U.S. Department of Transportation

Federal Highway Administration

City of Omaha

Traffic Signal System Master Plan

Final Report with Executive Summary and Appendices

Adopted by City Council Resolution #1318

October 1, 2013

EXECUTIVE SUMMARY

Background

A safe, efficient, and reliable transportation system is a vital component of a healthy and successful community. In Omaha, like many other cities, the level of safety, efficiency, and reliability is closely related to the performance of its traffic signal system. Traffic signals affect the lives of most citizens on a daily basis. While the green-yellow-red operation of the signals seems simplistic, it is an output of a complex system of computers, sensors, and communications that works in harmony to:

- Allow conflicting traffic movements to alternately pass through an intersection safely
- Efficiently progress traffic through a series of traffic signals to minimize congestion
- Allow pedestrians to safely cross busy streets
- Give priority to emergency vehicles, such as police cruisers, fire engines, and ambulances

In the City of Omaha, the Traffic Engineering Division of the Public Works Department is responsible for the planning, design, operation, and maintenance of the City's 1,000-plus traffic signal system. While the Traffic Engineering Division conducts many other important functions, the content of this master plan is solely focused on the traffic signal system, including its infrastructure, functionality, and staff.

The goal of the this project is to develop a clear and flexible traffic signal system master plan that results in the right-sized traffic signal system, providing value, improved safety, improved traffic operations, increased efficiency, and public support well into the future. This master plan can then be used to program projects, obtain funding, and upgrade the traffic signal system in a systematic and comprehensive manner over the next 10 years.

Need for Traffic Signal System Master Plan

The City of Omaha currently operates a traffic signal system that utilizes controllers and DOS-based management software that was largely developed in the 1970s and 1980s. The system communicates via dial-up modems to more than 60 closed-loop systems via on-street master controllers located throughout the City and an extensive twisted copper wire pair communications network. While functional, maintenance staff devotes an increasing amount of time to keep the communications system operational, while parts for the system are becoming increasingly difficult to obtain. In addition, the communications system is limited in its ability to transmit the required amount of data in a timely manner, and operations staff is unable to implement new traffic signal features that could improve the safety and efficiency for motorists, bicyclists, and pedestrians. In short, the system is functionally obsolete for many of the traffic management needs of a large and growing metropolitan area.

The goal of this project is to develop a clear and flexible traffic signal system master plan that results in the right-sized traffic signal system, providing value, improved safety, improved traffic operations, increased efficiency, and public support well into the future.

The City of Omaha and key stakeholders including the Metropolitan Area Planning Agency (MAPA) and Nebraska Department of Roads (NDOR) have proactively been planning a major upgrade to the traffic signal system. Development of this master plan is essential in helping the City and associated stakeholders evaluate the existing traffic signal system, identify needs, analyze improvement alternatives, and develop a concept design, cost estimate, and deployment strategy in order to secure funding for full deployment of the system. The master plan addresses the following major system components:

- traffic signal system hardware and software
- communications infrastructure
- location and functionality of a traffic management center (TMC)
- field devices such as video cameras for detection and system monitoring
- traffic sensors and arterial dynamic message signs (DMS)
- data sharing among key stakeholders
- traveler information to the public
- operations and maintenance activities

In addition to the master plan document, systems engineering documentation is being developed in accordance with Federal Highway Administration (FHWA) and NDOR requirements in order to secure and utilize federal funding for deployment of the traffic signal system. A Strategic Communications Plan was also developed to assist City officials in educating and garnering support from the public and to facilitate the need for funding.

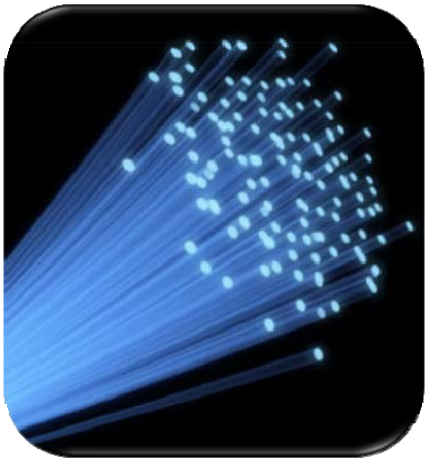
On a continuous, cyclical basis, certain physical and visible elements of the traffic signal system are being updated as parts of other projects and programs conducted by the Traffic Engineering Division. These include replacement of signal bulbs (from incandescent to more energy-efficient LED bulbs), replacement of poles and mast arms when they reach the end of their structural life, and installation of countdown pedestrian signal indications (as mandated by the federal government), to name a few. While these visible elements of the system are important and necessary, much of what is addressed in the master plan deals with elements of the traffic signal system that are not visible to the public but are required to serve as a roadmap to the City's next generation signal system.

Key Recommendations

The following list summarizes *key* recommendations identified in this master plan. Section 6.8 of the master plan lists all recommendations.

Traffic Signal System Hardware and Software

- Replace all existing controllers with Type 2070 ATC controllers.
- Convert all traffic signal cabinets to Type 332 cabinets, except where limited right-of-way exists.
- Procure advanced transportation management software (ATMS) to monitor, manage, and maintain traffic signals.
- Use the existing NDOR license for legacy ATMS software (Delcan NETworks), with the requirement that the ATMS the City procures for signal system management has the modules available in the future to also manage ITS devices. Ultimately migrate to a single ATMS software package in coordination with the selection of local controller software.



Communications System

- Construct a redundant, self-healing gigabit Ethernet backbone fiber optic network between eight hub locations located throughout the City.
- Deploy a high-speed, reliable, secure fiber optic cable network to most signals leveraging the existing agreement with Unite Private Networks (UPN) to minimize costs.
- Implement wireless communications to signals not located on arterial roadways.
- Establish internet protocol (IP) based communications on the new network.

Intelligent Transportation System (ITS) Devices

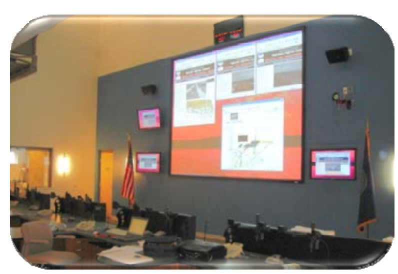
- Deploy approximately 200 closed-circuit television (CCTV) cameras with pan-tilt-zoom (PTZ) capabilities across the city at the intersections of arterial roadways, as well as other locations as needed.
- Consider deploying arterial DMS and trailblazer signs on certain routes for incident management, special events, congestion management, and travel time information.
- Coordinate with NDOR to integrate City cameras, DMS, and traffic data into the 511 system and other appropriate web sites for traveler information.
- Evaluate methods for disseminating traffic information to various media outlets.

- Install kiosks and other traffic-related information displays on the Farnam Street level of the Civic Center. Other locations could include high-activity areas such as public libraries, Eppley Airfield, CenturyLink Center, TD Ameritrade Park, the Old Market, and larger shopping centers.
- Continue deploying emergency vehicle preemption (EVP) systems per the procedures currently in place with various public safety agencies.
- Coordinate with Metro Transit to facilitate implementation of transit signal priority (TSP), bus rapid transit (BRT), or other transit projects.
- Explore software that integrates a future parking management system with the proposed central traffic signal management system software.

Traffic Operations and Management

- Establish traffic management capabilities at the following four facilities.

  1. Traffic Engineering Offices, Civic Center 6th Floor, 1819 Farnam Street
  2. Traffic Maintenance Facility, 50th and G Streets
  3. NDOR District Operations Center (DOC), 108th and I Streets
  4. Douglas County Emergency Operations Center (EOC), Civic Center lowest level



- Program additional staff to provide one TMC operator to monitor the traffic signal system and related devices from 6 am to 9 am and 3 pm to 6 pm, Monday through Friday, at a minimum.
- Program two to five additional traffic engineering staff and three to eight additional technicians to operate and maintain the existing and expanded traffic signal system.

- Continue to dedicate staff for evaluation of existing timing settings to ensure that they adhere to the latest Manual on Uniform Traffic Control Devices (MUTCD) guidelines, where available. Flashing schedules should also be periodically reviewed.
- Optimize traffic signal coordination plans, at a minimum, every 3 to 5 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 NDOR to carry out the procedures identified in the traffic incident management (TIM) guidelines as well as this document during freeway incidents.
- Develop, implement, monitor, and revise timing plans as necessary to accommodate special event traffic around major traffic-generating facilities.

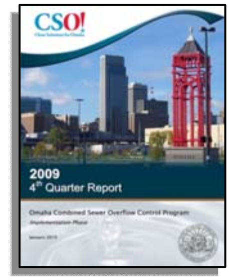
Maintenance

- Program additional staff positions to properly maintain the communications network and additional ITS devices deployed in the field.
- Continue to perform general traffic signal maintenance using internal maintenance staff, including fiber optic cable repairs.
- Continue to develop and implement a comprehensive and regular preventative maintenance program.
- Provide training for maintenance staff to adequately maintain the traffic signal system.

Estimated Cost

The total cost to upgrade the system, based on the recommendations outlined above, is $35 million not including design or system manager fees. This includes approximately $9.8 million for traffic signal hardware (controllers and cabinets) and software, $12.7 million for communications infrastructure, $6.5 million for ITS devices (cameras, signs, and sensors), and $0.5 million for traffic management center equipment. In addition, operations and maintenance costs are projected to increase from $1.8 million per year to $2.6 million per year at full system build out. This projection includes five additional staff positions, maintenance of new ITS devices (cameras, sensors, etc.), as well as server and other IT-related maintenance. Costs were kept to a minimum by incorporating these cost saving measures:

- **Fiber optic cable agreement**. A legal agreement between the City and Unite Private Networks (UPN) in 2011 will allow UPN to install fiber optic cable in City right-of-way in exchange for providing the City partial access to that fiber optic cable. UPN installations have already saved the City over $8 million. This savings will likely increase in the future as UPN installs additional fiber optic cable throughout the City.



- **Coordination with the Clean Solutions for Omaha (CSO) program**. The Traffic Engineering Division will coordinate with the CSO program to install fiber optic cable where necessary in conjunction with CSO projects. This will reduce costs associated with environmental reviews and installation of the conduit and cable itself. This process will also improve residents' quality of life by consolidating these separate construction projects into a single project.
- **Coordination and cooperation with NDOR**. NDOR constructed the District 2 Operations Center (DOC) at 108th and I Streets in 2005. This facility is used by NDOR and Nebraska State Patrol staff to monitor and manage traffic on Omaha area freeways. The facility was constructed to accommodate a City of Omaha traffic management staff person. Access to this facility and related equipment has eliminated the need for the City to construct its own traffic management center, saving the City millions of dollars in building construction costs. The City also has access to ATMS software through NDOR at no cost, saving the City up to $1 million initially for this functionality.
- **Removal of unneeded traffic signals**. When used appropriately, traffic signals perform an important and often necessary role. Over time, however, traffic conditions change. In some cases, existing traffic signals may no longer be needed, or they can even become a safety hazard. Existing traffic signals that are no longer justified should be removed which eliminates the costs required to upgrade the signals as well as recurring costs to operate and maintain them.

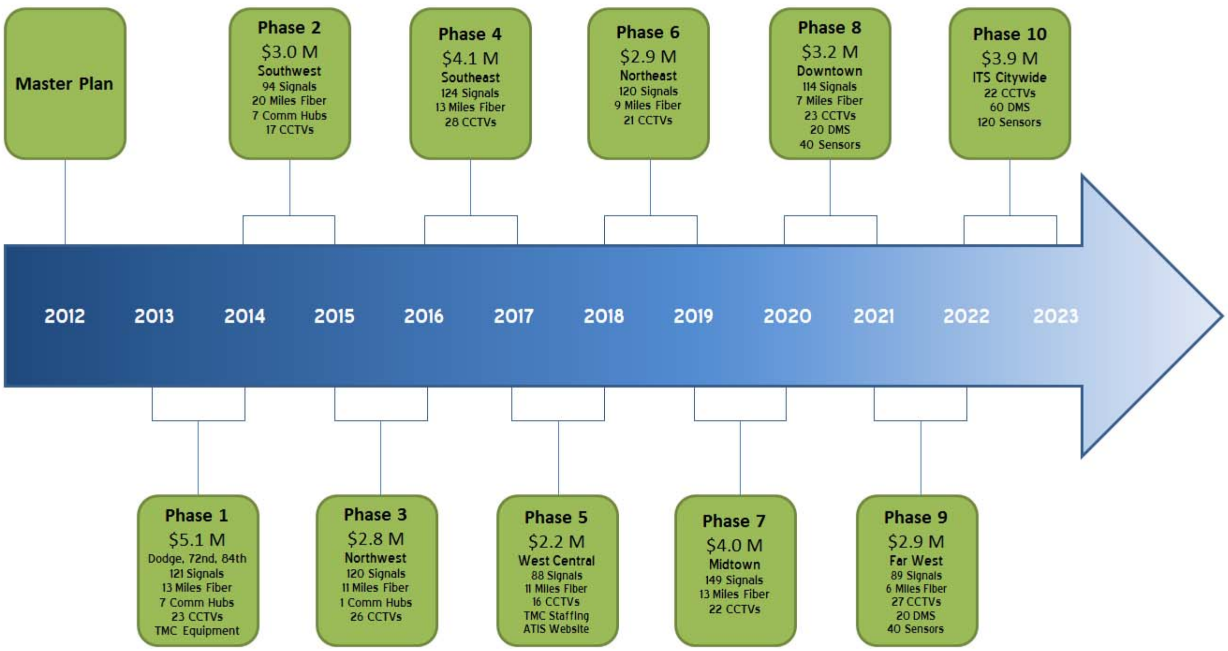
Deployment Strategy

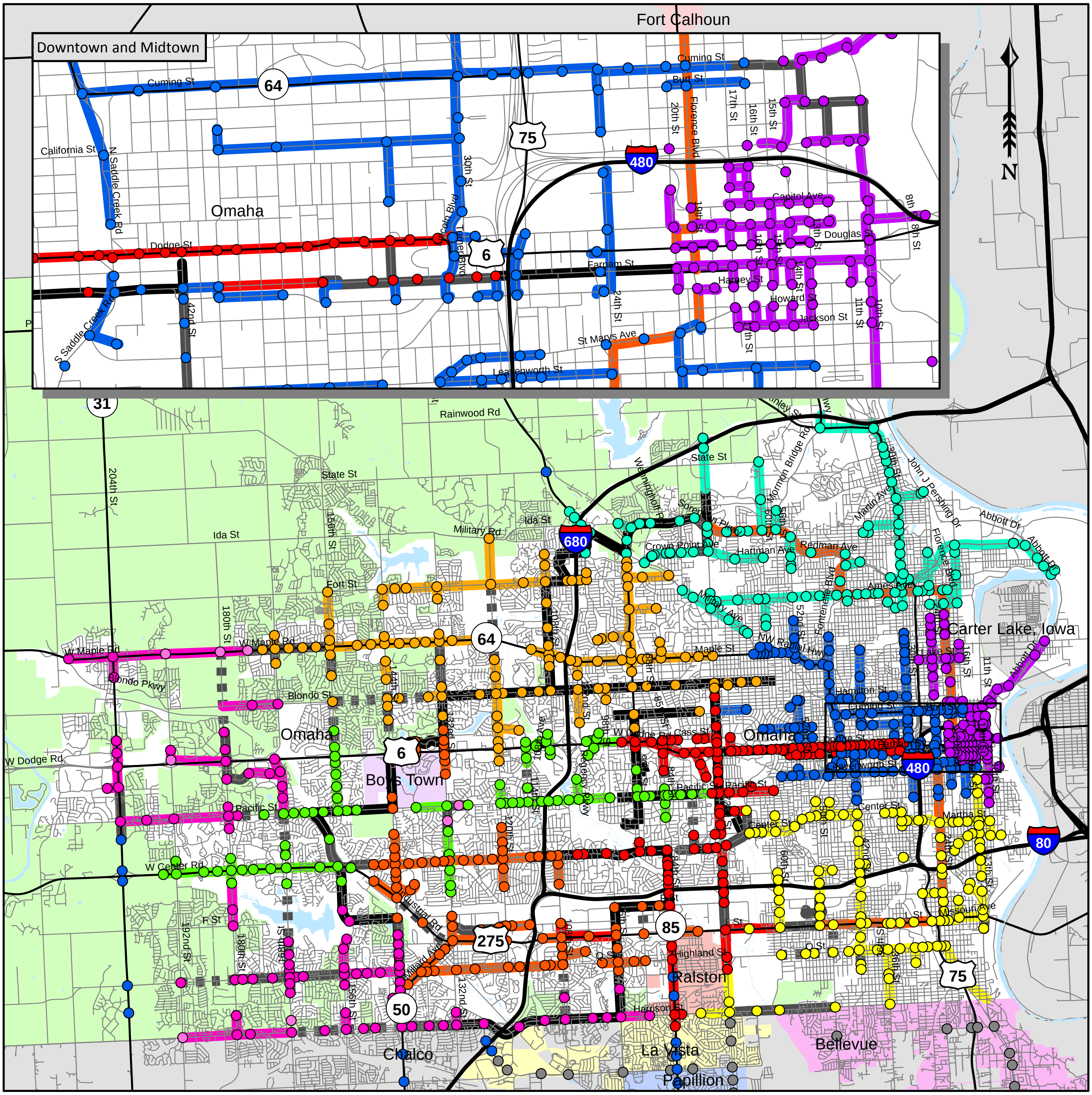
Recommended system upgrades are proposed to occur in 10 phases over a 10-year period. In general, the following table summarizes the geographic area and number of signals to be upgraded per phase. The figure at the end of this executive summary graphically illustrates the proposed deployment strategy.

Phase	No. of Signals	Geographic Area	Total Cost
1	121	Dodge, 72nd, and 84th Streets	$5,155,000
2	94	Southwest	$3,058,000
3	120	Northwest	$2,862,000
4	124	Southeast	$4,136,000
5	88	West Central	$2,272,000
6	120	Northeast	$2,923,000
7	149	Midtown	$4,046,000
8	114	Downtown	$3,247,000
9	89	Far West	$2,946,000
10	0	ITS Citywide	$3,954,000
Total	1,019	Citywide	$34,600,000

Next Steps

The City should move forward with deployment of the signal system which includes finalizing requirements for system software procurement and initiating design phases based on funding availability. Annual funding of $3.75 million was programmed by MAPA and City of Omaha over the next two years for the deployment of initial components of the traffic signal system; however, recent changes have modified the amount and timing of 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. These funds are obtained through approval of the NDOR safety committees, and a safety evaluation of the project(s) is required. Additional funding beyond that described above will likely be required to fully implement all projects identified in the master plan.





LEGEND

Existing City Fiber

Planned City Fiber (CIP)

Unite Fiber (by end of 2012)

0 1.25 2.5 5

Miles

Phase

1

2

3

4

5

6

7

8

9

Phase 10 (ITS Devices) not shown on this map.

Phasing Plan

DOCUMENT VERSION CONTROL

Document Name	Submittal Date	Version No.
Version 1.0	August 7, 2012	1.0
Version 2.0	June 27, 2013	2.0

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

A safe, efficient, and reliable transportation system is a vital component of a healthy and successful community. In Omaha, like many other cities, the level of safety, efficiency, and reliability is closely related to the performance of its traffic signal system. Traffic signals affect the lives of most citizens on a daily basis. While the green-yellow-red operation of the signals seems simplistic, it is an output of a complex system of computers, sensors, and communications that works in harmony to:

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The goal of this project is to develop a clear and flexible traffic signal system master plan that results in the right-sized traffic signal system, providing value, improved safety, improved traffic operations, increased efficiency, and public support well into the future.

The City of Omaha currently operates a traffic signal system that utilizes controllers and DOS-based management software that was largely developed in the 1970s and 1980s. The system communicates via dial-up modems to more than 60 closed-loop systems via on-street master controllers located throughout the City and an extensive twisted copper wire pair communications network. While functional, maintenance staff devotes an increasing amount of time to keep the communications system operational, while parts for the system are becoming increasingly difficult to obtain. In addition, the communications system is limited in its ability to transmit the required amount of data in a timely manner, and operations staff is unable to implement new traffic signal features that could improve the safety and efficiency for motorists, bicyclists, and pedestrians. In short, the system is functionally obsolete for many of the traffic management needs of a large and growing metropolitan area.

The City of Omaha and key stakeholders, including the Metropolitan Area Planning Agency (MAPA) and Nebraska Department of Roads (NDOR), have proactively been planning a major upgrade to the traffic signal system. 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 management center (TMC). It will also address intelligent transportation systems (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 greater Omaha area will be critical. The system will also need to be scalable and expandable to meet future system needs. **The goal of this project is to develop a clear and flexible traffic signal system master plan that results in the right-sized traffic signal system, providing value, improved safety, improved traffic operations, increased efficiency, 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 traffic signal system. To that end, a Strategic Communications Plan was developed that will guide City staff in achieving this important goal. The Strategic Communications Plan is included in Appendix A to the master plan.

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

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

2.0 SYSTEMS ENGINEERING

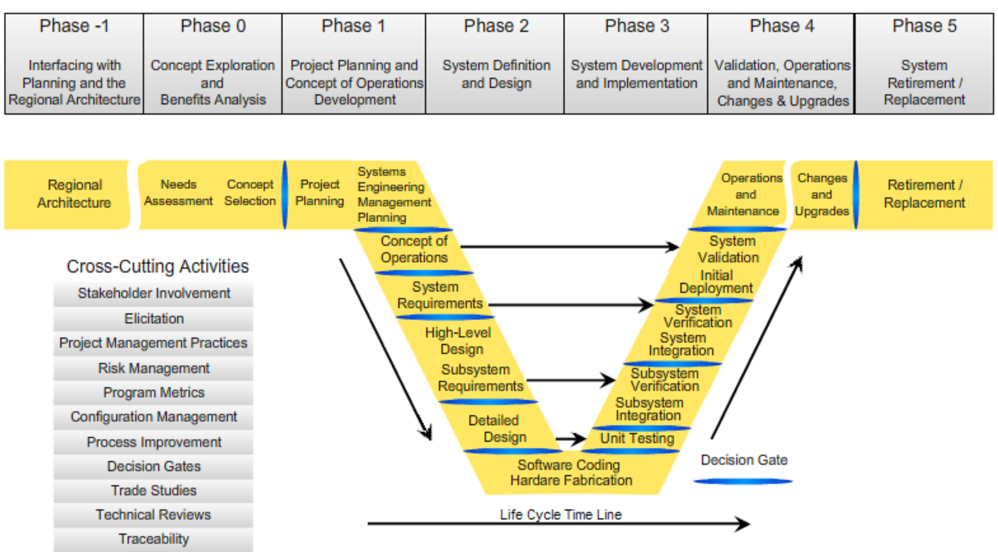
Systems Engineering (SE) documents were developed for four key deliverables. The Iteris team recently worked with the Federal Highway Administration (FHWA) and the Nebraska Department of Roads (NDOR) to develop template documents for the four SE documents that are intended to meet necessary documentation for projects in Nebraska. Deliverables include:

- **Project Plan** – This document provides a guide for all stakeholders that clearly define the Traffic Signal System Master Plan project scope, goals, schedule, and budget.
- **Systems Engineering Management Plan (SEMP)** – This document describes how the Systems Engineering Process will be integrated into the Traffic Signal System 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 requirements for the Traffic Signal System 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.

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.

The four systems engineering documents described above are provided as Appendices B, C, D, and E to the Traffic Signal System Master Plan.



3.0 EXISTING SYSTEM EVALUATION

One of the initial steps in developing a traffic signal system master plan for the City of Omaha 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.

Signal system 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 traffic signal system.

3.1 TRAFFIC SIGNAL SYSTEM

The components that were evaluated as part of the traffic signal system include: traffic signals, controllers, cabinets, detection, closed loop systems and software, uninterruptible power supply (UPS) systems, and signal ownership and maintenance agreements.

3.1.1 TRAFFIC SIGNALS

The City of Omaha currently operates 1,019 traffic signals. The City of Omaha owns 986 of these signals, while NDOR owns 7, Douglas County owns 24, and Sarpy County agencies own 2. Table 1 summarizes the number of traffic signals by type, including full vehicle installations, pedestrian installations, flashing beacons, lane control signals, speed feedback signs, and fire station (emergency) signals.

TABLE 1 – NUMBER OF TRAFFIC SIGNALS BY SIGNAL TYPE

Type of Installation	Number
Full Signal	830
Pedestrian Signal	119
Flashing Beacon	40
Lane Control Signal	19
Speed Feedback Signs	7
Emergency Signal	4
Total	1,019

In addition, eight signals are expected to be constructed and/or activated in the near future. Figure 1 illustrates the type and location of all traffic signals.

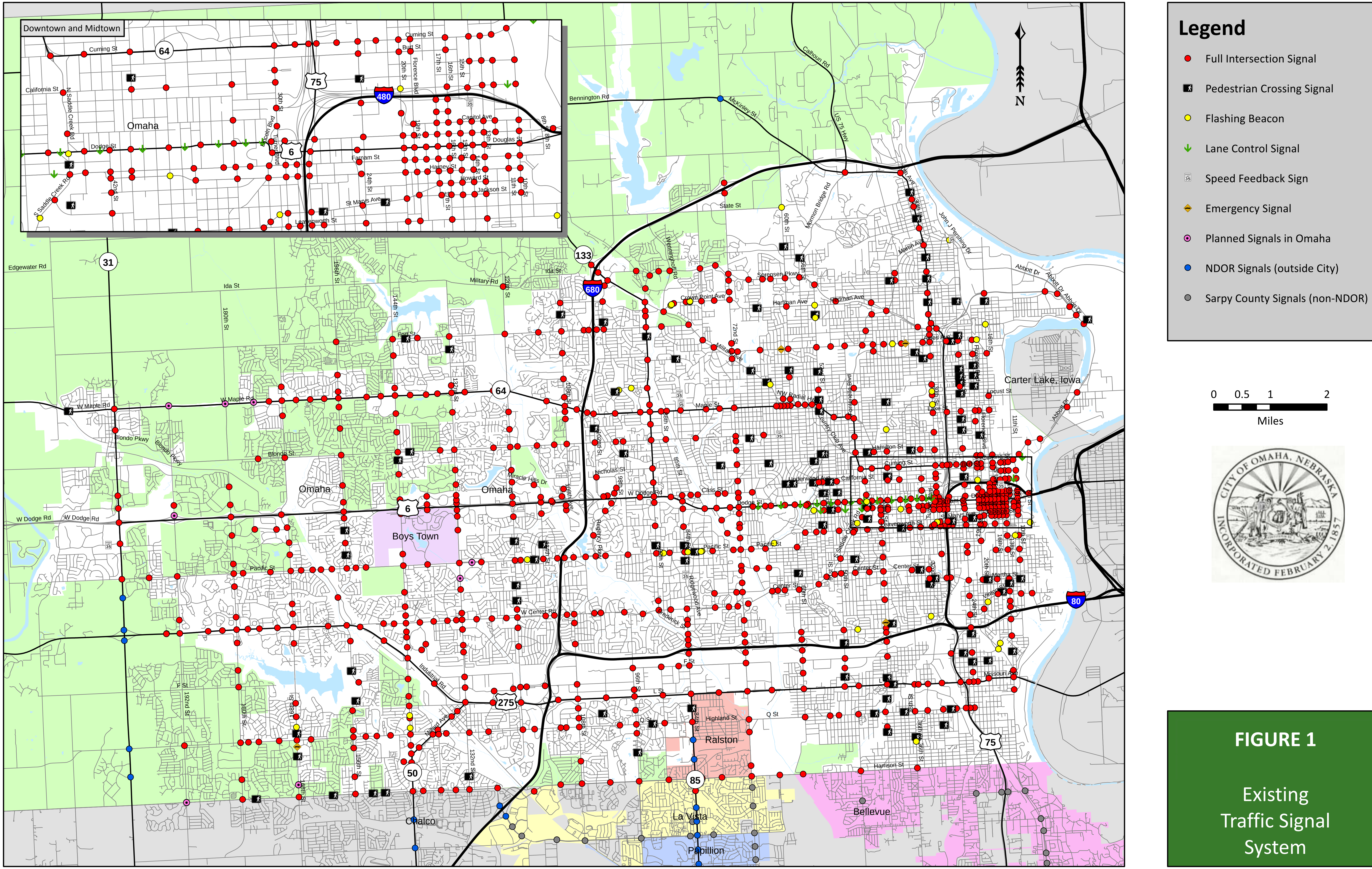


FIGURE 1

Existing Traffic Signal System

3.1.2 CONTROLLERS

All controllers in the field are Type 170E controllers operating on Wapiti Micro Systems local controller firmware, including W4IKS for actuated signals, W7OSM for on-street masters, and W9FT for fixed-time controllers. Ten intersections in the area around TD Ameritrade Park and the CenturyLink Center operate on 2070 controllers. The City of Omaha does own additional 2070 controllers. Figure 2 illustrates a cabinet with Type 170E local and master controllers.

FIGURE 2 – TYPE 170E LOCAL AND MASTER CONTROLLERS

3.1.3 CABINETS

The City of Omaha has a variety of traffic signal cabinets in the field. Table 2 summarizes the types of cabinets and the number of each used throughout the City.

TABLE 2 – TRAFFIC SIGNAL CABINET TYPES

Cabinet Type	Number
Type 303	343
Type 330	6
Type 332	269
Type 336	273
Type 336S	70
NEMA	50

NEMA cabinets are only used for most, but not all, flashing beacons and lane control signals. Figure 3 illustrates typical pad-mounted and pole-mounted cabinets. As shown in the figure, existing equipment uses virtually all available space in the pole-mounted cabinets. Figure 4 on page 9 illustrates cabinet types for all traffic signals.

FIGURE 3 – TYPICAL PAD-MOUNTED CABINET AND POLE-MOUNTED CABINET

3.1.4 DETECTION

Five types of vehicle detection were identified and summarized as part of the system evaluation: 1) inductive loops, 2) optical cameras, 3) wireless magnetic, 4) microwave, and 5) thermal cameras. These types of detection generally apply to vehicle-actuated full intersection signals. Of the 830 full intersection signals in the City, 154 operate in fixed time and currently do not require any detection, but may in the future dependent upon timing needs. In addition, pedestrian crossing signals generally use pedestrian-activated push-button detection. The remaining signals may or may not have detection, depending on their specific function and actuation requirements. Some signals utilize a combination of detection types. Table 3 summarizes the number of signals (not the actual number of devices) that use the various types of detection.

TABLE 3 – TYPES OF DETECTION CURRENTLY IN USE

Detection Type	Number of Signals
Inductive Loops	550
Optical Cameras	202
Wireless Magnetic	26
Microwave	2
Thermal Cameras	1

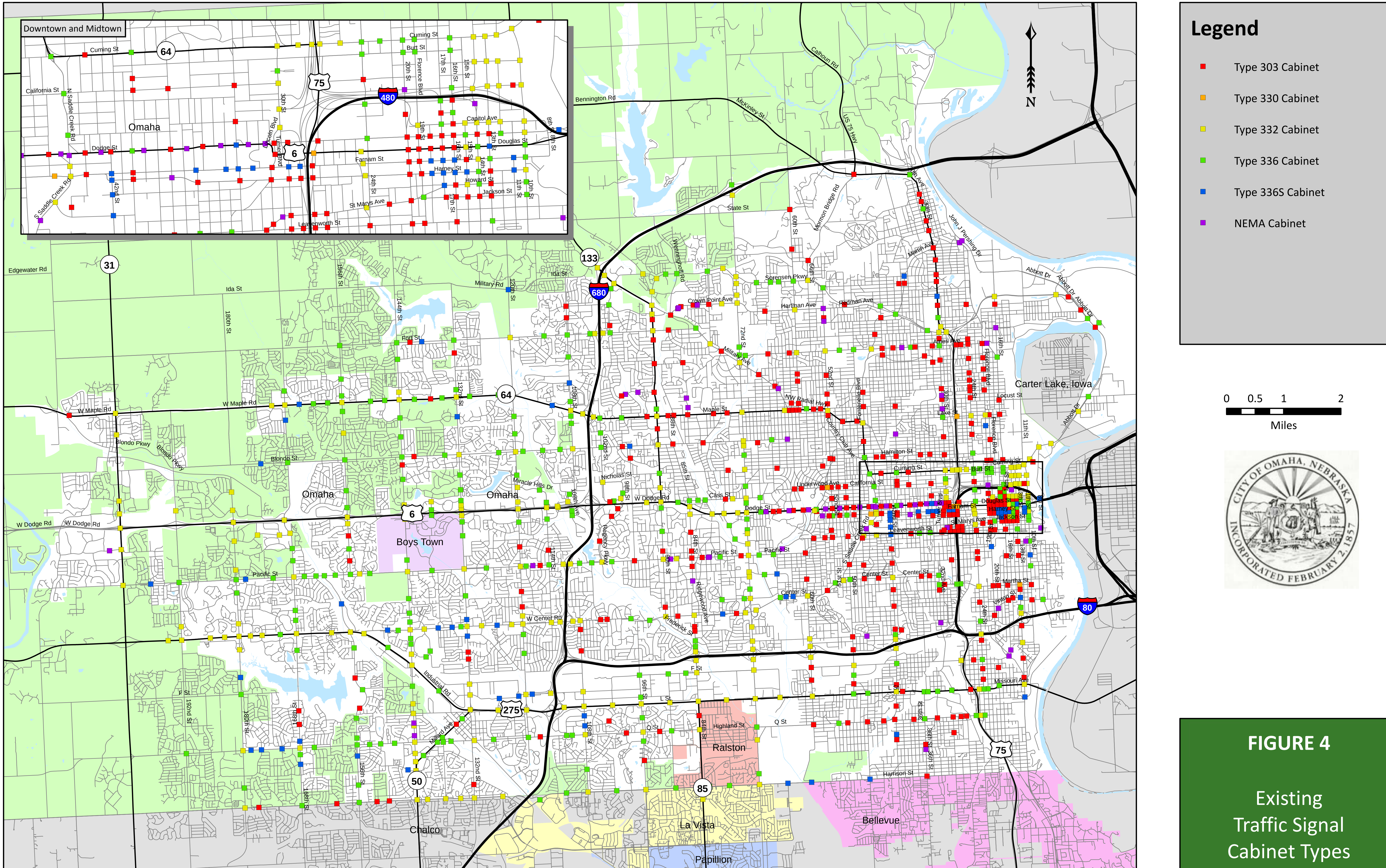


FIGURE 4

Existing Traffic Signal Cabinet Types

3.1.5 *Closed-Loop Systems and Software*

Currently, the City operates 72 closed loop systems, each with a master controller that communicates with the local controllers. Nine of these systems are stand-alone systems (only one signal in the system). Signals in stand-alone systems are generally located a significant distance from an adjacent closed-loop system. The remaining 63 systems have anywhere from 2 to 38 signals, with an average of 13 signals per system.

Of the 830 full intersection signals, 791 are part of a closed loop system. The remaining 40 are not part of a system and have no communications. Table 4 summarizes the number of signals in closed loop systems for each signal type. Figure 5 on page 11 illustrates the closed loop systems and master locations.

TABLE 4 – CLOSED LOOP SYSTEMS

Type of Signal	Number of Signals	
	Total	In Closed-Loop System
Full	830	791
Pedestrian	119	32
Flashing Beacon	40	2
Lane Control	19	6
Emergency	4	2

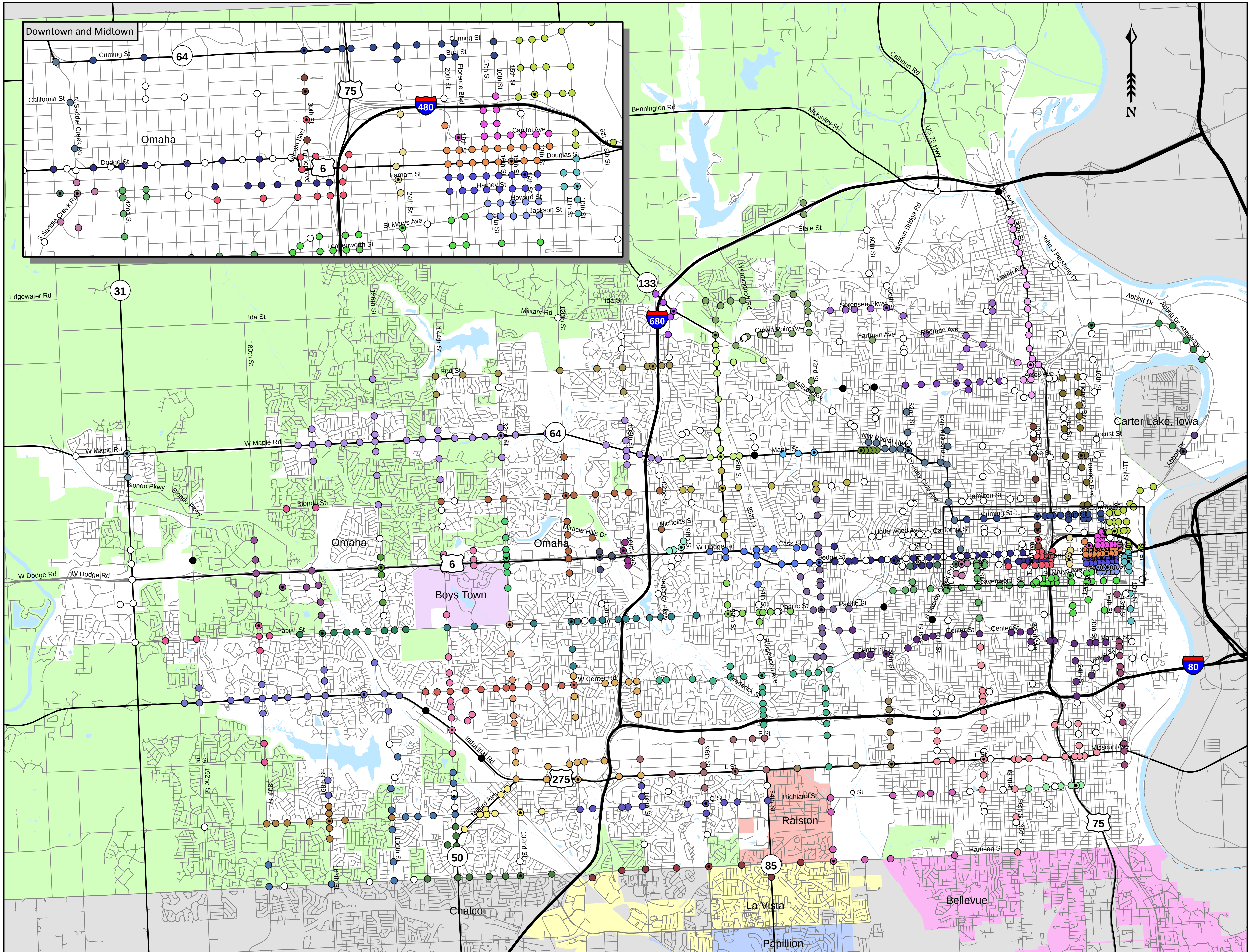
City staff communicates and uploads/downloads data to these signals through the Wapiti Traffic View software. This software is a DOS-based application that sends and receives data via dial-up modems to the master controllers in the field. This software is used on a daily basis to set time clocks, generate communication reports (to determine if/which signals are off-line), and to download signal timing data to controllers. This software is generally used by staff in the Civic Center or at the Traffic Maintenance Facility at 50th & G Streets, but can also be accessed via a virtual private network (VPN) connection after hours.

3.1.6 *Central Signal System Software*

The City is managing 10 intersections in North Downtown with 2070 controllers with the Centracs Advanced Traffic Management System. Communications to these signals are provided wirelessly via Encom serial radios atop the Civic Center. Centracs provides significant functionality for traffic signal management and some functionality for ITS device management.

3.1.7 *Uninterruptible Power Supply (UPS) Systems*

UPS systems are deployed at 22 signals. All but one is located at intersections. The other UPS system is located at the high water flashing beacon on Saddle Creek Road at the Dodge Street underpass. In general, several of these UPS system locations have been difficult to maintain and update with continued preventative maintenance due to staff commitments, differing system requirements, and battery charging cycle schedules. Comments were noted by signal technician staff regarding some systems not being operational when needed, intermittent operations, and dead batteries at specific locations.



Legend

- Master Controller*
- Local Controller*

** Each color represents a unique closed-loop system.*

- Standalone Master Controller
- Isolated Controller

0 0.5 1 2

Miles

FIGURE 5

Existing Closed Loop Systems

3.1.8 SIGNAL OWNERSHIP AND MAINTENANCE AGREEMENTS WITH OTHER AGENCIES

The City of Omaha owns, operates, and maintains all signals within the City limits. For signals located outside of the City limits but within Douglas County and a 3-mile planning jurisdiction, Douglas County owns the signal but pays the City of Omaha to operate and maintain the signals. Once any part of the land adjacent to the signal is annexed into the City, ownership of the signal transfers to the City of Omaha, and Douglas County ceases paying for maintenance. Douglas County signals are designed and constructed to the specifications of the City of Omaha, which facilitates this process. The City currently maintains 24 signals owned by Douglas County.

NDOR owns, operates, and maintains all signals located on state highways. In general, these functions transfer to the City once any part of the land adjacent to the signal is annexed by the City. Currently, there are eight signals on Highways 31, 36, and 133 that are located just outside of the existing City limits but within the 3-mile planning jurisdiction. NDOR also owns, operates, and maintains two signals on 84th Street (Highway 85) at Park Drive and Madison Street, which are located in Douglas County but on the borders of the Cities of Omaha and Ralston.

The City of Omaha also operates and maintains the signals on Harrison Street, which divide Douglas and Sarpy Counties. The City owns all of the signals, with the exception of those at 90th Street and 118th Street/Harry Andersen Avenue. The City has maintenance agreements with each respective jurisdiction in which the signal is located (Cities of Bellevue, La Vista, Ralston, Douglas and Sarpy Counties, and NDOR) to pay for maintenance costs and signal utility costs. Table 5 summarizes these agreements.

TABLE 5 – HARRISON STREET TRAFFIC SIGNAL MAINTENANCE AGREEMENTS

Traffic Signal	Maintenance	Utility Costs
36th St	Bellevue and Omaha	Bellevue
48th St	Bellevue and Omaha	Bellevue
60th St	Douglas County and Omaha	Douglas County
66th St	Sarpy County and Omaha	Sarpy County
72nd St	Omaha, La Vista and Ralston	Omaha
78th St	La Vista, Omaha and Ralston	Ralston/La Vista
83rd St	La Vista, Ralston and Omaha	Ralston/La Vista
84th St	La Vista, Ralston and Omaha	Ralston/La Vista
90th St	La Vista and Omaha	Ralston/La Vista
96th St	Omaha and La Vista	Omaha
102nd St	Sarpy County and Omaha	Sarpy County
108th St	Sarpy County and Omaha	Sarpy County
110th St	Sarpy County and Omaha	Sarpy County
118th St	La Vista	La Vista
Giles Rd	Omaha and Sarpy County	Omaha
132nd St	Sarpy County and Omaha	Omaha

Traffic Signal	Maintenance	Utility Costs
135th St	Sarpy County and Omaha	Sarpy County
138th St	Sarpy County and Omaha	Sarpy County
142nd St	Sarpy County and Omaha	Sarpy County
144th St	NDOR and Omaha	NDOR
150th St	Sarpy County, Douglas County and Omaha	Sarpy County
152nd St	Sarpy County, Douglas County and Omaha	Sarpy County
156th St	Sarpy County and Omaha	Sarpy County
161st St	Sarpy County, Douglas County and Omaha	Sarpy County
168th St	Sarpy County, Douglas County and Omaha	Sarpy County
177th St	Sarpy County, Douglas County and Omaha	Sarpy County
180th St	Sarpy County, Douglas County and Omaha	Douglas County

3.2 Communications Systems

The following sections describe the existing communications infrastructure currently in use, its condition, and other communications in place that could be utilized for the traffic signal system.

3.2.1 Existing Communications Infrastructure

There are currently three primary types of communications media throughout the City: 1) twisted pair copper (overhead or in conduit), 2) wireless radio, and 3) fiber optic. Table 6 summarizes the total mileage for City-owned communications for each type based on inventory data provided by City staff.

TABLE 6 – TYPES OF COMMUNICATIONS MEDIA AND AMOUNT IN USE

Communications Media	Mileage
Copper (overhead)	14.4
Copper (conduit)	153.2
Wireless Radio	47.3
Fiber Optic	22.4
Total	237.3

In general, the twisted pair copper lines are older than the wireless or fiber installations. Furthermore, twisted pair in the eastern portions of the City is older than that in the western portions. Most of the overhead installations are found in the eastern section of the City. Almost all twisted pair copper is 6-pair, although some 12-pair does exist.

Fiber optic installations generally coincide with roadway reconstruction and/or traffic signal improvements over the last several years (e.g., North Downtown, Midtown Crossing, Aksarben Village, Harrison Street, West Center Road and Industrial Road area, 192nd Street and West Dodge Road area). The City has been installing fiber optic interconnect since 1995.

Wireless communications are utilized at several locations around the City, primarily to communicate with signals that are relatively isolated or where hardwire communications has failed or not yet been installed. Currently, all radios are Encom brand. Figure 6 illustrates some of the existing communications pull box infrastructure.

FIGURE 6 – TYPICAL VARIED PULL BOXES AND FIBER VAULTS

3.2.2 Condition of Communications Infrastructure

As part of daily operations, the signal technicians at the Traffic Maintenance Facility at 50th and G Streets produce a daily communications report to determine which, if any, signals are not communicating. While all of the twisted pair copper is functional, technicians deal with recurring problems on a regular basis, primarily due to the fact that there are too many splices in the lines, or the conduit is in poor condition. Based on their qualitative knowledge of the system, the technicians developed a map that highlights sections of the communications network that is functionally obsolete. In total, technicians identified 22.2 miles of communications infrastructure (both overhead and in conduit) that is in poor condition.

Figure 7 illustrates the locations of all existing copper, wireless, and fiber installations throughout the City. Communications infrastructure identified as in poor conditions is also highlighted.

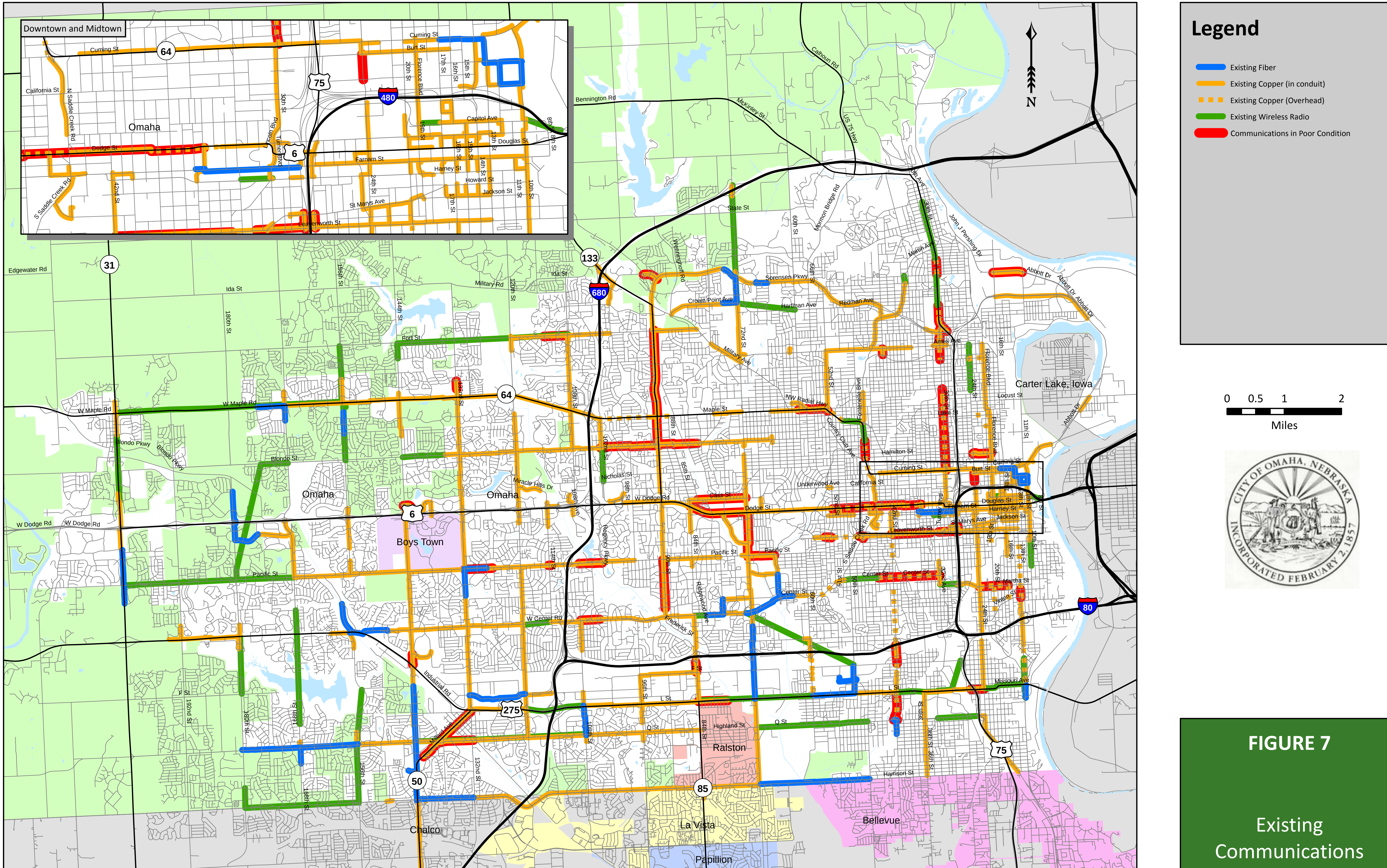


FIGURE 7

Existing Communications

3.2.3 Other Communications Infrastructure Available

In addition to the fiber optic segments that the City has already installed and owns, there are other entities that own additional fiber throughout the City. One such entity, Unite Private Networks (UPN), has a continuous, 21.6 mile section of fiber installed in City right-of-way, with an additional 14.6 miles planned. A potential contract between UPN and Omaha Public Schools (OPS) could provide additional fiber to the City. In addition, the City and UPN entered into an agreement in 2011 that provides at least 24 strands of fiber to the City for its exclusive use in exchange for UPN access to City right-of-way. Figure 8 illustrates a typical UPN fiber vault located near traffic signal cabinets along all UPN fiber installations. The existing and planned projects nearly create a complete fiber ring in the south central portion of the City.

Some other entities like UPN, including Cox Communications, were contacted to determine if similar agreements could be made to provide the City access to additional fiber. While no formal agreements were reached, Cox was open to working with the City in the future on a project-by-project basis.

FIGURE 8 – TYPICAL UNITE PRIVATE NETWORKS FIBER VAULT

The Douglas-Omaha Technology Commission (DOT.Comm), which is the information technology department for the City of Omaha and Douglas County, also owns a 96-pair fiber ring located Downtown. While DOT.Comm declined to provide the exact routing, the ring connects the following locations:

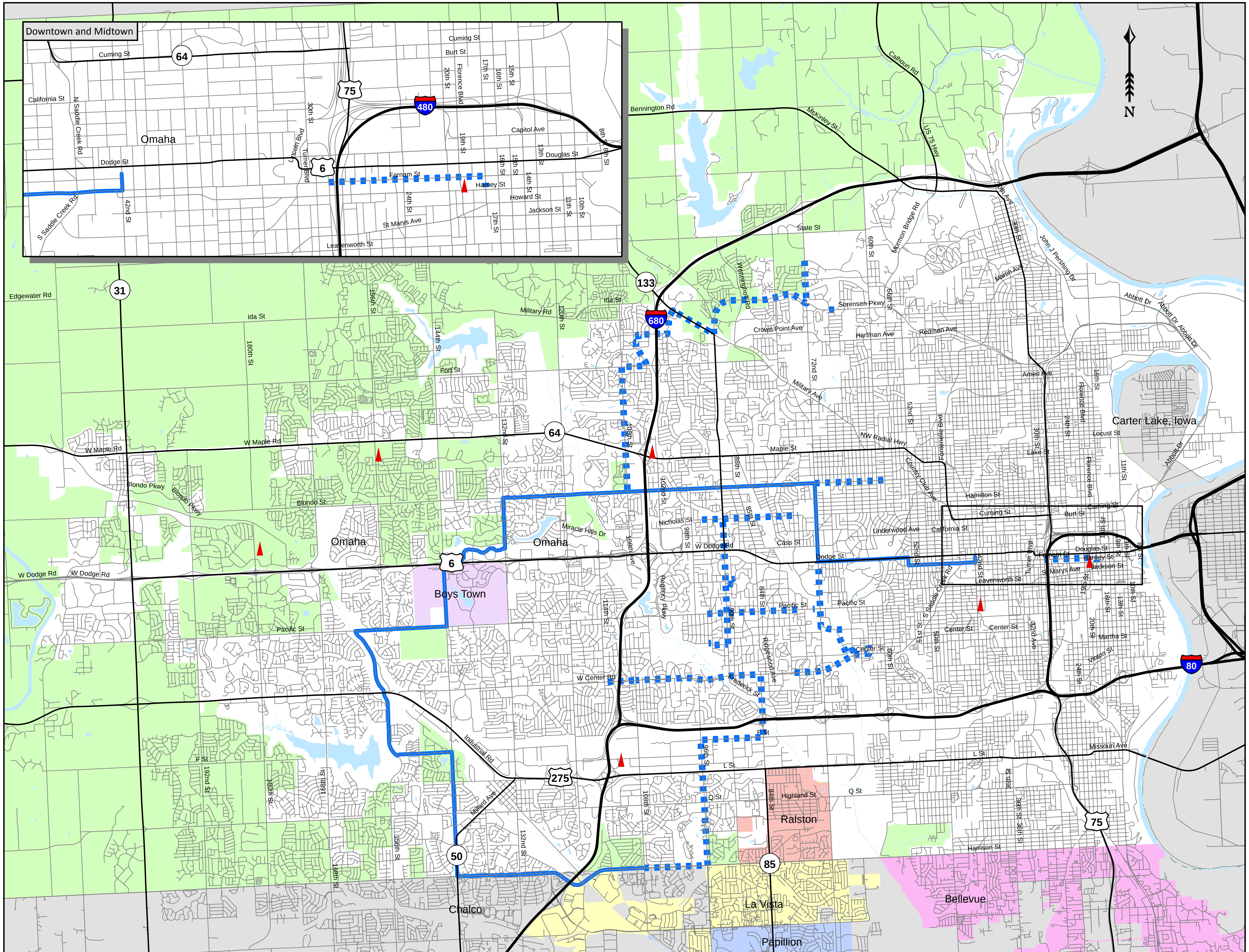
- Douglas-Omaha Technology Commission (DOT.Comm), 408 South 18th Street
- Civic Center, 1819 Farnam Street
- Douglas County Courthouse, 1701 Farnam Street
- Police Headquarters, 505 South 15th Street
- Fire Headquarters, 1516 Jackson Street
- Douglas County Corrections, 710 South 17th Street

DOT.Comm also provided information related to communications infrastructure owned by other agencies. Douglas County 911 maintains several microwave towers located around the County. These locations, as well as the UPN fiber, are shown in Figure 9.

There are additional towers located in Washington, Sarpy, and Pottawattamie Counties. These towers provide bi-directional communications and are primarily used for communications among the various county sheriffs. Fiber extends from some tower locations and is routed in various directions. These would be available for use if needed.

According to DOT.Comm, many City and County facilities located around the County are connected to the "Metro E" (Ethernet) system, which is maintained by Cox Communications. A few communications drops are provided by Cox at signal locations today, but according to City staff the status of these is intermittent, slow, and somewhat undesirable at present.

DOT.Comm does not work directly with any of the school districts in the City of Omaha, which include Omaha, Ralston, Westside, Millard, and Elkhorn. The only exceptions include joint school and public library facilities, which include the Saddlebrook Branch in northwest Omaha and the South Omaha Library.



Legend

- Existing Douglas County 911 Towers
- Existing UPN Fiber
- Planned UPN Fiber

0 0.5 1 2
Miles

FIGURE 9

UPN Fiber Network and Douglas Co 911 Tower Locations

3.3 Intelligent Transportation Systems (ITS) Devices

3.3.1 *Closed Circuit Television (CCTV) Cameras*

The City currently owns eight pan-tilt-zoom (PTZ) CCTV cameras. Six of them are IP addressable (Ethernet communications) and two are accessed via dial-up. In addition, the detection cameras (non-PTZ) at 144th Street and Q Street are also IP addressable. The City also has access to NDOR CCTV cameras via the Delcan NETworks software. NDOR has 24 cameras on Omaha area freeways, including I-80, I-480, I-680, US 75 (JFK Freeway), and US 6 (West Dodge Expressway).

3.3.2 *Dynamic Message Signs (DMS)*

The City does not own or operate any permanent DMS. NDOR does operate DMS signs on the freeway system in the City of Omaha. Figure 10 illustrates City and NDOR CCTV as well as NDOR DMS locations.

3.3.3 *Emergency Vehicle Preemption (EVP)*

EVP systems are currently deployed at 247 signals in the City. EVP systems include one or two receivers mounted on signal mast arms and in-vehicle transmitters within the various emergency responder vehicles. Figure 11 illustrates the signal locations equipped with EVP systems. All EVP systems use the Opticom Infrared technology to provide preemption for any emergency vehicle (typically police, fire, ambulance) equipped with a transmitter device and approaching a signal from any direction.

