Metro Region Arterial Management System

System Deployment Plan

FINAL

Prepared by:

WSP | PARSONS BRINCKERHOFF

In association with:

AECOM

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1 INTRODUCTION

1.1 Project Overview

The Michigan Department of Transportation (MDOT) seeks to enhance its transportation network assets by planning for future Intelligent Transportation Systems (ITS) deployments along its arterial trunklines throughout the Metro Region (Macomb, Oakland and Wayne counties). This document serves as a Deployment Plan intended to guide the final planning, design, and implementation of arterial management systems (AMS) throughout several corridors in the Metro Region.

The Deployment Plan follows a robust process that began with a Concept of Operations that served as the foundation for AMS development. The content within this Deployment Plan, as well as the Concept of Operations, was developed to align with the Southeast Michigan Council of Governments (SEMCOG) Metro Region ITS architecture and to support MDOT's mission of "providing the highest quality integrated transportation services for economic benefit and improved quality of life."

The AMS is intended to serve a number of purposes – reduction in crashes, improved incident management, improved travel time reliability, better awareness of real-time conditions, and enhanced operational control during freeway incidents and others. In general, the AMS will help to more effectively operate the trunkline routes and mitigate the negative impacts to motorists encountered during periods of recurring congestion and non-recurring conditions.

Similar to the freeway system operations, MDOT and stakeholders will work jointly to leverage these new ITS systems through concerted coordination of activities to support the varying needs of one another with one common goal of reducing the duration of time for abnormal periods of operation. Dependent upon the specific operational strategies chosen by MDOT the AMS should also afford the opportunity to improve normal operations through the utilization of more advanced system components to address smaller fluctuations in normal traffic patterns.

1.2 Systems Engineering Process Overview

MDOT utilized a collaborative approach to developing the regional AMS strategy, beginning with preparation of a Concept of Operations (ConOps). The development of a ConOps document is an integral step in the early part of the Systems Engineering Process (shown Figure 1) that MDOT follows for all ITS projects. During the ConOps process, stakeholders were invited to participate in a workshop to identify and prioritize the potential needs to be addressed by the future AMS. Participants were introduced to the project and objectives of the planning process, then given an overview of what other AMS deployments are comprised and capable of. Participants then instructed to separate into pre-determined breakout groups whereby they were tasked with discussing and identifying the needs of one of the four major topic areas of arterial management. The four major topic areas discussed were Traffic Operations, Traffic Incident Management, Information Dissemination and Infrastructure Maintenance.

Following the breakout group exercises, the participants reconvened and each group presented the identified needs to the entire stakeholder audience who was then asked to comment, revise or add to the list of needs. All participants then voted individually and privately on the priority ranking of the needs that the proposed AMS should address.

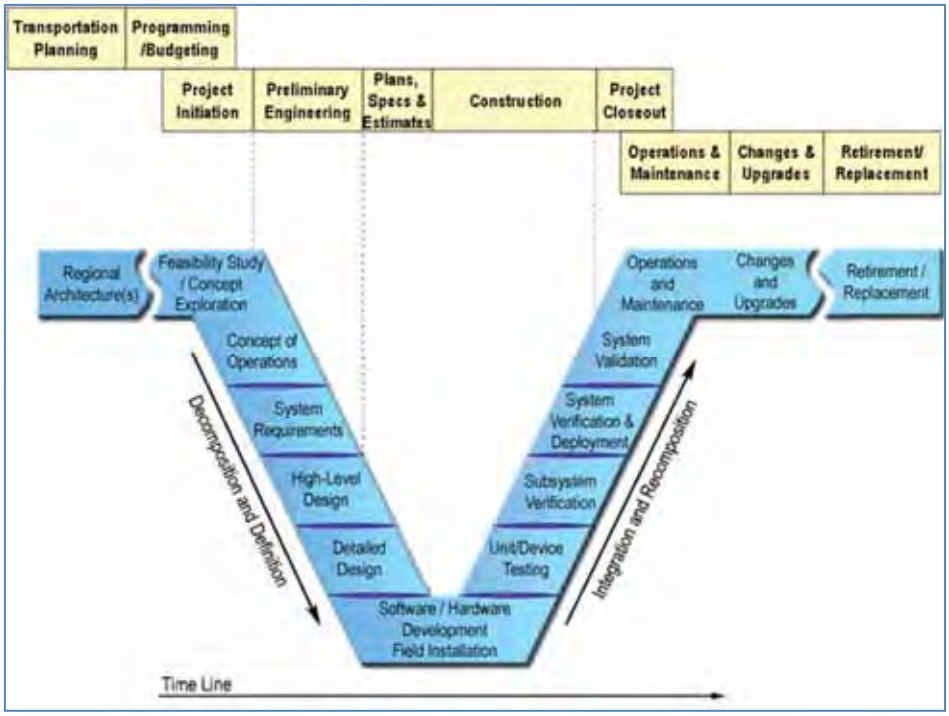


Figure 1: Systems Engineering Process

Evaluation of the SEMCOG Metro Region ITS architecture and a survey of arterial ITS projects implemented around the nation led to preliminary concept studies. Existing infrastructure inventories, both on the MDOT trunkline level and at a local agency level, were reviewed for system feasibility and operational compatibility throughout the region. The Concept of Operations addressed the findings from these assessments by including them in the proposed system operational needs, discussing them within the system overview and incorporating them into the operational scenarios.

This Deployment Plan document represents the next step in the systems engineering process, encompassing the high-level system requirements and system design for the overall AMS. It is anticipated that this document will serve as the foundation for programming and proceeding with detailed design of the many individual projects that will collectively make up the Regional AMS.

1.3 Document Organization

The Deployment Plan is organized into the following sections:

- Section 2 – High Level System Requirements: Provides a high level review of requirements introduced in the Concept of Operations.
- Section 3 – Deployment Locations: Presents the methodology considered and data evaluated for selecting and prioritizing corridors for AMS deployment, including the resulting corridor recommendations.
- Section 4 – Deployment Recommendations: This section provides a roadmap for deployment, including recommended actions and sequencing.
- Section 5 – Specific Deployment Actions: This section identifies specific near-term action steps to be undertaken to accomplish the recommendations, including responsible parties and sequence of actions.

2 HIGH-LEVEL SYSTEM REQUIREMENTS

A comprehensive summary of traffic management technologies which could be considered as part of the AMS was conducted to support this deployment plan, including a review of deployments in peer regions, and identification of lessons learned. This summary is included as Appendix A to this document.

Based on the technology review and needs assessment conducted through the Concept of Operations process, the following is a summary of the high-level requirements of the AMS. The complete list of high-level system requirements can be found in Appendix B. It should be noted that not all systems or devices are intended to be required at all locations; rather, these system requirements identify system elements to be considered based on the localized needs in individual corridors or locations.

2.1 Traffic Signal System

2.1.1 Centralized System Control

The ability to conduct remote, real-time operations on regional arterials was a high-priority need found throughout the ConOps process, which MDOT and partner operating agencies have limited ability to do today. It is recommended therefore that a centralized traffic signal system capable of remote monitoring and management be a key component of the AMS at all deployment sites. This element would include updated signal controller equipment, remote communications to all signal controllers, and an application used by operators to monitor and remotely manage signal system timings.

The Traffic Signal System element of the AMS will:

- Provide AMS system operators the ability to adjust current traffic signal system operations for single intersections or entire corridors/groups of intersections.
- Allow system operators to monitor current traffic signal system operations by intersection, groups of intersections or by corridor.
- Support traffic diversions through the deployment of pre-planned or customized traffic signal timing plans from the AMS system operator.
- Support directional congestion mitigation through the deployment of pre-planned or customized traffic signal timing plans.
- Include the development of intersection and corridor-specific traffic signal response timing plans to meet the defined operational needs of each AMS corridor.
- Provide system operators with the ability to remotely enact the pre-planned traffic signal response timing plans.
- Provide system operators with the ability to remotely access and program customized traffic signal timing plans in response to unique events for which pre-planned responses do not apply.
- Be capable of accepting pre-planned ICM traffic signal timing plans.
- Be able to accommodate various traffic signal timing plans to account for current construction or work zone-related activity along AMS or alternate AMS diversions routes.

2.1.2 Emergency Vehicle Preemption/Transit Signal Priority

Emergency vehicle preemption (EVP) and transit signal priority (TSP) were found to be lower-priority needs which are largely driven by third parties (emergency responders and transit agencies, respectively). To date there has been limited use of EVP in the region, and none on MDOT trunkline arterials. While TSP has been studied along the M-1 (Woodward Avenue) corridor, no TSP is currently in use the region, and the multiple transit operators and limited funding has complicated potential TSP deployment. Therefore, the AMS will include the *capability* to deploy EVP and TSP in the future

(through compatible signal controllers and communications infrastructure), but not the direct deployment of these systems on a routine basis. Deployment of TSP in particular should be considered on a localized basis and only after detailed study to consider the corridor-specific benefits to users.

2.2 Arterial Surveillance

2.2.1 Detectors

Various detector types will be required throughout the AMS for both vehicle and pedestrian detection. Additional detection is required to gather travel time data or data at mid-block locations for traffic volume and speed. Vehicle detection at intersections will enable the signals to potentially alter operations in real-time to accommodate actual conditions. Pedestrian detection will provide an interface for non-motorized users to be serviced efficiently by the signal (e.g., the signal may break a cycle length to service a push button call). Mid-block detection will support future real-time traffic signal system management and travel-time generation. Detectors will interface with the traffic signal controller and traffic signal control software. Detector data should be centrally archived to facilitate real-time information dissemination (travel time, speed, etc.) or for archival study purposes.

The Detector element of the AMS will:

- Supply AMS system operators with various data sets that reflect current travel conditions along AMS corridors.
- Support directional congestion mitigation by allowing AMS system operators to receive congestion condition information.
- Provide AMS system operators with notifications of incidents that are detected through automated means.
- Support the sharing of AMS travel conditions and other data streams with transit partners to support the delivery of more efficient and reliable services to transit customers.
- Provide AMS system operators with information that can be used to develop a situational awareness of the roadway and AMS upstream of, at and downstream of an active incident.
- Allow AMS system operators access to roadway condition information that will enable him/her to effectively operate the system during the incident and in preparation for the post-incident operations.
- Support the ability to gather various traffic data information from roadway traffic data collection systems, probe data systems, and other sources for use in AMS operational decision making, dissemination to stakeholders, dissemination to public and archiving.
- Include the ability to gather and incorporate vehicle speed data as gathered along AMS routes or at intersections to support the monitoring of travel conditions and/or the improvement of decision making logic.
- Support the inclusion of future roadside or third party applications (such as smartphone applications) that alert non-motorized users of AMS operational changes that may impact their travel decisions or safety.

2.2.2 Closed-Circuit Television Cameras

Expansion of the closed circuit television (CCTV) camera network onto arterial routes is a fundamental tool to that supports almost all the goals of the AMS. Visual verification of conditions is an important asset for TMC operations staff - and during unplanned events, weather emergencies, or special events the CCTV camera is a vital link to the field. Future enhancements such as automated incident detection systems and infrared technology may provide additional functionality and value to the long-term CCTV camera deployments. CCTV cameras can be placed at intersections or along corridors, and while exact

locations and quantities are not yet determined, CCTV camera coverage is expected to be needed along major portions of each identified trunkline.

The CCTV Camera element of the AMS will:

- Allow AMS system operators and trusted stakeholders to monitor travel conditions, verify incidents and observe real-time activity along select portions of certain AMS corridors.
- Support traffic diversions by allowing AMS system operators to monitor diversion route travel conditions and may accommodate the use of partnering agency CCTV cameras for diversion route monitoring.
- Support the detection of incidents by enabling AMS system operators with the ability to routinely monitor roadway operations in real-time.
- Support the verification of reported or detected incidents by allowing AMS system operators to obtain visual verification of incidents.
- Support ICM by allowing AMS system operators to monitor roadway operations along ICM routes.
- Allow AMS system operators to gather work zone information, including the location of work crews.

2.2.3 Vehicle Probe Data

The ability to capture probe data from Connected Vehicles was identified as a high-priority need to be addressed by the AMS. While it is acknowledged that the current and near-term fleet of equipped vehicles is very limited such that full-scale deployment of Connected Vehicle Roadside Units (RSU) to capture vehicle messages is not yet warranted, the AMS will accommodate the future deployment of RSUs at intersections through compatible Ethernet switches and backhaul communications.

MDOT currently sources probe data from existing providers, including HERE, Inrix, TomTom and others. This probe data is gathered by leveraging mobile devices in-vehicle and is packaged as a commercial data product. MDOT uses HERE today as a provider data for travel time information on the statewide freeway system, but does currently obtain data for arterial roadways as well. The AMS will further utilize this third-party data for travel time derivation and other measures as part of the Metro Region arterial roadway network.

2.2.4 Road Weather Information Systems

While Road Weather Information Systems (RWIS) has had limited penetration in the Metro Region to date, it is playing an increasingly significant role in the operations of the state's rural areas, with plans for urban area penetration in the Metro and Grand Regions. Metro region stakeholders identified increased RWIS data as an important element of the AMS going forward as a decision-support tool for operations and maintenance decisions, and for motorist information.

A concept of operations for RWIS in the Metro Region was completed in 2009 which identified recommended locations for Environmental Sensor Station (ESS) sites along regional routes. This document is planned to be updated in late 2015/early 2016. While most of these recommended sites are along freeways, a limited number of sites are proposed along arterial route locations. The system will therefore incorporate recommended ESS sites along arterial corridors proposed for AMS deployment, and provide weather data from all future regional ESS sites to operators to support operations and maintenance decisions and traveler information.

In addition, MDOT is currently piloting collection of road weather data through the Integrated Mobile Observation (IMO) program. This system includes equipping MDOT fleet vehicles with atmospheric sensors, which collect and transmit road weather data via cellular communications to back-office systems. These systems are then able to generate maintenance notifications and motorist advisories. IMO is anticipated to be a prominent element of MDOT's RWIS program going forward.

2.3 Traveler Information and Support

2.3.1 Dynamic Message Signs

The addition of dynamic message signs (DMS) will support the delivery of timely travel-related information directly to the roadside environment where passing motorists can view it. There are several different types of DMS which may be deployed, including traditional overhead signs, dual static/dynamic travel time signs or ICM routing signs. Traditionally, DMS locations are driven by advance notice for driver decision making, or proximity to major areas of congestion, special event traffic, or multi-modal locations like bus or transit stops.

The Dynamic Message Sign element of the AMS will:

- Provide AMS system operators the ability to remotely adjust DMS messages/content through the MDOT ATMS.
- Support traffic diversions through the use of DMS messaging to provide route guidance to motorists.
- Support ICM by allowing system operators to post DMS messages relative to ICM diversion routes.
- Support the communication of current incident-related information to the roadside to advise motorists of downstream travel conditions.
- Support the communication of current travel time or congestion-related information to the roadside to advise motorists of downstream travel conditions.
- Support the dissemination of special event traffic information.
- Allow AMS system operators to disseminate work crew location information via DMS messaging to support improved mobility in and around the work zone.

It should be noted that the role of DMS is likely to diminish over time, as in-vehicle messaging via smartphone applications and future Connected Vehicle applications proliferate into the vehicle fleet.

2.3.2 Website/Smartphone Applications

MDOT has an existing website and mobile application known as MiDrive, which provides information on speeds and congestion, incidents, construction and maintenance activities, and camera images from ITS system cameras around the state. The AMS will include the ability to display all data collected and derived through the system via the MiDrive site and applications.

2.3.3 Connected Vehicle Applications

Vehicle-to-Infrastructure (V2I) applications will play an important role in the future of arterial traffic management, whereby messages can be broadcast from the roadside directly to vehicles, where on-board systems receive and interpret the message and provide only relevant information or warnings to motorists. As stated previously, it is acknowledged that the current and near-term fleet of equipped vehicles is very limited such that full-scale deployment of Connected Vehicle Roadside Units (RSU) to broadcast vehicle messages is not yet warranted. MDOT is currently pursuing a Connected Vehicle Regional Concept of Operations and Deployment Plan which will identify near- and long-term RSU

deployment locations. However, it is the intention that the AMS will accommodate the future deployment of RSUs at *all* intersections through compatible Ethernet switches and backhaul communications. In addition, MDOT is currently pursuing development of the back-office systems necessary to generate and "push" messages to the roadside, a key building block in moving towards broad deployment of Connected Vehicle roadside infrastructure.

2.3.4 Courtesy Patrol

The Metro Region AMS may consider an arterial courtesy patrol or response unit, similar to the freeway courtesy patrol currently in place in the Metro Region to respond to non-emergency events and disabled vehicles.

2.4 Advanced Traffic Management Systems

Advanced Traffic Management Systems (ATMS) represents the software used by system operators to manage the AMS. MDOT's ATMS at their traffic operations centers statewide is currently used to manage existing systems primarily along freeways, including CCTV cameras, dynamic message signs, and traffic detectors. This ATMS will need to be modified to accommodate the additional requirements of the AMS. The Advanced Traffic Management System element of the AMS will:

- Recommend diversion route response plans by comparing predefined conditions to actual, recorded/observed conditions.
- Support the detection of incidents by collecting and reporting roadway operations information to AMS system operators in real time.
- Support the enactment of predefined response signal timing plans that are recommended by the MDOT ATMS using current traffic data collected by the AMS.
- Support the inclusion of weather-related information from RWIS to support operational adjustments based on real-time or forecasted weather conditions that may have an impact on roadway operations or safety.
- Support the inclusion of weather-related information from RWIS to support response plan generation.
- Support the integration and operation of standard ITS devices/subsystems, such as CCTV cameras, DMS and other systems similar to those already deployed on area freeways.
- Integrate critical data streams, as reasonable to streamline AMS system operator functions.
- Support the integration of traffic signal control alert functions to facilitate the monitoring of traffic signal operations and maintenance needs.
- Archive historic traffic incident information as gathered by system operators (or such information entered into other actively used databases).

2.5 System Coordination

MDOT Metro Region arterials are currently operated or maintained through various partnerships with local agencies in some cases, including with the Macomb County Department of Roads (MCDR) and the Oakland County Road Commission (RCOC). In order to streamline management of the AMS, it will be necessary to enter into inter-agency agreements which will govern roles and responsibilities of AMS operations.

3 DEPLOYMENT LOCATIONS

The identification of high priority corridors in the Metro Detroit region is the first step in deploying an arterial management system. At this phase only US and M routes were considered as viable corridors for deployment. In order to effectively identify and prioritize the highest need corridors, each signalized intersection along these routes was analyzed. Each intersection's volume composition, crash statistics, and congestion levels was utilized as metrics. This data was compiled using both SEMCOG's metro regions transportation network and the michigantrafficcrashfacts.org website for crash data. This data was used to rank each signal from highest to lowest priority for each of the following variables: AADT, crash frequency, crash rate, crash rate to critical crash rate ratio, volume to capacity ratio, transit ridership, and freight volume.

In addition to quantitative statistics, other important qualitative variables were considered critical in our identification of high priority corridors: understanding the geographical significance of arterials in how they might "fill gaps" in between existing freeway segments; understanding how an arterial might serve different needs based on commuting and transit use, or use by commercial vehicles for delivery of goods for manufacturing; taking into consideration major construction planned for freeway segments and how the temporary and in some instances permanent traffic pattern changes might impact the use of arterials; and consideration of previously deployed or planned technology and solutions that are present along certain corridors.

In the following sections, maps depicting the top 100 intersections of each variable will be displayed and the top corridors from each map will be identified.

3.1 Crash History

Three years of crash data from 2011 to 2013 was used to analyze the crash history of each intersection. Using this data, three variables were derived to rank the signals by their relative safety level:

- Annual crash frequency was used to identify the highest crash locations, although this metric is biased against lower volume intersections.
- Crash rate was calculated at each intersection to identify locations with high numbers of crashes relative to the total entering volume.
- A ratio of crash rate over critical crash rate identifies intersections that have a significantly higher crash rate than the average Metro Region intersection. A ratio greater than or equal to 1 means the intersection has a crash rate that is higher, with a 95% percent confidence level.

Utilizing these three metrics together will allow for the identification of the locations with the most significant crash histories which may be mitigated in part by technology solutions. Figures 2-4 illustrate the locations identified using these three measures.

