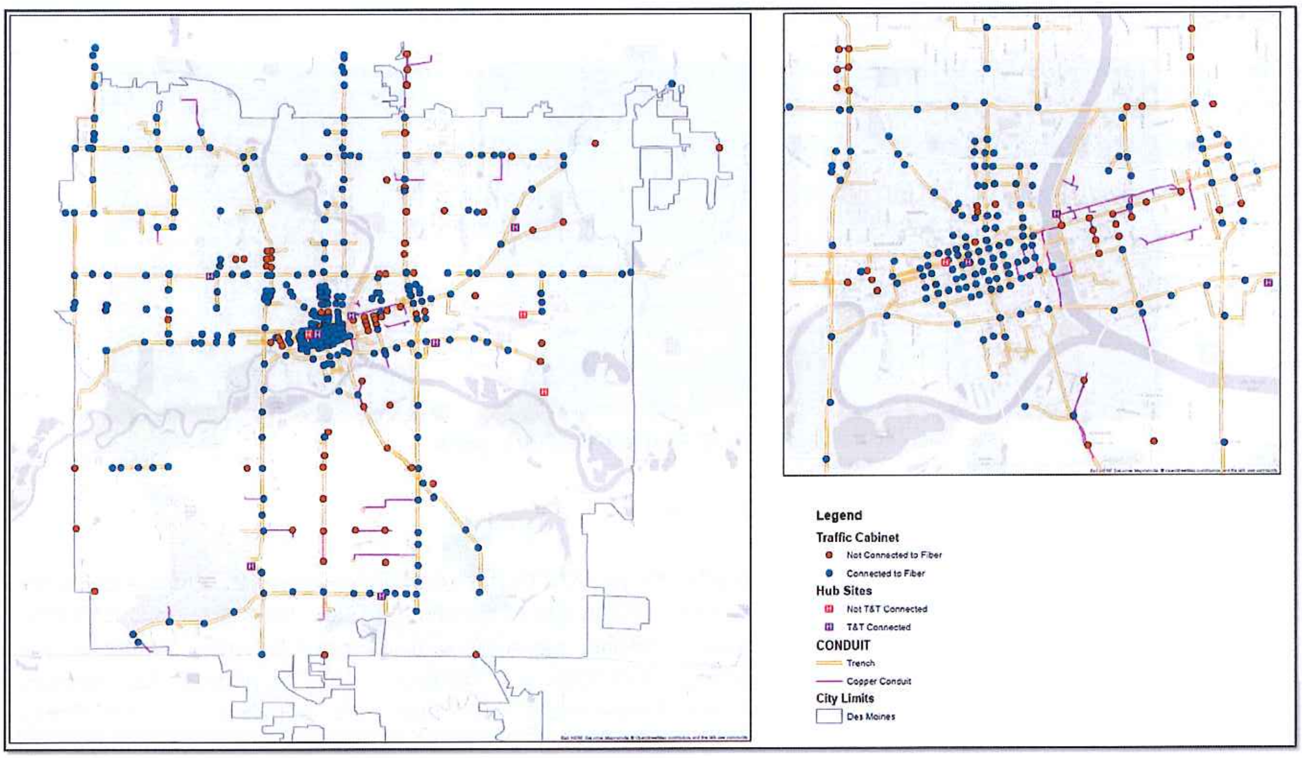


Figure 11 – Existing Conduit System

4.3 Intelligent Transportation Systems (ITS) Devices

The following subsections present a summary of the City's existing ITS element infrastructure.

4.3.1 Battery Backup Systems

The City currently has Battery Backup Systems (BBS) installed at 30 intersections. These locations currently use the Alpha Traffic BBS. The majority of these deployments consist of a supplemental "backpack" cabinet that is mounted to the main cabinet shell. **Figure 12** shows a typical installation of the BBS mounted to the cabinet. The battery backup locations are shown in **Figure 13**.

Figure 12 –Battery Backup System

4.3.2 Closed Circuit Television (CCTV) Cameras

The City currently has 29 CCTV cameras installed to monitor traffic from individual workstations. The video and data is transmitted from the CCTV camera to a hardened one-channel MPEG video/data encoder to the Ethernet switch located in the traffic signal controller cabinet, to the Gigabit Ethernet switch at the communication hub for transmission to the City's individual workstations. The CCTV cameras are managed using Cameleon (Version 4) camera management system by the "360 Surveillance" Company. However, due to lack of resources and staff the City does not currently monitor and maintain the system. Camera images are not currently shared with other agencies or websites. The CCTV locations are shown on **Figure 14**.

4.3.3 Emergency Vehicle Preemption (EVP)

EVP systems are currently deployed at 15 signals in the City, however they are not operational. The systems are activated from inside the emergency vehicle and/or at the emergency vehicle station. **Figure 15** illustrates the signal locations equipped with EVP systems. EVP systems are from various manufacturers and based on different technologies including infrared/strobe system (like GTT and TOMAR) as well as GPS/CAD based system. EVP systems provide preemption for any emergency vehicle (typically police, fire, ambulance) equipped with a transmitter device and approaching a signal from any direction to reach their destination quickly and safely.

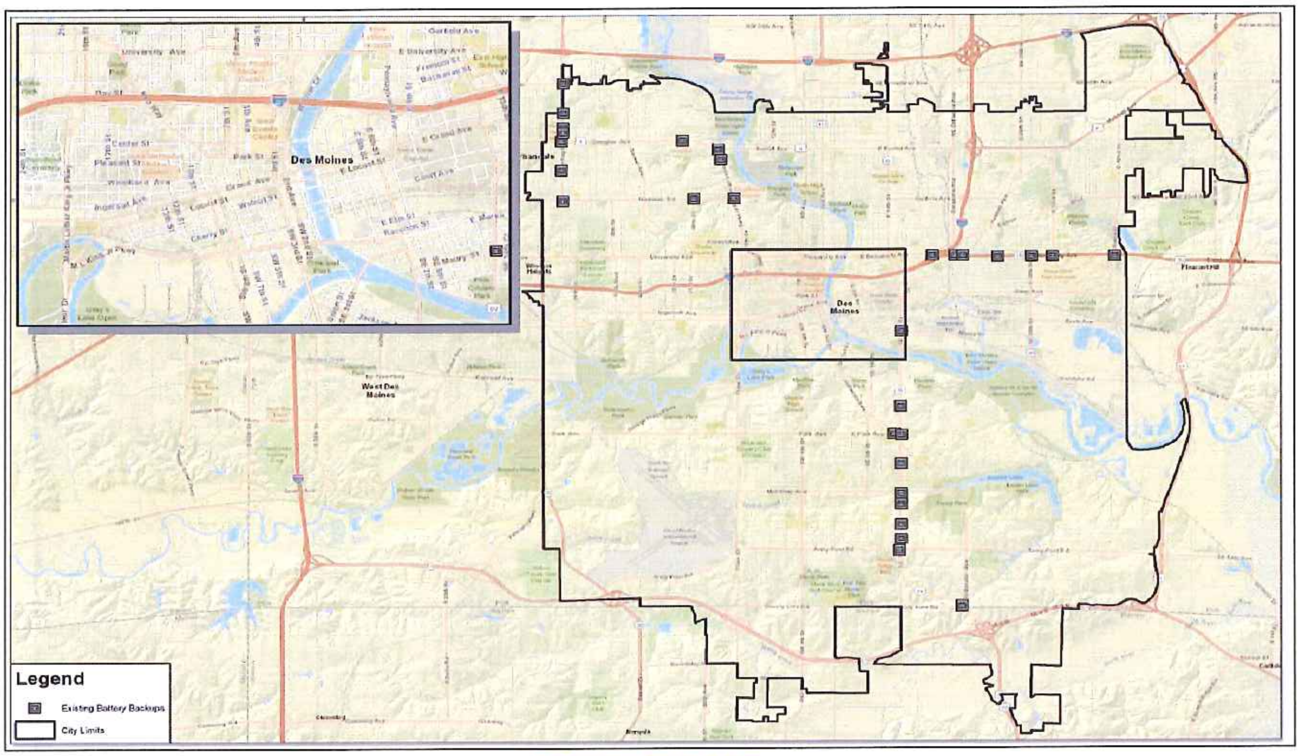


Figure 13 –Existing Battery Backup System

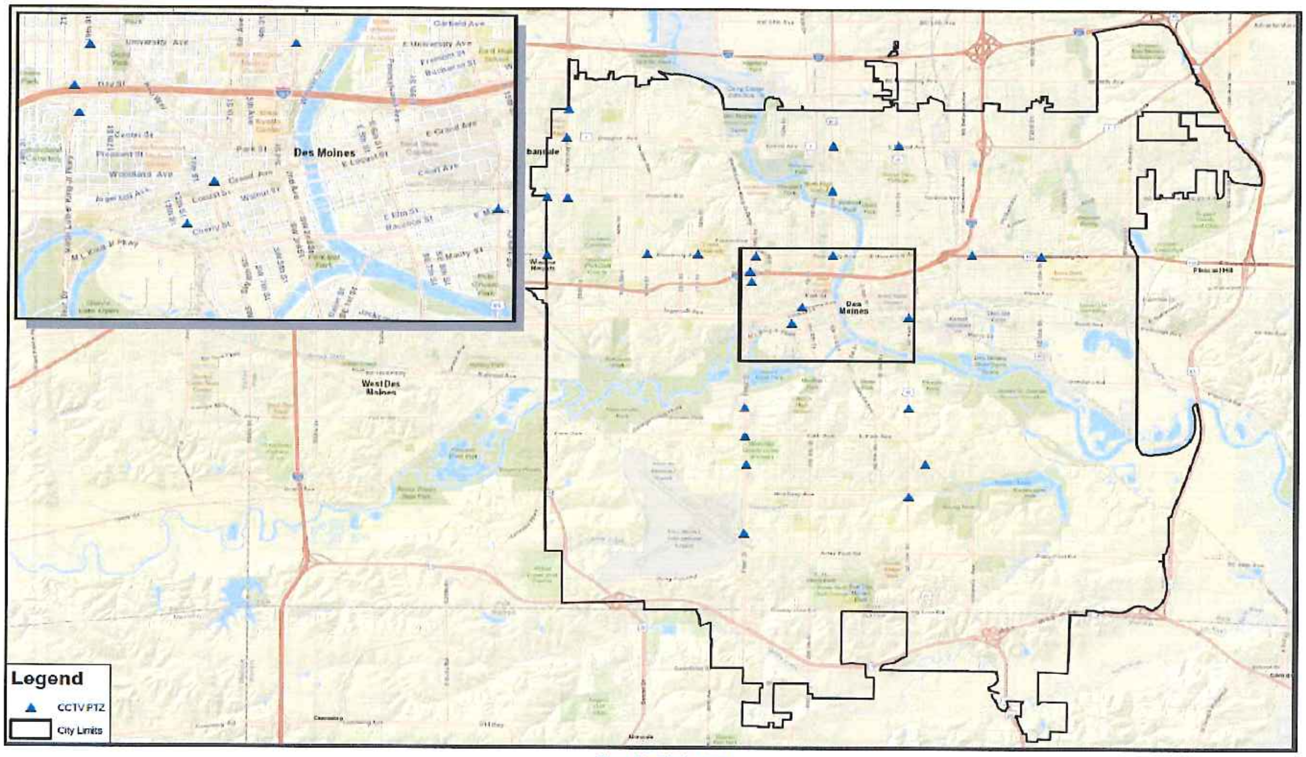


Figure 14 – Existing CCTV

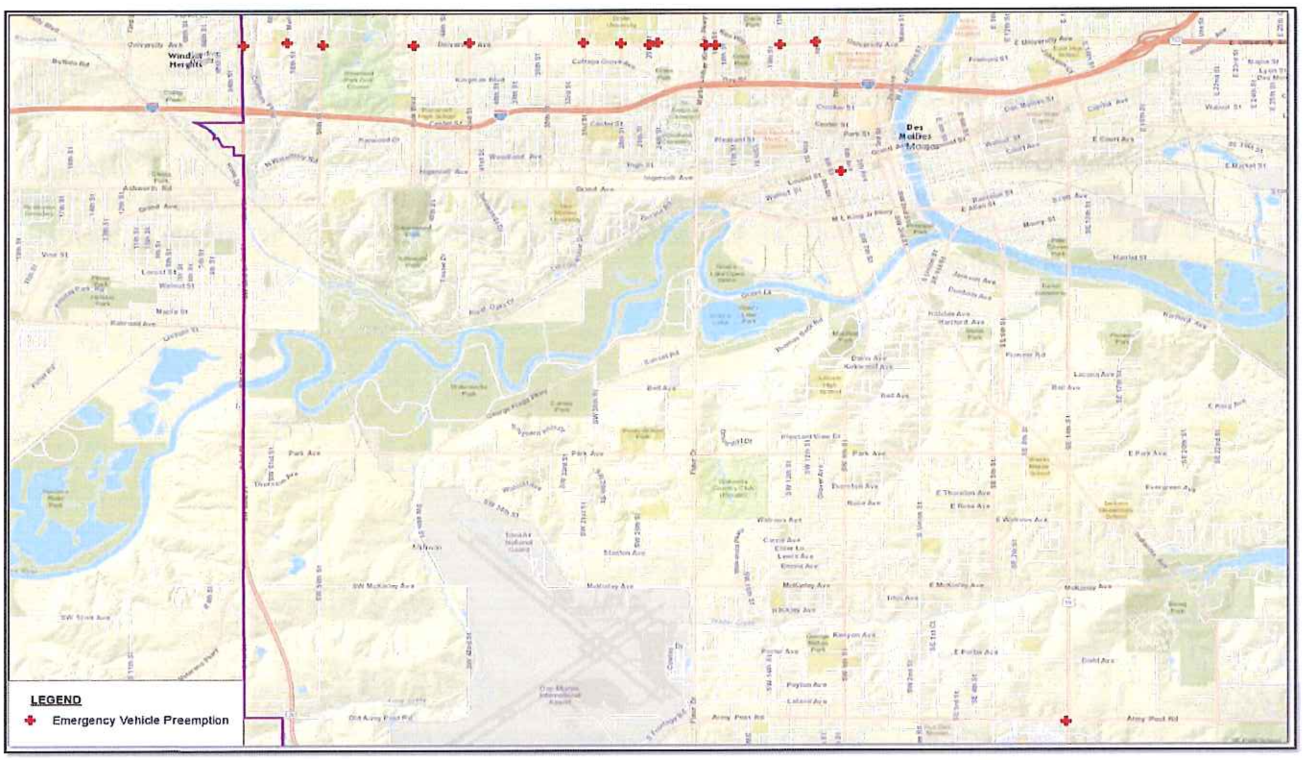


Figure 15 – Existing EVP

4.3.4 Dynamic Message Signs (DMS)

The City of Des Moines currently operates eight DMS throughout the city. The DMS panels are combination units with the DMS controller installed within the sign panel. DMS panels are Daktronics brand and have easy access to both front and back panels for maintenance. The DMS inform drivers of parking availability. The City uses Vanguard Version 4 Central Control Software to communicate with the DMS networks from individual workstations. The software allows for monitoring, message creation and provides diagnostic tools necessary to maximize the functionality of state-of-the-art NTCIP DMS. The DMS locations are shown in **Figure 16**.

4.3.5 Parking Management System

The City of Des Moines actively manages parking garages using parking garage gate software. The City also currently operates DMS through QuicNet system for disseminating parking wayfinding and parking availability and other parking related information to travelers, although this functionality will be discontinued in the future. QuicNet ATMS selects messages for these DMS based on the data from garage gate software translated by a middle software to QuicNet compatible data. The City will be procuring a new parking lot management system SKIDATA to manage all parking garages and provide better traffic flow. For an interim period, there could be two parking garage software systems operating in different parking garages before one software will be procured for all garages.

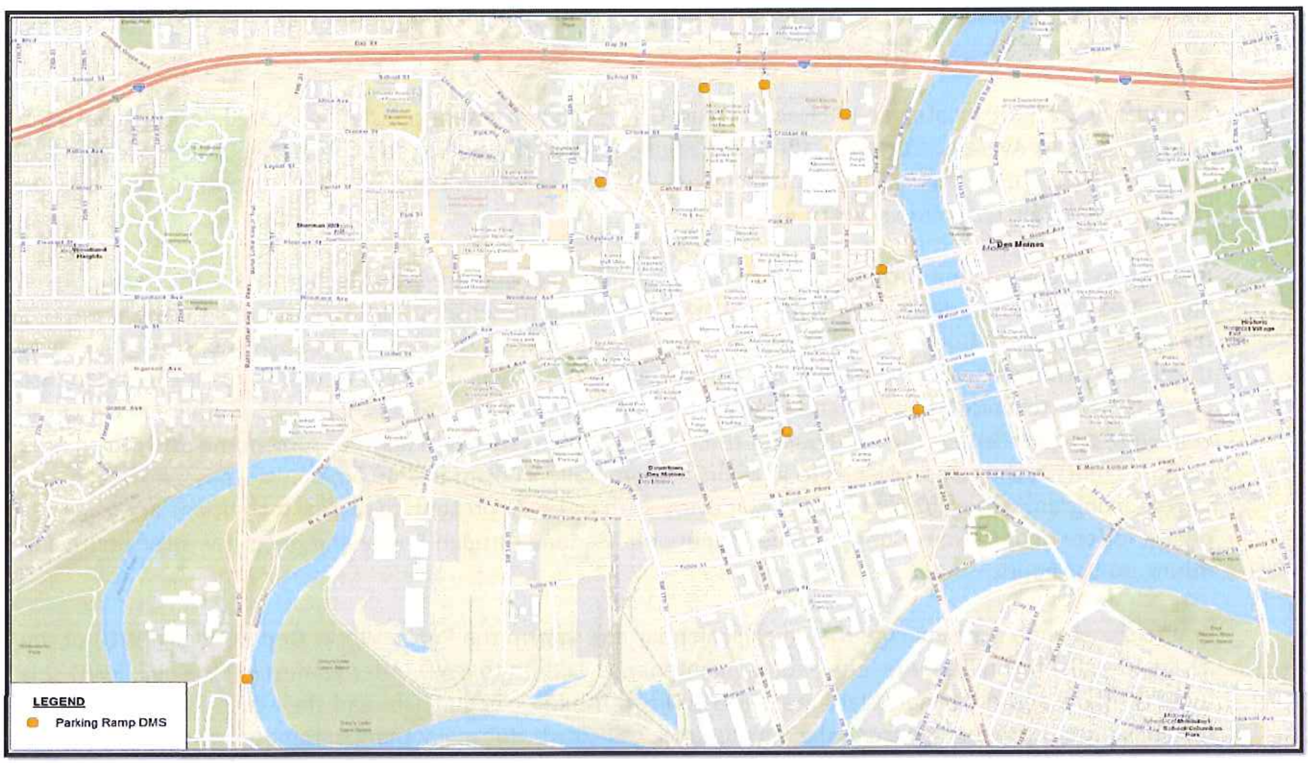


Figure 16 –Existing DMS

4.4 Transportation System Management

4.4.1 Facilities and Staff

All staff that conducts work related to the ITS is a part of the Traffic and Transportation (T &T) Division, which is located within the Engineering Department. Other divisions within the Engineering Department include Design and Construction, Real Estate and Bids and Contracts. **Figure 17** illustrates the organizational structure of the Engineering Department.

The T&T Division has engineering, maintenance, technician, and administrative staff that are responsible for traffic signals, traffic signs, traffic studies, street lighting, ROW management, street pavement marking, parking and Skywalk Operations and Maintenance.

Engineering staff are located at 400 Robert D Ray Drive, while maintenance staff is located at the Signal Shop at 2000 SE Scott Avenue. Currently, there are engineering staff including the City Traffic Engineer in the T&T Division. There are no engineering staff dedicated to traffic operations and ITS. The City anticipates hiring an ITS Engineer in the next several years.

In addition to engineering staff, there is one signal system chief and five signal technicians at the Traffic Signal Shop. The City has four device maintenance workers for traffic meter shop and six device maintenance workers for traffic sign/paint shop. There is maintenance chief and Signal System Chief that oversees the activities of the device maintenance workers and signal technicians. The City is divided into two zones for maintenance purposes. Two technicians are assigned in each zone. The City is in the process of buying another bucket truck. Following procurement of the third bucket truck, the City plans to create another zone in the downtown area with two more technicians assigned to it. Hours are generally 7:00 am to 3:30 pm on weekdays, however, one signal technician is on-call 24/7 for a week at every sixth week. At present, the signal technicians are using cell phone for communications during business hours on Monday through Friday and pager for after hours and during on-call hours.

Traffic Signal Shop staff manage the on-call calendar and inform the Public Works Department (PWD) of the assigned signal technician. Any after-hours maintenance calls go to PWD. After confirming the call, PWD sets up STOP signs and other necessary measures to keep the intersection safe and then calls the on-call signal technicians for further response to the maintenance call. City traffic maintenance staff does fiber maintenance such as pulling fiber, mechanical fiber terminations, etc. City maintenance staff do not currently perform fusion splicing. In addition to the in-house signal technicians, City also has an on-call contractor for maintenance items that they cannot handle.

The City also has an agreement with the Iowa DOT for providing maintenance and repair of primary roads in the City and emergency maintenance of State of Iowa owned traffic signals. Recently, the City started a traffic signal preventive maintenance program. Some City Departments have asset management systems, but, currently T&T Division does not have any system for managing signal and other ITS assets. The City has a "Heat" ticket system, which is basically a complaint system, but it is used for a maintenance work order management system. Spare parts are maintained and tracked in total, but not on per zone basis.

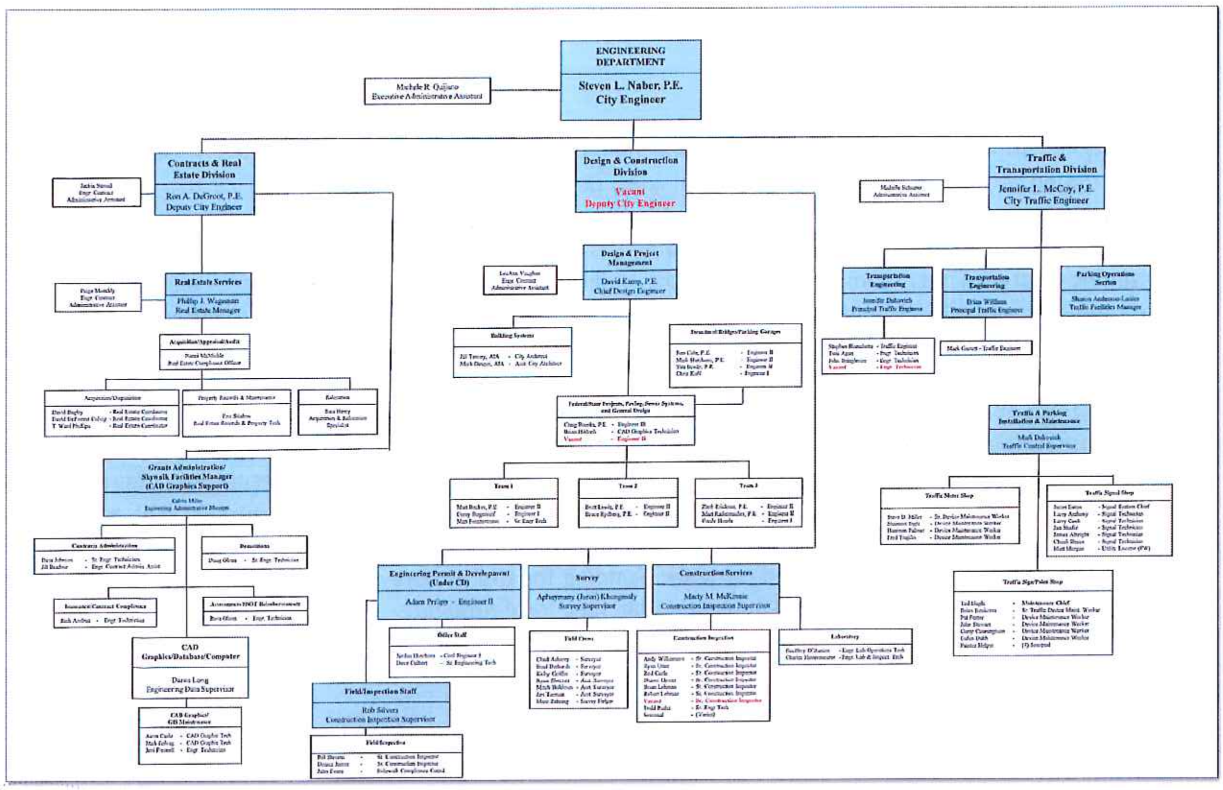


Figure 17 – City of Des Moines – Organizational Structure

4.4.2 Traffic Operations Center (TOC)

The City of Des Moines currently does not have a Traffic Operations Center (TOC). There is a conference room in City Hall that has a desktop computer and two 40" flat screen TV connected to the computer which can be used as TOC. Computers at these locations have QuicNet and Chameleon software to access the signal system and use the observation cameras. However, the computers provide limited ability to monitor traffic conditions and make necessary adjustments to the signal operations to provide the most efficient operation during emergency conditions. In addition, due to limited staff and resources operations are not monitored on a regularly scheduled basis. The Traffic and Transportation Division staff laptops/computers also have QuicNet and Chameleon software. The City is currently planning on utilizing individual workstations (computers with signal system access) as opposed to a dedicated TOC with enhanced screens in the Principal Traffic Engineer's office, the Signal Technician Chief's office, and the Public Works conference room for monitoring operations.