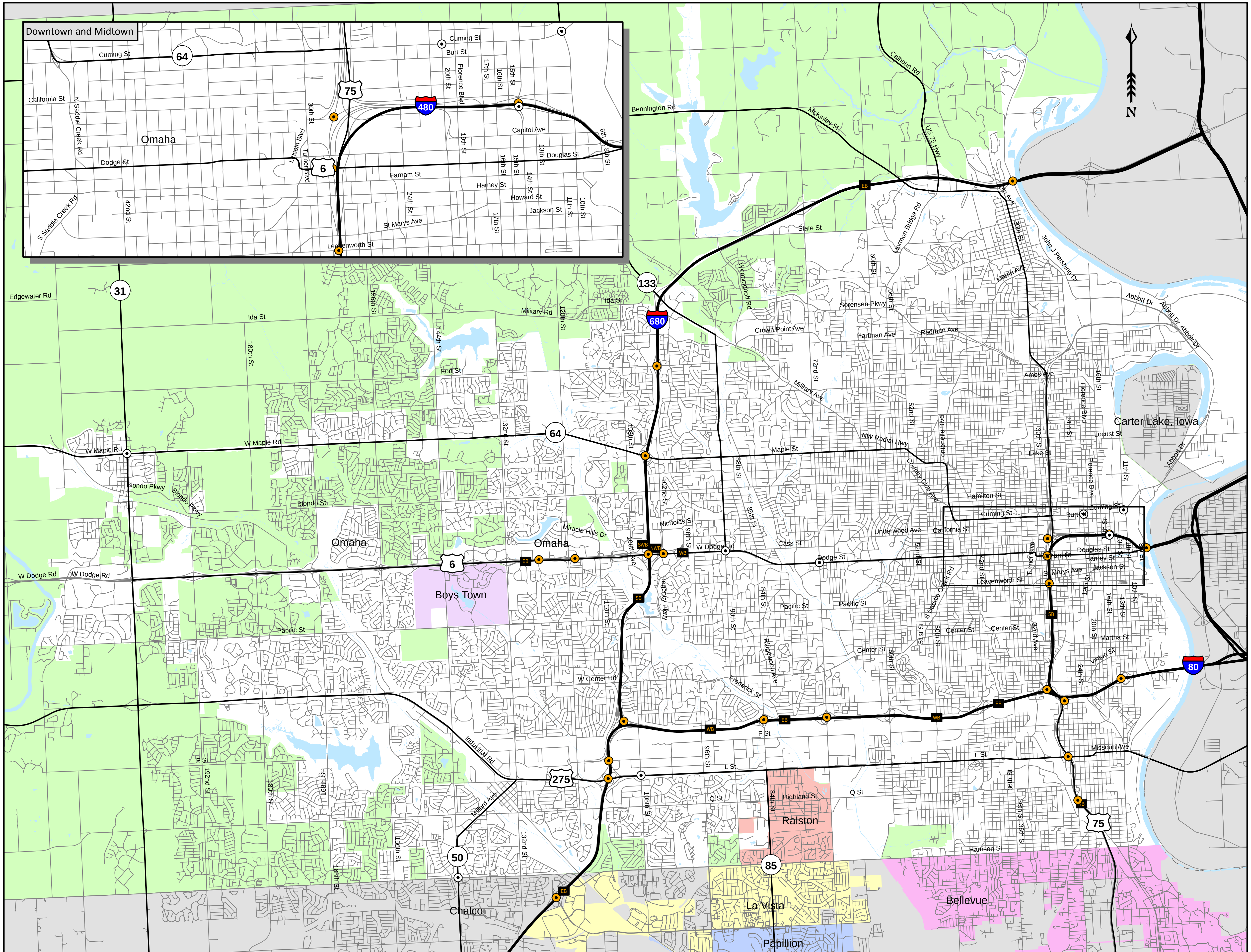
3.3.4 *Road Weather Information Systems (RWIS) and Anti-Icing Systems*

90th & West Dodge Road is the only location where the City currently operates an RWIS Station and in-pavement anti-icing system. The Street Maintenance Department is the primary user of the RWIS data and currently manually triggers the anti-icing system as needed.

3.3.5 *Parking Management Systems*

The City of Omaha currently does not actively manage any parking systems. The Metropolitan Entertainment and Convention Authority (MECA) currently owns and operates a parking management system for MECA-owned lots around the CenturyLink Center and TD Ameritrade Park in North Downtown. This system does include several dynamic message signs (DMS) on traffic signal mast arms used specifically for parking management purposes during special events.

The City Public Works Department currently maintains on-street parking meters and all City-owned parking garages. A centralized parking management system is being established as a division of the Public Works Department. A parking study recently completed by MAPA for the downtown area recommends consolidating all parking management activities to Public Works.



Legend

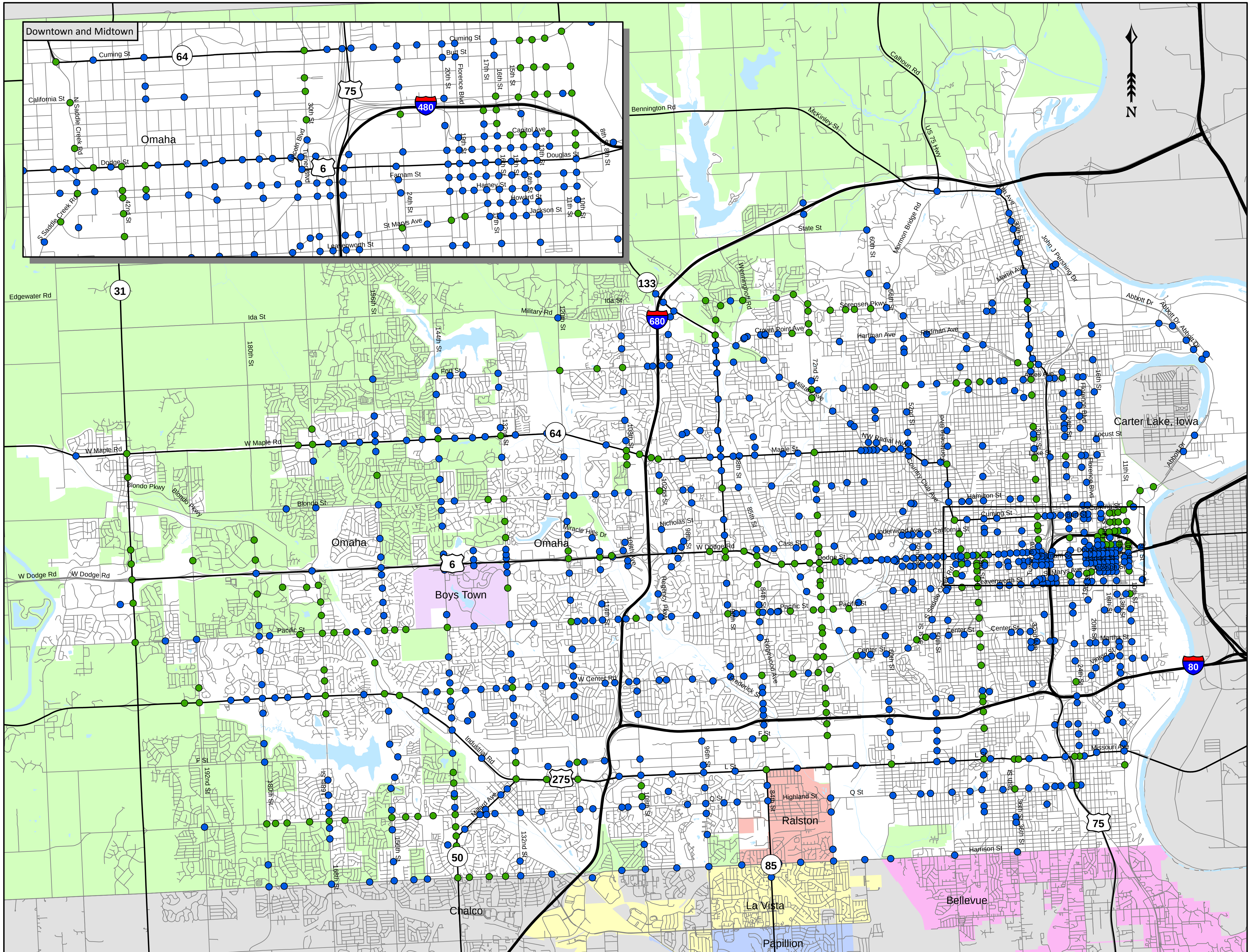
- Omaha CCTV Cameras
- NDOR CCTV Cameras
- NDOR DMS

** NDOR equipment are shown in a generalized, not exact, location.*

CITY OF OMAHA, NEBRASKA INCORPORATED FEBRUARY 2, 1857

FIGURE 10

City of Omaha and NDOR Cameras and DMS



Legend

- EVP Device not installed
- EVP Device Installed

0 0.5 1 2

Miles

FIGURE 11

Traffic Signals with Emergency Vehicle Preemption Devices

3.3.6 *Traffic Sensors*

The City does not own or operate any permanent traffic sensors for the purpose of collecting data on speed, volume, occupancy, etc. NDOR does have traffic sensors deployed on the freeway system in the City of Omaha, which collect speed data only.

3.3.7 *Transit Signal Priority (TSP) and Emergency Vehicle Priority*

Neither the City nor any other agencies (Metro Transit) operate any transit signal priority systems. Metro Transit is currently conducting the *Downtown-Midtown Transit Alternatives Analysis* (which is focusing on Dodge, Douglas, Farnam, and Harney Streets). MAPA will also be conducting a *Regional Transit Vision*, which will likely explore this technology (among others) for the entire region.

The City also does not operate any Emergency Vehicle Priority systems, which is different than an emergency vehicle preemption system described earlier. A priority system is GPS-based and is operated by a dispatcher from a central control center. Emergency vehicles assigned to the incident follow routes provided on in-vehicle displays, and the traffic signal system adjusts signal timing in real-time based on the location of the emergency vehicle in the street network.

3.4 Transportation System Management

3.4.1 *Facilities and Staff*

All staff that conducts work related to the traffic signal system is a part of the Traffic Engineering Division, which is located within the Transportation Services Section of the Public Works Department. Other divisions within Transportation Services include Construction, Design, Street Maintenance, Fleet Maintenance, and General Services. Figure 12 on page 23 illustrates the organizational structure of the Public Works Department.

The Traffic Engineering Division has 62 engineering, maintenance, technician, and administrative staff which are responsible for not only the traffic signal system, but also signing, pavement markings, traffic planning and design, parking meters, safety projects, traffic calming, driveway permits, and street lighting.

Currently, staff with positions related to the traffic signal system work out of one of two locations. Engineering staff is located in the Civic Center downtown, while maintenance staff is located at the Traffic Maintenance Facility at 50th and G Streets. NDOR District 2 also operates a District Operations Center (DOC) at 108th and I Streets which is staffed by the NDOR Operations Division and the Nebraska State Patrol (NSP). The facility was also designed to co-locate a City traffic management workstation within the DOC, allowing City staff to take advantage of the NDOR video wall and other equipment. Currently, no City staff is located there.

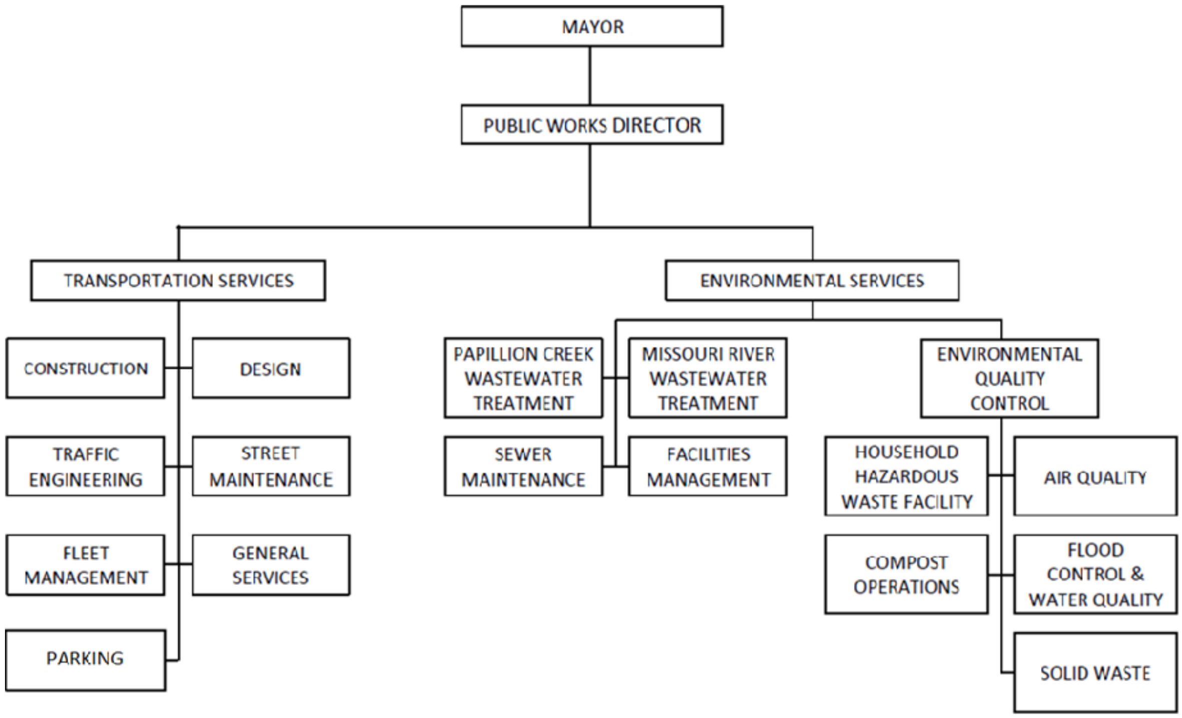


FIGURE 12 – ORGANIZATIONAL CHART FOR THE PUBLIC WORKS DEPARTMENT
Source: City of Omaha

Currently, there are eight engineering staff. Seven are located at the Civic Center. There is one Signal Operations Engineer who dedicates 90% of the time to signal timing and one Traffic Signal Engineer fully dedicated to signal design and signal warrants evaluations. Five other staff (three of whom are engineers) devote up to 20% of the time on traffic signal system related tasks. There is one additional staff, the Traffic Maintenance Engineer, who is located at the Traffic Maintenance Facility and oversees all traffic maintenance staff (not only signal maintenance staff).

In addition to engineering staff, there are seventeen traffic signal maintenance staff members based at the Traffic Maintenance Facility, including six Level II Signal Technicians (Tech II), six Level I Signal Technicians (Tech I), three Semi-skilled Laborers (two full-time and one part-time), one Cable Locator, and one Cable Checker. (One Signal Tech II position may be upgraded to a newly created Signal Tech III position). One Foreman III position is currently vacant. Staff is assigned to one of three groups: 1) District (East or West), 2) Shop, or 3) Project. Hours are generally 7:00 am to 3:30 pm on weekdays, however, the shifts of at least one worker in the Shop and each District are set to cover the afternoon rush hour and weekends.

The East District maintains signals east of 84th Street. It is staffed by one Level II Technician, two Level I Technicians, and one Semi-skilled Laborer Monday through Friday. An additional Level I Technician works Saturday through Tuesday to cover weekends.

The West District maintains signals west of (and including) 84th Street. It is staffed by one Level II Technician and two Level I Technicians Monday through Friday. An additional Level II Technician works Thursday through Sunday to cover weekends.

The Shop Group has two Level II Technicians conducting bench repair and other shop duties Monday through Friday. At least one staff is present between 6 am and 6 pm. The Project Group has one Level II Technician that inspects new installations, conducts special projects, and assists Districts as needed. The three Semi-skilled Laborers generally assist with cable pulling, digging, and installing signal heads and loops. These positions are not permanently assigned to Traffic Maintenance and could be reassigned at any time. Maintenance staff is on call 24 hours to respond to traffic signal related issues (malfunction, cabinet knockdowns, etc.).

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. Using these rules of thumb for the existing system, **the City should have an existing staff of 10 to 13 traffic engineers and 20 to 25 technicians**.

3.4.2 Traffic Signal Timing

Traffic signal timing at all 950+ traffic signals is conducted by the Signal Operations Engineer. 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. The engineer can communicate with signals on the closed loop systems from the office, but relies on traffic maintenance staff to upload timing to signals not on the communications system. Traffic maintenance staff is also responsible for delivering updated timing sheets to the cabinets. The engineer is 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) and operate in free or flash during the evenings and overnight.

3.4.3 Incident Management

There is no formal incident management program for surface streets in the City. In 2011, the Iowa Department of Transportation (Iowa DOT) sponsored a project to develop the *Omaha-Council Bluffs Traffic Incident Management Operations Guidelines*. As a participating agency, the City of Omaha has developed special timing plans to facilitate traffic diverted off I-80 between the L Street and 13th Street exits as a result of an incident. Timing plans were developed for Center Street and L Street as well as the connecting north-south arterials. While the timing plans are in place and can be activated in only a few minutes, continued improvements in coordination between agencies is needed to utilize the implementation of these timings. Figure 13 illustrates the traffic signals that are part of the I-80 incident management program.

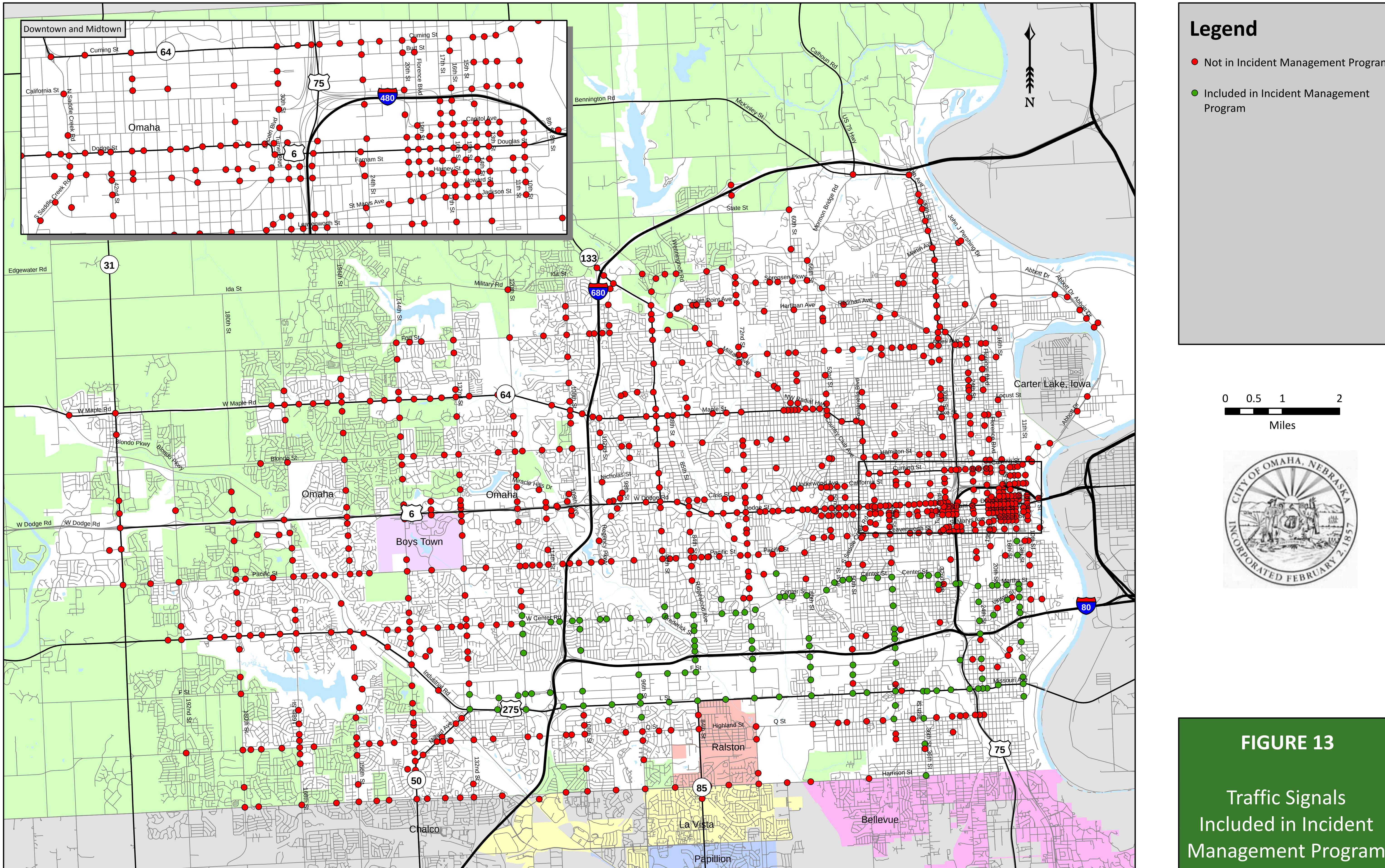


FIGURE 13

Traffic Signals Included in Incident Management Program

3.4.4 Congestion Management

Like incident management, there is no formal congestion management program on arterial streets conducted by the Public Works Department. The City does have special timing plans in place around the CenturyLink Center and TD Ameritrade Park to facilitate egress upon conclusion of events at those facilities. In many cases, the Omaha Police Department overrides these plans and operates the traffic signals by using hand cords and placing officers next to traffic signal cabinets.

3.4.5 Traffic Signal Preventative Maintenance

The City does have a traffic signal preventative maintenance program, which is logged in the TMIS database. All traffic signals are visited by a technician approximately once every 2 years, at which point the cabinets are cleaned and system components are tested and replaced as warranted. It was noted during the cabinet field review that due to the variability of signal hardware/equipment in the cabinets, some maintenance and troubleshooting activities are more difficult for newer signal technicians than others. Figure 14 illustrates the variety of equipment and a general lack of consistency in terms of the layout of wiring and certain devices within similar cabinet types.

FIGURE 14 –CABINET EQUIPMENT AND LAYOUTS

3.4.6 Communications Maintenance

Traffic maintenance staff monitors the status of the communications system on a daily basis. Every traffic signal on the system is polled every morning to determine if the signal is online. A report is generated which is then used to assign staff to investigate and resolve any problems.

4.0 NEEDS ASSESSMENT

Given the evaluation of the existing traffic signal system described previously, the needs assessment process is conducted to identify the stakeholder needs that must be satisfied in order for the City of Omaha to meet its goals and objectives relative to an upgraded traffic signal system.

Once needs have been identified, the “gaps” between the existing signal system and the future system that will be required to meet those needs were identified. In later steps, various alternatives and improvement options will be evaluated to determine which alternatives best “fill the gaps”. Ultimately, the best alternatives for each need will be summarized in a master plan, prioritized for deployment, and designed at a concept level to determine costs.

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 equipment (such as hardware, software, and communications), staffing, and traffic management needs for both existing and future conditions. The Concept of Operations discusses the operational scenarios in greater detail.

Based on evaluation of inventory, discussion with staff, and conducting operational scenarios, high-level needs, which have been divided into the seven categories, include:

1. Arterial Traffic Management
    - Improve operations for all modes of transportation
    - Improve efficiency of the traffic signal system
    - Improve efficiency of engineering, operations, and maintenance staff
    - Improve safety for all modes of transportation
    - Improve safety for engineering and maintenance staff
2. Safety Systems
    - Improve safety and operations for all modes during power outage or cabinet knockdown
    - Improve safety for drivers making left turns
    - 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
    - Improve performance of the traffic signal system
    - Improve efficiency of engineering and maintenance staff
    - Improve safety and operations for all transportation modes
    - Improve security and scalability of network to support traffic signal system goals

4. Incident Management
    - Improve operations for drivers 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
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. Maintenance and Construction Operations
    - Reduce failures of traffic signal system 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 preventative maintenance
    - Improve the consistency of traffic signal and ITS cabinets
    - Improve asset/infrastructure monitoring capabilities

From the meetings conducted with stakeholders, Table 7 summarizes the high-level needs, constraints, and expectations. Priority for each need 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 moves forward within the Concept of Operations and future Systems Engineering analysis and documentation.

TABLE 7 – PRIORITY AND STATUS OF STAKEHOLDER NEEDS, CONSTRAINTS, AND EXPECTATIONS

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS	PRIORITY	STATUS
1.0	**ARTERIAL TRAFFIC MANAGEMENT**		
1.01	Replace Type 170E controllers	H	N
1.02	Install upgraded software on controllers	H	N
1.03	Provide additional space in cabinets for additional components	H	P
1.04	Integrate traffic signals into a single traffic control system software	H	P
1.05	Integrate ITS field devices into a single management software	H	N
1.06	Designate central location for signal timing databases	H	P
1.07	Provide ability to easily update controller settings in the field	M	P
1.08	Improve system operation monitoring	H	P
1.09	Provide access to management software to various staff in various locations	H	P

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

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS	PRIORITY	STATUS
	management software		
2.07	Implement detection and develop timing specific to bicycles	M	N
2.08	Provide anti-icing systems on high-volume approaches with steep grades	L	P
2.09	Monitor speeds in real-time and conduct data collection at speed feedback sign locations	L	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	N
3.03	Provide staff in the field access to network	H	N
3.04	Provide the ability to transmit video	H	N
3.05	Provide central information clearinghouse	H	N
3.06	Develop interagency agreements	M	P
3.07	Provide communications to all signals	H	N
3.08	Provide remote access to the traffic signal network for management, software upgrades, and troubleshooting	H	N
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	M	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	P
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
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	H	N
5.05	Provide better work zone information and notification	M	P
6.0	**PUBLIC TRANSPORTATION**		
6.01	Provide transit priority at signals	L	N
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	**MAINTENANCE AND CONSTRUCTION OPERATIONS**		
7.01	Conduct preventative maintenance on traffic signals at regular intervals	H	P

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS	PRIORITY	STATUS
7.02	Standardize traffic control equipment	H	P
7.03	Standardize cabinet setup	H	N
7.04	Improve coordination on construction notification and information distribution	M	P
7.05	Improve work zone traffic handling plans	M	P
7.06	Monitor traffic remotely in and around work zones	M	N
7.07	Provide weather and pavement data collection to aid winter operations	L	P
7.08	Provide automated vehicle locations systems for maintenance and construction operations vehicles	L	N

Priority: H – High, M – Medium, L – Low; Status: N – Nonexistent, P – Partial, C – Complete

5.0 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 traffic signal system components and related ITS devices identified in the Needs Assessment and 2) summarize the recommended improvement strategies for each component that will satisfy the needs of the City of Omaha 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 systems engineering documents developed concurrently as part this project. These documents are provided in the Appendices D and E.

While this chapter recommends improvement strategies for each traffic signal system component, it does not seek to prioritize improvements either by system component (e.g., controllers, communications, traffic management 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 traffic signal system 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.

5.1 TRAFFIC SIGNAL SYSTEM

Traffic signal system components, including controllers, local controller software, cabinets, and ATMS are the basic components required to operate an efficient signal system. Each of these components is described in the following sections.

5.1.1 CONTROLLERS

The traffic signal controller acts as the brain of a signalized intersection. Traffic signal controllers provide functionality for signal actuation and providing vehicular and pedestrian traffic with appropriate timings. 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 8 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 Omaha currently operates most signalized intersections with Type 170E controllers in a mix of cabinets. The controllers operate with Wapiti firmware. There are 10 intersections around the CenturyLink Center and TD Ameritrade Park that are operated by 2070 controllers.

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

- Retain existing Type 170E controllers
- 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. Certain funding sources for installing Type 170 controllers are limited moving forward. In addition, Type 170 controllers have limited memory and processing capabilities, and cannot provide some of the new traffic signal operations permitted in the current Manual on Uniform Traffic Control Devices (MUTCD). Type 170 components (for repairs) are becoming more difficult to find (and purchase new) and will continue to be so in the future. 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. While the City does have an existing limited stock of 2070 controllers that could be utilized at some locations, **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.

5.1.2 Local Controller Software

In 2070 ATC controllers, much of the functionality of the traffic signal lies in the local controller software and not in the controller itself. Therefore, it is important to select local controller software that meets the needs identified in the Needs Assessment document. The table in Appendix F compares and contrasts a sampling of features and functions of the eight local controller software packages that are currently available on the market.

Based on the table in the Appendix F, the following four vendors provide the most features and functions:

- Northwest Signal Voyage
- Fourth Dimension Traffic D4
- Econolite ASC/3
- Intelight Maxtime

The City of Omaha should migrate to a single local controller software platform based on final system requirements developed in the initial project deployment phase. The selection of local controller software will be closely related to the controller hardware and central ATMS software.

5.1.3 Cabinets

The City of Omaha has a variety of traffic signal cabinets in the field. While most of the existing cabinets can accommodate the 2070 ATC controllers recommended in the previous section, many of the cabinets are at or near capacity with existing equipment. **It is recommended that all cabinets be converted to Type 332 cabinets, except in the downtown area or where limited right-of-way exists.** This cabinet type will provide additional space for equipment such as detection and video monitoring that may be added to cabinets in the future. **Pole mounted cabinets (where necessary) should generally follow a Type 346 configuration, which allows more space for equipment and future communications capabilities.** Some installations, such as communications hubs or locations with many devices, may require larger ITS cabinets (double 332). Based on existing inventory, there are already 269 Type 332 cabinets in the field.

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 Omaha traffic signal system is mostly comprised of Type 170E controllers in a mix of cabinet types, connected through a mix of communications media including twisted pair copper, wireless, and fiber optic cable. 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 each location. This promotes consistency and ease of maintenance. Staff should be able to open a cabinet door at any traffic signal and see nearly identical layouts of equipment and cabling.

5.1.4 Advanced Traffic Management System (ATMS)

Currently, the City operates 72 closed loop systems, each with a master controller that communicates with the local controllers. Nine of these systems are systems that are made up of a single signal. The remaining 63 systems have anywhere from 2 to 38 signals, with an average of 13 signals per system. City staff communicates and uploads/downloads data to these signals through the Wapiti Traffic View software.

The City is managing the 10 intersections with 2070 controllers with the Centracs Advanced Traffic Management System. Communications to these signals are maintained wirelessly via Encom serial radios atop the Civic Center. Centracs provides significant functionality for traffic signal management and some additional functionality for ITS device management. While Centracs is compatible with 170 controllers using Wapiti software, it is not compatible with the most recent version (version 62) the City currently uses. Also, Centracs is currently unable to communicate with any controllers via dial-up modem communications.

Like local controller software, the table in Appendix G compares nearly 300 various features and functions of some of the most common ATMS software 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 stakeholders' needs. While none of the systems summarized meet all features and functions, the following four ATMS vendors provide the most:

- Kimley Horn KITS
- Econolite Centracs
- TransCore TransSuite
- Naztec ATMS.Now

Because of the compatibility and communications limitations with the existing ATMS, the City has limited options for managing traffic signals during the migration of the traffic signal system from its current state to ultimate build out. The desired method for managing traffic signals during the build out of the communications system may have an impact on project phasing and the total amount of funding required. The options for the phasing of the traffic signal system upgrade are:

1. Operate two separate systems for dial-up and Ethernet. Under this scenario, the existing Wapiti software over dial-up communications to closed loop systems would be maintained. Management of traffic signals would be transferred from the closed loop dial-up system to the Ethernet-based ATMS as components (hardware, communications) at a group of intersections are upgraded in phases.
2. Operate a single ATMS compatible with Ethernet and dial-up. Under this scenario, the City could purchase an ATMS that is capable of communicating with existing 170s via dial-up, and upgrades would take place in the same way as the previous option. While the full functionality of the software could not be utilized until Ethernet communications is established, all signals could be managed in a single software package while maintaining capabilities available with the existing closed loop software. Only a limited number of ATMS products on the market support dial-up communications, or have limited capability to do so.
3. Operate a single ATMS over Ethernet only. This scenario requires upfront communications upgrades to make the existing 170E controllers Ethernet-ready. The existing 170E controllers are currently equipped with serial ports, but are also able to accommodate an Ethernet module. There are various options and solutions available for the existing controllers that can provide Ethernet-ready communications including:

    - Serial to Ethernet (SLIP) Converter: This equipment converts serial data coming in and out of the 170E traffic signal controller into Ethernet data. Though it is relatively inexpensive to install a SLIP (approximately $350 per unit), and it is compatible with the existing traffic controllers, there are some disadvantages to this solution. These include latency in transmission, often resulting in the signal being offline periodically and higher operations and maintenance (O&M) costs.
    - Modem upgrade: This solution involves replacing the existing 170E controller modem with an Ethernet module. As with the SLIP, this solution is also relatively low in cost (approximately $500 per unit) but has lower O&M costs associated with it. The only perceived disadvantage of this solution is if the existing controller already has reliability issues that may inadvertently be associated with the port replacement.

    Ethernet communications can be provided over the existing twisted pair copper interconnect via a connection to the fiber backbone or, if not in close proximity to the backbone, via a third party such as Cox Communications or CenturyLink.

These options for added costs to existing controller locations need to be carefully weighed as these “temporary” costs ($350,000 - $500,000 for SLIP or modem upgrades) during interim time frames potentially reduce budget available for other permanent system costs. Based upon information from the stakeholder feedback to date, while it is not desirable to run two separate systems (new and old), it could be managed adequately. The desire to add improved Ethernet communications to the existing controller locations, and manage them under a new central system will become more apparent as a larger percentage of the Citywide system is upgraded.

While the City currently does not operate and monitor existing CCTV cameras through any ATMS software, it has a need to do so, especially as it deploys additional cameras and other ITS devices throughout the City. NDOR currently provides the City with a license to use the statewide ATMS package (Delcan NETworks). This current statewide ATMS is utilized solely to manage ITS devices and not traffic signal system control as currently defined for the NDOR. This ATMS package does offer a separate traffic signal module with specific capabilities.

By leveraging this NDOR-provided ATMS for ITS devices, the City of Omaha could manage city-owned ITS devices and have "viewer" privileges of relevant NDOR ITS devices (CCTV and DMS) in one software package, and manage their specific traffic signal system in another. This would allow for desirable coordination between local NDOR District staff and City of Omaha staff to proactively manage incidents and share information, while helping to mitigate City licensing and integration costs for ITS device management.

Another strategy could combine management of all City ITS devices into the same software as the traffic signal system. Each of the ATMS packages have various modules for ITS field devices, typically at additional costs. **It is recommended the City initially use the license for Delcan NETworks ATMS software provided by NDOR, with the requirement that the ATMS the City procures for signal system management has the modules available to also manage ITS devices.**

Ultimately, the City of Omaha should 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 System Manager to 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 the existing system of 170 controllers with Wapiti 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 long-term software deployment phases.

5.2 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 Management Center (TMC). The data can be brought back to the TMC through several methods, a few of which are presented below.

5.2.1 Hardwire 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 can operate on 300 to 3000 Hz with typical data transmission rates of 1200 to 9600 bits per second (bps), but the trend is moving toward 19.2 kilobits per second (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 8 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 (Mbps).

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 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. Also, existing installations of twisted pair cable rarely include spare pairs for future use and it is generally not recommended to splice existing TWP SIC due to degradation in transmission quality.

The City of Omaha relies heavily on TWP SIC to transmit traffic signal controller data to the Civic Center and the Traffic Maintenance Facility. **No new installations of TWP SIC are recommended for the City at this time**, unless required to keep existing system operational**.** If the City retains the existing TWP SIC segments, particularly in the migration to a fiber optic cable, installation of additional equipment is recommended to provide Ethernet communications. Retaining the existing TWP SIC should be considered for 'last mile' communications to select signalized intersections, as a cost savings measure compared to installing new fiber optic cable in the existing conduit that supports the existing TWP SIC.

FIBER OPTIC CABLE

There are two major types of fiber optic cable – single-mode and multi-mode. Multi-mode 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 Traffic Signal System 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.

Fiber optic cable is envisioned to be the primary option to replace the existing twisted pair cable in the City of Omaha. Depending on the conditions of the existing conduit, installing the fiber optic cable may require the cable to first be installed within microduct. 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 is also a viable option to replace existing wireless communication links and/or complete existing communication gaps along the primary communication paths; as with TWP SIC, wireless is a viable solution for 'last mile' communications. Though installation costs for these will be significantly higher as new conduit is required, it will provide enhanced reliability and flexibility for future ITS elements. It is assumed that, where existing wireless equipment will be maintained, it will be upgraded, if necessary, to an IP-based protocol.

Dial Up Telephone Line

Dial up telephone lines, also called phone drops, utilize regular telephone lines that have a dial tone and an assigned, unique telephone number. Since the telephone company (local service provider) intends to time-share the available quantity of regular dial-up telephone line circuits among its many subscribers, this communications media is best for data communication which are sporadic, not continuous. The local service provider has structured the monthly rate on this type of service to achieve this type of usage.

Dial-up service also entails a small amount of time latency in establishing the communications link. Faster speeds are possible with dial-up, but link activation requires several seconds to connect. If the data exchange between a system and the controller isn't continuous, and the time delay in establishing the communications link is acceptable, then dial-up service provides a very attractive solution, both for cost and for integrity of the communications link. While individual leased data lines have been notorious for being accidentally "reused" by telephone company technicians, it is unlikely that individual dial-up telephone service is disrupted.

Dial-up service is currently being used at existing master controller locations to support communications with most signalized intersections. With the proposed communication improvements, it is envisioned that the need to use the phone drops will be negated. **No new phone drops are recommended for use in the City at this time.**

Leased Line Circuits

Obtaining communications links from a 3rd party provider is a valid method of quickly obtaining communications connectivity to individual locations and/or complete networked implementations. The monthly rates for these leased services include a base component, plus surcharges that are based on the distance of the link, the amount of bandwidth provided by the link and in some cases the time usage of the link. Authorized tariff charges will normally include a one-time charge for installation and hookup, a monthly charge for line and system use, and subsequent line conditioning costs. However, reliability of the leased line is an issue and there is a risk when leased lines support critical applications.

Traditional leased line communications as described above are not recommended as a permanent solution for use in the City at this time; however, they could be used in the

interim to establish Ethernet communications to certain traffic signals. While the City of Omaha has an agreement for fiber sharing with Unite Private Networks (UPN), the agreement is structured such that there are no ongoing fees for a service so it is not considered to be a leased line.

5.2.2 Wireless Communications Alternatives

The City of Omaha currently uses some wireless links to establish communications with traffic signal controllers.

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 not likely to 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 24 GHz microwave link consisting of a pair of approximately 12-inch microwave dishes 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 radios 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 radios can also be licensed; licensed microwave radios 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.

The City should consider microwave communications, particular for backbone or long distance needs.

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 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.

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 square miles of overlapping hotspots.

A typical Wi-Fi setup contains one or more Access Points (APs) and one or more clients. An AP broadcasts its service set identifier (SSID) via packets that are called beacons, which are broadcast every 100 milliseconds (ms). The beacons are transmitted at 1 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 of IEEE 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.

Wi-Fi technology, in the form of broadband radios, is a possible alternative to close existing communication gaps along 'last mile' segments.

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, 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 70 Mbps, which is enough to service 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 connection. 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.

The City of Omaha could consider deploying WiMax communications as a short- or mid-term wireless solution for traffic operations.

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.**

5.2.3 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 requires 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.

5.2.4 Communication Infrastructure

To serve the City of Omaha's 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 best but most 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 it would be less costly than installing new conduit. If multiple devices requiring high-bandwidth (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 fiber optic 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 serial data to IP-based communications. 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 TMC, 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 TMC will need to flow along the loop, thus it will be sized according to the future bandwidth needs.

This architecture assumes three different cables, 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 TMC.
- 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.
- Drop cables run from these splice vaults to a splice tray within the field cabinet and connects the distribution cable to the field elements.

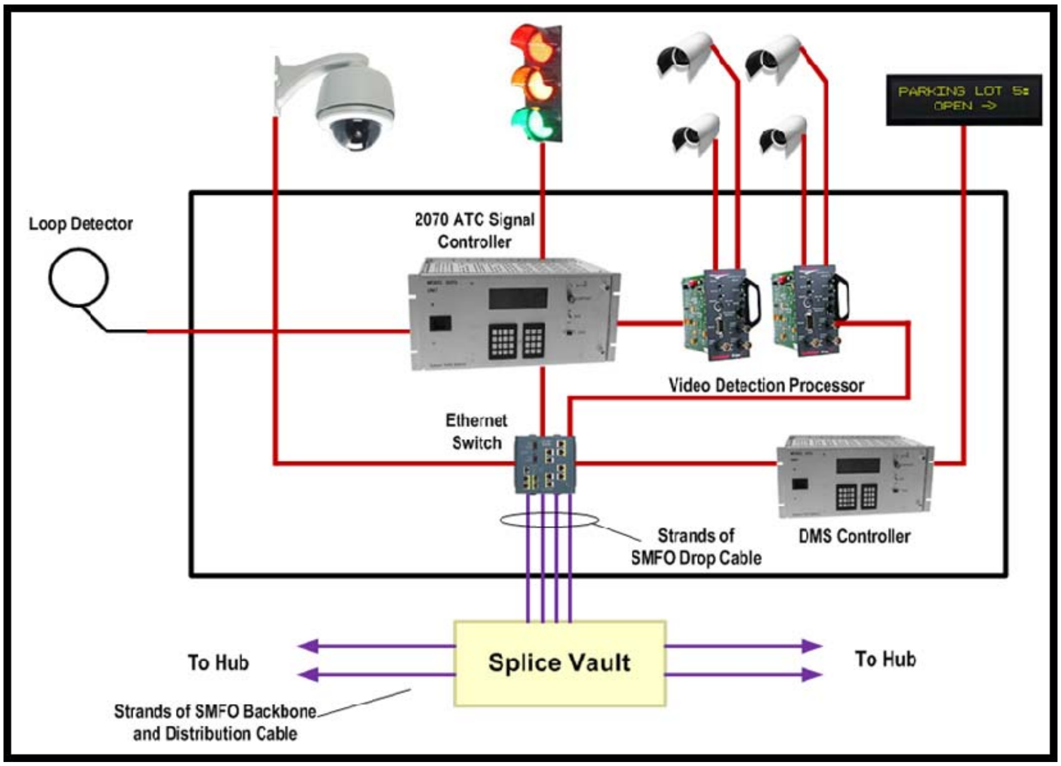


FIGURE 15 – ILLUSTRATION OF DISTRIBUTION AND DROP CABLES

All cables are assumed to be single-mode fiber optic cable. Transmission is assumed to use a 1310 nanometer (nm) 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/communications 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 eight hub locations:

- Hub 1: Bob Boozer Drive and Pacific Street
- Hub 2: 108th Street and I Street (NDOR DOC)
- Hub 3: 72nd Street and West Center Road
- Hub 4: 50th Street and G Street (Traffic Maintenance Facility)
- Hub 5: 19th Street and Farnam Street (Civic Center)
- Hub 6: 30th Street and Ames Avenue
- Hub 7: 108th Street and Blondo Street
- Hub 8: 72nd Street and Dodge Street

Communication hubs located in field cabinets will require the use of hardened Gigabit Ethernet switches. Communication hubs located in City facilities will not require the use of hardened equipment as it is assumed the hubs will be located in environmentally controlled areas. A large portion of the fiber backbone ring will utilize fiber installed by Unite Private Networks. The 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 and other ITS devices between communication hubs and various field elements.

The design uses a hub and spoke topology. The spokes will be distribution cables connecting field elements using dedicated or daisy chained connections. Daisy chain connections are assumed to be utilized wherever fiber optic cable exists. Most of the signals on arterial roadways will be served by fiber optic communications, while traffic signals on collector or local roads will be served by wireless communications. Signals located on non-urbanized roadways in developing areas can also be served by wireless communications until those roadways are urbanized, at which point fiber optic interconnect should be installed. The proposed communications network required to connect all existing and planned traffic signals is identified in Chapter 6.0.

5.2.5 City Facilities Coordination

Opportunities to share costs of installing shared communications infrastructure should be explored. 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 City facilities proposed communications conduit along the City's major corridors can provide the backbone communication network for future expansion by other City departments.

5.3 Intelligent Transportation Systems (ITS) Devices

5.3.1 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 TMC or 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 TMC 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.

To provide the City with additional tools to monitor intersection conditions, it is envisioned that CCTV cameras with PTZ will be deployed across the city at the intersections of arterial roadways and closer spacing on select corridors and certain areas including Downtown. Proposed locations of CCTV cameras are further discussed in Chapter 6.0.

5.3.2 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. 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 City TMC.

A typical arterial DMS is sized to be about 4 to 6 feet high and 8 to 10 feet long and are capable of displaying 3 rows of text. Examples of arterial DMS are illustrated in Figure 16. DMS are typically located mid-block between signalized intersections in advance 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.

FIGURE 16 – EXAMPLES OF SINGLE- AND DUAL-SIGN CANTILEVER DMS INSTALLATIONS

Portable signs (like those currently used by the City) can vary in size and include a generator 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 City TMC.

Trailblazer signs provide a simpler solution than DMS. Trailblazer signs (TBS) provide a fixed message or driver instruction that can be remotely turned on and off. The purpose of Trailblazer signs is to guide vehicles along a diversionary route during an incident or special event. The process of rerouting traffic should be coordinated between the fixed DMS and Trailblazer elements of the system. In a typical scenario, DMS combined with Trailblazer signs would re-route traffic on a roadway during an incident. During the incident, the rerouting would occur simultaneously on arterial roadways to provide drivers with alternative surface routes to avoid the incident.

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 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.

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)
Every 3 Months	Replace Air Filter	• 1 lane closure • 1 bucket truck at $100/hour • 2 men at $55/hour • 2 hours per sign (includes mobilization) • Clean Sign Face • Filter - $40	$1,840
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 does not own or operate any permanent DMS. NDOR does operate DMS signs on the freeway system in the City of Omaha. **The City of Omaha 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 Omaha/Council Bluffs Incident Response Plan. Because these signs facilitate the diversion of freeway traffic on arterial streets, the City of Omaha and NDOR should share the cost of these installations. It should be noted that due to cost implications, the wide-range deployment of arterial DMS has been identified as a lower priority than initial build out of primary components of the traffic signal system. The number of DMS signs and more specific locations will be identified in

Chapter 6.0. The figure also illustrates the primary routes for any incident that results in a diversion from the freeway, but does not illustrate specific sign locations on those routes.

Advanced Traveler Information 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 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 Nebraska 511 system is operated by NDOR. It can be updated at a central location such as a TMC or by remote 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 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 (http://map.commuteview.net). 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. Other mobile applications (or "apps"), such as viewing camera images from a mobile phone, should also be integrated.

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

MEDIA SERVICES

Media services refer to the use of television and radio to broadcast local traffic information to Omaha and adjacent agency travelers. Third party broadcasters disseminate local traffic information provided by the City's systems to the general public. One option includes 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, or major office buildings, 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 installed on the Farnam Street level of the Civic Center. Other locations could include high activity areas such as the arena/stadium in North Downtown, the Old Market, and larger shopping centers.

5.3.3 DETECTION AND SENSORS

The City currently uses a variety of vehicle detection for traffic signal actuation. 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. For existing optical cameras, it would be beneficial from a traffic management standpoint to be able to view the camera images remotely.

City staff is currently open to testing out new detection technologies, and should continue to evaluate emerging technologies to determine if those detection technologies can meet the needs of the City and be deployed in a cost-effective manner in the future.

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.

The increase in the use of bicycles both in mixed traffic and on exclusive bicycle facilities may create safety and/or operational issues that could be mitigated with better bicycle detection. The City should implement the detection for bicycles on corridors with bicycle lanes or corridors with high volumes of bicycle traffic.

The City does not own or operate any permanent traffic sensors for the purpose of collecting data on speed, volume, occupancy, etc. NDOR does have traffic sensors deployed on the freeway system in the City of Omaha. **The City should evaluate the installation of sensors on corridors on a project-specific basis, and consider the use of third party data for travel time and congestion information.** This 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 performance measurement.

5.3.4 Uninterruptible Power Supply (UPS) Systems

UPS systems are currently deployed at 22 signals. In general, several of these UPS system locations have been difficult to maintain and update with continued preventative maintenance due to staff commitments, differing system requirements, and battery charging cycle schedules. Comments were noted by signal technician staff regarding some systems not being operational when needed, intermittent operations, and dead batteries at specific locations.

UPS systems are a valuable asset for intersections that serve high volumes or are located on the fringe of maintenance areas, and should be evaluated for installation on a case-by-case basis. Alternative UPS systems should be explored that can:

- reduce or eliminate the maintenance requirements and battery charging schedules
- alert staff when the device is activated
- allow staff to monitor the status of the system.

5.3.5 Emergency Vehicle Preemption (EVP)

With population growth, the increase in traffic and congestion often limits the mobility of emergency vehicles to safely maneuver through traffic. Traffic and congestion can reduce vehicle response times to the detriment of the safety of the general public. 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 247 signals in the City, and are typically installed at the request of the police and fire departments. All EVP systems use the Opticom Infrared technology to provide preemption for any emergency vehicle (typically police, fire, ambulance) equipped with a transmitter device and approaching a signal from any direction.

An Emergency Vehicle Priority system is different than an emergency vehicle preemption system described earlier. A priority system is GPS-based, that is operated by a dispatcher from a central control center. Emergency vehicles assigned to the incident follow routes provided on in-vehicle displays, and the traffic signal system adjusts signal timing in real-time based on the location of the emergency vehicle in the street network.

The City of Omaha should continue deploying EVP systems per the procedures currently in place with various public safety agencies.

5.3.6 Transit Signal Priority (TSP)

Neither the City nor any other agencies (Metro Transit) operate any transit signal priority systems. Metro Transit is currently conducting the *Downtown-Midtown Transit Alternatives Analysis* (which is focusing on the Dodge, Douglas, Farnam, and Harney Streets corridor). MAPA will also be conducting a *Regional Transit Vision*, which may explore this technology (among others) for the entire region.

Transit signal priority (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. 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 of service would improve. TSP is an important component of Bus Rapid Transit (BRT). The goal of BRT is to decrease transit vehicle travel times along an entire corridor in order to make transit more appealing to commuters. BRT is often implemented in concert with Next Bus Arrival Signs and fewer bus stops.

TSP provided to small fleets and select intersections can be deployed at a relatively low cost. A number of equipment strategies can be used including: 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 Omaha is provided by Metro Transit. Several projects have been proposed for Metro bus routes but have not yet been deployed. **The City of Omaha should coordinate with Metro Transit to facilitate implementation of TSP or BRT projects.**

5.3.7 Road Weather Information Systems (RWIS) and Anti-Icing Systems

90th & West Dodge Road is the only location where the City currently operates an RWIS Station and in-pavement anti-icing system. The Street Maintenance Department is the primary user of the RWIS data, and currently manually triggers the anti-icing system as needed.

The City of Omaha should evaluate and install these systems as needed.

5.3.8 Parking Management Systems

The City of Omaha currently does not actively manage any parking systems with detection and central software system. The Metropolitan Entertainment and Convention Authority (MECA) currently owns and operates a parking management system for MECA-owned lots around the CenturyLink Center and TD Ameritrade Park in North Downtown. This system does include several dynamic message signs (DMS) on traffic signal mast arms used specifically and only for parking management purposes for special events.

The City Public Works Department currently maintains on-street parking meters, while the City Parks Department manages all City-owned parking garages. However, there is no centralized parking management system. A Parking Management Plan recently completed by the Metropolitan Area Planning Agency (MAPA) for the downtown area recommends consolidating all parking management activities to the Public Works Traffic Division.

While not required, the City could explore software that integrates a future parking management system with the proposed central traffic signal management system software.

5.4 Transportation System Management

5.4.1 Traffic Management Center

The key function of the TMC (sometimes also called a Traffic Operation Center, or 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 TMC can vary in complexity from a single desktop computer with the management software 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 TMC size is dependent on the number of signalized intersections and other field devices deployed that are to be managed from the TMC by one or more operators; the more signals and field devices to monitor and operate, the larger the TMC and number of TMC operators. Practically, TMC size is often determined by the agency's budget for the TMC and size of the area to house the TMC.

The TMC typically serves as the critical communication hub between the field elements and the Engineer. The TMC will have equipment installed that provides the ability to control signalized intersections, CCTV cameras, Dynamic Message Signs (DMS), and other field devices. The TMC equipment can also monitor priority requests at signals, if transit priority and/or emergency vehicle preemption operation are deployed. In addition, the TMC can serve as the central location to share data with other agency departments 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 can be done by one or multiple agencies, or by one or multiple departments within an agency.

For the City of Omaha, four existing facilities have been identified as locations for various traffic management activities. These locations include:

1. Traffic Engineering Offices, Civic Center 6th Floor, 1819 Farnam Street
2. Traffic Maintenance Facility, 50th and G Streets
3. NDOR District Operations Center (DOC), 108th and I Streets
4. Douglas County Emergency Operations Center (EOC), Civic Center lowest level

Staff located in the Traffic Engineering offices on the 6th floor of the Civic Center would be frequent users of the ATMS for traffic signal data management (including uploading/downloading of signal timing/phasing, data collection and reporting) and access to CCTV devices (for monitoring and verification) as well as detection and sensor devices.

A traffic management center at the Traffic Maintenance Facility would likely have two workstations, an adequately-sized video wall and could include areas for bench testing of signal and ITS equipment. Communications and additional server equipment space would be allocated on site, and this facility would likely be used for daily maintenance and operations activities, such as monitoring and troubleshooting of intersections, upload/download of timing information, and serve as a backup location for after-hours incident management.

The NDOR DOC, located at 108th & I Streets, was constructed several years ago and is well equipped to integrate the City traffic signal system and future ITS field devices. The facility would have at least a single workstation where City staff actively monitor and manage traffic on City streets, and coordinate as needed with other departments and agencies, including NDOR District 2 staff and the Nebraska State Patrol. Staff at this location would continuously use the ATMS to monitor status of traffic signals and monitor traffic flow via cameras and sensors. The functionality of this space makes it ideal for special event management and freeway/arterial coordination. Figure 17 shows an existing workstation and video wall at the DOC.

FIGURE 17 – EXISTING WORKSTATION AND VIDEO WALL AT THE NDOR DOC

The Douglas County Emergency Operations Center (EOC), which is located on the lowest level of the Civic Center, is used as part of a coordinated response to disasters and emergencies. The Emergency Operations Center was built after the 1975 tornado that struck the City of Omaha, after which it was determined that the facilities available were not sufficient to handle a major disaster. Each of the desks in the Emergency Operations Center is assigned to a different working group (i.e., Omaha Police, Omaha Fire, and Douglas County Sheriff's Department) where information can be passed to other agencies quickly and effectively.

The Emergency Operations Center is a two-story facility with just less than 25,000 square feet of operating space. There are over 50 dedicated phone lines that can be utilized during a disaster as well as two different message centers that can be used for agencies to conduct emergency communications. Several rooms are set aside for organizational meetings and situational briefings. Adjacent to the EOC is a backup 911 dispatch center. On the second floor of the EOC, there is a primary call center observation deck for agencies that need visual engagement of the EOC operations during telephone communications. The Emergency Operations Center is self-supporting and has back up electrical power, a radio room, kitchen, and planning room for extended operations. Figure 18 is a photograph of the Emergency Operations Center.

FIGURE 18 – DOUGLAS COUNTY EMERGENCY OPERATIONS CENTER

While this facility would not be used on a daily basis, a workstation should be identified and provided for traffic operations staff in this facility during natural disasters or other emergencies where coordinated response and in-person contact is necessary with other departments and agencies.

Extending the functional use of TMC infrastructure is also accomplished through remote workstations. The remote workstations can provide limited or full functionality for the remote user. This requires that the operator workstation software be developed as a client/server application, with clients connecting to the server for data exchange and device control. Communication between the server and clients will normally use a TCP/IP protocol and the system communication infrastructure must be developed to support this protocol.

Finally, the primary location for servers and related networking equipment will likely be at the Civic Center due to the current/recently constructed data center in the lower level that has full generator power backup and redundant communications infrastructure. The DOC may also have available space to house this equipment.

5.4.2 Staff

All staff that conducts work related to the traffic signal system is a part of the Traffic Engineering Division, which is located within the Transportation Services Section of the Public

Works Department. Other divisions within Transportation Services include Construction, Design, Street Maintenance, Fleet Maintenance, and General Services.

The Traffic Engineering Division has 62 engineering, maintenance, technician, and administrative staff which are responsible for not only the traffic signal system, but also signing, pavement markings, traffic planning and design, parking meters, safety projects, traffic calming, and driveway permits.

Currently, there is eight engineering staff, however, 1.5 full-time equivalent positions are dedicated to signal operations. There is one additional engineer located at the Traffic Maintenance Facility who oversees all traffic maintenance staff, not only signal maintenance staff. In addition to engineering staff, there is 17 traffic signal maintenance staff based at the Traffic Maintenance Facility.

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 TMC operator will be required to monitor the traffic signal system and related devices.**

Using these same rules of thumb for the existing traffic signal system (no-build scenario), **the City should have an existing staff of 10 to 13 traffic engineers and 20 to 25 technicians**. It is important to note that a staffing deficiency currently exists that is not associated with upgrade of the system. Additional traffic engineering and technician staff would allow the City to realize improvements to the overall operations, safety, and maintenance of the signal system now and in the future which results in benefits for the motoring public.

The TMC at the DOC may not be staffed on a 24-hour basis. Consideration should be given to establishing an agreement with NDOR staff to monitor City streets while City staff is not on duty. **It is recommended that the minimum hours for which the TMC will be monitored are 6 am to 9 am and 3 pm to 6 pm, Monday through Friday**. Beyond that, the TMC is staffed only when specific events or situations warrant, such as special events, incidents, or weather events. In some cases, the TMC operator can be comprised of existing staff whose duties are augmented to include TMC operations, or it may require new staff to support the additional job duties. However, it is assumed that TMC duties will be fulfilled by using City staff during peak periods and possibly NDOR staff during off-peak periods. 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
- 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 City maintenance staff, including fiber optic cable repairs.**

5.4.3 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 optimize time-based coordination plans on major corridors
- Continue to 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, specify certain timing parameters that operate during free or coordinated operation to safely and efficiently serve vehicle and pedestrian traffic. Some settings 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 continue to dedicate staff for evaluation of existing timing settings to ensure that they adhere to the latest MUTCD guidelines, where available. Flashing schedules should also be periodically reviewed.**

COORDINATED OPERATION

It is generally recommended to optimize traffic signal coordination plans, at a minimum, every 3 to 5 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. To facilitate this objective, vehicle detectors or additional sensors can be used to automatically collect turning movement counts in real time. Over a period of time, this data can illustrate changes in travel patterns by not only time of day, but day to day, week to week, and year to year, as well as the frequency of incidents and the effects of congestion on capacity.

Other Timing Solutions

In addition to coordination timings, **the City should determine the feasibility and/or benefits of installing adaptive or responsive systems on corridors with fluctuating and unpredictable traffic volumes.** Though upfront costs of installing adaptive systems may be high, the long-term benefits may outweigh the overall costs to install and maintain.

5.4.4 *Incident Management*

Given the development of the *Omaha-Council Bluffs Traffic Incident Management Operations Guidelines*, **the City of Omaha and NDOR should coordinate to carry out the procedures identified in this document during freeway incidents.** Additional guidelines should be developed for incidents along the West Dodge Expressway. Furthermore, the City should develop a similar document to manage traffic during incidents along high-volume, congested City streets including Dodge Street, 72nd Street, etc., coordinate with public safety agencies, and proactively disseminate information to the public.

5.4.5 *Congestion Management*

Like incident management, there is no formal day-to-day congestion management program on arterial streets conducted by the Public Works Department. The City does have special timing plans in place around the CenturyLink Center and TD Ameritrade Park to facilitate egress upon conclusion of events at those facilities. In many cases, the Omaha Police 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.**

5.4.6 *Traffic Signal Preventative Maintenance*

The City does have a traffic signal preventative maintenance program, which is logged in the TMIS database. All traffic signals are visited by a technician approximately once every 2 years, at which point the cabinets are cleaned and system components are tested and replaced as warranted. It was noted during the cabinet field review that due to the variability of signal hardware/equipment in the cabinets, some maintenance and troubleshooting activities are more difficult for newer signal technicians than others.