The top crash history corridors identified from Figures 2-4 are:

1. M-59 (Hall Road): M-53 to I-94
2. M-153 (Ford Road): County Line to M-39
3. M-59 (Hall Road): Teggerdine Rd to US-24
4. M-97 (Groesbeck Hwy): M-59 to I-696
5. M-1 (Woodward Ave): I-75 to I-94
6. US-24 (Telegraph Road): I-94 to I-96
7. M-3 (Gratiot): I-696 to M-59

Figure 2: Top 100 Crash Frequency Locations

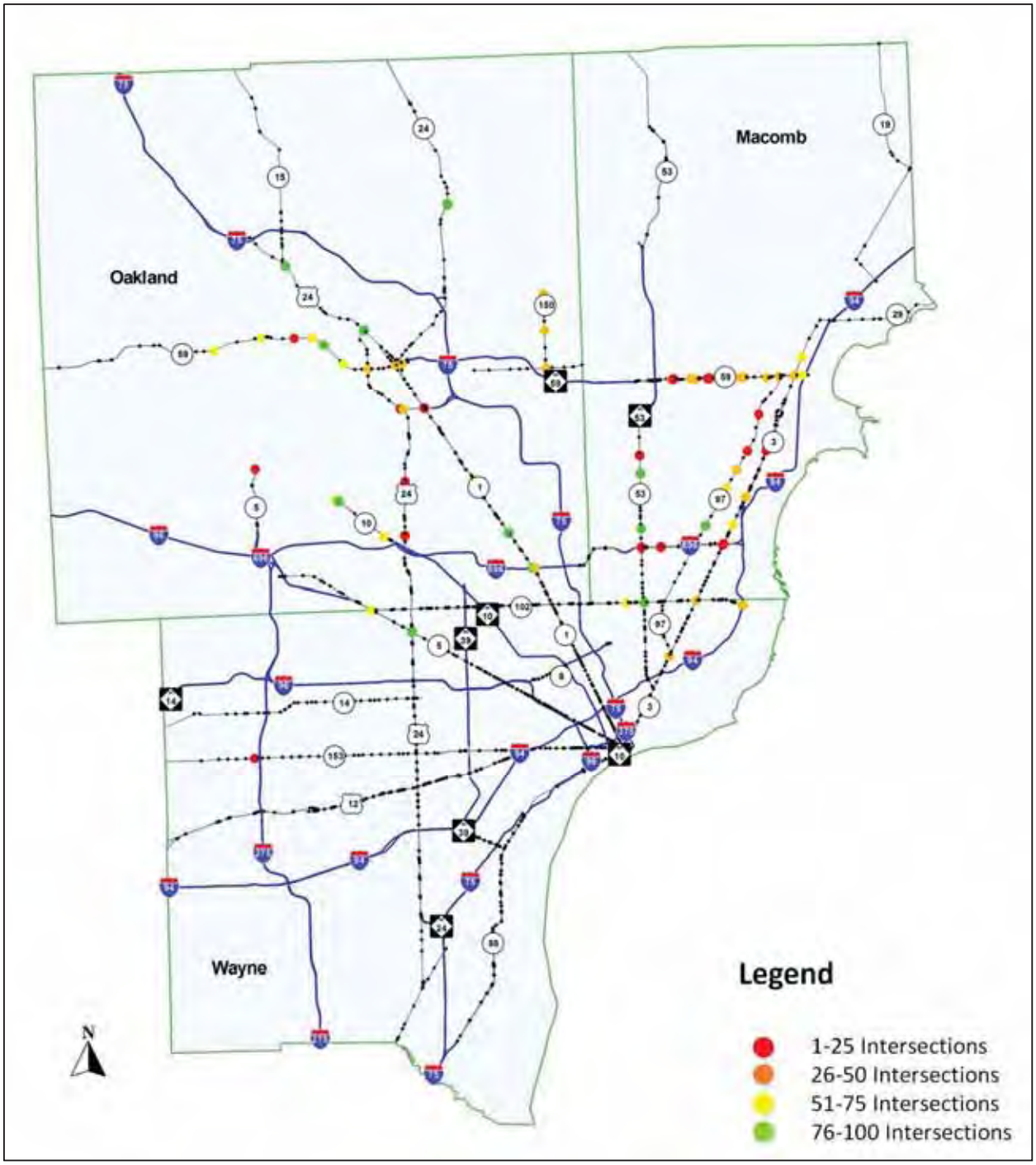


Figure 3: Top 100 Crash Rate Locations

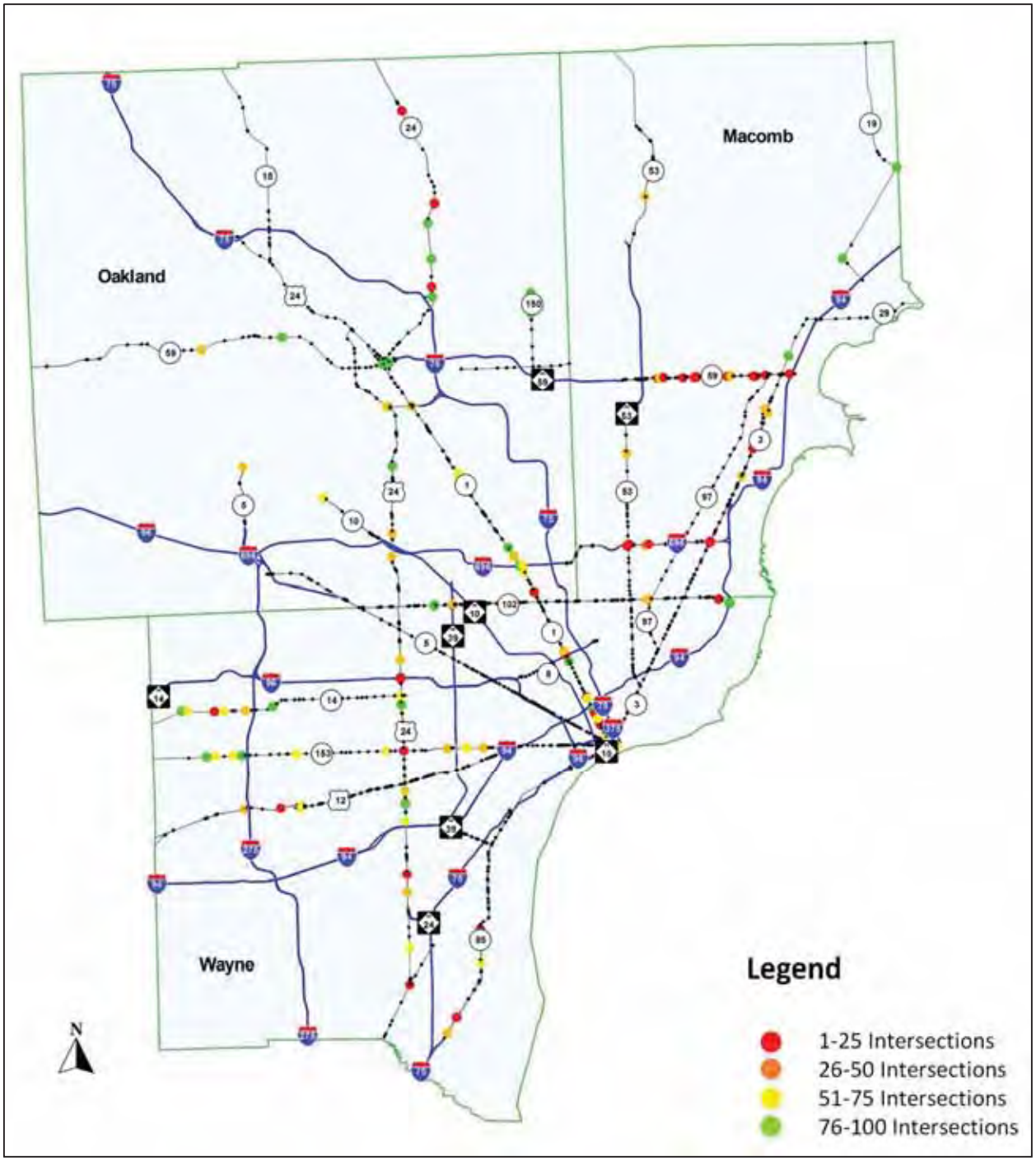
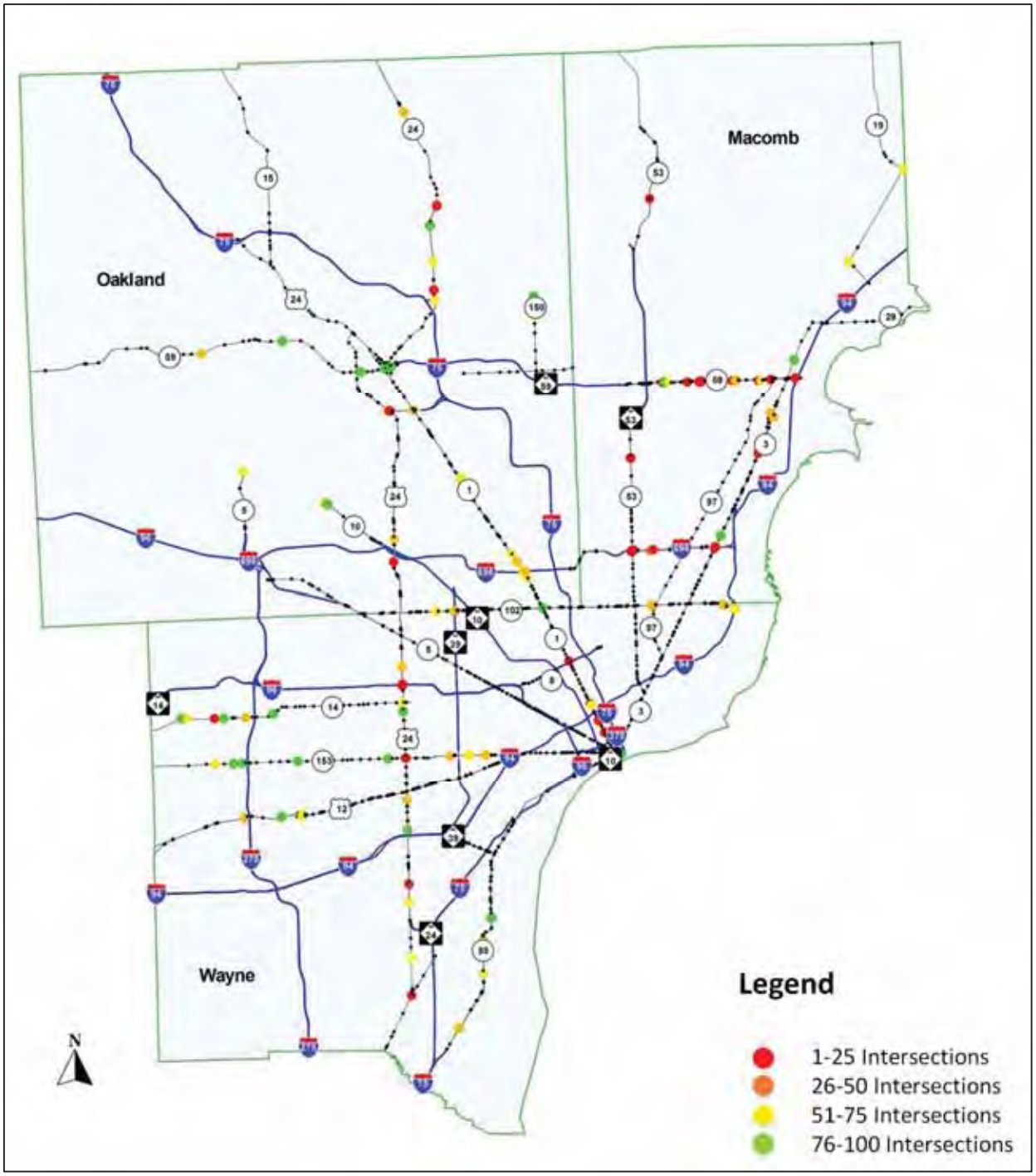


Figure 4: Top 100 Critical Crash Ratio Locations



3.2 Volume and Congestion

By utilizing the Southeast Michigan Council of Governments (SEMCOG) Travel Demand Model, an approximation of Average Daily Traffic (ADT) entering each intersection in the region was able to be calculated. Corridors with large volume reflect the importance of the facility and will maximize the exposure of the proposed ITS infrastructure to connected vehicles in the future. In addition, SEMCOG's transportation network has geometric features and the capacity of each roadway in Metro Detroit. Using this network, a volume over capacity (V/C) ratio was calculated for the legs of each intersection. The highest V/C ratio among the four legs was selected as the worst case scenario. If the V/C ratio is equal to or greater than 1 this signifies that the intersection is experiencing congestion, high delays, and poor level of service. This map illustrates locations which experience capacity issues on a typical day, which ITS and operational technologies may help to mitigate. Figures 5 and 6 illustrate the top 100 locations for both of the variables.

Corridors were identified by the number and the proximity of the intersections along them. Therefore, corridors that had a high number of identified intersections in any of the two variables was noted and identified as potential candidates for future consideration.

The top volume and congestion corridors identified from Figures 5 and 6 are:

1. M-3 (Gratiot): I-696 to M-59
2. M-5 (Grand River Ave): M-39 to Middlebelt Road
3. M-53 (Van Dyke): 8 Mile to 14 Mile Road
4. M-59 (Hall Road): M-53 to I-94
5. M-150 (Rochester Road): M-59 to Tienken Road
6. M-10 (Northwestern Hwy): I-696 to Orchard Lake Road
7. US-24 (Telegraph Road): I-696 to US-24 BUS

Figure 5: Top 100 Highest Volume Locations

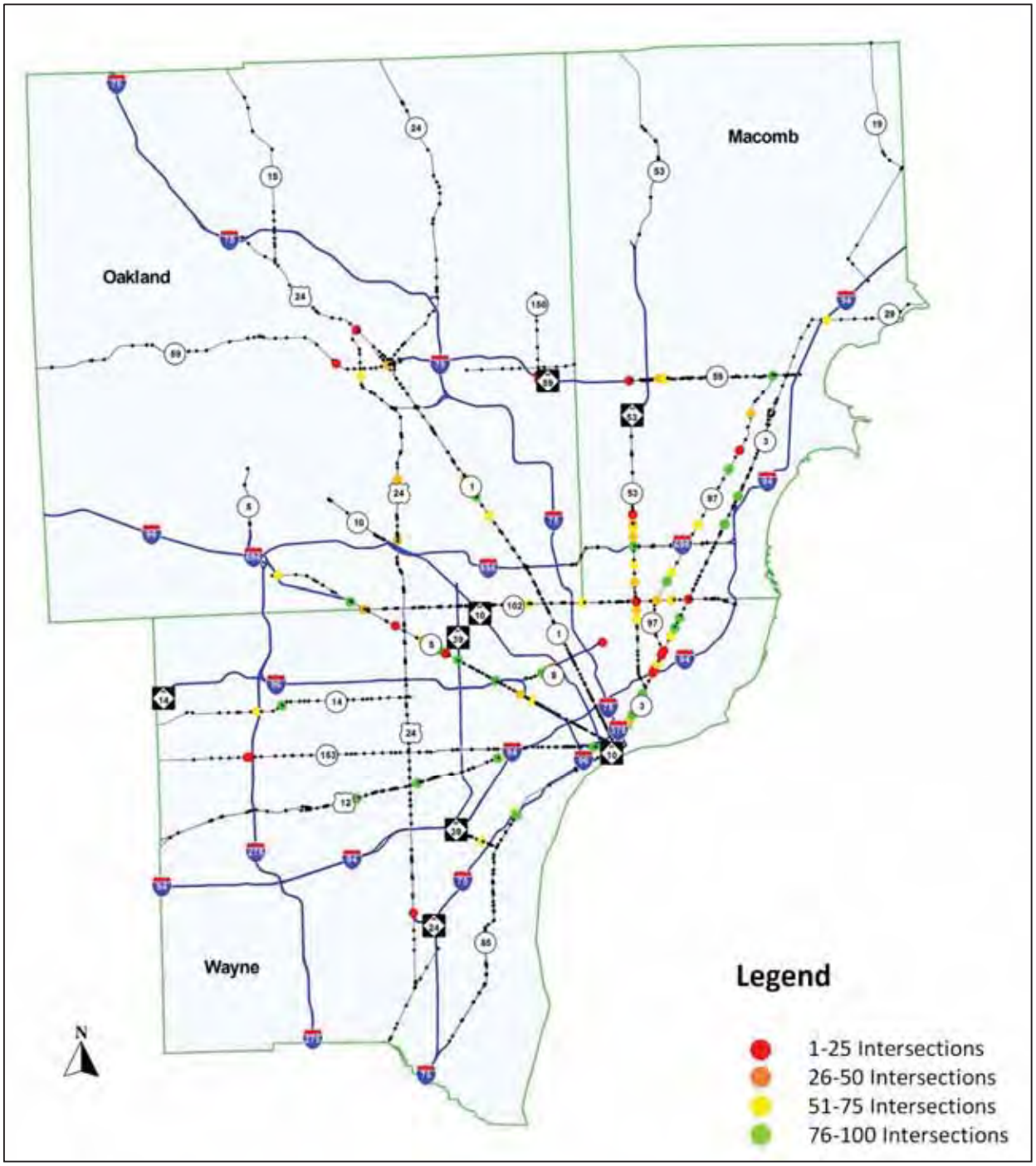
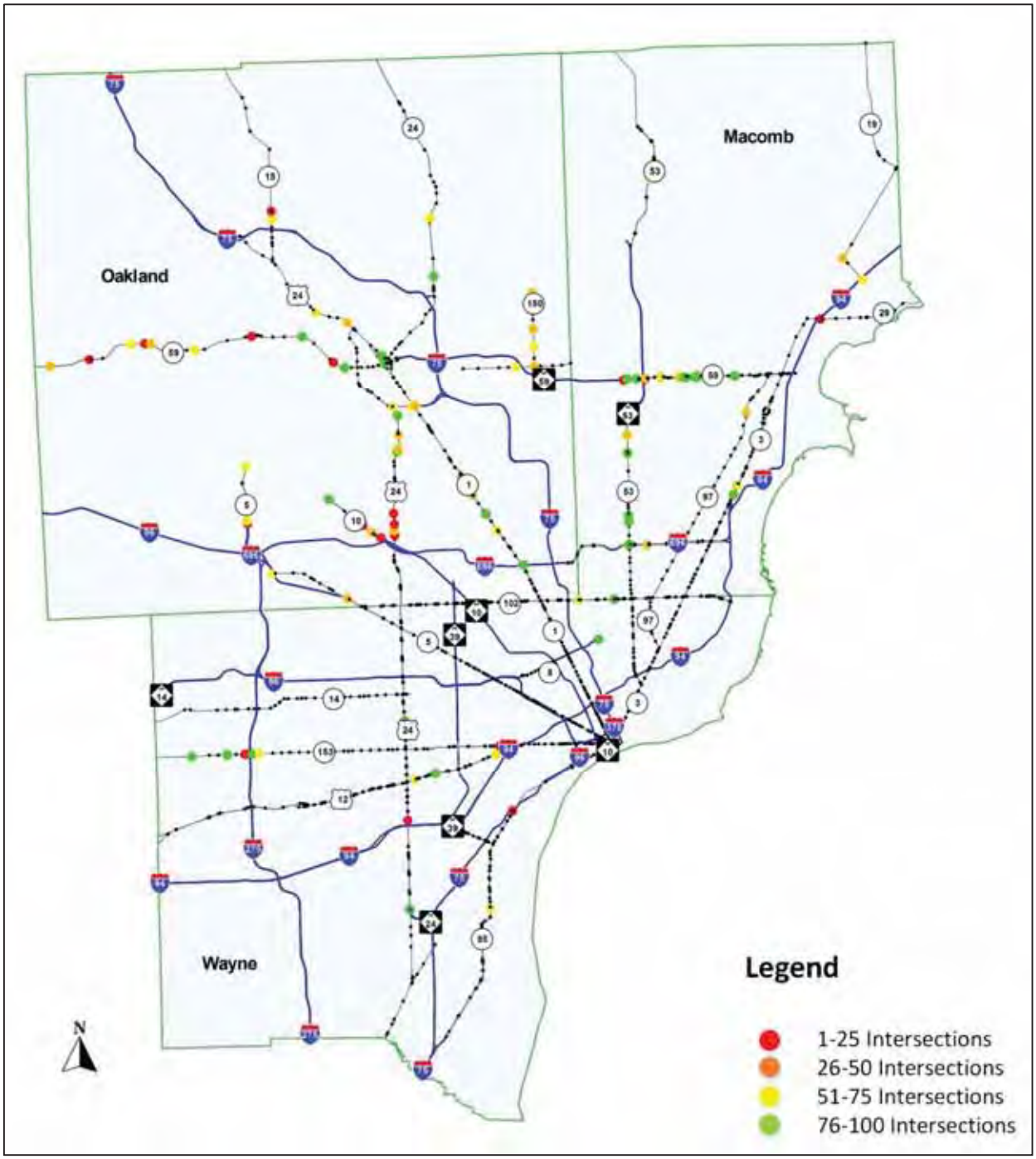