4.4.3 Traffic Signal Timing

The City of Des Moines doesn't have a full time Traffic Signal Engineer dedicated to traffic operations. Traffic signal timing at all 425 signals (389 traffic plus 36 pedestrian signals) is conducted by the engineering and technician staff. This includes basic timing (e.g., yellow-change and all-red clearance intervals, pedestrian walk and clearance intervals) and coordination parameters (cycle lengths, splits, and offsets), as well as responding to timing-related citizen complaints. From the individual workstations, the engineers and technicians can communicate with signals and can get some alerts from the signal controller. Traffic maintenance staff is also responsible for delivering updated timing sheets to the cabinets. The engineers are also responsible for creating and maintaining the traffic signal system model for capacity analysis and optimization. Currently, most traffic signals operate three patterns on weekdays (inbound, balanced, and outbound). The City currently has an RFP out for a review and update of the signal timing and phasing of the traffic signal system throughout Des Moines. The goal of the project is to increase efficiency of the traffic signal systems resulting in decreased travel times, reduced traffic congestion, and ultimately reduced vehicle emissions. The project will also consider signal timing and phasing for pedestrian and bicycle traffic in support of the City's efforts to provide a more walkable and bikeable transportation network. Funding for the project will be provided by a combination of Iowa Clean Air Attainment Program Funds and matching local funding.

4.4.4 Incident Management

Incident management includes various activities that help mitigate non-recurring congestion, such as rapid detection and response to accidents and stalled vehicles, disseminating congestion-related information to drivers, management of construction and maintenance activities, and management of traffic for special events. There is no formal incident management program for arterial streets in the City of Des Moines. The City and the neighboring jurisdictions are interested in coordination for regional incident management. Signal system compatibility (NEMA vs. 2070 controllers, different traffic management software, etc.) is something that needs to be addressed in the future to provide better coordination across agency boundaries. For example, State Fair traffic could be better managed with compatible signal systems across different jurisdictions. In addition, coordination with transit agencies such as Des Moines Area Regional Transit Authority (DART) on key routes during the State Fair would help in managing traffic efficiently. Except the State Fair and for soccer season at E 14th Street and Hartford Avenue for the James. W Cownie Soccer Park, the City does not have any special timing plans for managing traffic related to the special events at Iowa Events Center, Principal Park etc. to facilitate ingress and egress out of these event centers. In most cases, the Des Moines Police Department and the Polk

County Sheriff's Department manually operates traffic signals by placing officers next to traffic signal cabinets. The City is interested in implementing different strategies for managing congestion, but limited staffing/resources is a significant constraint.

5 NEEDS ASSESSMENT

Given the evaluation of the existing ITS described previously, the needs assessment process was conducted to identify the stakeholder needs that must be satisfied in order for the City of Des Moines to meet its goals and objectives relative to an upgraded ITS.

The identified needs "filled the gaps" between the existing ITS and the future ITS. Various alternatives and improvement options were evaluated to determine which alternatives best "filled the gaps". The best alternatives for each need are summarized in this master plan through prioritized deployment phases. Each deployment phase includes conceptual level design and planning cost.

The needs identified in this section were gathered directly through meetings with stakeholders, primarily through the course of several meetings, and in walking through various operational scenarios that identified stakeholder roles and responsibilities, equipment (such as hardware, software, and communications), staffing, and traffic management needs for both existing and future conditions. The Concept of Operations document included in the **Appendix A** discusses the operational scenarios in greater detail.

Based on evaluation of inventory, discussion with staff, and conducting operational scenarios, high-level needs have been identified. The identified needs are organized into the following eight categories:

1. Arterial Traffic Management
   - Improve operations for all modes of transportation
   - Improve efficiency of the ITS
   - Improve coordination with the Iowa DOT
   - Improve coordination with neighboring jurisdiction
   - Improve efficiency of engineering, operations, and maintenance staff
2. Safety Systems
   - Improve safety and operations for all modes during power outage or cabinet knockdown
   - Improve safety for pedestrians at intersections and mid-block locations
   - Improve safety for bicyclists at signalized intersections
   - Improve safety and operations for drivers during winter driving conditions
   - Improve safety for drivers and pedestrians by reducing speed-related crashes
   - Improve safety for drivers by reducing vehicle-to-vehicle crashes
3. Communications Systems
   - Provides remote access to the signal system components
   - Improve performance of the traffic management system
   - Improve efficiency of engineering and maintenance staff
   - Improve safety and operations for all transportation modes
   - Improve security and scalability of network to support ITS goals
4. Incident Management
   - Improve operations for drivers during incidents
   - Improve coordination with the Iowa DOT during incidents
   - Improve coordination with neighboring jurisdiction during incidents
   - Improve safety for the public and emergency response personnel

- Improve incident clearance time to restore roadways to normal operations

5 Traveler Information Systems
- Improve operations for drivers by providing pre-trip and en-route information
- Enhance traveler information system and use various media for delivering alerts e.g. text alerts
- Improve reliability of ITS components for disseminating traveler information among jurisdictions

6 Public Transportation
- Improve operations for transit vehicles at traffic signals
- Improve safety for transit vehicles
- Improve operations for vehicle and transit users
- Improve traveler information to increase transit ridership

7 Parking Management Systems
- Improve management of parking facilities
- Improve operations for drivers using parking facilities
- Improve pricing and duration to balance user expectations and system objectives

8 Maintenance and Construction Operations
- Reduce failures of ITS components
- Improve efficiency of technician staff
- Improve safety and efficiency of traffic approaching and moving through work zones
- Improve efficiency of staff and equipment during maintenance and winter operations
- Improve work order management
- Improve equipment parts inventory management process
- Improve preventative maintenance

From the meetings conducted with stakeholders, **Table 7** summarizes more detailed needs, constraints, and expectations based on the need assessment workshop conducted with stakeholders. For each, an initial priority was identified as high (H), medium (M), or low (L). In addition, the existing status of the fulfillment was identified as nonexistent (N), partially complete (P), or complete (C). These items will be evaluated further as the project team moves forward with the Concept of Operations and high-level requirements documentation.

Table 7 – Detailed Needs and Priority Summary

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS	PRIORITY	STATUS
1.0	TRAFFIC MANAGEMENT SYSTEM	H/M/L	N/P/C
1.01	Replace Type 170/170E controllers	H	N
1.02	Install upgraded software on controllers	H	N
1.03	Provide additional space in cabinets	M	N
1.04	Upgrade ATMS software	H	N
1.05	Improve multi-jurisdictional ATMS software compatibility	M	N
1.06	Integrate ITS field devices into a single management software	M	N
1.07	Designate central location for signal timing databases	H	P
1.08	Provide ability to easily update controller settings in the field	M	P
1.09	Improve system monitoring	H	P
1.10	Provide access to management software to various staff in various locations	H	N

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS	PRIORITY	STATUS
1.11	Improve ability to remotely modify signal timing	M	P
1.12	Provide notification of detector failures	H	P
1.13	Deploy timing plans to groups of intersections simultaneously	H	N
1.14	Receive automatic notifications for coordination errors	H	N
1.15	Setup alarm notifications for user-defined thresholds for various parameters	H	N
1.16	Download user-friendly operational reports on signal system operations (such as communications failures), timing data, and traffic data	H	N
1.17	Provide alarms for excessive queuing	L	N
1.18	Develop an automated logging system	H	N
1.19	Automatically archive data	H	N
1.20	Conduct traffic flow monitoring in real time	H	N
1.21	Obtain access to existing freeway monitoring capabilities	H	C
1.22	Provide high-quality real-time traffic information	L	N
1.23	Provide timely congestion and incident information to public	M	N
1.24	Provide the public with limited access to traffic management tools and activities	L	N
1.25	Integrate traffic data collection software with traffic signal system modeling software	L	N
1.26	Integrate traffic signal system modeling software with ATMS software	H	N
1.27	Improve signal coordination	H	P
1.28	Improve multi-jurisdictional coordination	H	N
1.29	Maintain high-quality coordination	H	P
1.30	Provide the ability to modify coordination correction modes	H	P
1.31	Measure signal timing performance	H	N
1.32	Provide dynamic lane assignment based on user-defined traffic data inputs	L	N
1.33	Develop special event timing for ingress and egress	H	P
1.34	Improve coordination among agencies and departments for planned activities/events and unplanned activities/events	H	P
1.35	Install adaptive traffic control on certain corridors	M	N
1.36	Provide adequate staffing to perform functions	H	P
1.37	Provide adequate staff training	H	P
1.38	Develop interagency agreements	H	P
1.39	Evaluate future vehicle-to-vehicle communications systems	M	N
1.40	Evaluate pedestrian and bicycle concerns	M	N
2.0	SAFETY SYSTEMS		
2.01	Provide automatic notifications for power outage and cabinet knockdowns	H	P
2.02	Provide indication for status of active UPS systems	M	P
2.03	Provide the ability to implement and program flashing yellow arrow operation for permissive left turns within the controller	H	N
2.04	Provide the ability to implement a pedestrian hybrid beacon within management software	H	N

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS	PRIORITY	STATUS
2.05	Provide the ability to implement pedestrian scramble operation within management software	H	N
2.06	Provide the ability to implement audible or accessible pedestrian features within management software	H	N
2.07	Implement detection and develop timing specific to bicycles	H	N
2.08	Monitor speeds in real-time and conduct data collection at speed feedback sign locations	M	P
3.0	COMMUNICATIONS SYSTEMS & INTEGRATION		
3.01	Increase speed, bandwidth, and reliability of field to field communications	H	P
3.02	Increase speed, bandwidth, and reliability of center to field communications	H	P
3.03	Provide staff in the field access to network	H	N
3.04	Provide the ability to transmit video	H	P
3.05	Provide central information clearinghouse	H	N
3.06	Develop interagency agreements	M	P
3.07	Provide communications to all signals	H	P
3.08	Provide remote access to the traffic signal network for management, software upgrades, and troubleshooting	H	P
3.09	Develop and implement network security protocols	H	N
3.10	Develop traffic signal IP schema/architecture for participating stakeholders	H	N
3.11	Evaluate IP schema/architecture for future stakeholder integration	H	N
4.0	INCIDENT MANAGEMENT		
4.01	Improve incident detection	H	N
4.02	Verify and monitor incidents	H	N
4.03	Provide staff to actively monitor and coordinate	H	N
4.04	Improve incident response coordination between agencies	H	P
4.05	Reduce traffic delays for emergency response vehicles	H	N
4.06	Develop methods for deployment of incident management for select corridors	M	P
4.07	Provide better coordination for ending incident management activities	M	N
4.08	Provide multi-jurisdictional diversion routes	H	N
4.09	Improve signal system compatibility to help coordination across agency boundaries	H	N
5.0	TRAVELER INFORMATION SYSTEMS		
5.01	Provide traveler information on the roadside	H	N
5.02	Provide quality real-time congestion-related information	H	N
5.03	Improve and expand traveler information delivery methods	M	N
5.04	Improve procedures to get accurate information disseminated in a timely manner	M	N
5.05	Provide better work zone information and notification	H	N
5.06	Improve integration and coordination of ITS equipment for disseminating traveler information system along multi-jurisdictions	M	N
6.0	PUBLIC TRANSPORTATION		
6.01	Provide a traffic controller with the ability to accommodate transit signal priority at	H	N

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS	PRIORITY	STATUS
	signals		
6.02	Provide traffic signal operations for at-grade transit crossings	L	N
6.03	Provide information exchange to/from transit agency	M	N
6.04	Use AVL data for traffic management	L	N
6.05	Provide transit ETA information	L	N
7.0	PARKING MANAGEMENT SYSTEMS		
7.01	Develop a parking management system for all public garages and on-street meters in the downtown area	M	N
7.02	Actively monitor parking demand	M	N
7.03	Improve dissemination of parking availability in real-time	M	N
7.04	Discuss options with Management Companies on integration of its parking management system(s) with ATMS/ATIS.	M	P
7.05	Based on accurate data and City Policy adjust Parking Rates.	L	N
8.0	MAINTENANCE AND CONSTRUCTION OPERATIONS		
8.01	Conduct preventive maintenance on traffic signals at regular intervals	H	P
8.02	Standardize traffic control equipment	H	P
8.03	Standardize cabinet setup	M	N
8.04	Improve coordination on construction notification and information distribution	M	P
8.05	Improve work zone traffic handling plans	M	P
8.06	Monitor traffic remotely in and around work zones	H	N
8.07	Provide signal priority for snow plowing vehicles during snow events	M	N
8.08	Provide weather and pavement data collection to aid winter operations	L	P
8.09	Provide automated vehicle locations systems for maintenance and construction operations vehicles	L	N
8.10	Provide centralized call system for responding to customer calls regarding traffic signals operations	H	N

6 ALTERNATIVES EVALUATION AND RECOMMENDED IMPROVEMENT STRATEGIES

The purpose of this chapter is to 1) describe the various alternatives that exist for key components of the ITS identified in the Needs Assessment and 2) summarize the recommended improvement strategies for each component that will satisfy the needs of the City of Des Moines and other stakeholders over the short- and long-term. The Alternatives Analysis and Recommended Improvement Strategy task is closely-related to the Concept of Operations and High-Level Requirements and Verification Plan, which are SE documents developed concurrently as part this project. These documents are provided in the **Appendix A** and **Appendix B.**

While this chapter recommends improvement strategies for each ITS component, it does not seek to prioritize improvements either by system component (e.g., controllers, communications, traffic operation center, etc.) or geography (e.g., which corridors should be upgraded first). It also does not calculate quantities, identify costs of the system, or develop a deployment strategy. These tasks will be summarized in later chapters.

Because the of the ITS components identified in this master plan are anticipated to be deployed over a long term period, the recommendations in this master plan should be revisited periodically as the project moves forward to capitalize on technological advances, availability of communications infrastructure, and changes in priorities that could affect the deployment strategy.

6.1 Traffic Signal System

6.1.1 Controllers

The traffic signal controller acts as the brain of a signalized intersection. Traffic signal controllers provide functionality for signal actuation and appropriate timings for vehicular, bicycle and pedestrian traffic. There are several models of controllers and compatible firmware/local controller software, but they are generally categorized by the following platforms: 170, 2070, ATC, and NEMA Type TS1 and Type TS2, which are described in greater detail below:

1. The Model 170 controller was developed in the 1970s by the states of California and New York. The standards cover cabinets and hardware specifications, but not software. The controllers have limited memory and cannot support more than eight phases, two rings, or NTCIP communications.

2. The Model 2070 controller was developed by Caltrans to replace the Model 170 controller. This model improves the processing, memory, and other functional limitations of the Model 170, and runs on an OS-9 operating system.

3. The ATC standards are developed by a combination of NEMA, ITE, and AASHTO, and are based on the 2070 standards. Like the 2070, the ATC specifies controller hardware, but not software. However, the ATC operates on a Linux operating system and adheres to NTCIP standards.

4. The NEMA standard defines functionality, interfaces, environmental endurance, electrical specifications, and some physical specifications for controllers, but in general does not specify

size, shape, or appearance. A NEMA controller generally cannot operate in a cabinet designed for the 170 controller.

The traffic signal controller industry is still largely proprietary, contrary to current and past efforts to implement standards with hardware platforms and communication protocols. Generally, traffic signal controllers are factory-configured with specific firmware and/or software that only operate with specific central signal system software. The Model 2070 controller and the latest ATC controller specification eliminates some of these issues specific to proprietary hardware, while the NTCIP standard communication protocol has tried to facilitate the interoperability of traffic signal controller hardware with central system software. However, proprietary features continue to exist with various controllers and central system software packages to force agencies to use controllers that are made by the same vendor as the central system. Thus with proprietary compatibility issues, the type of controller installed at an intersection narrows the choices of cabinets, some auxiliary equipment, local software, and central signal system software.

The City of Des Moines currently operates most signalized intersections with Type 170, Type 170E and Type 170S controllers in a mix of cabinets. The controller operate with BI Tran Systems' local firmware. The 170 controllers has numerous deficiencies such as:

- 1970's technology
- Limited user interface
- Limited to eight phase controller, dual ring
- Limited memory
- Most 170 firmware is not NTCIP compatible
- Not ready or compatible with new technology
- No native IP port
- Does not provide High Resolution Data
- Limited or no availability of parts

The City has a few options for controllers over both the mid and long term, including the following:

- Upgrade to 2070 controllers
- Upgrade to ATC controllers on a 2070 platform
- Upgrade to NEMA controllers

There are several factors that play into the migration and upgrade of controller equipment Citywide. Most of the City's existing signal cabinets will not readily accommodate NEMA type controllers, thus it would be cost prohibitive to change to this platform. **It is recommended the City upgrade all signals to type 2070 ATC traffic signal controllers.** The 2070 controller provides a standard platform which facilitates the changing of local controller software without the need to replace the hardware. In addition, the 2070 ATC controllers have major advantages over the 170 controller, such as:

- NTCIP compatible
- Built-in native Ethernet capability
- 16 phases with four rings
- Improved logging of events

- Adaptive traffic control
- Special event timing, flush plans
- Transit Signal Priority
- Connected Vehicles Compatibility
- High Resolution Data

6.1.2 Local Controller Software

The City of Des Moines currently operates its controller with BI Tran Systems' local firmware which is old and has numerous deficiencies. Therefore, it is important to select local controller software that meets the needs identified in the Needs Assessment document. The local controller software provides more flexibility in configuring and setting the controller to support various traffic operation scenarios. The table in **Appendix C** compares and contrasts a sampling of features and functions of the eight local controller software packages that are currently available on the market.

The City of Des Moines should migrate to a single local controller software based on final system requirements developed in the initial project deployment phase.

6.1.3 Cabinets

The City of Des Moines has a mix of 332 pad mounted and 336 pole mounted cabinets in the field. Signalized intersection traffic controllers are typically housed in a pad-mounted 332 cabinet; while the controllers at pedestrian crossing locations are typically housed in a pole-mounted 336 cabinet. While most of the existing cabinets can accommodate the recommended 2070 ATC controllers, **it is recommended that future new cabinets installed be Type 332D cabinet. Type 332 and 336 cabinets are still recommended to be used only at locations in the downtown area, where limited right of way, or at pedestrian crossing locations that do not need additional space for equipment**. 332D Cabinets are doublewide 332-type cabinets designed to meet the growing demands of modern traffic control. The cabinet provides two full 19" EIA racks that can easily accommodate all standard assemblies and components while leaving extra space for additional equipment such as UPS and CCTV. The cabinet interior can be easily accessed via two sets of double doors.

From a maintenance perspective, having standardized traffic equipment is more cost effective especially in terms of training signal technician staff, maintaining spare equipment and also in the repair and troubleshooting of equipment. The City of Des Moines traffic signal system is comprised of different types of 170 controllers in a mix of cabinet types, connected through a mix of twisted pair copper and fiber optic cable for communications. To facilitate traffic signal operations and maintenance, the City should take steps to migrate to a homogenous traffic signal system. In addition, as new cabinets are installed or existing cabinets are upgraded with hardware, the general layout and spacing of internal equipment should be specified and matched as relevant from location to location. This promotes consistency and ease of maintenance. Staff should be able to open a cabinet door at any traffic signal, and see nearly an identical layout of equipment and cabling.

6.1.4 Advanced Traffic Management Systems (ATMS)

The City of Des Moines currently uses QuicNet 4.0 traffic management system to manage and communicate with the traffic signals in field. Communication to these signals is via twisted pair cable or fiber optic cable. While QuicNet 4.0 provides significant functionality for traffic signal management and some additional functionality for ITS device management, it still lacks functions and features that are most commonly available in the ATMS currently in market.

Like local controller software, the table in **Appendix D** compares nearly 300 various features and functions of some of the most common ATMS currently available. Though all systems will allow for remote monitoring and control capabilities, all systems have various nuances regarding features, communications, and compatibility that differentiate them from one another, and preferences for each will depend largely on the user's needs.

It is recommended the City of Des Moines migrate to a single ATMS software package in coordination with the selection of controllers and local controller software. To achieve this, it is recommended that the City hire a temporary consultant to serve as System Manager and finalize system requirements, based on the high-level requirements developed to date, for controller hardware and associated equipment, local controller software, and ATMS software. As identified above, several vendors have products/software that satisfy the requirements and migration path identified relative to these system components. The selection of these components must be coordinated in order to meet requirements, be compatible with one another, and consider how existing system of 170 controllers with Bi Tran System software will be operated in the interim time period until it is eventually phased out. The System Manager would act as the City's representative in finalizing requirements, ensuring that appropriate system requirements and specifications are included in the procurement documents for software phases of deployment. In this manner, the City will have a solid understanding of what is being purchased as well as associated costs for both initial and longer-term software deployment phases.

6.2 Communications Systems

A robust communications network is paramount to a successful, dependable, and efficient transportation management system. The communications network provides the mechanism for field data to be brought back to a centralized location, such as a Traffic Operation Center (TOC). The data can be brought back to the TOC through several methods, a few of which are presented below.

6.2.1 Hardware Communications Alternatives

This type of communication media is widely used for traffic signal and ITS deployments and includes twisted pair copper wire signal interconnect cable (TWP SIC), fiber optic (FO) cable, dial-up telephone lines (phone drops), and leased line circuits. The hardwire cable is typically installed underground inside a conduit.

Twisted Pair Copper Wire Signal Interconnect Cable (TWP SIC)
Twisted pair copper wire consists of two insulated copper wire (also called pairs) wrapped around each other to convey electrical signals and is the most basic technology used to establish communication. Historically, this type of communication media has been the most common medium for signal control application because it provided a cost-effective solution for low-speed, low-volume data transmission over short distances. This technology has a usable bandwidth of 300 to 3000 Hz with typical data transmission rates of 1200 to 9600 bps, but the trend is moving toward 19.2 Kbps in support of the National Transportation Communications for ITS Protocols (NTCIP). Higher data transmission rates can be achieved with conditioned communication lines. It has a transmission range of approximately eight to 15 miles with repeaters. The higher the bandwidth desired, the closer the repeaters must be spaced; Ethernet over twisted pair cable can require repeaters spaced as close at 4000 feet to achieve maximum bandwidth as high as 40 Megabits per second.

System expansion depends on the number of spare pairs installed and the number of devices supported, and is therefore limited. Twisted wire pair technology requires less sophisticated communication equipment. Equipment costs of the copper wire is marginally lower when compared to FO cable, but is significantly higher than wireless solutions at locations where new conduit would be required. Twisted pair cable supports data, voice and slow scan video applications.

Regarding the installation cost, TWP SIC is typically slightly less expensive to install than other hardwire media such as fiber optic cable, with the majority of costs associated with installing new conduit.

Copper wire is subject to electromagnetic and radio frequency (RF) interference, and has limited bandwidth (very limited when compared to fiber optic cable). Also, existing installations of twisted pair cable rarely include spare pairs for future use and it is not generally recommended to splice existing TWP SIC due to degradation in transmission quality.

Currently, the City of Des Moines utilizes copper twisted pair cable (TWP) for signal interconnect at few signals. The SIC consists of 12-pair, 25-pair, and 50-pair copper cables. The majority of SIC installed is 12-pair cable and is installed within a dedicated SIC conduit and pull boxes network. The dedicated SIC conduit varies between two and three inches in diameter. All conduits are constructed of Polyvinyl chloride (PVC), a common type of material used for communications conduit. **It is recommended the City of Des Moines replace the TWP SIC with a single mode fiber. The single mode fiber cable installed should consist of 48 fibers at a minimum.** It is also recommended that the existing TWP SIC be removed when new fiber optic cable is being installed; this will free up capacity in the existing conduit and allow the existing TWP SIC to serve as pull wire as a cost saving measure.