To maintain equipment in proper condition and minimize maintenance issues, **the City should devote staffing resources to develop and implement a comprehensive and regular preventative maintenance program.**

5.4.7 *Communications Maintenance*

Currently, traffic maintenance staff monitors the status of the communications system on a daily basis. As the communications network is upgraded to include additional fiber optic and wireless infrastructure, **adequate staff training for maintenance staff should be provided to adequately maintain the system.**

5.5 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.

5.5.1 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 Omaha, examples of system-level integration include the following:

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

5.5.2 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 NDOR and neighboring agencies such as Cities of Bellevue, Ralston, Papillion, La Vista, and Council Bluffs. The City of Omaha or NDOR can implement an interface to a regional data center for the exchange of traffic data. 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 Omaha, examples of regional-level integration include the following:

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

6.0 CONCEPT DESIGN AND COST ESTIMATE

Based on the recommended improvement strategies identified in Chapter 5.0, Figure 19 illustrates the proposed traffic signal system 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.

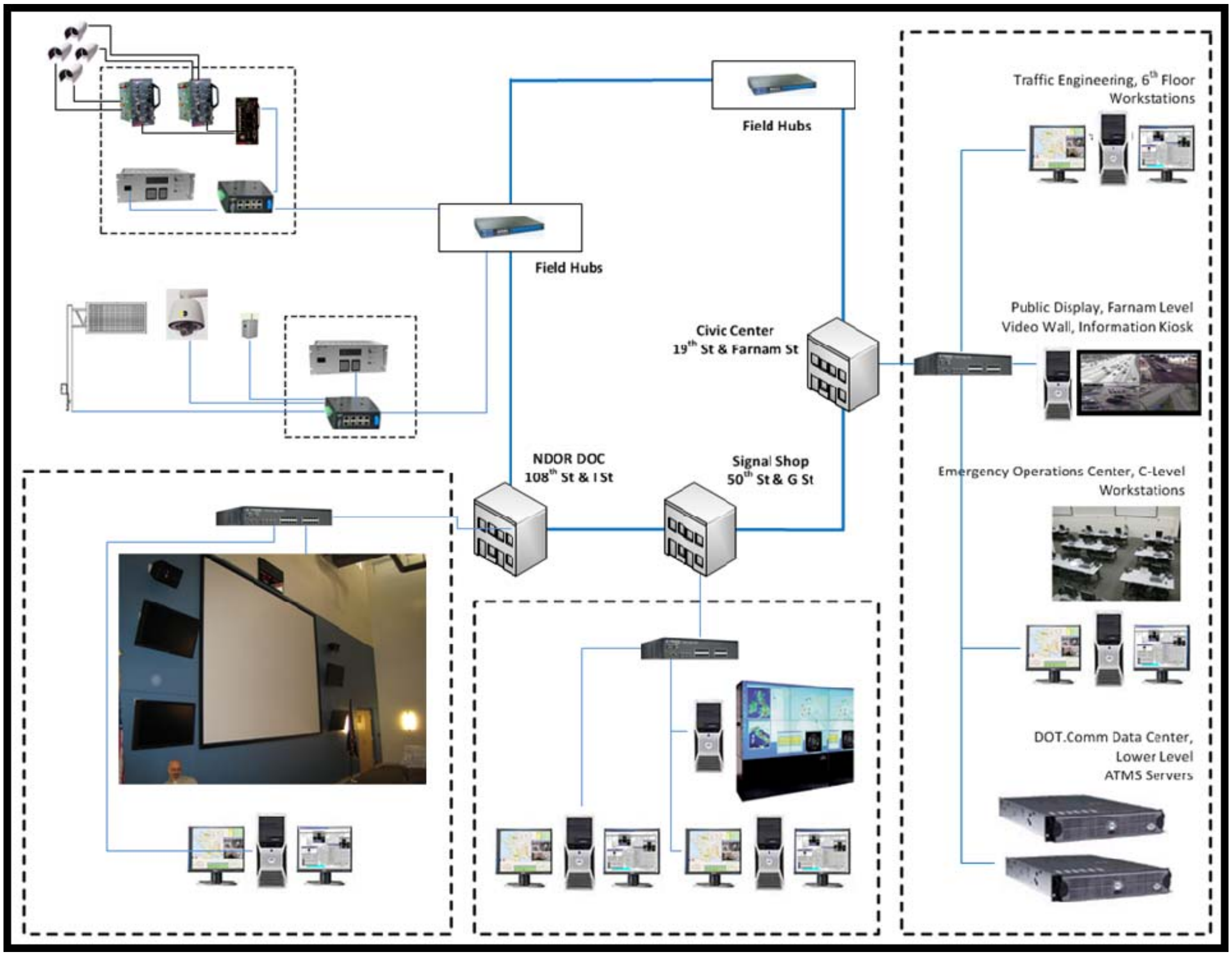


FIGURE 19 – TRAFFIC SIGNAL SYSTEM HIGH-LEVEL NETWORK DIAGRAM

6.1 TRAFFIC SIGNAL CABINETS

Traffic signal cabinets will be upgraded to a Type 332 style cabinet, except in locations with limited right-of-way (such as the downtown area). This cabinet size will enable existing (and future) equipment to be installed in a uniform manner simplifying maintenance tasks. Figure 20 illustrates a 332 cabinet with typical equipment. Currently, there are 269 Type 332 cabinets; therefore, up to 750 will need to be upgraded.

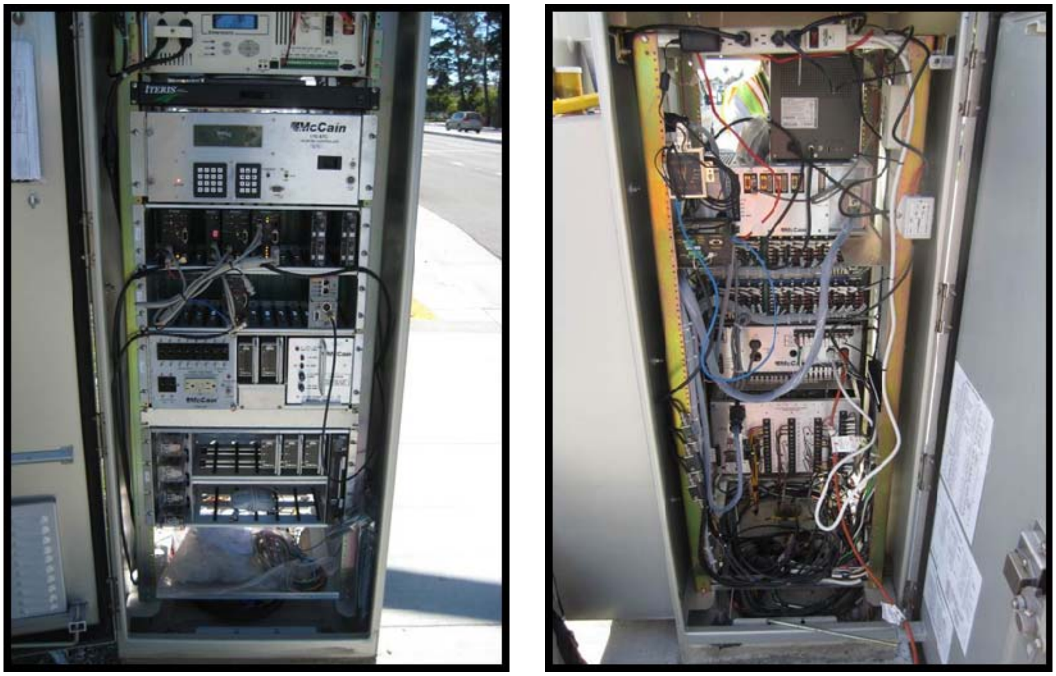


FIGURE 20 – SAMPLE TYPE 332 CABINET AND EQUIPMENT

6.2 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:

- Hub 1: 156th Street/Bob Boozer Drive and Pacific Street
- Hub 2: 108th Street and L Street
- Hub 3: 72nd Street and West Center Road
- Hub 4: 50th Street and G Street
- Hub 5: 19th Street and Farnam Street
- Hub 6: 30th Street and Ames Avenue
- Hub 7: 108th Street and Blondo Street
- Hub 8: 72nd Street and Dodge Street

A photograph of a hub cabinet is shown in Figure 21. More detailed information about each hub location follows.

FIGURE 21 – SAMPLE HUB CABINET

1. 156th Street/Bob Boozer Drive and Pacific Street
   - Present routing of the City's existing conduits: The hub is located along existing fiber optic cable and conduit.
   - Transmission distance of backbone communications: 12 to 13 miles to Hub #2, 7 to 8 miles to Hub #7
   - Proximity to field elements: Within 7 miles of all field devices west of 132nd Street.
   - Ease of constructability: No development adjacent to existing roadway.
   - Ease of access and maintainability: Vacant field located on corner of existing traffic cabinet.
   - Nearest indoor facility: Fire Station #56 at 16410 Pacific Street.

2. 108th Street and L Street
   - Present routing of the City's existing conduits: The hub is located along existing conduit.
   - Transmission distance of backbone communications: 12 to 13 miles to Hub #1, 4 to 5 miles to Hub #3
   - Proximity to field elements: Within 5 miles of all field devices south of Center Street and between 84th Street and 144th Street.

- Ease of constructability: Located in NDOR District Operations Center. About 5,000 feet of new conduit needs to be installed to provide connections to the backbone ring.
- Ease of access and maintainability: Located in NDOR District Operations Center.

3. 72nd Street and West Center Road
   - Present routing of the City's existing conduits: The hub is located at intersection of existing conduits.
   - Transmission distance of backbone communications: 4 to 5 miles to Hub #2, 2 to 3 miles to Hub #4, 2 miles to Hub #8.
   - Proximity to field elements: Within 5 miles of all field devices south of Pacific Street and between 96th Street and 60th Street.
   - Ease of constructability: No development adjacent to existing roadway.
   - Ease of access and maintainability: Located in interchange right-of-way.
   - Nearest indoor facility: Douglas County Extension Office at 8015 West Center Road or Douglas County Environmental Services at 6611 West Center Road.

4. 50th Street and G Street
   - Present routing of the City's existing conduits: The hub is located along existing conduit.
   - Transmission distance of backbone communications: 2 to 3 miles to Hub #3, 6 to 7 miles to Hub #5
   - Proximity to field elements: Within 5 miles of all field devices south of Dodge Street and east of 60th Street.
   - Ease of constructability: Located in Traffic Maintenance Facility
   - Ease of access and maintainability: Located in Traffic Maintenance Facility

5. 19th Street and Farnam Street
   - Present routing of the City's existing conduits: The hub is located along existing conduit.
   - Transmission distance of backbone communications: 6 to 7 miles to Hub #4, 3 to 4 miles to Hub #6, 4 miles to Hub #8.
   - Proximity to field elements: Within 5 miles of all field devices in the Downtown area
   - Ease of constructability: Located in Civic Center. About 2000' of new conduit needs to be installed to provide connections to the backbone ring.
   - Ease of access and maintainability: Located in Civic Center

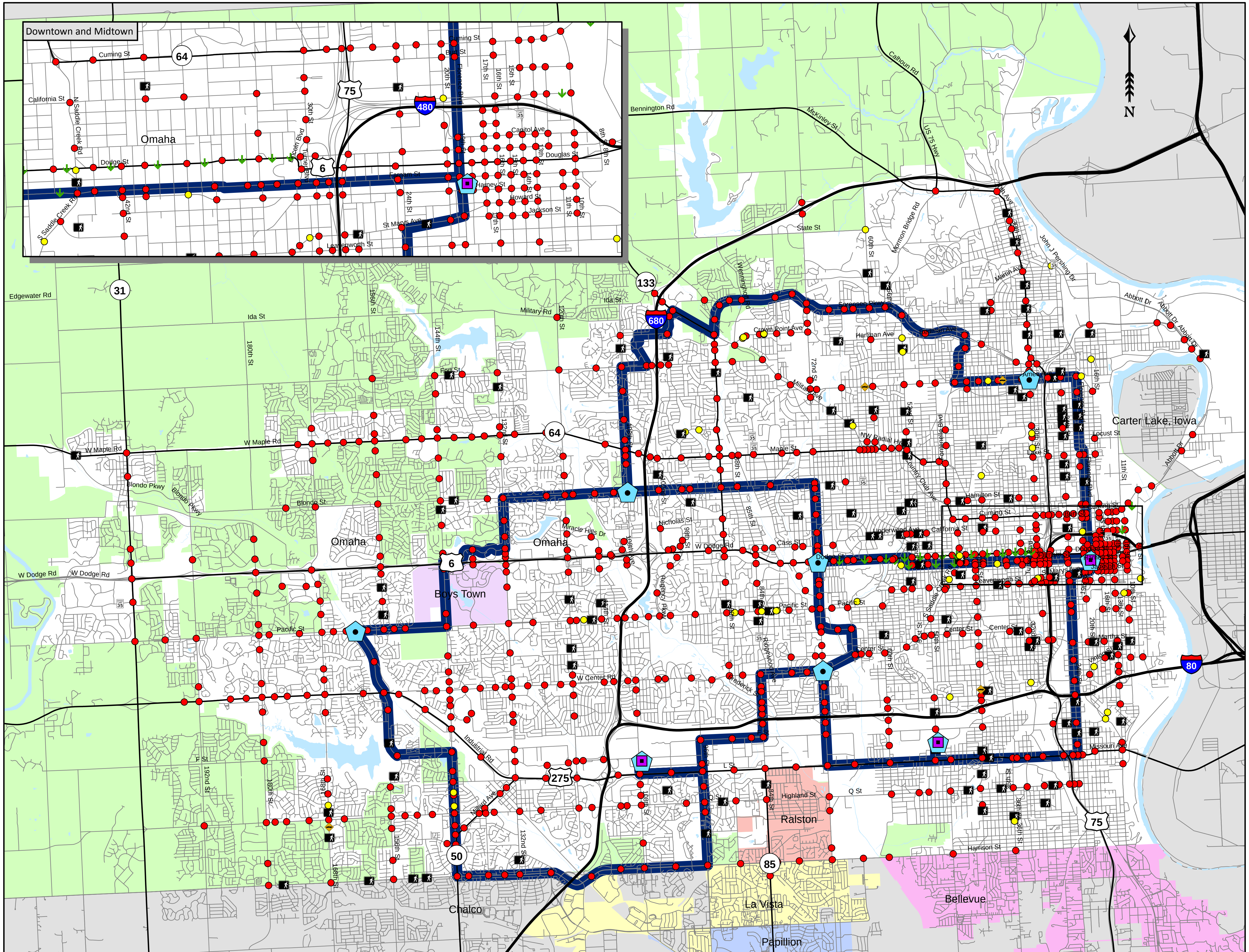
6. 30th Street and Ames Avenue
   - Present routing of the City's existing conduits: The hub is located along some existing conduit.
   - Transmission distance of backbone communications: 3 to 4 miles to Hub #5, 11 to 12 miles to Hub #7
   - Proximity to field elements: Within 4 miles of all field devices north of Cuming Street and east of 72nd Street.

- Ease of constructability: All existing parcels are at least 10 feet setback from existing roadway. About 6,700 feet of new conduit needs to be installed to provide connections to the backbone ring.
- Ease of access and maintainability: Restaurant located on corner of existing traffic cabinet.
- Nearest indoor facility: Northeast Police Precinct at 4316 N 30th Street or Washington Branch Library at 2868 Ames Avenue.

7. 108th Street and Blondo Street
   - Present routing of the City's existing conduits: The hub is located along existing fiber optic cable and conduit.
   - Transmission distance of backbone communications: 7 to 8 miles to Hub #1, 11 to 12 miles to Hub #6, 4 miles to Hub #8
   - Proximity to field elements: Within 6 miles of all field devices north of Pacific Street and west of 90th Street.
   - Ease of constructability: All existing parcels are at least 20 feet setback from existing roadway.
   - Ease of access and maintainability: Gas station located on corner of existing traffic cabinet.
   - Nearest indoor facility: none identified nearby.

8. 72nd Street and Dodge Street
   - Present routing of the City's existing conduits: The hub is located along existing fiber optic cable and conduit.
   - Transmission distance of backbone communications: 2 to 3 miles to Hub #3, 4 miles to Hub #5, 4 miles to Hub #7
   - Proximity to field elements: Within 4 miles of all field devices north of Cuming Street and east of 72nd Street.
   - Ease of constructability: All existing parcels are at least 10 feet setback from existing roadway. About 6,700 feet of new conduit needs to be installed to provide connections to the backbone ring.
   - Ease of access and maintainability: Restaurant located on corner of existing traffic cabinet.
   - Nearest indoor facility: Fire Station #53 at 8001 Dodge Street

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 22 provides an illustration of the proposed Gigabit Ethernet backbone and distribution routing. Backbone and distribution fiber will terminate at each of the hubs.



Legend

- Fiber Rings
- Hub Locations
- Traffic Facilities
- Full
- Ped
- Flash
- Lane
- Speed
- Emergency

0 0.5 1 2

Miles

FIGURE 22

Proposed Fiber Optic Backbone Network

Along the path of the backbone cable, the fiber optic cable will serve as both the backbone and distribution cable. Each link of the backbone network (connection between hubs) will require two fiber optic strands from the backbone cable. The remaining strands will be available for use for distribution (hub to intersection). Communication hubs located in field cabinets will require the use of hardened Gigabit Ethernet switches. Communication hubs located in City facilities will not require the use of hardened equipment as it is assumed the hubs will be located in environmentally controlled areas.

6.3 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 cables connecting field elements using dedicated, leap frog, or daisy chained connections. These connections are assumed to utilize the existing 24 strand fiber optic wherever possible. Figure 23 illustrates the proposed distribution network.

The City is currently undertaking a $1.7 billion program called Clean Solutions for Omaha (CSO), which will address problems related to the City's existing combined sewer system, primarily east of 72nd Street. This project is ongoing and is scheduled to be completed in 2024. Figure 24 illustrates individual project areas associated with this program.

While not directly related to the traffic signal system, regular coordination should be conducted with CSO staff for two primary purposes:

1. For traffic signal system conduit that will be placed in an area with pending CSO work, coordination should take place to determine if the proposed corridor will be affected, and if so, what modifications should be made.
2. For traffic signal system conduit that will be placed after completion of CSO work, coordination should take place to determine if the proposed conduit can be placed in conjunction with the CSO work.

This coordination could include one or more strategies including:

1. Delay the installation of that backbone segment until the completion of a sufficient number of CSO projects
2. Determine the extent of work in the project areas to possibly identify a corridor that will be unaffected or minimally affected by the CSO projects
3. Utilize wireless solutions over backbone segments traversing CSO project areas

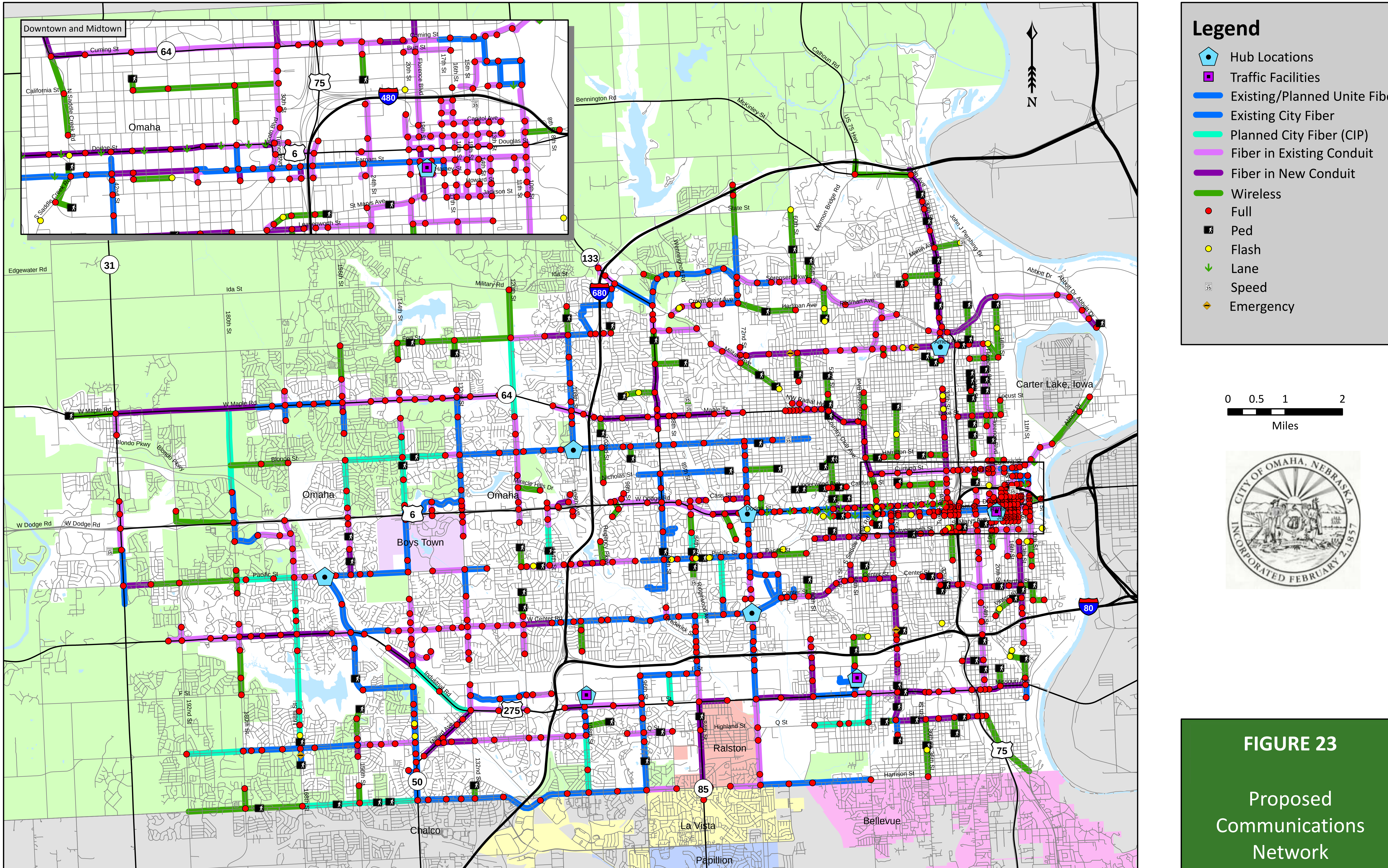


FIGURE 23

Proposed Communications Network

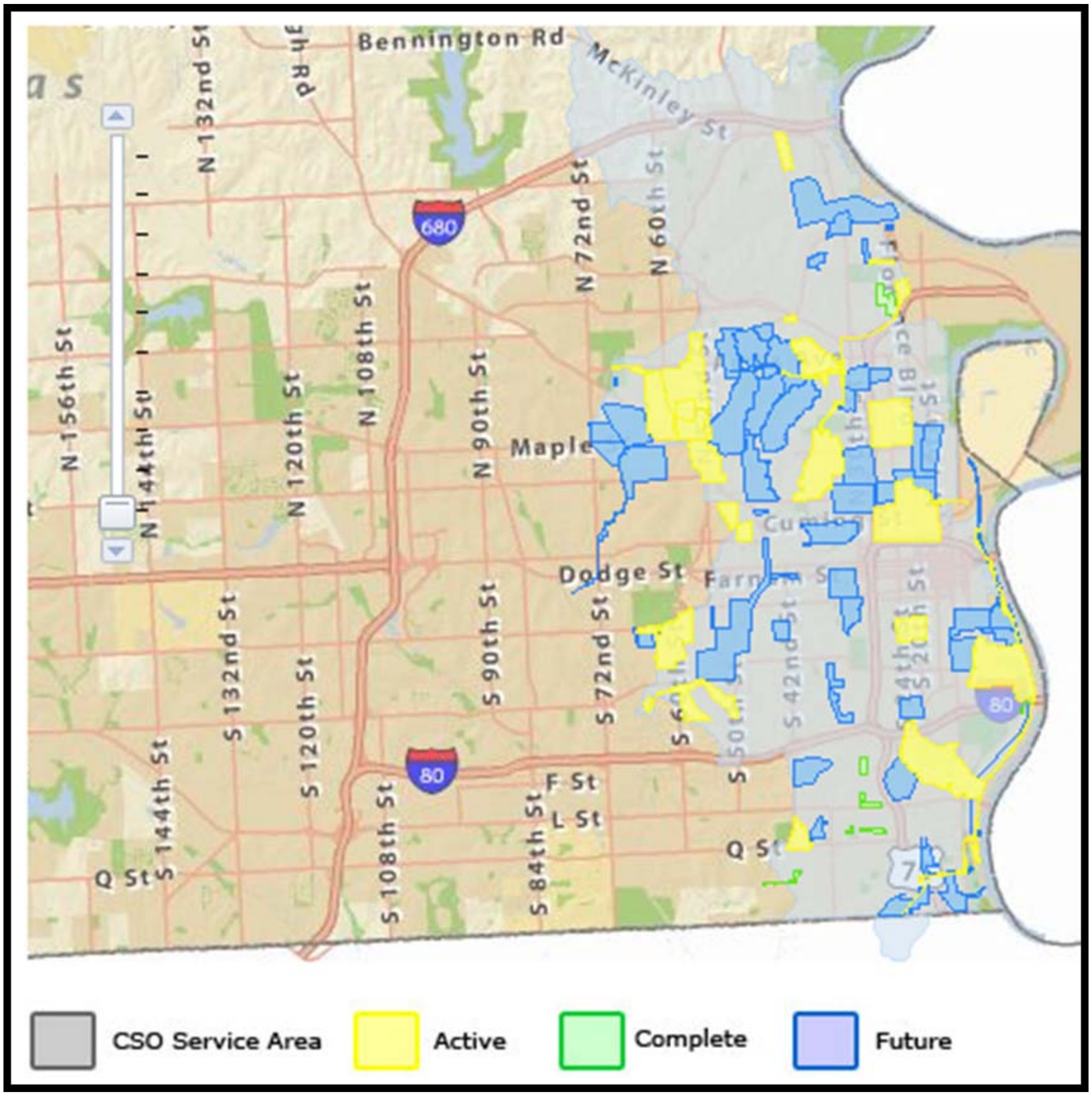
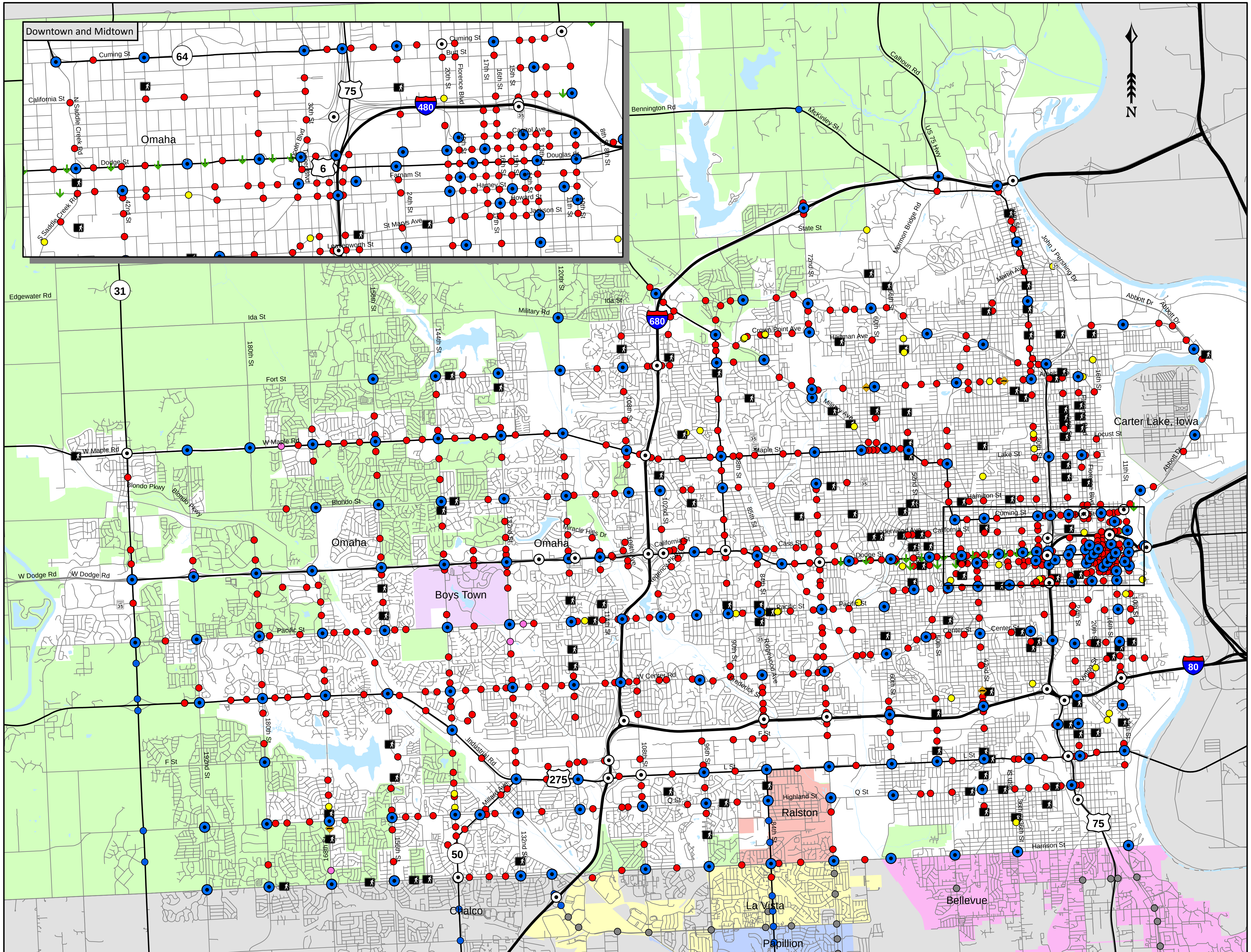


FIGURE 24 – CSO PROGRAM PROJECT MAP

6.4 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 the intersection of arterial corridors, which will result in spacing of approximately one mile, and other locations as needed. This will provide coverage of most major intersections as well as two intersecting corridors with a single camera. Additional cameras may be deployed on select corridors (for example, Dodge Street) and certain areas (such as downtown). Figure 25 illustrates a layout of proposed camera locations.



LEGEND

- Existing CCTV Camera
- Proposed CCTV Camera
- Full Signal
- Pedestrian Signal
- Flashing Beacon
- Lane Control Signal
- Speed Feedback Sign
- Emergency Signal
- Planned Signals
- NDOR Signals
- Sarpy Co Signals

0 0.5 1 2

Miles

CITY OF OMAHA, NEBRASKA INCORPORATED FEBRUARY 2, 1857

FIGURE 25

Proposed CCTV Camera Locations

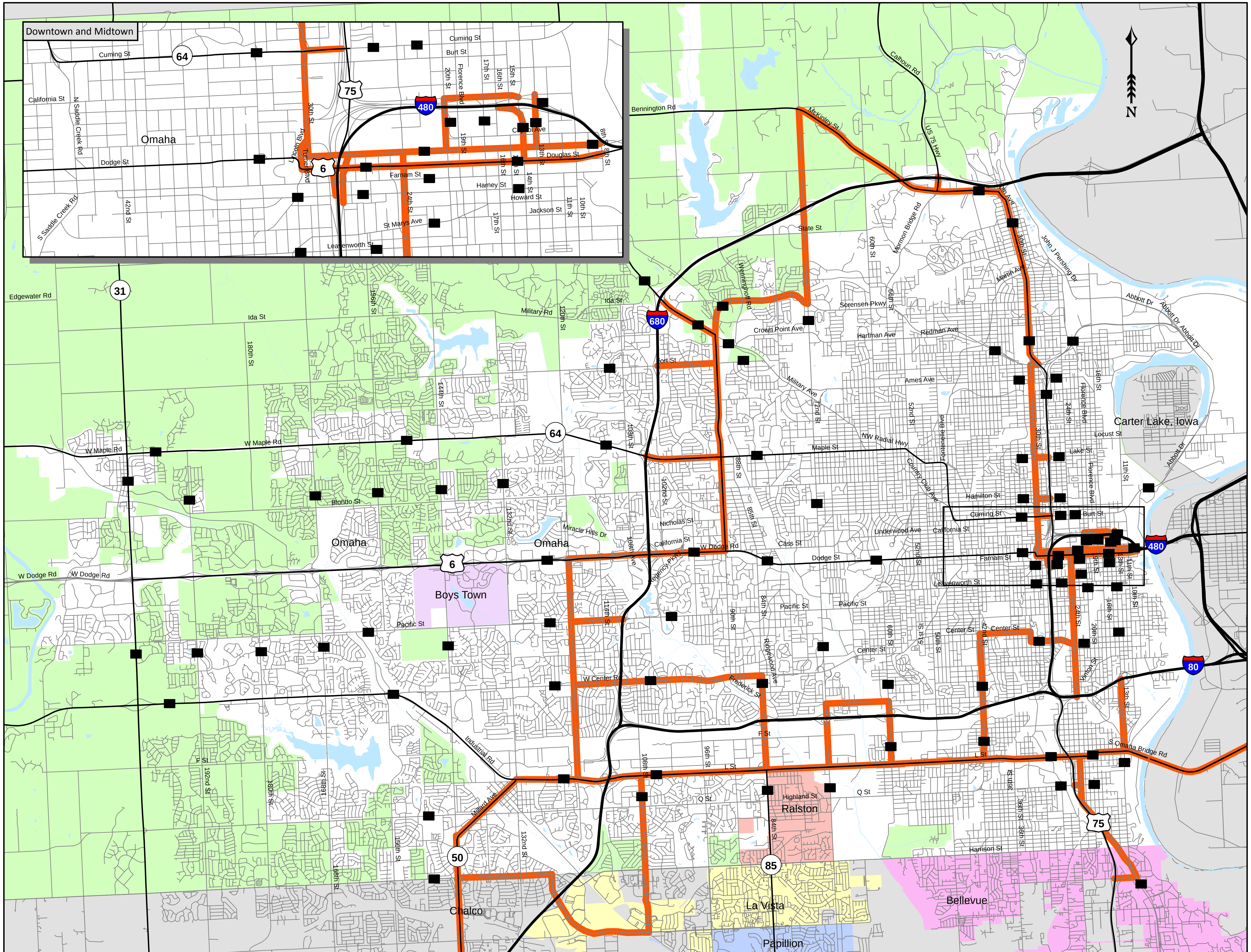
6.5 Dynamic Message Signs

The City does not own or operate any permanent DMS. NDOR does operate DMS signs on the freeway system in the City of Omaha. The City of Omaha should consider placing arterial DMS in strategic locations to alert drivers to incidents and congestion, and provide travel time and other traveler information.

While static signs could be used in certain locations, trailblazer signs should be considered for installation on primary diversion routes identified in the Omaha/Council Bluffs Incident Response Plan. Because these signs facilitate the diversion of freeway traffic on arterial streets, the City of Omaha and NDOR should share the cost of these installations. Figure 26 illustrates proposed DMS locations citywide. The figure also illustrates the primary routes for any incident that results in a diversion from the freeway at any point, but does not illustrate specific sign locations on those routes.

6.6 Traffic Sensors

The City of Omaha should consider installing traffic sensors on primary arterials in the long term, depending on technology advances over time and general industry standards. 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 27 illustrates potential corridors to be instrumented with traffic sensors.



LEGEND

■ Proposed DMS*

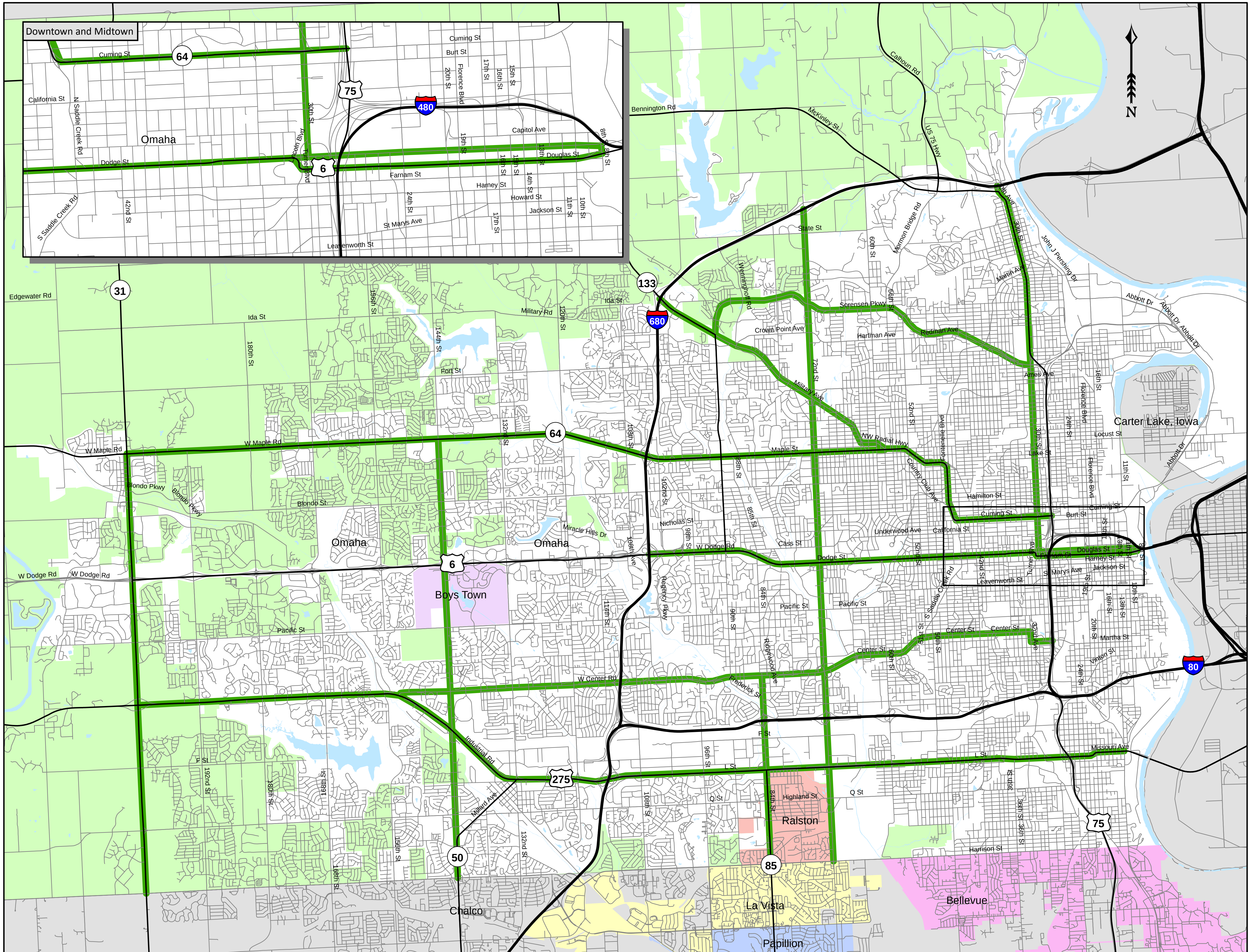
Incident Management Routes**

* Sign locations are generalized for illustration and cost estimating.

** Signs along incident management routes have not been specifically identified.

FIGURE 26

Proposed Dynamic Message Sign Locations



LEGEND

Arterials with Sensors

0 0.5 1 2

Miles

FIGURE 27

Potential Arterials with Sensors

6.7 Traffic Management Centers

Of the four facilities identified for obtaining traffic management capabilities, only one, the Traffic Maintenance Facility, requires physical modifications and equipment other than personal workstations, however, the physical structure already exists. Figure 28 illustrates a potential floor plan for the facility.

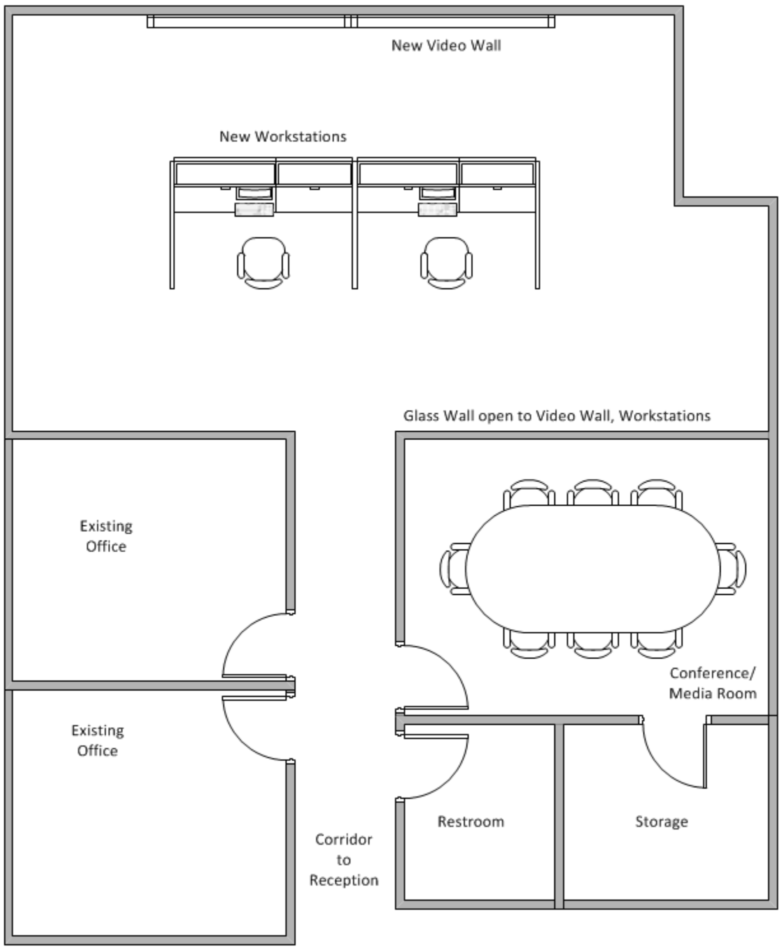
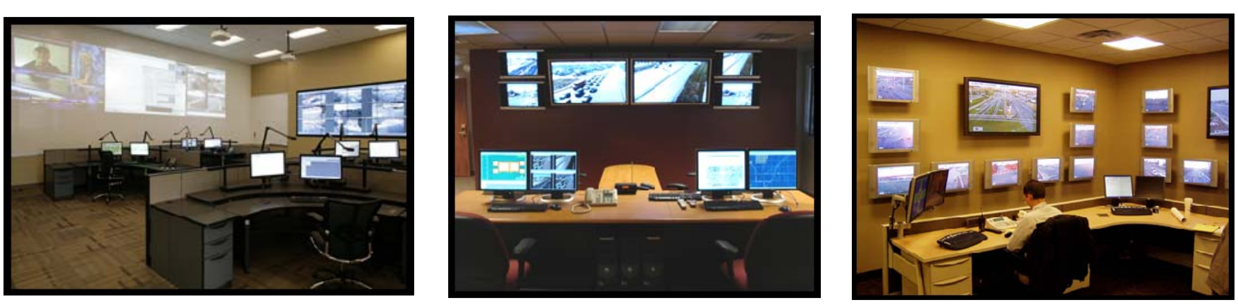


FIGURE 28 – POTENTIAL FLOOR PLAN AT TRAFFIC MAINTENANCE FACILITY



Kansas City, Missouri *Olathe, Kansas* *Overland Park, Kansas*

FIGURE 29 – PHOTOGRAPHS OF AREA TRAFFIC MANAGEMENT CENTERS

6.8 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.
- Convert all cabinets to Type 332 cabinets, except in the downtown area or where limited right-of-way exists.
    - Pole mounted cabinets (where necessary) should generally follow a Type 346 configuration, which allows more space for equipment and future communications capabilities.
- Use the license for legacy ATMS software (Delcan NETworks) provided by NDOR, with the requirement that the ATMS the City procures for signal system management has the modules available in the future to also manage ITS devices.
- Ultimately 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 existing twisted pair cable with fiber optic cable.
    - Traditional leased line communications are not recommended as a permanent solution at this time; however, they could be used in the interim to establish Ethernet communications to certain traffic signals.
- For signals on wireless links, the City should consider microwave, spread spectrum Ethernet radios, Wi-Fi technology (in the form of broadband radios), and WiMax.
- Establish internet protocol (IP) based communications on the new network.
- Construct a redundant, self-healing Gigabit Ethernet backbone fiber optic network between eight hub locations located throughout the City utilizing existing UPN fiber.
- 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 NDOR 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.
- Install kiosks and other traffic-related information displays on the Farnam Street level of the Civic Center. Other locations could include high-activity areas such as public

libraries, Eppley Airfield, CenturyLink Center, TD Ameritrade Park, the Old Market, and larger shopping centers.

- Continue to evaluate emerging technologies for detection and sensors.
- Evaluate the 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.
- Evaluate the need for UPS systems at high volume or fringe intersections on a case-by-case basis.
- Continue deploying EVP systems per the procedures currently in place with various public safety agencies.
- Coordinate with Metro Transit to facilitate implementation of TSP or BRT projects.
- Evaluate Road-Weather Information Systems (RWIS) at select intersections.
- Explore software that integrates a future parking management system with the proposed central traffic signal management system software.
- Establish traffic management capabilities at the following four facilities.
  1. Traffic Engineering Offices, Civic Center 6th Floor, 1819 Farnam Street
  2. Traffic Maintenance Facility, 50th and G Streets
  3. NDOR District Operations Center (DOC), 108th and I Streets
  4. Douglas County Emergency Operations Center (EOC), Civic Center lowest level
- 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 TMC operator to monitor the traffic signal system and related devices from at least 6 am to 9 am and 3 pm to 6 pm, Monday through Friday.
- Program two to five additional traffic engineering staff and three to eight additional technicians to operate and maintain the existing and expanded traffic signal system.
- Continue to perform general traffic signal maintenance using internal maintenance staff, including fiber optic cable repairs.
- Continue to dedicate staff for evaluation of existing timing settings to ensure that they adhere to the latest MUTCD guidelines, where available. Flashing schedules should also be periodically reviewed.
- Optimize traffic signal coordination plans, at a minimum, every 3 to 5 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 NDOR to carry out the procedures identified in the traffic incident management (TIM) guidelines as well as this document during freeway incidents.

- Develop, implement, monitor, and revise timing plans as necessary to accommodate special event traffic around major traffic-generating facilities.
- Develop and implement a comprehensive, regular preventative maintenance program.
- 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 $34.6 million, not including design or system manager fees. Table 9 details total system cost by item. In addition, operations and maintenance costs are projected to increase from $1.8 million per year to $2.6 million per year at full system build out. This projection includes five additional staff positions, maintenance of new ITS devices (cameras, sensors, etc.), as well as server and other IT-related maintenance.

TABLE 9 – OPINION OF PROBABLE COST FOR SYSTEM UPGRADE

System Component	Price/Unit	Unit	Qty	Total	% of Total
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	750	$6,000,000	
Controller, Type 2070 ATC	$2,200	EA	1,019	$2,241,800	
Traffic Signal Field Components				**$8,241,800**	**24%**
Local Controller Software	$700	EA	1,019	$713,300	
Central Signal System Software	$800,000	LS	1	$800,000	
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS	1	$50,000	
Traffic Signal Software Components				**$1,563,300**	**5%**
Fiber Cable & Conduit	$35	FT	212,900	$7,451,500	
Fiber Cable	$5	FT	336,700	$1,683,500	
Fiber Splice Pull Boxes	$900	EA	1,366	$1,229,760	
Misc. Comm. Hardware/Connections	$1,000	EA	1,019	$1,019,000	
Communication HUB Cabinets	$30,000	EA	8	$240,000	
Wireless Links	$6,000	EA	181	$1,086,000	
Communications Components				**$12,709,760**	**37%**
CCTV Monitoring Cameras	$4,000	EA	225	$900,000	
Arterial DMS	$50,000	EA	100	$5,000,000	
System Sensors	$2,500	EA	200	$500,000	
3rd Party Sensor Information	$50,000	LS	1	$50,000	
ITS Field Devices				**$6,450,000**	**19%**
Video Wall	$100,000	EA	1	$100,000	
Workstations	$10,000	EA	4	$40,000	
Misc. Server Equipment	$200,000	LS	1	$200,000	
Minor Remodel	$100,000	LS	1	$100,000	
ATIS Website	$100,000	LS	1	$100,000	
TMC Infrastructure (3 Sites)				**$540,000**	**2%**
Adaptive Traffic Signal Control - Central Module	$50,000	LS	1	$50,000	
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA	105	$525,000	
Misc. Items				**$575,000**	**2%**
Subtotal				**$30,079,860**	
Contingencies	15%		15%	**$4,511,979**	
TOTAL				**$34,591,839**	**100%**

7.0 DEPLOYMENT STRATEGY

As previously noted, there are over 1,000 signalized intersections operated and maintained by the City of Omaha. 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 Omaha and MAPA staff regarding potential, anticipated funding. The improvements were developed and based on the City's needs and overall traffic signal system goals. The proposed ten-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.

7.1 PHASE 1 – DODGE STREET, 72ND STREET, 84TH STREET, AND FACILITIES

7.1.1 OVERVIEW

The primary purpose of this phase is to connect the Civic Center, Traffic Maintenance Facility, and DOC to what will ultimately become the fiber backbone network. Seven of the eight communications hubs will be installed. Central signal software will be procured. Traffic management center facilities will be developed at the Traffic Maintenance Facility. A workstation at the DOC could also be implemented as a public relations tool even if the facility is not yet staffed full time. This phase also includes upgrades to 121 signals in the following existing closed loop systems:

1. 72nd Street and Dodge Street
2. Happy Hollow Boulevard and Farnam Street
3. 72nd Street and Pacific Street
4. 84th Street and Center Street

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

1. Dodge Street from 31st Street to 93rd Street
2. 72nd Street from Main Street (Ralston) to Seward Street
3. 84th Street from West Center Road to Harrison Street
4. West Center Road from 72nd Street to 105th Street

Additional signals on crossing or adjacent corridors (Cass Street, Farnam Street, Pacific Street) are included in this phase. Signal upgrades will include cabinets, controllers, related communications equipment (switches, radios, etc.), and some ITS devices, primarily CCTV cameras.

7.1.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new 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 requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN 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 fiber optic cable.
2. Fiber Backbone Communications: Gigabit Ethernet backbone communications will be employed between the 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 will be deployed in this phase from either Hubs 2, 3, 4, 5, or 8.
4. Communication Hubs: Communication hubs will be installed at all locations *except* the 30th Street and Ames Avenue location.
5. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
7. Wireless communications: Approximately six wireless links will be implemented in this phase.

Cabinet/Controller Upgrades

1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.
3. Ethernet switches: The 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 hardware.

ITS Devices

1. CCTV Cameras: 23 CCTV cameras will be installed in this phase.

Traffic Management Center

1. Central software system: The central signal software will be procured and configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. TMC Equipment: Communication rack to accommodate the fiber distribution rack and head-end Gigabit Ethernet hardware.
3. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects

1. Saddle Creek Sanitary Trunk Sewer Separation – Phases A and B (Begin 2024)
2. Farnam Street and Saddle Creek Sewer Separation (Begin 2020)
3. 33rd Street and Jackson Street Sewer Separation (Begin 2024)

7.1.3 Summary of Estimated Costs

Phase 1 improvements are estimated to cost $5.1 million. Table H1 in the Appendix H details Phase 1 costs in greater detail. Figure H1 in the Appendix H illustrates Phase 1 improvements.

7.2 Phase 2 – South Central and North/South Backbone Rings

7.2.1 Overview

Phase 2 includes 94 signals in the area generally bound by 144th Street, Industrial Road, and Millard Avenue on the west, 96th Street on the east, Q Street on the south, and West Center Road on the north. The remaining pieces of the north and south backbone rings will also be constructed.

7.2.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to accommodate slack fiber. It is assumed existing pull boxes are spaced every 1,000 to 1,500 feet.

3. Existing Conduit: This phase requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN fiber splice pull boxes to signal cabinets.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new fiber cable.
2. Fiber Backbone Communications: Gigabit Ethernet backbone communications will be employed between the communication hubs. The remainder of the North and South backbone rings will be constructed during this phase for use in Phase 3.
3. Fiber Distribution Communications: Distribution communication links will be deployed in this phase from either Hubs 1, 2, or 3.
4. Communication Hubs: Communication Hub 5 will be installed at 30th Street and Ames Avenue.
5. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
7. Wireless communications: Approximately five wireless links will be implemented in this phase.

Cabinet/Controller Upgrades

1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.
3. Ethernet switches: The 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 hardware.

ITS Devices

1. CCTV Cameras: 17 CCTV cameras will be installed in this phase.

Traffic Management Center

1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects

1. 39th Street and Fontenelle Street Sewer Separation

2. 45th St and Saratoga St Sewer Separation (Begin 2020)
3. 46th Street & Grand Street Sewer Separation (Begin 2019)
4. 46th Street & Grand Street Sewer Separation (Begin 2019)
5. 43rd Street & Boyd Street Sewer Separation (Begin 2021)
6. 33rd Street & Taylor Street Sewer Separation (active)
7. 26th & Corby Sewer Separation Phase 1 (active)
8. 18th Street & Seward Street Sewer Separation (Begin 2017)
9. Nicholas Street Sewer Separation Phase 2 (Begin 2014)
10. Nicholas & Webster Sewer Separation (active)
11. 20th Street and Poppleton Street Sewer Separation (active)
12. 20th St to 25th St, Oak St to Deer Park Sewer Separation (Begin 2018)
13. Spring Lake Park Project (Begin 2014)
14. Missouri Avenue Sewer Separation
15. 26th St and J St Sewer Separation (Begin 2018)

7.2.3 Summary of Estimated Costs

Phase 2 improvements are estimated to cost $3.0 million. Table H2 in the Appendix H details Phase 2 costs in greater detail. Figure H2 in the Appendix H illustrates Phase 2 improvements.

7.3 Phase 3 – Northwest

7.3.1 Overview

Phase 3 includes 120 signals in the area generally bound by 168th Street on the west, 72nd Street on the east, West Dodge Road on the south, and Fort Street on the north.

7.3.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new to accommodate slack fiber. It is assumed existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN fiber splice pull boxes to signal cabinets.

Communication Network

1. Ethernet-based communications: Deploy an Ethernet-based network, using fiber optic cable.
2. Fiber Distribution Communications: Distribution communication links will be deployed in this phase from either Hubs 7.

3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
5. Wireless communications: Approximately 23 wireless links will be implemented in this phase.

Cabinet/Controller Upgrades

1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.
3. Ethernet switches: The 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 hardware.

ITS Devices

1. CCTV Cameras: 26 CCTV cameras will be installed in this phase.

Traffic Management Center

1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects

1. None

7.3.3 Summary of Estimated Costs

Phase 3 improvements are estimated to cost $2.8 million. Table H3 in the Appendix H details Phase 3 costs in greater detail. Figure H3 in the Appendix H illustrates Phase 3 improvements.

7.4 Phase 4 – Southeast

7.4.1 Overview

Phase 4 includes 124 signals in the area generally bound by 13th Street, 60th Street, Harrison Street and Center Street.

7.4.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new 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 requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN 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 fiber optic cable.
2. Fiber Distribution Communications: Distribution communication links will be deployed in this phase from either Hubs 3 or 4.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
5. Wireless communications: Approximately 26 wireless links will be implemented in this phase.

Cabinet/Controller Upgrades

1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.
3. Ethernet switches: The 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 hardware.

ITS Devices

1. CCTV Cameras: 28 CCTV cameras will be installed in this phase.

Traffic Management Center

1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects

1. Saddle Creek Area – 55th Street to 64th Street Sewer Separation
2. 37th St and Frances St Downstream Sewer Separation (Begin 2024)
3. 20th St to 25th St, Oak St to Deer Park Sewer Separation (Begin 2018)
4. Martha Street Sewer Separation (Begin 2016)
5. Missouri Avenue Sewer Separation (Begin 2014)
6. 26th St and J St Sewer Separation (Begin 2018)

7. 38th St and D St Sewer Separation (Begin 2018)
8. 42 Street & Q Street Sewer Separation
9. 39th St and O St Sewer Separation (Begin 2018)
10. 20th Street & U Street Sewer Separation (Begin 2018)
11. South Barrel Conversion (Begin 2020)
12. Gilmore Avenue Sewer Separation (Begin 2018)

7.4.3 Summary of Estimated Costs

Phase 4 improvements are estimated to cost $4.1 million. Table H4 in the Appendix H details Phase 4 costs in greater detail. Figure H4 in the Appendix H illustrates Phase 4 improvements.

7.5 Phase 5 – West Central

7.5.1 Overview

Phase 5 includes 88 signals along the following arterials:

1. Pacific Street from 78th Street to 173rd Street
2. West Center Road from Industrial Road to HWS Cleveland Boulevard
3. 132nd Street from Pacific Street to Grover Street
4. 156th Street from Pacific Street to Burt Street/Cuming Street

Additional signals in the Westroads, Regency, and Old Mill areas are also included.

7.5.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new to accommodate slack fiber. It is assumed existing pull boxes are spaced every 1,000 to 1,500 feet.
3. Existing Conduit: This phase requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN fiber splice pull boxes to signal cabinets.

Communication Network

1. Ethernet-based communications: Deploy an Ethernet-based network, using fiber optic cable.
2. Fiber Distribution Communications: Distribution communication links will be deployed in this phase from either Hubs 1, 3, 7, or 8.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
5. Wireless communications: Approximately seven wireless links will be implemented in this phase.

Cabinet/Controller Upgrades
1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.
3. Ethernet switches: The 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 hardware.

ITS Devices
1. CCTV Cameras: 16 CCTV cameras will be installed in this phase.

Traffic Management Center
1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects
1. None.

7.5.3 Summary of Estimated Costs
Phase 5 improvements are estimated to cost $2.3 million. Table H5 in the Appendix H details Phase 5 costs in greater detail. Figure H5 in the Appendix H illustrates Phase 5 improvements.

7.6 Phase 6 – Northeast

7.6.1 Overview
Phase 6 includes 120 signals generally north of Ames Avenue and east of Military Avenue.

7.6.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new 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 requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.

4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN 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 fiber optic cable.
2. Fiber Distribution Communications: Distribution communication links will be deployed in this phase from either Hubs 6 or 7.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
5. Wireless communications: Approximately 33 wireless links will be implemented in this phase.

Cabinet/Controller Upgrades

1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.
3. Ethernet switches: The 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 hardware.