Figure 6: Top 100 Highest Congestion Locations

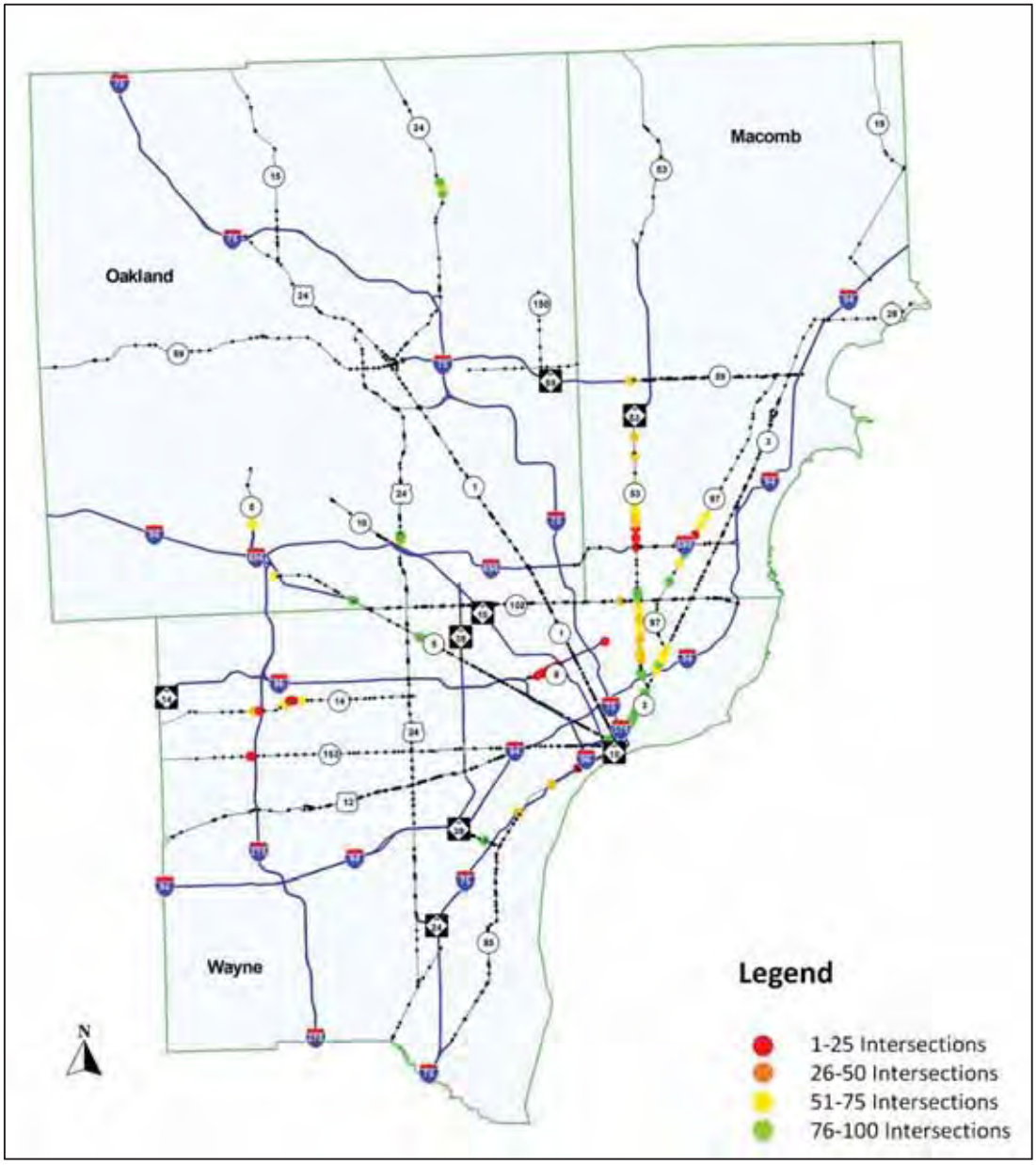


3.3 Corridor Function

How each corridor is utilized by motorists, freight, and transit lines will influence the attractiveness of the corridor for ITS deployment.

Heavy Vehicle Volume/Goods Movement: Transit and freight vehicles are large and decrease the capacity of the roadway that is traveled. Further, just-in-time goods movement is a critical consideration for businesses in Southeastern Michigan and affects the attractiveness of the region for manufacturing operations. The SEMCOG travel demand model was utilized to total the total heavy and medium vehicle volumes passing through each intersection. Top heavy vehicle intersections are depicted in Figure 7.

Figure 7: Top 100 Intersections for Heavy Vehicle Volume



It can be seen in Figure 7 that the following routes are major freight routes: M-8 (Davison St), M-3 (Gratiot), M-53 (Van Dyke), and M-97 (Groesbeck Hwy).

Transit Use: Transit is another potential key user of ITS applications along arterials. Ridership data was gathered from the two regional transit operators, the Detroit Department of Transportation (DDOT) and the Suburban Mobility Authority for Regional Transportation (SMART) in order to identify the intersection locations through which the highest passenger ridership occurs on a daily basis. These intersections are illustrated in Figure 8.

Figure 8: Top 100 Intersections by Transit Ridership Throughput

The corridors of M-5 (Grand River), M-1 (Woodward Ave), and M-3 (Gratiot) are the major transit lines in the City of Detroit. The current construction of the M-1 rail that runs from Downtown to New Center will further add transit traffic to this corridor. Additionally, SEMCOG and the Regional Transit Authority

(RTA) are currently studying the implementation of Bus Rapid Transit (BRT) along the M-1 and M-3 corridors, which would further increase their importance in terms of transit movement.

Freeway Alternates/Bypass Routes: Many regional arterials serve in the role of an alternate route for regional freeways in the case of an incident, severe congestion, or construction activities. MDOT has previously recognized the important roles of arterials in such cases, taking an Integrated Corridor Management (ICM) approach in three locations throughout the region, using nearby local and county roadways as alternate routes in the case of freeway incidents. Similarly, many of MDOT's regional arterials could serve as alternate routes during incidents along freeways, and could potentially benefit from an ICM approach using ITS technologies. Figure 9 illustrates the arterials which most significantly serve as freeway alternates due to location and points of connection to the freeway system.

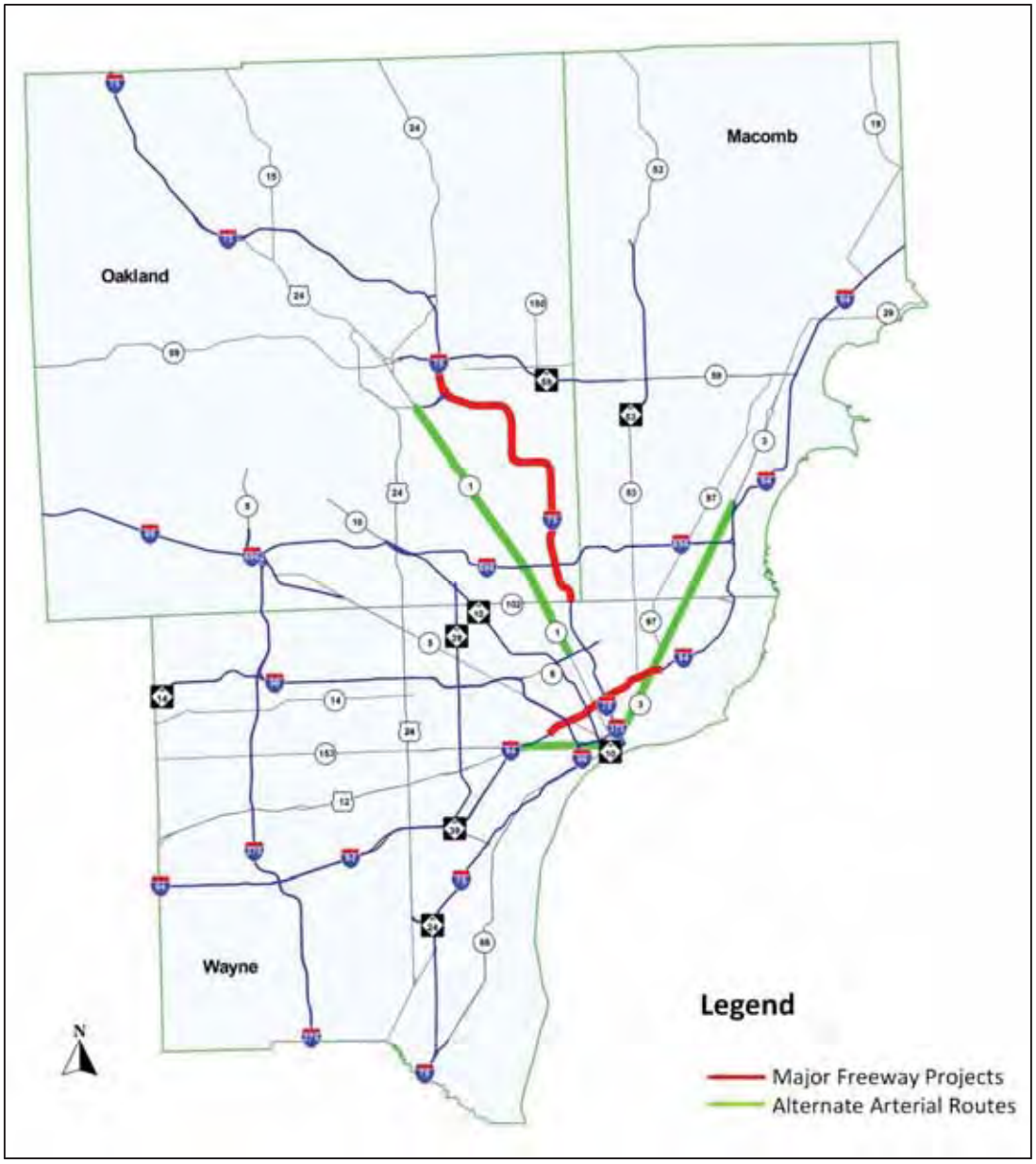
Figure 9: Major Freeway Alternates/Bypass Routes

In addition to typical congestion and incident conditions, two major long-term freeway reconstruction projects are planned in the Metro Region which will impact travel patterns throughout the region over many years:

- I-94: from west of I-96 to east of Connor Avenue in Detroit
- I-75: from M-102 (Eight Mile Road) to Adams Road in Oakland County

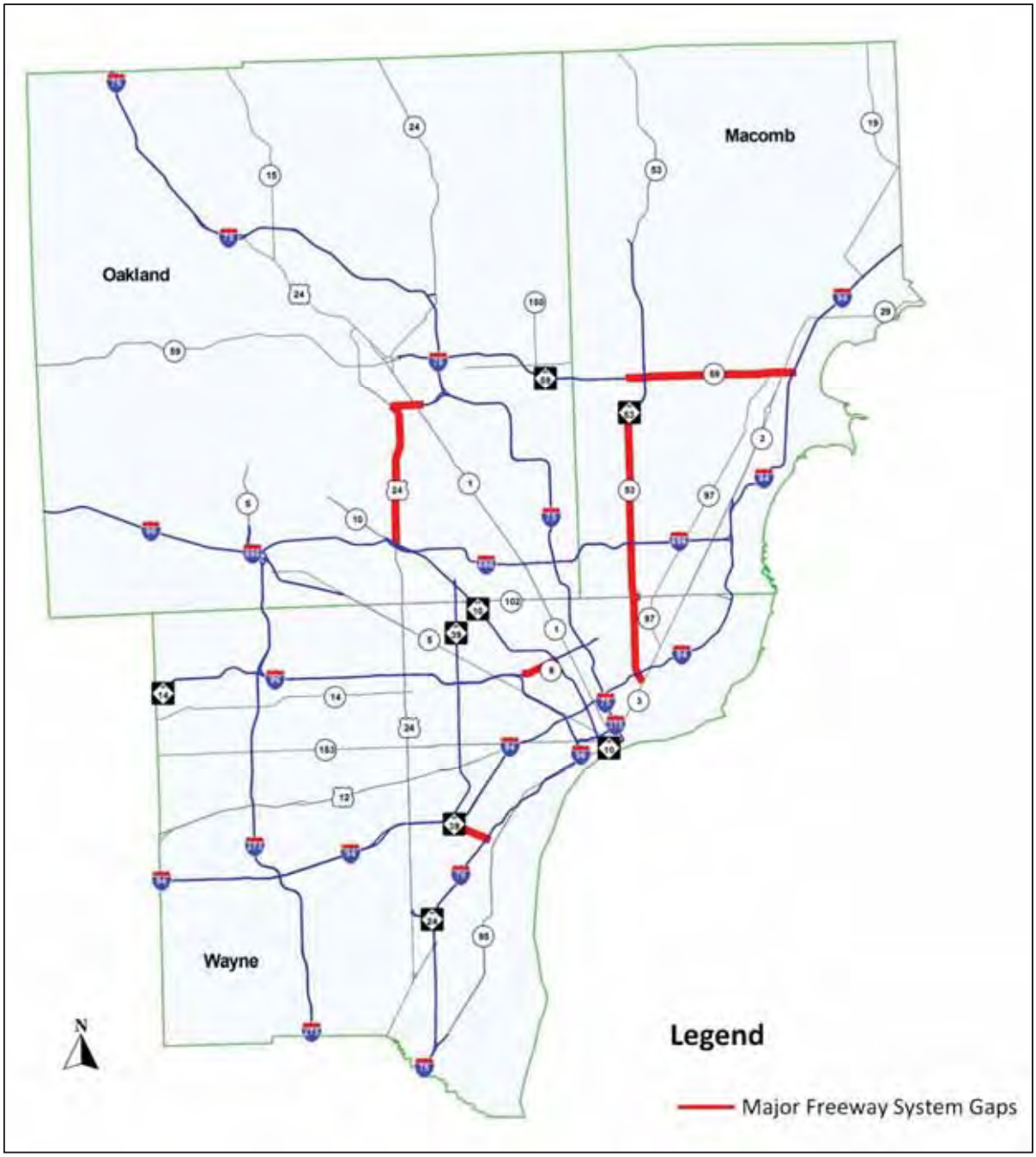
During these major projects, parallel regional arterials will play a significant role in mitigating traffic impacts and supporting traffic diversion from the freeway corridors. Figure 10 illustrates these two major freeway projects and the arterial corridors most likely to be impacted by traffic diversion during construction.

Figure 10: Major Construction Projects



Freeway System Gaps: Several segments of arterial roadway in the region have additional importance in that they fill gaps in the regional freeway network. These include a combination of locations which connect two segments of freeway via arterial, or complete high-volume link in an area without a nearby freeway option. These segments are typically characterized by high volumes, but would have a disproportionate impact on the surrounding roadway system during an incident or non-recurring congestion due to the importance of the segment in the regional network. Figure 11 illustrates corridors which complete major freeway system gaps.

Figure 11: Freeway System Gaps



Existing/Planned Deployments: Locations of existing or planned technology deployments were considered as a factor in determining the need for further investment in corridor locations. While most MDOT arterials in the region have limited technology deployments (either field devices or signal system communications), several locations have been (or are planned to be) equipped with such systems:

- Macomb County locations: The Macomb County Department of Roads (MCDR) has installed an extensive network of traffic signal system communications and Closed-Circuit Television (CCTV) camera coverage throughout the county, including on MDOT arterial routes which MCDR helps to operate under an inter-agency agreement. These locations are integrated into MCDR's central signal system, allowing MCDR to monitor conditions and make changes to signal operations in coordination with MDOT signals staff. The following corridors have existing (or planned by 2016) signal communications and CCTV coverage at major intersections:
    - M-53 (Van Dyke Avenue): M-102 (Eight Mile Road) to M-59 (Hall Road)
    - M-97 (Groesbeck Highway): M-102 (Eight Mile Road) to M-59 (Hall Road)
    - M-3 (Gratiot Avenue): M-102 (Eight Mile Road) to M-59 (Hall Road)
    - M-59 (Hall Road): Van Dyke Avenue to I-94

- Oakland County locations: The Road Commission for Oakland County (RCOC) has integrated 122 MDOT signal locations onto the county's SCATS adaptive signal control system, with an additional 21 location in process. Communications to these locations are largely addressed via phone drop connections, although a limited number include wireless communications links. There are no additional devices deployed at these locations.

- Woodward Avenue: MDOT is current conducting the reconstruction of Woodward Avenue between Adams Avenue and West Grand Boulevard in Detroit, coinciding with the construction of the M-1 RAIL streetcar. This project includes the construction of signal system communications/interconnect and CCTV cameras along the corridor to support overall operations as well as increased transit service and the unique streetcar operations.

Existing/planned system locations are depicted in Figure 12.

3.4 Corridor Prioritization

The quantitative and qualitative factors presented in Sections 3.1-3.3 were all considered in order to determine a prioritization of corridors for AMS deployment. As a first step in this process, intersections were ranked overall based on the quantitative factors (each factor for which the top 100 regional intersections were identified). Each variable was normalized to a range of 1 through 10 and was totaled. Each variable was assumed to have an equal weight in this analysis. Figure 13 depicts the top 100 locations.

Once this ranking was complete, existing/planned system locations were then removed from consideration. The remaining locations identified in the top 100 intersections were then considered alongside other qualitative factors, each given varying level of priority:

- Alternate routes for major reconstruction projects (HIGH priority)
- General alternate routes for freeways (MEDIUM priority)
- Freeway system gaps (HIGH priority)