Fiber Optic Cable

There are two major types of fiber optics cable – Single mode and Multimode. Multimode is best suited for short-range applications such as cabling inside office buildings and is typically built without heavy Kevlar bending rods. Single mode fiber is best suited for long-range and outdoor applications and is recognized by the Telecommunication Industry Association (TIA) and the Electronic Industries Association (EIA) for backbone cabling. The single mode fiber optic system provides a higher capacity with approximately the same costs as a multimode system. Unless noted otherwise, discussions on fiber optic cable in this ITS Master Plan are referring to single mode fiber optic cable only.

Whereas TWP cable has historically been the communications media for transportation, fiber optic cable is now the desired form of communications for transportation and ITS – it is the standard for hardwire communications due to the benefits detailed below.

- Fiber optic cable utilizes pulses of light sent through a long thin glass tube.
- This technology can accommodate very large amounts of data and/or video at very high speeds with lower error rates.
- Fiber optic cable has more flexibility to increase data transmission rates than twisted pair but requires special equipment and trained maintenance staff to install, splice, and terminate the fiber.

Fiber optic cable is immune to electromagnetic interference, or other noise, but is susceptible to attenuation. Fiber optic repeaters / amplifiers are used to regenerate the data signal at regular intervals, typically when the signal exceeds 20 to 30 miles. Currently, Ethernet hardware for traffic and ITS, which must meet National Electrical Manufacturers Association (NEMA) standards for installation in outdoor environments (hardened), has data capacities in excess of 1 Gigabit per second (Gbps). Non-hardened hardware for indoor, environmentally controlled environments can achieve 10 Gbps. Fiber optics can support data, voice, and full motion video applications.

The fiber optic network will be based on a hub and spoke topology, where communications to all signals is distributed from various "hubs" located throughout the City (either in field cabinets or inside various City facilities. These hubs are then connected together by a fiber ring, which will provide a redundant, self-healing Gigabit Ethernet backbone network.

Currently, both Single mode and Multimode fiber optic cables are being utilized at and between many of the signalized intersections. The City owns all Multimode fiber cables in use, solely owns many low count (i.e. 2-6 fibers) Single mode branch cables between signal installations, and has access to significant segments of Single mode cables as part of the MetroNet system. Any 36 or larger count Single mode fiber cable that has shared usage by at least two members of MetroNet (i.e. the City or other partner public entity) result in each member automatically being allocated 12 of the 36 fibers for their use. Fiber cables installed with counts larger than 36 fibers follow the same allocation for the first 36 fibers but the remaining fibers of the cable are owned and allocated for use by the installing member of MetroNet.

Fiber is currently available at 308 intersections, and the City connects signal controllers to the fiber network in the following ways: 1) direct fiber connection, 2) fiber modem (media converter), and 3) Ethernet switch.

It is recommended the City of Des Moines replace the Multimode fiber with Single mode fiber as it would provide higher communication speed. The single mode fiber cable installed should consist of 48 fibers at a minimum. It is also recommended that the existing Multimode fiber be removed when new Single mode fiber optic cable is being installed; this will free up capacity in the existing conduit and allow the existing Multimode fiber to serve as pull wire as a cost saving measure.

6.2.2 Wireless Communications Alternatives

The City of Des Moines utilizes IP based point-to-point broad band radios for link connections between traffic signals.

Where the installation of hardwire communications is cost prohibitive or right-of-way is an issue, a viable alternative is wireless communications. Wireless communications do not require the installation of conduit or cable infrastructure, but does typically rely on a clear line of sight between installations; especially when a fixed point-to-point application is employed. However, the line of sight requirements for new radios are much less stringent than in older radios; trees and other obstructions that prevented the use of radios just a few years ago are likely to not be an issue with current technology.

Fixed point-to-point applications are the most common use of wireless communication systems for traffic signal systems. Spread spectrum radio and microwave communication are two common types of fixed point-to-point applications that are discussed below. However, Wi-Fi and WiMax are quickly becoming viable solutions for providing reliable, cost effective communications for ITS applications. These and other common wireless communication applications are discussed below.

Microwave Communication

Microwave technology transmits data and video via radio waves and is a fixed point-to-point wireless technology. It is mostly used when a hardwire link is expensive or not available, such as installing fiber optic cable in new conduit. It requires a very clean direct line of sight between the two points being connected. At the low end of the scale of price and complexity, an unlicensed 2.4 GHz microwave link consisting of a pair of relatively small microwave dishes (approximately the size of a single traffic signal head section) facing each other would emulate a twisted pair copper cable connection, and would be used as a connection between two adjacent traffic signals, generally less than a distance of two miles. Bandwidth of several hundred Mbps can be achieved. Each additional intersection added to that initial link would also require a pair of microwave dishes. The microwave controller in the signal controller cabinet can manage two dishes, that being two dishes at that one intersection, each pointing toward a dish at the adjacent intersection. Unlicensed microwave can also be used at several other frequencies.

Microwave is also a medium that can be used for very high speed communications. In order to gain long-distance line of sight, the antenna would need to be a good distance higher than a normal traffic signal pole. This could be a solution for data links needing large data throughputs, such as live video and aggregated data streams from a proposed data communications backbone hub location.

Microwave can also be licensed; licensed microwave requires the end user to acquire a Federal Communications Commission (FCC) license. Licensed microwave ensures that another wireless system will not interfere with the communication link, and bandwidths up to 1 Gbps can be achieved.

Deployment of microwave communication, a fixed point-to-point wireless technology is not envisioned for traffic operations at this time.

Spread Spectrum Radio

Spread spectrum technology also relies on radio wave propagation for data and video transmission and is a fixed point-to-point wireless technology. The main difference between the spread spectrum radio and microwave is that spread spectrum radio only operates in the unlicensed 900MHz, 2.4GHz, and 5.7 GHz frequencies. Like microwave technology, spread spectrum radio also requires a clean line-of-sight, but again, line of sight is not as much of an issue with current radios. Other disadvantages include risks that the unlicensed radio spectrum bands allocated to the spread spectrum radio will become overcrowded, causing interruption to service in the future. However, spread spectrum radio has been successfully used in the transportation industry in lieu of installing twisted pair cable or fiber optic cable. Spread spectrum is a good alternative to provide communications to remote signalized intersections, or "last mile" intersections, located such that installing cable and conduit is cost prohibitive.

Newer spread spectrum Ethernet radios should be considered as part of the traffic signal system to provide communications to remote signalized intersections, or "last mile" intersections, located such that installing cable and conduit is cost prohibitive.

Wi-Fi Communications

Wi-Fi is the technology of wireless local area networks (WLAN) based on the IEEE 802.11 specifications. A person with a Wi-Fi device, such as a computer, telephone or PDA, and the proper security access, can connect to the Internet when in proximity of an access point. The region covered by one or several access points is called a hotspot. Hotspots can range from a single room to many mile squares of overlapping hotspots.

A typical Wi-Fi setup contains one or more Access Points (APs) and one or more clients. An AP broadcasts its SSID (Service Set Identifier, "Network Name") via packets that are called beacons, which are broadcast every 100 ms. The beacons are transmitted at 1 Megabits per second (Mbps), and are of relatively short duration and therefore do not have a significant influence on performance. Based on the settings, the client may decide whether to connect to an AP. Also the firmware running on the Client Wi-Fi card is of influence. Since Wi-Fi transmits in the air, it has the same properties as a non-switched Ethernet network.

Wi-Fi can support communications that utilizes the 4.9 GHz Public Safety frequency. The FCC-approved 4.9 GHz license gives an agency the right to use the entire 4940-4990 MHz frequency band, and is a licensed frequency that can only be used by public agencies. This is important because the widespread use 802.11 in home and business could pose interference problems. Also, unlike other applications, the use of Wi-Fi in transportation has been in a point-to-point or point-to-multipoint arrangement rather than access point functionalities. The system can support Ethernet communications to ITS field devices including traffic signal controllers, CCTV cameras, DMS, freeway sensors, etc., and could fill gaps in the fiber optic communications.

Deployment of Wi-Fi technology, in the form of broadband radios, which is a possible alternative to close existing communication gaps along 'last mile' segments is not envisioned for traffic operation at this time.

WiMax

The WiMax standard is a variant of Wi-Fi that provides high-speed broadband access via a wireless connection over a longer range than Wi-Fi. Because it can be used over long distances, it is an effective 'last mile' solution for delivering broadband level connections to remote places.

Based on the IEEE 802.16 Air Interface Standard, WiMax can provide a point-to-multipoint architecture, making it an ideal method to deliver broadband level communication to ITS locations where wired connections would be difficult or costly. Since a WiMax connection can also be bridged or routed to a standard wired or wireless Local Area Network (LAN) this solution is ideal for 'last mile' applications that connect to wire networks. Although it is a wireless technology, unlike other wireless technologies (spread spectrum), it does not require a direct line of sight between the source and endpoint, and it has a service range of up to 50 kilometers. It provides a shared data rate up to 70Mbps, which is enough to service most ITS applications on most corridors. WiMax also offers some advantages over Wi-Fi and other similar wireless technologies, in that it offers greater range and is more bandwidth-efficient.

WiMax performs best when the hardware is installed on towers, similar to a cell phone tower, to support a Base Station Unit (BSU) which is connected to the Internet or dedicated network using a standard wired (fiber optic) high-speed connections. A Subscriber Station Unit (SSU) acts as the interface point for network edge devices. However, for local agency deployments of WiMax network, existing poles at signalized intersections can be used.

Deployment of WiMax to deliver broadband level communication to ITS locations is not envisioned for traffic operations at this time.

Mesh Network

Mesh Network is another type of wireless technology and follows a unique ad-hoc, peer-to-peer, Mesh Enabled Architecture (MEA™) wireless communication network system that typically operates in the unlicensed 2.4 MHz spectrum with current hardware adding multiple radios to expand the frequency options such as 4.9 Ghz and 5.9 Ghz radios. Mesh Networks operate at slightly higher radio power output and utilize some "reserved" frequencies that are restricted from use by other spread spectrum radio systems. For these reasons, MEA™ systems have the ability to communicate effectively even in areas where other 2.4 GHz spread spectrum systems might experience interference and contention. Mesh radio deployments have been implemented for citywide deployments where multiple departments share these resources such as Transportation, Police, Fire and even public internet access "Hot Spots".

Mesh networks are typically deployed as an alternative to fiber communications as it provides coverage for a large geographic area. **Thus, deploying a mesh network communication is not envisioned for traffic operations at this time.**

6.2.3 Communication Protocol

As one of the project goals is to deploy a high-bandwidth, reliable and sustainable communications network, **it is recommended that the new communications system be internet protocol (IP) based.** IP-based communication allows multiple devices to transmit traffic data on the same communication path, i.e. two strands of fiber or one pair of TWP SIC. The alternative would be analog based communications which require a dedicated communication path for each device. The IP-based communication system will provide the City with the type of system that meets their goals and allows for a means to support city-wide communication and future growth as the City installs additional signal system equipment.

The supporting communication medium can be fiber optic cable, twisted pair copper, spread spectrum radio, microwave or cellular (Wi-Fi). Of these, fiber optic cable is the preferred type as it provides the greatest bandwidth potential. The infrastructure solutions listed below assume that the future communication system will be IP-based.

6.2.4 Communication Infrastructure

To serve the City of Des Moines need for a high-bandwidth communication network that supports two-way communications with all City signals, replacing the existing communication network and filling in communication gaps with an IP-based hardwire or wireless solution is recommended.

To enhance the existing communications infrastructure with minimal costs, and provide increased bandwidth for the proposed and future ITS elements, **it is recommended that fiber optic cable replace the existing network of twisted pair copper cable.** It is envisioned that the removal of the existing twisted pair cable will free up sufficient capacity in the existing conduit and that the amount of new conduit required would be minimized. The installation of fiber optic cable may require the upgrade of select pull boxes and conduit segments.

The most optimal and more costly solution for existing wireless communication needs is replacing these links with fiber optic cable. This would also require the installation or replacement of some pull boxes as well as the installation of new conduit. A less costly alternative is to replace any unreliable wireless equipment with IP-based wireless equipment. This would provide the City with IP-based communication and be less costly than installing new conduit. If multiple devices requiring high-bandwidth (typically CCTV cameras transmitting video data) are installed along some existing wireless communication segments, it is recommended that fiber optic cable be deployed in lieu of wireless equipment. Though wireless equipment can also transmit streaming video images without issue, when multiple streams of video are expected on a communication path, the preferred and more reliable solution is fiber optic cable.

Installing new IP-based communications where communication gaps currently exists is recommended for meeting the City-wide goal of two way communications. As discussed above, depending on the type of devices installed at these locations, the recommended medium is either FO cable in new conduit with new or upgraded pull boxes or IP-based wireless equipment.

Auxiliary equipment is also necessary to support the future communication system. **It is recommended that FAST (or Layer 2) Ethernet switches are installed at each intersection to facilitate the IP-based communication. In addition, it is recommended that strategically located "communication hubs" are included throughout the City providing higher bandwidth backbone rings. It is recommended that gigabit (Layer 2 or Layer 3) Ethernet aggregation switches are installed at each Hub.**

Depending on the infrastructure chosen for the communication system, additional equipment may be necessary. For example, if TWP SIC is retained, it is recommended that a very high bit rate Digital Subscriber Line (VDSL) equipment is installed at these intersections. The VDSL equipment converts the data from serial to IP. The locations served by TWP SIC will still require a FAST switch. Depending on the hardware vendor, the VDSL unit can be integrated into the FAST switch or stand-alone that connects to a FAST switch.

Fiber Backbone Network

The conceptual communication network consists of a number of counter rotating fiber optic rings supported by communication hubs. Concentrated and multiplexed data is transmitted on a high-speed, high capacity transmission system between each hub and the TOC, while video and data is transmitted from each field element to the closest hub. A hub, therefore, serves as a point of connection between high speed, high capacity trunk lines and field element distribution lines. Deployment of this backbone and distribution cable will be located along the same routing to support both the formation of the communication loop and distribution to the field elements. The backbone cable will fully form communication "loops" or rings within the City, providing a redundant communication path. The formation of a redundant loop provides a backup communication link in case the fiber is accidentally cut or damaged. If damage does occur, the flow of data is able to reverse direction and still reach the intended source. All information destined to the TOC will need to flow along the loop, thus it will be sized according to the future bandwidth needs.

This architecture assumes three different cables as shown in **Figure 18**, each with a specific function. The backbone cable provides the communication link between hubs, and supports the transmission of high-speed, multiplexed data. The backbone cable also provides connections between traffic-related facilities and the TOC. The distribution cable provides the communication link between each hub and the associated field elements supported by each hub. The distribution cable is spliced at each vault adjacent to the field elements. Lastly, drop cables run from these splice vaults to a splice tray within the field cabinet and connects the distribution cable to the field elements.

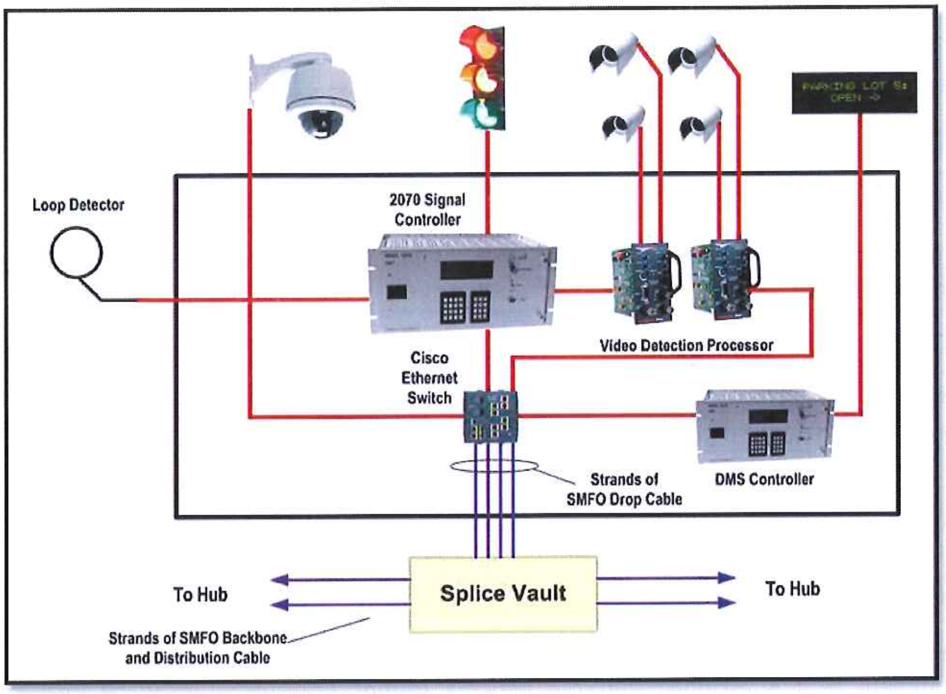


Figure 18 – Illustration of Distribution and Drop Cables

All cables are assumed to be single mode fiber optic cable. Transmission is assumed to use a 1310nm wavelength light/laser. Typically single-mode fiber optic cable can transmit data up to 20 miles in length which can vary based on the laser specified at each communication device.

Communication Hubs and Equipment

The communications network will be supported by communication hubs at select locations. It is recommended that the hubs be housed in either suitable typical controller cabinets or secured City-owned facilities. Hubs can also be housed in an underground vault, but this type of installation is not recommended due to restricted access to communications equipment.

Backbone fiber optic cables are brought into the hubs and terminated without any cable splices between hubs. Sufficient drop and insert communications hardware are provided to serve all traffic signals within the hub area to support communications to the associated data field elements (traffic signal controllers, DMS, etc.) via the distribution cable(s).

Communication hubs can be rather costly depending on the requirements of the communication hardware. The number and location of communication hubs is based on the need to serve present numbers of field elements, and the future expansion of the communications network. Therefore the locations of the hubs will be determined by the following factors:

- Present routing of the City's existing conduits

- Transmission distance of backbone communications
- Proximity to field elements
- Ease of constructability
- Ease of access and maintainability
- Consideration of immediate and long-range network expansion
- Proximity to major facilities for potential future access

It is recommended that a redundant, self-healing Gigabit Ethernet backbone fiber optic network be constructed between the following six hub locations:

	Building Name	Address	Comm Availability
Hub 1:	Armory	602 Robert D Ray Dr	T&T Connected
Hub 2:	9th and Locust Parking Ramp	801 Locust St	T&T Connected
Hub 3:	Police Academy	433 E Army Post Rd	T&T Connected
Hub 4:	East Side Library	2559 Hubbell Ave	T&T Connected
Hub 5:	Municipal Service Center	1551 E Martin Luther King Jr Pkwy	T&T Connected
Hub 6:	Old Parks Admin	3226 University Ave	T&T Connected

Communication hubs are proposed to be located in City facilities which would not require the use of hardened equipment as it is assumed the core network routing equipment would be located in environmentally controlled areas. Seven of the proposed hub locations are currently connected to T&T single mode fiber and it should be a relatively straight forward process to create the required routed circuits for the traffic system control and management network between these locations. The last hub site that is not currently connected with existing T&T fiber but can be included into the core routed network with small conduit/fiber installation projects. The hub locations and proposed routing of the fiber optic backbone ring is identified in Chapter 6.0.

Distribution Network

The City's distribution network will consist of a fiber optic network that will transmit data and video signals between communication hubs and traffic signal controllers, other ITS devices, and various field elements.

The proposed field device fiber connection design uses a hub and spoke topology. The spokes will be fiber distribution cables connecting field elements using dedicated circuits and/or daisy chained connections. The proposed locations of the multimode (MM) fiber upgrades to Single Mode (SM) as it would provide higher communication speed per phase is identified in Chapter 7.0.

6.2.5 City Facilities Coordination

Opportunities to share costs of installing shared communications infrastructure should be explored with other City facilities or private stakeholders similar to MetroNet, ICN where the City is currently sharing a single mode fiber backbone network. As a cost saving measure, the design of the existing traffic communication upgrades should take into account infrastructure sharing of communications conduit or installation of multiple communications conduits for future City traffic or facility use. Though the traffic conduit will not necessarily provide the door-to-door infrastructure that City facilities will require, the communications conduit proposed along the City's major corridors can provide the backbone communication network that other City departments can build on.

6.3 Intelligent Transportation Systems (ITS) Devices

6.3.1 Closed Circuit Television (CCTV) Cameras

Closed circuit television (CCTV) cameras provide a way to remotely monitor the conditions of an intersection and if necessary, dispatch equipment and personnel to repair equipment failures or assist in coordinated incident management. The ability to view real-time conditions at an intersection from a TOC or individual workstation, provides the operator with the ability to troubleshoot certain conditions as they occur. The live images can be shared with other departments (fire or police) or with adjacent agencies to assist with regional traffic management.

The two most commonly used types of cameras for traffic video monitoring are cameras with pan/tilt/zoom (PTZ) capabilities or fixed view cameras. Both cameras serve different implementation needs and have strengths and weaknesses associated with each.

Pan/Tilt/Zoom (PTZ) Cameras

CCTV cameras with PTZ are recommended for installation at strategic locations along priority corridors, especially at priority intersections with high incident frequencies or operational challenges. PTZ control will allow system operators to focus in and see traffic movement, provide incident verification, and potentially record live scenes, either digitally on a TOC server or as recorded video, for planning studies. In areas where privacy concerns might be an issue, PTZ stops can be placed in such a way as to limit the viewing angles to the roadway.

Fixed View Cameras

Fixed-view cameras operate in a similar fashion to CCTV cameras as described above, albeit without PTZ capabilities. They are typically deployed in areas where the need to see adjacent areas is not needed. For example, a fixed-view camera can be focused at a parking garage entry/exit ramp or intersection approach. Although they can be used as roadway monitoring cameras, the use of fixed-view cameras is typically associated with security and/or video detection installations. In the case of vehicle detection, these cameras can have dual functionality for signal operations and limited video monitoring (as the camera installation is optimized for detection versus monitoring). One advantage of fixed-view video is that, where images are shared, the competition to set the position of the video "field-of-view" of the cameras is remedied. Typically, video detection system cameras provide the necessary view of traffic on all approaches and can satisfy the monitoring function as well as detection.

The City currently has 29 CCTV cameras with PTZ installed to monitor traffic from individual workstations. **It is envisioned that CCTV cameras with PTZ will be deployed across the city at strategic locations along priority corridors, especially at priority intersections with high incident frequencies or operational challenges. In addition to CCTV camera with PTZ, City of Des Moines should consider installing Fixed View Cameras at parking garage entry/exit ramp.** Proposed locations of CCTV cameras are further discussed in Chapter 7.0.

6.3.2 Traveler Information Systems

Advanced Traveler Information Systems (ATIS) provide transportation related information to the traveling public. The methods of providing this information range from agency-owned devices such as message signs and agency websites to commercial services such as radio reports or private websites. The information is typically distributed as pre-trip or en-route information. Pre-trip traveler information is meant to inform people prior to the beginning of their trips (either locally or regionally). This is usually done through the use of media outlets (local news, public access cable TV), kiosks, or the Internet. Once travelers have begun their journeys, information received en-route can be given through devices including roadside elements (e.g., DMS, telephone services such as 511, etc.) and through in-vehicle media services (e.g., radio, navigation systems). The ATIS strategies discussed below include message signs, 511 or dial-in traveler information systems, traffic websites, media services and information displays.

Dynamic Message Signs and Trailblazers

Dynamic Message Signs (DMS), also known as variable (VMS) or changeable (CMS) message signs, display user-defined messages to the public. They are typically used to provide motorists with real-time traffic information, travel time information and detour advisories in advance of key decision points along freeways or primary arterials. Agencies can also use DMS to broadcast AMBER ALERTS, providing motorists with information regarding abducted children. The actual signs can be fixed or portable.

The fixed signs are sized based on the characteristics of the roadway, including the critical speeds of approaching vehicles, sight distance and message content. Communication to the fixed signs can be done through dial-up, TWP SIC, wireless/cellular, or FO from a central location, such as the TOC or individual workstations.

A typical arterial DMS is sized to be about four to six feet high and eight to ten feet long and are capable of displaying three rows of text. A typical DMS installation is shown in **Figure 19.** DMS are typically located mid-block between signalized intersections in advanced of key decision points, are sized such that they require dedicated poles, and require dedicated pole-mount or freestanding cabinets to house the controller and communications hardware. DMS typically require a dedicated service meter.