ITS Devices

1. CCTV Cameras: 21 CCTV cameras will be installed in this phase.

Traffic Management Center

1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects

1. 39th Street and Fontenelle Street Sewer Separation
2. 45th St and Saratoga St Sewer Separation (Begin 2020)
3. 46th Street & Grand Street Sewer Separation (Begin 2019)
4. 43rd Street & Boyd Street Sewer Separation (Begin 2021)
5. 33rd Street & Taylor Street Sewer Separation (active)
6. Cole Creek CSO 204 Sewer Separation (active)
7. 49th Street & Fowler Street Sewer Separation (Begin 2019)
8. Pershing and Storz Detention Basin Improvements (active)
9. Miller Park to Pershing Detention Basin Sewer Separation (active)

10. Minne Lusa Blvd Sewer Separation (Begin 2018)
11. 35th St and Redick St Sewer Separation (Begin 2020)
12. 31st St and Iowa St Sewer Separation (Begin 2020)
13. Forest Lawn Sewer Separation (Begin 2016)
14. 36th Street Sewer Separation (State Street to McKinley Street) (active)
15. Minne Lusa Avenue Storage Facility (Begin 2015)

7.6.3 Summary of Estimated Costs

Phase 6 improvements are estimated to cost $2.9 million. Table H6 in the Appendix H details Phase 6 costs in greater detail. Figure H6 in the Appendix H illustrates Phase 6 improvements.

7.7 Phase 7 – Midtown

7.7.1 Overview

Phase 7 includes 149 signals along the following arterials:

1. Leavenworth Street from 13th Street to Happy Hollow Boulevard
2. St. Mary's Avenue
3. Harney Street from 24th Street to 42nd Street
4. Underwood Avenue – California Street from 30th Street to 61st Street
5. Cuming Street from Saddle Creek Road to 16th Street
6. Hamilton Street from Northwest Radial Highway to 30th Street
7. Saddle Creek Road and Leavenworth Street to Northwest Radial Highway and 61st Street
8. 42nd Street from Woolworth Avenue to Farnam Street
9. 30th Street from Douglas Street to Bedford Avenue
10. 24th Street from Woolworth Avenue to Cuming Street

7.7.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new 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 requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN 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 fiber optic cable.

2. Fiber Distribution Communications: Distribution communication links will be deployed in this phase from either Hubs 5 or 8.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
5. Wireless communications: Approximately 43 wireless links will be implemented in this phase.

Cabinet/Controller Upgrades

1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.
3. Ethernet switches: The 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 hardware.

ITS Devices

1. CCTV Cameras: 22 CCTV cameras will be installed in this phase.

Traffic Management Center

1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects

1. Country Club Phase 2 Sewer Separation (active)
2. 50th Street & Sigwart Street Sewer Separation (Begin 2019)
3. Northwest Radial Highway Sewer Separation (Begin 2018)
4. 41st St and Nicholas St Sewer Separation (Begin 2018)
5. 33rd St and Cass St Sewer Separation (Begin 2018)
6. 30th St and Myrtle St, Southwest and Northeast Sewer Separation (Begin 2018)
7. 30th Street & Burdette Street Sewer Separation (Begin 2020)
8. Nicholas & Webster Sewer Separation (active)
9. Saddle Creek Sanitary Trunk Sewer Separation (Begin 2024)
10. Farnam St and Saddle Creek Sewer Separation (Begin 2020)
11. 33rd St and Jackson St Sewer Separation (Begin 2018)
12. 33rd St and Leavenworth St Southeast Sewer Separation (Begin 2018)

7.7.3 Summary of Estimated Costs

Phase 7 improvements are estimated to cost $4.0 million. Table H7 in the Appendix H details Phase 7 costs in greater detail. Figure H7 in the Appendix H illustrates Phase 7 improvements.

7.8 PHASE 8 – DOWNTOWN

7.8.1 OVERVIEW

Phase 8 includes 114 signals in the following areas:

1. The core Downtown and North Downtown areas
2. 10th Street south of Leavenworth Street
3. Abbott Drive from Cuming Street to Locust Street
4. 24th Street, Florence Boulevard, and 20th Street from Cuming Street to Ames Avenue
5. Lake Street from US 75 to 16th Street

Deployment of sensors and DMS are anticipated to begin in Phase 8 and continue through Phase 10. No specific corridors will be identified at this time.

7.8.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new 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 requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN 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 fiber optic cable.
2. Fiber Distribution Communications: Distribution communication links will be deployed in this phase from either Hubs 5 or 6.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
5. Wireless communications: Approximately 18 wireless links will be implemented in this phase.

Cabinet/Controller Upgrades

1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.

3. Ethernet switches: The 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 hardware.

ITS Devices

1. CCTV Cameras: 23 CCTV cameras will be installed in this phase.
2. DMS: Up to 20 DMS will be installed on corridors to be determined.
3. Sensors: Up to 40 units will be installed on corridors to be determined.

Traffic Management Center

1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects

1. 26th & Corby Sewer Separation (active)
2. 18th Street & Seward Street Sewer Separation (Begin 2017)
3. 16th Street & Grant Street Sewer Separation (Begin 2017)
4. Nicholas Street Sewer Separation (Begin 2014)
5. 7th St to 12th St, Mason St to Briggs St Sewer Separation (Begin 2018)

7.8.3 Summary of Estimated Costs

Phase 8 improvements are estimated to cost $3.2 million. Table H8 in the Appendix H details Phase 8 costs in greater detail. Figure H8 in the Appendix H illustrates Phase 8 improvements.

7.9 Phase 9 – Southwest

7.9.1 Overview

Phase 9 includes 89 signals (all remaining signals) in the far western portion of the City (west of 144th Street) as well as Harrison Street east to 90th Street.

7.9.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new 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 requires use of existing conduits. The existing conduit may require modification from right angle elbows to large radius sweeps at the interconnect pull boxes.

4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN 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 fiber optic cable.
2. Fiber Distribution Communications: Distribution communication links will be deployed in this phase from either Hubs 1, 2, or 7.
3. Fiber optic cable in existing conduit: Fiber optic cables with trace wire are recommended with 50 feet of cable 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 coiled in each pull box.
5. Wireless communications: Approximately 20 wireless links will be implemented in this phase.

Cabinet/Controller Upgrades

1. Cabinets: Upgrade all cabinets to Type 332, or Type 346 where necessary.
2. Controllers: The Type 170E controllers will be upgraded with new 2070 ATC controllers.
3. Ethernet switches: The 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 hardware.

ITS Devices

1. CCTV Cameras: 27 CCTV cameras will be installed in this phase.
2. DMS: Up to 20 DMS will be installed on corridors to be determined.
3. Sensors: Up to 40 units will be installed on corridors to be determined.

Traffic Management Center

1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

Coordination with CSO Projects

1. None.

7.9.3 Summary of Estimated Costs

Phase 9 improvements are estimated to cost $2.9 million. Table H9 in the Appendix H details Phase 9 costs in greater detail. Figure H9 in the Appendix H illustrates Phase 9 improvements.

7.10 Phase 10 – ITS

7.10.1 Overview

Phase 10 includes deployment of additional ITS devices, particularly sensors, cameras, and DMS. No signals are included in this phase.

7.10.2 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.
2. Mid-block Interconnect Pull boxes: The interconnect pull boxes will be upgraded to new 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 requires use of existing conduits. The existing conduit may require modification from elbows to large radius sweeps at the interconnect pull boxes.
4. New Conduit: All new conduits should be minimum 2 inch conduits. Additional conduit may need to be installed for drop cable access from UPN fiber splice pull boxes to signal cabinets.

Communication Network

1. Ethernet-based communications: The City will deploy an Ethernet-based network, using the new fiber optic cable.
2. Fiber Distribution Communications: Distribution communication links 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 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 coiled in each pull box.

ITS Devices

1. CCTV Cameras: 22 CCTV cameras will be installed in this phase.
2. DMS: Up to 60 DMS will be installed on corridors to be determined.
3. Sensors: Up to 120 units will be installed on corridors to be determined.

Traffic Management Center

1. Central software system: The central signal software will be configured for Ethernet-based communications to the controllers upgraded to Ethernet in this phase.
2. ATMS Software: ITS devices will be integrated into Delcan software.

7.10.3 Summary of Estimated Costs

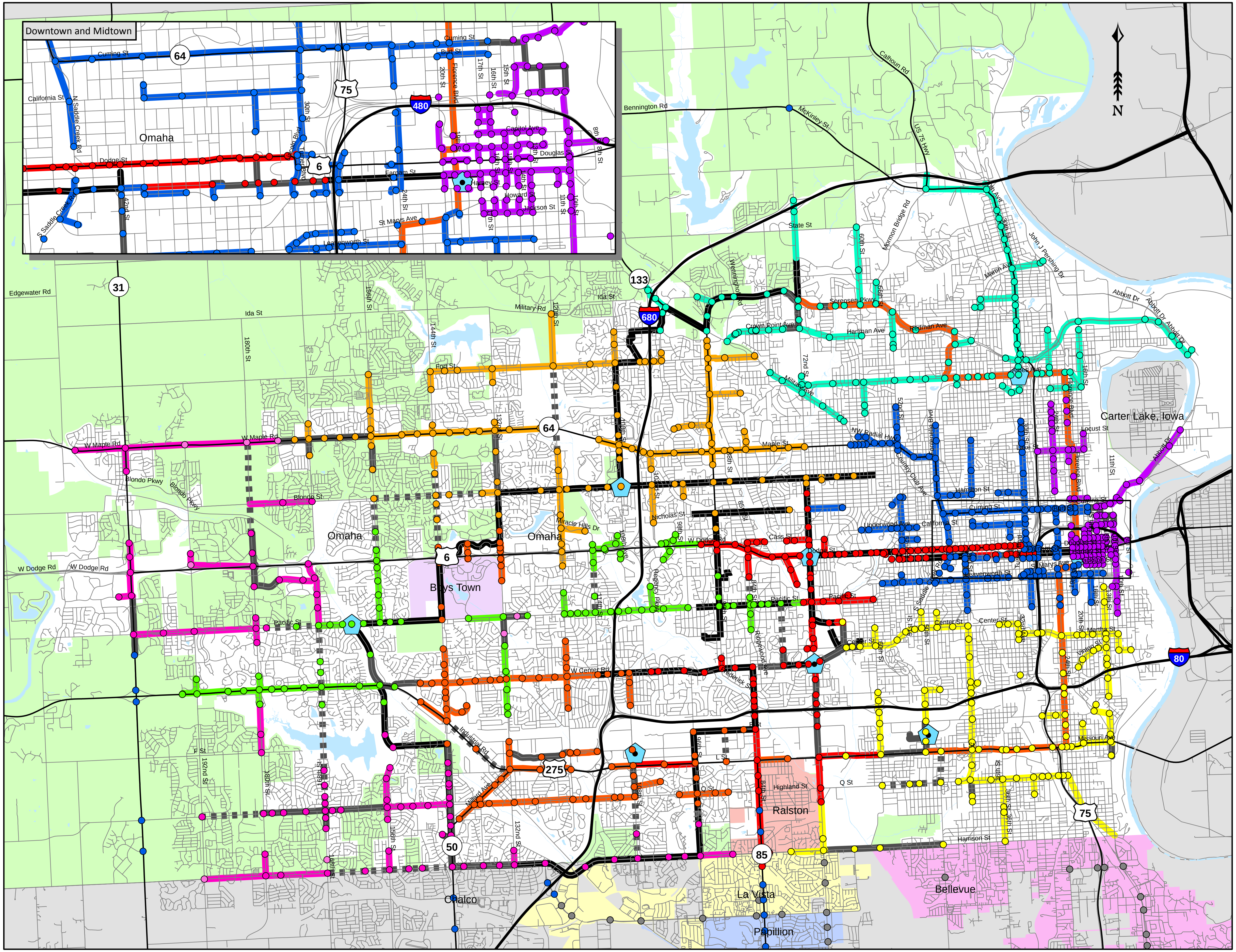
Phase 10 improvements are estimated to cost $4.0 million. Table H10 in the Appendix H details Phase 10 costs in greater detail.

Coordination with CSO Projects

1. None expected.

7.11 Summary of All Phases

Figure 30 summarizes improvements for Phases 1 through 9.



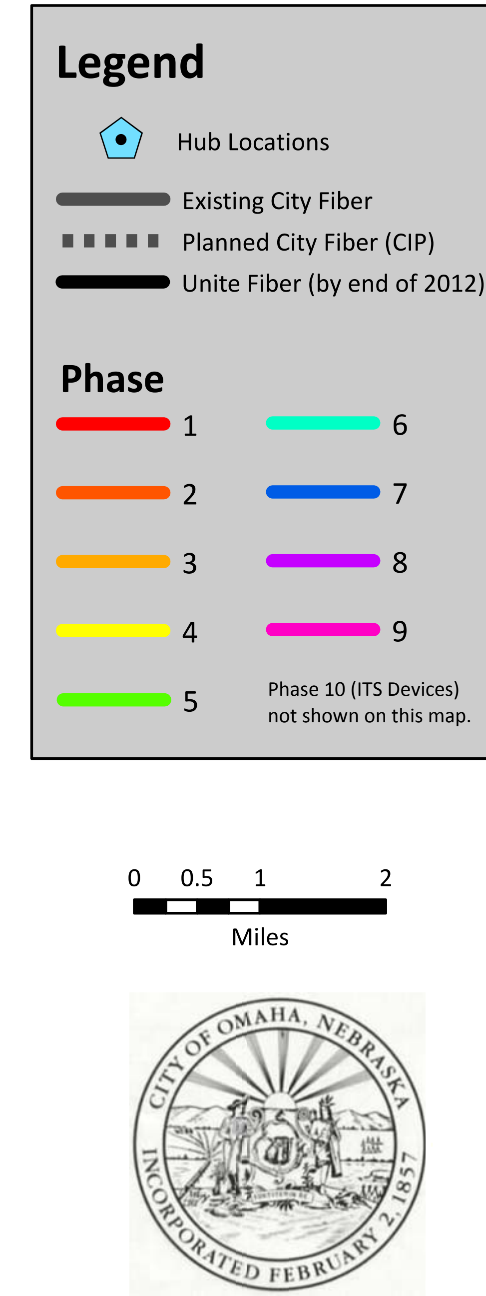


FIGURE 30

Summary of Phase Improvements

8.0 NEXT STEPS

The City should move forward with deployment of the signal system which includes finalizing requirements for system software procurement and initiating design phases based on funding availability. Annual funding of $3.75 million was programmed by MAPA and City of Omaha over the next two years for the deployment of initial components of the traffic signal system; however, recent changes have modified the amount and timing of 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. These funds are obtained through approval of the NDOR safety committees, and a safety evaluation of the project(s) is required. Additional funding beyond that described above will likely be required to fully implement all projects identified in the master plan.

APPENDIX A

STRATEGIC COMMUNICATIONS PLAN

U.S. Department of Transportation
Federal Highway Administration

City of Omaha
Traffic Signal System Master Plan

Strategic Communications Plan

August 28, 2012

DOCUMENT VERSION CONTROL

Document Name	Submittal Date	Version No.
Draft Version 1.0	May 2, 2012	1.0
Final Version 2.0	August 28 ,2012	2. 0

TABLE OF CONTENTS

APPENDICES

APPENDIX A: GRASSROOTS CONTACT LIST
APPENDIX B: SHARETHIS APPLICATION INSTRUCTIONS

1.0 KEY UNDERSTANDING

Omaha enjoys an efficient roadway system, but without planning foresight, that efficiency may not be maintained in the future as the city continues to grow. One of the key challenges faced in regards to the City of Omaha's Traffic Signal System Master Plan is that the public has expectations for travel times that may not be feasible in the future without changes. However, they may not yet see major deficiencies or understand that improvements can be made without major capital infrastructure changes.

Educating the public about the benefits of a Traffic Signal System Master Plan, specifically how it could improve traffic conditions, is important to gain public acceptance. This will allow for short- and long-term political and public awareness that will help define and fiscally support a better roadway system for Omaha through using the Traffic Signal Master Plan.

2.0 LESSONS LEARNED

Based on research of traffic signal system improvements and/or master plans in Bellflower, CA; Chino Hills, CA; Maricopa County, AZ; and Colorado Springs, CO, significant insights are offered related to public education and community benefits.

Project messaging should be the main area of focus—helping political entities and the public understand issues being addressed in terms of deficiencies and opportunities (i.e., wait times, emissions, accident rates, emergency response), and what technology is available as a solution. Throughout the process, new technology and how changes are being implemented should be addressed.

Another area of focus should be tangible or quantifiable benefits. Messaging and communication tools should be utilized that help political entities and the public understand what they can expect from current and future implementation and program investments. Examples could include:

- Improved mobility and access
- Boosted local economies
- Reduced crashes
- Reduced energy and fuel consumption
- Improved emergency response
- Improved traffic flow on arterial roadways
- Reduced vehicle emissions
- Ensuring the signal system works as designed
- Real time traveler information and video feed
- Performance measurement

2.1 Issues Faced

Public perception is the greatest issue affecting current implementation and future funding for the City of Omaha Traffic Signal System Master Plan. Because the actions of Public Works are typically limited to large-scale infrastructure projects in the public eye, public perception does not currently exist for elements of the proposed Traffic Signal System Master Plan. The lack of public perception will not automatically create opposition for the Plan, but it does indicate that political and public awareness, and therefore financial support, may not be easily gained. Creating a politically, publically, and financially supported plan means that the perception of Public Works, and the work the department accomplishes, needs to be framed in a positive and advantageous manner that highlight tangible and quantifiable benefits to the community.

Lack of major, visible road network deficiencies and traffic congestion may raise questions about the Plan's necessity at this point in time. Lack of support could also come from misunderstanding the nature of the study, specifically how traffic signal systems work. These factors could overshadow the potential benefits of the project.

3.0 STAKEHOLDER ANALYSIS

A broad definition of a stakeholder for the City of Omaha Traffic Signal System Master Plan is any person who is affected by transportation policy and planning decisions, programs or projects. This includes any person who may not be aware that these decisions could affect them. Within this broadly defined category are target groups that are directly impacted by the benefits of the proposed improvements, those that have a special interest, and those that are responsible for future funding decisions. Identifying all audiences that should be a target for communication messaging and outreach is the first step towards implementing meaningful political and public awareness of the Master Plan. The following is an initial list of stakeholders and target groups to be included in the process:

- City of Omaha
  - Mayor's Office
  - City Council
  - City Departments
- Surrounding Municipal Jurisdictions
- MAPA
- Metro Transit
- Leading Agencies
  - Nebraska Department of Roads
  - Federal Highway Administration
- Emergency Responders
- Federal Transit Administration
- General Public

4.0 COMMUNICATION OBJECTIVES

4.1 SHORT-TERM

The immediate objectives for the Traffic Signal System Master Plan are to establish a politically and publically accepted need for the study itself, which is to improve the operational efficiency and effectiveness of the Omaha roadway system by way of improving the traffic signal system.

Another short-term objective, which will carry through the entire study, is to educate the public on the benefits of technology improvements, rather than typical roadway infrastructure improvements, and the nature of roadways as systems that require operations and management. This concept may not be easily understood or recognized. Without this understanding, support will not be likely gained.

4.2 MEDIUM-TERM

After establishing the need and benefits, it will be important to implement tools that visibly demonstrate progress and the usefulness of a well-operating system (outside of driving conditions themselves). This includes highlighting high-profile projects, and assuring that all "low-hanging fruit" has been addressed. Demonstrating progress, especially on highly visible projects, will mitigate public frustration, perpetuate public interaction and education, assist in gaining public trust, and improve feedback and future planning.

4.3 LONG-TERM

The long-term goal will be to establish and continue to develop an identity for Public Works that encompasses the breadth of focus and accomplishments related to all projects. This includes continuous outreach through media associated with Public Works, Engage Omaha, Moving Omaha, the Mayor's office, City Council, and champion organizations such as (potentially) the American Council of Engineering Companies, Activate Omaha, Modeshift, and the National Utility Contractors Association. Regularly scheduled progress reports and less frequent milestone achievement features will show how the continued funding, and political and public support lead to success of an overall roadway system in the City of Omaha.

5.0 COMMUNICATION STRATEGIES

The strategies for implementing project communications are based on the context of Objectives and Stakeholders. This includes reaching the right people and addressing concerns/highlighting opportunities at the correct place and time in the project development process. Identified here are high-level messages that align with the Communication Objectives and the channels through which those messages are driven.

5.1 MESSAGING

Messages in this section are the broader, high-level concepts and ideas that inform each public-facing tool. General language laid out here is expanded upon when creating outreach materials, tailoring specific language for each medium while maintaining a consistent theme and voice throughout.

5.1.1 KEY MESSAGE

The City of Omaha Traffic Signal System Master Plan will modernize operations and increase overall traffic efficiency, through a defined vision and implementation plan for the City's traffic signal network. The development of an improved traffic communication network will provide many quantifiable benefits to the City of Omaha and its citizens including improved mobility and access, reduced vehicle emissions, reduced energy and fuel consumption, reduced crashes, and improved emergency response.

The City intends to use this master plan to develop a framework upon which the future of traffic management and traffic signal communication system of Omaha can be built. Once implementation is complete, an enhanced and efficient traffic network will exist for all users in the greater Omaha area.

5.1.2 BACKGROUND & RATIONALE

The traffic communication network in Omaha is based on 1970's technology: dial-up modems, multiple loosely connected computer systems, and signal controllers that lack desired modern functionality with an ability to use, communicate or integrate with other traffic management and Intelligent Transportation System tools. As the city grows and develops, the traffic signal communication system needs to adapt. The City of Omaha Traffic Signal System Master Plan will define how to manage future traffic growth, invest intelligently in modern technology, and create efficient communication between systems.

Omaha is a greater metropolitan area with multiple traffic signal system jurisdictions that overlap with those of the City of Omaha. These overlapping systems are in Sarpy County and locations in Douglas County outside the city limits, including NDOR signal systems on some state routes or ramp junctions. Consistency, scalability and compatibility between the City's system and the other systems are desired future outcomes of this effort.

5.1.3 *PROCESS*

There are currently over 1,000 signalized intersections operated and maintained by the City of Omaha. The implementation of the master plan will add several hundred devices (e.g., cameras, sensors, and message boards) and an upgraded communications network to the signal system. Due to these factors and existing budgetary constraints, the implementation of the Traffic Signal System Master Plan will be broken into deployable phases over several years. Section 7.0 of the Traffic Signal System Master Plan provides a discussion of the multi-year deployment strategy.

5.1.4 *BENEFITS*

The implementation of elements identified in the Traffic Signal System Master Plan will provide significant benefits. The benefits have been divided into seven categories and are as follows:

1. Arterial Traffic Management
    - Improved operations for all modes of transportation
    - Improved efficiency of the traffic signal system
    - Improved efficiency of engineering, operations, and maintenance staff
    - Improved safety for all modes of transportation
    - Improved safety for engineering and maintenance staff
2. Safety Systems
    - Improved safety and operations for all modes during power outage or cabinet knockdown
    - Improved safety for drivers making left turns
    - Improved safety for pedestrians at intersections and mid-block locations
    - Improved safety for bicyclists at signalized intersections
    - Improved safety and operations for drivers during winter driving conditions
    - Improved safety for drivers and pedestrians by reducing speed-related crashes
    - Improved safety for drivers by reducing vehicle-to-vehicle crashes
3. Communications Systems
    - Improved performance of the traffic signal system
    - Improved efficiency of engineering and maintenance staff
    - Improved safety and operations for all transportation modes
    - Improved security and scalability of network to support traffic signal system goals
4. Incident Management
    - Improved operations for drivers during incidents
    - Improved safety for the public and emergency response personnel
    - Improved incident clearance time to restore roadways to normal operations
5. Traveler Information Systems
    - Improved operations for drivers by providing pre-trip and en-route information
6. Public Transportation
    - Improved operations for transit vehicles at traffic signals
    - Improved safety for transit vehicles
    - Improved operations for vehicle and transit users

  - Improved traveler information to increase transit ridership
7. Maintenance and Construction Operations
   - Reduced failures of traffic signal system components
   - Improved efficiency of technician staff
   - Improved safety and efficiency of traffic approaching and moving through work zones
   - Improved efficiency of staff and equipment during maintenance and winter operations
   - Improved preventative maintenance
   - Improved the consistency of traffic signal and ITS cabinets
   - Improved asset/infrastructure monitoring capabilities

5.2 Tools

5.2.1 Master Plan Rollout

Implementing a public awareness rollout campaign will capitalize on required Master Plan adoption initiatives to help bolster public and political recognition for traffic signal planning benefits. This process will help to establish a framework for future implementation and funding.

5.2.1.1 City Council Subcommittee & Governing Bodies Presentation

Prior to final required presentation of the Master Plan to the governing body of the City Council and MAPA Board, the political representatives on the City Council Public Works Committee should be given an opportunity to provide input and receive educational information on the Master Plan elements. This presentation is intended to highlight the project messaging identified in the communication plan and the tangible and quantifiable benefits of implementation. In supplement to the presentation, a short executive summary of the same information will be produced. Presentation of the final Master Plan will be made at public forums to City Council at large, and the MAPA Board. These forums will be used to communicate and summarize the planning process, issues, program changes, cost implications and program benefits.

5.2.1.2 Media & Social Media

Earned media should be utilized in the form of press releases and neighborhood newsletters to bring attention to the City Council adoption of the Traffic Signal System Master Plan. Immediately following the accepted approval from City Council, a press release should be distributed from the City of Omaha highlighting implementation benefits of the plan, the need for future funding, and how to monitor success and implementation for the program through the City of Omaha Public Works Department communication tools such as the website and social media. Outreach should be extended to the *Omaha World Herald* and the Neighborhood Center of Omaha. The same information should be shared through the Public Works, Moving Omaha, Environment Omaha, Mayor’s site, and Police Department Twitter feeds, linking back to the Public Works website.

5.2.1.3 Grassroots Outreach

Recognizing community interaction and established communication channels within neighborhoods and the broader community, Public Works should foster relationships with grassroots networks within the metro area. Leading organizations should be used as local resources and messengers for public communication outreach. Newsletter content and a broad distribution email should be developed to educate about project progress, milestone achievements, behavioral changes that can made as identified in the campaign messaging, and opportunities for champion organizations to demonstrate support. A contact list of grassroots outreach is attached in Appendix A.

5.2.2 Website Enhancements

5.2.2.1 Immediate Opportunities

The City of Omaha Public Works website (http://www.cityofomaha.org/pw/) will be the online information center for all target audiences for the Traffic Signal System Master Plan and other program initiatives. Pages on the website contain information on the various programs and responsibilities of the Public Works Department. The current content pertaining to traffic engineering contains general information about traffic management and efforts to improve the overall roadway system in the City. Providing information about the Master Plan and incentives to act on this information will require modifications and more online awareness for the user of the website. Recommendations on website improvements follow.

Call to Action

The Public Works website has a clear call to action in the navigation options used most frequently by users including snow management, street closings, issue reporting, and EcoOmaha. However, additional department information is deeply embedded in the navigation of the site limiting ease of access to find pertinent information about ongoing projects and updates related to roadway system improvements of the City. It is recommended that an Announcement box be embedded in the Public Works home page, allowing ongoing and new project information to be updated as needed where the user can get immediate access. Content in the Announcements box would then lead back to the project specific action, in this case the Traffic Engineering home page.

In addition, the most important and user friendly tool available through the Traffic Engineering website navigation is the Street Closings map. Throughout implementation of the Master Plan, this map should be updated to include the areas of phased implementation, highlighting the areas where new traffic signal improvements will be made. To emphasize the work that Public Works does as a whole, and not just capital infrastructure projects, it is recommended that this map be renamed as Traffic Management Improvement Projects, to help meet the long-term goals of Public Works communication objectives. Other roadway improvement projects, including studies, should be added to this map.

Content on this page should also be modified to highlight the overall benefits provided from Traffic Engineering including the benefits of the Master Plan and other project initiatives. Other projects and studies do not need additional project pages, but should be linked seamlessly to the Moving Omaha website at http://movingomaha.org/.

ShareThis Social Media Integration

Frequent activity on social media will increase the Public Works online presence and enhance the limited in-person engagement efforts of the various department initiatives. For both Facebook (via Moving Omaha) and Twitter, participating in the online social discussion will aid relevance and visibility of the Master Plan. However, the goal of social media is intended to be a social conversation, which requires consistent management, and interaction with social media users. As with many infrastructure projects, though, there is not enough ongoing and relevant information to keep a social audience engaged in program elements, which make the return on time and investment in these tools very limited. Therefore, it is recommended that the website be updated with ShareThis applications (http://sharethis.com/) that allow for a website user to update their social networks with Public Works approved messaging without having to have a social media account. ShareThis application instructions are included in Appendix B.

Twitter

The existing Public Works Twitter account is frequently used to update the public and increase awareness on department initiatives. To highlight use of this tool, meet communication objectives of this plan, and to highlight the transparent and collaborative effort of the Public Works Department, it is recommended to embed the Twitter Feed on the home page of the Public Works website. Master Plan messages and ongoing implementation updates should be shared through this network on a regular basis always tying back to the website as the centerpiece of Traffic Engineering and the roadway system improvements public image. Throughout the master plan, the hashtag “#OmahaTraffic” will be used in related tweets. This will put a consistent, relevant mark on all project messages, and allow for more efficient tracking of message reach.

5.2.2.2 Consistent and Timely Content

The Traffic Engineering website should have clear messaging that is written for web delivery and is easy to understand. However, out-of-date content and static information will decrease the likelihood that interested audiences will engage in the program initiatives and spread the message through their social networks. Information should be posted on the home page about upcoming activities and engagement events. There should be limited information about past efforts with a call to action on how to get involved and be informed about department initiatives.

5.2.3 Internal Communications

The City of Omaha represents one of the largest employers in the Omaha metro region employing nearly 3,800 individuals. Tapping into this vast network, while also targeting political representatives such as the Mayor and City Council representatives, will allow Public Works and the Traffic Engineering department to catalyze internal support for program initiatives including implementation of the Master Plan. Once enhancements occur, user kiosks should be placed strategically throughout high-trafficked areas of City Hall encouraging use of the website while building awareness of program initiatives. In addition, streaming video from major intersections should be broadcasted on televisions that allow a viewer to see and understand how traffic is being managed and allow these individuals to make better route planning decisions.

APPENDIX A: GRASSROOTS CONTACT LIST

Midtown Crossing	Molly Skold 3220 Farnam Street, Suite 2102 (402) 598-9676 Molly.Skold@mutualofomaha.com	**Jeff Beals**	World Group 780 North 114th Street (402) 510-7468 jbeals@worldgroupllc.com
Greenstreet Cycles	Ben Swan 1310 Mike Fahey Street (402) 505-8002 ben@greenstreetcycles.com	**Mikki Frost**	Alegent Health 12809 West Dodge Road (402) 343-4691 Mikki.frost@alegent.org
Community Bike Project	Matt Martin 525 North 33rd Street (402) 957-2453 matt@communitybikeproject.org	**Kara Eastman**	Omaha Healthy Kids Alliance 5006 Underwood Ave (402) 934-9700 kara@omahahealthykids.com
Activate Omaha	Julie Harris 12565 West Center Rd, Suite 220 (402) 934-5923 jharris@activateomaha.org	**Marcella Thompson**	Environment Omaha 6001 Dodge St. 402.554.4010 marcella.thompson@conagrafoods.com
Connie Spellman	Omaha by Design 6001 Dodge St. (402) 554-4010 connie@omahabydesign.org	**Dave Ciaccio**	Vireo 1111 N. 13th Street, Suite 116 (402) 553-5485 dave@bevireo.com
Mike McMeekin	Lamp, Rynearson & Associates 14710 W Dodge Rd # 100 (402) 496-2498 mike.mcmeekin@lna-inc.com	**Marty Schukart**	RDG Planning and Design 900 Farnam, Suite 100 (402) 392-0133 mshukert@rdgusa.com
Amy Mathis	Omaha Public Library 215 S. 15th St (402) 444.4833	**Jay Noddle**	Noddle Companies 2285 S. 67th Street, Suite 250 (402) 496-1616 jay@noddlecompanies.com
Jamie Grayson-Bergland	Destination Midtown 1301 Harney St (402) 233-7142 jgrayson@selectgreateromaha.com	**Green Omaha Coalition**	Nicolette Amundson PO Box 3127 (402) 551-3887 namundson@bvh.com
Craig Moody	Verdis Group 1516 Cuming Street (402) 681.9458 craig@verdisgroup.com	**Rick Yoder**	University of Nebraska at Omaha 6001 Dodge St. (402) 554-6251 ryoder@unomaha.edu
Sandi Weinberg	Omaha Pedalers Bicycle Club PO Box 4729 Benson Station, NE 68104 (402) 451-8774 slwpug@cox.net	**Stephen Schnitker**	Bikeable Communities 12565 West Center Road Suite 220 (402) 934-5923 sschnitker@cox.net

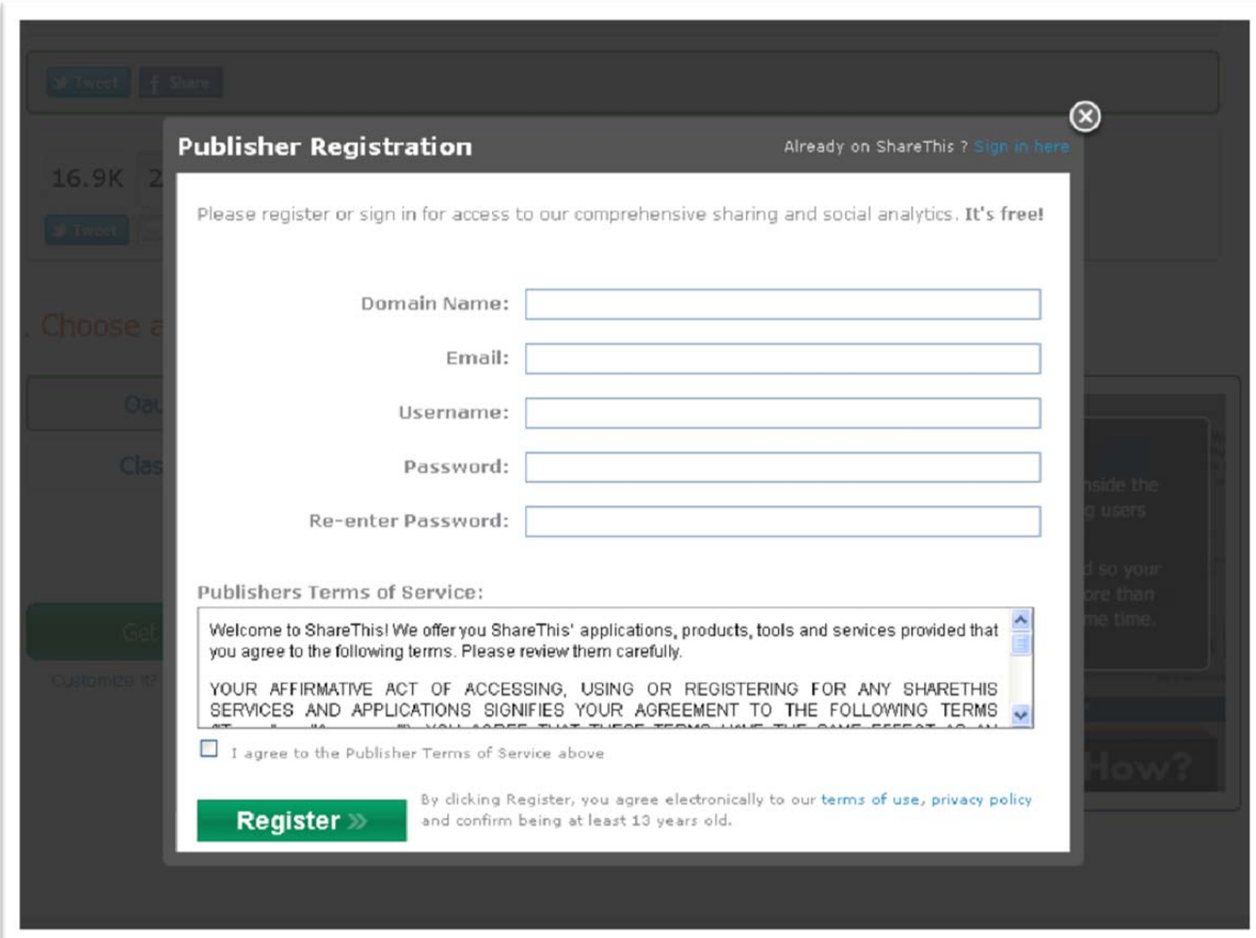
Kevin Flatowicz-Farmer	Mode Shift Omaha cal2neb@gmail.com	**Lizabet Arellano**	Omaha Area Health Education Center 5017 Leavenworth St Suite 101 (402) 502-1207 liza@ahecomaha.org
Kerri Peterson	Live Well Omaha 12565 W Center Rd Suite 220 (402) 934-5886 kpeterson@livewellomaha.org	**Sloan Dawson**	MAPA 2222 Cuming St (402) 444-6866 Ext. 218 sdawson@mapacog.org
Kay Farrell	National Safety Council, Nebraska 11620 M Cir (402) 896-0454	**Ron Abdouch**	Neighborhood Center 115 S 49th Ave (402) 319-5140 rabdouch@unomaha.edu
Carrie Hakencamp	WasteCap Nebraska 285 S 68th Street Pl # 540 Lincoln, NE 68510 (402) 436-2384	**Patrick McAtee**	Omaha Bikes 12565 W Center Rd Suite 220 (402) 934-5923
Anne Trumble	Emerging Terrain 1717 Vinton St (402) 884-8754	**Omaha B-Cycle**	525 N 33rd St (402) 957-2453 bcycle@communitybikeproject.org
Michael Grube	UNO Bikes (402) 554-2124	**VOICE Omaha**	info@voiceomaha.org

APPENDIX B: SHARETHIS APPLICATION INSTRUCTIONS

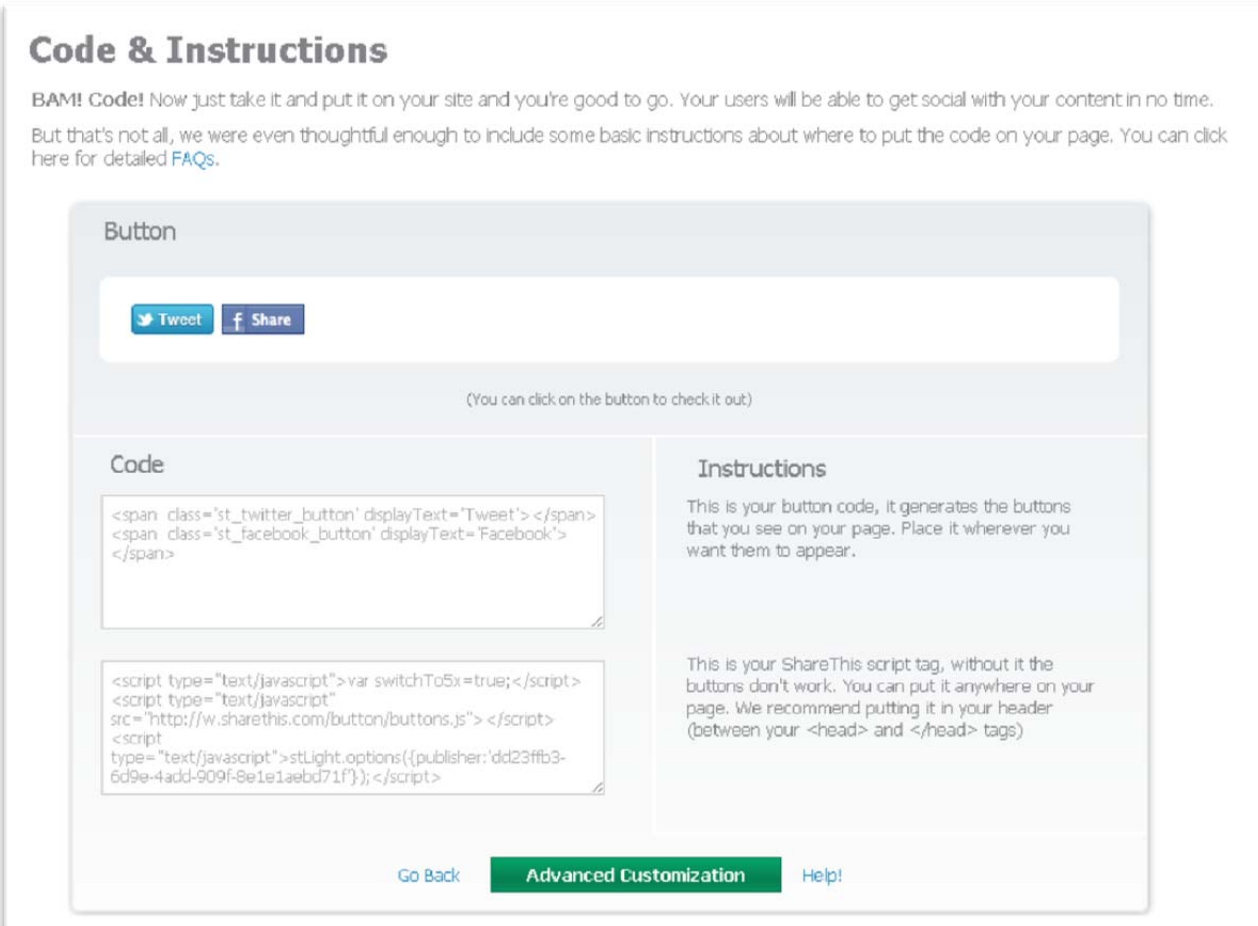
ShareThis.com Social Media Button Procedure

Pick your networks and button styles.

Register. This is all the information they need.



Place code in the HTML files.



Add the following code to the <head> of the webpage, changing information where indicated *in italics*. This information will help populate the Facebook post, Tweet, email, etc.

<meta property="og:title" content="*ADD BRIEF DESCRIPTION HERE* />

<meta property="og:type" content="website" />

<meta property="og:url" content="*ADD SITE URL HERE"* />

<meta property="og:image" content="*ADD URL PATH TO AN IMAGE HERE*" />

<meta property="og:locale:alternate" content="en_US" />

<meta property="og:description" content=" " />

<meta property="og:site_name" content="*ADD NAME OF PROJECT/WEBSITE HERE*/>

APPENDIX B

PROJECT PLAN

U.S. Department of Transportation

Federal Highway Administration

City of Omaha
Traffic Signal System Master Plan

Final Project Plan

January 28, 2013

Document Version Control

Document Name	Submittal Date	Version No.
Version 1.0	January 20, 2012	1.0
Version 2.0	March 13, 2012	2.0
Version 3.0	April 9, 2012	3.0
Version 4.0	January 28, 2013	4.0

TABLE OF CONTENTS

List of Tables

1.0 PURPOSE OF DOCUMENT

This Project Plan for the City of Omaha Traffic Signal System Master Plan provides the guidelines for development of a master plan and, in future phases, deployment of recommended traffic signal system components. This document is prepared to support the City of Omaha in completion of this project and provide documentation in compliance with FHWA Rule 23 CFR 940.11. The City of Omaha will work through the system engineering process described in the Rule and provide a Project Plan, a System Engineering Management Plan, a Concept of Operations and a Requirements and Verification Plan. The Project Plan is the first document in this set of systems engineering deliverables and consists of:

- Project Scope
- Project Goals and Objectives
- Project Effort and Schedule
- Project Budget

The purpose of the document is to provide a guide for all stakeholders that clearly define the Traffic Signal System Master Plan project scope, goals, schedule, and budget.

2.0 PROJECT SCOPE

The scope of this project includes the development of a Traffic Signal System Master Plan for the City of Omaha. The Metropolitan Area Planning Agency (MAPA) Regional ITS Architecture includes projects for improvements to the traffic signal system in the City of Omaha that is consistent with this project. The full documentation of this ITS architecture can be found at http://www.mapacog.org/intelligent-transportation-systems-its.

The master plan will address major system components that may include:

- Traffic signal system hardware and software
- Communications infrastructure
- Location and functionality of traffic management center
- Field devices for detection and system management (such as video cameras, traffic sensors, dynamic message signs (DMS), anti-icing systems, parking management systems, etc.)
- Emergency vehicle preemption (EVP)
- Adaptive signal control technology (ASCT)
- Data sharing among key stakeholders
- Provision of information to the traveling public

As part of the development of the master plan, the following tasks will be conducted:

- Project Management
- Existing System Evaluation and Needs Assessment
- Alternative Evaluation and Improvement Options
- Traffic Signal System Master Plan and Deployment Strategy
- Concept Design and Cost Estimates
- Strategic Communications Plan

Final Design and phased construction will be conducted as part of future projects. The Systems Engineering process will also be integrated, depending on the technical complexity of the project, into all required project tasks.

3.0 PROJECT GOAL AND OBJECTIVES

The goal of the project is to develop a clear and flexible traffic signal system master plan that results in the right-sized traffic signal system, providing value, improved safety, improved traffic operations, and public support well into the future. The traffic signal system must be compatible with the needs of multiple jurisdictions that are responsible for traffic management in the greater Omaha metropolitan area, and must be scalable and expandable to meet future system needs. Some specific objectives, not listed in any particular order, include:

- Integrate volume and timing data between turning movement counts, capacity analysis and optimization software, and signal timing databases
- Identify central location for signal timing databases
- Implement robust, reliable, and faster communications
- Receive real-time alarms from signals for detection or coordination errors
- Create user-friendly operational reports in real-time or based on historical data
- Create logging system to track and archive signal timing changes
- Collect performance measures to evaluate system operations
- Evaluate transit signal priority capabilities
- Develop traffic management center to monitor traffic, coordinate staff, and deploy timing in real-time
- Modify splits and offsets more easily in the field
- Evaluate use of uninterruptible power supply systems
- Receive notification of cabinet knockdowns and better coordinate among agencies
- Disseminate traffic information to the public via DMS, websites, or social media
- Conduct traffic monitoring and management around work zones
- Implement emergency vehicle priorities and capabilities
- Possible co-location with NDOR District 2 Operations Center
- Evaluation of potential locations for installation of ASCT
- Improve the overall safety and operations of the Omaha roadways and signalized intersection network

4.0 PROJECT EFFORT AND SCHEDULE

Table 1 summarizes the project scope and schedule. For each task, the table briefly describes the effort, team members involved, and expected deliverables. Dates of draft deliverables are approximate and subject to change based on review by City, NDOR, and FHWA staff.

TABLE 1: PRELIMINARY PROJECT TASKS AND SCHEDULE

Tasks and Deliverables	Key Team Members	Start Date	Completion Date
1. Systems Engineering Management Plan	- Iteris (Lead) - HDR - City of Omaha	Feb. 1, 2012	Feb. 29, 2012
2. Existing System Evaluation & Needs Assessment	- Iteris (Lead) - HDR - City of Omaha	Jan. 15, 2012	Feb. 29, 2012
3. Strategic Communications Plan	- HDR (Lead) - Iteris - City of Omaha	Jan. 15, 2012	Mar. 15, 2012
4. Concept of Operations	- HDR (Lead) - Iteris - City of Omaha	Mar. 1, 2012	Mar. 31, 2012
5. Alternatives Evaluation & Recommended Improvement Options	- Iteris (Lead) - HDR - City of Omaha	Feb. 1, 2012	Mar. 31, 2012
6. Requirements and Verification Plan	- Iteris (Lead) - HDR - City of Omaha	Apr. 1, 2012	Apr .30, 2012
7. Traffic Signal System Master Plan and Deployment Strategy	- Iteris (Lead) - HDR - City of Omaha	Mar. 15, 2012	Jun. 30, 2012
8. Concept Design & Cost Estimate	- Iteris (Lead) - HDR - City of Omaha	May. 1, 2012	Jun. 30, 2012
9. Phased Final Design*	- City of Omaha (Lead)	Aug. 2012	Mar. 2018 and beyond
10. Phased Construction/Deployment*	- City of Omaha (Lead)	Apr. 2013	Nov. 2019 and beyond

**Assumes phased final design and construction/deployment over potentially six (6) design and construction/deployment phases. Exact design/construction phasing plan to be determined based on Traffic Signal System Master Plan recommendations and consensu from City staff.*

5.0 PROJECT BUDGET

The City of Omaha has budgeted $195,000.00 for the completion of the Traffic Signal System Master Plan. Annual funding is currently programmed by the Metropolitan Area Planning Agency (MAPA) and City of Omaha for six years at $937,500.00 per year (for a total of $5,625,000.00) for the deployment of initial components of the traffic signal system. 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. These funds are obtained through approval of the NDOR safety committees, and a safety evaluation of the project(s) is required. Additional funding beyond that described above will likely be required to fully implement all projects identified in the master plan.

APPENDIX C

SYSTEMS ENGINEERING MANAGEMENT PLAN

U.S. Department of Transportation
Federal Highway Administration

City of Omaha
Traffic Signal System Master Plan

Final Systems Engineering Management Plan

July 18, 2012

DOCUMENT VERSION CONTROL

Document Name	Submittal Date	Version No.
Version 1.0	March 16, 2012	1.0
Version 2.0	April 10, 2012	2.0
Version 3.0	July 18, 2012	3.0

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 PURPOSE OF DOCUMENT

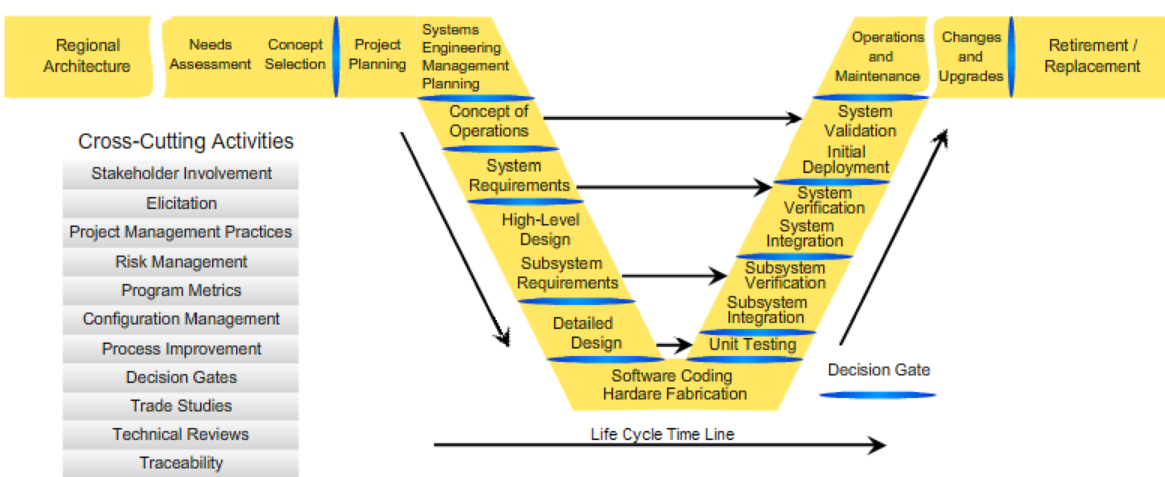
The Systems Engineering Management Plan (SEMP) for the City of Omaha Traffic Signal System Master Plan (TSSMP) provides a high-level plan for the management of Systems Engineering in compliance with the Federal Highway Administration (FHWA) Federal Rule 23 CFR 940.11 and Systems Engineering Guidelines. The SEMP is the second document in the set of systems engineering deliverables identified in the Project Plan, and consists of:

- Project Overview
- Project and Systems Engineering Documentation
- Project Management and Control
    - Traceability and Technical Review
    - Procurement Management
    - Risk Management
    - Change Management
    - Quality Management
    - Systems Acceptance
    - Operations and Maintenance, Upgrade and Retirement

The purpose of the SEMP is to describe how the Systems Engineering Process, illustrated in **Figure 1,** will be integrated into the Traffic Signal System Master Plan and subsequent design and deployment phases. The SEMP will guide the project from conception to operations and maintenance in a systematic way. The SEMP is an evolving document that will be updated as the project progresses.

FIGURE 1: SYSTEMS ENGINEERING PROCESS "V" DIAGRAM

Phase -1	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Interfacing with Planning and the Regional Architecture	Concept Exploration and Benefits Analysis	Project Planning and Concept of Operations Development	System Definition and Design	System Development and Implementation	Validation, Operations and Maintenance, Changes & Upgrades	System Retirement / Replacement



2.0 PROJECT OVERVIEW

The purpose of this project is to develop a Traffic Signal System Master Plan for the City of Omaha and lay the foundation for design and deployment of the projects identified in the TSSMP. The existing traffic signal system includes over 1,000 traffic signals and a vast hybrid communications system. While functional, stakeholders have identified needs that cannot be met with the current system. Related intelligent transportation system (ITS) devices for traffic management will also be included in this plan.

Currently, the City of Omaha operates all traffic signals within city limits (including state highways) as well as additional signals outside city limits through agreements with the Nebraska Department of Roads (NDOR), Douglas County, and other surrounding agencies. The signal system is operated and maintained by City staff from the Civic Center and the Signal Shop. The City is currently predominantly using 170E signal controllers with Wapiti firmware that communicate via dial-up modems and a mix of twisted pair copper, wireless radio, and fiber optic communications. Ten 2070 controllers have been installed at several intersections in North Downtown.

The signal system is currently comprised of many components and ITS devices which include:

- Traffic signal controllers and firmware
- Cabinets
- Detection devices (including inductive loops, wireless magnetic, video, microwave, and thermal)
- Emergency vehicle preemption (EVP) devices
- Uninterruptible power supply (UPS) systems
- Communications
  - Media (including twisted pair copper, wireless radio, fiber optic)
  - Hardware (switches, transceivers, modems, etc.)
  - Conduit and poles (for overhead copper)
- Closed Loop System Software
- Central Traffic Control System Software
- ITS and Other Devices
  - CCTV cameras
  - Dynamic message signs (DMS)
  - Reversible lane signals
  - Road weather information system (RWIS)
  - Anti-icing system
  - High water flashing beacons

2.1 Project Goals and Objectives

The goal of the Traffic Signal System Master Plan Project is ***to develop a clear and flexible traffic signal system master plan that results in the right-sized traffic signal system, meets the needs of all stakeholders, and provides value, improved safety, improved traffic operations, and public support well into the future.*** The plan will also include conceptual design, a phased deployment strategy, and cost estimates to guide the implementation of the plan. In addition to the components listed in section 2.0, the TSSMP will take into account the following elements:

- Traffic management center (TMC)
- Staffing requirements
- Arterial traffic management
- Safety systems
- Emergency management
- Traveler information systems
- Public transportation
- Maintenance and construction operations
- Data management for both in-house and public use

2.2 Project Scope and Schedule

The project scope and schedule are outlined in the Project Plan previously prepared for this project. The TSSMP will be developed in 2012. As part of the development of the master plan, the following tasks will be conducted:

- Project Management
- Existing System Evaluation and Needs Assessment
- Alternatives Evaluation and Improvement Options
- Traffic Signal System Master Plan and Deployment Strategy
- Concept Design and Cost Estimates
- Strategic Communications Plan

Implementation of projects identified in the master plan will begin in 2013. While the TSSMP will develop cost estimates and a deployment schedule, it is unknown at this time the amount of funding required to implement the entire master plan. The implementation schedule will be highly dependent on funding. Funding of $937,500 per year has been identified over the next six years to begin implementation. Additional funding will likely be required. The preparation of th TSSMP will include discussion with City staff and other stakeholders regarding identification of additional funding sources.

2.3 STAKEHOLDERS

Project Stakeholders anticipated for this project include:

- City of Omaha Public Works Department
- City of Omaha Traffic Engineering Division
- City of Omaha Traffic Maintenance Shop
- City of Omaha Street Maintenance Division
- Omaha Fire Department
- Omaha Police Department
- City of Omaha Planning Department
- Douglas-Omaha Technology Commission (DOT.Comm)
- Douglas County Engineer
- Douglas County Sherriff
- Douglas County 911 Communications
- Douglas County Emergency Management Agency
- Metropolitan Area Planning Agency (MAPA)
- Federal Highway Administration (FHWA) Nebraska Division
- NDOR District 2
- NDOR Traffic Engineering Division
- NDOR Operations Division
- NDOR District Operations Center
- Nebraska State Patrol
- Other Agencies Public Works, Police, and Fire Departments in Omaha Metropolitan area
- Metro Transit
- Metropolitan Entertainment and Convention Authority (MECA)
- University of Nebraska I^3 Lab
- Unite Private Networks
- Other Communications Partners
- Media
- Traveling Public

The Concept of Operations will formally identify these stakeholders. Some stakeholders may choose not to participate, or the lead agency may determine the agency should not be a stakeholder.

2.4 Relevant Project Documentation

The City of Omaha is the lead agency in the development of the Traffic Signal System Master Plan and subsequent design and deployment phases. The following regional-level planning documents describe the need for the upgrade of the City of Omaha's traffic signal system:

MAPA Regional ITS Architecture – The Metropolitan Area Planning Agency (MAPA) Regional ITS Architecture was completed in 2005 and identifies a project for improvements to the traffic signal system for the City of Omaha that is consistent with this project.

MAPA Transportation Improvement Program (TIP) – The 2012 MAPA TIP identifies annual funding sources over the next six years for $937,500.00 per year (for a total of $5,625,000.00) for the deployment of the traffic signal system. The funding sources for both the TSSMP 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. These funds are obtained through approval of the NDOR safety committees, and a safety evaluation of the project(s) is required.

3.0 PROJECT AND SYSTEMS ENGINEERING DOCUMENTATION

Table 1 identifies and describes the system engineering processes and deliverables that will be completed. Items 1-4 will be completed in conjunction with the development of the TSSMP, while the remaining system engineering documents (Items 5-7) will be completed as each project identified in the master plan is designed, deployed, tested, and accepted.