Figure 12: Existing/Planned AMS/Signal System Deployments

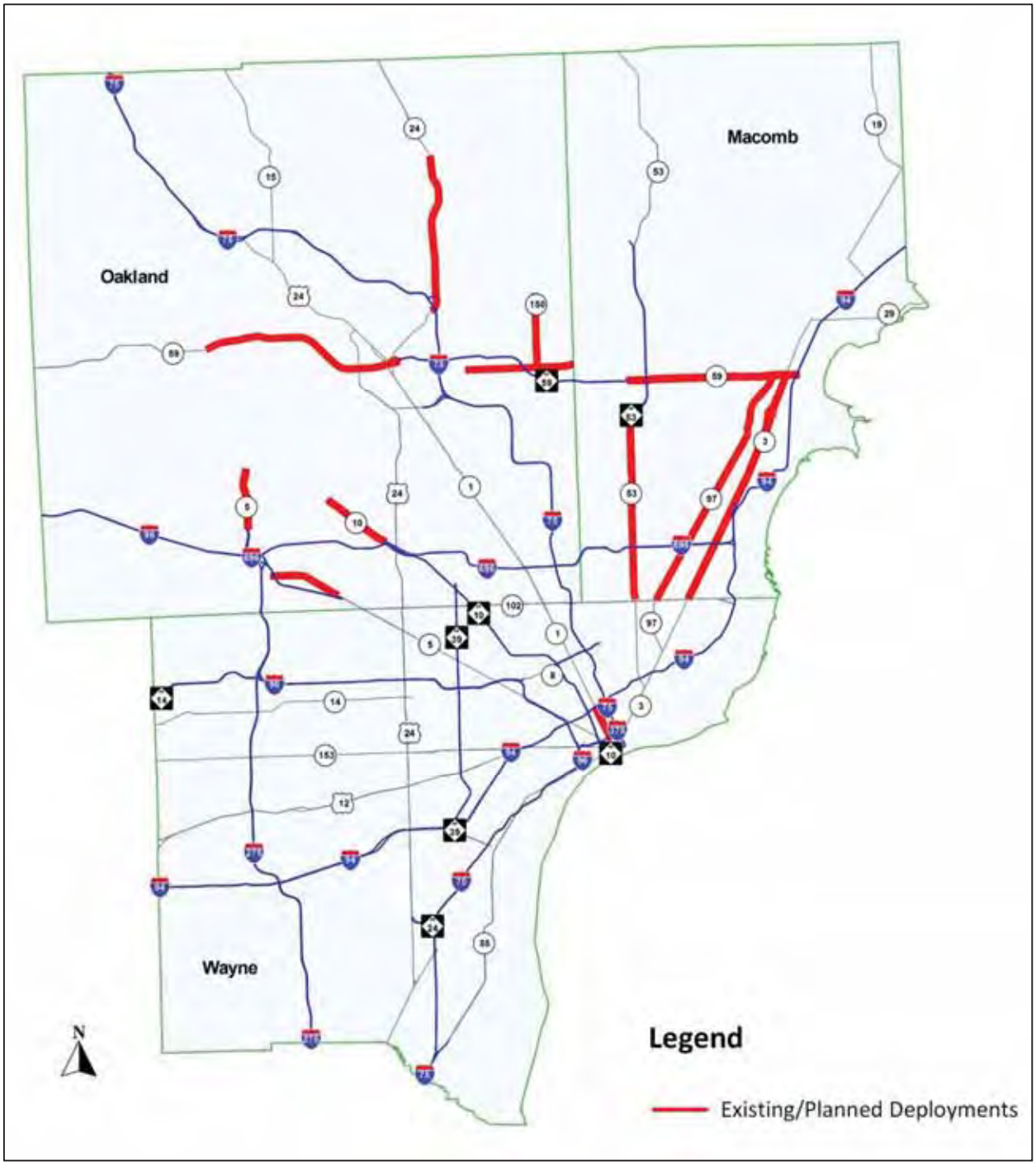
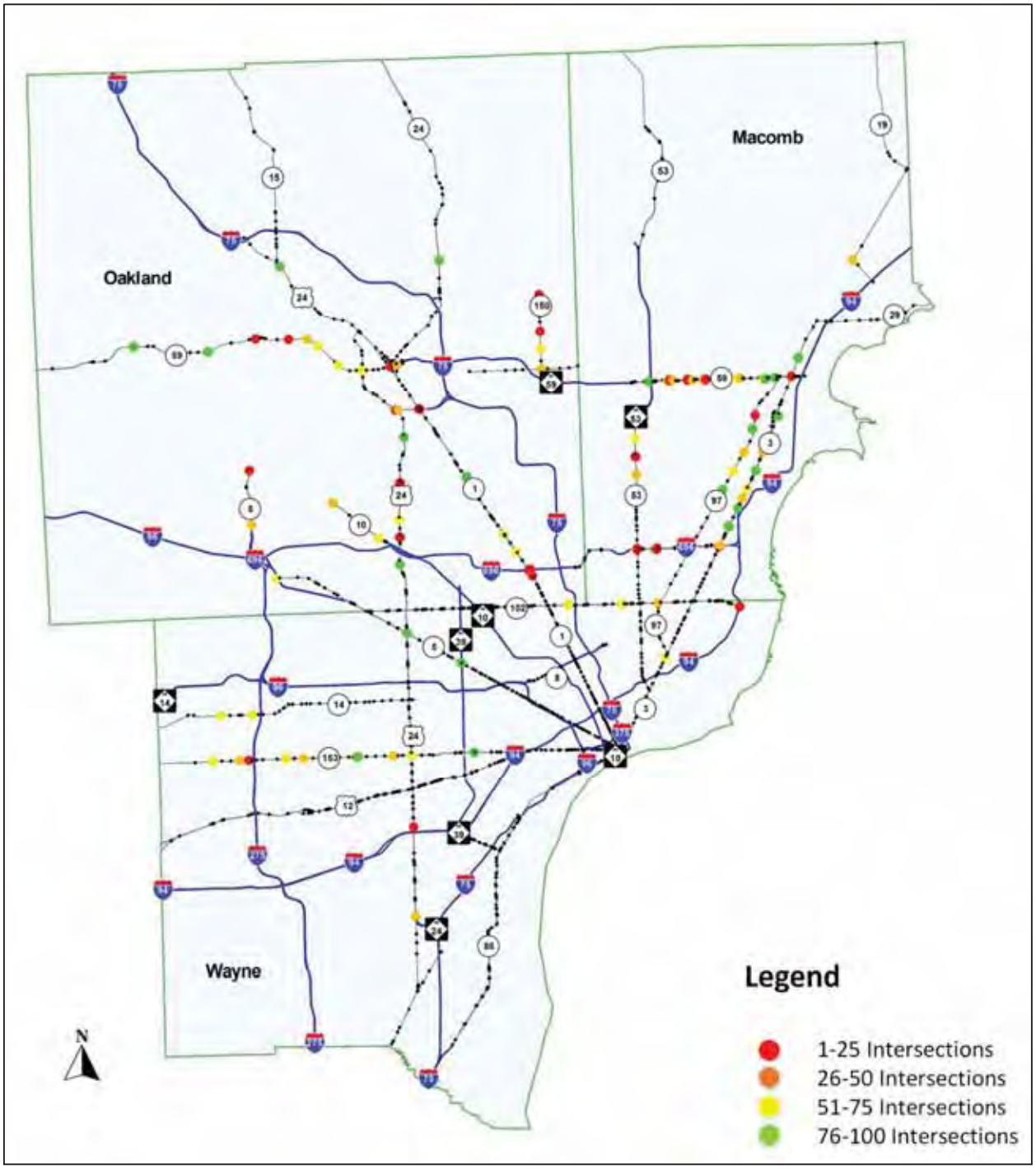


Figure 13: Top 100 Intersections by Quantitative Measures



The following locations recommended for the first two phases of AMS deployment based on this prioritization, as depicted in Figure 14:

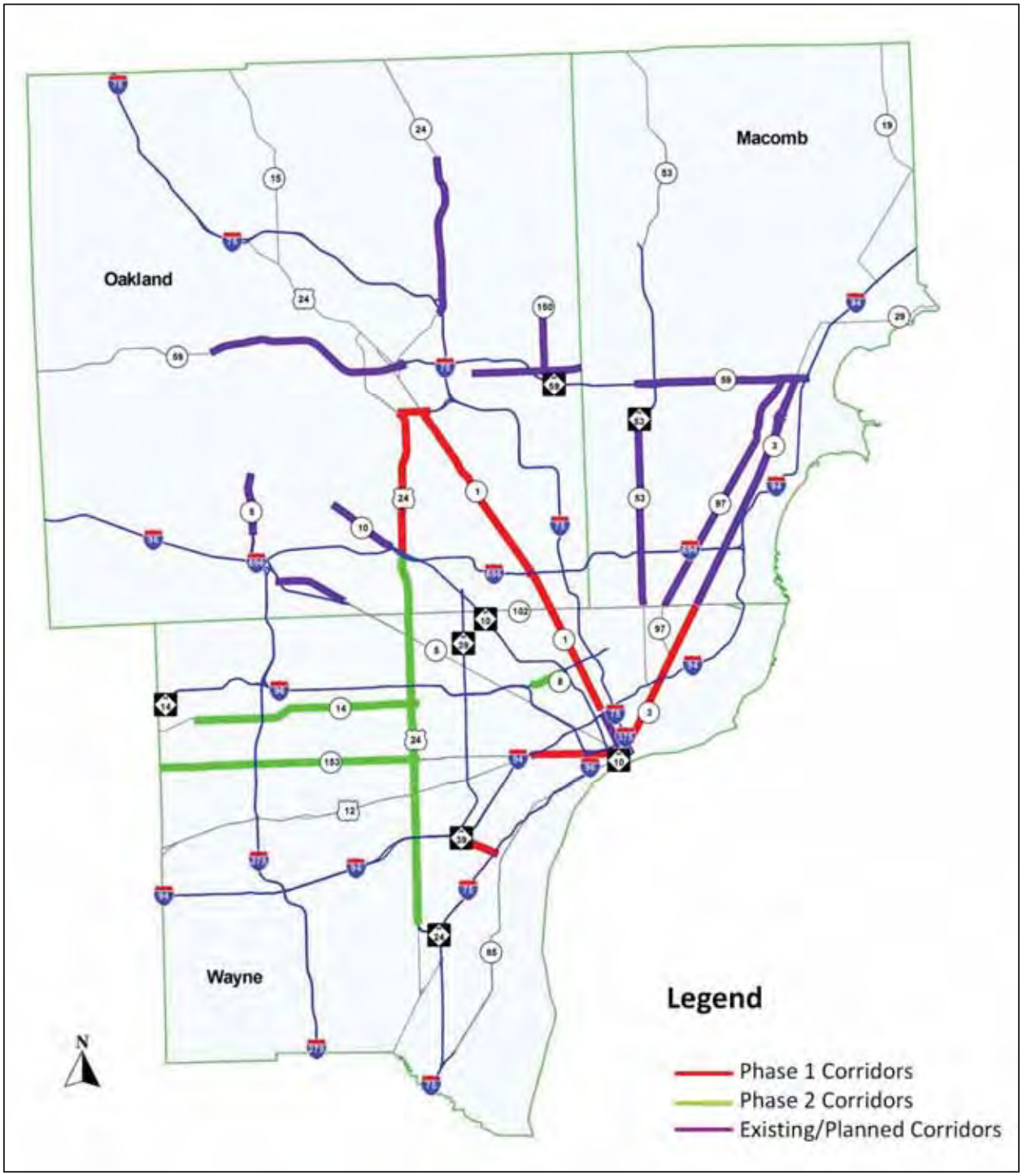
Phase 1 Corridors

- M-1 (Woodward Avenue): Grand Boulevard to M-102 (Eight Mile Road)
- M-1 (Woodward Avenue): M-102 (Eight Mile Road) to US-24 BL (Square Lake Road)
- M-3 (Gratiot Avenue): I-375 to M-102 (Eight Mile Road)
- M-39 (Southfield Road): I-94 to I-75
- US-12 (Michigan Avenue): I-94 to Third Street
- US-24 (Telegraph Road): I-696 to I-75 (via US-24 BL)

Phase 2 Corridors

- M-8 (Davison Avenue): I-96 to M-10
- Old M-14 (Plymouth Road): Downtown Plymouth to US-24 (Telegraph Road)
- M-153 (Ford Road): Canton Center to US-24 (Telegraph Road)
- US-24 (Telegraph): I-75 to I-94
- US-24 (Telegraph): I-94 to I-96
- US-24 (Telegraph): I-96 to I-696

Figure 14: Recommended AMS Corridors - Phases 1 and 2



4 DEPLOYMENT RECOMMENDATIONS

Three different system elements are envisioned to be implemented over time as part of the AMS deployment:

Element 1: AMS Infrastructure and Communications
Element 2: Operational Integration
Element 3: Connected Vehicle Infrastructure

Element 1 is the core of the AMS deployment, and is articulated as a first step which can be implemented independent of Elements 2 or 3 and still has the potential to achieve system benefits. Elements 2 and 3 represent deployment elements which would be initiated after the start of Element 1 to further increase system benefits and efficiency, and respond to advances in system technologies.

The following sections describe the deployment concept for each of these elements.

4.1 Element 1: AMS Infrastructure and Communications

4.1.1 Field Devices

Deployment Warrants
The criteria for deployment of ITS tools and solutions have long been a topic of debate among practitioners. Some of the ITS devices we utilize are covered under the Manual of Uniform Traffic Control Devices (MUTCD), while others have specific elements of the ITS device covered under national standards for interoperability (for example NTCIP, the National Transportation Communications for ITS Protocol). But additional tools for prioritization and location justification are still evolving at the national level and at this stage are still considered guidelines and not standardized warrants.

For more than 20 years a pooled fund study conducted by state DOT's have worked under the ENTERPRISE consortium, now including representatives from other countries and with significant involvement of the US Department of Transportation's Federal Highway Administration (FHWA). One of the consortium's key outcomes is "Planning Guidance for the Installation and Use of Technology Devices for Transportation Operations and Maintenance," a living set of lessons learned to help with the ITS deployment decision-making process. This work is specifically called out as planning guidance and not "warrants," eliminating the statutory/legal implications association with the publication of official warrants. MDOT is an official partner in the pooled fund ENTERPRISE consortium.

Combining the existing state-of-the-practice guidance with the ENTERPRISE guidance, a number of criteria are identified to be used to help prioritize and justify various AMS deployment segments. These criteria include but are not limited to:

- High traffic volume
- Commuter route to major metropolitan area
- Parallel corridor to freeways
- Fatality/injury accident location
- Courtesy patrol route (existing or future)
- Requested by TMC operators
- Prior accidents in the area

- Multi-modal access area
- Near major employment center
- Evacuation route
- Near major event generator (e.g., stadium or shopping)

It is logical to assume that within each corridor there might be a high priority intersection or location that would benefit from an immediate deployment of ITS technology. And while individual installations will provide a certain level of assistance, experience has proven that installation of ITS tools at several points along a corridor – and viewed as a system - have a significantly higher return on investment. In addition, construction costs are reduced if working along the same arterial rather than at independent locations, further boosting the cost-to-benefit ratio in a favorable direction.

Utilizing some of the above criteria to highlight segments of arterials – corridors within the corridors – we can then begin to review specific guidelines to determine which tools need to be deployed at various points along that segment. Table 1 highlights some of those considerations.

Additional Deployment Factors

In an unconstrained planning environment ideas and concepts can flow freely and deployment plans can be quickly labeled as unrealistic. It is important that during the process of prioritizing and establishing deployment plans the following challenges are taken into consideration to ensure this process moves forward efficiently:

- *Utility and Right-of-Way Considerations:* Device deployment should not be driven by utility considerations, but likewise those factors should not be ignored. An initial review of existing utility and ROW issues should be captured during preliminary engineering to ensure proper scoping of the deployment effort. It is possible that a segment could be lengthened or shortened – or a device added or delayed - due to the presence of ROW or utility issues.
- *Technology Choices:* Technologies are evolving rapidly, and long-term plans will invariably be limited in their ability to anticipate the impact of new technologies on deployment plans. It is therefore most important that the AMS strategy be scalable and adaptable to changes in technologies, with near-term deployments done with consideration of existing operations and maintenance capabilities, current practice with TMC personnel, the ability to expand as new demands are placed on the system.
- *Inter-Agency Coordination:* Consideration should be given to local agency systems in place on cross-streets to determine what approaches would most support not only MDOT arterial operations, but those of the region as a whole.
- *Funding:* Opportunities to break large corridors into segments should be considered, enhancing the probability of getting several segments done each construction season. Being able to show immediate benefits after Project #1 or #2, will facilitate more funding for Projects #3 and beyond.
- *Operational Policies and Standard Operating Procedures*: Are you implementing a tool that will not get used, or a tool that adds significant responsibility to an already strained system? If so, the procedures need to be addressed prior to making the final field connections or benefits won't be apparent and future projects could get shuttled.

Table 1: Considerations for Deployment of System Elements

System Element	Deployment Considerations
Upgraded and Networked Traffic Signal Controllers	• Capability for remote monitoring and access • Ability to support new timing plans and schemes • Facilitate interconnection of signal systems • Ability to provide Signal Phase & Timing (SPaT) data for connected vehicle applications
Deployment of Various Detectors	• Presence detection at signalized intersections • Mid-block travel time and presence detection • Volume, speed, and occupancy detection • Integrated corridor management • Pedestrian detection • Evacuation route monitoring
Deployment of Closed Circuit Television	• Placement to view frequent incident locations • Monitor any queue associated with planned or unplanned congestion • Allow maintenance dispatchers to view for weather impacts • Provide traveler information on congestion due to weather, special events, major employment centers, or work zones • Traffic signal operational verification and control changes • Other ITS Field Device verification
Deployment of Dynamic Message Signs	• Inform travelers ahead of decision points • Special event or evacuation notification • Weather information • Travel time information • Multi-modal information • Parking information • Frequent accident or congestion locations
Deployment of Roadway Weather Information System	• Site-specific data collection based on weather-related accidents or decision-points • Geographic balance as part of a larger RWIS network (filling gaps in data) • Allow maintenance dispatchers information for weather impacts and decision-making

Corridor-Specific Recommendations

Based on the identified user needs, specific geographic context and deployment considerations described above, AMS deployment concepts have been outlined for each of the Phase 1 and Phase 2 corridors identified in Section 3. These plans, included in Appendix C, detail corridor-specific deployment plans which identify recommended signals to be integrated, device locations, and communications topology and connectivity to the regional ITS communications system. Table 2 provides an estimated cost for deployment of each corridor.

Table 2: Element 1 AMS Deployment Costs

Roadway	Limits	Approximate Segment Length	Estimated Deployment Cost*
Phase 1			
M-1 (Woodward Avenue)	Grand Boulevard to M-102 (Eight Mile Road	6.0 miles	$1,650,000
M-1 (Woodward Avenue)	M-102 (Eight Mile Rd) to US-24 BL (Sq. Lake Rd.)	13.0 miles	$2,580,000
M-3 (Gratiot Avenue)	I-375 to M-102 (Eight Mile Road)	8.6 miles	$2,280,000
M-39 (Southfield Road)	I-94 to I-75	1.9 miles	$850,000
US-12 (Michigan Avenue)	I-94 to Third Street	4.7 miles	$1,400,000
US-24 (Telegraph Road)	I-696 to I-75 (via US-24 BL)	10.8 miles	$1,260,000
Phase 2			
M-8 (Davison Avenue)	I-96 to M-10	2.2 miles	$720,000
Old M-14 (Plymouth Road)	Downtown Plymouth to US-24 (Telegraph Road)	9.5 miles	$2,040,000
M-153 (Ford Road)	Canton Center Road to US-24 (Telegraph Road)	11.0 miles	$1,910,000
US-24 (Telegraph Road)	I-75 to I-94	6.0 miles	$1,140,000
US-24 (Telegraph Road)	I-94 to I-96	8.3 miles	$1,550,000
US-24 (Telegraph Road)	I-96 to I-696	7.3 miles	$1,190,000

*Estimated cost includes planning, design, and construction/integration in 2015 dollars

4.1.2 Communications Topology

Currently, any communication to MDOT traffic signals in the Metro Region is done via phone connections or county partner systems, and does not leverage MDOT's extensive communications infrastructure along the freeways. As part of this plan it is envisioned that this infrastructure will become the backbone for both freeway and arterial communications, with both signal system and traditional ITS data traveling over it. However, this represents a significant change in the use of the infrastructure, and will require both a topology that sufficiently protects access to the signal system and provides at least an interim pathway to remotely manage traffic signals using current operational approaches (either Lansing or regional signals engineering staff or partner agencies).

A communications needs workshop was conducted with key ITS and traffic signals staff in May, 2015, to evaluate both interim and ultimate needs for signal system communications in order to develop appropriate communications topologies. The primary need identified was the ability to access traffic signal communications over the internet for a range of users.

Figures 15 and 16 illustrate both the existing and recommended general communications topology for the AMS. Implementation of this topology will require a project coinciding with the first AMS deployment, which implements the following:

- Development of a Virtual Local Area Network (VLAN) for traffic signal system communications within the Metro Region ITS Network
- Provision of an internet circuit and associated firewall at SEMTOC (if existing circuits are not sufficient) for traffic signal communications to other MDOT and partner agency parties.