Portable signs can vary in size and include a generator (battery or diesel fuel) for power. They may also include solar panels to recharge batteries and a cellular modem to allow for changing of the pre-programmed messages from a remote location, such as the TOC or individual workstations.

Figure 19 –Dynamic Message Sign

Trailblazer Signs (TBS) are smaller versions of DMS that can display smaller, more limited messages to motorists such as event parking, restricted turning movements during special events or parking management. The advantages of TBS are that they can be mounted at the signalized intersection on traffic signal poles (depending on the size of the TBS) or smaller, less costly dedicated poles. Depending on the use of the TBS, the signs can be placed closer to the signalized intersection or parking structure, and can share the traffic signal controller cabinet for hardware and power. A typical TBS installation is shown in **Figure 20.**

Figure 20 – Trailblazer Sign

Prior to deciding to implement DMS, it is essential that an agency understand the maintenance costs associated with DMS prior to construction. **Table 8** summarizes typical maintenance activities and costs associated with each DMS sign. Note that cost items include mobilization which may result in a slight reduction in costs when multiple signs are deployed.

Table 8 – Maintenance Costs for Dynamic Message Signs

Schedule	Maintenance Activity	Assumptions	Annual Cost (approx.)	10 Year Cost (approx.)
Every 3 Months	Replace Air Filter	• 1 lane closure • 1 bucket truck at $100/hour • 2 people at $55/hour • 2 hours per sign (includes mobilization) • Clean Sign Face • Filter - $40	$1,840	$18,480
Every 12 Months	Routine Maintenance • Check UPS Battery • Check GFI (if applicable) • Check heat tapes (if applicable) • Check lights (if applicable) • Check floor drains (if applicable)			

Some DMS vendors offer what is called an automatic changing maintenance-free air filtration system, or automatic filtration system (AFS). Rather than having to replace an air filter every three months, the AFS includes an air filter on a roll that automatically advances to a new section of the air filter as needed. The result is that instead of replacing a filter every three months, the AFS provides a 10 to 15 year supply of air filters. Overall, this reduces the DMS maintenance from every three months to just one per year for routine maintenance. The result is an annual maintenance cost of approximately of $420 per year, or $4,200 over 10 years. Every 10 to 15 years, the AFS needs to be replaced at a cost of $2,500. Overall, the AFS can provide a savings in maintenance costs of $12,000 to $14,000 over a ten year period. The AFS adds about $5,000 to the cost of the DMS, which still results in a considerable savings over a ten year period.

The City of Des Moines currently operates eight DMS throughout the City. The DMS inform drivers of parking availability. **The City of Des Moines should consider deploying arterial DMS and TBS on certain routes for incident management, special events, congestion management, and travel time information.** TBS should be installed on primary diversion routes identified in the Iowa DOT's Incident Response Plan. Because these signs facilitate the diversion of freeway traffic on arterial streets, the City of Des Moines and DOT should coordinate the funding and installation cost.

511 Systems and Traffic Web Sites

In July 2000 the Federal Communications Commission (FCC) designated 511 nationally for use in disseminating traveler information. 511 is a three-digit-dial telephone number to access traveler information. The number itself is not a traveler information system, but provides access to a traveler information system. The FCC designation did not mandate that 511 be deployed, nor did it include funding for deployments. Deployment has been left to the states or regional and local agencies to make funding and deployment decisions.

The Federal Highway Administration (FHWA) has been successfully promoting 511 implementations at the state and regional level. The goal of the 511 effort is to provide a consistent traveler information service between states so that travelers have easy access to traveler information. Typically, the 511 service allows a caller to use voice-recognition technology or keypad entry to choose a route or area. The system then provides specific traveler information for the selection. 511 systems can be used to provide:

- Road-weather conditions
- Traffic information
- Transit information
- Other ridesharing information
- Tourism information
- Events and parking
- Driving directions
- Incident reporting
- Personalized traffic reporting
- Customer feedback

The Iowa 511 system is operated by Iowa Department of Transportation (DOT). It can be updated at a central location, such as a TOC or individual workstation. Systems vary in level of detail and method of operation, but are usually coupled with an Internet web site capable of providing the same information, often in greater detail. The 511 and Internet systems usually rely on the same transportation management databases to ensure consistency and timeliness of the information. These systems can achieve optimal performance when operated in coordination with other information dissemination strategies such as DMS and/or Highway Advisory Radio (HAR) systems.

Traffic websites, including those provided with the 511 service, provide traffic-related information through the internet. These websites are provided either through a public agency's webpage or a private company webpage (www.511IA.org). The information provided most frequently includes a color-coded speed map of the primary corridor freeway/arterial system, video feeds from CCTV cameras and links to other transportation services, such as local transit agencies. Specialized information may include average speeds, travel times and incident information.

The City and DOT should coordinate to integrate City cameras, dynamic message signs, and traffic data into the 511 system and other appropriate web sites.

Media Services

Media services refer to the use of television and radio to broadcast local traffic information to Des Moines and adjacent agency travelers. Third party broadcasters disseminate local traffic information provided by the City's systems to the general public. Options include using a public access television channel to broadcast live traffic information at peak traffic hours. This broadcast could be similar to the graphic map shown on internet websites with dynamic traffic conditions, including speeds and volumes, incidents and select CCTV camera images for the area. The signal format (NTSC) for this video feed will be one-way that does not pose a security risk to the local agency. **The City should evaluate methods for disseminating traffic information to various media outlets.**

Information Displays

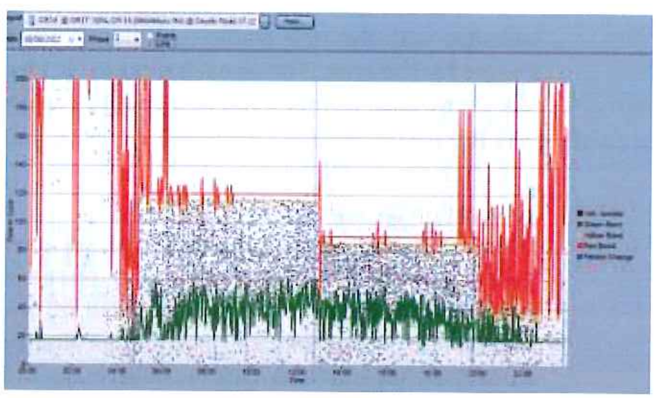
Information displays are a service typically provided through the use of public real-time information displays placed at strategic locations to provide travelers with a reliable source of pre-trip traffic and traveler information. For example, information displays could be deployed at modal transfer locations, civic facilities, major office buildings, etc., so that travelers can visually receive information regarding conditions on roadways in the region as well as freeways in the area. Information displays can take many different shapes. They can be as simple as small scrolling LED bar signs, large electronic boards containing several lines of text, large projection monitors which depict roadway congestion information, or kiosks. A kiosk could include a graphical user interface (GUI) that provides touch screen interaction by the user. Access to this data will allow travelers to make informed decisions with regard to travel route, time and mode prior to their departure. Kiosks quite frequently also provide links to other services and databases, such as transit schedules and "yellow page" type local business information.

Kiosks and other information displays should be considered for installation at the high activity areas such as the Downtown, State Fair, Iowa Events Center, and Principal Park.

6.3.3 Detection

The City currently uses the following types of detection systems: 1) inductive loops, 2) video detection, 3) microwave radar detection and 4) wireless sensors or pucks. These detection types generally apply to vehicle actuation, but some locations also include bicycle detection. Some intersections utilize a combination of the above detection types. The video detection equipment used are mix of Iteris' Vantage, Traficon, and ITS Plus. The City is currently phasing out their use of wireless pucks for vehicle detection. The majority of intersections outside of the downtown also provide push-button detection for pedestrian crossing with select intersections operating with Polara or Pelco Accessible Pedestrian Signals (APS). Regarding the type of vehicle detection currently used, the City may continue to use a variety of detection technologies as long as it meets the intended need. At locations with video detection, **it is recommended that the City add capability to enable remote viewing of the real-time video and data from individual workstations.** Also, with the increase in the use of bicycles both in mixed traffic and on exclusive bicycle facilities **it is recommended that the City implement bicycle detection along arterials and collector streets marked with bicycle lanes to detect and differentiate bicycles from other vehicles at traffic signals. The detection will provide a unique output to the controller to extend the green time of that phase and allow bicyclists more time to cross the intersection, providing them safety from cross traffic.** The City should also consider future operational strategies of traffic signals, such as traffic responsive and adaptive, when designing and installing detection at new intersections or rebuilding traffic signals.

6.3.4 Traffic Sensors



The City owns and operates permanent traffic sensors on major arterials that are capable of collecting data on speed, volume, occupancy, etc., while the Iowa DOT also has traffic sensors deployed on the freeway system in the City of Des Moines. Traffic sensor data could be used for a variety of applications, including: incident detection, congestion management, travel time information (via DMS, 511 systems, and websites), data collection, and signal performance measurement. **It is recommended that the City evaluate the upgrade of the existing traffic sensors as necessary and implement additional installation of**

sensors on corridors on a project-specific basis. The City should also consider the use of third party data (such as Inrix).

6.3.5 Signal Performance Measures (SPM)

The City does not own or operate automated traffic signal performance measures for real time monitoring and operations of traffic. Various signal performance metrics such as approach volumes, approach speeds, split monitor, approach delay, arrivals on red, travel time etc., are used to optimize mobility and manage traffic signal timing and maintenance to reduce congestion, save fuel costs and improve safety. **The City of Des Moines should consider deploying Signal Performance Measures (SPM) software to identify operational deficiencies, optimize mobility and help manage traffic signal timing and maintenance.**

6.3.6 Battery Backup Systems

The City currently has Battery Backup Systems (BBS) installed at 30 intersections. These locations currently use the Alpha Traffic BBS. The majority of these deployments consist of a supplemental "backpack" cabinet that is mounted to the main cabinet shell. **BBS are a valuable asset for intersections and City should determine locations that should be installed with BBS based on criteria's such as high traffic and pedestrian volumes, limited sight distance, crash statistics etc.** Alternative BBS systems that can reduce or eliminate the maintenance requirements and battery charging schedules should be explored.

6.3.7 Emergency Vehicle Preemption (EVP)

With rapid population growth, the increase in traffic and congestion often limits the mobility of emergency vehicles to safely maneuver through traffic, the traffic and congestion can reduce vehicle response times, to the detriment of the general public's safety. Emergency Vehicle Preemption (EVP) systems have been successfully deployed throughout many cities in the United States to assist emergency vehicles to safely pass through intersections and reduce their response times. By preempting a traffic signal cycle and triggering a green light in their direction, emergency vehicles reduce wait time and the risk of entering an intersection with conflicting cross traffic. Since collisions involving emergency vehicles trigger two additional service calls (one to the new collision and one to the location to which the original emergency vehicle was responding), EVP has a multiplicative benefit.

EVP systems are currently deployed at 15 signals in the City, however they are not operational. EVP systems are from various manufacturers and based on different technologies including infrared/strobe system (like GTT and TOMAR) as well as GPS/CAD based system. To reduce the response time and increase the mobility of emergency vehicles, **it is recommended that the City of Des Moines work with Fire Department (FD) to identify critical intersections and major routes for EVP expansion. In addition, the City of Des Moines should participate and create a standard procedures for EVP systems with various public safety agencies across the region.**

6.3.8 Transit Signal Priority (TSP)

Neither the City nor Des Moines Area Regional Transit Authority (DART) currently operate any TSP. TSP uses technology on the transit vehicle and in traffic signal controllers to improve transit operation with reduced trip times and delays caused by traffic signal operation. As buses approach a traffic signal, a signal is sent to the intersection controller requesting priority based on specific, user-defined requirements (e.g. the bus is behind schedule by more than a certain number of seconds, has passed a passenger load threshold, etc.). Within limits potentially set to coordinate with the actual traffic counts at an intersection, the green time for the transit vehicle approach can be shifted or extended.

TSP allows buses to be granted priority service at selected intersection. The long queues restricting the bus progress could be flushed through the signalized intersection(s). Buses would suffer fewer schedule disruptions due to traffic congestion at traffic signal controlled intersections, and the reliability (and customer satisfaction) of service would improve.

TSP provided to small fleets and select intersections can be deployed at a relatively low cost. A number of equipment strategies can be used. They include: Opticom (strobe-light based) installations such as those already used for emergency vehicles in the City; Dedicated Short Range Communications (DSRC) based transponders; and wireless radio frequency (RF) transmitters communicating with receivers at the controller cabinet.

Some relatively minor traffic signalization infrastructure changes may be required. These may include the addition of left- or right-turn signals at some intersections. Alterations in the "normal" signal operation can be identified for the signalized intersections within the corridor on an intersection-by-intersection basis. Priority is distinct from pre-emption in that a priority call can be accommodated without disrupting coordination; however, in order to provide the necessary slack time in the cycle, a longer cycle length must be used than may otherwise have been provided, which has the effect of slightly increasing delay to other users.

Bus service in City of Des Moines is provided by DART. Several potential corridors (Ingersoll, University, SW 9th, and Hubbell) have been identified by DART for TSP implementation but have not yet been deployed. **To improve transit operation and reduce trip times and delays caused by traffic signal operation, it is recommended that the City of Des Moines procure controllers that provide TSP capability. In addition, the City of Des Moines should coordinate with DART to facilitate funding and implementation of TSP projects.**

6.3.9 Road Weather Information Systems (RWIS)

RWIS provides agencies a way to monitor and receive real-time weather conditions from their central traffic control system. The City Public Works Department is currently testing out a few Road Weather Information System (RWIS) deployments. Future deployment of RWIS will be based on the test deployment.

6.3.10 Parking Management Systems

The City of Des Moines actively manages parking garages using parking garage gate software. Also, the City operates DMS through QuicNet system for disseminating parking wayfinding and parking availability and other parking related information to travelers. QuicNet ATMS selects messages for these DMS based on the data from garage gate software translated by a middle software to QuicNet compatible data. The City will be procuring a new parking lot management system SKIDATA to manage all parking garages and provide better traffic flow. For an interim period, there could be two parking garage software systems operating in different parking garages before SKIDATA will be procured for all garages. Since, the City of Des Moines actively manages parking garages using parking garage gate software, **it is recommended that the City explore features of the new parking lot management system SKIDATA to ensure that it can integrate with the proposed ATMS software or vice versa. The integration will help eliminate the use of middle software to translate data from parking garage gate software to ATMS and increase overall efficiency**

6.4 Transportation System Management

6.4.1 Traffic Operations Center

The key function of the Traffic Operation Center (TOC) is to provide traffic management staff with the capability to interface with the traffic control equipment / system and to monitor traffic information from a central location. The TOC can vary in complexity, with something as simple as a single desktop computer with the management software connected to field controllers to an elaborate room with large video monitors for viewing CCTV images, workstation displays with space dedicated for communication and other traffic related equipment. Ideally, the TOC size is dependent on the number of signalized intersections and other field devices deployed that are to be managed from the TOC by one or more operators; the more signals and field devices to monitor and operate, the larger the TOC and number of TOC operators. Practically, TOC size is often determined by the agency's budget for the TOC and size of the area to house the TOC.

The TOC typically serves as the critical communication hub between the field elements and the Engineer. The TOC will have equipment installed that provides the ability to control signalized intersections, CCTV cameras, Dynamic Message Signs (DMS), and other field devices. The TOC system equipment can also monitor priority requests at signals, if transit priority and/or emergency vehicle operation are deployed. In addition, the TOC can serve as the central location to share data with other agency departments (Police) and partner agencies to share information across jurisdictional boundaries in anticipation of incidents affecting mobility in the region. For example, signal operation access, and CCTV camera video and control, can be set such that viewing and/or modification (PTZ) can be done by one or multiple agencies, or by one or multiple departments within an agency.

The City of Des Moines currently does not have a Traffic Operations Center (TOC). There is a conference room in City Hall that has a desktop computer and two 40" flat screen TV connected to the computer which can be used as TOC. Computers at these locations have QuicNet and Chameleon software to access the signal system and use the observation cameras. However, the computers provide limited ability to monitor traffic conditions and make necessary adjustments to the signal operations to provide the most efficient operation during emergency conditions. In addition, due to limited staff and resources operations are not monitored on a regularly scheduled basis. The Traffic and Transportation Division staff laptops/computers also have QuicNet and Chameleon software. The City is currently planning on utilizing individual workstations (computers with signal system access) as opposed to a dedicated TOC with enhanced screens in the Principal Traffic Engineer's office, the Signal Technician Chief's office, and the Public Works conference room for monitoring operations.

6.4.2 Staff

All staff that conducts work related to the ITS are a part of the Traffic and Transportation (T&T) Division, which is located within the Engineering Department. Other divisions within the Engineering Department include Design and Construction, Real Estate and Bids and Contracts. In addition to the T&T staff, the Network IT group is also heavily involved with the work related to the ITS.

The Traffic and Transportation Division has engineering, maintenance, technician, and administrative staff that are responsible for traffic signals, traffic signs, traffic studies, street lighting, ROW management, street pavement marking, parking and skywalk operations and maintenance.

Engineering staff are located at 400 Robert D Ray Drive, while maintenance staff is located at the Signal Shop at 2000 SE Scott Avenue. Currently, there are five engineering staff including a City Traffic Engineer, two Principal Traffic Engineers, and two Traffic Engineers. One Principal Engineer and one Traffic Engineer are dedicated to signal design and studies. The staff are responsible for numerous traffic engineering tasks, but there are no staff dedicated to traffic operations and ITS.

In addition to engineering staff, there is one Signal System Chief and five Signal Technicians at the Traffic Signal Shop. The City has four Device Maintenance Workers for the traffic meter shop, one Traffic Maintenance Chief, and five Device Maintenance Workers for the traffic sign/paint shop. There is a Traffic Control Supervisor that oversees the activities of the Device Maintenance Workers and Signal Technicians. The City is divided into two zones for signal maintenance purposes. Two technicians are assigned in each zone. The City has purchased another bucket truck and plans to create another zone in the downtown area with one technician assigned to it.

The **ITE Traffic Engineering Handbook and Traffic Control System Operations: Installation, Management and Maintenance Manual** estimates, as a rule of thumb, that one traffic engineer is needed to properly operate and maintain every 75 to 100 signals and one technician to operate and maintain every 40 to 50 signals. **While certain elements of the signal system will improve staff efficiency, several new maintenance technicians will be required to properly maintain the communications network and additional ITS devices (depending on the number of cameras, signs, sensors, etc.) deployed in the field, while at least one TOC operator will be required to monitor the traffic signal system and related devices, which can be done on an individual workstation.**

Using these same rules of thumb for the operation and maintenance of existing traffic signal system (no-build scenario), **the City should have an existing staff of four to six Traffic Engineers and nine to eleven Signal Technicians.** Currently, staff includes five Traffic Engineers and five Signal Technicians.

The signal system through the workstations at the City may not be monitored on a 24-hour basis. Consideration should be given to establishing an agreement with DOT staff or hiring a consultant to monitor City streets while City staff is not on duty. **It is recommended that the minimum hours for which the signal system will be monitored are 6:00 to 9:00 AM and 3:00 to 6:00 PM, Monday through Friday.** Beyond that, the signal system is monitored only when specific events or situations warrant, such as special events, incidents, or weather events. In some cases, the signal system monitor can be comprised of existing staff whose duties are augmented to include signal system operations, or it may require new staff to support the additional job duties. Functions of the system for which operations staff will be responsible include:

- Traffic signals and traffic control;
- Traffic and system monitoring;
- Special event management;
- Coordination and collaboration with other agencies;
- Information gathering and dissemination; and
- Incident management.

Maintenance staffing will be critical to ensure that the City's traffic signal system is functioning properly. **It is assumed that general traffic signal maintenance will continue to be performed by the existing and recommended Signal Technicians.**

6.4.3 Traffic Signal Timing

To supplement the proposed communication and traffic signal system management improvements, efficient traffic operation can provide motorists with decreased travel times, enhanced safety, and lower emissions. This category covers both the peak hour timings (typically associated with coordinated operation) and non-peak hour timings. The needs identified for this category include:

- Periodically evaluate and optimized time-based coordination plans on major corridors
- Re-evaluate existing timing settings to ensure their adherence to the latest City and MUTCD timing standards
- Explore use of more advanced adaptive or traffic responsive operation

Basic Timing and Phasing Settings
Basic timing settings, such as minimum green, yellow-change, all-red clearance, pedestrian walk and clearance intervals that operate during free or coordinated operation are very important for the safe operation of an intersection and may result in significant liability if they do not meet minimum standards. As such, **it is recommended that the City re-evaluate existing timing settings to ensure that they adhere to the latest MUTCD guidelines, where available.**

Coordinated Operation
It is generally recommended to optimize traffic signal coordination plans, at a minimum, every three to five years based on typical traffic volume and pattern fluctuations. If traffic volumes do not change significantly along a corridor year after year, the optimization activities can be put on-hold for a longer period of time then the recommended time period. Likewise, where traffic volumes are constantly changing, optimization should be conducted more frequently.

To maintain optimal coordination timings during peak traffic volume hours the City should, at regular intervals, evaluate traffic volumes at key intersections and ADT data along coordinated corridors to determine the need for optimization.

The City is currently about to begin the first phase of a multi-phase effort to review and update the signal timing and phasing of the traffic signal systems in Des Moines. The goal of the project is to increase efficiency of the traffic signal systems resulting in decreased travel times, reductions in traffic congestion, and ultimately the reduction of vehicle emissions. The project will also consider signal timing and phasing for pedestrian and bicycle traffic in support of the City's efforts to provide a more walkable and bikeable transportation network. As part of Phase 1 of the project, 84 signalized intersections along the following major corridors in Des Moines are included:

- Fleur Drive – Army Post Road to Martin Luther King Jr Parkway
- Martin Luther King Jr Parkway – Fleur Drive to East 15th Street
- Army Post Road – HWY 28 to East 14th Street
- SW 9th Avenue – Army Post Road to Bell Avenue
- Indianola Avenue – Easter Lake Drive to Indianola Road
- East 14th Street – Army Post Road to Martin Luther King Jr Parkway

Other Timing Solutions

In addition to coordination timings, **the City should determine the feasibility and/or benefits of installing an adaptive or responsive system on corridors with fluctuating and unpredictable traffic volumes.** Though upfront costs of installing an adaptive system may be high and additional staff would likely be needed for heightened maintenance, the long-term benefits may outweigh the overall costs to install and maintain. **The City should also consider using signal performance measures system when installed to identify operational deficiencies, optimize mobility and help manage traffic signal timing and maintenance.**

6.4.4 Incident Management

Incident management includes various activities that help mitigate non-recurring congestion, such as rapid detection and response to accidents and stalled vehicles, provision of congestion-related information to drivers, management of construction and maintenance activities, and management of traffic for special events. There is no formal incident management program for arterial streets in the City of Des Moines. **It is recommended that the City of Des Moines work closely with the neighboring agencies to maintain signal system compatibility and provide better coordination for regional incident management.**

6.4.5 Congestion Management

Like incident management, there is no formal day-to-day congestion management program on arterial streets conducted by the City of Des Moines. The City does have special timing plans in place for special events, which include the State Fair and during soccer season at the soccer complex located at E 14th and Hartford, to facilitate egress upon conclusion of events at those facilities. In most cases, the Des Moines Police Department and the Polk County Sheriff's Department manually operates traffic signals by placing officers next to traffic signal cabinets. **Timing plans should be developed, implemented, monitored, and revised as necessary to accommodate special event traffic around these facilities.**

6.4.6 Traffic Signal Preventive Maintenance

The City does have a traffic signal preventive maintenance program, which was started recently. Some City departments have asset management systems, but, currently the T&T Division does not have any system for managing signal and other ITS assets. The City has a "Heat" ticket system, which is basically a complaint system, but it is used for a maintenance work order management system. Spare parts are maintained and tracked in total, but not on per zone basis. The City also has an agreement with the Iowa DOT for providing maintenance and repair of primary road in municipalities and emergency maintenance of State of Iowa owned traffic signals.