TABLE 1: TRAFFIC SIGNAL SYSTEM MASTER PLAN AND DEPLOYMENT DOCUMENTATION

Systems Engineering Processes	Status	Description	Deliverables
1. Project Plan	In Progress	The Project Plan will provide a guide for all stakeholders that clearly define the scope, goals, schedule, and budget of the Traffic Signal System Master Plan project as well as subsequent design and deployment phases.	Draft and Final Project Plan
2. System Engineering Management Plan	In Progress	The Systems Engineering Management Plan will provide project managers and stakeholders an overview of how the TSSMP and subsequent design and deployement phases will follow and be integrated with the systems engineering processes.	Draft and Final Systems Engineering Management Plan

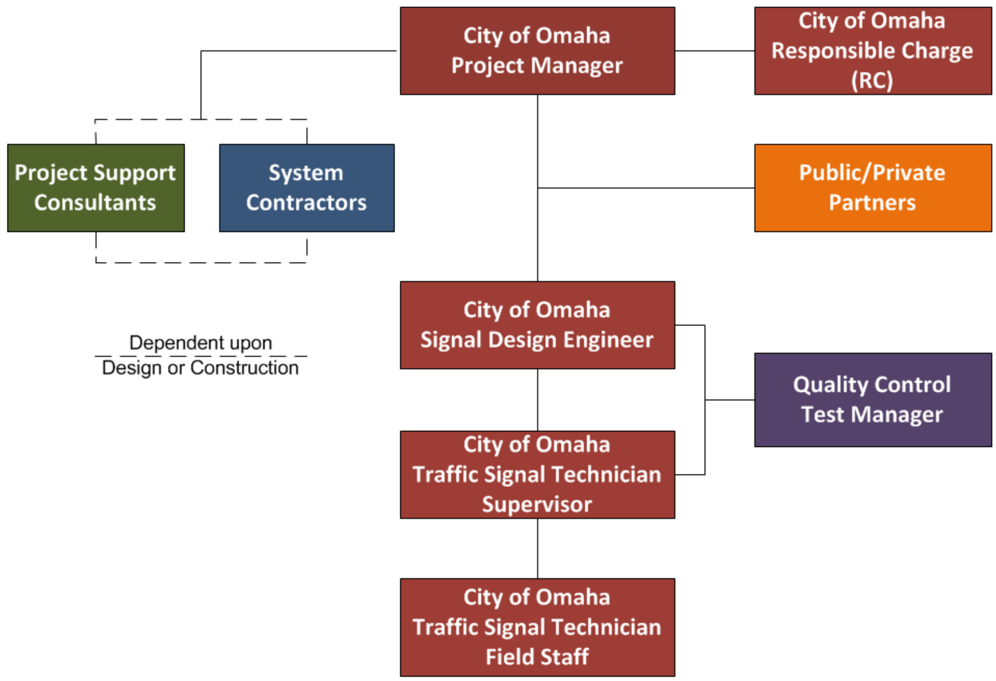
Systems Engineering Processes	Status	Description	Deliverables
3. Concept of Operations	In Progress	The Concept of Operations will identify the needs as well as roles and responsibilities of all stakeholders identified in the SEMP as it relates to the City of Omaha traffic signal system. The Concept of Operations will define what the traffic signal system will look like and how it will operate based on discussion of operational scenarios and alternative concepts.	Draft and Final Concept of Operations
4. High-Level Requirements and Verification Plan	Not Started	The High-Level Requirements and Verification Plan will develop high-level requirements for the traffic signal system. The requirements will be traced back to the stakeholder needs that were identified in the Concept of Operations. The System Requirements determine what the system must do and drive the system design. A Requirements and Verification Plan will be prepared as part of this project that addresses the expected process to determine that the requirements are satisfied during the subsequent deployment of system components.	Draft and Final High-Level Requirements and Verification Plan
5. High-Level Design	Not Started	High-level Design Plans will develop a plan package for individual traffic signal system components that will adequately meet the requirements identified in the System Requirements and Verification Plan.	Draft and Final High-Level Design Plan Package(s)
6. Detailed Design Plans and Requirements Traceability Spreadsheet	Not Started	Detailed Design Plans will be prepared that are consistent with the Concept of Operations, System Requirements, and High-Level Design. The Requirements Traceability Spreadsheet will be developed to trace requirements through the final design phases, procurement, installation integration, testing, and acceptance.	Detailed Design Plans and Specifications; Requirements Traceability Spreadsheet(s)
7. Procurement, Installation and Integration	Not Started	Using the final plans and specifications, the components will be procured, installed and integrated into the traffic signal system by City of Omaha staff and/or contractors/vendors (depending on the procurement process).	System Component Procurement, Installation and Integration Documentation

Systems Engineering Processes	Status	Description	Deliverables
8. Testing and Acceptance Plans	Not Started	This Plan will summarize the expected testing and schedule associated with the installation of system components and will build on the High-Level Requirements and Verification Plan. Depending on the component being installed, the documentation of the test could include inspection, demonstration and/or execution of basic scripts. The QC/Test Manager will be responsible for performing and documenting all testing with the City or its agents present to observe and verify the results. All modifications will be reviewed and either approved or rejected by the City of Omaha Project Manager.	Testing and Acceptance Plans and Results Documentation

4.0 PROJECT MANAGEMENT AND CONTROL

Figure 2 illustrates the organizational structure for the City of Omaha Traffic Signal System Master Plan Project and subsequent design and deployment phases. Brief descriptions of anticipated project roles are included following the organizational chart.

FIGURE 2: TRAFFIC SIGNAL SYSTEM MASTER PLAN DESIGN & DEPLOYMENT ORGANIZATIONAL CHART



City of Omaha Project Manager – The City of Omaha Project Manager will be responsible for the management of the TSSMP project as well as subsequent design and deployment projects. The Project Manager will be responsible for managing consultant and contractor staff that support the City throughout the planning, design and deployment phases of the project, monitoring project progress and approving or denying any changes to the scope, delegating roles for specific efforts throughout the project, and ensuring the project is completed as agreed upon, that the system meets its goals and objectives, and that the project is properly documented.

Project Support Consultants – Project Support Consultants will provide technical support to the City of Omaha Project Manager. Initially, Project Support Consultants will develop the TSSMP that meets project goals and objectives and ensures the project is consistent with systems engineering processes and documentation specified previously. In subsequent deployment projects, Project Support Consultants will also develop requirements, plans, specifications and estimates. The Consultants may also support the Quality Control Test Manager in reviewing and supporting the efforts of acceptance testing during upon completion of deployment and integration phases.

System Contractor – The System Contractor will construct or install the signal system components. The System Contractor will report directly to the City of Omaha Project Manager and work closely with other City staff. The System Contractor will provide the equipment, labor, hardware, and/or software for the deployment, and will integrate the system, as needed, with legacy traffic signal and communications systems. The System Contractor will be expected to work with the Quality Control Test Manager until the requirements in the Testing and Acceptance Plans are met.

City of Omaha Responsible Charge (RC) – FHWA requires the local public agency (LPA) designate a full time employee to be in "responsible charge" of federal-aid projects and assure compliance with the LPA Guidelines Manual for Federal-aid Projects and federal and state rules and regulations. Primary duties of this position include: administering activities dealing with cost, time, adherence to contract requirepments, construction quality and scope; maintaining familiarity with day-to-day operations, participates in decisions about changes in scope; reviewing financial process transcations, and documentation to minimize fraud, waste, and abuse; directing project staff (agency or consultant) to carry out administration and contract oversight, including proper documentation; and being aware of the qualifications, assignments, and on-the-job performance of the agency and consultant staff at all stages of the project.

Public/Private Partners – The team will include members from third party public and private partners. The role of these partners is to support the planning, design and deployment process based on existing roles or those defined in the planning/design/deployment process. This role requires identification of potential risks that may hinder the progress of the project as well as managing any proposed changes that may be proposed on this project (see Sections 4.3 and 4.4). A list of Public/Private Partners can be found in Section 2.3.

City of Omaha Signal Design Engineer – The City of Omaha Signal Design Engineer will be responsible for working with the City of Omaha Project Manager and the City of Omaha Traffic Signal Technician Supervisor. The Signal Design Engineer will provide input in development of the TSSMP. During deployment phases, the Signal Design Engineer will provide technical support to the City of Omaha Project Manager and Project Support Consultants/Contractors. The Signal Design Engineer will review the requirements, plans, specifications and estimates to ensure they are consistent with the City of Omaha specifications. The Signal Design Engineer may also work with the Traffic Signal Technician Supervisor and Quality Control Test Manager in carrying out the Testing and Acceptance processes and documentation.

City of Omaha Traffic Signal Technician Supervisor – The City of Omaha Traffic Signal Technician Supervisor will be responsible for working with the City of Omaha Project Manager and City of Omaha Signal Design Engineer to provide input for the development of the TSSMP. During deployment phases, the Supervisor will aslo be responsible for ensuring projects are constructed or installed in accordance with the plans, specifications, and requirements, and managing and assigning field staff during deployment projects. The Traffic Signal Technician Supervisor will also work as the liaison between the System Contractor and the City of Omaha Traffic Signal Technician Field staff during installation.

City of Omaha Traffic Signal Technician Field Staff – The City of Omaha Traffic Signal Technician Field Staff will work under direction of the Traffic Signal Technician Supervisor, and will also work with the System Contractors during deployment phases to properly install, integrate, and test the signal system components according to the project plan and specifications. Field Staff will ultimately be responsible for day-to-day maintenance and some of the operational aspects of the system.

Quality Control Test Manager – The Quality Control Test Manager will be an independent third party and is expected to oversee all system testing. The Quality Control Test Manager will work with the System Contractor to prepare the final acceptance test plans. This person will work closely with the City of Omaha Signal Design Engineer, Traffic Signal Technician Supervisor, Traffic Signal Technician Field Staff, and System Contractor to ensure that testing and acceptance procedures and documentation are executed in conformance with the Testing and Acceptance Plans. The Quality Control Test Manager will also be responsible for documenting and reporting the results of all testing to the Project Manager.

4.1 Traceability and Technical Review

The City of Omaha Project Manager is responsible for technical review of all project and systems engineering documents related to development of the TSSMP as well as all phases of future project deployments. The Project Manager will review documents to ensure that the needs and requirements identified in initial systems engineering documents (such as the Concept of Operations) are being carried forward through the System Requirements, Design Plans, and Testing and Acceptance Plans. This traceability makes certain that signal system deployments are being implemented in accordance with the original goals of the TSSMP.

4.2 Procurement Management

The City of Omaha currently has several options for the procurement of equipment and professional services. The following summarize those options:

Equipment

For procurements under $20,000, vendors and/or contractors may submit price quotes. The Purchasing Department selects based on a “lowest and best” provision, which means the lowest bidder that complies to the specifications by the issuing department is selected and issued a purchase order.

For procurements over $20,000, a bid package is prepared. The lowest responding bidder, pending approval by City Council, is awarded the contract. For federal-aid projects, the bid must be let by NDOR using its specifications (with City specs as special provisions).

Procurements for maintenance follow a similar process.

Professional Services

For services under $100,000, projects can be awarded to firms on a pre-approved list. For projects between $100,000 and $250,000, a request for proposals is issued, and a a five-person selection committee awards the projects based on the proposals. For projects over $250,000, a request for proposals is also issued. Firms are short-listed based on proposals, and then interviewed by a selection committee.

For services involving federal-aid funds, the City must follow state and federal requirements, and can now utilize an NDOR On-Call ITS Consultant contract (at the discretion of NDOR). It is envisioned that a variety of procurement options, including design-bid-build, design-build, system manager, and equipment procurement may be desired to complete the system deployment.

As part of the development of the TSSMP, additional procurement options will be explored and recommended if existing options do not meet certain objectives or potential options can be utilized to make the procurement process more efficient and/or streamlined.

Currently, the City does have a list of approved products and vendors for certain traffic signal system components such as video detection cameras, emergency vehicle preemption, signal heads and pedestrian signals, wireless interconnect radios, service disconnect pedestals, fiber patch cables, and fiber fusion splice trays.

4.3 Risk Management

The risk associated with this project has been discussed with City staff and stakeholders. Project needs were discussed to reduce the amount of risk in the project. Areas of risk include:

- Condition of communications network
- Contractor installation and integration
- Transition/integration with legacy equipment/devices
- Changes in technology
- Reliability of latest technology
- Political and public support
- City of Omaha staffing levels
- Staff expertise/training

Risk will be managed through coordination with project stakeholders and preparation of thorough plans and specifications that meet project requirements. The risk management group will be led by members from the City of Omaha. The City Project Manager will coordinate with this team to ensure the installation, integration and maintenance elements are managed to reduce overall project risk.

The risk management team is expected to include the following agencies:

- City of Omaha (Lead agency)
- Douglas-Omaha Technology Commission (DOT.Comm)
- Nebraska Department of Roads (NDOR)
- Metropolitan Area Planning Agency (MAPA)

4.4 Change Management

Change management is needed throughout the planning and deployment process to provide accurate documentation and approval of any changes related to stakeholder needs, system requirements, design plans, or product specifications. A change or system upgrade may be needed to keep pace with changing stakeholder roles and responsibilities, advancing and changing technology, or addition of system components over time. Changes in the TSSMP should also be reflected in the MAPA Regional ITS Architecture as appropriate.

The City of Omaha Project Manager will be responsible for change management throughout the project (i.e., development of master plan, design, deployment, and acceptance testing). In this capacity, the Change Management Team will review all proposed project changes and coordinate with the appropriate management for approval or rejection. Proposed changes will be discussed during project status meetings. If a change is accepted, the Project Manager and the Project Support Consultant or Contractor will agree on the impact the change has on schedule and project budget.

The change management team is expected to include the following agencies:

- City of Omaha (Lead agency)
- Douglas-Omaha Technology Commission (DOT.Comm)
- Nebraska Department of Roads (NDOR)
  Metropolitan Area Planning Agency (MAPA)

4.5 Quality Management

The City of Omaha Quality Management practices will be applied to all stages of the TSSMP and the design and deployment of the traffic signal system components. The City of Omaha should require all Project Support Consultants, System Contractors, and Quality Control Test Managers to develop and adhere to internal quality assurance/quality control practices and to develop and follow quality control procedures for all project activities.

4.6 Systems Acceptance

The Testing and Acceptance Plan will document how the traffic signal system deployment will function and must be consistent with the agreed-upon functional requirements. The Quality Control Test Manager will be responsible for review and verification of the System Acceptance Plan. Verification by the Quality Control Test Manager means the test plan has adequate tests to address each system requirement. Depending on the project, testing and acceptance can be done at one or more levels (device, subsystem, and system).

The Quality Control Test Manager and System Contractor, in conjunction with the City of Omaha Signal Design Engineer, Traffic Signal Technician Supervisor, and Traffic Signal Technician Field Staff, will be responsible for executing the Testing and Acceptance Plan for each signal system deployment.

The following are examples of acceptance tests that may be performed for system deployments:

- Factory acceptance testing – The Quality Control Test Manager will ensure that the product being procured meets the required specifications and that it has been configured in a manner that is consistent with the system requirements.
- Shop Drawing Review – The Quality Control Test Manager will compare factory specifications to ensure they meet or exceed those required in design plans.
- On-Site Visual Confirmation or Demonstration – The Quality Control Test Manager will verify on-site that the component was installed and is operating in accordance with design plans and specifications.
- Scripted Demonstrations
    - One-day acceptance testing (System turn-on) – The Quality Control Test Manager will ensure that the system meets the system requirements at the beginning of the project deployment. If the system does not meet a requirements to the satisfaction of the Test Manager, the system will be redesigned and the requirement will be retested at a later date.
    - Reliability testing - The Quality Control Test Manager will ensure that the system meets the system requirements over the course of the acceptance testing process (nominally 30 days). If the system does not meet a requirement to the satisfaction of the Test Manager, the system will be redesigned and the requirement will be retested at a later date. The thirty-day acceptance test is done concurrently with the one-day acceptance test.

Once the system is accepted by the Quality Control Test Manager, including initial and retested requirements, the City accepts and becomes responsible for the operation and maintenance of the system component. The Quality Control Test Manager will be responsible for reporting the results of all tests. The City of Omaha Project Manager will use this information to make final decisions on system acceptance.

4.7 Operations and Maintenance, Upgrade and Retirement

Operations and Maintenance, Upgrade and Retirement are dependent upon the technology deployed and the warranty of the products or services procured. The Concept of Operations should document at the high-level, the expected plan for:

- Operations – This will include a high-level summary of the staffing needs to operate the system and the roles and responsibilities for signal system operation, management, information sharing and reporting.
- Maintenance – This will include the staffing needed to maintain system software, hardware and communications. Current maintenance needs will be documented, and the purchase of extended warranties will be evaluated.
- Upgrade – This will include opportunities for hardware, software and communications upgrades. The City of Omaha will use potential upgrade options to develop a strategy for budgeting and performing system upgrades.
- Retirement – This will include estimates for software, hardware and communications replacement. This will be based on industry trends and the City of Omaha vision for continued, proactive traffic management.

APPENDIX D

CONCEPT OF OPERATIONS

U.S. Department of Transportation

Federal Highway Administration

City of Omaha
Traffic Signal System Master Plan

Final Concept of Operations

December 4, 2012

DOCUMENT VERSION CONTROL

Document Name	Submittal Date	Version No.
Version 1.0	August 27, 2012	1.0
Version 2.0	October 18, 2012	2.0
Version 2.1	December 4, 2012	2.1

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 SCOPE OF THE PROJECT

1.1 SYSTEM OVERVIEW

The purpose of this project is to develop a Traffic Signal System Master Plan (TSSMP) for the City of Omaha and form the foundation for design and deployment of the projects identified in the TSSMP. This document will focus mainly on the traffic signal system; however, the City realizes that there are many opportunities to improve intersection safety and operations through utilizing non-signalized strategies. These may include improvements to geometrics, construction of roundabouts, removal of unwarranted signals and changes to access control. The City will continue to monitor, analyze and evaluate opportunities to incorporate non-signalized strategies. The Omaha Transportation Master Plan provides a detailed discussion regarding non-signalized strategies.

The existing traffic signal system includes over 1,000 traffic signals and a vast hybrid communications system. While functional, stakeholders have identified needs that cannot be met with the current system. Related intelligent transportation system (ITS) devices for traffic management will also be included in this plan.

Currently, the City of Omaha operates all traffic signals within city limits (including state highways) as well as additional signals outside city limits through agreements with the Nebraska Department of Roads (NDOR), Douglas County, and other surrounding agencies. The signal system is operated and maintained by City staff from the Civic Center and the Traffic Maintenance Facility. The City is currently predominately using 170E signal controllers with Wapiti Micro Systems local controller firmware that communicate via dial-up modems and a mix of twisted pair copper, wireless radio, and fiber optic communications. The City has deployed several 2070 signal controllers at intersections in the downtown area.

The TSSMP project includes evaluation of the traffic signal system as well as other related items, which include:

- Traffic signal controllers and firmware
- Cabinets
- Detection devices (including inductive loops, wireless magnetic, video, microwave, and thermal)
- Emergency vehicle preemption (EVP) devices
- Uninterruptible power supply (UPS) systems
- Communications
    - Media (including twisted pair copper, wireless radio, fiber optic)
    - Hardware (switches, transceivers, modems, etc.)
    - Conduit

- Closed Loop System Software
- Advanced Transportation Management System Software
- ITS components
    - CCTV cameras
    - Dynamic message signs (DMS)
    - Parking management system components

1.2 Document Overview

The Concept of Operations (ConOps) for the TSSMP is a document that describes the expected operations of the system from the user's viewpoint and provides documentation in compliance with FHWA Rule 23 CFR 940.11 and Systems Engineering Guidelines. The ConOps is the third document in the set of systems engineering deliverables identified in and including the Project Plan and the Systems Engineering Management Plan (SEMP), and consists of:

- Scope of the Project
- Reference Documents
- Current Situation
- Operational Needs
- Proposed Operations
- Operational Scenarios
- Summary of Impacts
- Next Steps

The purpose of the ConOps document is to communicate overall qualitative system characteristics to the City of Omaha and other involved stakeholders. This document will define the user needs that will drive the requirements for the TSSMP.

1.3 Goals and Objectives

The goal of the TSSMP project is ***to develop a clear and flexible traffic signal system master plan that results in the right-sized traffic signal system, meets the needs of stakeholders, and provides value, improved safety, improved traffic operations, and public support well into the future.*** The project will also include conceptual design, a phased deployment strategy, and cost estimates to guide the implementation of the plan. In addition to the components listed in section 1.1, the TSSMP will take into account the following elements:

- Traffic management center (TMC)
- Staffing requirements
- Arterial traffic management
- Safety systems
- Emergency management

- Traveler information systems
- Public transportation
- Maintenance and construction operations
- Data management for both in-house and public use

2.0 REFERENCE DOCUMENTS

The following documents have been used in the preparation of this ConOps. Some of these documents provide policy guidance for the Traffic Signal System Master Plan, some are standards with which the system must comply, while others report the conclusions of discussions, workshops and other research used to define the needs of the project and subsequently identify project requirements.

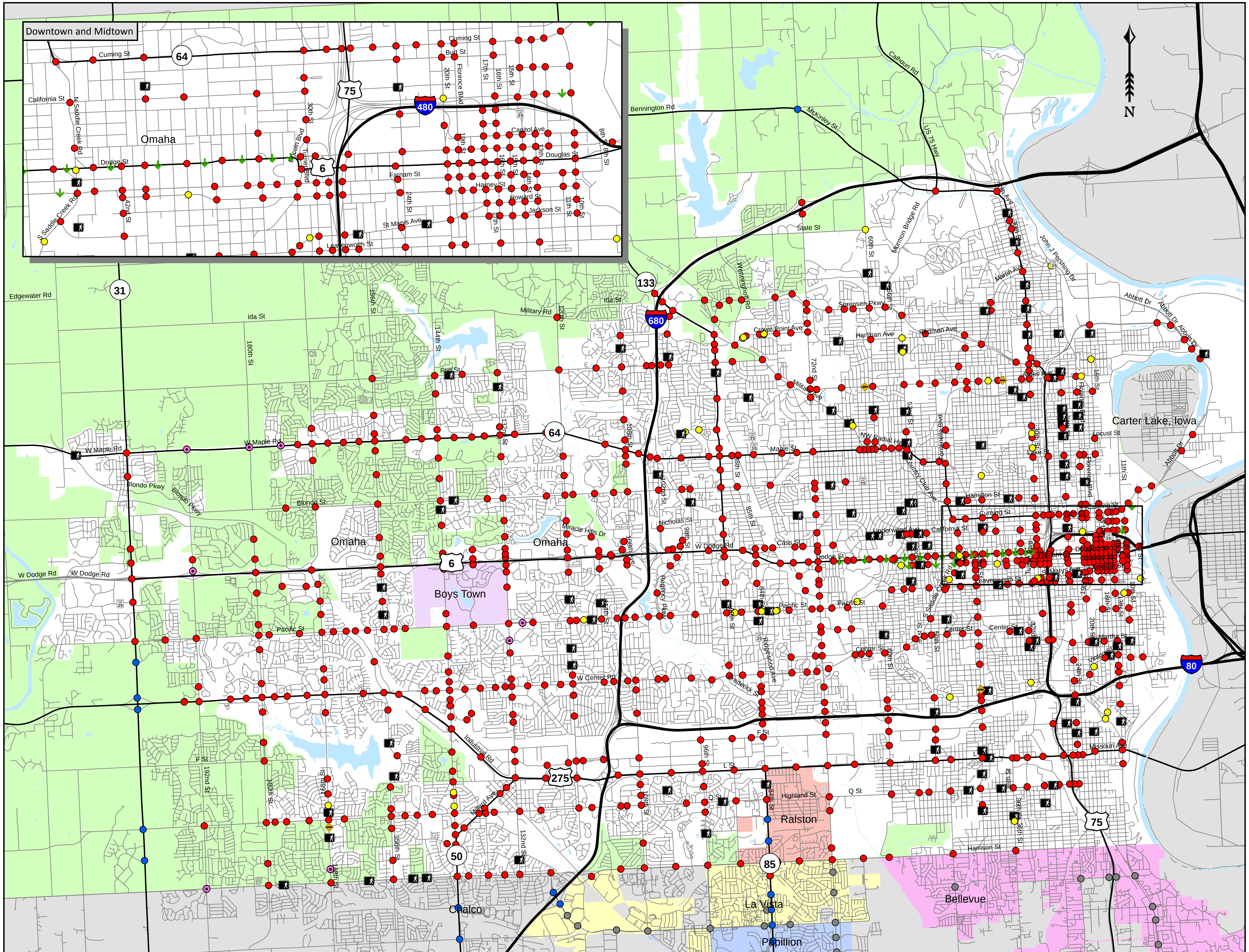
- *MAPA Regional ITS Architecture* - http://www.mapacog.org/intelligent-transportation-systems-its
- *MAPA Long Range Transportation Plan 2035* - http://www.mapacog.org/long-range-transportation-planning
- *City of Omaha Transportation Master Plan* - http://www.cityofomaha.org/tmplan/
- *MAPA Transportation Improvement Program* - http://www.mapacog.org/transportation-improvement-program
- *City of Omaha Capital Improvements Program 2012-2017* - http://www.cityofomaha.org/finance/images/stories/pdfs/CIP2012-2017.pdf
- *City of Omaha Traffic Signal System Master Plan*
- *Systems Engineering Guidebook for ITS, California Department of Transportation, Division of Research & Innovation, Version 3.0* - http://www.fhwa.dot.gov/cadiv/segb/
- *Nebraska* 2012-*2016 Strategic Highway Safety Plan (SHSP)* - http://www.nebraskatransportation.org/traffeng/shsp/shsp-current.pdf
- *Omaha-Council Bluffs Traffic Incident Management Operations Guidelines* - http://www.tim.ne.gov/alternate-routes/metro-ocb/O-CB%20TIM%20Ops%20Guide%202011-03-22.pdf

The MAPA Regional ITS Architecture identifies elements of the TSSMP within the context of regional ITS planning, identifies the user services, describes the data flows and identifies the relevant ITS communications standards. The operational concept for the ITS architecture identified ten congestion management strategies that included deployment of a central traffic control system and other projects consistent with the TSSMP. The market packages related to the TSSMP include ATMS 01 – Network Surveillance, ATMS 03 – Surface Street Control, ATMS – 06 Traffic Information Dissemination, and ATMS 18 – Reversible Lane Management.

3.0 CURRENT SITUATION

The traffic communication network in Omaha is based on 1970's technology: dial-up modems, multiple connected computer systems, and signal controllers that lack desired modern functionality with an ability to use, communicate or integrate with other traffic management and ITS tools.

Omaha is a metropolitan area with multiple jurisdictions that overlap with those of the City of Omaha, including Sarpy County, Douglas County outside the city limits, and NDOR. Figure 1 illustrates the existing traffic signal system.



Legend

- Full Intersection Signal
- Pedestrian Crossing Signal
- Flashing Beacon
- Lane Control Signal
- Speed Feedback Sign
- Emergency Signal
- Planned Signals in Omaha
- NDOR Signals (outside City)
- Sarpy County Signals (non-NDOR)

0 0.5 1 2
Miles

CITY OF OMAHA, NEBRASKA
INCORPORATED FEBRUARY 2, 1857

FIGURE 1

Existing Traffic Signal System

3.1 Existing System

A thorough and accurate assessment of the City of Omaha existing system was conducted and documented in the *City of Omaha TSSMP*. This document provides a detailed description of the existing system and documented the traffic signal system, communications system, intelligent transportation system devices and transportation system management. A summary is provided in the following text.

3.1.1 Traffic Signal System

Traffic Signals

The City of Omaha currently operates 1,012 traffic signals. The City of Omaha owns 979 of these signals, while NDOR owns 7, Douglas County owns 24, and Sarpy County agencies own 2. Table 1 summarizes the number of traffic signals by type, including full vehicle installations, pedestrian installations, flashing beacons, lane control signals, speed feedback signs, and fire station (emergency) signals.

Table 1 – Number of Traffic Signals By Signal Type

Type of Signal	Number
Full Signal	830
Pedestrian Signal	119
Flashing Beacon	40
Lane Control Signal	19
Emergency Signal	4
Total	1,012

The City has added countdown timers to the majority of the pedestrian signal heads and is in the process of adding countdown timers to the remaining signals.

Approximately 60 of the 119 pedestrian signals are non-compliant in accordance with Manual on Uniform Traffic Control Devices (MUTCD) Official Ruling Sg-44. The City is in the process of either relocating or removing the pedestrian signals that are non-compliant.

Additional traffic signals are continually being constructed, modified and/or activated.

Controllers

Most controllers in the field are Type 170E controllers operating on Wapiti Micro Systems local controller firmware, including W4IKS for actuated signals, W7OSM for on-street masters, and W9FT for fixed-time controllers. Ten intersections in the area around TD Ameritrade Park and the CenturyLink Center operate on 2070 controllers. The City of Omaha does own some additional 2070 controllers.

Cabinets

The City of Omaha has a variety of traffic signal cabinets in the field. Table 2 summarizes the types of cabinets and the number of each used throughout the City.

TABLE 2 – TRAFFIC SIGNAL CABINET TYPES

Cabinet Type	Number
Type 303	344
Type 330	6
Type 332	269
Type 336	273
Type 336S	70
NEMA	50

NEMA cabinets are only used for most (but not all) flashing beacons, lane control signals, and speed feedback signs.

Detection

Five types of vehicle detection were identified and summarized as part of the system evaluation: 1) inductive loops, 2) optical cameras, 3) wireless magnetic, 4) microwave, and 5) thermal cameras. These types of detection generally apply to vehicle-actuated, full intersection signals. Of the 830 full intersection signals in the City, 154 operate in fixed time and currently do not have any detection. The pedestrian crossing signals generally use pedestrian-activated push-button detection. The remaining signals may or may not have detection, depending on their specific function and actuation requirements. Some signals utilize a combination of detection types. Table 3 summarizes the number of signals (not the actual number of devices) that use the various types of detection.

TABLE 3 – TYPES OF DETECTION CURRENTLY IN USE

Detection Type	Number of Signals
Inductive Loops	550
Optical Cameras	202
Wireless Magnetic	26
Microwave	2
Thermal Cameras	1

Closed-Loop Systems and Software

Currently, the City operates 72 closed loop systems, each with a master controller that communicates with the local controllers. Nine of these systems are stand-alone systems (only one signal in the system). Signals in stand-alone systems are generally located a significant distance from an adjacent closed-loop system. The remaining 63 systems have anywhere from 2 to 38 signals, with an average of 13 signals per system.

Of the 830 full intersection signals, 791 are part of a closed loop system. The remaining 39 are not part of a system and have no communications. Table 4 summarizes the number of signals in closed loop systems for each signal type.

TABLE 4 – CLOSED LOOP SYSTEMS

Type of Signal	Number of Signals	
	Total	In Closed-Loop System
Full Signal	830	791
Pedestrian Signal	119	32
Flashing Beacon	40	2
Lane Control Signal	19	6
Emergency Signal	4	2

City staff communicates and uploads/downloads data to these signals through the Wapiti Traffic View software. This software is a DOS-based application that sends and receives data via dial-up modems to the master controllers in the field. This software is used on a daily basis to set time clocks, generate communication reports (to determine if/which signals are off-line), and to download signal timing data to controllers. This software is generally used by staff in the Civic Center or at the Traffic Maintenance Facility at 50th & G Streets, but can also be accessed via a virtual private network (VPN) connection for after hours operation.

In addition to the Wapiti Traffic View software, there are ten traffic signals in the area around TD Ameritrade Park and the CenturyLink Center being controlled with Econolite Centracs software.

Uninterruptible Power Supply (UPS) Systems

UPS systems are deployed at 22 signals. All but one is located at full intersection traffic signals. The other UPS system is located at the high water flashing beacon on Saddle Creek Road at the Dodge Street underpass. In general, several of these UPS locations have been difficult to maintain and update with continued preventative maintenance. This is due to lack of available staff time, differing system requirements, and battery charging cycle schedules. Comments were noted by signal technician staff regarding some systems not being operational when needed, intermittent operations, and dead batteries at specific locations.

Signal Ownership and Maintenance Agreements with Other Agencies

The City of Omaha owns, operates, and maintains all signals within the City limits, as previously illustrated in Figure 1. For signals located outside of the City limits, but within Douglas County and a 3-mile planning jurisdiction, Douglas County owns the signal but pays the City of Omaha to operate and maintain the signals. Once any parcel of the land adjacent to the signal is annexed into the City, ownership of the signal transfers to the City of Omaha, and Douglas County ceases paying for maintenance. Douglas County signals are designed and constructed to specifications of the City of Omaha, which facilitates this process. Currently, the City maintains 24 signals owned by Douglas County.

The NDOR owns, operates, and maintains all signals located on state highways. In general, these functions transfer to the City once any parcel of the land adjacent to the signal is annexed by the City. Currently, there are eight signals on Highways 31, 36, and 133 that are located just outside of the existing City limits but within the 3-mile planning jurisdiction. NDOR also owns, operates, and maintains two signals on 84th Street (Highway 85), at Park Drive and Madison Street, which are located in Douglas County but on the borders of the Cities of Omaha and Ralston.

The City of Omaha also operates and maintains the signals on Harrison Street, which divide Douglas and Sarpy Counties. The City owns all of the signals, with the exception of those at 90th Street and 118th Street/Harry Andersen Avenue. The City has maintenance agreements with each respective jurisdiction in which the signal is located (Cities of Bellevue, La Vista, Ralston; Douglas and Sarpy Counties; and NDOR) to pay for maintenance costs and signal utility costs. Table 5 summarizes the Harrison Street traffic signal maintenance agreements.

TABLE 5 – HARRISON STREET TRAFFIC SIGNAL MAINTENANCE AGREEMENTS

Traffic Signal	Maintenance	Utility Costs
36th St	Bellevue and Omaha	Bellevue
48th St	Bellevue and Omaha	Bellevue
60th St	Douglas County and Omaha	Douglas County
66th St	Sarpy County and Omaha	Sarpy County
72nd St	Omaha, La Vista and Ralston	Omaha
78th St	La Vista, Omaha and Ralston	Ralston/La Vista
83rd St	La Vista, Ralston and Omaha	Ralston/La Vista
84th St	La Vista, Ralston and Omaha	Ralston/La Vista
90th St	La Vista and Omaha	Ralston/La Vista
96th St	Omaha and La Vista	Omaha
102nd St	Sarpy County and Omaha	Sarpy County
108th St	Sarpy County and Omaha	Sarpy County
110th St	Sarpy County and Omaha	Sarpy County
118th St	La Vista	La Vista
Giles Rd	Omaha and Sarpy County	Omaha
132nd St	Sarpy County and Omaha	Omaha
135th St	Sarpy County and Omaha	Sarpy County
138th St	Sarpy County and Omaha	Sarpy County
142nd St	Sarpy County and Omaha	Sarpy County
144th St	NDOR and Omaha	NDOR
150th St	Sarpy County, Douglas County and Omaha	Sarpy County
152nd St	Sarpy County, Douglas County and Omaha	Sarpy County
156th St	Sarpy County and Omaha	Sarpy County
161st St	Sarpy County, Douglas County and Omaha	Sarpy County
168th St	Sarpy County, Douglas County and Omaha	Sarpy County
177th St	Sarpy County, Douglas County and Omaha	Sarpy County
180th St	Sarpy County, Douglas County and Omaha	Douglas County

3.1.2 COMMUNICATIONS SYSTEMS

Communications Infrastructure In Use

There are currently three primary types of communications media throughout the City: 1) twisted pair copper (overhead or in buried conduit), 2) wireless radio, and 3) fiber optic. Table 6 summarizes the total mileage for City-owned communications for each type based on inventory data provided by City staff.

TABLE 6 – TYPE OF COMMUNICATIONS MEDIA AND AMOUNT IN USE

Communications Media	Mileage
Copper (overhead)	14.4
Copper (conduit)	153.2
Wireless Radio	47.3
Fiber Optic	22.4
Total	237.3

In general, the twisted pair copper lines are older than the wireless or fiber installations. Furthermore, twisted pair in the eastern portions of the City is older than that in the western portions. Most of the overhead installations are found in the eastern section of the City. Almost all twisted pair copper is 6-pair, although some 12-pair does exist.

Fiber optic installations generally coincide with roadway reconstruction and/or traffic signal improvements over the last several years (e.g., North Downtown, Midtown Crossing, Aksarben Village, Harrison Street, West Center Road and Industrial Road area, 192nd Street and West Dodge Road area). The City has been installing fiber optic interconnect since 2002.

Wireless communications are utilized at several locations around the City, primarily to communicate with signals that are relatively isolated or where hard wire communications has failed or not yet been installed. Currently, all radios are Encom brand.

Condition of Communications Infrastructure

As part of daily operations, the signal technicians at the Traffic Maintenance Facility at 50th and G Streets produce a daily communications report to determine which, if any, signals are not communicating. While all of the twisted pair copper is functional, technicians deal with problems on a regular basis, primarily due to the fact that there are too many splices in the lines, or the conduit is in poor condition. Based on their qualitative knowledge of the system, the technicians developed a map that highlights sections of the communications network that is functionally obsolete. In total, technicians identified 22.2 miles of communications (both overhead and in conduit) that is in poor condition. An illustration of the communications in poor conditions is contained on the Figure 7 of the *Existing System Evaluation and Needs Assessment Technical Memorandum.*

Other Communications Infrastructure Available

In addition to the fiber optics that the City has already installed and owns, there are other entities that own additional fiber throughout the City. One such entity, Unite Private Networks (UPN), has a continuous, 21.6 mile section of fiber installed in City right-of-way, with an additional 14.6 miles planned. In addition, the City and UPN entered into an agreement in 2011 that provides at least 24 strands of fiber to the City for its exclusive use in exchange for UPN access to City owned conduit. The existing and planned projects nearly create a complete fiber ring in the south central portion of the City. An illustration of the UPN fiber network is contained on the Figure 9 of the *Existing System Evaluation and Needs Assessment Technical Memorandum.*

The Douglas-Omaha Technology Commission (DOT.Comm), which is the information technology department for the City of Omaha and Douglas County, also owns a 96-pair fiber ring downtown. While DOT.Comm declined to provide the exact routing, the ring connects the following locations:

- Douglas-Omaha Technology Commission (DOT.Comm), 408 South 18th Street
- Civic Center, 1819 Farnam Street
- Douglas County Courthouse, 1701 Farnam Street
- Police Headquarters, 505 South 15th Street
- Fire Headquarters, 1516 Jackson Street
- Douglas County Corrections, 710 South 17th Street

DOT.Comm also provided information related to communications infrastructure owned by other agencies. Douglas County 911 maintains several microwave towers located around the County.

There are additional towers located in Washington, Sarpy, and Pottawattamie Counties. These towers provide bi-directional communications and are primarily used for communications among the various county sheriffs. Fiber extends from some tower locations and is routed in various directions.

According to DOT.Comm, many City and County facilities located around the County are connected to the "Metro E" (Ethernet) system, which is maintained by Cox Communications.

DOT.Comm does not work directly with any of the school districts in the City of Omaha, which include Omaha, Ralston, Westside, Millard, and Elkhorn. The only exceptions include joint school and public library facilities, which include the Saddlebrook Branch in northwest Omaha and the South Omaha Library.

A meeting was conducted with Omaha Public Power District (OPPD) to determine if they had available fiber optics in the City. They stated that they currently do not have any available fiber optics in the City but there may be potential for fiber optics sharing in the future.

3.1.3 Intelligent Transportation Systems (ITS) Devices

Closed Circuit Television (CCTV) Cameras

The City currently owns eight pan-tilt-zoom (PTZ) CCTV cameras. Six of them are IP addressable (Ethernet communications) and two are accessed via dial-up. In addition, the detection cameras (non-PTZ) at 144th & Q Streets are also IP addressable. The City also has access to NDOR CCTV cameras via the Delcan NETworks software. NDOR has 24 cameras on Omaha area freeways, including I-80, I-480, I-680, US 75 (JFK Freeway), and US 6 (West Dodge Expressway).

Dynamic Message Signs (DMS)
The City does not own or operate any permanent DMS. NDOR does operate DMS signs on the freeway system in the City of Omaha. The City does have portable DMS signs and seven speed feedback signs.

Emergency Vehicle Preemption (EVP)
EVP systems are currently deployed at 247 signals in the City. EVP systems include one or two receivers mounted on signal mast arms and in-vehicle transmitters with the various emergency responder vehicles. All EVP systems use the Opticom Infrared technology to provide preemption for any emergency vehicle (typically police, fire, ambulance) equipped with a transmitter device and approaching a signal from any direction.

Parking Management Systems
The City of Omaha currently does not actively manage any parking systems. The Metropolitan Entertainment and Convention Authority (MECA) currently owns and operates a parking management system for MECA-owned lots around the CenturyLink Center and TD Ameritrade Park in North Downtown. This system does include several dynamic message signs (DMS) on traffic signal mast arms used specifically and only for parking management purposes for special events.

The City Public Works Department currently maintains on-street parking meters and all City-owned parking garages. A centralized parking management system is being established as a division of the Public Works Department. A parking study recently completed by the Metropolitan Area Planning Agency (MAPA) for the downtown area recommends consolidating all parking management activities to the Public Works Traffic Division.

Traffic Sensors
The City does not own or operate any permanent traffic sensors for the purpose of collecting data on speed, volume, occupancy, etc. NDOR does have traffic sensors, which only collect speed, deployed on the freeway system in the City of Omaha.

Transit Signal Priority (TSP) and Emergency Vehicle Priority
Neither the City nor any other agencies (Metro Transit) operate any transit signal priority systems. Metro Transit is currently conducting the *Downtown-Midtown Transit Alternatives Analysis* (which is focusing on the Dodge, Douglas, Farnam, and Harney Streets). MAPA will also be conducting a *Regional Transit Vision*, which will likely explore this technology (among others) for the entire region.

The City also does not operate any Emergency Vehicle Priority systems, which is different than an emergency vehicle preemption system described earlier. A priority system is GPS-based, that is operated by a dispatcher from a central control center. Emergency vehicles assigned to the incident follow routes provided on in-vehicle displays, and the traffic signal system adjusts signal timing in real-time based on the location of the emergency vehicle in the street network.

3.2 EXISTING TRANSPORTATION SYSTEM OPERATION AND MANAGEMENT

Facilities and Staff

All staff that conducts work related to the traffic signal system is a part of the Traffic Engineering Division, which is located within the Transportation Services Section of the City of Omaha's Public Works Department. Other divisions within Transportation Services include Construction, Design, Street Maintenance, Fleet Maintenance, and General Services. Figure 2 illustrates the organizational structure of the Public Works Department.

The Traffic Engineering Division has 62 engineering, maintenance, technician, and administrative staff which are responsible for not only the traffic signal system, but also signing, pavement markings, traffic planning and design, parking meters, safety projects, traffic calming, and driveway permits.

Currently, staff with positions related to the traffic signal system work out of one of two locations. Engineering staff are located in the Civic Center downtown, while maintenance staff is located at the Traffic Maintenance Facility at 50th and G Streets. NDOR District 2 also operates a District Operations Center (DOC) at 108th and I Streets which is staffed by the NDOR personnel and the Nebraska State Patrol (NSP). The facility was also designed to co-locate a City traffic management workstation within the DOC, allowing City staff to coordinate traffic operations between the arterial and freeway system. Currently, no City staff is located there.

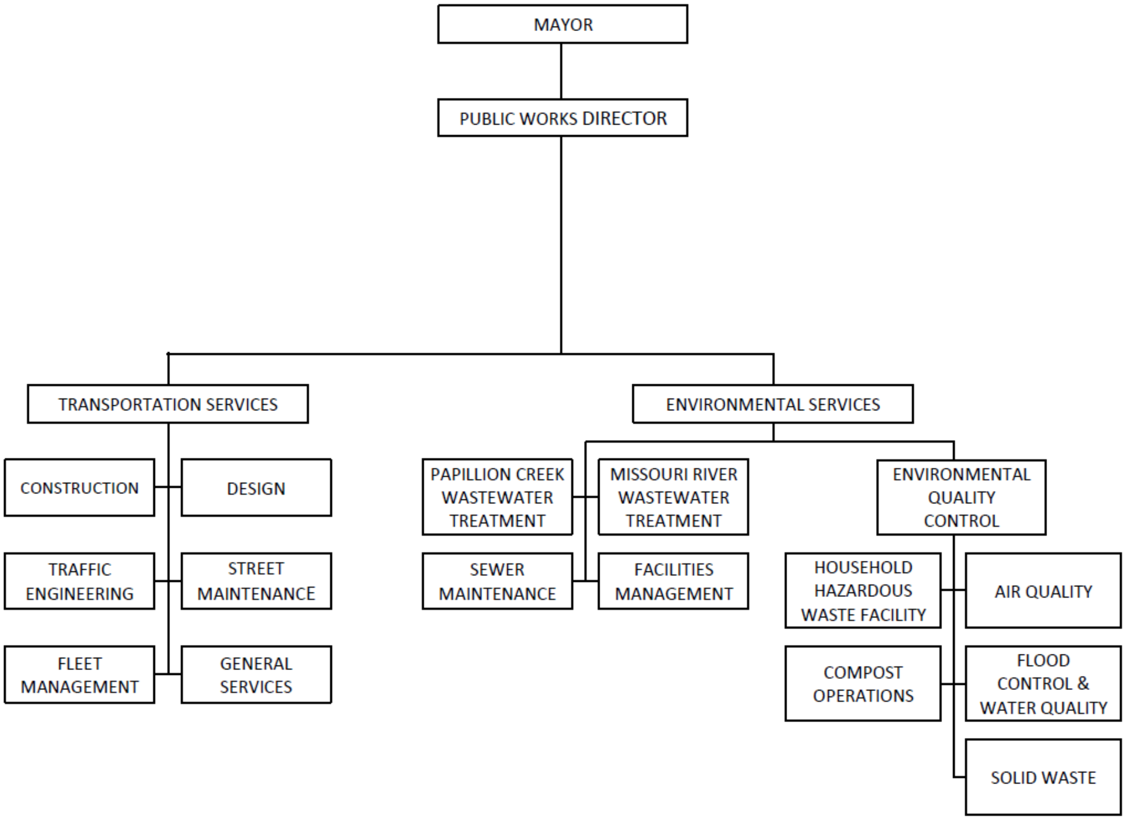


FIGURE 2 – ORGANIZATIONAL CHART FOR THE PUBLIC WORKS DEPARTMENT

Source: City of Omaha

Currently, there are eight engineering staff. Seven are located at the Civic Center. There is one Signal Operations Engineer fully-dedicated to signal timing and one Traffic Signal Engineer fully-dedicated to signal design and signal warrants evaluations. A third Engineer dedicates approximately 50% of their time assisting the Signal Timing Engineer. Four other engineers (including the City Traffic Engineer) devote up to 20% of their time on traffic signal system related tasks. The Traffic Maintenance Engineer, who is located at the Traffic Maintenance Facility and oversees all traffic maintenance staff (not only signal maintenance staff).

In addition to engineering staff, there are 17 traffic signal maintenance staff members based at the Traffic Maintenance Facility, including six Level II Signal Technicians (Tech II), six Level I Signal Technicians (Tech I), three Semi-Skilled Laborers (two full-time and one part-time), one Cable Locator, and one Cable Checker. Staff is assigned to one of three groups: 1) District (East or West), 2) Shop, or 3) Project. Hours are generally 7:00 am to 3:30 pm on weekdays, however, the shifts of at least one worker in the Shop and each District are set to cover the afternoon rush hour and weekends.

Signal maintenance staff is on call 24 hours/day to respond to traffic signal related issues (malfunction, cabinet knockdowns, etc.).

The *FHWA Traffic Signal Operations and Maintenance Staffing Guidelines* suggests a staffing level of 75 to 100 signals per traffic engineer and 30 to 40 signals per technician. The *ITE Traffic Control System Operations: Installation, Management and Maintenance Manual* indicates that a reasonable guideline is a single maintenance person can maintain 40 to 50 signals or other field devices. Using these two guidelines, the City should have 10 to 13 traffic engineers and 20 to 34 technicians.

The current signal staffing levels allow the City staff to be mostly reactionary in addressing the signal needs. With current staffing, there are limited resources for the staff to be proactive making modifications and improvements to the signal system operations. This limits the efficiency of the existing signal system.

Traffic Signal Timing

Traffic signal timing at all traffic signals is conducted by the Signal Operations Engineer. 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. The engineer can communicate with signals on the closed loop systems from the office, but relies on traffic maintenance staff to upload timing to signals not on the communications system. Traffic maintenance staff is also responsible for delivering updated timing sheets to the cabinets. The engineer is 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), and operate in free or flash mode during the evenings and overnight.

There are currently 355 intersections that operate in flash mode during some portion of the day. When there are crashes at a signal operating in flash mode, the City reviews the crash data and determines if the signal should remain in flash mode.

Incident Management

There is no formal incident management program for surface streets in the City. In 2011, the Iowa Department of Transportation (Iowa DOT) sponsored a project to develop the *Omaha-Council Bluffs Traffic Incident Management Operations Guidelines*. As a participating agency, the City of Omaha has developed special timing plans to facilitate traffic diverted off I-80 between the L Street and 13th Street exits as a result of an incident. Timing plans were developed for Center Street and L Street as well as the connecting north-south arterials. While the timing plans are in place and can be activated in only a few minutes, continued improvements in coordination between agencies is needed to utilize the implementation of these timings.

Congestion Management
Like incident management, there is no formal congestion management program on arterial streets conducted by the Public Works Department. The City does have special timing plans in place around the CenturyLink Center and TD Ameritrade Park to facilitate ingress and egress for events at those facilities. In many cases, the Omaha Police Department overrides these plans and operates the traffic signals by using hand cords and placing officers next to the signal cabinets. Overriding the signal plans allows for more time to be given to a specific direction; however, this takes the system out of coordination.

Safety Review
The Public Works Department collects traffic accident data for the City of Omaha and creates an annual report. The document includes a summary by type of accident and accident severity. This document also includes a ranking of the intersections by the total number of accidents, accident rate, accident severity and a combination of the three.

The City uses this information to identify intersections to evaluate for safety improvements through utilizing both non-signalized and signalized strategies.

Traffic Signal Preventive Maintenance
The City does have a traffic signal preventive maintenance program, which is logged in the Traffic Maintenance Information System (TMIS) database. All traffic signals are visited by a technician approximately once every 2 years, at which point the cabinets are cleaned and system components are tested and replaced as warranted. It was noted during the cabinet field review that due to the variability of signal hardware/equipment in the cabinets, some maintenance and troubleshooting activities are more difficult for newer signal technicians than others.

Communications Maintenance
Traffic maintenance staff monitors the status of the communications system on a daily basis. Every traffic signal on the system is polled every morning to determine if the signal is online. A report is generated which is then used to assign staff to investigate and resolve any problems.

3.3 Roles and Responsibilities

There are numerous stakeholders with interest in the Traffic Signal System Master Plan. Table 7 summarizes the Traffic Signal System stakeholders and their roles.

TABLE 7 – STAKEHOLDER ROLES FOR THE TRAFFIC SIGNAL SYSTEM

Stakeholder	Role
City of Omaha Public Works Department	Budgeting and project programming
City of Omaha Traffic Engineering Division	Traffic management and public safety for the City
City of Omaha Traffic Maintenance Shop	Maintain City traffic signal system, signs and pavement markings
City of Omaha Street Maintenance Division	Maintain City street system
Omaha Fire Department	Public safety for the City
Omaha Police Department	Public safety for the City
Douglas-Omaha Technology Commission (DOT.Comm)	Manage computer technologies for the County and the City
Douglas County Engineer	Traffic management and public safety for the County
Sarpy County Engineer	Traffic management and public safety for the County
Douglas County 911 Communications	Dispatch for City and County
Metropolitan Area Planning Agency (MAPA)	Transportation planning, distribute federal funding, project programming, and maintain regional ITS architecture for metropolitan area
Federal Highway Administration (FHWA) Nebraska Division	Oversight of projects
NDOR Traffic Engineering Division	Traffic management and public safety for State facilities
NDOR Operations Division	Operations and maintenance of State ITS system
NDOR District 2	Operations and maintenance of the freeway system
Nebraska State Patrol	Public safety for the State
Other Agencies Public Works, Police, and Fire Departments in Omaha Metropolitan area	Traffic management and public safety for adjacent jurisdictions
Metro Transit	Transit provider for metropolitan area
Metropolitan Entertainment and Convention Authority (MECA)	Manage special events for CentruryLink Center and TD Ameritrade Park
Unite Private Networks	Provider of fiber optic networks
Other Communications Partners	Providers of communications networks
Media	Disseminate travel information to the public
Traveling Public	Make travel decisions, users of the traffic signal system

4.0 OPERATIONAL NEEDS

Given the evaluation of the existing traffic signal system described in Section 3.1, the operational needs assessment process is conducted to identify the stakeholder needs that must be satisfied in order for the City of Omaha to meet its goals and objectives relative to an upgraded traffic signal system. The primary focus of this section is on documenting the needs that were described at a high-level and adding detail to create operational needs that can be used to build an action plan and more detailed requirements. Once the needs are described, a preliminary list of performance measures was identified to support the evaluation of the goals and objectives.

The needs identified in this section were gathered through meetings with stakeholders, primarily through the course of several meetings, and in walking through various operational scenarios that identified equipment (such as hardware, software, and communications), staffing, and traffic management needs for both existing and future conditions.

Seven categories were created to identify high-level needs and include:

1. Arterial Traffic Management
    - Improve operations for all modes of transportation
    - Improve efficiency of the traffic signal system
    - Improve efficiency of engineering, operations, and maintenance staff
    - Improve safety for all modes of transportation
    - Improve safety for engineering and maintenance staff
2. Safety Systems
    - Improve safety and operations for all modes during signal power outage or cabinet knockdown
    - Improve safety for drivers making left turns
    - 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
    - Improve performance of the traffic signal system
    - Improve efficiency of engineering and maintenance staff
    - Improve safety and operations for all transportation modes
4. Incident Management
    - Improve operations for drivers 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
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. Maintenance and Construction Operations
    - Reduce failures of traffic signal system 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 preventative maintenance
    - Improve the consistency of traffic signal and ITS cabinets
    - Improve asset/infrastructure monitoring capabilities

Through stakeholder workshops, more detailed needs were identified based on various operational scenarios that are further described in the next section. These needs and associated requirements are further documented and traced in the requirements and verification plan. Table 8 summarizes the needs:

TABLE 8 – OPERATIONAL NEEDS

NO.	Needs Identified in Stakeholder Workshops (Feb 23, 2012 and Mar 8, 2012)
1.0	**ARTERIAL TRAFFIC MANAGEMENT**
1.01	Need to replace Type 170E controllers
1.02	Need to install upgraded software on controllers
1.03	Need to provide additional space in cabinets for additional components
1.04	Need to integrate traffic signals into a single traffic control system software
1.05	Need to integrate ITS field devices into a single management software
1.06	Need to designate central location for signal timing databases
1.07	Need to provide ability to easily update controller settings in the field
1.08	Need to improve system operation monitoring
1.09	Need to provide access to management software to various staff in various locations
1.10	Need to provide ability to modify and verify signal timing through central software
1.11	Need to provide notification of detector failures
1.12	Need to deploy timing plans to groups of intersections simultaneously
1.13	Need to receive automatic notifications for coordination errors
1.14	Need to setup alarm notifications for user-defined thresholds for various parameters

1.15	Need to download user-friendly operational reports on signal system operations and performance (such as communications failures), timing data, and traffic data
1.16	Need to provide alarms for excessive queuing
1.17	Need to develop an automated logging system
1.18	Need to automatically archive data
1.19	Need to conduct traffic flow monitoring in real time with individual detectors
1.20	Need to obtain access to existing freeway monitoring capabilities
1.21	Need to provide high-quality real-time traffic information
1.22	Need to provide timely congestion and incident information to public
1.23	Need to provide the public with limited access to traffic management tools and activities
1.24	Need to integrate traffic data collection software with traffic signal system modeling software
1.25	Need to integrate traffic signal system modeling software with Central Signal System Software
1.26	Need to improve signal coordination
1.27	Need to maintain high-quality coordination
1.28	Need to provide the ability to modify coordination correction modes
1.29	Need to conduct traffic data collection from permanent stations
1.30	Need to measure signal timing performance
1.31	Need to provide dynamic lane assignment based on user-defined traffic data inputs
1.32	Need to develop special event timing
1.33	Need to install adaptive traffic control on certain corridors
1.34	Need to provide adequate staffing to perform functions
1.35	Need to provide adequate staff training
1.36	Need to develop interagency agreements for providing access to software and information.
1.37	Need to evaluate future vehicle-to-vehicle communications systems
1.38	Need to evaluate pedestrian and bicycle concerns
2.0	**SAFETY SYSTEMS**
2.01	Need to provide automatic notifications for power outage and cabinet knockdowns
2.02	Need to provide indication for status of active UPS systems
2.03	Need to provide the ability to implement flashing yellow arrow operation for permissive turns within management software
2.04	Need to provide the ability to implement a pedestrian hybrid beacon within management software
2.05	Need to provide the ability to implement pedestrian scramble operation within management software
2.06	Need to provide the ability to implement audible or accessible pedestrian features within management software
2.07	Need to implement detection and develop timing specific to bicycles
2.08	Need to provide anti-icing systems on high-volume approaches with steep grades
2.09	Need to monitor speeds in real-time and conduct data collection at speed feedback sign locations
3.0	**COMMUNICATIONS SYSTEMS & INTEGRATION**
3.01	Need to increase speed, bandwidth, and reliability of field to field communications
3.02	Need to increase speed, bandwidth, and reliability of center to field communications
3.03	Need to provide staff in the field access to network

3.04	Need to provide the ability to transmit video
3.05	Need to provide central information clearinghouse
3.06	Need to develop interagency agreements
3.07	Need to provide communications to all signals
3.08	Need to provide remote access to the traffic signal network for management, software upgrades, and troubleshooting
3.09	Need to develop and implement network security protocols
3.10	Need to develop traffic signal IP schema/architecture for participating stakeholders
3.11	Need to evaluate IP schema/architecture for future stakeholder integration
4.0	**INCIDENT MANAGEMENT**
4.01	Need to improve incident detection
4.02	Need to verify and monitor incidents
4.03	Need to provide staff to actively monitor and coordinate
4.04	Need to improve incident response coordination between agencies
4.05	Need to reduce traffic delays for emergency response vehicles
4.06	Need to develop methods for deployment of incident management for select corridors
4.07	Need to provide better coordination for ending incident management activities
5.0	**TRAVELER INFORMATION SYSTEMS**
5.01	Need to provide traveler information on the roadside
5.02	Need to provide quality real-time congestion-related information
5.03	Need to improve and expand traveler information delivery methods
5.04	Need to improve procedures to get accurate information disseminated in a timely manner
5.05	Need to provide better work zone information and notification
6.0	**PUBLIC TRANSPORTATION**
6.01	Need to provide transit priority at signals
6.02	Need to provide traffic signal operations for at-grade transit crossings
6.03	Need to provide information exchange to/from transit agency
6.04	Need to use AVL data for traffic management
6.05	Need to provide transit ETA information
7.0	**MAINTENANCE AND CONSTRUCTION OPERATIONS**
7.01	Need to conduct preventive maintenance on traffic signals at regular intervals
7.02	Need to standardize traffic control equipment
7.03	Need to standardize cabinet setup
7.04	Need to improve coordination on construction notification and information distribution
7.05	Need to improve work zone traffic handling plans
7.06	Need to monitor traffic remotely in and around work zones
7.07	Need to provide weather and pavement data collection to aid winter operations
7.08	Need to provide automated vehicle locations systems for maintenance and construction operations vehicles

Performance Measures

The project stakeholders shared established performance measures for the Traffic Engineering Division of Public Works that includes:

- number of traffic signal timing changes,
- number of bench repairs (controllers, communications, conflict monitors)
- number of traffic signal calls
- number of traffic signals built
- number of traffic signals rebuilt

Based on the operational needs additional performance measures can be tracked that will help document that established goals and objectives are being accomplished, including:

- Number of controllers upgraded
- Number of controllers – software enhancements
- Number of ITS Devices – Installed
- Percentage of Communications Network Constructed
- Final Acceptance of Central Signal Software (CSS)
- Final Acceptance of an Advanced Traveler Information System (ATIS) public web-site
- Operational Hours logged in CSS
- Remote Operation of CSS
- VPN hours logged
- Number of traffic signals managed with in CSS
- Number of ITS devices managed with in CSS
- Number of alarms and notifications from the CSS
- Communications Percentage Up-time Existing System
- Communications percentage Up-time New System
- Calculate Arterial Travel Time for Key Corridors
- Collect and Report Traffic volumes through CSS
- Collect and Report Speed information through CSS
- Collect and Report Pedestrian information through CSS
- Number of Incidents identified through CSS
- Number of Incidents logged in ATIS
- Number of multi-jurisdictional incidents coordinated
- Number of approved standard plans (traffic cabinets, work zone traffic control)
- Number of incidents CSS operators document to ATIS
- Collect and Report Device Up-time through CSS:
    - Signals
    - Emergency Vehicle Preemption
    - DMS
    - CCTV
    - RWIS

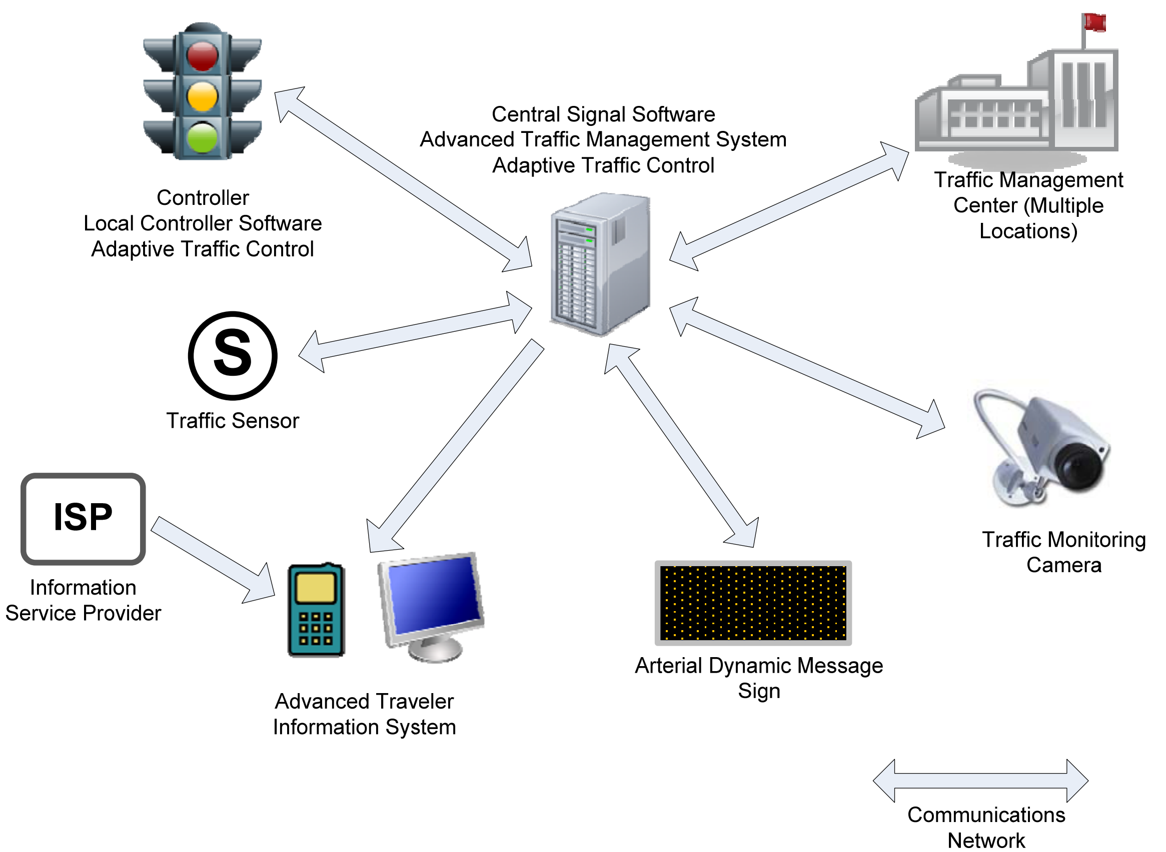
Tracking these performance measures during the phased construction will document the stepped deployment and integration of the new system. These measures will also be used during the long term operations and maintenance of the system. These performance measures will be reviewed with the stakeholders in more detail during the design process to prioritize the list and create a series of performance measures that can realistically be tracked and documented with the limited resources available to the city.