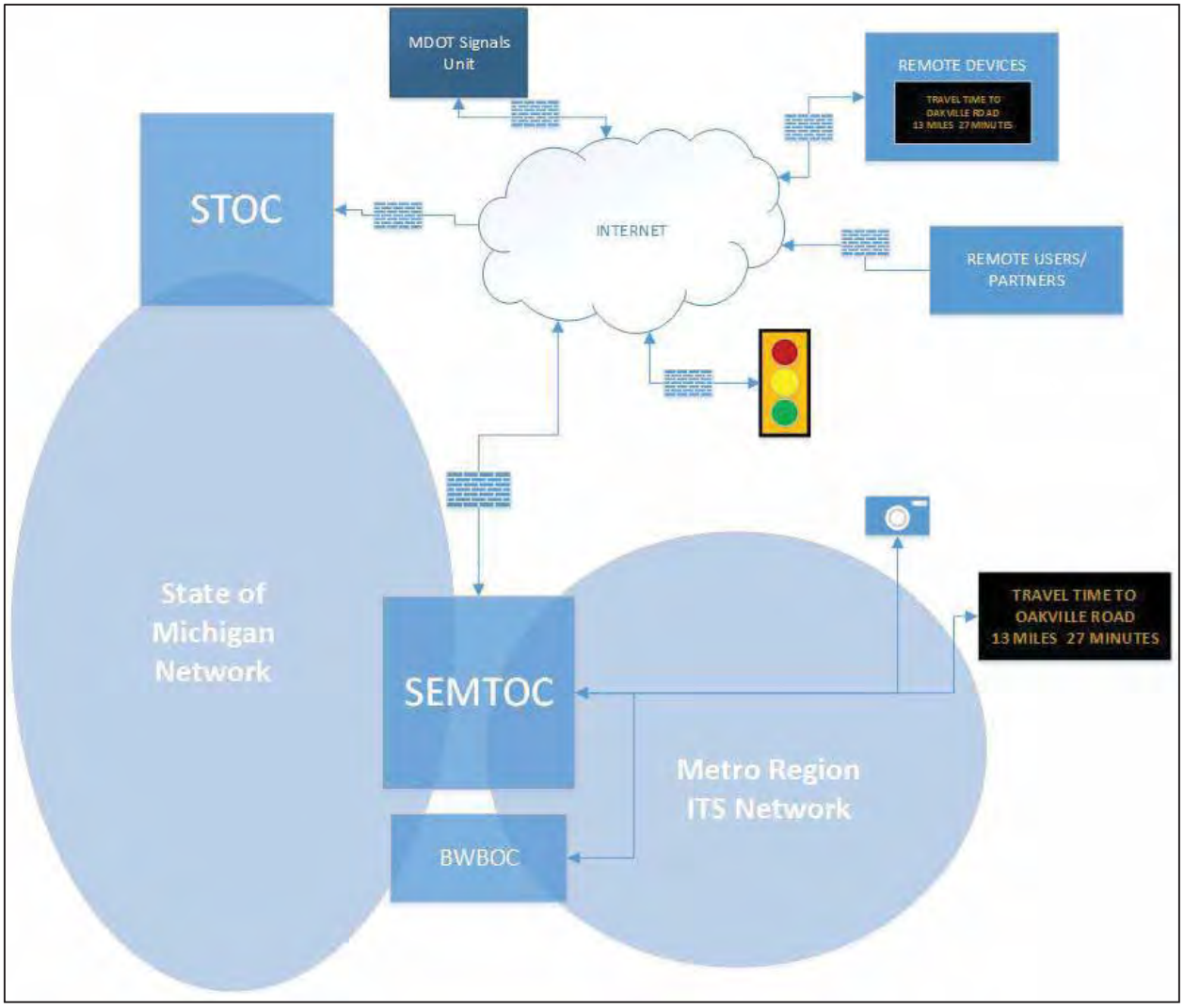


Figure 15: Existing Communications Topology

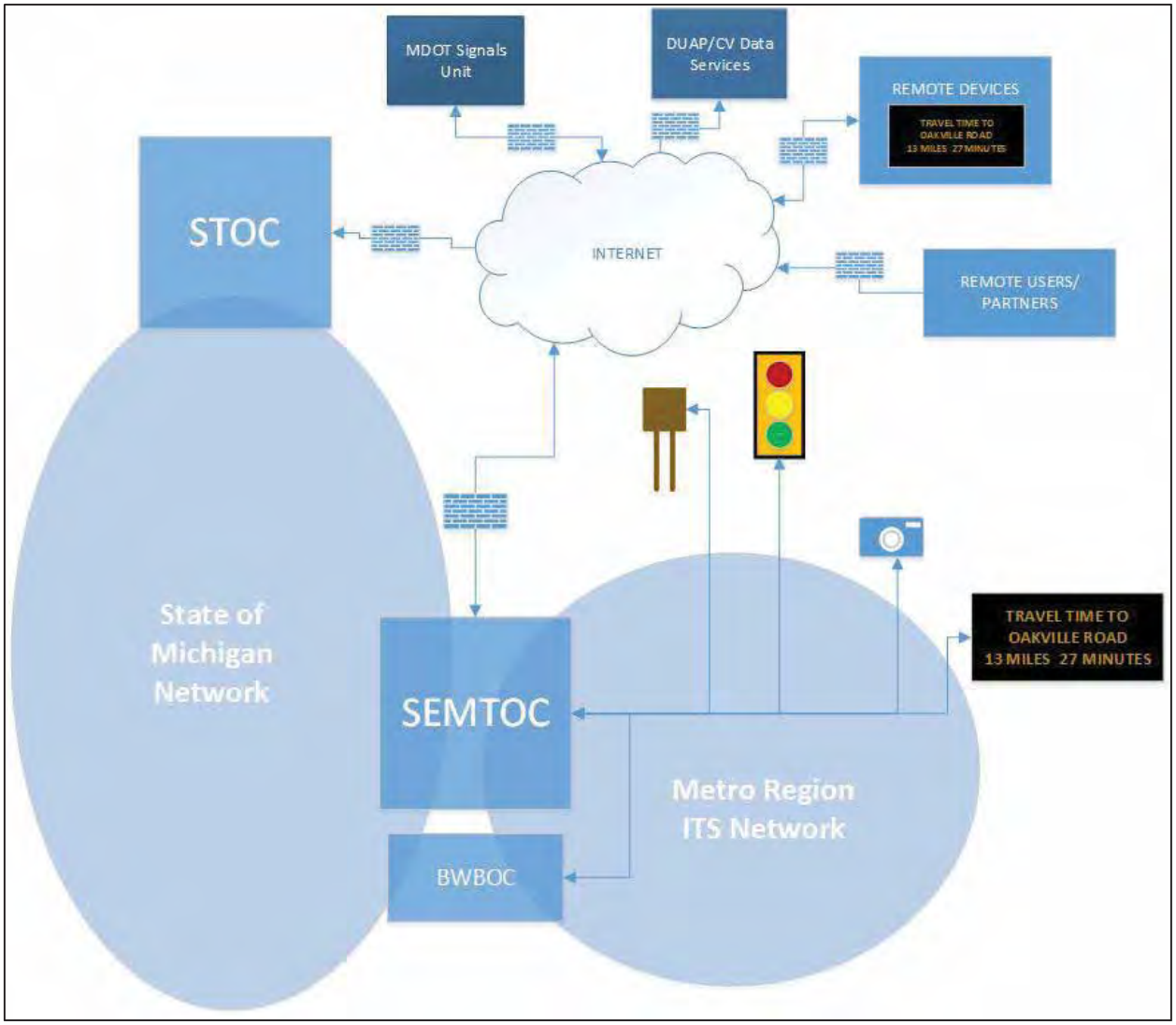


Figure 16: Recommended Communications Topology

4.1.3 Interim Operational Approach

Historically, MDOT has not incorporated traffic signal operations into TOC operations in the Metro Region. Most signals do not have systems in place for real-time monitoring and management, with those that do being operated generally by RCOC and MCDR. Signal operational decisions are largely made by the Lansing or regional signal operations staff through coordination with partner agencies. However, changes to this operational model have begun with the implementation of the three Integrated Corridor Management (ICM) pilots in various stages of deployment around the Metro Region.

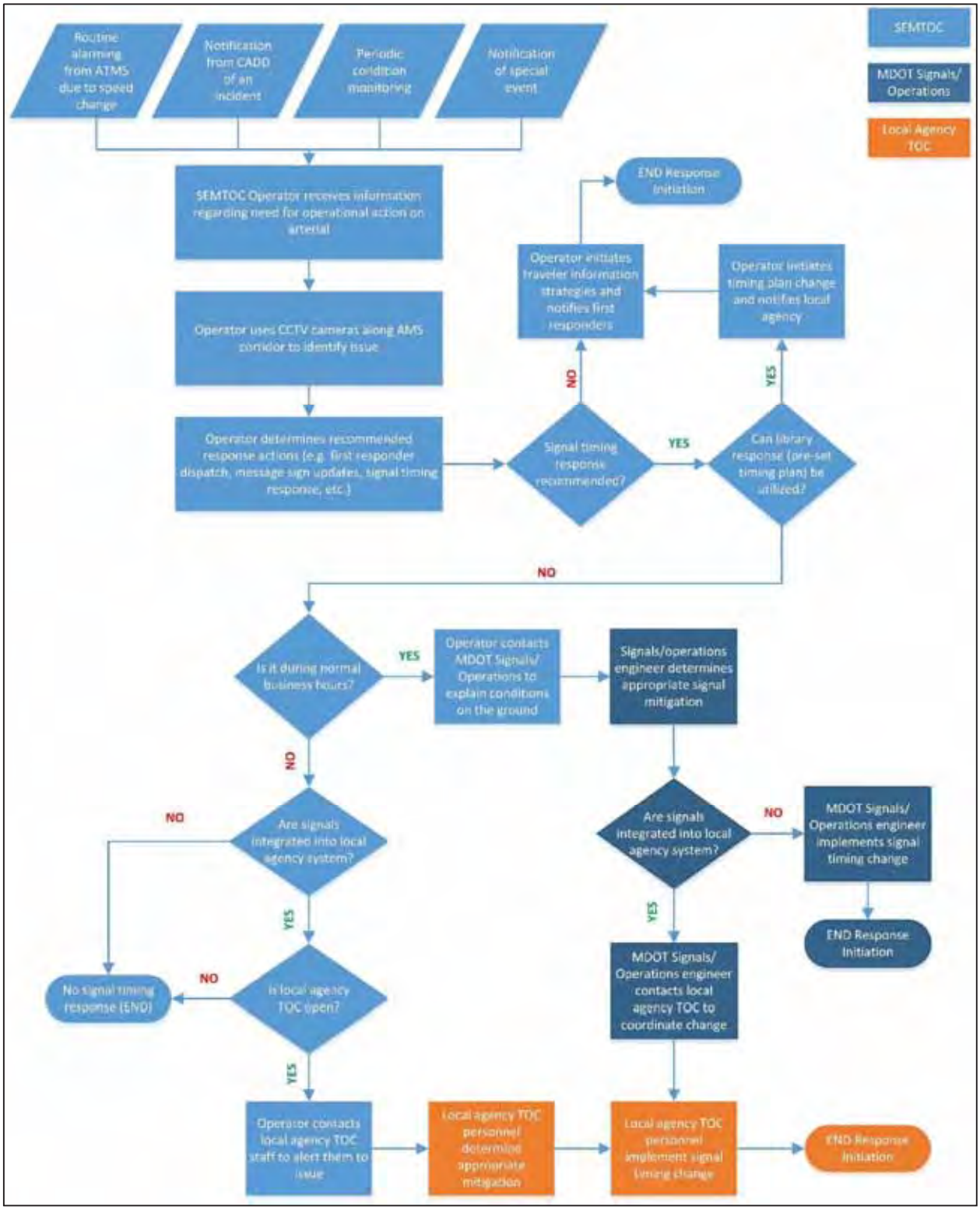
The ICM systems are intended to help manage incidents along freeway routes by providing dynamic route guidance and signal timing strategies on parallel portions of the arterial roadway system. Under the operational model developed for the ICM systems, SEMTOC operators would have the technical mechanism and authority to initiate a pre-programmed signal timing change along the ICM corridors in the event of an incident which is impacting a freeway in the ICM project areas, with notification being sent simultaneously to MDOT signals unit and partner counties of the incident and new timing plan being implemented.

Fully integrating signal operational control into TOC operations will require more significant changes in terms of operator staffing and expertise, and the development of standard procedures and protocols for making signal timing changes and operational decisions. These institutional changes to SEMTOC operations are likely to follow after deployment of the first AMS. Therefore, an interim operational approach which more closely mirrors the approach taken for the ICM system is assumed to be in place as part of Element 1 to accommodate the first AMS deployments until Element 2 (operational integration) is undertaken. This interim operational approach is envisioned to largely leverage the existing operational responsibilities of SEMTOC operators, the existing ATMS functionality, and increased communications between SEMTOC operators and MDOT and local agency traffic signal operations. Implementation of the interim operational strategy is expected to require the following actions:

- Updating of Standard Operating Procedures (SOP) for SEMTOC staff
- SEMTOC operations staff training
- Device (camera, DMS, detectors, etc.) integration into the existing ATMS software
- Traffic signal integration into existing signal control software packages used by MDOT and local agencies, and installation of a user interface to those software packages at SEMTOC
- Development of standard traffic signal plans for appropriate response scenarios (i.e. planned special event, traffic diversion due to incident, etc.)

Figure 17 illustrates a potential response flow to an incident or other operational event identified by a SEMTOC operator along an AMS-equipped arterial corridor. This is a high-level operational scenario which details only the processes with which a response would be *initiated*, not through full resolution. This process envisions that SEMTOC operators would have authority and technical means to initiate pre-programmed changes to signal timings in response to specific events from a response library. Any custom responses required would require coordination and approval from the MDOT signals unit and/or local agency TOC personnel.

Figure 17: Interim SEMTOC Operational Approach



4.2 Element 2: Operational Integration

Operational integration refers to the process of fully centralizing Metro Region arterial management system control at SEMTOC, and integrating all system functionality into MDOT's ATMS. The following sections outline potential steps for achieving operational integration.

4.2.1 ATMS Updates

MDOT is continuing to roll out new ATMS software in all statewide TOCs which is capable of controlling existing and planned ITS devices around the state. However, the ATMS package, Intelligent NETworks developed by Delcan Technologies, was not provisioned to include the traffic signal module as part of the software. Therefore, adding traffic signal control functionality at SEMTOC would require one of two strategies:

- Option 1: Install MDOT's current traffic signal control software (TACTICS) to operate in parallel to the existing ATMS (in whole or in part accomplished under Element 1), or;
- Option 2: Modify the existing ATMS to add the traffic signal module

In order to determine the appropriate path forward, it is recommended that a detailed requirements workshop be held focusing on required ATMS functionality, including SEMTOC and signals unit staff, to determine technical requirements. Using those requirements, a determination can be made as to whether they can be satisfied with Option 1, or whether Option 2 would be necessary to meet the requirements, and a cost/benefit analysis can be considered.

4.2.2 Operational Control

Under Element 1 it is envisioned that an interim operational approach be put in place under which SEMTOC staff have limited authority and technical ability to implement pre-programmed signal timing sequences in response to specific events from a response library. Under Element 2, the operational strategy would migrate to one in which SEMTOC staff have the authority and technical tools to conduct any signal operational changes in real-time. This approach would require a change in staffing strategy and/or staff training for SEMTOC operations in order to have sufficient resources and expertise for this increased responsibility. Among the factors to be considered in determining the best approach to this migration include:

- Hours of the day/days of the week where coverage is required
- Level of expertise required for operational changes to signals (engineer/engineering intern/technician/trained operator)
- Willingness/ability to outsource signal operations role
- Funding availability

In addition to deployment of the AMS, anticipated deployment of Active Traffic Management (ATM) systems on I-96 in Oakland County will similarly drive the need for greater traffic operations expertise at SEMTOC into the future. These factors together warrant development of a new model for operations which responds to these new needs within the existing funding profile or helps articulate the need for additional funding to fully yield the benefits of these systems.

Multiple operational models exist which could be utilized to introduce appropriate traffic operational expertise into SEMTOC operations:

- *On-Site MDOT Engineering Staff:* Create a new position (or relocate an existing regional operations or central office signal operations position) at SEMTOC for an engineer to be on-site. Although not required full time on the operations floor, having an on-site operations position would increase accessibility and speed of decision-making for operators who will identify issues and seek support with resolution.
- *MDOT Intern Position:* A well-trained MDOT intern could be introduced onto the operations floor, serving as a decision-maker or intermediary between the operators and MDOT engineering support. This model could be better aligned to introduce on-the-floor support. In addition, this approach could supplement on-site engineering support during off hours.
- *Outsourced Position:* similar to the on-site staff model, MDOT could include provision of an operations engineer as part of future TOC operations contracts. This model is currently utilized by MCDR for their TOC operations.
- *Outsourced Performance-Based Model:* The Atlanta region has implemented a fully outsourced operational model in which individual contractors are responsible for operations and maintenance of specific regional corridors, with a metrics-based performance contracts. Known as Regional Traffic Operations Program (RTOP), Georgia Department of Transportation has taken a multi-jurisdictional approach to improving traffic flow and reducing congestion on some of the region's busiest corridors (see Technology Evaluation Memorandum in Appendix A for more details).

As part of the requirements definition task envisioned for ATMS functionality, it is recommended that multiple groups within MDOT conduct a similar exercise to consider these and other operational models and balance resources to best achieve operational requirements.

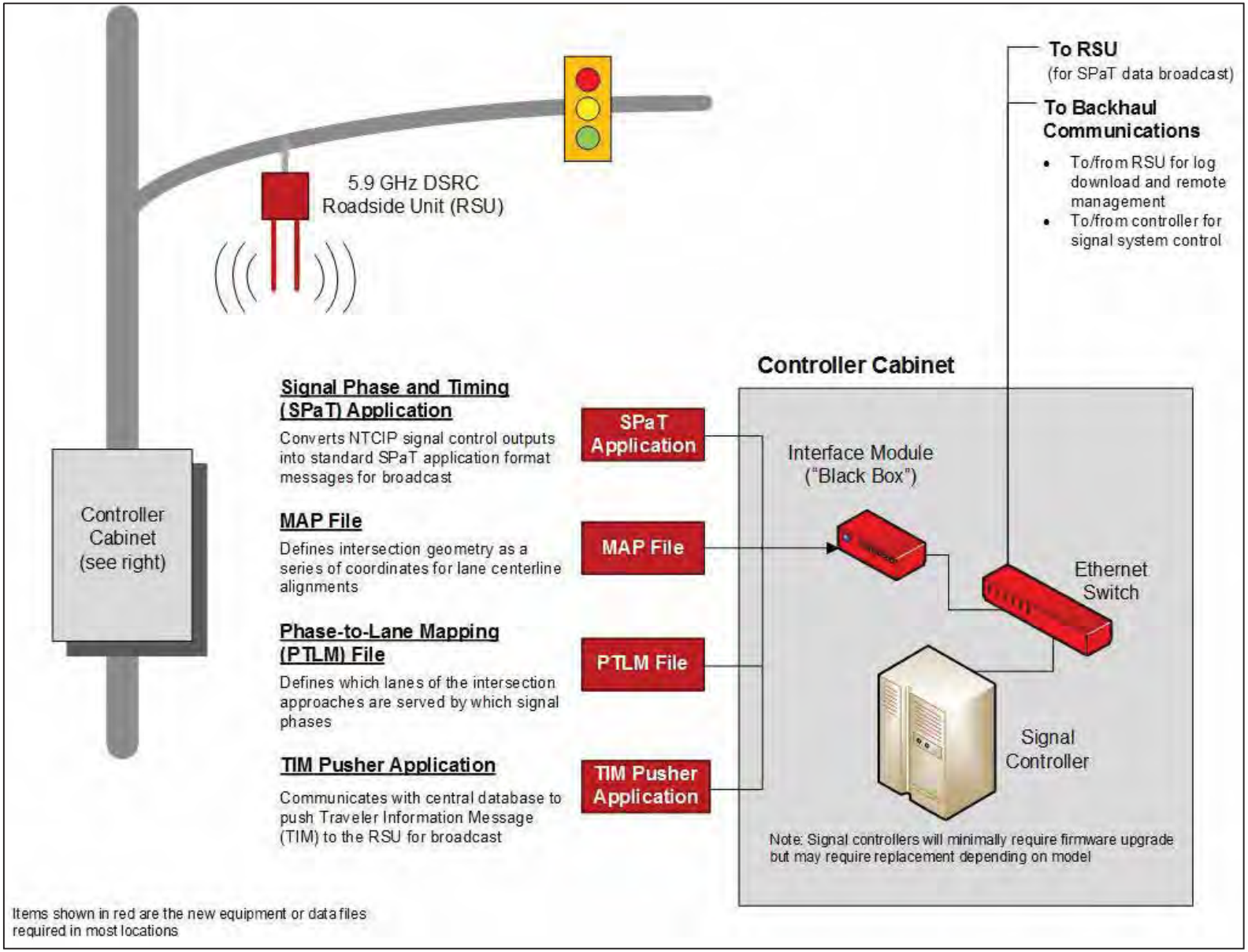
4.3 Element 3: Connected Vehicle Infrastructure

MDOT continues to be a leader in the research and deployment of connected vehicle technologies, initiating or supporting numerous deployments of Dedicated Short-Range Communications (DSRC) Roadside Units (RSUs) around the Metro Region to date. While connected vehicle deployments are on-going as part of various research initiatives, they are not yet integrated into MDOT's operational systems, nor is the deployment of equipped vehicles mature enough to warrant consistent, broad-based deployment as part of the AMS. While Element 1 will include various deployment steps to make locations "connected vehicle-ready," the following sections outline the steps for ultimate deployment of connected vehicle systems on Metro Region arterials as currently envisioned.

4.3.1 Field Infrastructure

While many connected vehicle applications will leverage third-party communications mechanisms, such as cellular, satellite radio and other mediums, the cornerstone of public-sector infrastructure for connected vehicle systems is DSRC and associated intersection-based RSU infrastructure, including next-generation signal controllers. Figure 18 illustrates the elements of a "connected intersection" as currently envisioned in the present connected vehicle architecture.

Figure 18: Connected Intersection Field Equipment



While MDOT is deploying field infrastructure in a number of locations around the Metro Region as part of various test beds and model deployments, broad-scale deployment is not yet recommended due to the limited extent of equipped vehicles in the overall vehicle fleet, and lack of mature Vehicle-to-Infrastructure (V2I) applications. MDOT is currently beginning a separate Concept of Operations and Deployment Plan for connected vehicle technologies in order to determine the best strategy and timing for approaching this deployment activity. That plan will consider the recommendations of this document, including initial AMS corridors which will have the foundational elements (communications, Ethernet switches, etc.) necessary for connected vehicle technology deployment.