To help manage its traffic signal infrastructure and maintenance operations, **the City should implement an asset management system. In addition, the City of Des Moines should also implement a work management system, which cooperates with the department's asset management practices. This will help the department to build a history of each asset and view an overall picture of the current state of City's infrastructure.**

6.5 Systems Integration

System integration is perhaps the most important component of any ITS deployment. System integration brings the "pieces of the puzzle" together to form a composite picture of the current conditions, and disseminates that information to the proper recipient. Without it, both the system manager and users will typically only receive a portion of the intended and desired system-wide benefits. There are two separate levels of integration; system and regional. Although system integration is an important element of the overall system, it is the one piece which the motoring public cannot see since it focuses on ensuring the individual elements complement and support the others' functionality.

6.5.1 System Level Integration

System level integration includes taking data prepared by one element or subsystem, and converting that data into information through methods such as data smoothing, synthesizing, etc. Once this process is complete, the information is then transferred to another subsystem for use, such as broadcasting it to the public through either pre-trip or en-route traveler information methods. The process of successfully and automatically moving the data/information from one subsystem to another is commonly referred to as system integration. For this to occur, the data must be prepared using a methodology understood by another subsystem with little or no errors within the process. For the City of Des Moines, examples of system-level integration include the following:

- The deployment of an ATMS that is envisioned to support traffic signal controllers and other ITS devices.
- The deployment of new communication throughout the City to connect field equipment to various City facilities.

6.5.2 Regional Level Integration

This type of integration is similar to system level integration, although on a much larger scale and sometimes with reduced detail. With partnering agency communication and coordination, data sharing between agencies can become a reality. One element of regional integration can be seen through data sharing of the City traffic information with DOT and neighboring agencies such as Cities of Urbandale, Pleasant Hills, Windsor Heights, and West Des Moines. The City of Des Moines or the Iowa DOT can implement an interface to a regional data center for the exchange of traffic data (congestion, incidents, CCTV surveillance video). The City could also provide roadway congestion information to the regional data center for area-wide dissemination. The City could become part of a much larger system giving the ability to disseminate their information to a much broader audience. Conversely, the City will be able to obtain data from other agencies. For the City of Des Moines, examples of regional-level integration include the following:

- Sharing of information with other City departments, DOT and other surrounding municipalities, and the public.
- Sharing communications with other City departments such as Police and Fire Departments.
- Developing coordinated signal timing plans with adjacent jurisdictions.

7 CONCEPT DESIGN AND COST ESTIMATE

Based on the recommended improvement strategies identified in Chapter 6.0, **Figure 21** illustrates the proposed ITS at a high level, identifying major components, facilities, and communications. Additional design details, cost information by system component, and cost estimate for all elements will be summarized in the following pages. Chapter 7.0 will summarize the proposed deployment strategy.

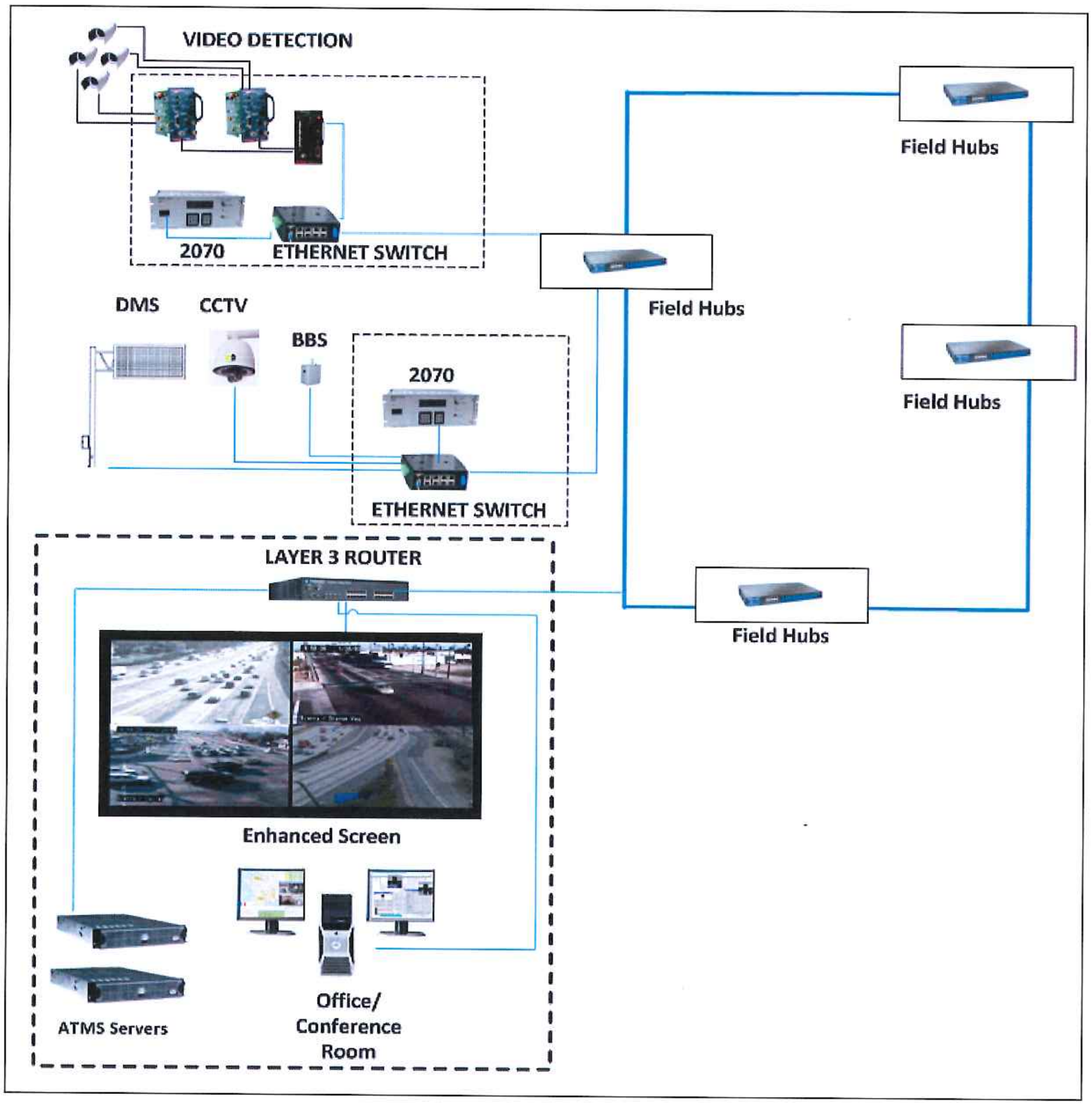


Figure 21 – ITS High-Level Network Diagram

7.1 Traffic Signal Controllers

Traffic signal controllers will be upgraded to type 2070 ATC controller. In total, 425 controllers (389 traffic signal and 36 pedestrian signal controllers) will be upgraded. **Figure 22** illustrates a 2070 ATC controller in Type 332 cabinet.

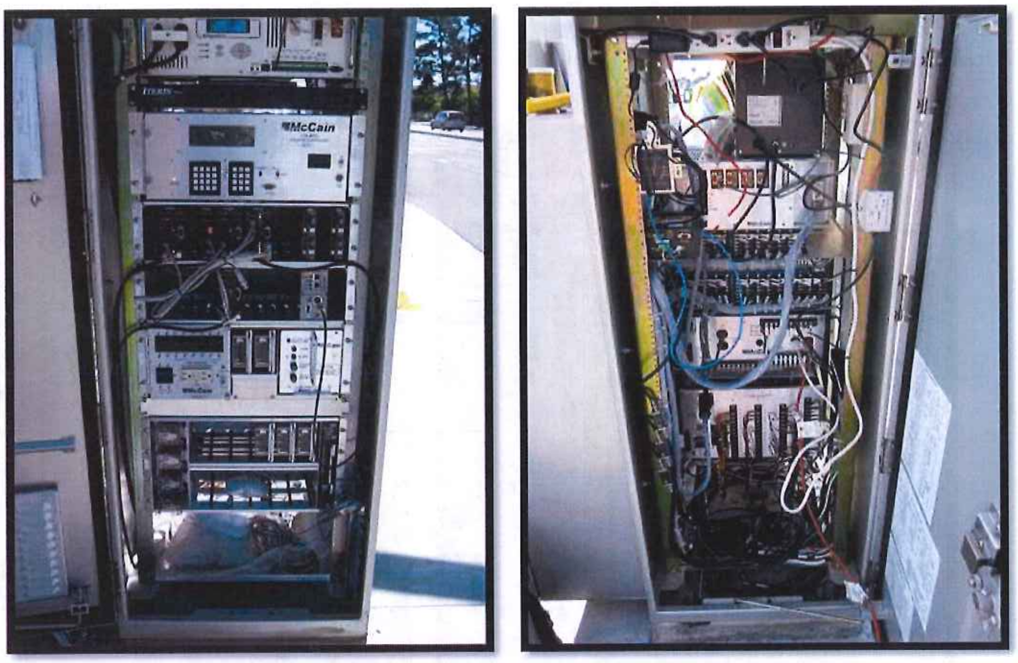


Figure 22 – Sample 2070 ATC Controller in Type 332 Cabinet

7.2 Backbone Fiber Network and Hubs

A primary need of the traffic signal system is a high-bandwidth, redundant communications network to support the transmission of video and data. It is recommended that a Gigabit Ethernet communications network be deployed to support the transportation system. Deploying a Gigabit Ethernet communications network will require implementing communication hubs at select locations. The communication hubs will serve as aggregation switches to provide Ethernet-based communications (100 Mb) to signalized intersections and field elements, with a grouping of signalized intersections supported by each communication hub. The communication ring and hubs will also provide a redundant, self-healing Gigabit Ethernet backbone network. Since the network is intended to serve as a Citywide network, some of the communication hubs will be located within City facilities. At other locations, it is necessary to implement field hubs whereby dedicated controller cabinets are installed. Ethernet based communications between the signalized intersections will occur at the following communication hubs:

	Building Name	Address	Comm Availability
Hub 1:	Armory	602 Robert D Ray Dr	T&T Connected

Hub 2:	9th and Locust Parking Ramp	801 Locust St	T&T Connected
Hub 3:	Police Academy	433 E Army Post Rd	T&T Connected
Hub 4:	East Side Library	2559 Hubbell Ave	T&T Connected
Hub 5:	Municipal Service Center	1551 E Martin Luther King Jr Pkwy	T&T Connected
Hub 6:	Old Parks Admin	3226 University Ave	T&T Connected

A photograph of a hub cabinet is shown in **Figure 23**. At each of the hubs listed above, a high-bandwidth communication ring will be implemented between hubs to support a specific backbone communication ring. **Figure 24** provides an illustration of the proposed Gigabit Ethernet backbone and distribution routing. Backbone and distribution fiber will terminate at each of the hubs.

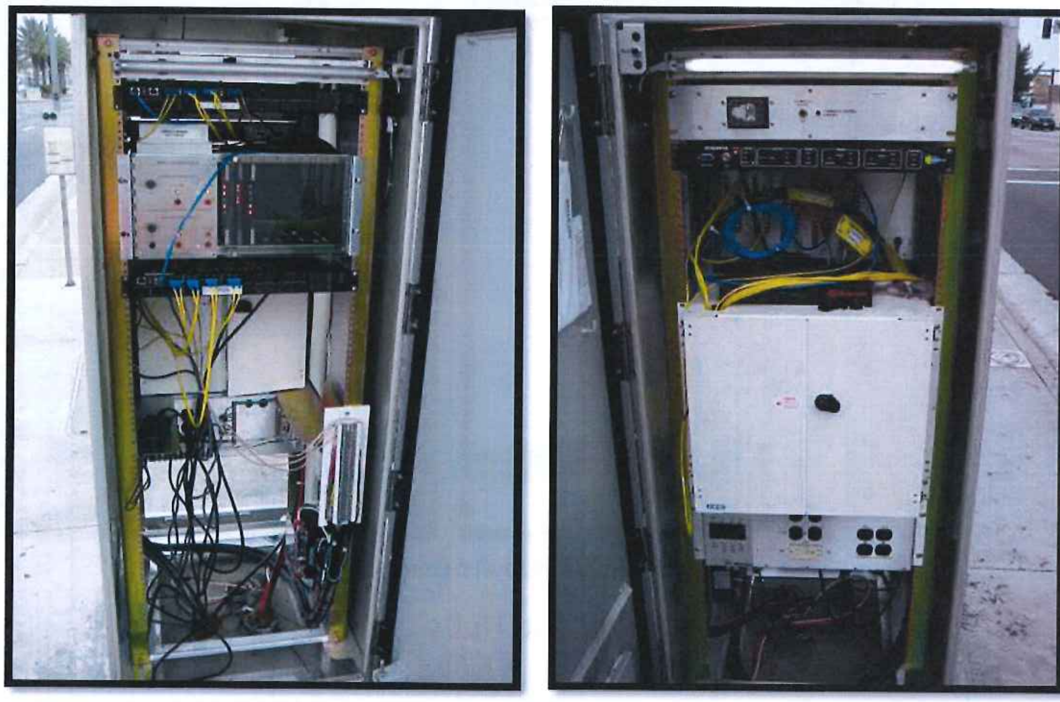


Figure 23 – Sample Hub Cabinet

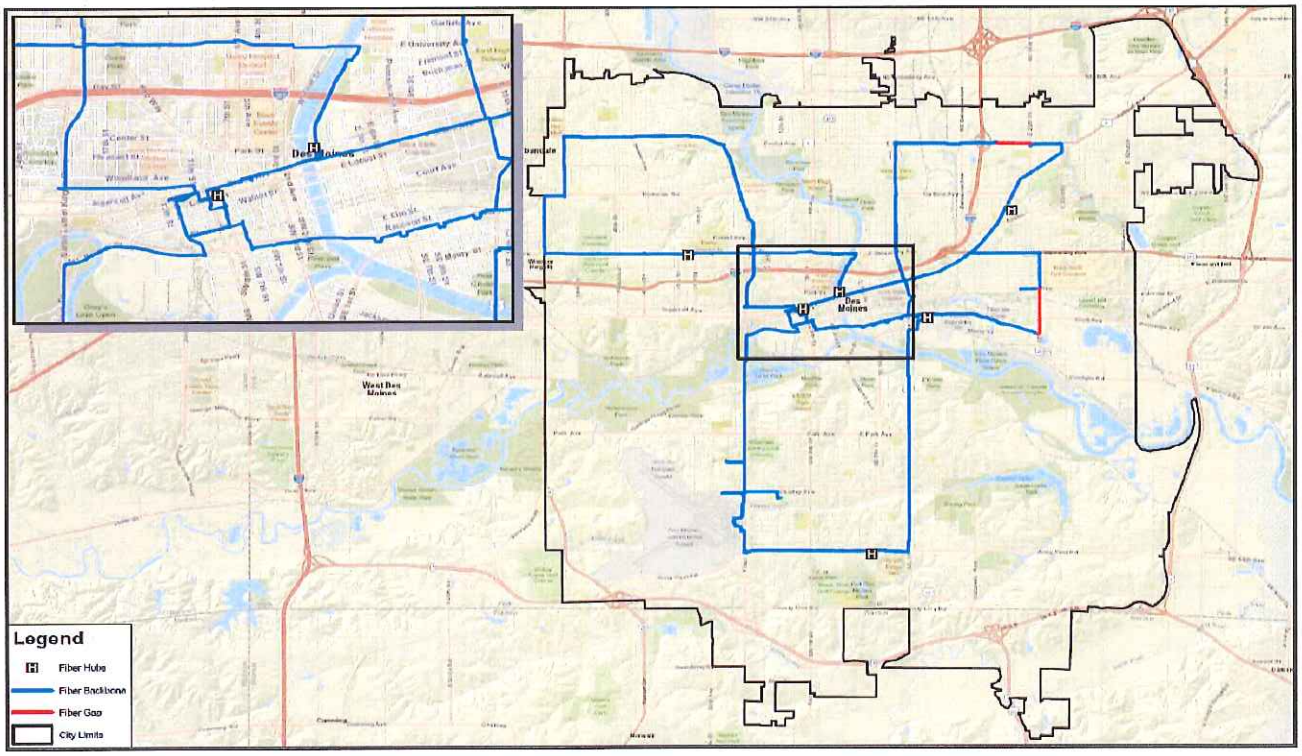


Figure 24 – Proposed Backbone and Hub Locations

7.3 Distribution Fiber Network

The City's distribution network will consist of a fiber optic network that will transmit data and video signals between communication hubs and various field elements.

The design uses a hub and spoke topology. The spokes will be distribution fiber optic cables connecting field elements using dedicated, leap frog, or daisy chained connections. Connections will be created to be true 'rings' wherever possible either through diverse routes or collapsed rings in single fiber optic cables when required. These connections are assumed to utilize the existing 24 strand fiber optic wherever possible. New installations and upgrades of fiber optic cables are recommended to have a minimum of 48 strand fibers. **Figure 25** illustrates the proposed distribution network.

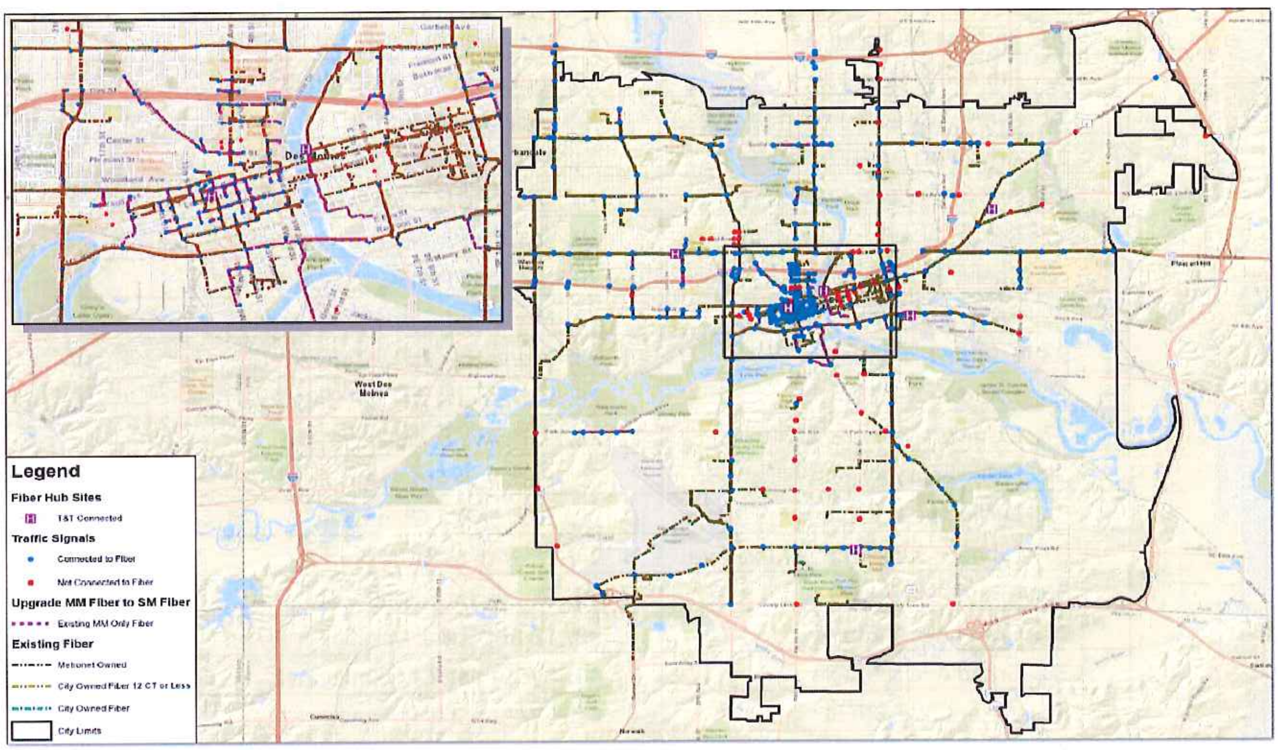


Figure 25 – Proposed Distribution Network

7.4 CCTV Cameras

To provide the City with additional tools to monitor intersection conditions, it is envisioned that CCTV cameras with pan/tilt/zoom capabilities will be deployed across the city at strategic locations along priority corridors, especially at priority intersections with high incident frequencies or operational challenges. **Figure 26** illustrates a layout of proposed camera locations. Proposed CCTV camera locations are listed below:

1. 18th St & Grand Ave/ Locust St	2. Guthrie Ave & E 14th St
3. 19th St & Clark St	4. Hubbell Ave & E Douglas Ave *
5. 2nd Ave & Aurora Ave	6. Hubbell Ave & Guthrie Ave
7. 2nd Ave & Crocker St	8. Indianola Ave & Evergreen Ave
9. 6th Ave & Laurel St	10. Indianola Ave & SE 6th St
11. Army Post Rd & Indianola Ave	12. Locust St & 15th St
13. Army Post Rd & SE 14th St	14. M L King Jr Pkwy & Fleur Dr
15. Army Post Rd & SW 9th St	16. M L King Jr Pkwy & Hickman Rd
17. Beaver Ave & Hickman Rd	18. M L King Jr Pkwy & Ingersoll Ave
19. Cherry St & 5th Ave	20. M L King Jr Pkwy & SW 11th St
21. Crocker St & Center St	22. M L King Jr Pkwy & SW 3rd St
23. E 14th St & E Walnut St	24. Merle Hay Rd & Meredith Dr
25. E Aurora & E 14th St	26. Park Ave & George Flagg Pkwy
27. E University Ave & E 14th St	28. Park Ave & Indianola Ave
29. E University Ave & Williams St	30. Park St & 6th Ave
31. Euclid Ave & E 29th St	32. E 6th St & E Grand Ave
33. Fillmore St & Pennsylvania Ave	34. SE 14th St & Hartford Ave
35. Grand Ave & 12th St	36. SE 14th St & Maury St
37. Grand Ave & 6th Ave	38. SE 6th St & E M L King Jr Pkwy
39. Grand Ave & 9th St	40. SW 9th St & McKinley Ave
41. Walnut St & 8th St	42. SW 9th St & Park Ave
43. M L King Jr Pkwy & E 30th St	44. M L King Jr Pkwy & Douglas Ave/Euclid St

* Future Signalized Intersection

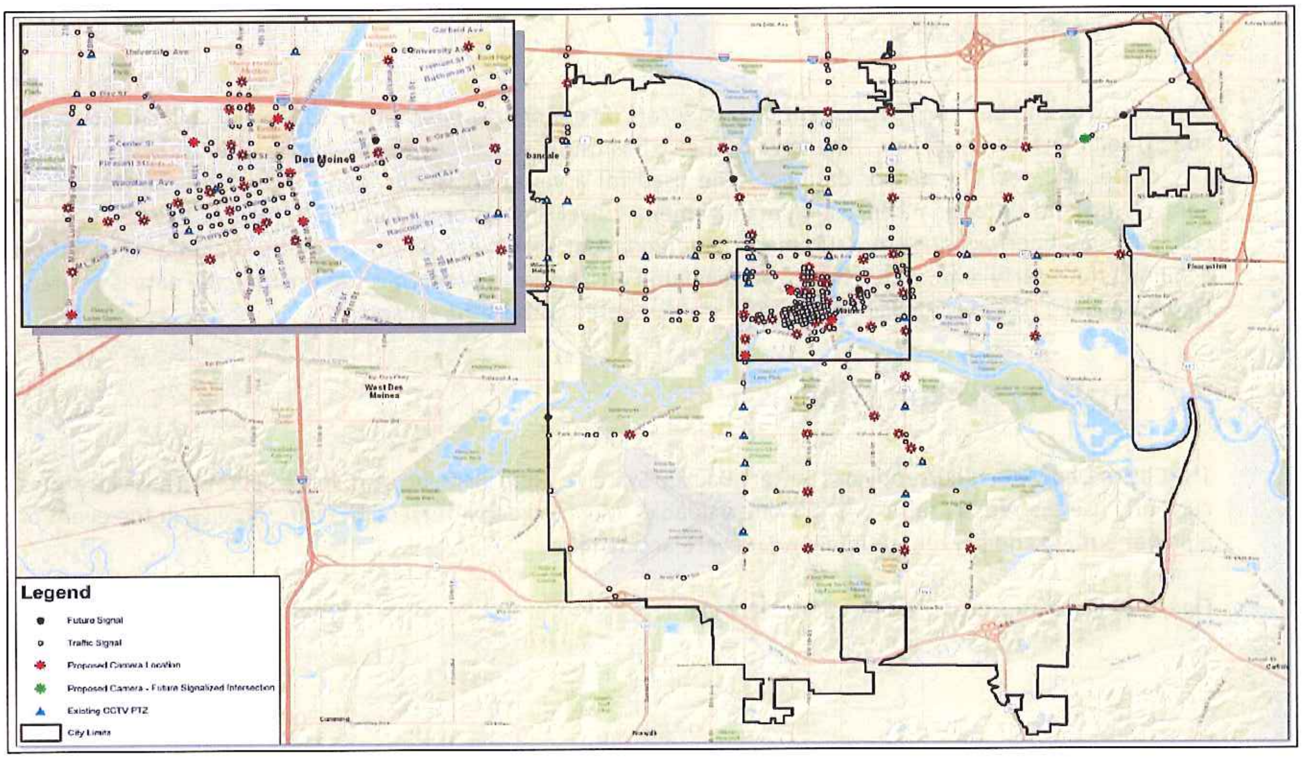


Figure 26 – Proposed CCTV Cameras

7.5 Dynamic Message Signs

The City of Des Moines currently operates eight DMS throughout the City. The DMS inform drivers of parking availability.