5.0 PROPOSED OPERATIONS

The concept for the traffic signal system has been established through coordination with multiple stakeholders to address the needs identified in Section 4.0. This concept focuses mainly on the traffic signal system; however, the City realizes that there are many opportunities to improve intersection safety and operations through utilizing non-signalized strategies. These may include improvements to geometrics, construction of roundabouts, removal of unwarranted signals and changes to access control. The City will continue to monitor, analyze and evaluate opportunities to incorporate non-signalized strategies. The Omaha Transportation Master Plan provides a detailed discussion regarding non-signalized strategies.

The proposed traffic signal system concept is illustrated in Figure 3 and described in the following section.

FIGURE 3 – TRAFFIC SIGNAL SYSTEM CONCEPT



The traffic signal system concept is comprised of multiple elements which can be grouped into four main categories, including traffic management, traffic monitoring, information dissemination, and the communications network. The following provides a description of each:

- Traffic Management
    - Traffic Management Center (TMC) – Potential TMCs would be provided in various locations including the Traffic Maintenance Facility, the Civic Center, and the NDOR District Operations Center (DOC), along with the potential to access the TMC remotely using an internet connection. The TMC would allow staff to monitor and manage traffic.
    - Central Signal Control Software – The central signal control software would provide a means to remotely monitor and manage the traffic signal system in near real-time to improve traffic flow and safety.
    - Advanced Traffic Management System (ATMS) Software – The ATMS software would provide a means to remotely monitor and manage various devices related to intelligent transportation systems including traffic monitoring cameras, dynamic message signs and traffic sensors. The ATMS and the Central Signal Control Software may be an integrated system or separate systems.
    - Adaptive Signal Control Technologies (ASCT) – ASCT would allow for traffic signal timing changes to adapt based on real-time traffic demand. ASCT will be considered on corridors where traditional time-of-day plans do not accommodate the traffic variations.
    - Controller – Upgrading to advanced traffic signal controllers would allow for more advanced signal timing options and traffic management capabilities.
    - Local Controller Software - Upgrading the local controller software would allow for more advanced signal timing options and traffic management capabilities.
- Traffic Monitoring
    - Cameras – Traffic monitoring cameras would allow staff to view near real-time traffic conditions.
    - Traffic Sensors – Traffic sensors would allow staff to obtain near real-time traffic characteristics.
- Traffic Dissemination
    - Advanced Traveler Information System (ATIS) – ATIS would provide the users of the transportation system with real-time information that could be used to make decisions about route choices, estimate travel times, and to avoid congestion. A traffic website and a mobile application are envisioned to provide this data to the users. The data could be provided by the TMC or by third party internet service providers (ISPs).
    - Arterial Dynamic Message Signs (DMS) – Arterial DMS would provide en-route information to drivers regarding traffic and roadway conditions.
- Communications System
    - The communications would be a hybrid system of wired and wireless communications and be connected to all of the central and field elements.

6.0 OPERATIONAL SCENARIOS

This section presents a number of operational scenarios that are intended to capture activities associated with operation of the system. The objective of developing operational scenarios is to capture user needs from the perspective of the users.

The operational scenarios capture the activities to be performed which are both routine and non-routine, in order to identify user requirements. It is important that the operational scenarios are realistic and reasonable.

The operational scenarios include the following:

- Scenario 1: Traffic Signal Control
- Scenario 2: Major Incident on I-80
- Scenario 3: Traffic Surveillance
- Scenario 4: Traffic Dissemination
- Scenario 5: Work Zone Management

The scenarios listed above are detailed below for the proposed system.

6.1 SCENARIO 1: TRAFFIC SIGNAL CONTROL

The TMC operator automatically uploads traffic count data into the traffic control software via a link. The system requests verification from the operator prior to updating the count data. The operator then uses the automatic interface between the traffic control software and Synchro to update the signal timings.

The traffic signal system software allows the operator to view, monitor, upload or download signal timings for an intersection or a corridor using real time communications to the signals. This operation is available from traffic management centers or remotely using an internet connection. The system allows the operator to implement advanced signal timing features, transit signal priority, active traffic management and the ability to implement special event timing plans.

Notifications from the signals will be automatically sent to specified users when the system detects that there is a problem or certain user defined thresholds have been met. All of the system operations and changes are logged and archived in the system and the operator can generate custom operations reports from the logged and archived data.

6.2 SCENARIO 2: ADAPTIVE SIGNAL CONTROL TECHNOLOGY ON DODGE STREET

During the peak periods Dodge Street is oversaturated and the primary objective of the system is to maximize throughput along Dodge Street. The period between phases will be the maximum permitted by the TMC operator with demand present. The system will be subject to user-specified constraints, such as allowable phase sequences, and minimum and maximum phase times. The system will determine the optimal order of phases to provide the best coordination along Dodge Street.

6.3 Scenario 3: Incident Management on I-80

The on-call TMC operator receives a phone call after hours from the NDOR District 2 DOC stating that there is an incident on I-80 which requires them to detour I-80 eastbound traffic to 'L' Street. The TMC operator implements the incident management timing plans on 'L' Street using real time communications to the traffic signal system. The TMC operator continues to monitor the incident using CCTV cameras and then restores the regular signal timing operation when the incident is over.

6.4 Scenario 4: Traffic Surveillance and Dissemination on Dodge Street

The TMC operator receives an alarm notification from the traffic control software of a possible incident on Dodge Street. The TMC operator uses the CCTV camera to visually verify the alarm notification. Upon visual verification, the TMC operator implements an updated timing plan along Dodge Street to minimize traffic congestion. The TMC operator posts messages on the dynamic message signs and to the advance traveler information system to inform motorist of potential delays due to the incident.

6.5 Scenario 5: Work Zone Management for Construction Project on West Center Road

The TMC operator monitors the work zone on West Center Road during the AM peak hour using a portable CCTV camera. The eastbound traffic is experiencing significant congestion. The TMC operator implements an updated timing plan to minimize the traffic congestion.

7.0 SUMMARY OF IMPACTS

7.1 OPERATIONAL IMPACTS

The implementation of elements identified in the traffic signal system concept will allow for significant operational improvements. The additional capabilities will allow staff to monitor, manage and maintain the system, improve safety and efficiency of the system, and provide information to the public that can be used to make travel decisions. The following summarizes the operational impacts in regards to the seven categories of operational needs discussed in Section 4.0.

1. Arterial Traffic Management – The traffic signal system concept will allow for the ability to monitor and manage the system to improve operations, efficiency and safety.
2. Safety Systems – The traffic signal system concept will improve the response time to signal outages and improve safety through traveler information and advanced signal timing capabilities.
3. Communications System – The traffic signal system concept will improve the communications system to provide near real-time remote monitoring and management of the system.
4. Incident Management – The traffic signal system concept will improve incident management through improved notification of incidents, the ability to monitor incidents, the ability to manage the system, and the ability to disseminate traveler information.
5. Traveler Information Systems – The traffic signal system concept will improve operations for travelers by providing pre-trip and en-route information
6. Public Transportation – The traffic signal system concept will improve transit vehicle operations and provide traveler information.
7. Maintenance and Construction Operations – The traffic signal system concept will improve the efficiency of technician staff by reducing failures and conducting preventative maintenance through remote access, diagnostics and reports.

7.2 ORGANIZATIONAL IMPACTS

The implementation of the traffic signal system concept may place greater burden on the City of Omaha Traffic Staff. The system will improve some efficiencies in maintaining and operating the system; however, with the additional functionality the staff will have additional roles and responsibilities to manage the system. This may require additional resources or the reallocation of resources.

8.0 NEXT STEPS

The project team will develop high-level system requirements and a preliminary verification plan consistent with this Concept of Operations for the Traffic Signal System Master Plan. This final section of the Concept of Operations summarizes the need to manage and document the system engineering design and installation process to meet stakeholder project requirements.

City of Omaha or their representatives will track and amend the verification plan, project plans, specifications and requirements based on the Change Management process described in the System Engineering Management Plan (SEMP). The responsibility to manage the project changes will be the responsibility of the City of Omaha Traffic Signal System Project Manager. These changes will be documented in the acceptance testing and tracked through the mapped requirements back to the Concept of Operations. City of Omaha will review the mapped changes and determine the time-frame to amend the Concept of Operations.

APPENDIX E

HIGH-LEVEL REQUIREMENTS AND VERIFICATION PLAN

U.S. Department of Transportation

Federal Highway Administration

City of Omaha
Traffic Signal System Master Plan

Final High-Level Requirements and Verification Plan

June 27, 2013

DOCUMENT VERSION CONTROL

Document Name	Submittal Date	Version No.
Version 1.0	July 18, 2012	1.0
Version 2.0	January 28, 2013	2.0
Version 3.0	June 27, 2013	3.0

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 PURPOSE OF DOCUMENT

The High-Level Requirements and Verification Plan for the City of Omaha Traffic Signal System Master Plan (TSSMP) summarizes the system requirements and verification activities that are expected to be completed to demonstrate that the deployment ultimately meets the needs of the project stakeholders. This document is being developed in compliance with the Federal Highway Administration (FHWA) Federal Rule 23 CFR 940.11 and Systems Engineering Guidelines. The High-Level Requirements and Verification Plan is the fourth (and final) document in the set of systems engineering deliverables identified in the Omaha TSSMP Project Plan.

The verification plan covers the total system deployment and provides a preliminary plan for documenting how the following components and activities will be satisfied:

- Traffic Signal Controller Hardware and Software
- Central Signal System Software
- Enhanced Communications
- Staffing
- ITS Field Upgrades
- Advanced Traveler Information System (ATIS)
- Advanced Traffic Management System (ATMS)
- Transit Enhancements

This verification plan is expected to be a living document with edits managed from the System Contractor's selection through the preparation of the acceptance test. This document will be used to guide City of Omaha staff and the System Contractors during the deployment with the understanding that the project requirements and verification will guide the installation, integration, and testing of the traffic signal system. To put it simply, City staff and the System Installation Contractors will have full knowledge of the test requirements as they construct the project, be able to deploy a system that passes the test, and will therefore be able to meet the stakeholder requirements and goals.

2.0 SCOPE OF PROJECT

The purpose of this project is to develop a Traffic Signal System Master Plan for the City of Omaha and lay the foundation for design and deployment of the projects identified in the TSSMP. The existing traffic signal system includes over 1,000 traffic signals and a vast hybrid communications system. While functional, stakeholders have identified needs that cannot be met with the current system. Related intelligent transportation system (ITS) devices for traffic management will also be included in this plan.

The signal system is currently comprised of many components, and some additional ITS devices, which include:

- Traffic signal controllers and firmware
- Cabinets
- Detection devices (inductive loops, wireless magnetic, video, microwave, and thermal)
- Emergency vehicle preemption (EVP) devices
- Uninterruptible power supply (UPS) systems
- Communications
  - Media (including twisted pair copper, wireless radio, fiber optic)
  - Hardware (switches, transceivers, modems, etc.)
  - Conduit and poles (for overhead copper)
- Closed Loop System Software
- Central Traffic Control System Software
- ITS Components and Other Devices
  - CCTV cameras
  - Dynamic message signs (DMS)
  - Reversible lane control signals
  - Road weather information system (RWIS)
  - Anti-icing system
  - High water flashing beacons

Currently, construction on various system components is expected to begin in Fall of 2013. Some funding has been identified, and is flexible such that it can be utilized over a two to six year period. Additional funding will likely be required to fully deploy all system components.

Traffic signal system components identified above are intended to satisfy the following high-level needs:

1. Arterial Traffic Management at various Traffic Management Centers
2. Safety
3. Communications
4. Incident Management
5. Traveler Information
6. Public Transportation
7. Maintenance and Construction Operations

Three signal system components (traffic signal controller hardware and software, central signal system software, and enhanced communication) have been identified as the highest priority components. Traffic management capabilities will be implemented at the following four facilities:

1. Traffic Engineering Offices, Civic Center 6th Floor, 1819 Farnam Street
2. Traffic Maintenance Facility, 50th & G Streets
3. NDOR District Operations Center (DOC), 108th & I Streets, and
4. Douglas County Emergency Operations Center (EOC), Civic Center lowest level

Medium priority components include staffing, ITS field upgrades, ATIS, and ATMS, while lower priority components include transit enhancements.

The traffic signal system has the following stakeholders:

- City of Omaha Public Works Department
- City of Omaha Traffic Engineering Division
- City of Omaha Traffic Maintenance Shop
- City of Omaha Street Maintenance Division
- Omaha Fire Department
- Omaha Police Department
- Douglas-Omaha Technology Commission (DOT.Comm)
- Douglas County Engineer
- Douglas County 911 Communications
- Sarpy County Engineer
- Metropolitan Area Planning Agency (MAPA)
- Federal Highway Administration (FHWA) Nebraska Division
- NDOR District 2
- NDOR Traffic Engineering Division
- NDOR Operations Division
- Nebraska State Patrol
- Other Agencies' Public Works, Police, Fire Departments in Omaha Metropolitan area
- Metro Transit
- Metropolitan Entertainment and Convention Authority (MECA)
- Unite Private Networks (UPN)
- Other Communications Partners
- Traveling Public

The goal of the TSSMP is ***to develop a clear and flexible traffic signal system master plan that results in the right-sized traffic signal system, meets the needs of stakeholders, and provides value, improved safety, improved traffic operations and public support well into the future.*** The traffic signal system components will serve as tools for engineers, technicians, operators, decision-makers, and the public to improve the safety and efficiency of the transportation system in the City of Omaha.

Project Challenges

This project has identified a number of challenges that the project team will need to monitor during the selection, deployment and maintenance of signal system components:

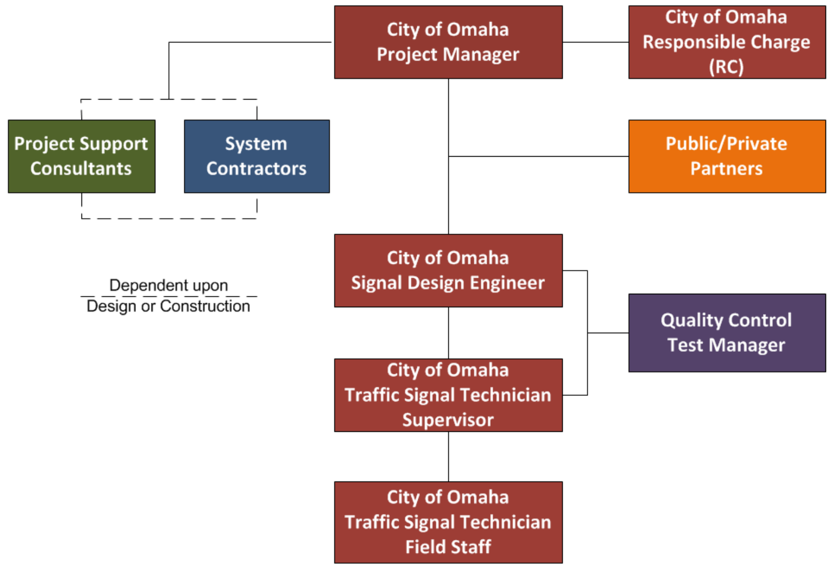
- Environmental documentation and approval processes for construction
- Transition from existing to new traffic signal controllers and software, while maintaining legacy support as needed
- Introduction of new technologies (communications, software, ITS devices)
- Funding
- Coordination with other agencies and departments, particularly as it relates to communications infrastructure.

To mitigate these challenges, the system will be planned, designed, and implemented with these goals:

- The master plan will identify projects and phasing which will facilitate completion of environmental documentation and identify projects for inclusion in the Omaha Capital Improvement Program (CIP) or MAPA Transportation Improvement Program (TIP).
- Traffic signal hardware and software will migrate to a standardized set of specifications which will reduce the body of knowledge required for design, implementation, operation, and maintenance of these components.
- Additional staff training will be required; however, all technology will migrate towards a NTCIP platform and other open-architecture platforms.
- The master plan will identify project phasing consistent with existing funding levels and facilitate obtaining additional funding by identifying needs.
- The master plan will address communications network technologies and identify communications champions within each stakeholder agency.

The City of Omaha has an established project management process for the deployment that places the responsibility to edit and execute the verification plan with the City of Omaha Project Manager. Elements of the verification plan are delegated to a Signal Design Engineer, Traffic Signal Technician Supervisor, or Traffic Signal Technician Field Staff. These representatives will carry the majority of the responsibility to execute the verification plan. The System Contractor can propose suggested modifications to the verification plan. The City of Omaha Project Manager will review these suggested System Contractor modifications and accept or deny based on the impact to the project.

FIGURE 1 – TRAFFIC SIGNAL SYSTEM MASTER PLAN DESIGN AND DEPLOYMENT ORGANIZATIONAL CHART



3.0 REFERENCE DOCUMENTS

The following documents were used in the development of the system requirements and verification plan:

Some of these documents provide policy guidance for the Traffic Signal System Master Plan, some are standards with which the system must comply, while others report the conclusions of discussions, workshops and other research used to define the needs of the project and subsequently identify project requirements.

- *MAPA Regional ITS Architecture* - http://www.mapacog.org/intelligent-transportation-systems-its
- *MAPA Long Range Transportation Plan 2035* - http://www.mapacog.org/long-range-transportation-planning
- *City of Omaha Transportation Master Plan* - http://www.cityofomaha.org/tmplan/
- *MAPA Transportation Improvement Program* - http://www.mapacog.org/transportation-improvement-program
- *City of Omaha Capital Improvement Program 2012-2017* - http://www.cityofomaha.org/finance/images/stories/pdfs/CIP2012-2017.pdf
- *City of Omaha Traffic Signal System Master Plan, January 2013*
- *Omaha-Council Bluffs Traffic Incident Management Operations Guidelines* - http://www.tim.ne.gov/alternate-routes/metro-ocb/O-CB%20TIM%20Ops%20Guide%202011-03-22.pdf
- *Systems Engineering Guidebook for ITS, California Department of Transportation, Division of Research & Innovation, Version 3.0* - http://www.fhwa.dot.gov/cadiv/segb/

4.0 REQUIREMENTS

Table 1 identifies detailed requirements for high-priority needs, categorized by signal system component, which are based on user needs and which were developed from scenario-based discussions and functionality matrices for various software packages. Detailed requirements for medium and low priority needs will be developed in the future as related projects are identified.

TABLE 1 – DETAILED REQUIREMENTS FOR HIGH-PRIORITY NEEDS

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
1.0	ARTERIAL TRAFFIC MANAGEMENT				H/M/L
1.01	Need to replace Type 170E controllers	S1	R1	The project shall replace the existing local traffic signal controllers with 2070 ATC controllers.	H
		S1	R2	The project shall upgrade select local controllers with 170E modifications.	H
1.02	Need to install upgraded software on controllers	S1	R3	The project shall install new local controller software.	H
1.03	Need to provide additional space in cabinets for additional components	S1	R4	The project shall standardize on a 332 cabinet for all replacement cabinets and future installations.	H
		S1	R5	The proposed cabinet shall meet or exceed the standard 332 cabinet specifications.	H
1.04	Need to integrate traffic signals into a single traffic control system software	S2,S3	R6	The project shall integrate a Central Signal System Software.	H
		S2,S3	R7	The project shall establish IP-based communications to all signals and devices.	H
1.05	Need to integrate ITS field devices into a single management software	S7	R8	The project shall deploy compatible ITS devices into the NDOR ATMS without software modification.	H
1.06	Need to designate central location for signal timing databases	S2	R9	The project shall provide a server configured with the necessary database and data dictionary format.	H
		S2	R10	The project shall allow access to the signal timing database to appropriate staff.	H
1.07	Need to provide ability to easily update controller settings in the field	S2,S3			M
1.08	Need to improve system operation monitoring	S3,S5	R11	The project shall deploy full motion pan/tilt/zoom cameras citywide through a phased implementation plan.	H
		S3,S5	R12	Camera shall produce NTSC standard definition composite video.	H
		S3,S5	R13	The project shall deploy compatible field hardened video server technology into the NDOR ATMS software without modification.	H

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
		S3,S5	R14	The video server shall allow for setting and adjusting the video stream frame rate.	H
		S3,S5	R15	The project shall provide a CCTV camera with the ability to provide color camera images by day and black/white images at night.	H
		S3,S5	R16	The project shall provide a CCTV camera with the ability to operate in the extremes of the MAPA regional climate.	H
		S3,S5	R17	The project shall deploy a CCTV camera with the ability to remotely control Pan, Tilt, Zoom, auto Iris and auto Focus.	H
		S3,S5	R18	The project shall provide and deploy a video server with the ability to adjust the framerate of the transferred image.	H
1.09	Need to provide access to management software to various staff in various locations	S3	R19	The project shall deploy a communication system that allows for remote operations through a secure VPN or other secure access.	H
1.10	Need to provide ability to modify and verify signal timing through central software	S2,S3			M
1.11	Need to provide notification of detector failures	S1,S2	R20	The project shall deploy detector cards with the ability to recognize errors and failures.	H
		S1,S2	R21	The project shall deploy a Central Signal System (CSS) software with the ability to monitor detector information at each traffic signal location.	H
		S1,S2	R22	The project shall deploy a CSS software with the ability to set alarm notification based on detector status.	H
1.12	Need to deploy timing plans to groups of intersections simultaneously	S2			M
1.13	Need to receive automatic notifications for coordination errors	S1,S2	R23	The project shall deploy a local controller that must store/upload notifications for a wide variety of events and occurrences to central system.	H
		S1,S2	R24	The project shall deploy a CSS software with the ability to monitor traffic signal coordination attributes for each traffic signal.	H
		S1,S2	R25	The project shall deploy a CSS software with the ability to monitor traffic signal coordination attributes for an operator defined group of traffic signals.	H
		S1,S2	R26	The project shall deploy a CSS software with the ability to send alarm notifications based on coordination errors as monitored for each traffic signal and group of traffic signals.	H

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
1.14	Need to setup alarm notifications for user-defined thresholds for various parameters	S2	R27	The project shall deploy a CSS software with the ability to establish user defined thresholds for coordination, traffic volumes, traffic speeds, traffic queuing.	H
1.15	Need to download user-friendly operational reports on signal system operations and performance (such as communications failures), timing data, and traffic data	S2			M
1.16	Need to provide alarms for excessive queuing	S1,S2			L
1.17	Need to develop an automated logging system	S1,S2	R28	The project shall deploy a local controller that must maintain a large historical log, available for front panel queries of a wide variety of events and occurrences including:	H
		S1,S2	R28a	a. Cabinet events (door open, conflict flash, watchdog timer, power restart, UPS activation...)	H
		S1,S2	R28b	b. Emergency Vehicle Preemption events (direction, start, finish, and back in sync)	H
		S1,S2	R28c	c. Transit Signal Priority events (direction, start, and finish)	H
		S1,S2	R28d	d. Coordination events (cycle length, phase sequence)	H
		S1,S2	R28e	e. User ID of technician who edited a database (cross-referenced by password)	H
		S1,S2	R28f	f. Detection events (constant call, no call, malfunction)	H
		S1,S2	R29	The project shall deploy a local controller that must maintain a large historical log for central system retrieval, of a wide variety of events and occurrences including:	H
		S1,S2	R29a	a. Cabinet events (door open, conflict flash, watchdog timer, power restart, UPS activation…)	H
		S1,S2	R29b	b. Emergency Vehicle Preemption events (direction, start, finish, and back in sync)	H
		S1,S2	R29c	c. Transit Signal Priority events (direction, start, and finish)	H
		S1,S2	R29d	d. Coordination events (cycle length, phase sequence)	H
		S1,S2	R29e	e. User ID of technician who edited a database (cross-referenced by password)	H
		S1,S2	R29f	f. Detection events (constant call, no call, malfunction)	H
1.18	Need to automatically archive data	S1,S2	R23	The project shall deploy a local controller that must store/upload notifications for a wide variety of events and occurrences to central system.	H

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
		S1,S2	R30	The project shall deploy a local controller that must automatically generate a wide variety of events and occurrences based on user-defined thresholds.	H
		S1,S2	R31	The project shall deploy a central system software that automatically stores a wide variety of traffic signal controller information (alarms, detector status, count information, etc).	H
		S1,S2	R32	The project shall deploy a central system software that automatically writes and appends data to a central database.	H
		S1,S2	R33	The project shall deploy a database with permissions restricted by unique assigned user identification and passwords.	H
1.19	Need to conduct traffic flow monitoring in real time with individual detectors	S1,S7	R34	The City of Omaha will provide Staff at the TMC to monitor system and peak period operations.	H
		S1,S7	R35	The project shall deploy a local controller that must automatically aggregate and store raw count accumulations (detector actuations):	H
		S1,S7	R35a	a. from most/all of its locally-connected detectors (both phase call / extend detection and system detection)	H
		S1,S7	R35b	b. in user-defined time-duration bins	H
		S1,S7	R35c	c. for a significantly long time so that infrequent count retrievals by the central system are possible	H
1.20	Need to obtain access to existing freeway monitoring capabilities	S7	R39	City of Omaha has license for NDOR ATMS Software. Document ATMS operating requirements.	H
		S7	R85	The City of Omaha shall access freeway monitoring capabilities through NDOR ATMS software.	H
1.21	Need to provide high-quality real-time traffic information	S6		The field devices shall collect traffic information project shall create a public facing web-site that provides real-time arterial traffic information.	L
1.22	Need to provide timely congestion and incident information to public	S6			M
1.23	Need to provide the public with limited access to traffic management tools and activities	S6	R40	The project shall create a public facing web-site that provides real-time arterial traffic information.	H
1.24	Need to integrate traffic data collection software with traffic signal system modeling software	S2			M
1.25	Need to integrate traffic signal system modeling software with Central Signal System Software	S2	R41	The project shall automate the transfer of Synchro traffic signal optimization to CSS timing plan updates.	H

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
1.26	Need to improve signal coordination	S4	R42	The project shall evaluate additional timing/phasing options (eg, adaptive, flashing yellow arrow, peds).	H
1.27	Need to maintain high-quality coordination	S1,S2,S3	R43	The project shall evaluate signal timing on regular basis (eg, once every three years) by establishing performance measures that identify high growth corridors that may require the re-timing at a more specific schedule.	H
		S1,S2,S3	R44	The project shall deploy a CSS that has the ability to collect specific intersection controller information (such as phase duration, traffic volume per phase, queue detection).	H
		S1,S2,S3	R45	The project shall deploy a CSS that has the ability to generate operator specified performance reports.	H
1.28	Need to provide the ability to modify coordination correction modes	S1,S2	R46	Provide options at select locations not currently available with 170s.	H
1.29	Need to conduct traffic data collection from permanent stations	S1			M
1.30	Need to measure signal timing performance	S2			M
1.31	Need to provide dynamic lane assignment based on user-defined traffic data inputs	S1,S2			L
1.32	Need to develop special event timing	S4			M
1.33	Need to install adaptive traffic control on certain corridors	S1,S2	R47	The City shall identify specific corridors for adaptive solutions based on safety and operational issues that cannot be addressed with existing systems and evaluate Adaptive Signal Control Technology (ASCT) solutions. (Corridors are not being identified as part of this project.)	H
		S1,S2	R48	The project shall deploy a local traffic controller and CSS that integrate with the selected ASCT solution.	H
1.34	Need to provide adequate staffing to perform functions	S4	R49	Increase engineering and operations staff levels for existing system needs; expand as necessary with future system deployments.	H
1.35	Need to provide adequate staff training	S4	R50	Software application and maintenance training for engineering, operations, and maintenance staff.	H
		S4	R51	Hardware equipment installation, configuration troubleshooting and maintenance for engineering, operation, and maintenance staff.	H
1.36	Need to develop interagency agreements for providing access to software and information.	S4			M
1.37	Need to evaluate future vehicle-to-vehicle communications systems	S4			M

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
1.38	Need to evaluate pedestrian and bicycle concerns	S4			M
2.0	**SAFETY SYSTEMS**				
2.01	Need to provide automatic notifications for power outage and cabinet knockdowns	S3	R52	The project shall deploy a local traffic controller and CSS that provide specific alarm notifications.	H
2.02	Need to provide indication for status of active UPS systems	S3	R53	The project shall deploy a local traffic controller that can provide notification of active UPS system.	M
2.03	Need to provide the ability to implement flashing yellow arrow operation for permissive turns within management software	S1	R54	The project shall deploy a local traffic controller that can implement and manage Flashing Yellow Arrows.	H
		S1	R55	The project shall deploy a CSS that can monitor the operation and report phase status and errors for Flashing Yellow Arrows.	H
2.04	Need to provide the ability to implement a pedestrian hybrid beacon within management software	S1	R56	The project shall deploy a local traffic controller with the ability to implement a pedestrian hybrid beacon within local controller and CSS.	H
2.05	Need to provide the ability to implement pedestrian scramble operation within management software	S1	R57	The project shall deploy a local traffic controller with the ability to implement pedestrian scramble operation within management software.	H
2.06	Need to provide the ability to implement audible or accessible pedestrian features within management software	S1,S2	R58	The project shall provide a local traffic controller with the ability to implement audible or accessible pedestrian features within management software.	H
2.07	Need to implement detection and develop timing specific to bicycles	S1			M
2.08	Need to provide anti-icing systems on high-volume approaches with steep grades	S1,S5			L
2.09	Need to monitor speeds in real-time and conduct data collection at speed feedback sign locations	S5,S7			L
3.0	**COMMUNICATIONS SYSTEMS & INTEGRATION**				
3.01	Need to increase speed, bandwidth, and reliability of field to field communications	S3	R59	The project shall provide a 99% level and quality of service on the backbone network.	H
		S3	R60	The project shall accommodate communication over media including at least the following:	H
		S3	R60a	Twisted Pair	H
		S3	R60b	Wi-Fi	H
		S3	R60c	Telephone	H
		S3	R60d	Radio	H
		S3	R60e	Cellular	H
		S3	R60f	Fiber Optic	H

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
		S3	R61	The project shall deploy a communications system that will allow the transfer of local traffic controller data, traffic cabinet monitoring data and other specific devices from each intersection to a communications Hub cabinet.	H
3.02	Need to increase speed, bandwidth, and reliability of center to field communications	S3	R62	The project shall deploy a Communications system of leased or owned wired and wireless devices technology.	H
3.03	Need to provide staff in the field access to network	S3	R63	The project shall provide the network security to allow a remote wireless VPN connection for management of the CSS and local controllers.	H
3.04	Need to provide the ability to transmit video	S3	R64	The project shall deploy a communications infrastructure from the device cabinet to the hub locations that provides for at least 200 cameras to provide 20 frames per second (in order to provide a quality image but minimize bandwidth).	H
3.05	Need to provide central information clearinghouse	S6	R65	The project shall design and implement a Transportation Web-portal that allows data sharing throughout the MAPA region.	H
3.06	Need to develop interagency agreements	S4			M
3.07	Need to provide communications to all signals	S3	R66	The project shall accommodate communication to existing signals via at least the following:	H
		S3	R66a	Twisted Pair	H
		S3	R66b	Wi-Fi	H
		S3	R66c	Telephone	H
		S3	R66d	Radio	H
		S3	R66e	Cellular	H
		S3	R66f	Fiber Optic	H
3.08	Need to provide remote access to the traffic signal network for management, software upgrades, and troubleshooting	S3	R67	Provide Engineering and maintenance staff wired and wireless communications to the internet to allow VPN and remote management of the CSS and local controllers.	H
3.09	Need to develop and implement network security protocols	S3	R68	The project shall design and deploy an IT network that is scalable to 1500 traffic signals, 2000 cabinets with UPS, 300 cameras, 80 DMS and 750 sensors.	H
3.10	Need to develop traffic signal IP schema/architecture for participating stakeholders	S3	R69	The project shall design and deploy a network IP management plan to accommodate unique IP addresses for each device.	H

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
		S3	R70	The project shall design and deploy a network IP management plan to accommodate the necessary bandwith for cumulative load of each device at each hub and server location.	H
3.11	Need to evaluate IP schema/architecture for future stakeholder integration	S3	R71	The project shall meet with City representatives to identify future integration and provide scalability of the IT network.	M
4.0	**INCIDENT MANAGEMENT**				
4.01	Need to improve incident detection	S1,S5	R27	The project shall deploy a CSS software with the ability to establish user defined thresholds for coordination, traffic volumes, traffic speeds, and traffic queuing.	H
		S1,S5	R11	The project shall deploy full motion pan/tilt/zoom cameras citywide through a phased implementation plan.	H
		S1,S5	R12	Camera shall produce NTSC standard definition composite video.	H
4.02	Need to verify and monitor incidents	S3,S5	R11	The project shall deploy full motion pan/tilt/zoom cameras citywide through a phased implementation plan.	H
			R12	Camera shall produce NTSC standard definition composite video.	H
4.03	Need to provide staff to actively monitor and coordinate	S4	R72	The project shall provide Staff at TMC to monitor system and peak period operations.	H
4.04	Need to improve incident response coordination between agencies	S4,S7	R73	The project shall provide staff to coordinate with NDOR and public safety agencies.	H
4.05	Need to reduce traffic delays for emergency response vehicles	S1	R74	The project shall deploy a controller that provides two railroad preempt sequences, four emergency vehicle sequences, and four transit priority sequences.	H
		S1	R75	The project shall deploy a local controller that provides a maximum preemption duration timer, beyond which the preempt call will be disregarded.	H
		S1	R76	The project shall deploy a local controller that provides a reduced pedestrian flashing DON'T WALK timing parameter, for use when a preempt call is active.	H
		S1	R77	The project shall deploy a local controller that provides an exit-from-preemption strategy for the local controller.	H
		S1	R78	The project shall deploy a local controller that provides a quick transition back to 'in coordination' rather than a fixed preempt exit phase.	H

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
		S1	R79	The project shall deploy a local controller that must drop the controller exactly back into the appropriate phase for the current coordination cycle timer.	H
4.06	Need to develop methods for deployment of incident management for select corridors	S4			M
4.07	Need to provide better coordination for ending incident management activities	S4			M
5.0	**TRAVELER INFORMATION SYSTEMS**				
5.01	Need to provide traveler information on the roadside	S5	R80	This project shall deploy DMS.	H
		S5	R81	The project shall deploy compatible DMS into the NDOR ATMS without software modification.	H
		S5	R82	The project shall deploy DMS with 3 lines and 12 characters per line.	H
		S5	R83	The project shall deploy DMS that communicates with NTCIP protocol.	H
5.02	Need to provide quality real-time congestion-related information	S6	R40	The project shall create a public facing web-site that provides real-time arterial traffic information.	H
5.03	Need to improve and expand traveler information delivery methods	S6		Distribute information through websites, kiosks, media, social media.	M
5.04	Need to improve procedures to get accurate information disseminated in a timely manner	S4,S6	R84	The project shall develop a Traffic Management Handbook with On-call information and SOP.	H
5.05	Need to provide better work zone information and notification	S6		Update 511 system with lane and road closure information.	M
6.0	**PUBLIC TRANSPORTATION**				
6.01	Need to provide transit priority at signals	S1,S8			L
6.02	Need to provide traffic signal operations for at-grade transit crossings	S1,S8			L
6.03	Need to provide information exchange to/from transit agency	S6			M
6.04	Need to use AVL data for traffic management	S3,S8			L
6.05	Need to provide transit ETA information	S8			L
7.0	**MAINTENANCE AND CONSTRUCTION OPERATIONS**				
7.01	Need to conduct preventive maintenance on traffic signals at regular intervals	S4	R85	The project shall develop and maintain a preventive maintenance schedule.	H
7.02	Need to standardize traffic control equipment	S1	R1	The project shall replace the existing local traffic signal controllers with 2070 ATC controllers.	H
		S1	R7	The project shall establish IP-based communications to all signals and devices.	H
		S1	R11	The project shall deploy full motion pan/tilt/zoom cameras citywide through a phased implementation plan.	H

NEED NO.	NEEDS STATEMENTS (from Stakeholder Workshops)	SYS. COMP. NO.	REQ. NO.	PRELIMINARY REQUIREMENT STATEMENTS	PRIORITY
		S1	R12	Camera shall produce NTSC standard definition composite video.	H
		S1	R20	The project shall deploy detector cards with the ability to recognize errors and failures.	H
7.03	Need to standardize cabinet setup	S1	R4	The project shall standardize on a 332 cabinet for all replacement and future installations.	H
		S1	R5	The proposed cabinet shall meet or exceed the standard 332 cabinet specifications.	H
7.04	Need to improve coordination on construction notification and information distribution	S4,S6			M
7.05	Need to improve work zone traffic handling plans	S4			M
7.06	Need to monitor traffic remotely in and around work zones	S5,S7			M
7.07	Need to provide weather and pavement data collection to aid winter operations	S5,S7			L
7.08	Need to provide automated vehicle locations systems for maintenance and construction operations vehicles	S5			L

5.0 VERIFICATION APPROACH

This section provides details on how the verification plan is expected to be accomplished for the traffic signal system projects. The City of Omaha Project Manager is responsible for all system verification and acceptance testing. Some of this effort will be delegated to the City of Omaha support team and some will be provided by the System Contractor and approved by the Project Manager. The Project Manager will control the plan and tests but will also work with the System Contractor to clarify the verification procedure and acceptance test.

The System Contractor will be responsible for providing all materials, equipment and staff to complete the testing. The proposed date and time of all acceptance testing will be planned in advance and coordinated with the Project Manager.

The verification and acceptance testing will be accomplished at approved City of Omaha locations and at specific field locations within the City. The acceptance test is expected to include the following elements:

- Shop drawing reviews
- Inventories
- Field demonstrations of device performance
- TMC Test Scripts of CSS and NDOR ATMS

Contractors and integrators will test system components. Operational documentation of the field components is expected to be completed with no more than a laptop, internet connection and associated cabling.

Acceptance testing will be a critical part of implementation, including one-day acceptance and 30-day reliability tests. The acceptance test is expected to consist of a one day test of the field components described above in the field and tests at selected locations. A 30-day reliability test for each component installed as part of the project will also be documented. The 30-day test is expected to the document the verification of daily operation.

In the event that one or more of the requirements are not satisfied during the acceptance tests, a test variance will be created. A variance form, which will be developed at a later date based on more detailed requirements, will be completed and tracked through the resolution of the requirement. It is the responsibility of the System Contractor to complete, track, and resolve each variance to the satisfaction of the Project Manager.

6.0 VERIFICATION REVIEW AND TESTING

Based on the stakeholder user needs and the definition of requirements for the project components, a traceability matrix will be created to further develop the requirements and verification plan. To verify the traffic signal system will meet the user needs of the stakeholders and satisfy the requirements, the verification plan identifies requirements that should be tested in a step-by-step order to show the functionality that is described in the Concept of Operations.

The Concept of Operations and Detailed Requirements for High-Priority Needs table identified key project components for which verification procedures will be specifically identified in future projects. An all-inclusive list of specific verification procedures are difficult, if not impossible, to identify at the master plan level, and will therefore be identified through traceability matrices as system components are implemented and detailed requirements are finalized through individual projects in the future. Preliminary verification procedures are summarized in Table 2.

TABLE 2 – SUMMARY OF PRELIMINARY VERIFICATION PROCEDURES

S1-Traffic Signal Controller Upgrades
Cabinet Shop Drawing Review
Local Controller Shop Drawing Review
Product Inventory
On-Site Verification and Field Documentation
Local Controller Test Case
Remote Operation and Configuration through VPN
S2-Central Signal System Software
CSS Test Case for Local Controller Configuration
CSS Test Case for Database Logging - Real Time
CSS Test Case for Database Logging - Archived Data
CSS Test Case for Intersection Status
CSS Test Case for Alarms & Notification
CSS Test Case for Reporting
CSS File Transfer to ATIS
Remote Operation and Configuration
S3-Enhanced Communications
Communications Device Shop Drawing Review
Communication Cabling Shop Drawing Review
Product Inventory
On-Site Verification and Field Documentation
Field to Field Device Communication Test Case
Field Verify Bandwidth and Usage from each new device
Field Verify Bandwidth and Usage at each Hub
TMC Test Case for Communication Status Report
TMC Test Case for Communication Alarms & Notification
Center to Field Device Communication Test Case
S4-Staffing
Staff at TMC during documented hours of operation.
MOU's with agencies for maintenance support.
S5-ITS Field Upgrades
Cabinet Shop Drawing Review
ITS Device Shop Drawing Review
Product Inventory
On-Site Verification and Field Documentation
Field ITS Device Test Case for control and management

TMC Test Case for ATMS Control and Management
Test Case for Remote Operation and Configuration of ITS Device through VPN
S6-ATIS
Interface Control Document Review
Document Host Location IT Requirements
ATIS Test Case for Data Transfer to other systems
ATIS Test Case for Data Transfer from other systems
Documentation of Web Browser Tests
Documentation of User Group Tests
S7-ATMS
ITS Device Shop Drawing Review
TMC Test Case for ATMS ITS Device Status
TMC Test Case for ATMS ITS Device GUI Interface
TMC Test Case for ATMS Control and Management - CCTV
TMC Test Case for ATMS Control and Management - DMS
TMC Test Case for ATMS Remote Operation
S8-Transit Enhancements
ATIS Test Case for Data Transfer to other systems
ATIS Test Case for Data Transfer from other systems

7.0 NEXT STEPS

The System Engineering documents associated with the master plan project will be used with the deployment strategy to identify the scope and magnitude of the first phase of the signal system upgrade. The Requirements and Verification Plan will be used to track modifications through the final design to trace the changes as the detailed requirements are developed from the high-level requirements. Ultimately the requirements and final plans with specifications are tracked and incorporated into the final bid package for bid, letting and project deployment.

APPENDIX F

LOCAL CONTROLLER SOFTWARE FEATURES MATRIX

DESIRED FUNCTIONS CHECK LIST

DESIRED FUNCTIONS	Econolite ASC/3	Siemens EPAC	McCain 2033	McCain ATC OmnieX	Naztec Version 50/60	Intelight MaxTime	4th Dimension D4	Northwest Signal M1
Category 1: Alarms								
1. Local controller must maintain a large historical log, available for front panel queries and central system retrieval, of a wide variety of events and occurrences:	Y	Y			Y	Y	Y	Y
a. Cabinet events (door open, conflict flash, watchdog timer, power restart, …)	Y	Y			Y	Y	Y	Y
b. Emergency Vehicle Preemption events (direction, start, finish, and back in sync)	Y	Y			Y	Y	Y	Y
c. Transit Signal Priority events (direction, start and finish)	Y	Y			Y	P	Y	Y
d. Coordination events (cycle length, phase sequence)	Y	Y			Y	Y	Y	Y
e. User ID of technician who edited a database (cross-referenced by password)	Y	N			P	N	Y	P
f. Detection events (constant call, no call, malfunction)	Y					Y	Y	Y
2. Local controller must store/upload notifications for a wide variety of events and occurrences to central system	Y					Y	Y	Y
3. Local controller must automatically generate a wide variety of events and occurrences based on user-defined thresholds	Y					Y	N	Y
Category 2: Communications							Y	
1. The local controller must be capable of receiving a timeclock setting / correction command from an external source (e.g., a WWV radio, a GPS device, etc.) for unconnected system groups operating under time-based coordination).	Y	Y	Y	Y	Y	Y	Y	Y
2. The local controller must support NTCIP protocols	Y	Y	Y	Y	Y	Y	Y	Y
a. Ethernet	Y	Y	Y	Y	Y	Y	Y	Y
b. EIA-232, EIA-485, or EIA-574	Y	Y	Y	Y	Y	Y	Y	Y
Category 3: Intersection Control							Y	
1. Pedestrian Control								Y
a. An overlapped pedestrian phase should be able to stay in WALK when transitioning past an omitted phase.	Y	N			Y	?		Y
b. Exclusive pedestrian phase service, with user-selectable pedestrian phases included	Y	Y			Y	Y	Y	Y
c. Advance start and/or delayed start for pedestrian WALK interval, selectable by phase	P	Y			Y	Y	Y	Y
d. Reservice pedestrian call	Y					Y		Y
2. Options							Y	Y
a. Must have comprehensive, integrated logic programming functions to handle unique situations requiring special operations, phasing, sequencing, timing, and/or rules.	Y	N	Y		Y	Y	Y	Y
b. Phase rotation of left turn and opposing through phases to provide for leading or lagging left turn service must be provided. This phase rotation could be enacted for any such phase pair, and would be allowed on a time-of-day basis.	Y	Y	Y	Y	Y	Y	Y	Y
3. Protected-permissive left turn Control	P						Y	Y
a. Capable of Flashing Yellow Arrow Control	Y				Y	Y	Y	Y
b. Capable of "Fourth Car Detection" logic where protected left turns only appear if at least four cars are detected prior to start of green.	Y	Y			P	Y	Y	Y
c. Phase Backup Prevention of controller phase change sequences that would create a "Yellow Trap" condition for left turn, without the use of wired jumpers in the cabinet	Y	Y	Y	N	Y	Y		Y
4. Eight programmable overlap phases	Y	Y	Y	Y	Y	Y	Y	Y
5. Exclusive phases which will time in one ring, while all phases in the other ring are held in red rest	Y					Y	Y	Y
6. Capable of Advance warning flasher or Pedestrian hybrid beacon programming, for up to 2 signs	Y	Y			Y	Y	Y	Y
7. Ability to redirect any controller phase output (whether peds, vehicles or overlaps) to any other load switch input	Y	Y	Y	Y	Y	Y	Y	Y
8. Capable of local adaptive or traffic responsive operation		Y					Y	Y
9. Phase specific parameters	Y						Y	Y
a. Multiple MAX GREEN (up to 3) parameters that can be selected by a coordination plan or external input	Y	Y			P	Y	Y	Y
b. Dynamic "Max" time	Y	Y	Y	Y	Y	Y	Y	Y
c. Alternate Minimum Green for bicycle, where their presence has been provided to the controller via alternate detector inputs	Y	Y			N	P	Y	Y
d. Conditional Services (during free and coordinated conditions), allowing a leading left to be served again as a lagging left if sufficient time remains in the phase operating in the other ring before a barrier force-off phase termination	Y	Y	Y	Y	Y	P	Y	Y
e. Volume-density phase timing	Y	Y	Y	Y	Y	Y	Y	Y
f. Simultaneous gapout termination capability; if not selected, a phase whose gap timer expires must wait in Green Rest, and subsequent calls on that phase must not restart the gap timer.	Y	Y	Y	Y	Y	Y	Y	Y
Category 4: Coordination							Y	

DESIRED FUNCTIONS CHECK LIST

DESIRED FUNCTIONS	Econolite ASC/3	Siemens EPAC	McCain 2033	McCain ATC OmnieX	Naztec Version 50/60	Intelight MaxTime	4th Dimension D4	Northwest Signal M1
1. Ability to utilize any combination of up to 9 discrete cycle lengths (i.e., 9 Plans) each with 3 discrete offsets	Y	P	Y	Y	Y	Y		Y
2. Phase assignments that can allow for user-specified leading and/or lagging left turn sequencing	Y	Y	Y	Y	Y	Y		Y
3. User-programmable assignment of the coordination/sync phases for each Plan	Y	Y	Y	Y	Y	Y	Y	Y
4. Ability to reservice a phase while in coordination	Y	Y	Y	Y	Y	Y	Y	Y
5. Ability to use fully-actuated coordination where the coordinated phases may gap out in absence of demand	Y	Y	Y	Y	Y	N	Y	Y
6. Ability to use recall phases (vehicle or pedestrian) per coordination plan	Y	Y	Y	Y	Y	Y	Y	Y
7. Ability to determine how the unused non-coordinated green time will be distributed (fixed force-off versus float force-off)	Y	Y	Y	Y	Y	Y	Y	Y
8. Ability to do basic error checking of split times when entered locally	Y	Y	Y	Y	Y	Y	Y	Y
9. Three programmable permissive periods per cycle	P	Y	Y	Y	N	N	Y	Y
10. Capable of adapting splits	Y	Y				Y	Y	Y
11. Capable of omitting phases for each Plan	Y	Y				Y	Y	Y
12. Describe controller operation when left-turn phase lags and has force-off as same coordinated/sync phase:							Y	Y
a. Coordinated phase may terminate before programmed force off in absense of left-turn demand	P	P					Y	Y
b. Left turn phase displays regardless of left-turn demand	N			N			N	Y/N
13. Describe controller operation when phase is timing past its programmed force-off (typically due to pedestrian timing):	P						Y	Y
a. Local cycle timer is unaffected and terminates next phase at programmed force-off (controller may skip, or reduce the split of, the next phase)	P	N			P	Y	Y	Y
b. Local cycle timer "stops" and controller enters transition to correct offset (controller still times programmed split of next phase)	P	Y			P	P	Y	Y
c. Controller enters uncoordinated/free mode and transitions to re-enter coordination	P					P	Y	N
13. Capable of modifying multiple coordination correction modes	Y	Y	Y	Y	Y	Y	Y	Y
Category 5: Data Collection							Y	
1. The local controller must automatically aggregate and store raw count accumulations (detector actuations) …	Y	Y			Y	Y	Y	Y
a. from most/all of its locally-connected detectors (both phase call / extend detection and system detection),	Y	Y			Y	Y	Y	Y
b. in user-defined time-duration bins	Y	Y			Y	Y	Y	Y
c. for a significantly long time so that infrequent count retrievals by the central system are possible.	Y	Y			Y	P	Y	Y
2. The local controller should monitor detector activity for malfunction and/or inconsistent operation;	Y	Y		Y	Y	Y	P	Y
a. Failed detection should be converted to a constant detection call	Y	Y			P	Y	Y	Y
b. Malfunctioning detectors should be flagged by the controller for notification to the central system	Y	Y			Y	Y	Y	Y
Category 6: Detection							Y	
1. Detector cross-switching (detector assignment) must be full-featured and user-assignable. It must be individually selectable for any coordination plan.	Y	Y		Y	Y	Y	Y	Y
2. A single detector input must be able to provide calls to multiple phases with no special hardware, wiring or logic.	Y	P			N	Y	Y	Y
3. Type 3 (call detector that also serves as a phase extend detector) detection disconnect timer, allowing a type 3 detector to revert back to a simple calling detector after a user-specified time has expired in the green phase service.	Y	P	Y	Y	Y	Y	Y	Y
4. At least 32 discrete detector inputs, each assignable to phase calls with delay and/or extend call timing	Y	Y	Y	Y	Y	Y	Y	Y
5. Any detector input may also be treated as a system (count) detector	Y	Y	Y	Y	Y	Y	Y	Y
Category 7: Features							Y	
1. Any partial or complete controller database that is downloaded from the COTS ATMS to the local controller must be placed into non-volatile memory. If the controller requires actual operation with the database being in volatile memory, then the controller database stored in non-volatile memory must be an exact copy of the operating database, and is to be stored only for redundancy / safekeeping / backup & restoration. Upon power loss and restoration to the controller unit, the database in non-volatile memory must be automatically utilized for the restarted controller	Y	Y			Y	Y		Y
2. Complete controller database interaction must be provided via a wired laptop connection.	Y	Y		N	Y	Y	Y	Y
3. The local controller front panel displayed page should be easily and quickly changed between several routinely viewed pages (such as "active" timing tables). For example, this could be achieved with a short 'favorites' list of pages that could be scrolled through, or a short 'hot-key' keystroke sequence (of no mor ethan 2 button presses), or some other method that is shorter than stepping through screen menus.	Y	N	N	N	N	P	Y	Y

DESIRED FUNCTIONS CHECK LIST

DESIRED FUNCTIONS	Econolite ASC/3	Siemens EPAC	McCain 2033	McCain ATC OmnieX	Naztec Version 50/60	Inteligh MaxTime	4th Dimension D4	Northwest Signal M1
4. The controller software should set a "change noted" flag whenever the database is modified locally by laptop, PDA or front panel entry.	Y	N				Y	Y	Y
a. The COTS ATMS should periodically (at least once per hour) monitor this flag in all controllers, and prompt the system operator to perform database uploads, either manually or set for an unattended automatic manner	Y	N			Y	P	Y	Y
b. The COTS ATMS should automatically identify the parameter(s) which have been changed in the local controller, and create a "changes log" archive of database changes by location	Y	N			P	P	Y	Y
5. Controller database changes should be permission-restricted by unique assigned passwords	Y	Y			Y	P	Y	P
6. Detail how many software versions have been issued for this platform. Over what time frame								Y
7. Describe procedure of installing software updates.							Y	Y
a. Remotely update, reboot, and resume online operation for verification	N					N	Y	N
b. Local field update, manual reboot, and resume online operation for verification	Y	Y	Y				Y	Y
8. Ability to install/update applications software and operating system using serial port, Ethernet port, or USB port						Y	Y	Y
a. Laptop computer connected to serial port or Ethernet port	Y			Y		Y	Y	Y
b. external device connected to serial port, Ethernet port, USB port, or datakey port	N			Y		Y	Y	Y
9. Other vendor central systems are compatible with controller software.	P	N	N	N	N	P	Y	Y
10. Controller software conforms to ITE ATC Standard						Y	Y	Y
11. Controller software conforms to Cabinet standards:						Y	Y	Y
a. Type 170/179	Y	Y	Y	Y	Y	Y	Y	Y
b. NEMA TS1/TS2	Y	Y	Y	Y	Y	Y	Y	Y
c. ITE ITS		Y				Y	Y	Y
12. The capability to create special timing, phasing, and/or sequencing based on user logic statements – (and, or, nand, not, etc.) for separate timing plans/banks, advance warning signs, etc.	Y	N			Y	Y	Y	Y
13. The capability to override local patterns with central system group control						Y		Y
14. Capable of central adaptive or traffic responsive operation						Y		Y
Category 8: Preemption								
1. Two railroad preempt sequences, four emergency vehicle sequences and four transit priority sequences	Y	Y	Y	Y	Y	Y	Y	Y
2. A maximum preemption duration timer, beyond which the preempt call will be disregarded	Y	Y	Y	Y	Y	Y	Y	Y
3. Reduced pedestrian flashing DON'T WALK timing parameter, for use when a preempt call is active	Y	Y		Y	Y	Y	Y	Y
4. An exit-from-preemption strategy for the local controller:	Y						Y	Y
5. Should provide a quick transition back to 'in coordination' rather than a fixed preempt exit phase	Y	N			Y	Y	Y	Y
6. Must drop the controller exactly back into the appropriate phase for the current coordination cycle timer	Y	N			Y	P	Y	Y
7. Railroad Preemption (RRPE)	Y				Y			
a. The local traffic signal controller software must provide the appropriate response to the RRPE call, clearing phases that might have vehicles stored on the grade crossing, then omitting phases that conflict with the train presence, and finally transitioning back into normal operation.	Y	Y	Y	Y	Y	Y	Y	Y
b. With regard to the recovery back to 'normal' operation of the corridor, it is desirable for the local controller to provide for the immediate servicing of the appropriate phase combinations that would get the intersection back into "step" with the corridor's then-current timing plan as quickly as possible.	Y	N			Y	P	Y	Y
8. Traffic Signal Priority (TSP). The proposer must provide a detailed description of how TSP algorithms function within the proposed COTS ATMS or controller, not only for the response to provide enhanced service for the transit vehicle, but also for:	Y	Y			Y	Y	Y	Y
a. how extended green phase split is achieved	Y	Y	Y		Y	Y	Y	Y
b. how early green service is achieved, and whether phase skipping or phase sequence changes may be involved	Y	Y	Y		Y	P	Y	Y
c. the capability to "lock out" closely-spaced TSP calls for an operated-selected number of cycles or an operator defined number of seconds	Y	Y	Y		Y	Y	Y	Y
d. how the controller modifies timing and/or phase sequencing after the TSP event to get back into proper coordination	Y	Y	Y		Y	Y	Y	Y
e. Early and/or extended green must be individually allowable.	Y	Y	Y		Y	P	Y	Y
f. TSP service must not require any function or feature programming of additional controller rings.	Y	Y	Y		Y	P	Y	Y
g. Modified phase split being timed during a TSP event must be shown in controller front panel display by additional characters (such as "*", "TSP", etc.) or mode (such as phase number blinking, etc.).	Y	Y	Y		P	Y	Y	Y
h. It must be possible to program the controller to disallow TSP re-service for a specified number of cycles.	Y	Y	Y		Y	Y	Y	Y