4.3.2 Back Office Processing

In order for MDOT to collect and use connected vehicle data being broadcast from vehicles, the back-office processing systems must be put in place to capture the data, and put it to use in various applications which support agency functions.

Over the past several years, MDOT has undertaken the Data Use, Analysis and Processing (DUAP) program, with a goal of developing and piloting applications for use of connected vehicle data. This system is currently being modified to be able to capture data coming over current generation RSU networks being deployed by MDOT, and within the framework of the connected vehicle data architecture for the region being implemented as a pilot by USDOT. These modifications are intended to be scalable in order to manage data from new RSU deployments into the future.

4.3.3 Applications

While capturing over-the-air data off of vehicles is one key function of the RSUs for the benefit of MDOT, it is envisioned that the RSUs will be used to broadcast information to passing vehicles as part of a suite of V2I applications supporting safety, mobility and traveler information. Development of applications is still largely in the prototype stage, but it is understood that several applications may rely on data originating from MDOT (such as information on road construction or maintenance, travel advisories, road weather conditions, and others), with messages being developed, destinations being determined, and payload being “pushed” to field RSUs by MDOT/agency systems. Therefore, the development of this functionality is an important cornerstone of current and future RSU deployment in the region.

As part of the Smart Corridor initiative, MDOT is currently beginning development of a prototype of these messaging systems, in support of testing being conducted by several industry partners. This prototype system is being designed to support the Southeast Michigan connected vehicle support systems developed by USDOT in conformance with the emerging architecture standard, the Connected Vehicle Reference Implementation Architecture (CVRIA).

5 Specific Deployment Actions

The recommendations in Section 3 and 4 form the basis of the AMS deployment strategy, including near-term and long-term actions for full deployment and operational integration of the system. Some intermediate actions are also necessary to lead to steps for full implementation of this system vision.

Table 3 identifies discrete actions to be undertaken in the near-term to move towards AMS system deployment. For each action, the initiating and participating parties are identified, as well as the general sequence of activities required. Actions that can be undertaken immediately (which are either currently planned/underway, or do not require additional funding or other prerequisite steps) are noted.

Table 3: Deployment Plan Action Steps

Category	Action	Description	Parties (Initiating party in BOLD)	Sequence
1.0 Agreements and Operations and Maintenance Planning	1.1 Internal Signal Operations Agreement	Development of an agreement between SEMTOC and various units within MDOT responsible for signal operations and maintenance, on how an interim (Element 1) operational arrangement using pre-planned timing packages will work, including limits of responsibility and authority, standard operating procedures, event escalation procedures, and other matters.	***Metro Region Operations,*** SEMTOC operations, Lansing Signals Unit, ITS program office	Immediate
	1.2 Local Agency Operations Agreements	Development of an agreement between MDOT and each local agency with inter-agency maintenance agreements for MDOT arterials. The agreement should outline operational responsibilities and authority for each organization, procedures for delegating control, and communication requirements for coordinating between MDOT and local roadway corridors.	***Metro Region Operations,*** SEMTOC operations, Lansing Signals Unit, ITS program office, local agency operations and maintenance	Immediate
	1.3 SEMTOC Operational Planning and Contractual Impacts	Determine the ability under the current SEMTOC operational structure and contract to absorb the additional AMS management efforts on an interim basis, until additional funding or resources are programmed for the TOC, if necessary. Identify any required no-cost contractual changes related to scope and responsibilities for the operations contract, and execute contract modification.	***SEMTOC operations,*** operations contractor, ITS Program Office, Metro Region Operations	Immediate

Category	Action	Description	Parties (Initiating party in BOLD)	Sequence
2.0 AMS Corridors	1.4 AMS Maintenance Agreements	Coordinate maintenance responsibilities between MDOT signals maintenance (internal and contracted), existing or potential local agency maintenance agreements, and the statewide ITS maintenance contract. Identify additional funding requirements and sources for maintaining the AMS. Execute inter-agency or inter-departmental agreements as required.	***ITS Program Office/SEMTOC,*** Lansing Signals Unit, Metro Region Operations, local agency maintenance	Immediate
	1.5 AMS Maintenance Training	Training MDOT maintenance staff/ electricians on the maintenance of new AMS system components.	***Metro Region Operations,*** Lansing Signals Unit, ITS Program Office	Immediate
	2.1 Project Programming	Program the funding for Phase 1 (and Phase 2, if appropriate) corridors identified in this document, including capital and O&M funding.	***SEMTOC project development,*** ITS Program Office, Metro Region Operations, DTMB	Immediate
	2.2 Corridor Design	Conduct the preliminary and final design of corridor-specific projects as funding is available, including all physical infrastructure and systems to be installed along the corridor.	***SEMTOC project development,*** ITS Program Office, Lansing Signals Unit, Metro Region Operations, DTMB	After 1.0, 2.1
	2.3 Response Plan Design	In conjunction with each corridor design, develop response plans for use in each corridor, including pre-programmed signal timing plans, dynamic sign sequences, etc., as well as identifying the triggers for each response. It is recommended that this activity be conducted with the corridor design.	***MDOT Design Project Manager,*** SEMTOC operations, MDOT Signals Unit, Metro Region operations staff, local agency operations	With 2.2

Category	Action	Description	Parties (Initiating party in BOLD)	Sequence
3.0 Core Services	2.4 Corridor Construction/System Integration	Construct and integrate the corridor-specific systems. Integrate the traffic signals into the MDOT or local agency traffic signal system software. Program response timing plans. Program response sign sequences into ATMS.	***SEMTOC System Manager***, ITS program office, Metro Region Operations, DTMB	After 2.2
	3.1 Communications network design and configuration	Design and implement networking upgrades to the regional ITS communications systems in order to deliver new arterial devices and traffic signal communications to SEMTOC and to Lansing Signals and partner agencies (as appropriate). This project may be done in conjunction with the first AMS corridor project or as a stand-alone project, but must be in place at the timing of commissioning of the first AMS corridor.	***SEMTOC project development***, ITS program office, DTMB	With 2.2
	3.2 TACTICS interface installation	Install a TACTICS interface (either full package or simplified web interface) at SEMTOC for operator use in deploying pre-programmed signal timing plans. This project may be done in conjunction with the first AMS corridor project or as a stand-alone project, but must be in place at the timing of commissioning of the first AMS corridor.	***SEMTOC operations***, Lansing signals unit, Metro Region Operations, DTMB	With 2.4
4.0 Operations	4.1 Update SEMTOC SOPs	Update the standard operating procedures for SEMTOC operations to include use of the AMS, as defined in the intra- and inter-agency agreements, and based on specific response plans included in the first AMS corridor projects.	***SEMTOC operations,*** Metro Region Operations	After 1.1, 1.2, 1.3, 2.3

Category	Action	Description	Parties (Initiating party in BOLD)	Sequence
5.0 Future Element Planning and Programming	4.2 Operator Training	Conduct operator training as necessary in the new SOPs and use of new/updated systems for the AMS.	***SEMTOC operations,*** Metro Region Operations	After 4.1
	5.1 Operational Integration Requirements Definition	Conduct a workshop and requirements development exercise to determine both the technical requirements of the ATMS as well as the staffing requirements and model for fully integrating AMS operational control into SEMTOC.	***SEMTOC operations***, MDOT signals unit, Metro Region operations, ITS program office, DTMB	Immediate
	5.2 Budget Programming for Operational Integration	Develop budgetary requirements for integrated operational requirements and identify and program funding to meet requirements. Discuss (as appropriate) structural changes within department staffing to accomplish requirements.	***SEMTOC operations***, ITS program office, Metro Region Operations, Lansing Signals Unit	After 5.1
	5.3 Concept of Operations/Deployment Plan for Connected Vehicle Deployments	Develop a concept of operations and deployment plan for connected vehicle technologies in the Metro Region. The plan should identify locations, applications, and deployment timing, and consider plans and phasing for this AMS strategy.	***ITS program office,*** SEMTOC project development, Metro Region Operations, Lansing Signals Unit, DTMB	Immediate
	5.4 Development of Connected Vehicle Back Office Systems and Infrastructure	Develop systems and infrastructure to capture and process connected vehicle data, as well as develop and send appropriate messages for V2I applications.	***ITS program office,*** SEMTOC project development, Metro Region Operations	Immediate

APPENDIX A

ARTERIAL MANAGEMENT TECHNOLOGY EVALUATION MEMORANDUM

URS

Project Memorandum

To: **Michele Mueller (MDOT)**

From: **Matt Klawon (URS)**
Luke Liu (URS)
Maureen Peters (URS)

Client: MDOT
Project Name: Metro Region Arterial ITS Concept of Operations
Location: Metro Region
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Subject: **Arterial ITS Best Practices and Technologies**

The Michigan Department of Transportation (MDOT) seeks to investigate nationally-recognized technologies and best practices to improve mobility and safety as part of preparations and planning for the expansion of their intelligent transportation system (ITS) along Trunkline arterial corridors. As part of this investigation, MDOT has consulted Parsons Brinckerhoff and URS to perform an evaluation of existing arterial ITS deployments and develop a concept of operations that is applicable to the Metro Region. The purpose of this memorandum is to educate and inform MDOT and Stakeholders about the high-level research results and the in-depth details relating to existing deployments, while identifying lessons learned and adopted best practices, so that future workshops will yield productive discussions that can be held to establish the goals and requirements of the system.

The research portion of this study was multi-faceted. It began with an investigation of various ITS technologies and how the application of each may or may not correlate to improved traffic operations. Next, an evaluation of how various agencies applied such technologies was conducted to determine the successes and pitfalls of the deployments. Then the best practices and lessons learned were extracted from the investigated deployments and previous studies. Lastly, the project team organized some thoughts and ideas that are intended to initiate MDOT and other Stakeholders to begin thinking about a future MDOT deployment in advance of the first workshop.

ITS Technologies Evaluation

The term "arterial traffic management" can encompass a wide spectrum of explanations depending on who is asked. Typically, however, the common goals of improving traffic operations, mitigating congestion and reducing environmental impacts are at the core of the definition. The means and methods applied to achieve these goals tend to vary between deployments as a consequence of the unique regional characteristics. For example, Region A may have an intricate transit system that often conflicts with bicycle and pedestrian traffic operations while Region B may have a tightly knit traffic signal system that is failing to accommodate the heavy traffic volumes it encounters daily. In order to account for regional variations, planners have organized the variety of technologies to allow practitioners to understand the options available and how they may apply to the particular problem they are solving."

The commonly used ITS strategies and technologies have been bundled into "Market Packages"; which allow for the application of one or many strategies to be applied while maintaining consistency with predefined regional ITS architecture. The deployment of any one market package can yield improved operations, while a hybrid of several market packages within a single project may be able to solve many regional deficiencies at the same time. The various strategies that were researched as part of this project are discussed next and the applicable market packages are listed below each strategy.

URS Corporation
27777 Franklin Road
Suite 2000
Southfield, MI 48034
Tel: 248.204.5900
Fax: 248.204.5901
www.urscorp.com

Traffic Signal Control – Real-time monitoring and management of a traffic signal system allows signal timings to be updated manually or automatically (depending on the system configuration) as conditions change and can yield optimal results for corridor and region-wide traffic operations. Similarly, an advanced traffic signal system allows for maintenance monitoring and asset management from a remote location.

The "2012 National Traffic Signal Report Card" published by the National Transportation Operations Coalition (NTOC) presents the aggregate results of a nationwide self-assessment of multiple agencies' traffic signal systems. The NTOC received 241 responses to the survey, representing 39% of all traffic signals in the United States. The self-assessments revealed an overall grade of 69, or D+, thereby indicating a need for improvement in the nation's traffic signal operations.

In an effort to raise the grade of the nation's traffic signals and improve arterial traffic operations, advanced traffic signal systems are being integrated into operations around the country. Various systems are available and most can typically be tailored to meet the needs of the region. Some well-known, proven systems include SCATS (Sydney Coordinated Adaptive Traffic System), SCOOT (Split Cycle Offset Optimization Technique), ACS (Adaptive Control Software) and Siemens TACTICS software. Such systems are typically deployed along with a central computer or monitoring system.

Applicable Market Packages:
ATMS03 – Surface Street Control

Roadway Surveillance – Roadway information collected by means of closed-circuit television (CCTV) camera viewing or continuous roadway sensor outputs can provide critical real-time and historic information regarding corridor operations. Such information can be used to:

- Identify abnormal conditions quickly on arterials
- Develop and calibrate travel demand models
- Identify, implement and review changes to the traffic signal system
- Determine travel time on arterials and be able to disseminate the information to the public
- Forecast traffic volumes and assist in the development of future signal timings
- Control signals in a fully adaptive signal system for current conditions instead of using pre-determined time-of-day plans

Data collected from the roadway can aid in optimizing corridor performance, either manually or automatically, assist in incident and special event traffic management or allow infrastructure health checks to be performed remotely. Collected information can be shared with stakeholders and the public when appropriate communication equipment and agency agreements are in place.

Applicable Market Packages:
ATMS01 – Network Surveillance
ATMS07 – Regional Traffic Management
ATMS08 – Traffic Incident Management System
MC08 – Work Zone Management

Transit Management – The ability to know where transit vehicles are at any given time or being able to prioritize traffic signal phases to serve transit vehicles more efficiently can lead to a better managed transportation system, allow the system to service a greater amount of customers more quickly and encourage others to utilize transit in lieu of personal vehicles.

The use of automatic vehicle location (AVL) equipment on transit vehicles, when installed as a stand-alone module, can be used to monitor schedule adherence. When coupled with other technologies, such as global information systems (GIS) or computer-aided dispatch (CAD) technologies, schedules can be adjusted in real time, the number of trips provided can be optimized and information can be shared with passengers.

Where transit vehicles share the roadway with other vehicles, transit signal priority (TSP) can be integrated into signal operations to allow the transit phase to be serviced more efficiently. The installation of TSP equipment on transit vehicles and at traffic signals allows the signal system to detect when a transit vehicle is approaching a traffic signal and can therefore extend the transit phase green time or end an opposing red phase early, depending on where the signal is in the cycle. TSP is beneficial because it not only maintains schedule adherence, but also reduces delay for a greater number of road users.

Transit security systems can be installed on transit vehicles and at transit facilities to increase the security and safety of the passengers, drivers, equipment and facilities. Transit security technologies include radios, silent alarms, CCTV cameras and microphones. Such technologies can communicate on-scene security concerns to monitoring off-site personnel, who can then activate the necessary response to combat the issue. The implementation of security systems can protect both personnel and property, thereby making them valuable assets for the transit industry.

Applicable Market Packages:
APTS01 – Transit Vehicle Tracking
APTS02 – Transit Fixed-Route Operations
APTS03 – Demand Response Transit Operations
APTS05 – Transit Security
APTS08 – Transit Traveler Information
APTS09 – Transit Signal Priority

Lane Use Management – In an urban/suburban environment with centralized business areas there tend to be directional traffic patterns during the morning and evening peak periods. A variety of lane use applications exist that may assist in mitigating congestion due to "over capacity" issues. Some applications include:

- Reversible lane management – providing more travel lanes in the inbound direction during the morning commute, while providing more travel lanes in the outbound direction during the afternoon commute.
- Intersection geometry management – allowing lanes to be used for different vehicular movements during different times of the day. For example, during the morning peak, there could be two SB right turn lanes from a main artery onto a service drive, while in the afternoon peak, there is a need for only one right turn lane and two through lanes on the SB approach.
- Dynamic turning restriction management – the installation of dynamic, electronic case signs to indicate when right or left turns are permitted and when they are not, based on signal phase operations or time of day.
- High Occupancy Vehicle (HOV) lanes – the installation of HOV lanes is intended to encourage ridesharing and as a result reduce congestion.

Adjusting the lane usage to provide more capacity for a given direction along a corridor or turning movement at an intersection during a specified time of day can allow traffic to be serviced more efficiently. The effective use of HOV lanes can potentially reduce congestion on busy corridors.

Applicable Market Packages:
ATMS05 – HOV Lane Management (not selected as part of MDOT's SEMCOG regional architecture)
ATMS18 – Reversible Lane Management (not selected as part of MDOT's SEMCOG regional architecture)

Information Dissemination – Traffic information is typically gathered (when available) and stored in a central network location. Making the congestion, incident, travel time, etc. information available to the driving public through the use of websites, smartphone applications or dynamic message signs empowers drivers to make travel decisions before and during their commutes, which can ultimately result in more dispersed traffic patterns and less congestion on any given corridor. Coordination with and agreements between agencies are critical in order for a reliable information dissemination system to exist.

Applicable Market Packages:
ATMS06 – Traffic Information Dissemination
EM06 – Wide-Area Alert
EM10 – Disaster Traveler Information
MC08 – Work Zone Management

APTS08 – Transit Traveler Information
ATIS01 – Broadcast Traveler Information
ATIS02 – Interactive Traveler Information
ATIS04 – Dynamic Route Guidance
ATIS08 – Dynamic Ridesharing

Integrated Corridor Management – When periods of congestion occur, either routinely or as a result of a traffic incident or special event, drivers naturally divert to adjacent roadways in an effort to avoid great delays. By implementing an integrated corridor management (ICM) system that will provide optimal roadway operations (ICM signal timing plans) and guide motorists beyond the congestion and back to the mainline (dynamic trailblazer signs), more customers are able to be serviced more efficiently using existing roadways. Cross-jurisdictional coordination and interagency agreements may be necessary for an ICM system to operate as intended.

Applicable Market Packages:
ATMS07 – Regional Traffic Management
ATMS08 – Traffic Incident Management System
EM09 – Evacuation and Reentry Management
ATIS04 – Dynamic Route Guidance

Service Patrol – Safety service patrol drivers respond to and assist in the clearance of incidents, debris, disabled vehicles, etc. from travel lanes to maintain maximum capacity along a corridor at any given time. Safety service patrol dispatch typically takes place at transportation operations centers (TOC) since operators at the TOC have access to the latest, real-time traffic information. The use of safety service patrols can reduce corridor delay by clearing the roadway of obstructions more quickly and routinely, thereby maximizing capacity and minimizing the impacts to traffic flow.

Service patrol roles and responsibilities can vary between deployments. Some patrol roadways for disabled vehicles and offer gas or tire fixes, others focus on traffic incident scene clearance and some even assist minor vehicle mechanical issues and towing. The most effective service patrol programs are operated 24 hours a day, seven days a week and can identify issues on the roadway either by routine patrol or by being dispatched from a control center.

Applicable Market Packages:
ATMS08 – Traffic Incident Management System
EM04 – Roadway Service Patrols
EM08 – Disaster Response and Recovery

Dynamic Parking System – In urban areas where parking is a low commodity, maintaining a parking management system can prove to be beneficial in assisting drivers with finding empty parking spaces more quickly, and as a result, reduces vehicle emissions and congestion on the roadway by decreasing the amount of time the driver spends circling the block looking for a space. Different levels of deployment exist: some deployments count vehicles entering parking lots and disseminate capacity information to the public, while others can adjust parking meter rates in real-time based on available capacity to encourage or discourage parking in specific locations. The purpose of a dynamic parking system is to optimize the number of available parking spaces throughout a region or neighborhood and make that information available to the general public.

Applicable Market Packages:
ATMS16 – Parking Facility Management
ATMS17 – Regional Parking Management (not selected as part of MDOT's SEMCOG regional architecture)

Transportation Operations Center – A TOC is the central location that collects, analyzes and disseminates traffic information. Video feeds from field CCTV cameras; volume, speed and occupancy data from traffic sensors; weather information from roadside weather information systems (RWIS) and other traffic-related information is typically communicated back to the TOC. TOCs can

serve as a central communications hub between stakeholders during incident and special event management, construction projects and daily traffic events. Most effective TOCs are operated 24 hours a day, seven days a week and have the ability to adjust roadway operation strategies in real-time.

Applicable Market Packages:
AD01 – ITS Data Mart
AD03 – ITS Virtual Data Warehouse

In 2008, MDOT worked to define the SEMCOG regional ITS architecture. The study reviewed the national-level Market Packages and selected those applicable to the SEMCOG region since the National ITS Architecture is "a general framework for planning, defining and integrating ITS." This was also completed to ensure that the ITS deployments in the Metro Region are in compliance with the National ITS Architecture as defined by the Transportation Equity Act for the 21st Century, Section 5206(e). Next, the selected packages were prioritized into three categories based on regional needs: High Priority (0-3 years), Medium Priority (4-8 years) and Low Priority (>8 years). Any ITS deployments planned for the Metro Region must fit within this predefined architecture. The applicable Market Packages listed below each strategy may not necessarily conform to the SEMCOG architecture; the project team will work with MDOT to narrow the selections to those that do conform.