While static signs could be used in certain locations, trailblazer signs should be installed on primary diversion routes identified in the Iowa DOT's Incident Response Plan. Because these signs facilitate the diversion of freeway traffic on arterial streets, the City of Des Moines and Iowa DOT should share the cost of these installations. **Figure 27** illustrates proposed DMS locations citywide

7.6 Traffic Sensors

The City owns and operates permanent traffic sensors on major arterials that are capable of collecting data on speed, volume, occupancy, etc. The Iowa DOT also has traffic sensors deployed on the freeway system in the City of Des Moines. The sensor data could be used for a variety of applications, including: adaptive traffic control, incident detection, congestion management, travel time information (via DMS or 511 systems), data collection, and performance measurement. Additional data for these or any corridors could be obtained by acquiring third party data, which should be evaluated on a project specific basis at the time the data is desired. **Figure 28** illustrates potential corridors to be instrumented with traffic sensors.

7.7 Battery Backup Systems

The City of Des Moines currently has Battery Backup Systems (BBS) installed at 30 intersections. These locations currently use the Alpha Traffic BBS. BBS are valuable assets to keep intersection traffic flowing in the event of a power outage and prevent or minimizes severe accidents.

Figure 29 illustrates proposed locations citywide

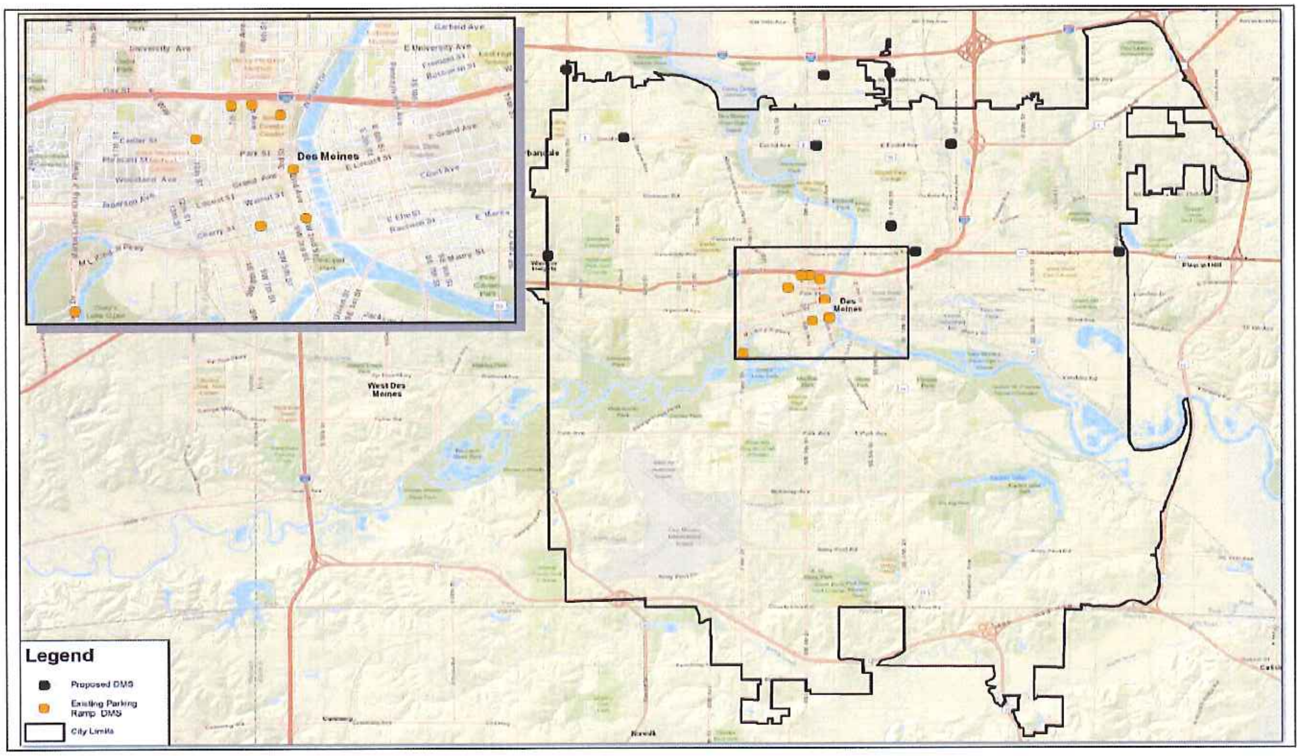


Figure 27 – Proposed Dynamic Message Signs

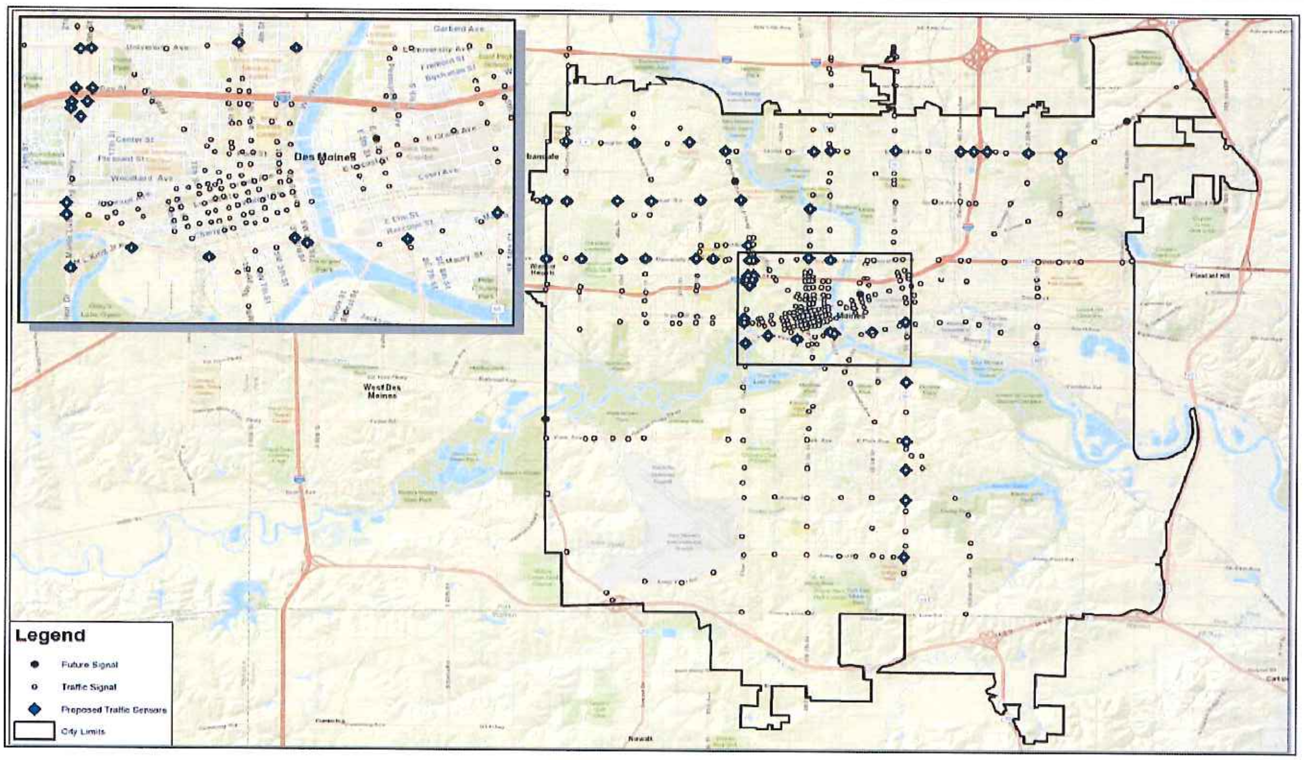


Figure 28 – Proposed Traffic Sensors

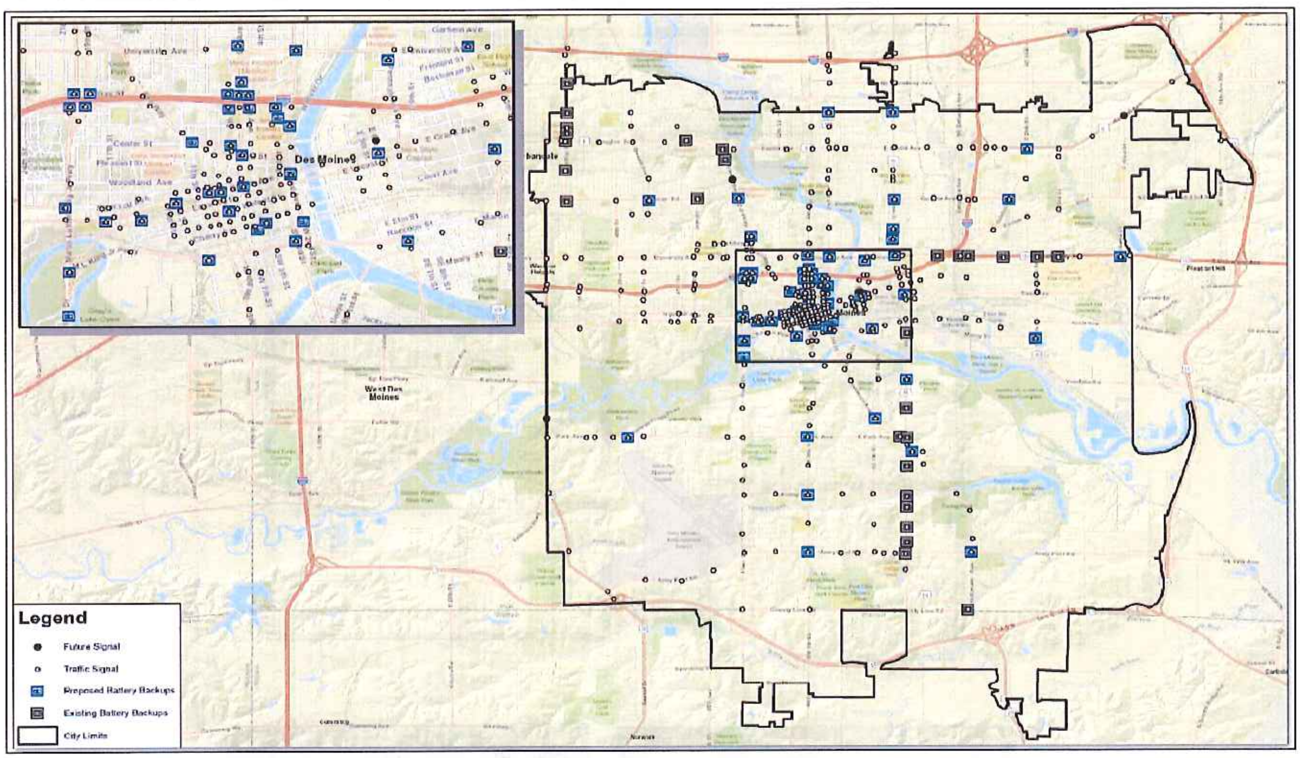
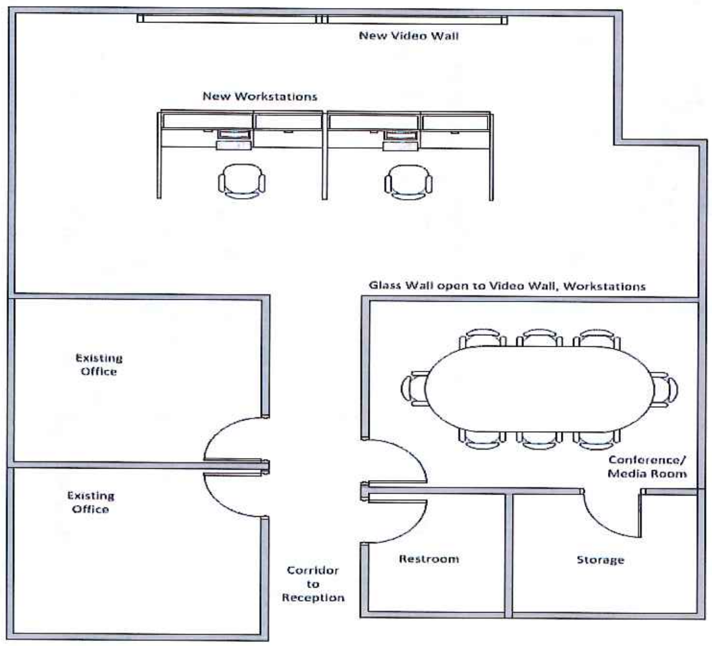


Figure 29 – Proposed Battery Backup Systems

7.8 Traffic Operation Centers

The City of Des Moines currently does not have a Traffic Operations Center (TOC). There is a conference room in City Hall that can be used as a TOC that has a desktop computer and two 40" flat screen TV connected to the computer, although the City is planning on utilizing individual workstations (computers with signal system access) as opposed to a dedicated TOC with enhanced screens in the Principal Traffic Engineer's office, the Signal Technician Chief's office, and the Public Works conference room for monitoring operations. **Figure 30** illustrates a sample floor plan for the facility. **Figure 31** illustrates sample photographs of TOCs.

Figure 30 – Sample TOC Floor Plan



Kansas City, Missouri

Olathe, Kansas

Figure 31 – Photographs of Traffic Operation Centers

7.9 Summary of Recommendations and Estimated Cost of Ultimate Build Out

The following list summarizes all recommendations previously identified in this master plan.

- Upgrade all signals to Type 2070 ATC traffic signal controllers.
- Migrate to a single local controller software platform based on final system requirements developed in the initial project deployment phase.
- Migrate to a single ATMS software package in coordination with the selection of controllers and local controller software.
- Hire a System Manager to finalize system requirements, based on the high-level requirements developed to date, for controller hardware, associated equipment, local controller software, and ATMS software.
- Replace the Multimode fiber with Single mode fiber. Add new conduit with fiber optic cable.
- Establish internet protocol (IP) based communications on the new network.
- Construct a redundant, self-healing Gigabit Ethernet backbone fiber optic network between six hub locations located throughout the City. Both hub and local signal controller connections will be created to be true 'rings' wherever possible either through diverse routes or collapsed rings in single fiber optic cables when required.
- Deploy CCTV cameras with PTZ across the City at the intersections of arterial roadways.
- Consider deploying arterial DMS and TBS on certain routes for incident management, special events, congestion management, and travel time information.
- Coordinate with the Iowa DOT to integrate City cameras, dynamic message signs, and traffic data into the 511 system and other appropriate web sites.
- Evaluate methods for disseminating traffic information to various media outlets.
- Consider installation of Kiosk and other information displays at the high activity areas such as the Downtown, State Fair, Iowa Events Center, and Principal Park.
- Continue implementation of bicycle detection. Add capability to enable remote viewing of the real-time video and data from individual workstations at locations with video detection.
- Evaluate the upgrade and/or installation of sensors on corridors on a project-specific basis, and consider the use of third party data for travel time and real-time congestion information.
- Consider deploying Signal Performance Measures (SPM) to identify operational deficiencies, optimize mobility and help manage traffic signal timing and maintenance.
- Consider deploying BBS at high volume or fringe intersections on a case-by-case basis.
- Coordinate with neighboring public safety agencies for creating a standard procedures for EVP systems.
- Coordinate with Des Moines Area Regional Transit Authority (DART) to facilitate implementation of TSP projects.
- Explore features of the new parking lot management system SKIDATA to ensure that it can integrate with the proposed ATMS software or vice versa.

- Provide enhanced screens and make the central system available on individual workstations at the Principal Traffic Engineer's office, Signal Technician Chief's office and the Public Works conference room.
- Program additional staff positions to properly maintain the communications network and additional ITS devices (depending on the number of cameras, signs, sensors, etc.) deployed in the field.
- Acquire at least one workstation to monitor the traffic signal system and related devices from at least 6:00 am to 9:00 am and 3:00 pm to 6:00 pm, Monday through Friday.
- Program one additional traffic engineering staff and four to six additional signal technicians to operate and maintain the existing and expanded traffic signal system.
- Continue to perform general traffic signal maintenance using internal maintenance staff.
- Continue to dedicate staff for evaluation of existing timing settings to ensure that they adhere to the latest MUTCD guidelines, where available.
- Optimize traffic signal coordination plans, at a minimum, every three to five years based on traffic volume and pattern fluctuations.
- Determine the feasibility and/or benefits of installing an adaptive or responsive system on corridors with closely-spaced signals and fluctuating, unpredictable traffic volumes.
- Coordinate with the neighboring agencies to maintain signal system compatibility and provide better coordination for regional incident management
- Develop, implement, monitor, and revise timing plans as necessary to accommodate for special events such as Iowa State Fair, Iowa Events Center, Principal Park etc. to facilitate ingress/egress upon conclusion of events.
- Develop and implement a comprehensive, regular preventative maintenance program. Implement work management system to help manage traffic signal infrastructure and maintenance operations.
- Provide training for maintenance staff to adequately maintain the traffic signal system.

Based on these recommendations, planning level costs have been developed to implement related equipment and infrastructure. The opinion of probable cost at the master planning stage is estimated to be $12.5 million, including design and system manager fees. **Table 9** details total system cost by item.

Table 9 – Opinion of Probable Cost for System Upgrade

System Component	Price/Unit	Unit	Qty	Total	% of Subtotal
Controller, Type 2070 ATC with Software	$6,000	EA	425	$2,550,000	
Traffic Signal Field Components				**$2,550,000**	**27%**
ATMS Software	$375,000	LS	1	$375,000	
Integration	$50,000	LS	2	$100,000	
Traffic Signal Software Components				**$475,000**	**5%**
Fiber Cable & Conduit	$32.50	FT	42,650	$1,386,125	
Fiber Cable	$12	FT	76,000	$912,000	

System Component	Price/Unit	Unit	Qty	Total	% of Subtotal
Fiber Pull Boxes	$1,200	EA	10	$12,000	
Misc. Comm. Hardware/Connections	$2,500	EA	425	$1,062,500	
Communication HUB Equipment	$25,000	EA	6	$150,000	
Communications Components				**$3,522,625**	**37%**
Misc. Bike/Pedestrian Detection	$2,500	EA	36	$90,000	
Emergency Vehicle Preemption (EVP)	$8,000	EA	35	$280,000	
Battery Backup System (BBS)	$8,000	EA	60	$480,000	
Closed-circuit television (CCTV) Monitoring Cameras	$8,000	EA	52	$416,000	
Arterial Dynamic Message Sign (DMS)	$50,000	EA	10	$500,000	
System Sensors	$2,500	EA	45	$112,500	
ITS Field Devices				**$1,878,500**	**20%**
Video Wall	$100,000	EA	1	$100,000	
Workstations	$10,000	EA	2	$20,000	
Misc. Server Equipment	$65,000	LS	1	$65,000	
Minor Remodel	$65,000	LS	1	$65,000	
ATIS Website	$125,000	LS	1	$125,000	
TOC Infrastructure				**$375,000**	**4%**
Signal Performance Measures	$50,000	LS	1	$50,000	
Adaptive Traffic Signal Control - Intersection Module	$22,500	EA	27	$607,500	
Work Order System	$105,000	LS	1	$105,000	
3rd Party Sensor Information	$50,000	LS	1	$50,000	
Misc. Items				**$812,500**	**8%**
Subtotal				**$9,613,625**	
Contingencies	15%		15%	**$1,442,044**	
Engineering Services	15%		15%	**$1,442,044**	
TOTAL				**$12,497,713**	**100%**

8 DEPLOYMENT STRATEGY

As previously noted, there are over 400 signalized intersections operated and maintained by the City of Des Moines. The implementation of this master plan will add several hundred devices and an upgraded communications network to the signal system. Due to these factors and existing budgetary constraints, proposed improvements have been broken into deployment phases based on discussion with City of Des Moines staff regarding potential anticipated funding. The improvements were developed and based on the City's needs and overall traffic signal system goals. The proposed seven-year deployment strategy is summarized in the following sections.

The selection of signals/corridors within each phase was based on a variety of factors. These factors were scored and weighted based on input from City staff. Factors include:

- Average daily traffic (ADT)
- Volume to capacity (V/C) ratio
- Annual number of crashes per signal
- Truck route designation
- Transit route designation
- Existing operational issues
- Condition of existing communications

In addition to the factors listed above, geography and access to fiber optic backbone network were also considered when developing deployment strategy.

8.1 Phase 1 – Martin Luther King Jr Parkway

8.1.1 Overview

The primary purpose of this phase is to close the fiber communication gap to build a redundant, self-healing Gigabit Ethernet backbone fiber optic network. Multimode fiber will be replaced with Single mode fiber (48 strands) to provide higher communications. Out of the six communications hubs, three hubs (Hub 1 - Armory, Hub 2 – 9th and Locust Parking Ramp and Hub 5 – Municipal Service Center) will be installed in this phase. ATMS software and a work order system will be procured. Individual workstations at the Principal Traffic Engineer's office, the Signal Technician Chief's office and at the Public Works conference room, will be procured and integrated.

Phase 1 includes 20 signals in the area generally bound by Fleur Drive on the west, SE 30th Street on the east, Maury Street on the south, and Martin Luther King Jr Parkway on the north.

The signals in this phase are primarily located along the following arterials:

1. Martin Luther King Jr Parkway/E Martin Luther King Jr Parkway - Fleur Drive to SE 30th Street

8.1.2 Summary of Upgrades

Communication Infrastructure Upgrades

1. Home Run Pull boxes: At locations where a dedicated interconnect pull box does not exist, a new dedicated interconnect pull box is recommended to be installed.
2. Mid-block Interconnect Pull boxes: The existing interconnect pull boxes will be upgraded to new larger boxes to accommodate slack fiber. It is assumed that the existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase will utilize existing conduit and upgrade 11,000' of the Multimode fiber to Single mode fiber (48 strands). The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: This phase will install 7000' of new conduits and fiber optic cable to close the communication gap. New conduit should be minimum 2 inch and fiber optic cable should be minimum 48 strands. Additional conduit may need to be installed for drop cable access from fiber splice pull boxes to traffic signal cabinets.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new and existing fiber optic cables.
2. Communication Hubs: Networking equipment for communication routing and field distribution will be installed at the Armory (Hub Location 1), 9th and Locust Parking Ramp (Hub Location 2) and Municipal Service Center (Hub Location 5).
3. Fiber Backbone Communications: Gigabit Ethernet backbone communications will be employed between these communication hubs. The backbone communications will also support distribution communications between the signalized intersections and the communication hubs.
4. Fiber Distribution Communications: Distribution communication links to field devices and signalized intersections will be deployed in this phase from either Hubs 1, 2 and 5.
5. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.
6. Fiber optic cable in new conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

Cabinet/Controller Upgrades

1. Controllers: 20 Type 170/170E/170S controllers will be upgraded with new 2070 ATC controllers.
2. Ethernet switches: 20 signalized intersections will be equipped with new Ethernet switches.
3. Fiber optic cable hardware: The signalized intersections in this phase will be equipped with the fiber optic termination and attachment hardware.

ITS Devices

1. CCTV Cameras: 3 CCTV cameras will be installed in this phase.

Office/Conference Room

1. ATMS Software: ATMS software will be procured and configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. Individual workstations with enhanced screens will be installed at the at the Principal Traffic Engineer's office, the Signal Technician Chief's office and at the Public Works conference room in this phase.

3. Work Order Management System: Work Order Management System will be implemented in this phase.

8.1.3 Summary of Estimated Costs

Phase 1 improvements are estimated to cost $1.5 million. **Figure 32** illustrates Phase 1 improvements. **Appendix E** provides a detailed cost breakdown of individual phases.