APPENDIX G

CENTRAL SIGNAL SYSTEM SOFTWARE FEATURES MATRIX

DESIRED FUNCTIONS CHECK LIST

DESIRED FUNCTIONS	CURRENTLY PROVIDED? ("**Y**" *for Yes,* "**N**" *for No**, "**P**" *for Partial**)								COMMENTS * If "**P**" (Partial) is input, please provide additional information elaborating which functions the system currently can or can not provide; If "**N**" (No) is input, please elaboration on how the required functionality could be achieved.
	Econolite Centracs	Inteligent MaxView	Kimley-Horn KITS	McCain Quicnet	Naztec ATMS.NOW	Siemens Tactics	Telvent MIST	Transcore TranSuite	
CENTRAL SYSTEM									
Category 1: TMC Hardware and LAN									
1. The proposed commercial off-the-shelf (COTS) Advanced Traffic Management System (ATMS) components must operate on its own dedicated computer server(s) and local area network (LAN) of servers and workstations.	Y	Y	Y		Y	Y	Y	Y	Centracs servers are 'server class' dedicated systems with redundancy and serviceability features; Tactics supports operating on dedicated computer server or a local area network
Support an unlimited number of workstations and unlimited software licenses.	P	Y	Y		Y	Y	Y	Y	Centracs servers can support up to 20 workstations with additional Microsoft CAL licenses for SQL Server.
2. The proposed COTS ATMS must have the following central system functionality:									
a. Computation and execution of associated algorithms, including real-time retrieval of traffic flow parameters from field-located system detectors	Y	P	Y		Y	Y	Y	Y	Tactics communicates real-time with all field equipment assigned to the system
b. Database storage and management	Y	Y	Y		Y	Y	Y	Y	Centracs & Tactics utilizes Microsoft SQL Server 2008 for data storage and management.
c. Communications system management with field devices	Y	Y	Y		Y	Y	Y	Y	Tactics supports a robust communications server for management of field device equipment
d. Support for all user workstations each running an COTS ATMS workstation client software interface to the COTS ATMS	Y	Y	Y		Y	Y	Y	Y	All workstations running a Tactics client will be supported by the central software
e. Management of user profiles and permissions	Y	Y	Y			Y	Y	Y	Tactics fully supports management of user profiles and permissions
3. The proposed COTS ATMS client must require a username and password for all users, to be assigned by the System Administrator. This username/password may be the same as that used by the operating system (i.e., successful logon to the workstation allows uninhibited access to the system client).	Y	Y	Y		Y	Y	Y	Y	The user's Centracs password may be the same as that used by the operating system but the user will still be prompted for username/password upon launch of the Centracs client. Each Tactics user can be set with permissions unique to the work needs of the user. Access to download, change, and read data is selectable on the basis of each type of data desired
4. The proposed COTS ATMS should track workstation inactivity, such that after a configurable amount of time, users are required to log back into their client session. All security options must be applicable to both networked and remote/dial-in users.	Y	Y	P		Y	N	Y	Y	Tactics currently does not track workstation inactivity: KITS utilizes Windows login for security, therefore this feature must be configured in Windows to operate as describe
5. The proposed COTS ATMS should support each workstation unique user profiles, with each assigned specific privileges within the program.	Y	P	Y		Y	Y	Y	Y	Centracs supports an unlimited number of user profiles. Tactics user management supports assigning each user unique privileges and permissions
6. The proposed COTS ATMS must allow for user privileges to be defined by the System Administrator. By default, all users should have read-only or no privileges for the full system.	Y	Y	Y		Y	Y	Y	Y	By default no users have access to Centracs until a username is configured and roles assigned by the administrator. For Tactics, only users assigned as system administrators have access to assign individual user privileges
7. Additional operating privileges must be available for the following functional activities:									
a. System Administration & Configuration	Y	Y	Y		Y	Y	Y	Y	
b. User Profile Configuration	Y	P	Y		Y	Y	Y	Y	
· Device Configuration	Y		Y		Y	Y	Y	Y	Tactics supports assigning users read-only change, and download privileges for device configuration
· Database Configuration	Y		Y		Y	Y	Y	Y	Tactics supports assigning users read-only change, and download privileges for database configuration
· Database Report Creation & Generation	Y		Y		Y	Y	Y	Y	Tactics supports assigning users read-only or change privileges for database report creation and generation
· Map Editing	Y		Y		Y	Y	Y	Y	Tactics supports assigning users read-only or change privieges for map editing
· GUI Settings and Editing	Y		Y		Y	Y	Y	Y	Tactics supports assigning users read-only or change privieges for GUI settings and editing
· Communications Configurations	Y		Y		Y	Y	Y	Y	Tactics supports assigning users read-only or change privieges for communications configuration
c. System Operation	Y	P	Y		Y	P	Y	Y	
· Modify Timing Data	Y		Y		Y	Y	Y	Y	Tactics supports assigning users read-only, change, and download privileges for modifying device time data
· Upload Data	Y		Y		Y	N	Y	Y	Tactics currently allows all users to upload data
· Download Data	Y		Y		Y	Y	Y	Y	Tactics supports assigning users read-only, change, and download privileges for device downloads
d. ITS Operation (Optional, vendors to specify additional cost implications, if any)	P	P	Y		P	Y	Y	Y	
· CCTV Operation	Y		Y		N	Y	Y	Y	Tactics supports assigning users read-only or change privileges for CCTV operation
· Video Switch Operation	Y		Y		N	Y	Y	Y	
· Changeable Message Sign (CMS) / Dynamic Message Sign (DMS) Operation	Y		Y		N	Y	Y	Y	Tactics supports assigning users read-only or download privileges for CMS/DMS operation
· CMS / DMS Scheduler	N		Y		N	Y	Y	Y	Tactics supports assigning users read-only or download privileges for CMS/DMS operation
· Traffic Monitoring Station (TMS) Operation	N		Y		N	Y	Y	Y	Tactics supports downloading of system count reports to the central database
· TMS (i.e., 'system detectors') Data Viewing	Y		Y		N	Y	Y	Y	Tactics supports viewing of system detector counts. Systems count reports may be downloaded to the central database
· Incident Creation & Editing	N		Y		Y	Y	Y	Y	
· Response Plan Creation & Editing	N		Y		N	Y	Y	Y	
· Response Plan Implementation	N		Y		N	Y	Y	Y	
Automate camera selection and positioning to incident location									
8. The proposed COTS ATMS must provide a user priority assignment, configurable by the System Administrator, for resolution of command conflicts from concurrent uses. Users with higher priority should be able to override commands from lower priority users, take control of devices from lower priority users, etc.	Y	P	Y		P	N	P	N	Naztec's database are locked while editing; Centracs provides priorities (last command is winning command); all TransSuite users have the same priority (last command entered is used) Tactics does not support user override by system administrators
Category 2: Maintenance Malfunction Notification									
1. Notification Capabilities	Y	Y	Y		Y	Y	P	Y	
a. The proposed COTS ATMS must have the capability to automatically send alphanumeric (i.e., text) messages to email accounts, PDAs or mobile phones (to be carried by maintenance personnel) upon detecting problems with or within the system.	Y	Y	Y		Y	Y	Y	Y	Centracs can send automated SNS or email messages. Tactics is an integrated system which provides users with a common user interface to meet their control needs. Alarms are displayed on the screen.Tactics can be configured to automatically send an electronic page for critical alarms. Users may select alpha numeric paging for critical alarms

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	Econolite Centracs	Inteligh MaxView	Kimley-Horn KITS	McCain Quicnet	Naztec ATMS.NOW	Siemens Tactics	Telvent MIST	Transcore TranSuite	
b. Upon detection of an event, which triggers a system event, the designated operator(s) must be paged by the method described above, and the alarm message(s) presented.	Y	Y	Y		Y	Y	N	Y	Tactics can be confgured automatically send an electronic page for critical alarms. Users may select alpha numeric paging for critical alarms
c. This feature must be fully programmable allowing designation of operator(s), Time-of-Day/Day-of-Week of operator on-call shifts, multiple pages per event depending on severity, and critical event to trigger.	Y	N	Y		Y	Y	N	Y	Centracs has an escalation function. Tactics supports assigning user notification by time of day
d. The Time-of-Day/Day-of-Week function must allow specified events to initiate the page only during a specified time frame.	Y	N	Y		Y	Y	N	Y	Tactics supports assigning user notification by time of day
e. The proposed COTS ATMS must have the capability to automatically send after hour email notifications to maintenance staff.	Y	Y	Y		Y	Y	Y	Y	Tactics supports assigning user notification by time of day
2. Notification Paging	Y	P	P		N	Y	P	P	
a. The paging alarm system must have a call back confirmation function to assure that the call was received.	Y	N	P		N	Y	N	N	Centracs alert subsystem. Tactics acknowledgement feature assures that the call was received; KITS: Text-back confirmation is currently being implemented since pagers are becoming less and less common
b. If the confirmation does not happen, the paging system must continue to page subsequent pagers in the notification list at an operator's selectable time interval until confirmation of the alarm is received.	Y	N	P		N	Y	N	N	Centracs alert subsystem. Tactics Pagee List is a configuration tool for determing the users to be paged for incoming critical alarms
c. All alarm pages must also be displayed in a new pop-up window on all workstations currently connected to the COTS ATMS and running the COTS ATMS client software.	Y	Y	Y		N	Y	Y	Y	Tactics is an integrated system which provides users with a common user interface to meet their traffic control needs. Alarms are displayed on the screen
Category 3: System Graphical User Interface (GUI)									
1. GUI's graphic display capabilities	Y	Y	Y		Y	Y	Y	Y	
a. The proposed COTS ATMS must include a user-friendly utility for import and generation of graphic images for the graphics display system (GDS), allowing them to be updated whenever new source files are available.	Y	Y	Y		Y	Y	Y	Y	Tactics allows for the importing of Shape, DWG, DXF,DGN,TIF,Bitmap,Jpeg, and Sid files to be used as graphic images
b. The graphic display system function is to be an integrated function within the COTS ATMS, which provides graphic displays such as dynamic maps. The GDS must allow for a second-by-second, (near) real-time monitoring of system operation, including polling of all field devices and refreshing/updating of graphical maps.	Y	Y	Y		Y	Y	Y	Y	Tactics supports a site map feature that provides a second-by-second real-time monitoring of system operation
c. The interface to the graphics display must be an integrated module of the COTS ATMS.	Y	Y	Y		Y	Y	Y	Y	Tactics includes an integrated functionality to display site maps and intersection graphics
d. All commands for manipulating the graphics display must be available directly from the system user interface.	Y	Y	Y		Y	Y	Y	Y	Tactics supports manipulation of all graphics directly from within the user interface
e. Detailed intersection displays representative of theAutoCAD-based design files or aerial photographs must be able to be imported and generated for the graphics display. For large-scale maps (i.e., corridor or region-wide map display), the ability to use GIS based maps (ESRI shape and data files) would be preferable.	Y	Y	Y		Y	Y	Y	Y	Tactics supports many different file types to assist the users in importing and generating graphic images. For large scale maps, Tactics full supports ESRI shape and data files
2. From this graphic generation utility, the user must be able to create and revise all the maps and intersection drawings displayed. The displayed drawings must use a multi-layered paradigm for displaying different categories of system data.	Y	Y	Y		Y	Y	Y	N	Cannot modify the map in TransSuite (tools for modifying the intersection drawings are provided). Tactics supports direct manipulation by the user of site maps and intersection graphics.Additionally, Tactics supports a multi-layered paradigm for displaying ESRI shape and data files
a. Once the GUI at the central server is updated, the GUI screens at all the user workstations must automatically be updated.	Y	Y	Y		Y	Y	Y	Y	Tactics supports direct manipulation of site maps and intersection graphics. Can display multi-layer
3. The proposed COTS ATMS must include a small library of typical intersection files. The System Vendor must develop, using the library templates where possible, detailed intersection diagrams for all the intersections installed.	Y	P	Y		P	Y	P	Y	Naztec utilization of the GIS makes the redundant. Tactics includes a library of intersection graphics to assist the end user in developing intersection and site files.
4. All custom and commercially available software required for operation and modification of the graphics generation utility package must be provided with the proposed COTS ATMS. The proposed COTS ATMS must also include any additional hardware required to use the included graphics generation utility package.	Y	N	Y		Y	Y	Y	P	Tactics require no additional hardware or software; Transcore will not provide a copy of ESRI to update the ESRI shapefiles. All other softwares will be provided
5. All static graphic displays should be designed and developed in such a way as to ensure instantaneous redraw of the graphic display. This display includes the background map and the real-time feedback data. For example, if the workstation operator pans to the left, the entire screen needs to be redrawn.	Y	Y	Y		Y	Y	Y	Y	Centracs map and status displays provide an instantaneous redraw even as the user performs the pan or zoom function. Tactics supports zoom in, zoom out, and scroll with automatic redraw
6. GUI display extents	Y		Y		Y	Y	Y	Y	Tactics supports a zoom extents op the displayed maps
a. The proposed COTS ATMS must include a zoomed-out view of the system extents that covers all the intersections currently in the project area.	Y	Y	Y		Y	Y	Y	Y	Siemens-Tactis will develop the zoomed-out view of the system extents that covers all the intersections of the current project
7. The user must be able to set up both dynamic and static informational layers that are displayed at different view scale levels by defining the view scale levels in a zoom level set-up configuration database table. By setting up the zoom scale range and appropriately enabled/disabled layers, the operator must be able to control which layers display at different zoom scales. For example, at the region-wide scale level the operator might enable roadway centerlines (static information) as well as the following dynamic information:	Y	P	Y		Y	Y	Y	Y	These overlays are configured through a GUI interface built into Centracs client. Tactics supports both static and dynamic layers to be displayed on the map. Each of these layers may be assigned a different zoom scale settings
a. A communication status indication for each intersection controller	Y	Y	Y		Y	Y	Y	Y	Tactics supports a communication status indicator for each intersection controller on the site map
b. The controller operating mode status indication for each intersection controller	Y	Y	Y		Y	Y	Y	Y	Tactics supports a controller operating mode status indicator for each intersection controller on the site map
c. The detector failure status indication for each intersection (at corridor- or group-zoom level)	P	Y	Y		Y	Y	Y	Y	Centracs shows detector failure in intersection display. Tactics supports displaying system detector failure status for each intersection controller on the site map
8. At a minimum, the region-wide display must dynamically identify the following status for each traffic signal in real-time, or near real-time (less than 2 seconds old):	Y	Y	Y		P	Y	Y	P	
a. Free Operation	Y	Y	Y		Y	Y	Y	Y	Tactics supports identifying Free Operation in real-time for each intersection in the system
b. Coordinated Operation (nominal; could be absence of any status)	Y	Y	Y		Y	Y	Y	Y	Tactics supports identifying Coordinated Operation in real-time for each intersection in the system
c. Responsive Operation	N	Y	Y		P	Y	Y	Y	Naztec is optional item - Traffic Responsive at Central. Tactics supports identifying Traffic Responsive Operation in real-time for each intersection in the system; Centracs does not show responsive operation as a status indicator
d. Dynamic Grouping – current group boundaries and/or membership	Y	N	Y		Y	N	Y	N	Tactics currently does not support Dynamic Groups
e. Pattern transition from free to coordinated operation or from one coordinated plan to another;	Y	Y	Y		Y	Y	Y	Y	Tactics supports identfying patterns transitions from free to coordinated operation or from one plan to another in real-time for each intersection in the system

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f. Tripped conflict monitor	P	Y	Y		Y	Y	Y	Y	Centracs overview map shows intersection in flash. Tactics supports identifying both conflict flash and diagnostic flash for each intersection in the system
g. Flash (differentiated between manual flash and conflict flash)	P	Y	Y		Y	Y	Y	Y	Centracs overview map shows intersection in flash. Tactics supports identifying the difference between manual flash and conflict flash for each intersection in the system
h. Loss of Communications	Y	Y	Y		Y	Y	Y	Y	Tactics supports identifying loss of communications for each intersection in the system
i. Emergency vehicle or Railroad Preemption	Y	Y	Y		Y	Y	Y	Y	Tactics supports identifying preemption status for each intersection in the system
j. Transit Priority Service	Y	Y	Y		Y	Y	Y	Y	Tactics supports identifying transit priority status for each intersection in the system
k. Monitor off (i.e., set to be ignored by system)	P	N	Y		Y	Y	Y	Y	Centracs alerts can be configured by user. Tactics supports allowing the user to turn intersection monitoring on and off from the site map
l. Manual operation switch engaged at the local controller cabinet	P	N	Y		Y	Y	Y	Y	Centracs shows this status in intersection disply not citywide. Tactics supports identifying if the manual operations switch has been engaged at the local cabinet for each intersection in the system
9. When window-zooming into, or otherwise selecting a group (i.e., changing the view scale to a corridor display), the graphics display must automatically provide a greater level of detail information. In addition to providing the signal status listed above, the graphics should display green return status for phases of all the intersections in the displayed group.	Y	Y	Y		Y	Y	Y	P	Tactics supports a corridor detail map that may contain one or more intersections. From this detail map, the green return status may be displayed
a. Display of overlap green return status	Y	Y	Y		Y	Y	Y	Y	Tactics supports a corridor detail map that may contain one or more intersections. From this detail map, the overlap green return status may be displayed
b. Display of yellow return status	Y	Y	Y		Y	Y	Y	N	TransSuite retrieves the green status of each phase. Tactics supports a corridor detail map that may contain one or more intersections. From this detail map, the yellow return status may be displayed
c. Display of WALKs and DONT WALKs return	Y	Y	Y		Y	Y	Y	Y	TransSuite retrieves the walk status from each phase. Tactics supports a corridor detail map that may contain one or more intersections. From this detail map, the walk/don't walk return status may be displayed
10. For purposes of zooming in on the map, the operator must be able to select a smaller area of the map to expand to the current window size, or expand to fill a new window, which can be resized.	Y	Y	Y		Y	Y	Y	Y	Tactics supports standard zoom to fit commands. The user can select a portion of the map and Tactics will zoom to that area filling the current map window
11. The zoom capabilities must also allow for returning to the entire graphic image, as well as redisplaying the previous view's scaled image.	Y	Y	Y		Y	Y	Y	Y	Tactics allows the user to return to any previous saved zoom levels
12. By double clicking on the intersection icon on the overview map at any zoom level, the COTS ATMS must open a new, individual detailed intersection in a window of the traffic display. The intersection display must depict the intersection in an easy to understand display. Multiple intersection display windows must be available for the operator. The number of display windows must only be restricted to the number that can be feasibly displayed on the workstation client desktop. The operator must be able to minimize and maximize a detailed intersection display.	Y	Y	Y		Y	N	Y	Y	Tactics currently does not support opening a new intersection details window by double clicking an intersection on the site map. By double clicking the intersection on the site map, Tactics opens a new command window. On the command window there is an option to open the intersection details map
13. The information available for intersection displays must include all information available for that intersection. At a minimum these must include the following:	Y	Y	Y		P	Y	Y	Y	
a. Street names	Y	Y	Y		Y	Y	Y	Y	Tactics supports displaying the Street Name field from the shape file
b. North Arrow is desired	Y	N			N	Y	Y	Y	Tactics supports many different graphic file formats. A North Arrow may be inserted to any graphic file being used as a background image
c. Intersection phase diagram	Y	Y			N	Y	Y	Y	Tactics supports many different graphic file formats. An intersection phase diagram may be inserted to any graphic file being used as a background image
d. Current timing plan in use (cycle length and offset or Free)	Y	Y	Y		Y	Y	Y	Y	Tactics supports displaying timing plan parameters by launching the configuration screen from the map
e. Signal displays (vehicle and pedestrian)	Y	Y	Y		Y	Y	Y	Y	Tactics will actively update the intersection map with the current signal color and pedestrian signals assigned to each phase
f. Current communications status	Y	Y	Y		Y	Y	Y	Y	Tactics will actively update both the site map and the intersection map with the current communication status
g. Control mode status	Y	Y	Y		Y	Y	Y	Y	Tactics will actively update both the site map and the intersection map with the current control mode status
h. Vehicle calls by phase	Y	Y	Y		Y	Y	Y	Y	Tactics will actively update the intersection map with vehicle calls by phase
i. Pedestrian calls by phase (display of pedestrian interval countdown timing is also desired)	Y	Y	Y		Y	Y	Y	Y	Tactics will actively update the intersection map with pedestrian calls by phase
j. Detector status and actuation	P	Y	Y		Y	Y	Y	Y	Centracs failed detection will appear as an alarm; MIST status of detectors on same approach in different lanes shown individually. Tactics will actively update the intersection map with detector status and actuation
k. Special functions, such as time-of-day detector settings (min/max/ped recalls, locking, etc), overriding system plan commands, and modifying phase sequences (omit or lead/lag), is desired	Y	Y	Y		P	Y	Y	P	Tactics supports displaying Special Function status (On/Off) directly on the intersection map. The user may view additionally features by launching the configuration screen from the intersection map; TransSuite TCS provides the operator with the ability to activate/deactivate special function outputs on the controller. If the controller supports multiple timing banks then TransSuite TCS can activate the timing
l. Timing plan parameters	Y	Y	Y		P	Y	Y	Y	Tactics supports displaying timing plan parameters by launching the configuration screen from the map

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m. Active, incrementing cycle clock	Y	Y	Y		Y	Y	Y	Y	Tactics supports displaying the decrementing active cycle clock
n. Active, incrementing (or better, countdown) phase/interval timer	Y	Y	Y		Y	Y	Y	Y	Tactics split monitor supports displaying of the decrementing phase/interval timer
14. ATMS integration with other ITS elements, such as DMS and CCTV	Y	P			Y	Y	Y	P	The requested integration is available with the TransSuite TIS and VCS modules
a. These elements must be spotted on the ATMS map as icons	Y	P			Y	Y	Y	P	Naztec optional items only (not included). Tactics supports separate icons for DMS and CCTVequipment
b. Double-clicking the ITS icon should launch a detailed monitor view in a separate window	Y	P			Y	Y	Y	P	Naztec optional items only (not included). Tactics supports double clicking an ITS icon to launch s separate monitoring window; TransSuite assumes available Active-X control
c. The separate window could be an integrated software subroutine of the ATMS, or it could be a separate software program (e.g., provided by the ITS device manufacturer)	Y	P			Y	Y	Y	P	Naztec optional items only (not included). Tactics supports running equipment specific equipment from a separate window from the intersection map; TransSuite assumes available Active-X control
15. The timing windows displayed for the intersections in the COTS ATMS should match the controller front panel displays.	P	P			Y	Y	Y	N	Tactics supports a timing screen that has been designed to look and feel like the SEPAC front panel; Centracs utilizes the higher resolutions and colors available on a workstation display to better present controller information. The information displayed is the same and in similar groupings but not necessarily an exact match to the controller front panel; TransSuite configures the real-time displays and the database displays based on data definitions provided by NTCIP standards committees and
Category 4: System Configuration and Access									
1. Multiple Concurrent User Access	Y	Y	Y		Y	Y	Y	Y	
a. The system must simultaneously support all workstations at any one time for high and extended usage which might occur during special events to both networked and remote / dial-in users.	Y	Y	Y		Y	Y	Y	Y	Centracs servers can support 20 simultaneously connected clients. Tactics can support an unlimited number of workstations and software licenses
b. The system should be capable of secure Virtual Private Network (VPN) access from remote sites.	Y	Y	Y		Y	Y	Y	Y	Tactics supports VPNs for access from remote users
c. The system must provide jurisdictional access, which allows each Agency to fully view, monitor, display, and access any COTS ATMS control interface, but only be allowed to modify and change signals in their jurisdiction.	Y	N	Y		Y	Y	Y	Y	Tactics supports the creation of multiple Agencies within the system. Users with unique privileges are then assigned to each Agency
d. Data latency must be consistent and never exceed two seconds from actual field conditions.	Y	Y	Y		Y	Y	Y	Y	Centracs depends upon communication. Tactics supports second-by-second monitoring of field equipment if sufficient bandwidth exists on the communication channel to support the data transfer
e. The COTS ATMS must arbitrate conflicts among current users, device controls, and upload/download commands.	Y	Y	Y		Y	Y	Y	Y	
2. The COTS ATMS must, at a minimum, support a multi-terminal, multi-user interface, with each workstation's COTS ATMS client software program running under a current Microsoft Enterprise operating system (64-bit).	Y	Y	Y		Y	P	Y	Y	Tactics does support Windows 7 only 32 bit version
3. The COTS ATMS software should, at a minimum, be compatible with any future Microsoft operating system within a year.	Y	Y	Y		Y	Y	Y	Y	Tactics supports both Windows 7 (32 bit) and Windows XP
4. This COTS ATMS must allow access to multiple levels of the system simultaneously.	Y	Y	Y		Y	Y	Y	Y	Centracs access control is by roles and permissions. Tactics is designed as a scalable software package allowing
5. The COTS ATMS must establish and maintain a security system to prevent unauthorized access to the system. This applies to executable files as well as text files and database files.	Y	Y	Y		Y	P	Y	Y	Tactics: Windows, Tactics, and DB all require user name and password
6. Individual operator privileges must be definable on a functional level.	Y	N	Y		Y	Y	Y	Y	Tactics currently supports over 50 function level privileges
7. The proposed COTS ATMS workstation client must support multiple monitors / displays (typically, two, but allow for up to four) to allow for more GUI desktop space for easing user management of the ATMS via additional windows that will be open.	Y	P	Y		Y	Y	Y	Y	Tactics supports as many monitors as the system computer supports
8. Any changes to intersection configuration must require extra confirmation (i.e. ring structures, overlap assignments)	Y	Y	Y		P	Y	Y	Y	Natztec defined by user privileges. Tactics requires additional confirmation when downloading intersection configuration changes
Category 5: Traffic Signal Control Modes									
1. Timing Execution in Controllers	Y	Y	Y		Y	Y	Y	Y	
a. The COTS ATMS must utilize intelligent local intersection controllers and operate with distributed or central intelligence for all modes.	Y	Y	Y		Y	Y	Y	Y	Tactics supports user selectable modes of operation. Those modes are Manual, Quick Response, Traffic Responsive, Time of Day, and Free
b. The local controllers must be programmed with timing plans, Time of Day/Day of Week (TOD) schedules, and all other required parameters to operate the intersection in basic coordination mode, such coordination either commanded by the ATMS or occurring due to fall-back in the case of ATMS-to-controller communication loss.	Y	Y	Y		Y	Y	Y	Y	Tactics supports the uploading of time of day plans, time of week plans, and all other required parameters for TOO coordination to continue in case of ATMS-to-Controller communication loss
2. All intersection controllers must be capable of being monitored on a real-time, once-per-second basis by the COTS ATMS.	Y	Y	Y		Y	Y	Y	Y	Tactics supports once-per-second monitor of entity equipment
3. System startup conditions	Y	Y	Y		Y	Y	Y	Y	
a. At main server startup, the COTS ATMS must automatically establish communications with all intersection controllers and begin real-time monitoring.	Y	Y	Y		Y	Y	Y	Y	Upon the initial start-up of the Tactics System central server, Tactics will automatically reestablishes communications with all intersections and starts real-time monitoring
b. The COTS ATMS must automatically update its internal clock using the WWV radio interface or GPS clock, and then broadcast a time clock resync to all intersections.	Y	Y	Y		Y	Y	Y	Y	Centracs can also utilize an NTP server. The system on which runs Tactics will be synchronized with the current version of the atomic clock maintained by the National Institute of Standards and Technology through third party software such as Atomic Clock Sync 3.0
c. The COTS ATMS must start to process both incoming data and operator requests within two minutes after server boot-up.	Y	Y	Y		Y	Y	Y	Y	Upon the initial start-up of the Tactics System central server, Tactics will automatically reestablishes communications with all intersections and starts real-time monitoring
d. At system startup, the default mode must always be user-settable.	Y	Y	Y		Y	Y	Y	Y	Centracs starts up in 'full operations' mode by default. Tactics supports user selectable start-up options
e. Traffic Communicaiton process should be a Windows Service.	Y	Y	Y		N	Y		Y	Centracs starts up in 'full operations' mode by default
4. The COTS ATMS must be designed for unattended operation 24 hours per day, seven days a week, without requiring an operator to be logged into the system.	Y	Y	Y		Y	Y	Y	Y	Tactics supports unattended operation of the entity equipment twenty-four (24) hours per day, seven (7) days a week

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5. Control Modes	Y	Y	Y		Y	Y	Y	Y	
a. The software must include at least these four control modes:	Y	Y	Y		Y	Y	Y	Y	
· Traffic Responsive Pattern Selection (TR)	Y	N	Y		Y	Y	Y	Y	Optional for Naztec (not included with base price). When in Traffic Responsive mode, Tactics will select the coordination plan that's split times most closely match the detected traffic pattern based on volume and occupancy data provided by the system detectors
· Time of Day/Day of Week (TOD)	Y	Y	Y		Y	Y	Y	Y	When in TOD mode, Tactics will broadcast the traffic pattern based the time of day program in the central system
· Manual	Y	Y	Y		Y	Y	Y	Y	When in Manual mode, Tactics will broadcast the traffic pattern selected by the user
· Free	Y	Y	Y		Y	Y	Y	Y	When in Free mode, Tactics will not assign any coordination pattern to the intersection equipment
b. The control mode must be operator selectable.	Y	Y	Y		Y	Y	Y	Y	Tactics supports user selectable modes of operation. Those modes are Manual, Quick Response, Traffic Responsive, Time of Day, and Free
c. Identify whether the proposed system has traffic adaptive capabilities or a separate module that can provide adaptive operation and its associated additional cost.	P	N	Y	Y	Y	Y	Y	Y	Optional for Naztec (not included with base price); Centracs has ACS Lite (not with base price); KITS is being integrated with ACS Lite. Tactics supports Traffic Responsive as an integrated module of the Central software; The Centracs adaptive module, ACS-lite is available for an additional cost. Please note that this module is only available if the ASC/3-2070 firmware option
6. The COTS ATMS's full-featured traffic-responsive mode of operation must be adjustable or tunable with respect to the following:	P	N	Y		Y	Y	Y	Y	
a. Grouping of intersections selected for TR mode.	Y	N	Y		Y	Y	Y	Y	Tactics supports grouping of intersections into zones that can be placed into Traffic Responsive mode
b. Selecting and adjusting of smoothing variables, factors and/or parameter.	Y	N	Y		Y	Y	Y	Y	Tactics supports user configuration of averaging times and K factor
c. Data collection period	Y	N	Y		Y	Y	Y	Y	Tactics supports user selectable time intervals for data collection
d. Adjusting the algorithm implementation formula	P	N	Y		Y	Y	Y	Y	Centracs user can specify/adjust the formula parameters, variables, and list, but the 'formula' is built into Centracs; TransSuite provides the user with the ability to set some parameters. Tactics supports user selectable Traffic Responsive algorithm definitions with adjustable thresholds
e. Weighting by lane	Y	N	Y		Y	Y	Y	Y	Tactics supports user selectable weighting by lane
f. Separate weighting of occupancy parameter	Y	N	Y		Y	Y	Y	Y	
g. Control over the decision algorithm definition is desirable	P	N	Y		Y	Y	Y	Y	Tactics supports user selectable Traffic Responsive algorithm definitions with adjustable thresholds
h. TR-induced changes should be based on smoothed data (rolling averages), not raw data, and the averaging intervals should be user-selectable	Y	N	Y		Y	Y	Y	Y	Tactics supports user configuration of averaging times and K factor
Category 6: System Monitoring									
1. Preemption and Priority Service	Y	Y	Y		Y	Y	Y	P	
a. The COTS ATMS must have the ability to monitor all forms of traffic signal pre-emption and priority that will occur at the signalized intersections through the local traffic signal control and to report the signal pre-emption/priority back to the central computer on a continuous basis.	Y	Y	Y		Y	Y	Y	Y	Sepac supports a Preemption Status display that shows the current status for the local controller, dynamically updated once per second. Tactics supports continuous monitoring of the intersection
b. This information must also need to be provided on the graphic user interface screens identifying the type of pre-emption or priority, such as railroad, emergency, bus etc., and displaying the current state (e.g., transitioning to, or in, or recovering from).	Y	N	Y	P	Y	Y	Y	N	Data is not availabe in real time in TransSuite. Sepac supports up to six (6) uniquely identified preempts.Tactics supports monitoring the state of each of the preempts
2. Detector Monitoring	P	Y	Y		Y	P	Y	Y	
a. The detector feedback from the field must be continuously monitored for proper operation.	Y	Y	Y		Y	Y	Y	Y	Tactics supports continuous monitoring of field equipment
b. Detectors must be classified as acceptable, disabled, or failed.	Y	N	Y		Y	Y	Y	Y	Sepac supports the detector classifications as: On-line, Disabled, or Failed
c. Detector failures must be reported to the system log and operator alarm.	Y	Y	Y		Y	P	Y	Y	Tactics supports storing detector failures in the system log. However, at this time Tactics does not support the generation of an alarm for detector failures
d. Detector counts must be routinely aggregated and reported to the COTS ATMS for preparation of traffic flow reports on demand by the user.	Y	Y	Y		Y	Y	Y	Y	Tactics supports scheduling the downloading of traffic counts from the entity intersections for the use in traffic flow reports
e. Collection and central database storage of an unlimited number of system detector counts (user-defined intervals, but nominally 15-minutes) must be provided.	P	Y	Y		Y	Y	Y	Y	Centracs can support a large number, but not unlimited. Tactics supports the storage of an unlimited number of system detectors. Sepac supports a maximum of twenty-four (24) system detectors per intersection
3. Detector Failure Monitoring	Y	N	Y		Y	P	P	Y	
a. The COTS ATMS must have operator-selectable filters that define the thresholds that a detector must exceed to be considered failed.	Y	N	Y		Y	Y	Y	Y	Per Centracs, configured locally at the controller. SEPAC supports user defined filters for detector diagnostics
b. The filter values must be selectable on a time-of-day basis.	Y	N	Y		Y	N	N	Y	Per Centracs, configured locally at the controller. SEPAC currently does not support changing filters by TOD
c. Multiple time-of-day settings must be available.	Y	N	Y		Y	N	N	Y	Centracs has 4 TOD settings available. SEPAC currently does not support changing filters by TOD
d. The following failure types must be provided at a minimum:	Y		Y		Y	Y	Y	Y	
· Maximum Presence - if an active detector exhibits continuous detection over an operator-defined time interval	Y		Y		Y	Y	Y	Y	SEPAC supports detector diagnostics for maximum presence
· No Activity - if an active detector does not exhibit any actuation during an operator-defined elapsed time interval	Y		Y		Y	Y	Y	Y	SEPAC supports detector diagnostics for no activity
· Erratic Output - if an active detector exhibits excessive actuation (i.e., field count over an operator-defined elapsed time interval exceeds user programmed threshold)	Y		Y		Y	Y	Y	Y	SEPAC supports detector diagnostics for erratic counts
· Failed Communication - failed or disabled detectors must not be available for traffic control strategies	Y		Y		Y	Y	Y	Y	Tactics supports not allowing failed or disabled detectors from being available for traffic control strategies
Category 7: Time / Date Broadcast									
1. The COTS ATMS must keep all intersections synchronized to a common time base.	Y	Y	Y		Y	Y	Y	Y	Tactics supports verifying intersection clocks to central time. User defined options allow for the intersection clocks to be recalibrated as needed

DESIRED FUNCTIONS CHECK LIST

DESIRED FUNCTIONS	CURRENTLY PROVIDED? ("Y" for Yes, "N" for No*, "P" for Partial*) Econolite Centracs	Inteligh MaxView	Kimley-Horn KITS	McCain Quicnet	Naztec ATMS.NOW	Siemens Tactics	Telvent MIST	Transcore TranSuite	COMMENTS * If "P" (Partial) is input, please provide additional information elaborating which functions the system currently can or can not provide; If "N" (No) is input, please elaboration on how the required functionality could be achieved.
2. The COTS ATMS server must provide a method of external time and date synchronization such as WWV radio clock, GPS clock, CDMA, or by other means.	Y	Y	Y		Y	Y	Y	Y	The system on which runs Tactics will be synchronized with the current version of the atomic clock maintained by the National Institute of Standards and Technology through third party software such as Atomic Clock Sync 3.0.
3. Synchronizing Controller Clocks	Y	Y	Y		Y	Y	Y	Y	
a. The COTS ATMS must provide a means of verifying intersection controller clocks and checking them against the central time clock with an option to recalibrate the controller clock on an as needed basis.	Y	Y	Y		Y	Y	Y	Y	Tactics supports verifying intersection clocks to central time. User defined options allow for the intersection clocks to be recalibrated as needed
b. A simultaneous synchronization broadcast from the COTS ATMS to all controller internal time clocks must be able to occur automatically at least twice per 24 hours.	Y	Y	Y		Y	Y	Y	Y	Tactics supports a user defined automated synchronization of intersection clocks. The time of day and interval between synchronization is also user selectable but will occur at least twice per twenty-four (24) hours
c. The times of day that the simultaneous synchronization broadcast occurs must be settable by the user.	Y	Y	Y		Y	Y	Y	Y	Tactics supports a user defined automated synchronization of intersection clocks The time of day and interval between synchronization is also user selectable but will occur at least twice per twenty-four (24) hours
Category 8: Preemption and Priority Service									
1. Preemption and Priority Capabilities	P	P	Y		Y	Y	Y	P	
a. The COTS ATMS must support and manage multiple types of signal preemption and/or signal priority service that occurs at the local intersection controller level.	Y	Y	Y		Y	Y	Y	Y	
b. This information must also need to be provided on the graphic user interface screens displaying the current state of the preemption or priority(e.g., transitioning to, or in, or recovering from).	Y	Y	Y		Y	Y	Y	N	TransSuite does not get this data from the controllers
c. The COTS ATMS must support transit priority.	P	Y	Y		Y	Y	Y	P	Per Centracs, TSP is at the controller; TransSuite: Due to lack of deployed standards for TSP TransSuite supports TSP reporting on a controller firmware basis. TSP reporting for D4 is supported. TSP reporting for NextPhased has not been integrated
2. Emergency Vehicle Preemption (EVPE)	Y	Y	Y					P	
a. It is desirable for the proposed COTS ATMS's algorithms to allow for immediate response to the presence of a valid "high priority" EVPE call, just the same as if the intersection were not under the control of the COTS ATMS.	Y	Y	Y					Y	Fuction of local controller
b. With regard to the recovery back to 'normal' operation of the corridor under COTS ATMS control after completion of an EVPE event, it is desirable for the COTS ATMS to provide for the immediate return to servicing of the appropriate phase combinations that would have been served at that time if an EVPE routine had not been initiated.	Y	P	Y					N	Fuction of local controller; if desired Transcore can work with vendor to have this capability incorporated into the controller firmware
c. Rather than the controller always serving a pre-programmed EVPE return phase (a typical non-COTS ATMS parameter), the controller should instead serve a phase which would get the intersection back into "step" with the corridor's then-current COTS ATMS timing plan as quickly as possible.	Y	P	Y					N	Fuction of local controller; if desired Transcore can work with vendor to have this capability incorporated into the controller firmware
2. The COTS ATMS must display, on the detailed intersection graphics GUI, the transition status during the period when recovering back to a 'normal' coordination plan following preemption or priority service.	Y	Y	Y		Y	Y	Y	Y	Sepac supports a Preemption Status display that shows the current status for the local controller, dynamically updated once per second. Tactics supports continuous monitoring of the intersection
Category 9: Data Collection (ATMS)									
1. The central system must retrieve all traffic counts from local controllers	Y	Y	Y		Y	Y	Y	P	
a. On a user-settable automated repeating schedule (if other than a fixed interval such as 15 minutes, please detail in a comment), and	Y	Y	Y		Y	Y	Y	Y	Tactics supports the repeated scheduling of downloading traffic counts from each intersection
b. On an immediate basis by central operator demand	Y	N	Y		Y	Y	Y	N	TransSuite uploads stored traffic counts in a bin in the controller. Tactics supports the immediate downloading of traffic counts from each intersection
c. Raw count data must be stored and archived for later analysis by workstation operators	Y	Y	Y		Y	Y	Y	Y	Tactics supports the storage of raw traffic counts in the database for later analysis and reporting
2. Local controller database changes made through front panel or locally-connected laptop computer (or other interface device) should	Y	Y	Y		P	P	P	P	
a. Trigger a flag setting alerting the central system that the database has been changed, and	P	Y	Y		P	N	P	Y	Centracs can perform a scheduled upload/compare; KITS can have keyboard press create an alert at central and also supports a field requested download; TransSuite receives database change in controller; Tactics currently does not support immediate notification of field data changes
b. Auto-upload and compare	P	Y	Y		P	Y	N	N	Tactics supports scheduling of automatic upload/compare. Results are stored in database for later reporting; Centracs: This is available with the ASC/3-2070 firmware option, not with the D4 firmware option
3. Central system should automatically and periodically collect such "flags" and prominently alert the system console operator of the list of such changed intersections; this period may be selectable on a per controller basis	P	N	Y		Y	N	N	Y	Centracs reports contains this information. This is available with the ASC/3-2070 firmware option, not with the D4 firmware option; Tactics currently does not support immediate notification of field data changes
4. The specific database fields that were changed must be captured	Y	N	Y		Y	Y	Y	Y	After an upload/compare, Tactics supports the displaying of changed data fields
Category 10: Communication									
1. Central system –to– local controller communication may be proprietary, but the COTS ATMS must also support communications to different 2070 and/or NEMA controller platform firmware packages	Y	Y	Y		N	Y	Y	Y	Tactics supports communication to controllers running Sepac NextPhase, and NTCIP compliant firmware
2. NTCIP standards are still in a state of development and continues to be updated. However the COTS ATMS should meet or exceed the minimum requirements of the following NTCIP standards:	P	Y	P		P	P	P	P	
a. NTCIP 1101 (formerly TS 3.2) – Simple Transportation Management Framework (STMF)	Y	Y	Y		Y	Y	Y	Y	Tactics supports NTCIP 1101 specifying the set of rules for processing, organizing and exchanging information between transportation centers and transportation equipment
b. NTCIP 1201 (formerly TS 3.4) – Global Object (GO) Definitions	Y	Y	Y		Y	Y	Y	Y	Tactics supports NTCIP 1201 the standard that provides the commands, responses and information necessary for general device management, including those objects required for device identification, time-based schedule configuration, and event log configuration

DESIRED FUNCTIONS CHECK LIST									
DESIRED FUNCTIONS	**CURRENTLY PROVIDED?** ("Y" for Yes, "N" for No*, "P" for Partial*) Econolite Centracs	Intelight MaxView	Kimley-Horn KITS	McCain Quicnet	Naztec ATMS.NOW	Siemens Tactics	Telvent MIST	Transcore TranSuite	**COMMENTS *** If "P" (Partial) is input, please provide additional information elaborating which functions the system currently can or can not provide; If "N" (No) is input, please elaboration on how the required functionality could be achieved.
c. NTCIP 1202 (formerly TS 3.5) – Object Definitions for Actuated Traffic Signal Controllers (ASC)	Y	Y	Y		Y	Y	Y	Y	Tactics supports NTCIP 1202 the standard that provides the commands, responses and information necessary for traffic management and operations personnel to control, manage, and monitor Actuated Traffic Signal Controller Units
d. NTCIP 1203 (formerly TS 3.6) – Object Definitions for Dynamic Message Signs (DMS)	P	N	Y		N	Y	Y	Y	Tactics supports NTCIP 1203 the standard that provides the commands, responses, and information necessary for traffic management and operations personnel to advise and inform the vehicle operators of current highway conditions by using dynamic message signs; Centracs: Module scheduled for Q4 2011
e. NTCIP 1205 (formerly TS 3.CCTV) – Objects for CCTV Camera Control	Y	N	Y		N	N	N	Y	Tactics does not support NTCIP 1205
f. NTCIP 1211 – Objects for Signal Control and Prioritization (SCP)	N	N	N		Y	N	P	N	Tactics does not support NTCIP 1211. Centracs does not support. ASC/2 S does not support. ASC/3 supports some objects
3. The proposed COTS ATMS must support the AB3418E protocol and message set.	P	N	Y		N	N	Y	Y	Tactics does not support AB3418E protocol and message set; Centracs: With the proposed option to install D4 firmware, the database upload and download is performed using the AB3418E protocol and message set. Second-by-second status update are performed using the NTCIP protocol and message set. With the proposed option for ASC/3-2070 firmware, the ASC/3 supports the AB3418E protocol and message set but database uploads, downloads and second-by-second status updates are
5. Polling to all intersections for status feedback must be accomplished at least once per second.	Y	Y	Y		Y	Y	Y	Y	Tactics supports once per second polling of entity controllers for status information
All real-time dynamic data that are to be displayed on the graphic map must be refreshed based on polling of all field devices on a time interval no greater than once-per-second	Y	Y	Y		Y			Y	
6. The COTS ATMS's communication protocol must be user selectable between the COTS ATMS's proprietary format (if this exists) and the NTCIP standard on a per communications channel basis (e.g. AB3418E).	Y	Y	Y		N	Y	Y	Y	Centracs contains only NTCIP; Tactics supports the user selecting Sepac, NextPhase, or NTCIP protocols on a per communications channel basis
7. The communication system must be designed to work with a variety of communication media, from the existing TWP signal interconnect to fiber optic to wireless radio communications.	Y	Y	Y		Y	Y	Y	Y	Tactics supports the following communication medias: Two or four wire TDM/FSK, Single or multi-mode fiber, CATC, Fixed or spread spectrum radio, Private coaxial cable, and TCP/IP or Ethernet fiber or radio
8. The serial data communication modem or switch for the traffic controller should communicate reliably with the new COTS ATMS at a baud rate no slower than 1200 with 19,200 or greater preferable.	Y	Y	Y		Y	Y	Y	Y	Tactics supports the following communication medias and transfer rates: 1200 Baud - two or four wire TDM/FSK 1200-19200 Baud - Single or multi-mode fiber 1200-19200 Baud - CATC 1200-19200 Baud - Fixed or spread spectrum radio 1200-19200 Baud - Private coaxial cable
The system should be capable of secure Virtual Private Network (VPN) access from remote sites.	Y		Y					Y	
9. The COTS ATMS must provide for a communications architecture which allows for IP-based communications protocol	Y	Y	Y		Y	Y	Y	Y	Tactics supports TCPIIP communications
a. IP capability must be provided between the central system and field communication hubs	Y	Y	Y		Y	Y	Y	Y	Tactics and Sepac support TCPIIP communications
b. IP capability must be provided all the way to the local controller	Y	Y	Y		Y	Y	Y	Y	Tactics and Sepac support TCP/IP communications
10. The COTS ATMS must be able to communicate with standard IEEE 802.X Ethernet specifications.	Y	Y	Y		Y	Y	Y	Y	Tactics supports communication using the IEEE 802.3 Ethernet specifications
Category 11: Execution									
1. The COTS ATMS must be able to operate without the need for field master controllers	Y	Y	Y		Y	Y	Y	Y	Tactics supports direct control of the local controller without the need on a on-street master
2. The COTS ATMS must be able to operate with multiple local controller hardware platforms and/or software packages	Y	Y	Y		Y	Y	Y	Y	Tactics supports communication to both 2070 and NEMA controllers running Sepac NextPhase, and NTCIP compliant firmware
3. The COTS ATMS must be error-tolerant of imperfect communications, by continuing to provide reasonable functionality and system response and sustained hub communication functionality despite intermittent communications errors	Y	Y	Y		Y	Y	Y	Y	Tactics has built-in error correction to handle intermittent communication errors that may disrupt communication to entity equipment
4. The COTS ATMS should have the capability to adjust splits on each cycle when in TR mode (for the intersections selected for CIC operation)	Y	N	Y		Y	Y	N	Y	When in Traffic Responsive mode, Tactics will select the coordination plan that's split times most closely match the detected traffic pattern based on volume and occupancy data provided by the system detectors
The COTS ATMS have the capability to apply a traffic-adaptive mode of operation along a corridor (it is not intended that the adaptive mode or module be supplied in this current procurement)	Y	N	Y		Y	Y	Y	Y	Tactics supports Traffic Responsive mode of control
6. The COTS ATMS must distribute the execution of timing and/or timing plans to the local controllers' coordinator for nominal operation modes (Free, TOD, TR)	Y	Y	Y		Y	Y	Y	Y	Tactics supports the following control modes: Quick Response, Traffic Responsive, Time of Day, and Free
7. The COTS ATMS must have a database file for each location listing all of the events (including time and date of occurrence) which occurred at the location. Events include, but are not limited to the following:	P	Y	Y		Y	Y	P	Y	Centracs utilizes Microsoft SQL Server 2008
a. Cabinet door open / close	Y	Y	Y		Y	Y	Y	Y	Tactics supports the event logging of cabinet door open/close events
b. Controller database changed locally	P	N	Y		Y	Y	N	Y	Achieved throgh auto-upload compare in Centracs; Tactics supports the event logging of controller database change events
c. Controller database changed remotely	P	Y	Y		Y	Y	Y	Y	Achieved throgh auto-upload compare in Centracs; Tactics supports the event logging of controller database change events
d. On-line (TOD, or restored after comm failure)	Y	Y	Y		Y	Y	Y	Y	Tactics supports the event logging of on-line events
e. Off-line (TOD free)	Y	Y	Y		Y	Y	Y	Y	Tactics supports the event logging of off-line events
f. Off-line (communications failure)	Y	Y	Y		Y	Y	Y	Y	Tactics supports the event logging of communication failure events
g. TOD pattern command	Y	Y	Y		Y	Y	Y	Y	Tactics supports the event logging of pattern change events
h. EVPE start and end	Y	Y	Y		Y	Y	Y	Y	Tactics supports the event logging of the start and end time for preemption
i. Transition start and end	Y	Y	Y		Y	Y	Y	Y	Tactics supports the event logging of the start and end time for transit priority
j. TR mode commencement	Y	N	Y		Y	Y	Y	Y	Tactics supports the event logging of the start and end time for traffic responsive
8. The COTS ATMS must provide a comprehensive controller database editor	Y	Y	Y		Y	Y	P	Y	

DESIRED FUNCTIONS CHECK LIST									
DESIRED FUNCTIONS	**CURRENTLY PROVIDED?** ("**Y**" *for Yes,* "**N**" *for No*,* "**P**" *for Partial**)								**COMMENTS *** If "**P**" (Partial) is input, please provide additional information elaborating which functions the system currently can or can not provide; If "**N**" (No) is input, please elaboration on how the required functionality could be achieved.
	Econolite Centracs	Inteligt MaxView	Kimley-Horn KITS	McCain Quicnet	Naztec ATMS.NOW	Siemens Tactics	Telvent MIST	Transcore TranSuite	
a. The editor must operate on both an COTS ATMS workstation and on a laptop computer	Y	Y	Y		Y	Y	Y	Y	Tactics supports the database of entity equipment to be loaded on both the ATMS workstations and on field laptop computers
b. The editor must contain a compare function to allow for identification of parameter value differences in two different complete controller databases	Y	P	Y		Y	Y	Y	Y	Tactics supports a compare function to identify differences between the field database and the central database
c. The editor must incorporate convenience "tools" and tips to allow for assisted and error-free populating of the database	Y	Y	Y		Y	Y	N	Y	Tactics supports both a comprehensive auto error-checking scheme and Help files to assist the user in populating the database with error free data
d. The editor must perform comprehensive error-checking and identify the location and reason for coding errors	P	Y	Y		Y	Y	Y	N	TransSuite provides for range checking within the controller database; Tactics supports comprehensive error checking of data entered by the user; Centracs: Based upon NTCIP value checking
e. The editor must reject proposed values that are beyond operator-settable parameter limits	P	Y	Y		Y	Y	N	N	KITS user interface are typically consistent with the permitted values set in the firmware; Tactics supports invalid data entry correction. If entered data is invalid, changes shall not be permitted and the user shall be alerted by an on screen error message; Centracs: Based upon NTCIP value checking; TransSuite UCM does not provide for operator specified range checks
f. The editor must perform all possible summation checks to assure that the component parts of a larger variable (such as cycle length) have valid values.	P	P	Y		Y	Y	N	N	TransSuite provides for range checking within the controller database; Tactics supports error-checking to ensure the summation of component variables result in valid values when applied to larger variables; Centracs: Based upon NTCIP value checking
g. The editor must allow for copying and pasting inputs from one intersection to another	P	Y	Y		Y	Y	Y	Y	Can copy entire data in Centracs; Tactics supports copying/pasting inputs from one intersection to another
9. The COTS ATMS must allow for the operator to select or program how the transitions between different coordination patterns are implemented. The control over how transitions are made should be comprehensive.	Y	Y	Y		Y	Y	Y	Y	Tactics supports a user selectable transition between patterns by allowing a unique coordination mode to each be assigned to each pattern
10. The COTS ATMS must provide the ability to easily transfer database changes made at offline intersections with a laptop or PDA into the central database. This must work in reverse also, allowing easy updates to laptop or PDA from the central database	Y	Y	Y		Y	Y	Y	Y	Tactics supports easy transfer of database changes made at intersections by an offline laptop or PDA. Additionally, Tactics supports easy transfer of database to laptops or PDAs for offline transfers at the intersections
11. The COTS ATMS should provide the ability to segregate and manipulate controller databases for a subset of one or more intersections, and easily re-integrate those back into the central database.	Y	N	Y		Y	Y	Y	N	Tactics supports easy transfer of database changes made at intersections by an offline laptop or PDA. Additionally, Tactics supports easy transfer of database to laptops or PDAs for offline transfers at the intersections; TransSuite UCM does not provide for the operator to change the database in a group of intersections simultaneously. TransSuite UCM does provide for the operator to maintain multiple versions of controller's database
12. The central communication system function must be an integrated function within the COTS ATMS that provides the communication protocol to, and manages the data exchange with the network of local intersection controllers	Y	Y	Y		Y	Y	Y	Y	Tactics supports a communication server to manage communication to field equipment. The communication server is fully integrated scalable module of Tactics
13. The COTS ATMS must utilize a communications architecture that employs field communication hubs and provides for fault-tolerant communications.	Y	Y	Y	Y	Y	Y	Y	Y	Tactics can work with field communication hubs to increase fault-tolerant communications
Category 12: Verification									
1. The COTS ATMS must provide second-by-second monitoring of local controllers:	Y	Y	Y		Y	P	Y	P	
a. The COTS ATMS must be able to accommodate access by multiple users at the same time, including remote dial-in users.	Y	Y	Y		Y	Y	Y	Y	
b. Current operational status (e.g., free, on-line, preemption, communication fail, etc.) must be available for the entire system.	Y	Y	Y		Y	Y	Y	Y	
c. Color returns for all phases must be available when examining a corridor grouping of up to 25 intersections.	Y	Y	Y		Y	Y	Y	Y	
d. Full status on all monitored parameters must be available when examining a group of up to 5 intersections.	Y	Y	Y		Y	Y	Y	Y	
e. Proportionately less than second-by-second monitoring would occur when the number of intersections exceeds the above observation scenarios.	Y	Y	Y		Y	P	Y	N	Tactics drops back to once-per-minute when once-persecond not needed; TransSuite TCS polls all on-line controllers all the time
2. The data and information displayed to the workstation operator should be accurate in real time. When real-time status is unavailable, these data displays should change to a 'no information' condition, rather than continuing to statically display potentially inaccurate data.	Y	Y	Y		Y	Y	Y	Y	
3. The COTS ATMS must periodically interrogate the local controllers' timeclock values to either	Y	P	Y		Y	Y	Y	Y	Telvent: D4 Only
a. Assure that they are synchronized with the COTS ATMS' master timeclock	Y	Y	Y		Y	Y	N	Y	
b. Automatically issue a timeclock resynchronization command if not	Y	Y	Y		Y	Y	N	Y	
4. The COTS ATMS must perform partial and full uploads and downloads of controller databases:	P	Y	P		P	P	P	Y	Telvent: Not for D4, Y for Nextphaser
a. It should be possible to force an upload or download from the controller front panel	P	N	P		P	N	N	Y	Naztec, Centracs, and TransSuite has download ONLY; Sepac currently does not support a forced upload/download from the front pane; KITS: This is supported by D4. We will implement the download bit support for this project. KITS supports remote download for Bi Tran 233 and 255
b. Partial database transfers should be possible for single parameters, and logical groups of parameters	P	Y	Y		Y	P	P	Y	TransSuite supports logical block transfer; Tactics supports the transfer of logical groups of parameters. At this time Tactics does not support a single parameter transfer; Centracs: ASC/2S supports only full upload/download. ASC/3 supports logical groups of parameters; Telvent: NextPhase can do logical groups
5. Alarm conditions at local controllers must	Y	Y	Y		Y	Y	Y	Y	
a. Display an alert on COTS ATMS workstations and, limited by time-of-day, as messages to e-mail addresses, and	Y	P	Y		Y	Y	Y	Y	
b. The conditions which constitute such an alarm must be user-definable and have user-settable parameters	Y	Y	Y		Y	Y	Y	Y	
6. The real-time display of a controller on an COTS ATMS workstation must display all returns with a minimal amount of latency	Y	Y	Y		Y	Y	Y	Y	
7. The COTS ATMS should be able to produce on operator demand to print and export to Excel a concise, formatted controller database printout for any local intersection.	Y	Y	Y		Y	Y	Y	Y	