Existing Arterial ITS Deployments

A number of arterial ITS deployments have been installed throughout the nation in the past several decades. From installing surveillance devices along the corridor to outfitting with a reversible lane system or transit options, a magnitude of deployment types have been integrated into operations depending on the specific needs of the region. The project team performed an initial research effort to identify regions with transportation networks, traffic patterns and regional characteristics similar to Metro Detroit. Specifically, the regions with similar populations according to the US census and active arterial ITS networks were selected as "peer agency" studies. **Table 1** lists the metropolitan areas with similar populations.

Table 1 - Metropolitan Statistical Areas in the United States and Puerto Rico with 2010 Populations Comparable to Metro Detroit

Area	Population		Change, 2000 to 2010	
	April 1, 2000	April 1, 2010	Number	Percent
San Diego-Carlsbad, CA	2,813,833	3,095,313	281,480	10.0
Minneapolis-St. Paul-Bloomington, MN-WI	3,031,918	3,348,859	316,941	10.5
Seattle-Tacoma-Bellevue, WA	3,043,878	3,439,809	395,931	13.0
Phoenix-Mesa-Scottsdale, AZ	3,251,876	4,192,887	941,011	28.9
Riverside-San Bernardino-Ontario, CA	3,254,821	4,224,851	970,030	29.8
Detroit-Warren-Dearborn, MI	4,452,557	4,296,250	-156,307	-3.5
San Francisco-Oakland-Hayward, CA	4,123,740	4,335,391	211,651	5.1
Boston-Cambridge-Newton, MA-NH	4,391,344	4,552,402	161,058	3.7
Atlanta-Sandy Springs-Roswell, GA	4,263,438	5,286,728	1,023,290	24.0
Miami-Fort Lauderdale-West Palm Beach, FL	5,007,564	5,564,635	557,071	11.1
Washington-Arlington-Alexandria, DC-VA-MD-WV	4,837,428	5,636,232	798,804	16.5

Source: http://www.census.gov/population/metro/data/index.html

In the search for peer agency information, the project team reviewed online resources such as agency web sites and also made phone calls and sent emails to individuals associated with each project (agency) in attempts to conduct a more in-depth interview. In-depth information was only received from three regions and brief project profiles are attached to this memo for each:

- Atlanta, Georgia (Regional Transportation Operations Project)
- Minneapolis, Minnesota (various arterial ITS deployments)
- Phoenix, Arizona (various arterial ITS deployments)

The projects that were researched are listed in **Table 2**. The various project components are identified within the table. Some deployments may include technologies other than those listed; only the components discovered in the project team's research are

included. As indicated in the table, most arterial ITS deployments are based around signal control and arterial surveillance systems. The signal control can be responsive with the use of detection and the real-time implementation of pre-developed timing plans, adaptive with the use of detection and real-time signal timing changes based on vehicle demand or manual with operators/engineers monitoring roadway conditions and adjusting timings as needed.

A common objective among the deployments is cross-jurisdictional coordination or full corridor optimization. These strategies consider the arterial roadway as a whole, regardless of the owning agencies, to ensure that the driving experience is uniform when crossing the borders of various jurisdictions on any given trip. Many times local intersecting or parallel roadways are optimized and controlled in conjunction with the main arterial to provide optimal network operations. Inter-agency agreements and understandings are used to assign responsibility for operations and maintenance of signals and ITS equipment.

Table 2 - Sample Agency System Components

Location	Components													General Description	Owning Agencies
	Signal	CCTV	Emergency Vehicle Preemption/Transit Signal	Transit	Lane Use Management*	Parking Management	TMC	Traveler Information	Ramp Metering	Electronic Tolling	Freeway Management	Service Patrol	Other		
San Diego, CA	X	X		X	X		X	X	X		X		Decision Support System	San Diego ICM	SANDAG, USDOT, Caltrans, Metropolitan Transit System, North County Transit District, Cities of Escondido, Poway and San Diego
Dallas, TX	X	X		X	X	X	X	X			X		Decision Support System	Dallas ICM	TXDOT, USDOT, DART, North Texas Tollway Authority, North Central Council of Governments, Cities of Dallas, Highland Park, Richardson, Plano and University Park
San Francisco Bay Region, CA	X	X						X		X		X	Call Boxes	Arterials Operations Program	Arterial Operations Committee
Walnut Creek, CA	X	X					X							ATMS	City of Walnut Creek
Corona, CA	X	X					X							ATMS	City of Corona
Fort Collins, CO	X	X					X							ATMS	City of Fort Collins
Manatee County, FL	X	X					X							ATMS	Manatee County, Sarasota County, City of Sarasota, City of Bradenton, and the City of Palmetto, FDOT
Santa Monica, CA	X	X		X		X	X						EVP	ATMS	City of Santa Monica
New York City	X	X				X		X					EZ-Pass readers	Midtown in Motion	New York City
Varies														Various	Gannett Fleming (consultant design services)
Palm Beach County, FL	X	X					X	X			X		Bluetooth transponders	ATMS/TMC	FDOT, Palm Beach County
Montgomery County, MD	X	X		X	X		X	X					Aerial Surveillance	ATMS	Montgomery County
Detroit, MI	X	X					X	X					EVP	ATMS	City of Detroit
Oakland County, MI	X	X					X							FAST-TRAC	Road Commission for Oakland County
Atlanta, GA	X	X					X	X					Active peak period management and traffic signal maintenance	RTOP (Regional Transportation Operations Program)	Georgia Department of Transportation, local agencies

Location	Components													General Description	Owning Agencies
	Signal	CCTV	Emergency Vehicle Preemption/Transit Signal	Transit	Lane Use Management*	Parking Management	TMC	Traveler Information	Ramp Metering	Electronic Tolling	Freeway Management	Service Patrol	Other		
Lexington, KY	X	X			X		X	X						TMC	City of Lexington
Broward County, FL		X		X			X	X		X			MVDS detection, DMS, Bluetooth travel time, AVI travel time using toll tags	ATMS	FDOT, District 4
Kane County, IL	X	X					X							ATMS (Smart Corridors)	Kane County Division of Transportation
Seattle, WA	X	X		X			X	X					Traveler info website, license plate cameras for travel times, DMS signs	SDOT ITS Program	SDOT
Overland Park, KS	X	X					X	X					DMS signs for event circulation and safety messages	City of Overland Park, Kansas ITS	City of Overland Park
Northern Virginia District	X	X					X						Manages a traffic signal system of 1300 signals.	MIST (Management Information System for Transportation)	Virginia DOT
Minneapolis, MN	X	X	X	X			X	X	X		X	X		ATMS	Minnesota DOT
Phoenix, AZ	X	X					X	X						Regional ITS	Arizona DOT, City of Phoenix
Boston, MA	X	X					X	X					Loop Detectors	ATMS	City of Boston
Arlington, VA	X	X	X	X			X	X		X				Regional ITS	City of Arlington
Riverside, CA	X	X	X				X	X						Regional ITS	Caltrans

Best Practices and Lessons Learned

Each new ITS deployment brings a new set of lessons learned. By documenting and sharing these lessons, later deployments can benefit and be integrated into operation more smoothly and efficiently. Throughout the research portion of this project, the following lessons were discovered with regard to scheduling and planning, equipment and technologies and operations and maintenance.

Scheduling and Planning

- Consider a modular approach to system deployment. There are pros and cons to a modular (incremental) deployment that should be considered when planning the deployment schedule. (Minnesota DOT)
  - PROS: Each module has a narrowed set of goals.
    Operators/engineers can learn system operations incrementally.
    The ability to apply lessons learned to later modules exists.
  - CONS: There is a longer deployment schedule with a modular approach.
    Stakeholders may lose interest over a longer span of time.
    There may be funding interruptions.
    The project may incur more delays over a longer period.

- Focus on solving an existing problem – have a purpose for the deployment. (Seattle, WA)

- Develop the communication system to the correct scale and plan ahead to ensure that all applicable IT departments are involved from the beginning. (Georgia DOT – RTOP)

- Be smart about what you are measuring so that comparisons later on will be meaningful and so the benefits can be realistically measured. (Georgia DOT – RTOP)

Equipment and Technologies

- Have the state purchase electronic equipment directly from the vendor rather than having the contractor supply it. This approach allows the state to use its preferred equipment and the contractor does not carry the risk of the system working together properly. (Minnesota DOT)

- Develop a thorough process for procuring equipment. Consider different approaches for purchasing standard "commodity" type equipment versus unique ITS components to reduce the amount of time and effort wasted on procuring "commodity" items. (San Jose, CA)

- Implement a communications structure across jurisdictions to allow agencies to transfer information and coordinate signals. (various agencies)

- Consider using different contract mechanisms for subsystems in a complex project. (Minnesota DOT)

Operations and Maintenance

- Program a wide variety of cycle lengths/timing plans to make the system function properly. (Georgia DOT – RTOP)

- Program pattern "overrides" when practical. (Georgia DOT – RTOP)

- Have a contractor on the project team to speed up the delivery time of simple improvements. (Georgia DOT – RTOP)

- Consider sharing equipment between agencies to reduce costs. (Arizona – Maricopa Association of Governments)

- ITS systems cannot operate to produce the anticipated benefits without skilled people at local agencies and a sufficient budget to operate/maintain them. Secure these resources before deployment. (Arizona – Maricopa Association of Governments)

- Retain qualified staff to deploy, operate and maintain the system. (Seattle, WA)

- Integrate freeway operations and arterial systems to achieve greater benefits. The benefits of an integrated system are far greater than the sum of two separate systems. (San Antonio, TX)

- Establish a working group among public partners to address liability issues. Develop written policies for coordination/control of signal timings across jurisdictions. (Phoenix, AZ)

Moving MDOT Forward

MDOT strives to be a leader in ITS, and as such, looks for ways to improve its roadways and provide a better driver experience. By considering the implementation of proven ITS technologies onto its arterials as well as integrating cutting edge ideas, MDOT can continue to move the ITS field forward. MDOT's roadway network in the Metro Region is wide-spread across multiple freeways and arterials throughout four counties. The most effective traffic management strategies consider the region's road network as a whole – freeway traffic management requires an understanding of how surrounding arterial roads operate, transit modes require synchronization with vehicular traffic and planned and unplanned traffic events require close coordination between traffic engineers/operators and first responders. To better coordinate such strategies, ITS technologies can be deployed along the roadways. **Table 3** presents the discovered success rates for various ITS technologies previously deployed around the nation.

Table 3 - Technology Success Ranking

Technology	Problem Addressed/Solved	Ranking
Coordinated Signal System	Allows for traffic signal timings to be adjusted based on real-time (or historic) traffic demand levels.	Reliable/Proven
Emergency Vehicle Preemption/Transit Signal Priority	Provides more efficient signal operations and less delay for emergency and transit vehicles and creates more incentive for people to use transit.	Reliable/Proven
Roadway Surveillance (CCTV)	Allows operators to monitor the roadway system and respond appropriately as incidents are detected.	Reliable/Proven
Roadway Surveillance (Detection)	Provides information to the operator and/or network components that may allow manual or automatic changes to be made to the system in real time.	Reliable/Proven
Reversible Lane System	Allows greater demand to be serviced by better managing pavement use. In areas with heavy inbound/outbound patterns, the capacity can be increased/decreased for the favored direction during different conditions.	Questionable
Dynamic Lane Use	Allows intersection lanes to be used differently during different conditions. In the morning, there may be two SB right turn lanes and one thru lane while the evening may warrant two thru lanes and one right turn lane on the SB approach.	Questionable
Dynamic Turn Restrictions	Allows for more efficient use of turning restrictions. A "no turn on red" indication may be warranted during the morning, but not needed throughout the rest of the day.	Reliable/Proven

Technology	Problem Addressed/Solved	Ranking
	This technology allows for restrictions to be implemented only as needed.	
Parking Management System	Reduces the amount of time drivers spend trying to find parking spaces by adjusting parking rates and encouraging drivers to park in less expensive, higher-capacity areas.	Questionable
Ramp Metering	Helps manage congestion by metering the flow of traffic onto major collectors.	Questionable
Traveler Information (DMS, web site, smartphone applications, 511 systems etc.)	Provides road operations condition information to drivers in real time that can be referenced before or during travel.	Reliable/Proven
Integrated Corridor Management	By operating the region's roadways as a cohesive network, traffic can be managed more efficiently.	Reliable/Proven
Service Patrol (Arterial Roadways)	Provides for quicker clearance of travel lane obstacles and improved flow of traffic.	Reliable/Proven
Transportation Management Center	Allows for real-time monitoring and management of the roadway system. Detection and response times to incidents can be reduced and corridor operations can be optimized to meet the current demand levels.	Reliable/Proven

The implementation of proven technologies may be able to provide quicker realized benefits; however, opportunities exist to utilize newer technologies in different applications that may prove to be most beneficial in the long-term. Examples of "new age" technologies may include portable red light running system or automated crash detection systems at intersections.

A portable red light running system may be deployed where there is a high rate of angle crashes. By detecting when vehicles are running red lights, an engineer is able to review the intersection and data collected to determine if there are timing changes or other responses that can be implemented to reduce the occurrence of red light running violations, thus improving safety. Specific law enforcement activity can also be utilized as a tool but only after engineering countermeasures have been exhausted. By utilizing portable technology to create these systems they can be moved when a reduction in red light running is recognized at one site and be redeployed at a different site to address the problems there.

MDOT is currently considering automated incident detection (AID) systems as part of another project. As part of arterial traffic management, an intersection-based AID system may be considered to detect when an incident has occurred in an intersection and can send an alarm to an operator, who will then be able to better assess the roadway conditions and determine if signal timings should be adjusted, if first responders should be contacted or if other responses should be enabled.

Whether MDOT chooses to deploy proven technologies on its arterial roadway network or push the envelope and test new technologies, the next steps in the development of an arterial ITS network in the Metro Region should include the following.

1. **Identify goals and objectives for arterial management in Metro Region** – MDOT, local agencies, first responders and other stakeholders should gather together and identify the objectives they would like to meet in regards to arterial roadway operations throughout the region. Coordination and communication from the beginning will lead to stronger involvement

and more informed decision making later in the project. The problems of the various jurisdictions can be discussed and overall system-wide goals can be established.

2. **Develop a methodology and criteria for prioritizing arterials to be outfitted with ITS equipment** – With the region's goals in mind, the involved parties can determine where the systems should be deployed to provide the greatest benefit. It is unrealistic to believe that ITS can be deployed on all Metro Region arterials at once, so by using the established criteria, arterial ITS deployments can be prioritized and installed incrementally as funds become available.
3. **Select desired technologies to apply to the region's arterial roadways** – The available ITS technologies should be reviewed and those that best satisfy the goals of the region may be selected for implementation. MDOT may choose proven technologies or innovative solutions to solving the region's arterial operations problems. Specific Market Packages will be identified in this step.
4. **Define arterial performance measures** – Prior to finalizing the system technologies, the various measures that will be used to gauge system performance should be defined. By determining the performance measures early in the project, the correct equipment and communications technologies can be properly integrated into the system.
5. **Analyze costs, sources of available funding and financial risks** – As with any project, funding must be secured before implementation can take place. With ITS projects, it is important to consider the initial costs of deployment as well as the long-term funding requirements for operations and maintenance of the system to ensure that the greatest benefit is achieved.

As a recognized front-runner in ITS technologies, MDOT is looking to expand its portfolio to include arterial ITS deployments. The establishment of arterial traffic management goals, the selection of technologies and the strategic deployment of equipment can guide MDOT through the process of outfitting its arterials with ITS technologies and encourage a safer, more efficient travel system for the drivers of Metro Detroit.

Signed: Matthew G. Klawon, PE
URS Corporation

cc: Project File

Atlanta – Sandy Springs – Roswell, Georgia

Population
5,286,728

Project Description:

Georgia Department of Transportation's (GDOT) Regional Traffic Operations Program (RTOP) is a signal operations initiative across multiple jurisdictions aimed at improving traffic flow and reducing emissions along the busiest corridors in the Atlanta region utilizing SCATS, SCOOT, a BlueToad system, emergency vehicle preemption and transit priority. The program creates a platform for GDOT and local agencies to work together to develop cohesive traffic signal timings throughout the entire region, regardless of jurisdictional boundaries. The program provides peak period traffic management from a TMC, closed-circuit television (CCTV) surveillance and travel time measurements twice a year to measure program benefit. The Midtown area near downtown Atlanta has worked with GDOT and adopted features similar to RTOP for its local roadways.

The city of Johns Creek, a suburb of Atlanta, operates a service patrol where their Transportation Response Vehicles (TRV) patrol the city's roadways and respond to motorist needs during peak periods and handle routine and preventive maintenance needs for the city's traffic signal infrastructure during non-peak periods. The program was launched in August 2011.

Surrounding counties and communities staff individual Traffic Control Centers (TCC) for their respective roadways.

System Statistics:

- 450 signals connected to GDOT TMC (goal to have 1200 signals connected by the end of 2013)
- Additional signals connected to local TCCs
- In 2012 during the AM and PM peaks, the entire RTOP program:
    - Eliminated 1.2 million hours of delay
    - Saved 700,000 gallons of fuel
    - Reduced number of stops by 8.3%
    - Reduced stopped time delay by 12%
    - Traffic volume increased by 9%

Lessons Learned:

- In order to make the system function properly, a wide variety of cycle lengths/timing plans should be programmed.
- Program pattern "overrides" when practical.
- Have a contractor on the project team to speed up the delivery time of simple improvements.
- Develop the communication system to the correct scale and plan ahead to ensure that all applicable IT departments are involved from the beginning.

References

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- http://www.johnscreekga.gov/news2013/2013-04-01_trv.aspx
- Marc Start, RTOP Corridor Manager (URS)
- Project Contact: Kofi Wakhisi (ARC), 404.463.3473, kwakhisi@atlantaregional.com

Minneapolis – St. Paul – Bloomington, Minnesota

Population
3,348,859

Regional ITS Overview:

Throughout the Minneapolis/St. Paul metropolitan area, the Minnesota Department of Transportation (MnDOT) has integrated intelligent transportation systems (ITS) technologies into its arterial roadway system. MnDOT has implemented a central signal control system to communicate with several arterial traffic signals individually, rather than having an on-street master controller. The existing traffic operations staff operates the system; there are no dedicated live operators. The system is configured to send notifications to the traffic operations staff when problems are detected.

Closed-circuit television (CCTV) cameras have been installed for signal operations. MnDOT has found that these installations work best at locations with fiber optic communications, but snapshots are possible where fiber is not present. Variable message signs (VMS) are installed to provide information about arterial and freeway operations. Transit signal priority and emergency vehicle preemption have been incorporated into traffic signal operations to more efficiently manage various vehicle needs within the same system. A major motivator for implementing ITS on the arterial system was the desire to provide quicker response to signal problems since a great number of the signals are at high volume locations and signal malfunctions can cause major delays. Other goals statewide were to make signal operations more efficient by coordinating city and state efforts.

Lessons Learned:

- Consider a modular approach to deployment (each module has a narrowed set of goals, learn system operations incrementally, apply lessons learned to later modules)
- Be aware that there are risks to a modular deployment (longer deployment schedule, stakeholders loss of interest over time, funding interruptions, delays)
- Consider using different contract mechanisms for subsystems in a complex project
- MnDOT has found it most effective to have the state purchase electronic equipment directly rather than having the contractor supply the equipment. This ensures that MnDOT uses its preferred equipment and the contractor does not carry the risk of the system working together properly.

References

- http://www.itslessons.its.dot.gov/ITS/benecost.nsf/ID/DE15F990C72500BD8525775000504F08?OpenDocument&Query=LLApps
- Project Contact: Ray Starr (MnDOT), 651.234.7050, ray.starr@state.mn.us

Phoenix – Mesa – Scottsdale, Arizona

Population
4,192,887

Regional ITS Overview:

The Maricopa Association of Governments (MAG) region; which includes the cities of Phoenix, Mesa and Scottsdale, among others; has more than 3,000 traffic signals, over 475 existing and more than 450 planned closed-circuit television (CCTV) cameras, permanent and portable dynamic message signs (DMS), various detection technologies and fiber, copper, wireless and T1 communications along its arterials. Devices along the arterials are owned and operated by local agencies. Cross-jurisdictional operations exists in some cases, especially near freeway interchanges where Arizona Department of Transportation (ADOT) owns the signals, but the local agency operates them. Nearly 70% of the traffic signals are monitored, controlled or operated from an agency transportation operation center (TOC). Most of the TOCs operate during business hours and some extend hours to cover special events or major incidents.