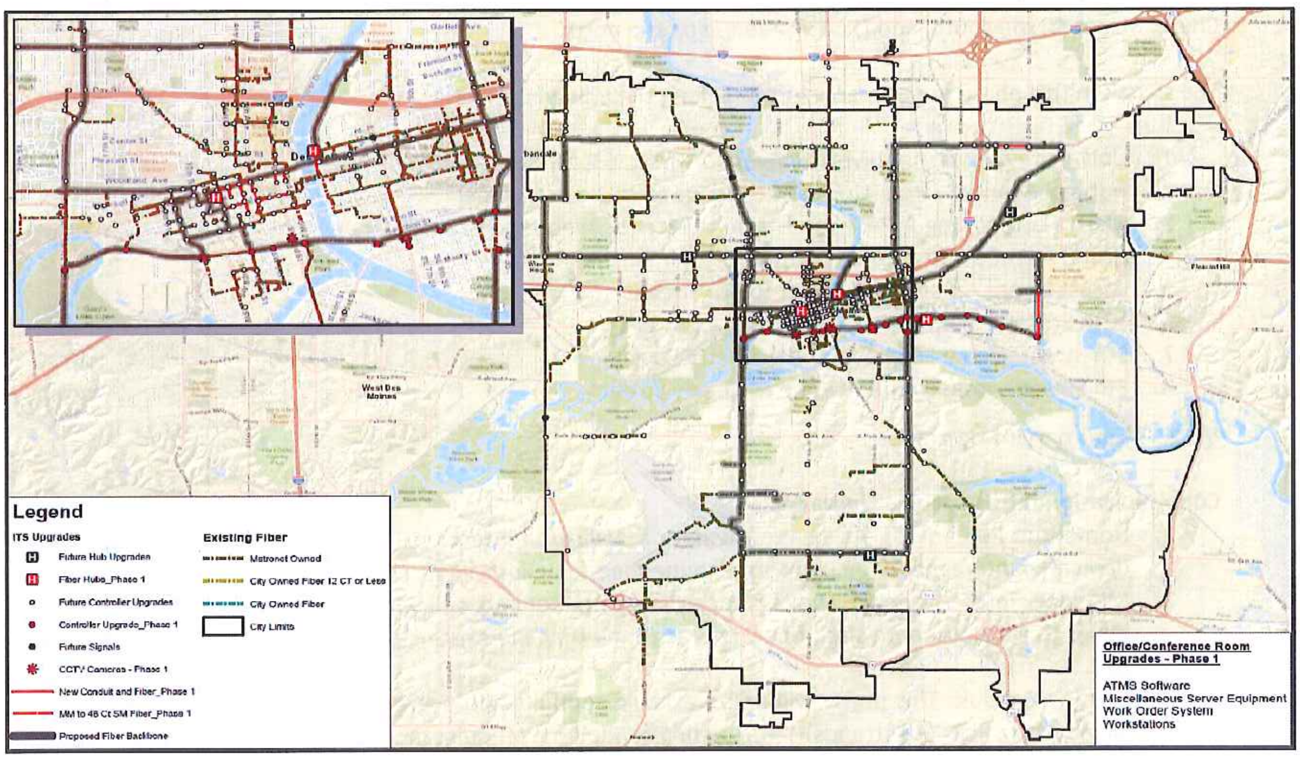


Figure 32 – Phase 1 Improvements

8.2 Phase 2 – Downtown

8.2.1 Overview

The primary purpose of this phase is to upgrade controllers, communications and add ITS devices. Multimode fiber will be replaced with Single mode fiber (48 strands) to provide higher communications. Out of the six communications hubs, one communication hub (Hub 6 – Old Parks Admin) will be installed in this phase. DMS signs, CCTV cameras and bicycle detections will be installed.

Phase 2 includes 70 signals in the area generally bound by 63rd Street on the west, Hubbell Avenue on the east, Cherry Street on the south, and NE 48th Avenue on the north.

The signals in this phase are primarily located along the following arterials:

1. University Avenue/E University Avenue – from 63rd Street to Hubbell Avenue
2. Hubbell Avenue – from University Avenue to NE 46th Avenue
3. Martin Luther King Jr Parkway – from University Avenue to Grand Avenue
4. Grand Avenue – from Martin Luther King Jr Parkway
5. Locust Street – from 17th Street to 8th Street
6. 12th Street – from High Street to Cherry Street
7. 9th Street – from Locust Street to Cherry Street
8. 8th Street – from Grand Avenue to Cherry Street

8.2.2 Summary of Upgrades

Communication Infrastructure Upgrades

1. Home Run Pull boxes: At locations where a dedicated interconnect pull box does not exist, a new dedicated interconnect pull box is recommended to be installed.
2. Mid-block Interconnect Pull boxes: The existing interconnect pull boxes will be upgraded to new larger boxes to accommodate slack fiber. It is assumed that the existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase will utilize existing conduits and upgrade 25,000' of Multimode fiber to Single mode fiber (48 strands). The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new and existing fiber optic cables.
2. Communication Hubs: Networking equipment for communication routing and field distribution will be installed at the Old Parks Admin (Hub Location 6).
3. Fiber Backbone Communications: Gigabit Ethernet backbone communications will be employed between these communication hubs. The backbone communications will also support distribution communications between the signalized intersections and the communication hubs.
4. Fiber Distribution Communications: Distribution communication links to field devices and signalized intersections will be deployed in this phase from either Hubs 1, 2, 5, and 6.

5. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.
6. Fiber optic cable in new conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

Cabinet/Controller Upgrades

1. Controllers: 70 Type 170/170E/170S controllers will be upgraded with new 2070 ATC controllers.
2. Ethernet switches: 70 signalized intersections will be equipped with new Ethernet switches.
3. Fiber optic cable hardware: The signalized intersections in this phase will be equipped with the fiber optic termination and attachment hardware.

ITS Devices

1. CCTV Cameras: 22 CCTV cameras will be installed in this phase.
2. DMS: 2 Arterial DMS will be installed in this phase
3. Detection: Bicycle detection will be installed at 3 locations in this phase.

8.2.3 Summary of Estimated Costs

Phase 2 improvements are estimated to cost $1.5 million. **Figure 33** illustrates Phase 2 improvements.

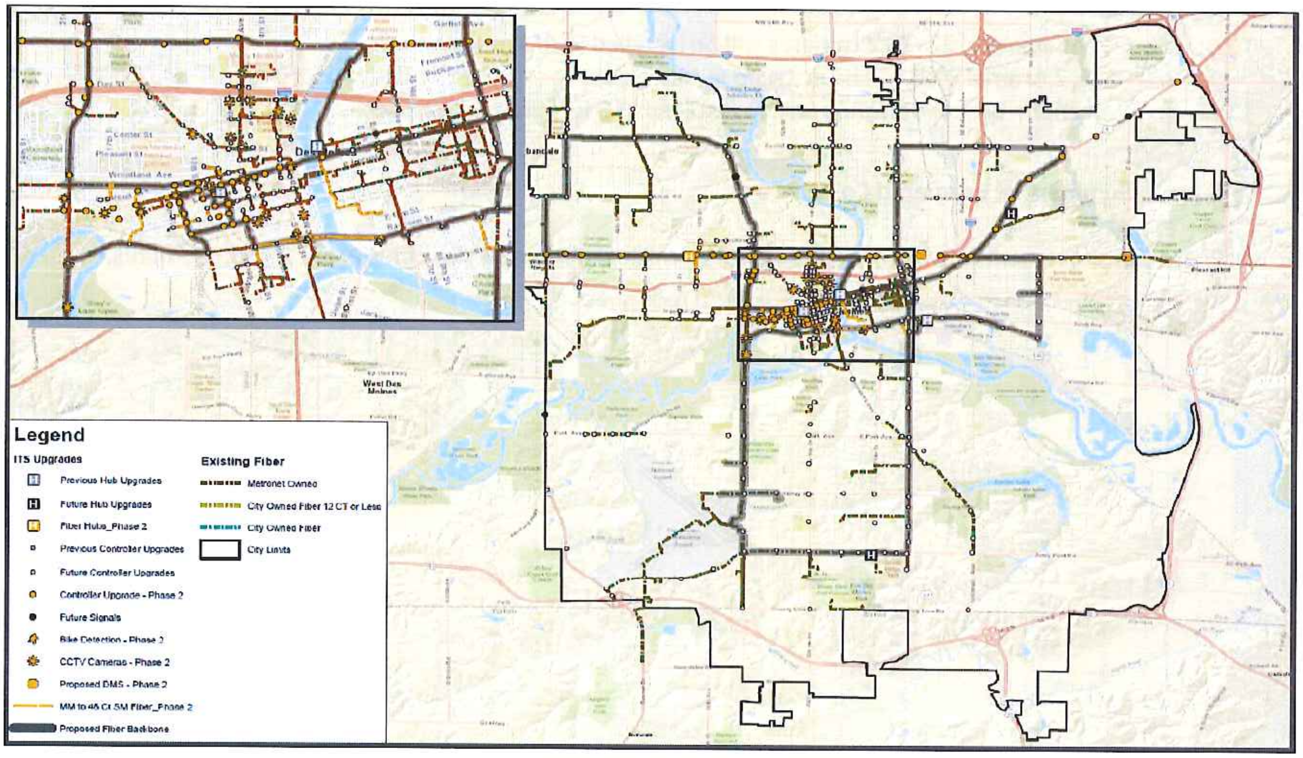


Figure 33 – Phase 2 Improvements

8.3 Phase 3 – North and East Downtown

8.3.1 Overview

The primary purpose of this phase is to upgrade controllers, communications, add ITS devices and build enhanced screens for monitoring at the Principal Traffic Engineer's office, the Signal Technician Chief's office and at the Public Works conference room. Multimode fiber will be replaced with Single mode fiber (48 strands) to provide higher communications. DMS signs, CCTV cameras and bicycle detections will be installed.

Phase 3 includes 60 signals in the area generally bound by 13th Street on the west, 2nd Avenue on the east, Cherry Street on the south, and Laurel Avenue on the north.

The signals in this phase are primarily located along the following arterials:

- 2nd Avenue – from School Street to E Court Avenue
- 3rd Street – from School Street to E Court Avenue
- 5th Avenue – from Day Street to Cherry Street
- 6th Avenue – from Laurel Street to Cherry Street
- 7th Street – from Laurel Street to Mulberry Street
- 8th Street – from Center Street to High Street
- 9th Street – from Center Street to Grand Avenue
- Walnut Street – from 13th Street to 2nd Avenue
- Mulberry Street – from 13th Street to 5th Avenue

8.3.2 Summary of Upgrades

Communication Infrastructure Upgrades

1. Home Run Pull boxes: At locations where a dedicated interconnect pull box does not exist, a new dedicated interconnect pull box is recommended to be installed.
2. Mid-block Interconnect Pull boxes: The existing interconnect pull boxes will be upgraded to new larger boxes to accommodate slack fiber. It is assumed that the existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase will utilize existing conduits and upgrade 30,000 of the Multimode fiber to Single mode fiber (48 strands). The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new and existing fiber optic cables.
2. Fiber Backbone Communications: Gigabit Ethernet backbone communications will be employed between these communication hubs. The backbone communications will also support distribution communications between the signalized intersections and the communication hubs.
3. Fiber Distribution Communications: Distribution communication links to field devices and signalized intersections will be deployed in this phase from either Hubs 1, 2, 5 and 6.

4. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.
5. Fiber optic cable in new conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

Cabinet/Controller Upgrades

1. Controllers: 60 Type 170/170E/170S controllers will be upgraded with new 2070 ATC controllers.
2. Ethernet switches: 60 signalized intersections will be equipped with new Ethernet switches.
3. Fiber optic cable hardware: The signalized intersections in this phase will be equipped with the fiber optic termination and attachment hardware.

ITS Devices

1. CCTV Cameras: 7 CCTV cameras will be installed in this phase.
2. DMS: 2 Arterial DMS will be installed in this phase.
3. Detection: Bicycle detection will be installed at 6 locations in this phase.

Office/Conference Room

1. Office/Conference Room remodeling will done in this phase.
2. Enhanced screens will be installed in this phase.

8.3.3 Summary of Estimated Costs

Phase 3 improvements are estimated to cost $1.5 million. **Figure 34** illustrates Phase 3 improvements.

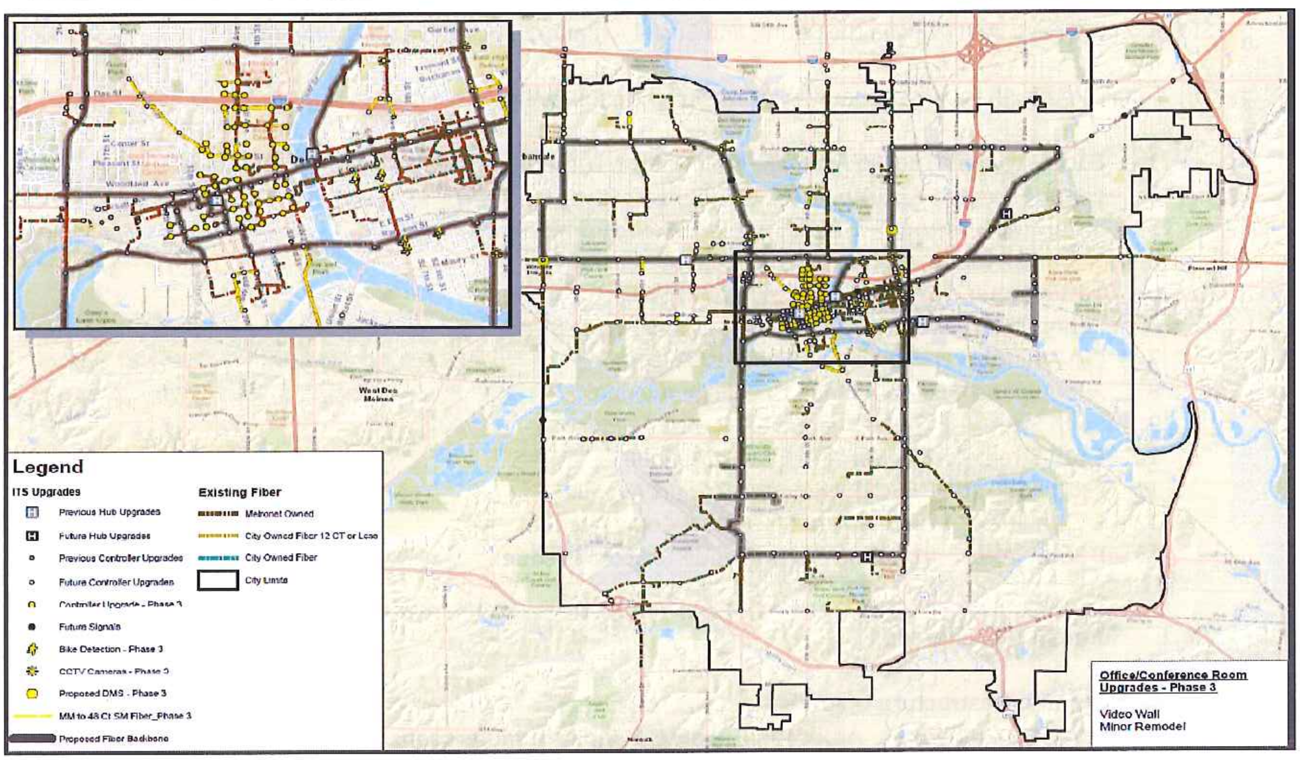


Figure 34 – Phase 3 Improvements

8.4 Phase 4 – Northeast Des Moines

8.4.1 Overview

The primary purpose of this phase is to upgrade controllers, communications, add ITS devices and build ATIS website. Out of the six communications hubs, one communication hub (Hub 4 – East Side Library) will be installed in this phase. DMS signs, CCTV cameras, bicycle detections and traffic sensors will be installed. Advanced Traveler Information Systems (ATIS) website will be installed.

Phase 4 includes 85 signals in the area generally bound by Martin Luther King Jr Parkway on the west, E 42nd Street on the east, Dart Way on the South, and Euclid Avenue/E Euclid Avenue on the north.

The signals in this phase are primarily located along the following arterials:

1 Euclid Avenue/E Euclid Avenue – from Martin Luther King Jr Parkway to E 33rd Street
2 Guthrie Avenue – E 14th Street to I-235 East Ramp
3 E University Avenue – E 26th Street to Winegardner Road
4 E Grand Avenue – E 4th Street to E 21st Street
5 Tuttle Street – SW 9th Street to SW 7th Street
6 Pennsylvania Avenue – Filmore Street to E Locust Street
7 6th Avenue – Euclid Avenue to Forest Avenue
8 2nd Avenue – Euclid Avenue to College Avenue
9 E 4th Street – E Grand Avenue to E Court Avenue
10 E 6th Street – I-235 North to E Court Avenue
11 E 14th Street – E Euclid Avenue to E Court Avenue
12 E 15th Street – from Walker Street to E Court Avenue
13 E 30th Street – from University Avenue to Scott Avenue

8.4.2 Summary of Upgrades

Communication Infrastructure Upgrades

1. Home Run Pull boxes: At locations where a dedicated interconnect pull box does not exist, a new dedicated interconnect pull box is recommended to be installed.
2. Mid-block Interconnect Pull boxes: The existing interconnect pull boxes will be upgraded to new larger boxes to accommodate slack fiber. It is assumed that the existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase will utilize existing conduits and upgrade 5000' of the Multimode fiber to Single mode fiber (48 strands). The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new and existing fiber optic cables.
2. Communication Hubs: Networking equipment for communication routing and field distribution will be installed at the East Side Library (Hub Location 4).

3. Fiber Backbone Communications: Gigabit Ethernet backbone communications will be employed between these communication hubs. The backbone communications will also support distribution communications between the signalized intersections and the communication hubs.
4. Fiber Distribution Communications: Distribution communication links to field devices and signalized intersections will be deployed in this phase from either Hubs 1, 2, 4, 5 and 6.
5. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.
6. Fiber optic cable in new conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

Cabinet/Controller Upgrades

1. Controllers: 85 Type 170/170E/170S controllers will be upgraded with new 2070 ATC controllers.
2. Ethernet switches: 85 signalized intersections will be equipped with new Ethernet switches.
3. Fiber optic cable hardware: The signalized intersections in this phase will be equipped with the fiber optic termination and attachment hardware.

ITS Devices

1. CCTV Cameras: 10 CCTV cameras will be installed in this phase.
2. DMS: 2 Arterial DMS will be installed in this phase.
3. Detection: Bicycle detection will be installed at 5 locations in this phase.
4. Traffic Sensors: 15 traffic sensors will be installed in this phase.

Office/Conference Room

1. Advanced Traveler Information Systems (ATIS) website will be installed in this phase.

8.4.3 Summary of Estimated Costs

Phase 4 improvements are estimated to cost $1.5 million. **Figure 35** illustrates Phase 4 improvements.

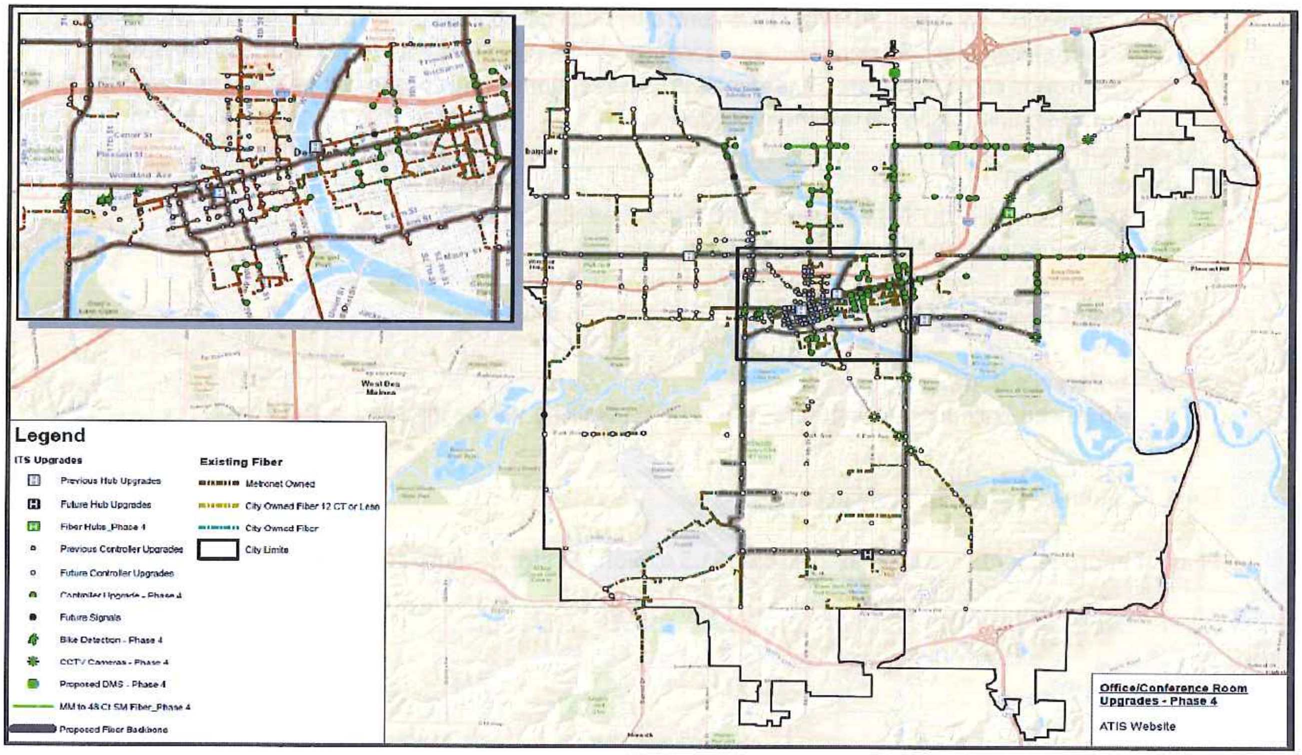


Figure 35 – Phase 4 Improvements

8.5 Phase 5 – Southern Des Moines

8.5.1 Overview

The primary purpose of this phase is to upgrade controllers, communications and add ITS devices. Out of the six communications hubs, one communication hub (Hub 3 – Police Academy) will be installed in this phase. DMS signs, CCTV cameras, traffic sensors, bicycle detections, Battery Backup System (BBS), Emergency Vehicle Preemption (EVP) and Signal Performance Measures (SPM) will be installed.

Phase 5 includes 55 signals in the area generally bound by Fleur Drive on the West, Indianola Avenue on the East, County Line Road on the South, and Jackson Avenue on the North.

The signals in this phase are primarily located along the following arterials:

1. Fleur Drive – Grays Lk to County Line Road
2. SW 9th Street – Bell Avenue to County Line Road
3. SE 14th Street – Hartford Avenue to South Ridge Mall Entrance
4. Indianola Avenue – SE 1st Street to E County Line Road
5. Park Avenue – Fleur Drive to SE 14th Street
6. McKinley Avenue – Fleur Drive to Indianola Avenue
7. Army Post Road – from Fleur Drive to Indianola Avenue
8. County Line Road – from Fleur Drive to Indianola Avenue

8.5.2 Summary of Upgrades

Communication Infrastructure Upgrades

1. Home Run Pull boxes: At locations where a dedicated interconnect pull box does not exist, a new dedicated interconnect pull box is recommended to be installed.
2. Mid-block Interconnect Pull boxes: The existing interconnect pull boxes will be upgraded to new larger boxes to accommodate slack fiber. It is assumed that the existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase will utilize existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new and existing fiber optic cables.
2. Communication Hubs: Networking equipment for communication routing and field distribution will be installed at the Police Academy (Hub Location 3).
3. Fiber Backbone Communications: Gigabit Ethernet backbone communications will be employed between these communication hubs. The backbone communications will also support distribution communications between the signalized intersections and the communication hubs.
4. Fiber Distribution Communications: Distribution communication links to field devices and signalized intersections will be deployed in this phase from all hubs.

5. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.
6. Fiber optic cable in new conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

Cabinet/Controller Upgrades

1. Controllers: 55 Type 170/170E/170S controllers will be upgraded with new 2070 ATC controllers.
2. Ethernet switches: 55 signalized intersections will be equipped with new Ethernet switches.
3. Fiber optic cable hardware: The signalized intersections in this phase will be equipped with the fiber optic termination and attachment hardware.

ITS Devices

1. CCTV Cameras: 10 CCTV cameras will be installed in this phase.
2. DMS: 2 Arterial DMS will be installed in this phase.
3. Traffic Sensors: 15 traffic sensors will be installed in this phase.
4. BBS: 30 BBS will be installed in this phase.
5. EVP: 20 EVP will be installed in this phase.
6. Detection: Bicycle detection will be installed at 14 locations in this phase.