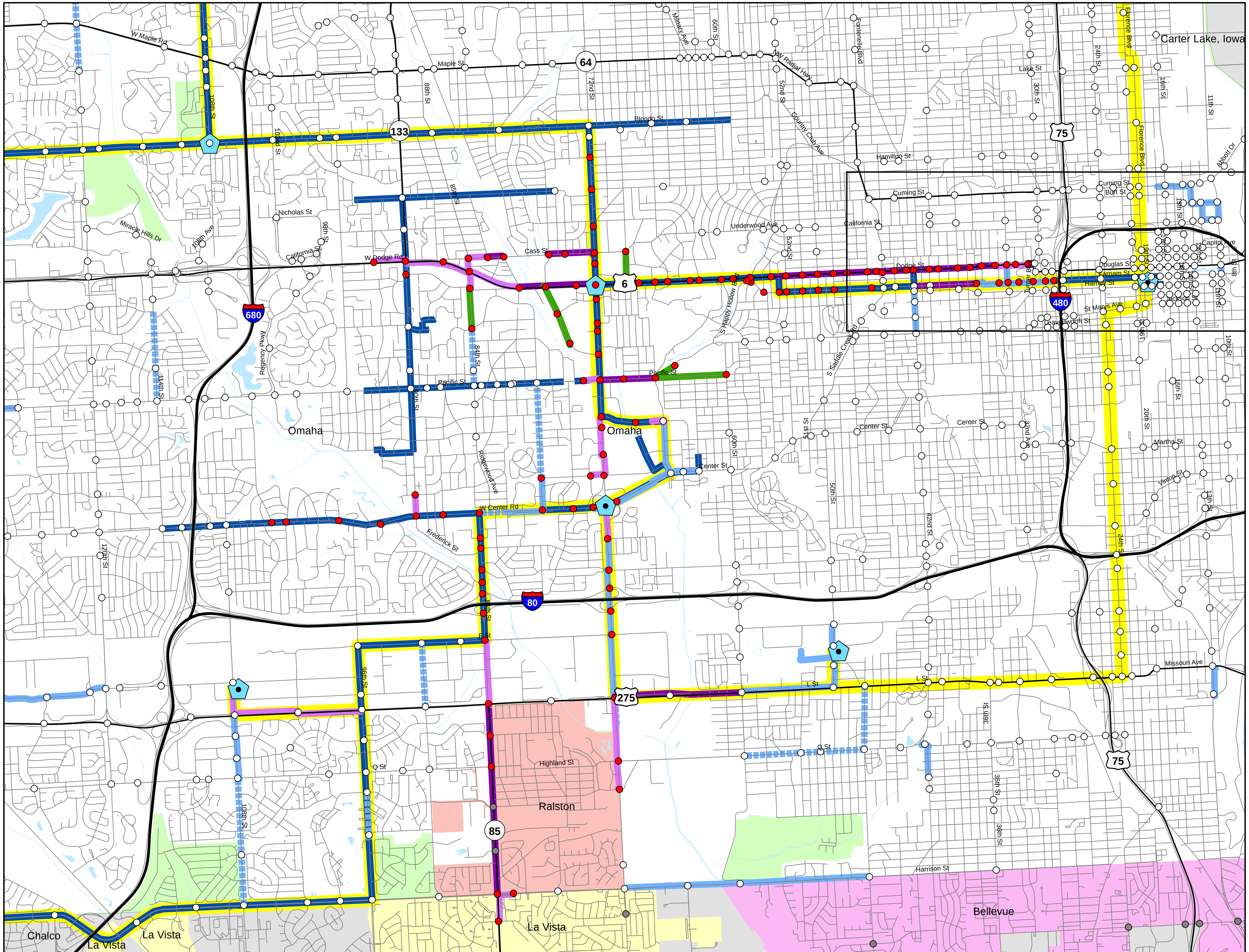
DESIRED FUNCTIONS CHECK LIST

DESIRED FUNCTIONS	Econolite Centracs	Inteligh MaxView	Kimley-Horn KITS	McCain Quicnet	Naztec ATMS.NOW	Siemens Tactics	Telvent MIST	Transcore TranSuite	COMMENTS *
	CURRENTLY PROVIDED? ("**Y**" *for Yes,* "**N**" *for No*,* "**P**" *for Partial**)								If "**P**" (Partial) is input, please provide additional information elaborating which functions the system currently can or can not provide; If "**N**" (No) is input, please elaboration on how the required functionality could be achieved.
Category 13: Evaluation									
1. The COTS ATMS should include a context-sensitive, on-line help system with detailed documentation	Y	Y	Y		Y	Y	N	P	TransSuite TCS includes an on-line help system but is not context sensitive
2. The COTS ATMS should include a "maintenance online management" system (MOMS) to provide a continuous, full-time monitoring system for the COTS ATMS communications features	P	N	P		P		P	P	Centracs provides full monitoring, alerts, acknowledgements, and escalatio capabilities for monitoring TCS operation including communication; KITS: Provides reports and analysis of comminication performance. Identification of specific failed equipment (e.g., field IP switch) is not providedl; TransSuite TCS contiuously monitors communications with all intersections online or in standby. Any communication failure is logged in the TransSuite system log and optionally transmitted as
a. The MOMS should operate automatically without routine need for operator action or intervention	Y	N	Y		Y		Y	Y	
b. The MOMS should operate in the COTS ATMS central system and also be capable of running from a laptop computer	Y	N	Y		P		P	N	Telvent: Standalone application; TransSuite: The communication monitoring runs as part of the TransSuite TCS system and thus not available as a standalone program
c. The MOMS should provide end-to-end communications monitoring at all points in the communications linkages, all the way from the central system to each local controller	N	N	N		Y		P	P	KITS provides reports and analysis of comminication performance. Identification of specific failed equipment (e.g., field IP switch) is not provided. Diagnostic tools that emulate controller response are available to assist in pinpointing problems; Telvent: Monitors to end of IP netword; TransSuite: The communication monitoring runs as part of the TransSuite TCS system and monitors end to end communication with the controllers. When a problem has been identified then other tools can be utilized to
d. The MOMS should be capable of operating at the hub controllers, for testing and monitoring communications both to the local controllers and to the central system.	N	N	Y		Y			N	TransSuite: The communication monitoring runs as part of the TransSuite TCS system and this will not operate at the hubs
e. The MOMS should provide a loopback test capability	N	N	Y		Y		N	N	
f. None of the MOMS processes should have any effect on any other typical ongoing COTS ATMS communications functions or duties (that is, MOMS is to be a low-priority execution task)	Y	N	Y		Y		Y	Y	
3. A comprehensive time-space diagramming toolset, as part of the COTS ATMS:	P	N	Y		Y	P	P	Y	
a. Must be capable of operating in real-time, building a time-space diagram (TSD) with current splits	Y	P	Y		Y	N	Y	Y	Tactics currently does not support building a time space diagram in real time. Tactics collects actual data from controllers for userspecified number of cycles, and then draws the time space diagram
b. Should be capable of operating on a scheduled basis with both raw data and completed TSD reports saved for later review. Multiple, concurrent and overlapping TSD sessions should be possible without limitation	N	P	Y		Y	P	N	Y	Tactics supports a manually download of the raw traffic counts, and storage of the data for later review. Tactics currently does not support a scheduled download and activation of a time space diagram by TOD; Centracs: Not run by schedule. This is an on-screen interactive process
c. Should allow for user modification of links selected, link lengths, link speeds, and duration of TSD collection	Y	P	Y		Y	Y	P	Y	Telvent: Arterial configuration is done in the Config tool
d. Must allow for at least 15 contiguous signals to be monitored at a time	Y	Y	Y		Y	Y	Y	Y	
e. Must be able to run while making database changes	Y	Y	Y		Y	Y	Y	Y	
f. Should be able to produce a color print copy	Y	Y	Y		Y	Y	Y	Y	
4. A comprehensive split monitor function, as part of the COTS ATMS:	Y	N	Y		Y	P	P	Y	
a. Must be capable of operating in real time	Y	N	Y		Y	P	Y	Y	Tactics currently displays split monitoring information after the record period has paced
b. Must be capable of operating on an operator-scheduled basis for some start and/or stop time in the future (allowing for a collection time of up to 24 hours)	Y	N	Y		Y	N	N	Y	Centracs not ran by schedule (on-screen interactive process); Tactics currently does not support scheduling of the collection of split monitoring data
c. The split monitor table must be capable of being examined while a split monitor collection is underway	Y	N	Y		Y	N	N	Y	Tactics currently does not support the examination of the split monitor while data is being collected. Tactics shows data at the end of data collection period
d. It should be capable of collecting split monitor records on an unlimited number of intersections simultaneously	Y	Y	Y		Y	Y	N	Y	
Category 14: Other Uncategorized COTS ATMS Features									
1. The COTS ATMS must provide a true multi-user setup (for multiple agencies) with read and write permission levels present both for groups (agencies) and users (individual technicians, operators, administrators and engineers)	P	N	Y		Y	Y	P	P	
a. By jurisdiction (geographic coverage area)	Y	N	Y		Y	Y	P	Y	
b. By COTS ATMS functions	Y	N	Y		Y	Y	Y	Y	
c. By controller database categories (e.g., full access or only basic timing)	P	Y	Y		Y	Y	N	N	TransSuite TCS can restrict a user to upload only but if a user has download privileges then that user can download any database item
2. The COTS ATMS must provide the capability for an individual intersection's database to be discretely managed, updated, modified, viewed, and/or stored	Y	Y	Y		Y	Y	Y	Y	
3. Video System Capability	Y	Y	Y		N	Y	Y	Y	
a. The ATMS system should have an interface to support real-time CCTV and video detection images and control functions from multiple manufacturers.	Y	P	Y		N	Y	Y	Y	TransSuite optional item (not included in base)
4. Dynamic Message Sign Capability	Y	N	Y		N	P	P	Y	
a. The COTS ATMS should have the capability to fully integrate (or, alternatively, launch and operate in a cooperative additional window display on the COTS ATMS workstation's desktop) a system for providing message commands to Dynamic Message Signs (DMS), independent of this current COTS ATMS deployment project.	Y	N	Y		N	Y	Y	Y	
b. The DMS's native message management system software should be utilized in this function, so that future software upgrades by the DMS manufacturer can be implemented without the need for software integration revision by the COTS ATMS provider.	Y	N	Y		N	P	N	Y	Tactics supports an interface to support realtime management and control functions for NTCIP STMP clients OMS
5. The ATMS system must fully support multiple controllers and firmware via IP, serial, or data radio's communications, as listed:	P		P		P	P	P	P	
a. Hardware:		Y		Y	Y	Y			
· Type 2070N controller or equivalent	Y	Y	Y	Y	Y	Y	Y	Y	

DESIRED FUNCTIONS CHECK LIST									
DESIRED FUNCTIONS	**CURRENTLY PROVIDED?** ("**Y**" *for Yes,* "**N**" *for No**, "**P**" *for Partial**)								**COMMENTS *** If "**P**" (Partial) is input, please provide additional information elaborating which functions the system currently can or can not provide; If "**N**" (No) is input, please elaboration on how the required functionality could be achieved.
	Econolite Centracs	Inteligh MaxView	Kimley-Horn KITS	McCain Quicnet	Naztec ATMS.NOW	Siemens Tactics	Telvent MIST	Transcore TranSuite	
· ATC Controllers		Y		Y	Y	Y			
b. Software, at a minimum:	P		P		N	P	P	P	
· Siemens NextPhase versions 1.4x via AB3418E	N	N	P		N	Y	N	N	Telvent: NextPhase 1.4x via NTCIP
· Siemens NextPhase versions 1.7x via IP	N	P	P		N	Y	Y	Y	
· Any NTCIP compliant software (defined Management Information Bases or MIBs)	P	Y	Y		N	Y	Y	Y	
· Fourth Dimension (D4 firmware)	Y	P	Y		N	N	Y	Y	Tactics currently does not support D4 firmware
· Northwest Signal (Voyage firmware)	N	P	N		N	N	N	Y	Tactics currently does not support Voyage firmware
· Intelight: ATC and software (hardware/firmware)	N	Y	Y		N	N	N	P	Tactics currently does not support Intelight hardware or firmware
d. Vender should list any other firmware that the COTS ATMS will support.	Y	Y	Y		Y	Y			Naztec = Naztec
e. Vender should list any other controller that the COTS ATMS will support.	Y	Y	Y		Y	Y			Naztec = Naztec
6. The ATMS system must be able to connect to and support all signals.	Y	Y	Y		Y	Y	Y	Y	
7. The COTS AMTS should incorporate an interface with Synchro v7 or PASSER v09 signal timing software	Y	N	Y		Y	Y	N	Y	
8. The following items should be available:	P	Y	Y		Y	Y	Y	Y	
a. Structure of database, with a database schema and entity diagrams.	P	Y	Y		Y	Y	Y	Y	Centracs: This is proprietary information and not generally released. If desired such information could be placed in an Escrow account. Fees and setup for such account are not included with this proposal
b. Image of the workstation applications for ease of restore	Y	Y	Y		Y	Y	Y	Y	

APPENDIX H

IMPROVEMENTS AND ESTIMATED COSTS BY PHASE



Legend

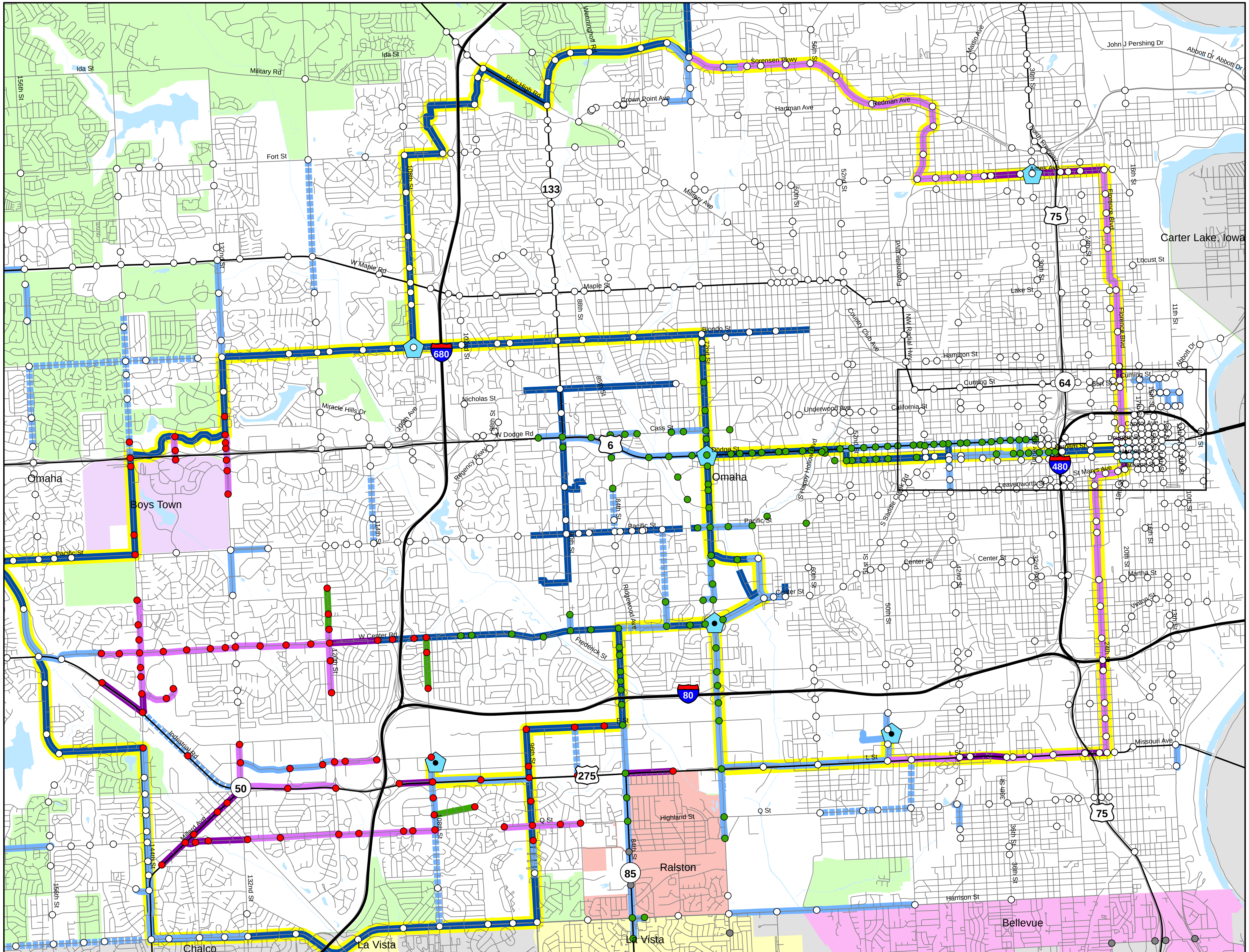
- Hub Locations
- New Fiber in Existing City Conduit
- New Fiber in New City Conduit
- New Wireless Link
- Existing City Fiber
- Planned City Fiber (CIP Program)
- Existing Unite Fiber
- Fiber Backbone Route
- Signal to be upgraded in this Phase.
- Signal to be upgraded in future Phase.
- Signal upgraded in previous Phase.

0 0.25 0.5 1

Miles

FIGURE H1

Phase 1 Improvements



Legend

- Hub Locations
- New Fiber in Existing City Conduit
- New Fiber in New City Conduit
- New Wireless Link
- Existing City Fiber
- Planned City Fiber (CIP Program)
- Existing Unite Fiber
- Fiber Backbone Route
- Signal to be upgraded in this Phase.
- Signal to be upgraded in future Phase.
- Signal upgraded in previous Phase.

0 0.5 1 2
Miles

FIGURE H2

Phase 2 Improvements

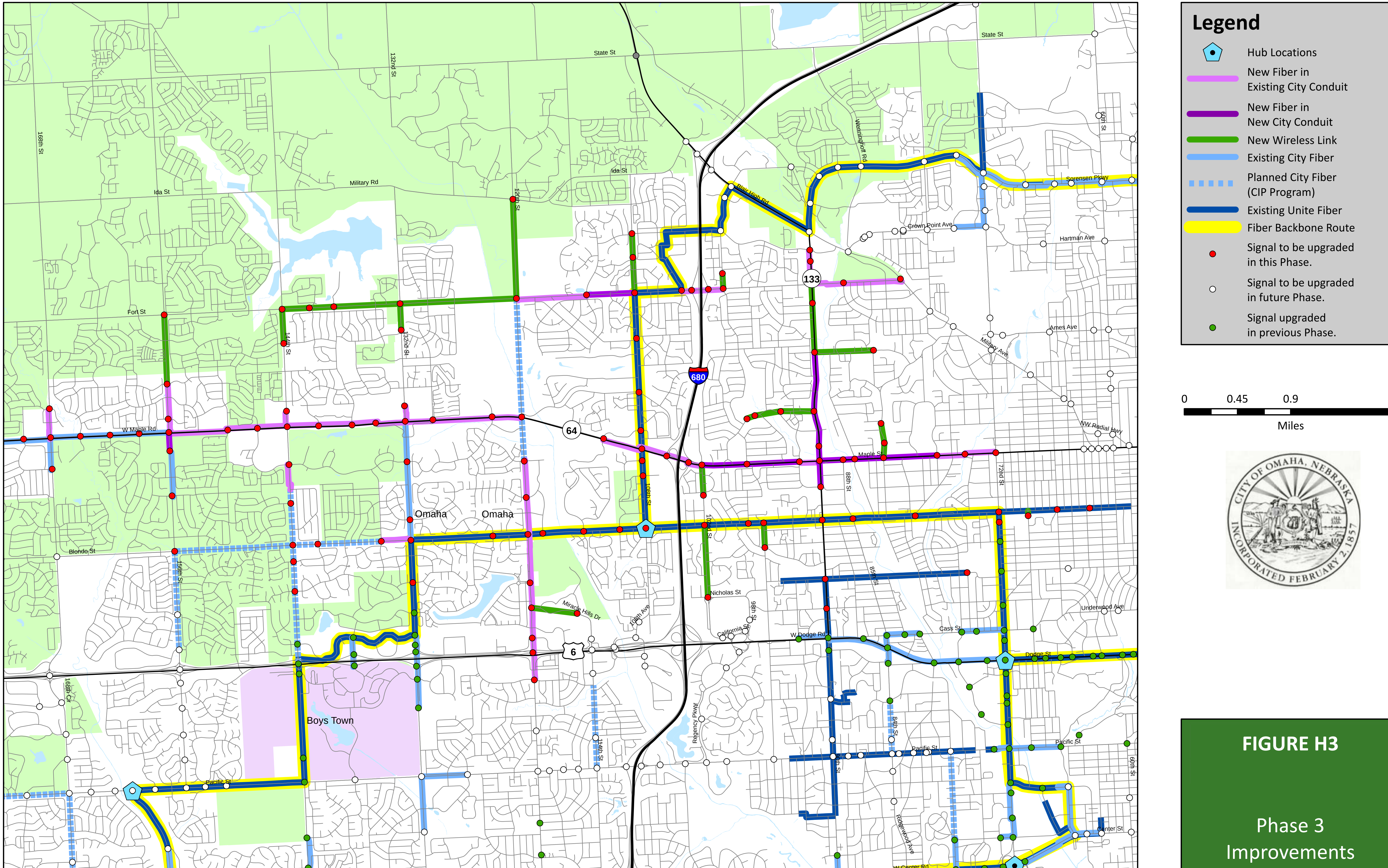
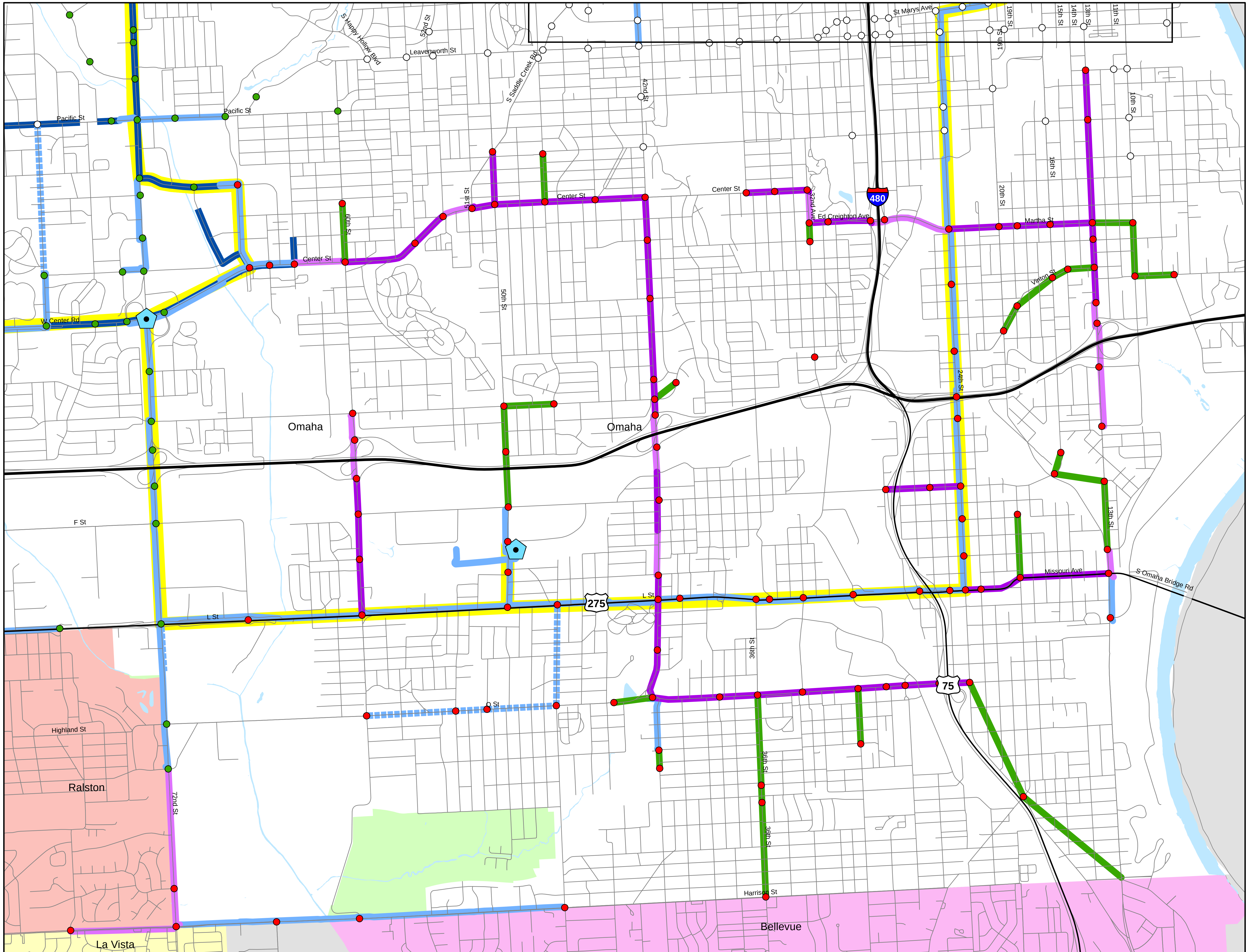


FIGURE H3

Phase 3 Improvements



Legend

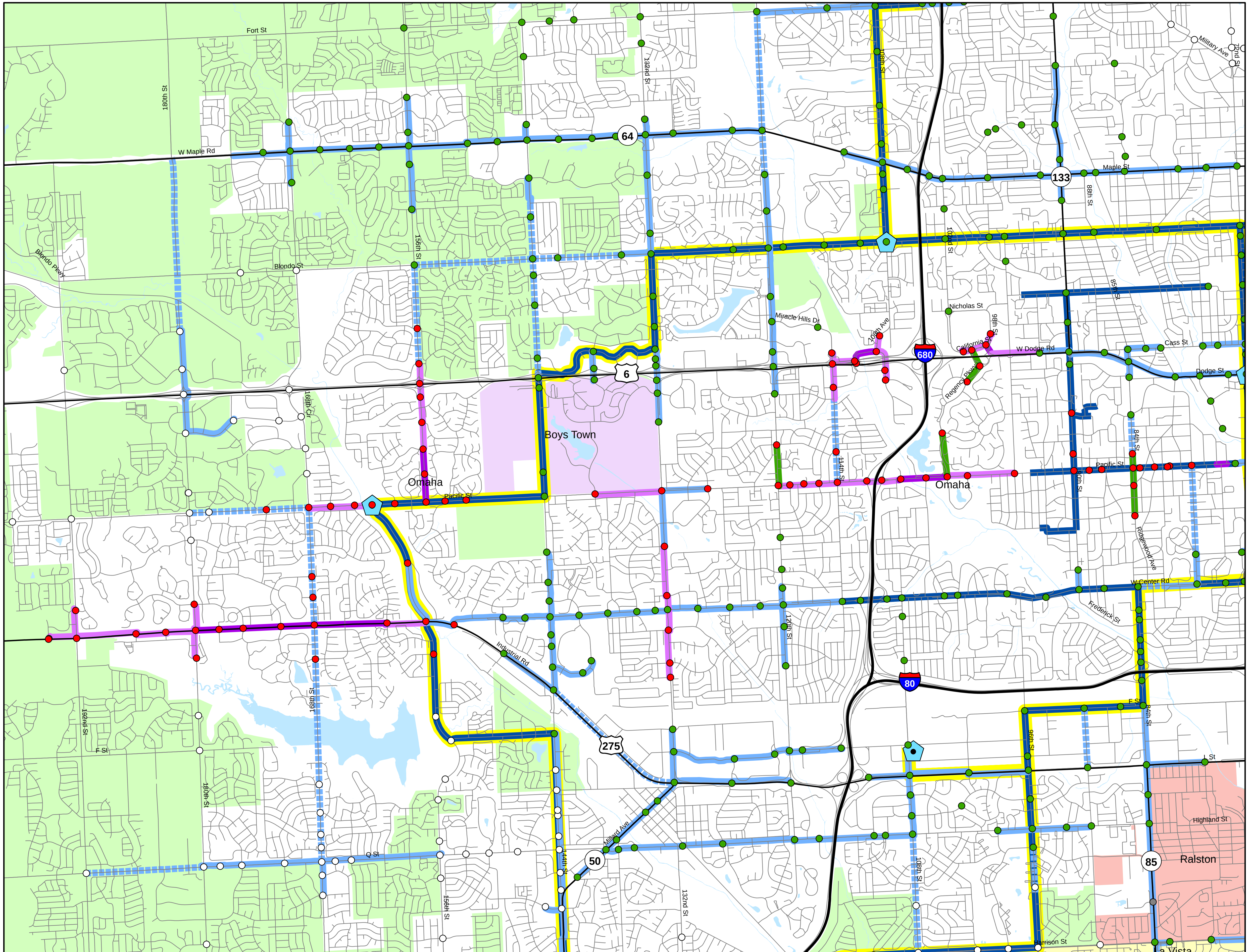
- Hub Locations
- New Fiber in Existing City Conduit
- New Fiber in New City Conduit
- New Wireless Link
- Existing City Fiber
- Planned City Fiber (CIP Program)
- Existing Unite Fiber
- Fiber Backbone Route
- Signal to be upgraded in this Phase.
- Signal to be upgraded in future Phase.
- Signal upgraded in previous Phase.

0 0.25 0.5 1

Miles

FIGURE H4

Phase 4 Improvements



Legend

- Hub Locations
- New Fiber in Existing City Conduit
- New Fiber in New City Conduit
- New Wireless Link
- Existing City Fiber
- Planned City Fiber (CIP Program)
- Existing Unite Fiber
- Fiber Backbone Route
- Signal to be upgraded in this Phase.
- Signal to be upgraded in future Phase.
- Signal upgraded in previous Phase.

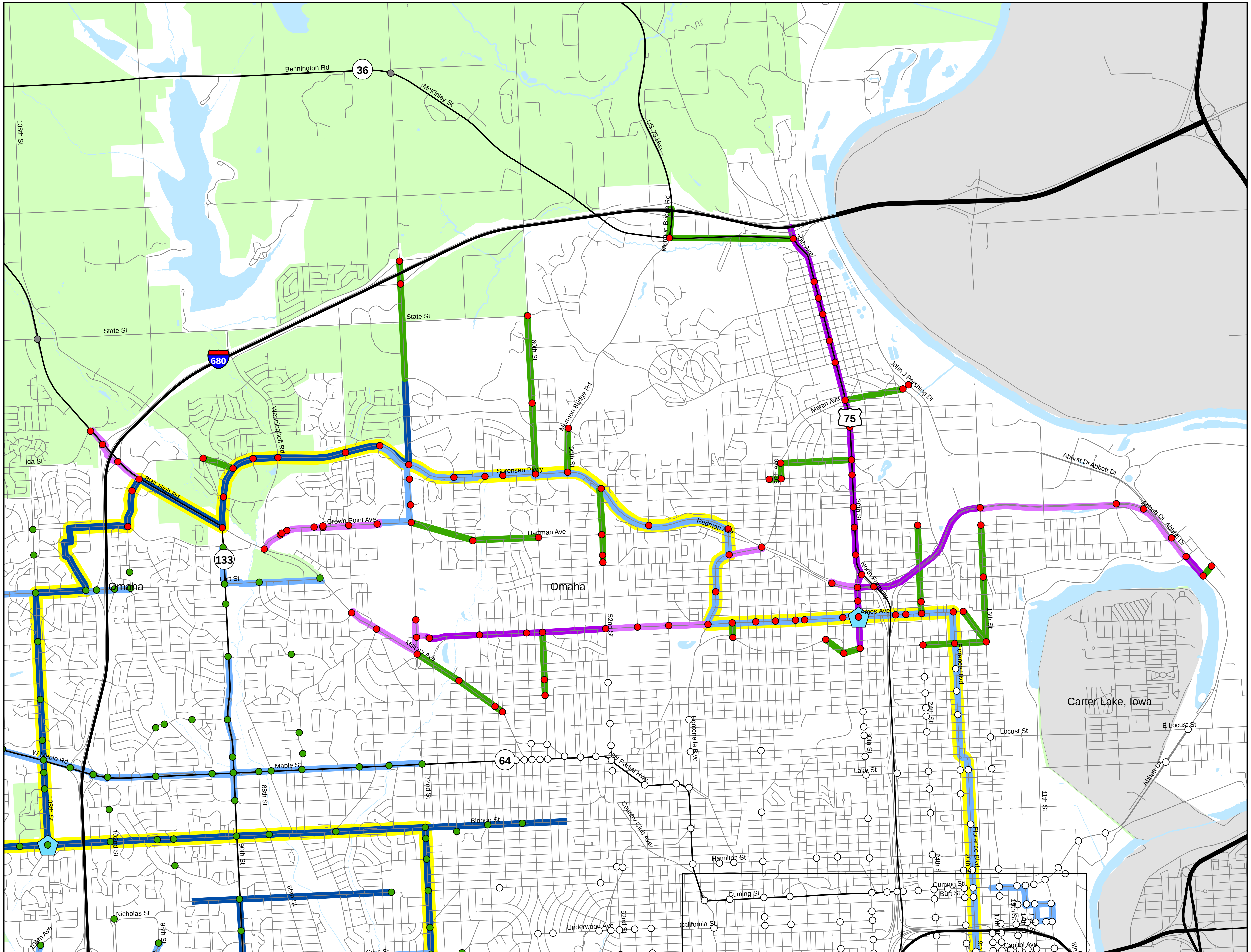
0 0.5 1 2

Miles

CITY OF OMAHA, NEBRASKA INCORPORATED FEBRUARY 2, 1857

FIGURE H5

Phase 5 Improvements



Legend

- Hub Locations
- New Fiber in Existing City Conduit
- New Fiber in New City Conduit
- New Wireless Link
- Existing City Fiber
- Planned City Fiber (CIP Program)
- Existing Unite Fiber
- Fiber Backbone Route
- Signal to be upgraded in this Phase.
- Signal to be upgraded in future Phase.
- Signal upgraded in previous Phase.

0 0.45 0.9 1.8

Miles

CITY OF OMAHA, NEBRASKA INCORPORATED FEBRUARY 2, 1857

FIGURE H6

Phase 6 Improvements

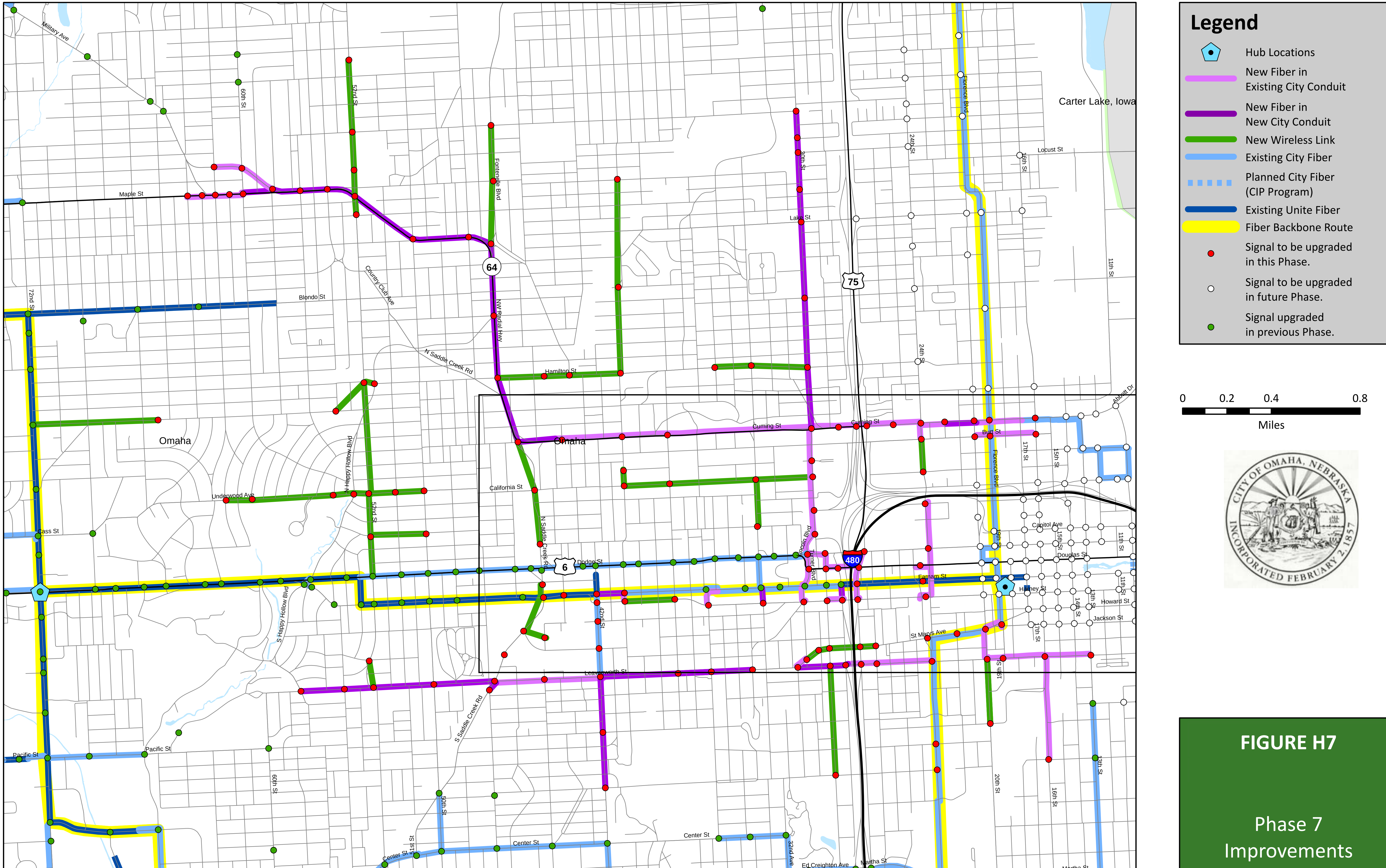
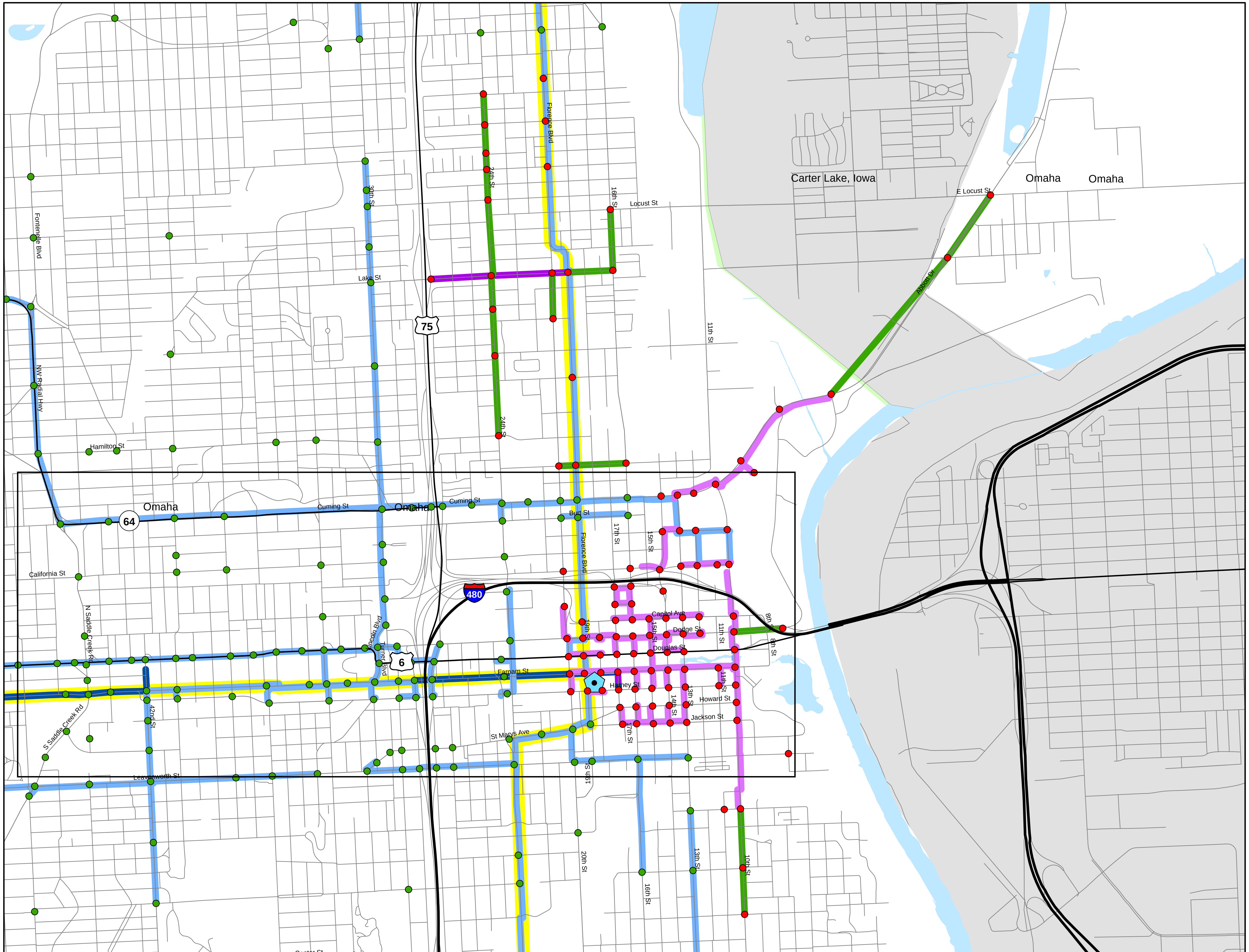


FIGURE H7

Phase 7 Improvements



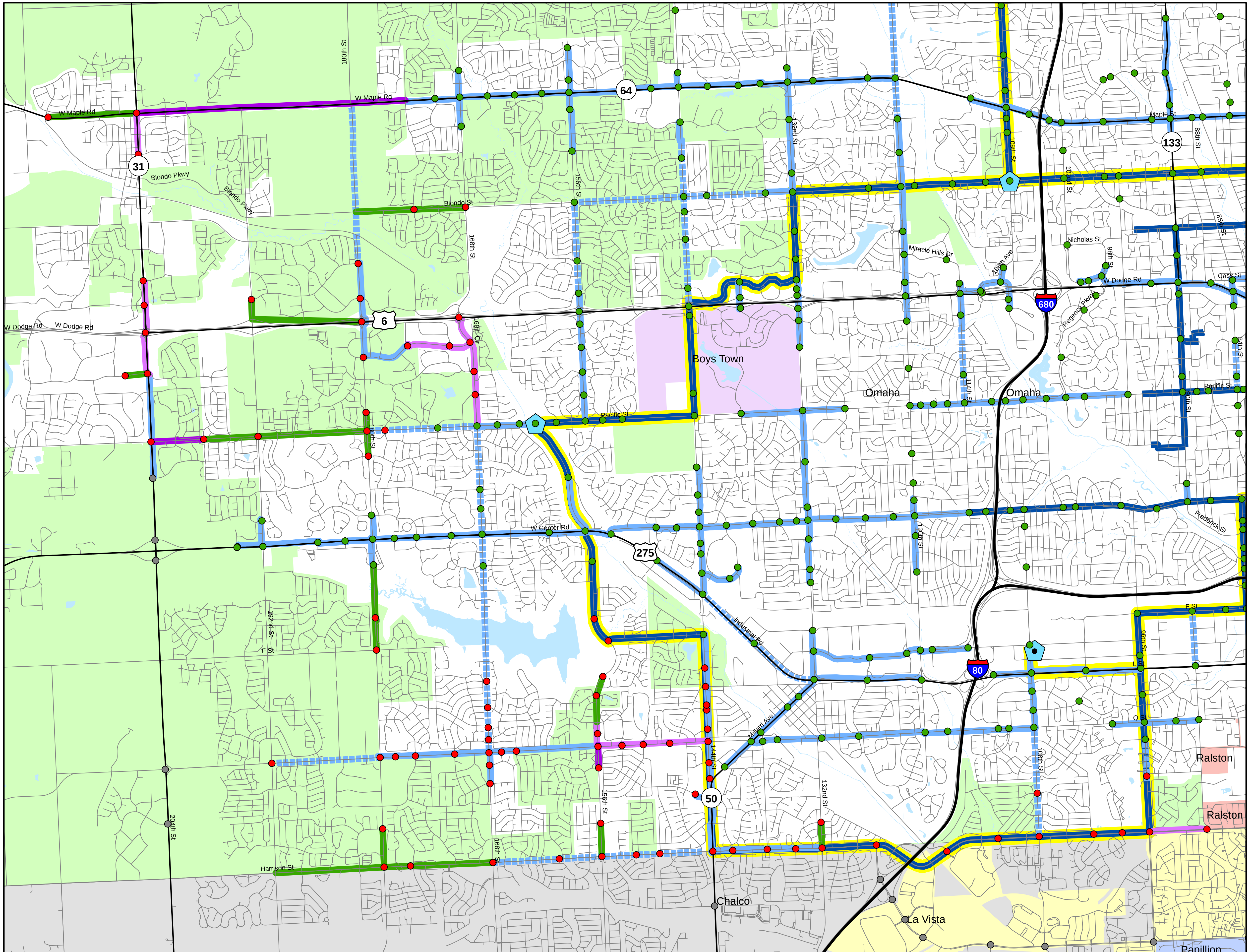
Legend

- Hub Locations
- New Fiber in Existing City Conduit
- New Fiber in New City Conduit
- New Wireless Link
- Existing City Fiber
- Planned City Fiber (CIP Program)
- Existing Unite Fiber
- Fiber Backbone Route
- Signal to be upgraded in this Phase.
- Signal to be upgraded in future Phase.
- Signal upgraded in previous Phase.

0 0.2 0.4 0.8
Miles

FIGURE H8

Phase 8 Improvements



Legend

- Hub Locations
- New Fiber in Existing City Conduit
- New Fiber in New City Conduit
- New Wireless Link
- Existing City Fiber
- Planned City Fiber (CIP Program)
- Existing Unite Fiber
- Fiber Backbone Route
- Signal to be upgraded in this Phase.
- Signal to be upgraded in future Phase.
- Signal upgraded in previous Phase.

0 0.5 1 2

Miles

FIGURE H9

Phase 9 Improvements

Table H1 - Opinion of Probable Cost for Phase 1 Upgrade				
System Components			**Phase 1**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	84	$672,000
Controller, Type 2070 ATC	$2,200	EA	121	$266,200
Traffic Signal Field Components				**$938,200**
Local Controller Software	$700	EA	121	$84,700
Central Signal System Software	$800,000	LS	1	$800,000
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS	1	$50,000
Traffic Signal Software Components				**$934,700**
Fiber Cable & Conduit	$35	FT	34,100	$1,193,500
Fiber Cable	$5	FT	37,100	$185,500
Fiber Splice Pull Boxes	$900	EA	168	$151,620
Misc. Comm. Hardware/Connections	$1,000	EA	121	$121,000
Communication HUB Cabinets	$30,000	EA	7	$210,000
Wireless Links	$6,000	EA	6	$36,000
Communications Components				**$1,897,620**
CCTV Monitoring Cameras	$4,000	EA	23	$92,000
Arterial DMS	$50,000	EA		
System Sensors	$2,500	EA		
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$92,000**
Video Wall	$100,000	EA	1	$100,000
Workstations	$10,000	EA	2	$20,000
Misc. Server Equipment	$200,000	LS	1	$200,000
Minor Remodel	$100,000	LS	1	$100,000
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$420,000**
Adaptive Traffic Signal Control - Central Module	$50,000	LS	1	$50,000
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA	30	$150,000
Misc. Items				**$200,000**
Subtotal				**$4,482,520**
Contingencies	15%			**$672,378**
TOTAL				**$5,154,898**

Table H2 - Opinion of Probable Cost for Phase 2 Upgrade				
System Components			**Phase 2**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	56	$448,000
Controller, Type 2070 ATC	$2,200	EA	94	$206,800
Traffic Signal Field Components				**$654,800**
Local Controller Software	$700	EA	94	$65,800
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$65,800**
Fiber Cable & Conduit	$35	FT	32,300	$1,130,500
Fiber Cable	$5	FT	72,600	$363,000
Fiber Splice Pull Boxes	$900	EA	164	$147,540
Misc. Comm. Hardware/Connections	$1,000	EA	94	$94,000
Communication HUB Cabinets	$30,000	EA	1	$30,000
Wireless Links	$6,000	EA	5	$30,000
Communications Components				**$1,795,040**
CCTV Monitoring Cameras	$4,000	EA	17	$68,000
Arterial DMS	$50,000	EA		
System Sensors	$2,500	EA		
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$68,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA		
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$0**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA	15	$75,000
Misc. Items				**$75,000**
Subtotal				**$2,658,640**
Contingencies	15%			**$398,796**
TOTAL				**$3,057,436**

Table H3 - Opinion of Probable Cost for Phase 3 Upgrade				
System Components			**Phase 3**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	90	$720,000
Controller, Type 2070 ATC	$2,200	EA	120	$264,000
Traffic Signal Field Components				**$984,000**
Local Controller Software	$700	EA	120	$84,000
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$84,000**
Fiber Cable & Conduit	$35	FT	18,700	$654,500
Fiber Cable	$5	FT	37,600	$188,000
Fiber Splice Pull Boxes	$900	EA	158	$141,780
Misc. Comm. Hardware/Connections	$1,000	EA	120	$120,000
Communication HUB Cabinets	$30,000	EA		
Wireless Links	$6,000	EA	23	$138,000
Communications Components				**$1,242,280**
CCTV Monitoring Cameras	$4,000	EA	26	$104,000
Arterial DMS	$50,000	EA		
System Sensors	$2,500	EA		
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$104,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA		
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$0**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA	15	$75,000
Misc. Items				**$75,000**
Subtotal				**$2,489,280**
Contingencies	15%			**$373,392**
TOTAL				**$2,862,672**

Table H4 - Opinion of Probable Cost for Phase 4 Upgrade				
System Components			**Phase 4**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	103	$824,000
Controller, Type 2070 ATC	$2,200	EA	124	$272,800
Traffic Signal Field Components				**$1,096,800**
Local Controller Software	$700	EA	124	$86,800
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$86,800**
Fiber Cable & Conduit	$35	FT	50,400	$1,764,000
Fiber Cable	$5	FT	20,500	$102,500
Fiber Splice Pull Boxes	$900	EA	171	$154,140
Misc. Comm. Hardware/Connections	$1,000	EA	124	$124,000
Communication HUB Cabinets	$30,000	EA		
Wireless Links	$6,000	EA	26	$156,000
Communications Components				**$2,300,640**
CCTV Monitoring Cameras	$4,000	EA	28	$112,000
Arterial DMS	$50,000	EA		
System Sensors	$2,500	EA		
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$112,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA		
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$0**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA		
Misc. Items				**$0**
Subtotal				**$3,596,240**
Contingencies	15%			**$539,436**
TOTAL				**$4,135,676**

Table H5 - Opinion of Probable Cost for Phase 5 Upgrade				
System Components			**Phase 5**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	58	$464,000
Controller, Type 2070 ATC	$2,200	EA	88	$193,600
Traffic Signal Field Components				**$657,600**
Local Controller Software	$700	EA	88	$61,600
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$61,600**
Fiber Cable & Conduit	$35	FT	15,100	$528,500
Fiber Cable	$5	FT	44,900	$224,500
Fiber Splice Pull Boxes	$900	EA	128	$115,200
Misc. Comm. Hardware/Connections	$1,000	EA	88	$88,000
Communication HUB Cabinets	$30,000	EA		
Wireless Links	$6,000	EA	7	$42,000
Communications Components				**$998,200**
CCTV Monitoring Cameras	$4,000	EA	16	$64,000
Arterial DMS	$50,000	EA		
System Sensors	$2,500	EA		
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$64,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA	2	$20,000
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS	1	$100,000
TMC Infrastructure (3 Sites)				**$120,000**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA	15	$75,000
Misc. Items				**$75,000**
Subtotal				**$1,976,400**
Contingencies	15%			**$296,460**
TOTAL				**$2,272,860**

Table H6 - Opinion of Probable Cost for Phase 6 Upgrade				
System Components			**Phase 6**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	93	$744,000
Controller, Type 2070 ATC	$2,200	EA	120	$264,000
Traffic Signal Field Components				**$1,008,000**
Local Controller Software	$700	EA	120	$84,000
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$84,000**
Fiber Cable & Conduit	$35	FT	19,700	$689,500
Fiber Cable	$5	FT	29,300	$146,500
Fiber Splice Pull Boxes	$900	EA	153	$137,400
Misc. Comm. Hardware/Connections	$1,000	EA	120	$120,000
Communication HUB Cabinets	$30,000	EA		
Wireless Links	$6,000	EA	33	$198,000
Communications Components				**$1,291,400**
CCTV Monitoring Cameras	$4,000	EA	21	$84,000
Arterial DMS	$50,000	EA		
System Sensors	$2,500	EA		
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$84,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA		
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$0**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA	15	$75,000
Misc. Items				**$75,000**
Subtotal				**$2,542,400**
Contingencies	15%			**$381,360**
TOTAL				**$2,923,760**

Table H7 - Opinion of Probable Cost for Phase 7 Upgrade				
System Components			**Phase 7**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	129	$1,032,000
Controller, Type 2070 ATC	$2,200	EA	149	$327,800
Traffic Signal Field Components				**$1,359,800**
Local Controller Software	$700	EA	149	$104,300
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$104,300**
Fiber Cable & Conduit	$35	FT	34,212	$1,197,420
Fiber Cable	$5	FT	37,000	$185,000
Fiber Splice Pull Boxes	$900	EA	196	$176,827
Misc. Comm. Hardware/Connections	$1,000	EA	149	$149,000
Communication HUB Cabinets	$30,000	EA		
Wireless Links	$6,000	EA	43	$258,000
Communications Components				**$1,966,247**
CCTV Monitoring Cameras	$4,000	EA	22	$88,000
Arterial DMS	$50,000	EA		
System Sensors	$2,500	EA		
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$88,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA		
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$0**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA		
Misc. Items				**$0**
Subtotal				**$3,518,347**
Contingencies	15%			**$527,752**
TOTAL				**$4,046,099**

Table H8 - Opinion of Probable Cost for Phase 8 Upgrade				
System Components			**Phase 8**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	85	$680,000
Controller, Type 2070 ATC	$2,200	EA	114	$250,800
Traffic Signal Field Components				**$930,800**
Local Controller Software	$700	EA	114	$79,800
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$79,800**
Fiber Cable & Conduit	$35	FT	3,200	$112,000
Fiber Cable	$5	FT	32,500	$162,500
Fiber Splice Pull Boxes	$900	EA	138	$124,020
Misc. Comm. Hardware/Connections	$1,000	EA	114	$114,000
Communication HUB Cabinets	$30,000	EA		
Wireless Links	$6,000	EA	18	$108,000
Communications Components				**$620,520**
CCTV Monitoring Cameras	$4,000	EA	23	$92,000
Arterial DMS	$50,000	EA	20	$1,000,000
System Sensors	$2,500	EA	40	$100,000
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$1,192,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA		
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$0**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA		
Misc. Items				**$0**
Subtotal				**$2,823,120**
Contingencies	15%			**$423,468**
TOTAL				**$3,246,588**

Table H9 - Opinion of Probable Cost for Phase 9 Upgrade				
System Components			**Phase 9**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA	52	$416,000
Controller, Type 2070 ATC	$2,200	EA	89	$195,800
Traffic Signal Field Components				**$611,800**
Local Controller Software	$700	EA	89	$62,300
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$62,300**
Fiber Cable & Conduit	$35	FT	5,000	$175,000
Fiber Cable	$5	FT	24,600	$123,000
Fiber Splice Pull Boxes	$900	EA	109	$97,860
Misc. Comm. Hardware/Connections	$1,000	EA	89	$89,000
Communication HUB Cabinets	$30,000	EA		
Wireless Links	$6,000	EA	20	$120,000
Communications Components				**$604,860**
CCTV Monitoring Cameras	$4,000	EA	27	$108,000
Arterial DMS	$50,000	EA	20	$1,000,000
System Sensors	$2,500	EA	40	$100,000
3rd Party Sensor Information	$50,000	LS		
ITS Field Devices				**$1,208,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA		
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$0**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA	15	$75,000
Misc. Items				**$75,000**
Subtotal				**$2,561,960**
Contingencies	15%			**$384,294**
TOTAL				**$2,946,254**

Table H10 - Opinion of Probable Cost for Phase 10 Upgrade				
System Components			**Phase 10**	
	Price Per Unit	**Unit**	**Qty**	**Total**
Signal Cabinet (Type 332 or equivalent)	$8,000	EA		$0
Controller, Type 2070 ATC	$2,200	EA		$0
Traffic Signal Field Components				**$0**
Local Controller Software	$700	EA		$0
Central Signal System Software	$800,000	LS		
ATMS for ITS Devices (NDOR Delcan)	$50,000	LS		
Traffic Signal Software Components				**$0**
Fiber Cable & Conduit	$35	FT		$0
Fiber Cable	$5	FT		$0
Fiber Splice Pull Boxes	$900	EA		$0
Misc. Comm. Hardware/Connections	$1,000	EA		$0
Communication HUB Cabinets	$30,000	EA		$0
Wireless Links	$6,000	EA		$0
Communications Components				**$0**
CCTV Monitoring Cameras	$4,000	EA	22	$88,000
Arterial DMS	$50,000	EA	60	$3,000,000
System Sensors	$2,500	EA	120	$300,000
3rd Party Sensor Information	$50,000	LS	1	$50,000
ITS Field Devices				**$3,438,000**
Video Wall	$100,000	EA		
Workstations	$10,000	EA		
Misc. Server Equipment	$200,000	LS		
Minor Remodel	$100,000	LS		
ATIS Website	$100,000	LS		
TMC Infrastructure (3 Sites)				**$0**
Adaptive Traffic Signal Control - Central Module	$50,000	LS		
Adaptive Traffic Signal Control - Intersection Module	$5,000	EA		
Misc. Items				**$0**
Subtotal				**$3,438,000**
Contingencies	15%			**$515,700**
TOTAL				**$3,953,700**