Office/Conference Room

1. Signal Performance Measures (SPM) will be installed in this phase.

8.5.3 Summary of Estimated Costs

Phase 5 improvements are estimated to cost $1.5 million. **Figure 36** illustrates Phase 5 improvements.

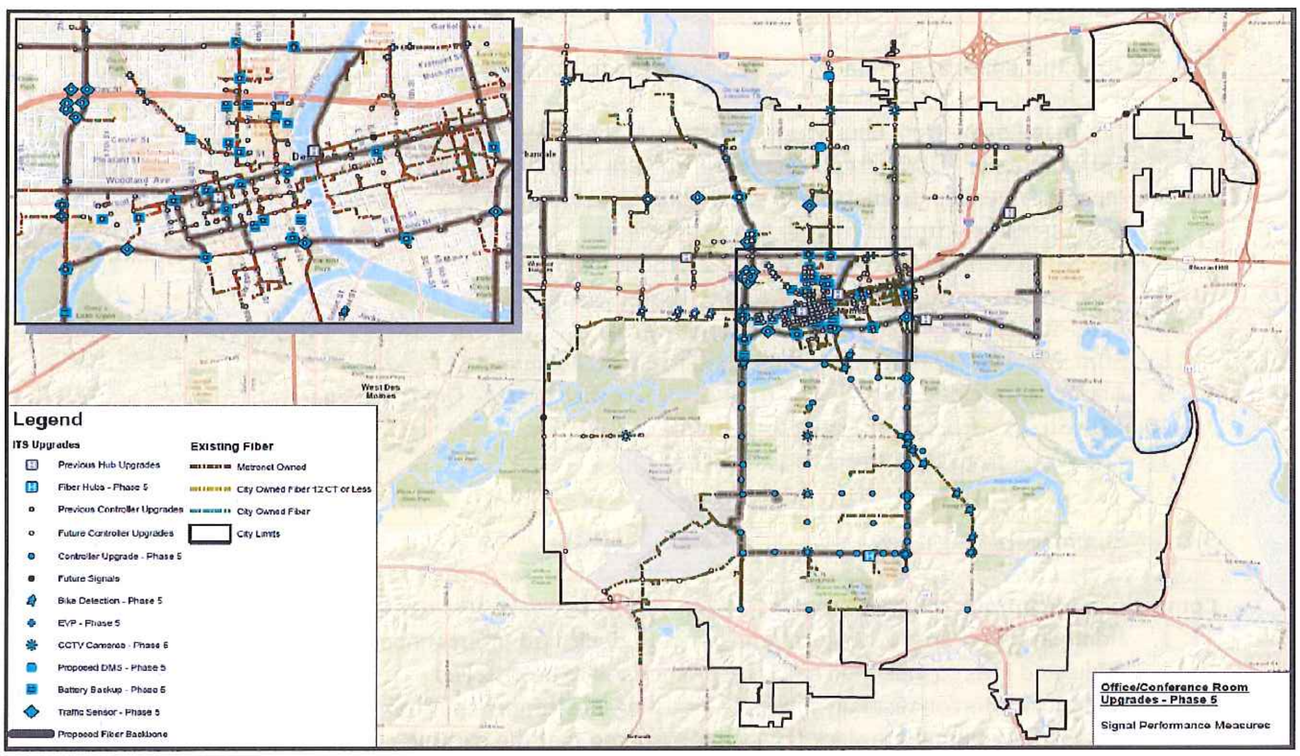


Figure 36 – Phase 5 Improvements

8.6 Phase 6 – Western Des Moines

8.6.1 Overview

The primary purpose of this phase is to upgrade controllers, communications and add ITS devices. Adaptive Software, DMS signs, traffic sensors, bicycle detections, Battery Backup System (BBS), Emergency Vehicle Preemption (EVP) and third party data (such as Inrix) will be installed.

Phase 6 includes 45 signals in the area generally bound by 63rd Street on the west, Keo Way on the east, Grand Avenue on the south, and Hickman Road on the north.

The signals in this phase are primarily located along the following arterials:

1. Hickman Road – from 63rd Street to Martin Luther King Jr Parkway
2. Forest Avenue – 30th Street/31st Street to 19th Street
3. Ingersoll Avenue – from 42nd Street to 28th Street
4. Grand Avenue – from 56th Street to 28th Street
5. 63rd Street – from Hickman Road to I-235 South Ramp
6. 56th Street – from I-235 North Ramp to Grand Avenue
7. 42nd Street – Kingman Boulevard Grand Avenue
8. 30th Street/31st Street – Hickman Road to Grand Avenue
9. Martin Luther King Jr Parkway – from Clark Street to Cottage Grove Avenue
10. 19th Street – from Clark Street to Keo Way
11. Keo Way – from 19th Street to 12th Street

8.6.2 Summary of Upgrades

Communication Infrastructure Upgrades

1. Home Run Pull boxes: At locations where a dedicated interconnect pull box does not exist, a new dedicated interconnect pull box is recommended to be installed.
2. Mid-block Interconnect Pull boxes: The existing interconnect pull boxes will be upgraded to new larger boxes to accommodate slack fiber. It is assumed that the existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase will utilize existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new and existing fiber optic cables.
2. Fiber Distribution Communications: Distribution communication links to field devices and signalized intersections will be deployed in this phase from all hubs.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

4. Fiber optic cable in new conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

Cabinet/Controller Upgrades

1. Controllers: 45 Type 170/170E/170S controllers will be upgraded with new 2070 ATC controllers.
2. Adaptive Software: 15 controllers will be upgraded with adaptive software.
3. Ethernet switches: 45 signalized intersections will be equipped with new Ethernet switches.
4. Fiber optic cable hardware: The signalized intersections in this phase will be equipped with the fiber optic termination and attachment hardware.

ITS Devices

1. DMS: 2 Arterial DMS will be installed in this phase.
2. Traffic Sensors: 15 traffic sensors will be installed in this phase.
3. BBS: 20 BBS will be installed in this phase.
4. EVP: 15 EVP will be installed in this phase.
5. Detection: Bicycle detection will be installed at 8 locations in this phase.

Office/Conference Room

1. Third Party Data Service: Third party data service (such as Inrix) will be installed in this phase.

8.6.3 Summary of Estimated Costs

Phase 6 improvements are estimated to cost $1.5 million. **Figure 37** illustrates Phase 6 improvements.

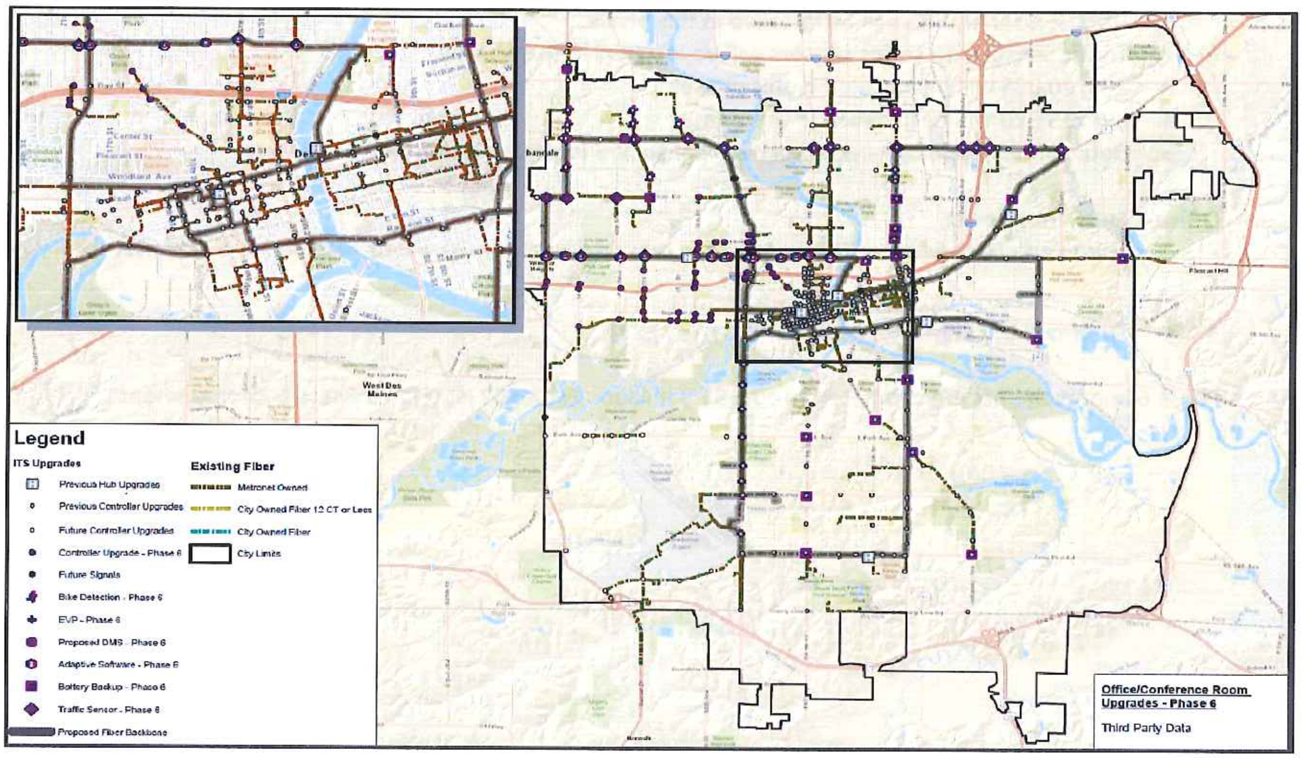


Figure 37 – Phase 6 Improvements

8.7 Phase 7 – North and Southwest Des Moines

8.7.1 Overview

The primary purpose of this phase is to upgrade controllers, communications and add ITS devices. Battery Backup System (BBS) will be installed. Adaptive software and 511 system will be installed.

Phase 7 includes 54 traffic signals in the area generally bound by 63rd Street on the west, NE 56th Street on the east, IA-5 on the south, and I-35/I-80 on the north. In addition, Phase 7 also includes 36 pedestrian signals located Citywide.

The traffic signals in this phase are primarily located along the following arterials:

1. Merle Hay Road – from I-80/I-35 to Urbandale Avenue
2. Beaver Avenue – from Aurora Avenue to Franklin Avenue
3. NW 2nd Street/2nd Avenue – From NW 49th Street to Douglas Avenue
4. NE14th Street/E 14th Street – from I-80/I-35 North Ramp to E Madison Avenue
5. SW 63rd Street/ S 1st Street – from Park Avenue to IA-5
6. Douglas Avenue – from 62nd Street to Lower Beaver Road
7. Park Avenue – from SW 63rd Street/ S 1st Street to SW 24th Street
8. Army Post Road – from SW 63rd Street/ S 1st Street to SW 28th Street

8.7.2 Summary of Upgrades

Communication Infrastructure Upgrades

1. Home Run Pull boxes: At locations where a dedicated interconnect pull box does not exist, a new dedicated interconnect pull box is recommended to be installed.
2. Mid-block Interconnect Pull boxes: The existing interconnect pull boxes will be upgraded to new larger boxes to accommodate slack fiber. It is assumed that the existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase will utilize existing conduits and upgrade 5000' of Multimode fiber to Single mode fiber (48 strands). The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new and existing fiber optic cables.
2. Fiber Distribution Communications: Distribution communication links to field devices and signalized intersections will be deployed in this phase from all hubs.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.
4. Fiber optic cable in new conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

Cabinet/Controller Upgrades

1. Controllers: 90 Type 170/170E/170S controllers will be upgraded with new 2070 ATC controllers.
2. Adaptive Software: 12 controllers will be upgraded with adaptive software.
3. Ethernet switches: 90 signalized intersections will be equipped with new Ethernet switches.
4. Fiber optic cable hardware: The signalized intersections in this phase will be equipped with the fiber optic termination and attachment hardware.

ITS Devices

1. Battery Backup System: 10 BBS will be installed in this phase.

Office/Conference Room

1. 511 System: 511 System will be installed in this phase.

8.7.3 Summary of Estimated Costs

Phase 7 improvements are estimated to cost $1.5 million. **Figure 38** illustrates Phase 7 improvements.

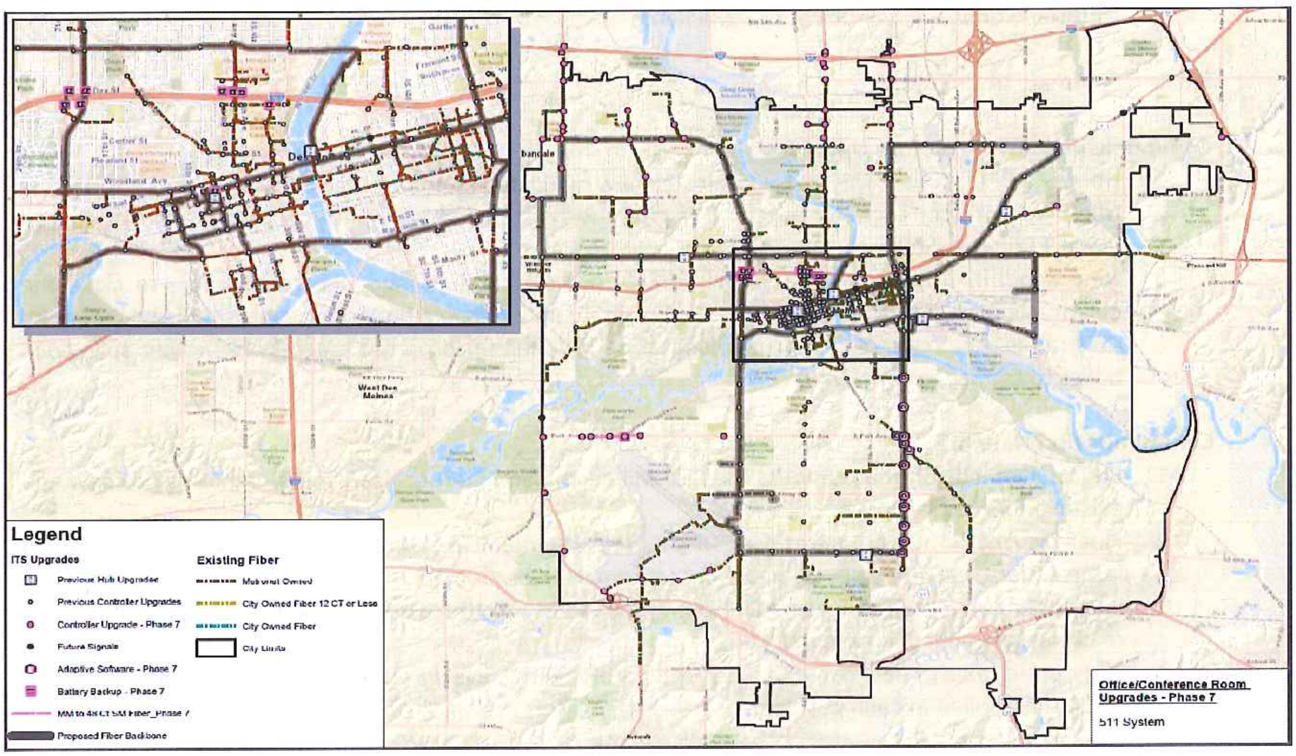


Figure 38 – Phase 7 Improvements

8.8 Phase 8 – Northeast and South Des Moines

The primary purpose of this phase is to provide communications and connect un-connected traffic signals along the following the arterials:

- NW 2nd Street – NE Broadway Avenue to NW 49th Place
- E 14th Street – NE Broadway Avenue to I-35 Ramp
- SW 9th Street – Army Post Road to Bell Avenue
- McKinley Avenue – SE 5th Street to SW 14th Street
- Forest Avenue – Martin Luther King Jr Parkway to 27th Street
- Guthrie Avenue – E 14th Street to I-235 Ramp

8.8.1 Summary of Upgrades

Communication Infrastructure Upgrades

1. Home Run Pull boxes: This phase will install new dedicated interconnect pull box.
2. Mid-block Interconnect Pull boxes: This phase will install mid-block interconnect pull boxes spaced every 1,000 to 1,500 feet.
3. New Conduit: This phase will install 35650' of new conduits and fiber optic cable to close the communication gap. New conduit should be minimum 2 inch and fiber optic cable should be minimum 48 strands. Additional conduit may need to be installed for drop cable access from fiber splice pull boxes to traffic signal cabinets.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new and existing fiber optic cables.
2. Fiber Distribution Communications: Distribution communication links to field devices and signalized intersections will be deployed in this phase from all hubs.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.
4. Fiber optic cable in new conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable slack coiled in each pull box.

Cabinet/Controller Upgrades

1. Fiber optic cable hardware: The signalized intersections in this phase will be equipped with the fiber optic termination and attachment hardware.

8.8.2 Summary of Estimated Costs

Phase 8 improvements are estimated to cost $1.5 million. **Figure 39** illustrates Phase 8 improvements

8.9 Summary of All Phases

Figure 40 summarizes ITS Master Plan improvements for Phases 1 through 8.

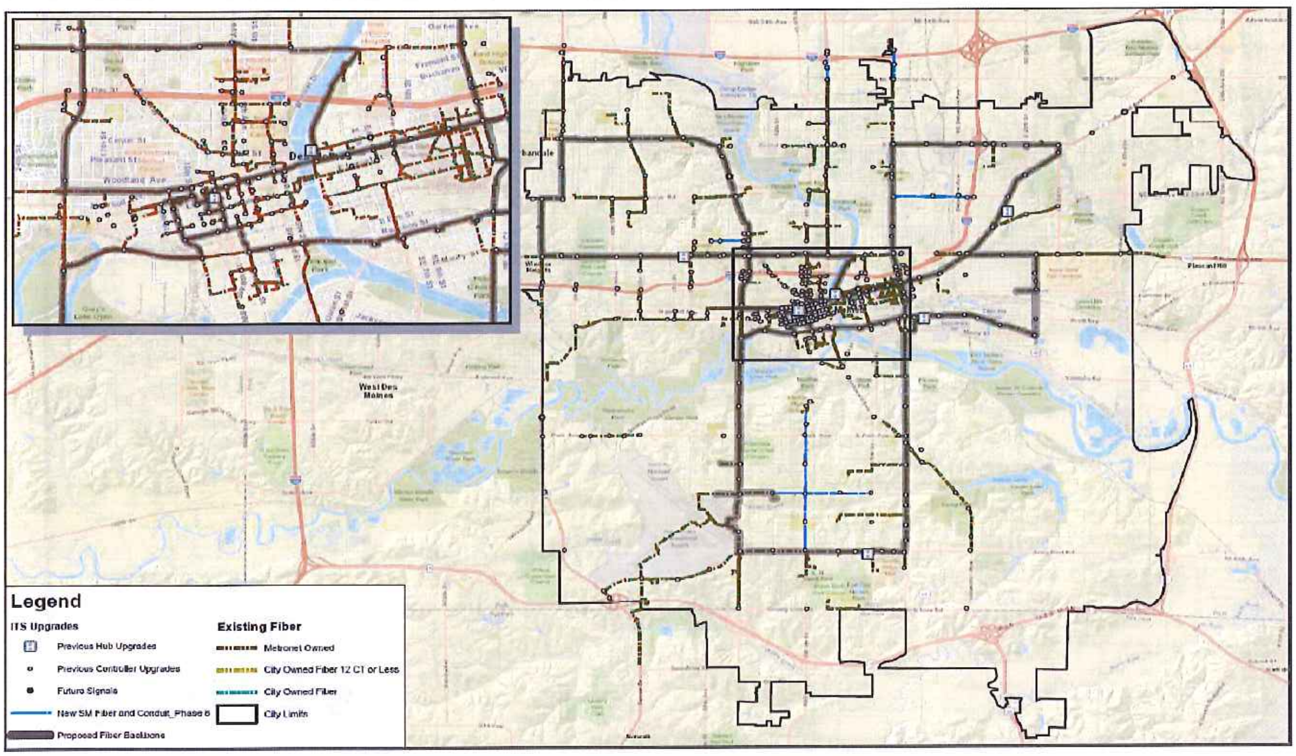


Figure 39 – Phase 8 Improvements

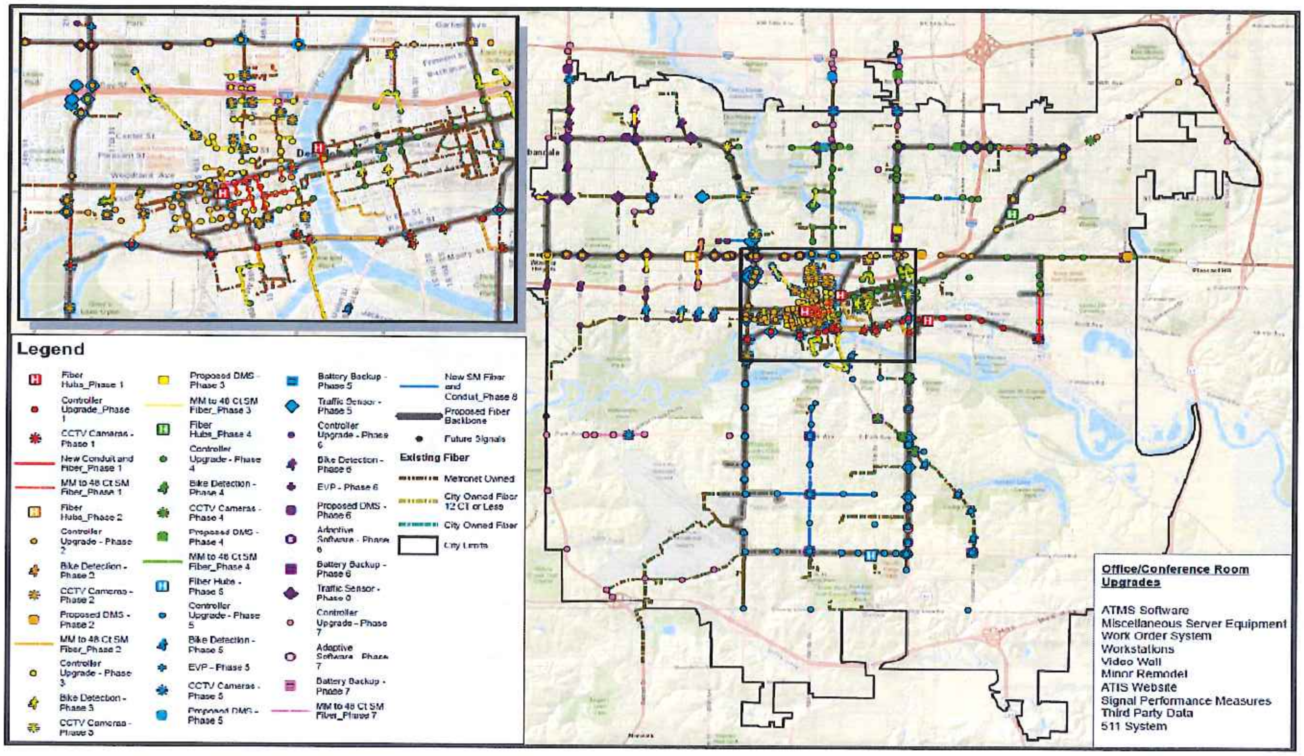


Figure 40 – ITS Master Plan Improvements by Phase

9 NEXT STEPS

The City should move forward with deployment of the ITS Master Plan which includes finalizing requirements for system software procurement and initiating design phases based on funding availability. The funding sources for both the master plan and the deployment projects are Surface Transportation Program (STP) federal funds (80%) and local funds (20%). Additional funding may be available through the Federal Highway Safety Improvement Program (HSIP), which has a match rate of 90% federal and 10% local. Additional funding beyond that described above will likely be required to fully implement all projects identified in the master plans.

APPENDIX A – CONCEPT OF OPERATIONS

APPENDIX B – HIGH-LEVEL REQUIREMENTS AND VERIFICATION PLAN

APPENDIX C – LOCAL CONTROLLER SOFTWARE FEATURES MATRIX

APPENDIX D – CENTRAL SIGNAL SYSTEM SOFTWARE FEATURES MATRIX

APPENDIX E – ITS MASTER PLAN PHASE IMPROVEMENT COST SPREADSHEET

1700 Carnegie Avenue, Suite 100
Santa Ana, CA 92705

iteris.com

Innovating Through Informatics™