The MAG Region has developed tools to to encourage a regional system approach to arterial operations, instead of many municipalities working independently from one another. The "Regional Community Network," "Highway Closures and Restrictions" applications, "Camera Cameleon" and "Regional Archived Data Server" are some of the shared resources available. In recent years, there has been an increased focus on coordinating traffic signal operations on cross-jurisdictional corridors.

All proposed arterial intelligent transporation system (ITS) projects must fit within the Region ITS Architecture and be reviewed by the MAG ITS Committee. Once the project has been approved, ADOT and the Federal Highway Administration (FHWA) provide design oversight. Congestion and emission reductions are the primary goals of ITS projects; however, speeds, levels of service and travel times are starting to be used as performance measures.

Lessons Learned:

- Consider sharing equipment between agencies to reduce costs. In Phoenix, many jurisdictions abandoned institutional barriers and created a more regional approach to information sharing/reporting.
- Plan for operations and maintenance before construction as ITS systems cannot operate to produce the anticipated benefits without skilled people at local agencies and a sufficient budget to continue to operate the systems. Many agencies build systems that they are unable to staff or operate at levels required to justify investments.

References

- http://www.azmag.gov/Transportation/Regional_Transportation_Systems_Management_and_Operations.asp
- http://www.azmag.gov/archive/itsystems/asn.asp
- http://www.aztech.org/
- http://www.itslessons.its.dot.gov/ITS/benecost.nsf/ID/13654436B49661E28525707E0061C559?OpenDocument&Query=LLApps

- Project Contact: Sarath Joshua (MAG), 602.254.6300, sjoshua@azmag.gov

APPENDIX B

HIGH-LEVEL SYSTEM REQUIREMENTS

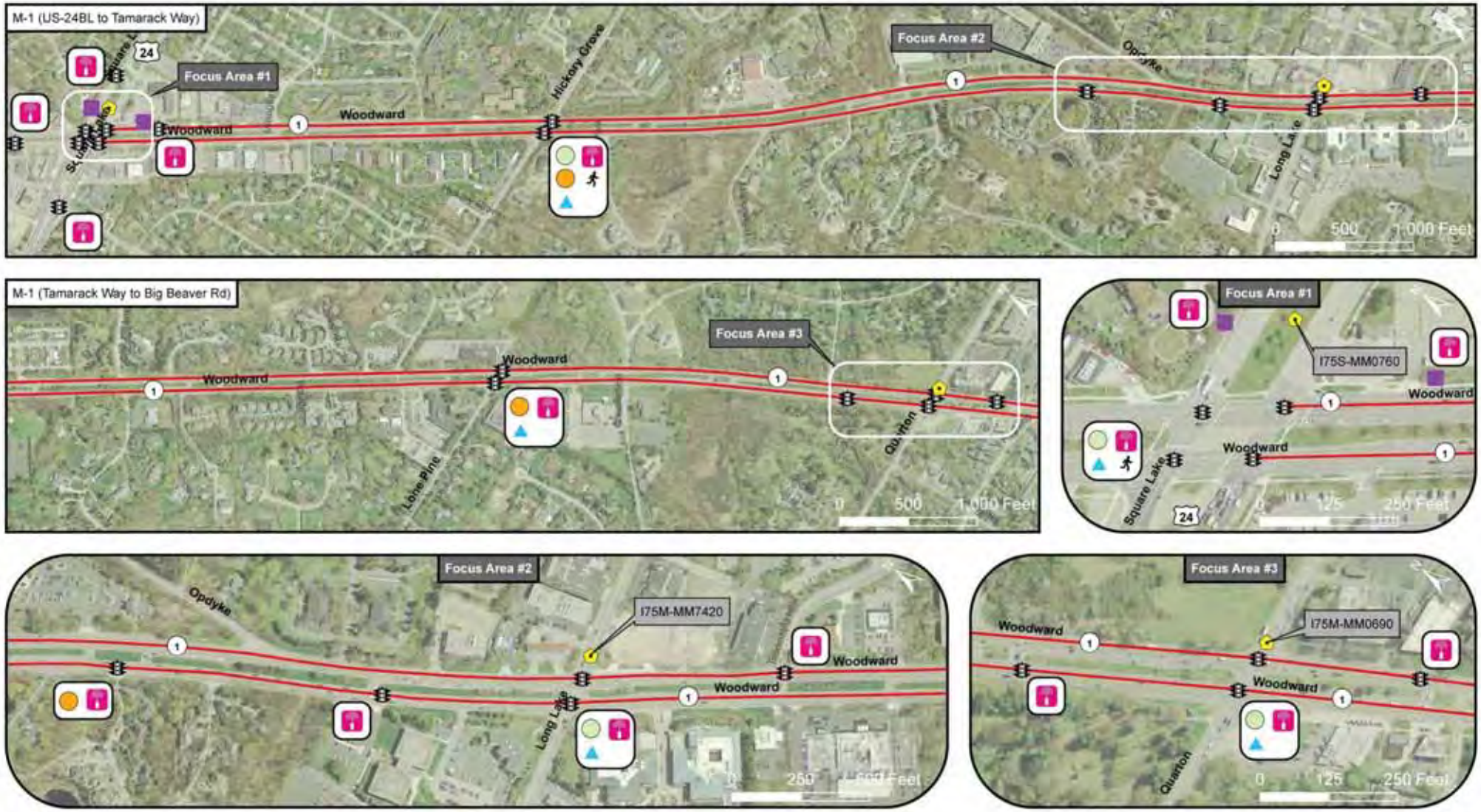
Metro Region Arterial Management System High-Level Requirements

			ATMS/Signal System Capabilities (ATMS-##)														Data Collection (DC-##)							Information Dissemination (ID-##)					Operations and Maintenance (OM-##)		
	User Needs	Description	01	02	03	04	05	06	07	08	09	10	11	12	13	14	01	02	03	04	05	06	07	01	02	03	04	05	01	02	03
Operations	OPER.N.01	Ability to conduct remote, real-time operations	X	X			X	X							X									X							
	OPER.N.02	System monitoring for maintenance and operations					X			X							X														
	OPER.N.03	Better coordinate/integrate MDOT and local agency systems						X						X																	
	OPER.L.01	Ability to divert traffic			X		X										X								X						
	OPER.L.02	Address directional congestion					X											X						X							
	OPER.L.03	Inter-agency operating agreements						X																							
	OPER.L.04	Automated incident detection											X																		
	OPER.L.05	Better integrate transportation modes							X																		X				
Incident Management	IM.N.01	Incident detection															X	X													
	IM.N.02	Response signal timing plans			X		X																								
	IM.N.03	Coordination with Integrated Corridor Management					X										X								X						
	IM.L.01	Situational awareness during incident monitoring																X													
	IM.L.02	Emergency vehicle preemption							X																						
	IM.L.03	Arterial courtesy patrol																													X
	IM.L.04	Data compatibility																					X	X							
	IM.L.05	Incident data archiving										X																			
Maintenance	MAINT.N.01	Clearly defined roles and responsibilities of various agencies																											X		
	MAINT.N.02	Budgeting for entire life cycle of system components																												X	
	MAINT.L.01	Consolidate systems and infrastructure	X																												
	MAINT.L.02	Inclusion of full maintenance management systems		X																											
Information	INFO.N.01	Incident information																		X				X							
	INFO.N.02	Travel time and congestion information																X						X							
	INFO.N.03	Construction/Work zone					X													X				X							
	INFO.N.04	Connected vehicle information																			X					X					
	INFO.L.01	Transit vehicle and operations information																				X									
	INFO.L.02	System/power outages								X																					
	INFO.L.03	Special Event information																		X				X							
	INFO.L.04	Commercial vehicle rerouting/restrictions																		X							X				
	INFO.L.05	Traffic Counts																X													
	INFO.L.06	Work crew location															X							X							
	INFO.L.07	GPS information for emergency vehicles																	X												
	INFO.L.08	Speed data																X													
	INFO.L.09	Current signal timings									X																				
	INFO.L.10	Cautionary information to non-motorized users														X												X			
	INFO.L.11	Weather information including pavement conditions				X																									

Requirement Identifier	High-Level System Requirement
ATMS-01	The ATMS and traffic signal system will be developed in a manner that maximizes existing infrastructure, consolidates redundant systems and integrates new devices into existing systems.
ATMS-02	The ATMS and traffic signal system will distribute, receive and archive a variety of data for use in other operation and maintenance systems.
ATMS-03	The ATMS and traffic signal system will advise operators of when predefined contingency timing plans are recommended for use; and support their enactment.
ATMS-04	The ATMS and traffic signal system will support the inclusion of weather-related information for system operations and maintenance.
ATMS-05	The ATMS and traffic signal system will allow system operators to remotely monitor, program, adjust, diagnose and retrieve data related to traffic signal system programming and operations.
ATMS-06	The ATMS and traffic signal system will allow for the management of various levels of user rights and privileges for system operation, maintenance and data-sharing.
ATMS-07	The ATMS and traffic signal system will support pre-emptive or priority operations of the system for transit and emergency vehicles.
ATMS-08	The ATMS and traffic signal system will alert applicable system users when it detects a potential roadway incident, equipment failure or critical alarm.
ATMS-09	The ATMS and traffic signal system will support the Connected Vehicle (CV) applications that require the broadcast of applicable infrastructure data.
ATMS-10	The ATMS and traffic signal system will archive data such as timing plan changes, incident information, alarms/alerts and more for use in operations, maintenance and system assessment.
ATMS-11	The ATMS and traffic signal system will support automated incident detection either through the use of system data or standalone detection systems.
ATMS-12	The ATMS and traffic signal system will support the incorporation of devices and data between the AMS and complimentary local agency systems to jointly improve operational coordination and system
ATMS-13	The ATMS will enable operators to remotely adjust messages and content on roadside Information Dissemination (ID) systems.
ATMS-14	The ATMS and traffic signal system will support the determination of when cautionary information is necessary to broadcast relative to non-motorized users in AMS corridors.
DC-01	CCTV cameras will allow for detecting, monitoring and verifying travel conditions, incidents, first responders, work crews, alternate routes and more.
DC-02	System detectors will allow for gathering of traffic data such as volumes, travel speeds/times, headway spacing and other data to support AMS operations.
DC-03	The AMS will support the gathering and use of GPS data from emergency responder and transit vehicles to support pre-emptive and priority based operations.
DC-04	The AMS will support the ability to gather and utilize construction, special events, route restrictions and incident information from stakeholders to support system operations.
DC-05	Roadside Units (RSUs) will gather Connected Vehicle (CV) information for agency use in the operation, maintenance and assessment of system performance.
DC-06	The AMS will support the gathering and use of transit vehicle and transit system operations-related information to support traveler trip making decisions.
DC-07	The AMS will allow for the gathering of travel conditions and traveler information to roadway users and stakeholders using DMS, travel time signs, websites, data pushes and other applications.
ID-01	The AMS will allow for the dissemination of travel conditions and traveler information to roadway users and stakeholders using DMS, travel time signs, websites, data pushes and other applications.
ID-02	Dynamic Message Signs (DMS) and Dynamic Trailblazer Signs (DTS) will be utilized at strategic locations to provide route guidance to motorists during active traffic diversions.
ID-03	Roadside Units (RSUs) will support the dissemination of appropriate infrastructure-related information to connected vehicles to support on-board applications
ID-04	The AMS will support data information sharing to support logistics planning for public transit, commercial passenger and freight service providers.
ID-05	The AMS will support data information sharing with third party applications (such as smartphone applications) to support active route guidance and information dissemination.
OM-1	Incorporate agreements that clearly define the role and responsibility of each agency or partner actively involved in the maintenance of the AMS.
OM-2	The AMS should be deployed when adequate funding has been identified for deployment, operation and maintenance of the system.
OM-3	The inclusion of arterial courtesy patrol services should be assessed on a corridor-by-corridor basis as necessary to support AMS program goals.

APPENDIX C

CONCEPTUAL DEPLOYMENT PLANS BY CORRIDOR



Legend

- M-1 Corridor
- Other Route

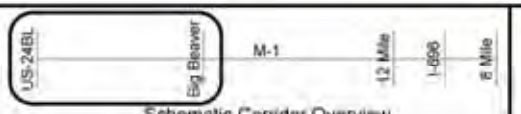
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



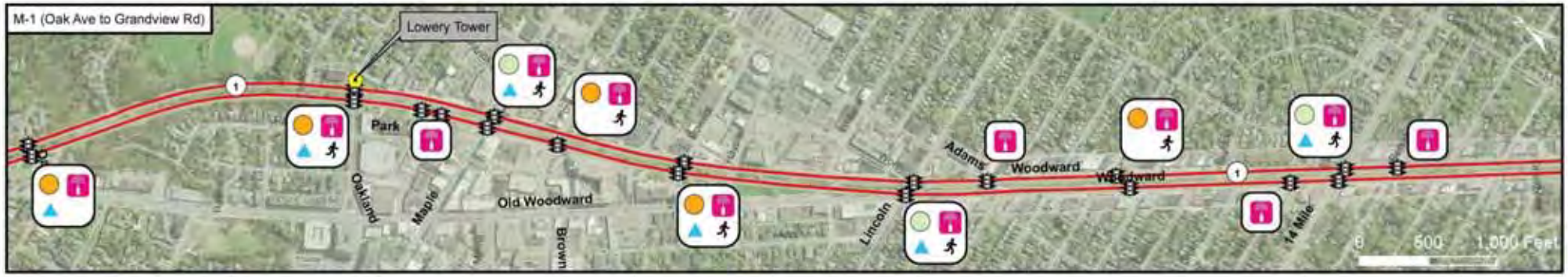
Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-1 (Woodward Avenue)
US-24BL to M-102
Sheet 1 of 3

MDOT

PARSONS BRINCKERHOFF



Legend

- M-1 Corridor
- Other Route

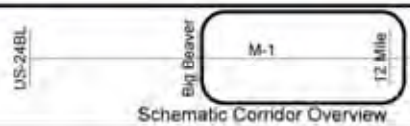
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-1 (Woodward Avenue)
US-24BL to M-102
Sheet 2 of 3

MDOT

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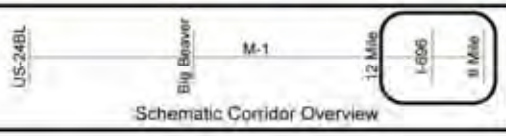
Legend

M-1 Corridor
Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV
Potential Fiber-Optic Communication Linkage Point
Potential Wireless Communication Linkage Point

Proposed Detection:
Side Street Stop Bar
Mainline System
Communication Radio
Main Line Stop Bar
Pedestrian



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-1 (Woodward Avenue)
US-24BL to M-102
Sheet 3 of 3

MDOT
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Legend

- M-1 Corridor
- Other Route

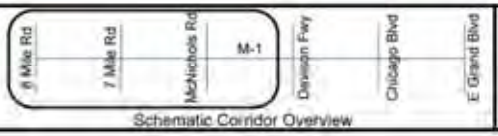
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-1 (Woodward Avenue)
M-102 to E Grand Ave
Sheet 1 of 2

MDOT

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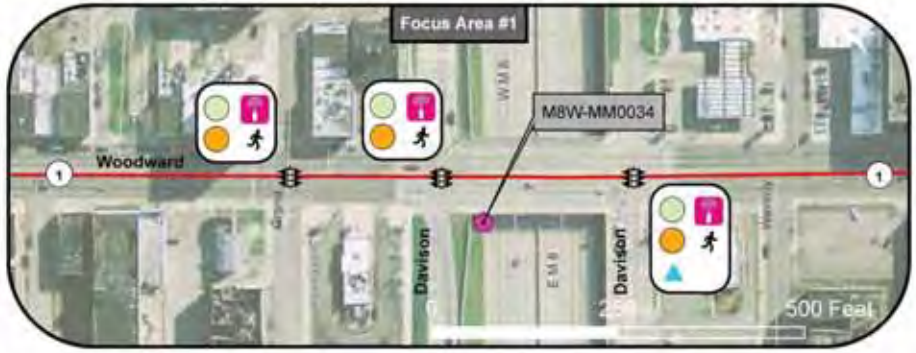


Legend

- M-1 Corridor
- Other Route

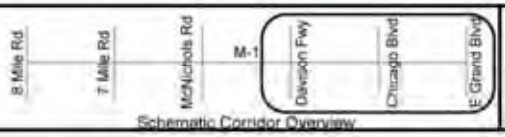
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-1 (Woodward Avenue)
M-102 to E Grand Ave
Sheet 2 of 2

MDOT

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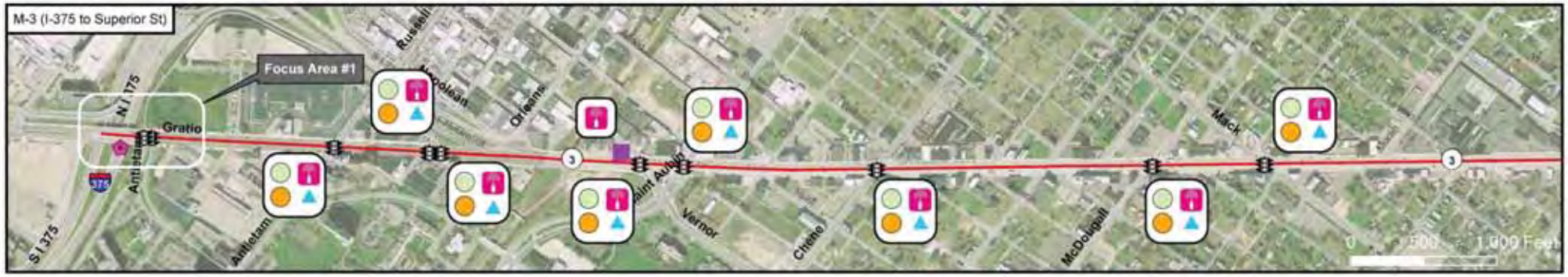


Legend

- M-3 Corridor
- Other Route

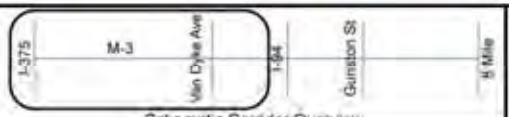
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-3 (Gratiot Avenue)
I-375 to M-102
Sheet 1 of 2

MDOT

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Legend

- M-3 Corridor
- Other Route

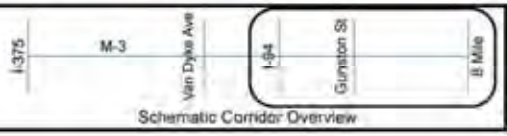
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-3 (Gratiot Avenue)
I-375 to M-102
Sheet 2 of 2

MDOT

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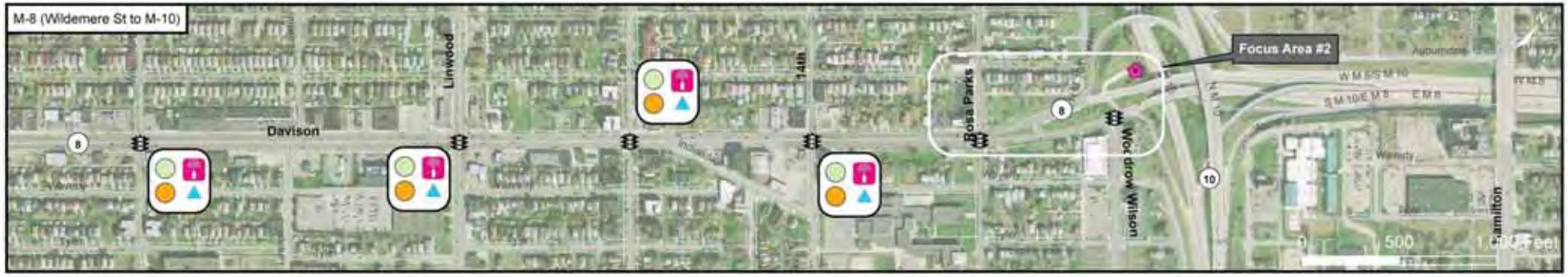


Legend

- M-8 Corridor
- Other Route

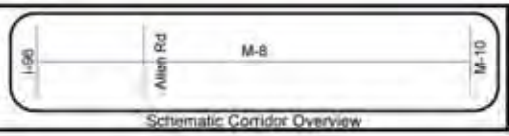
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-8 (Davison Street)
I-96 to M-10
Sheet 1 of 1

MDOT

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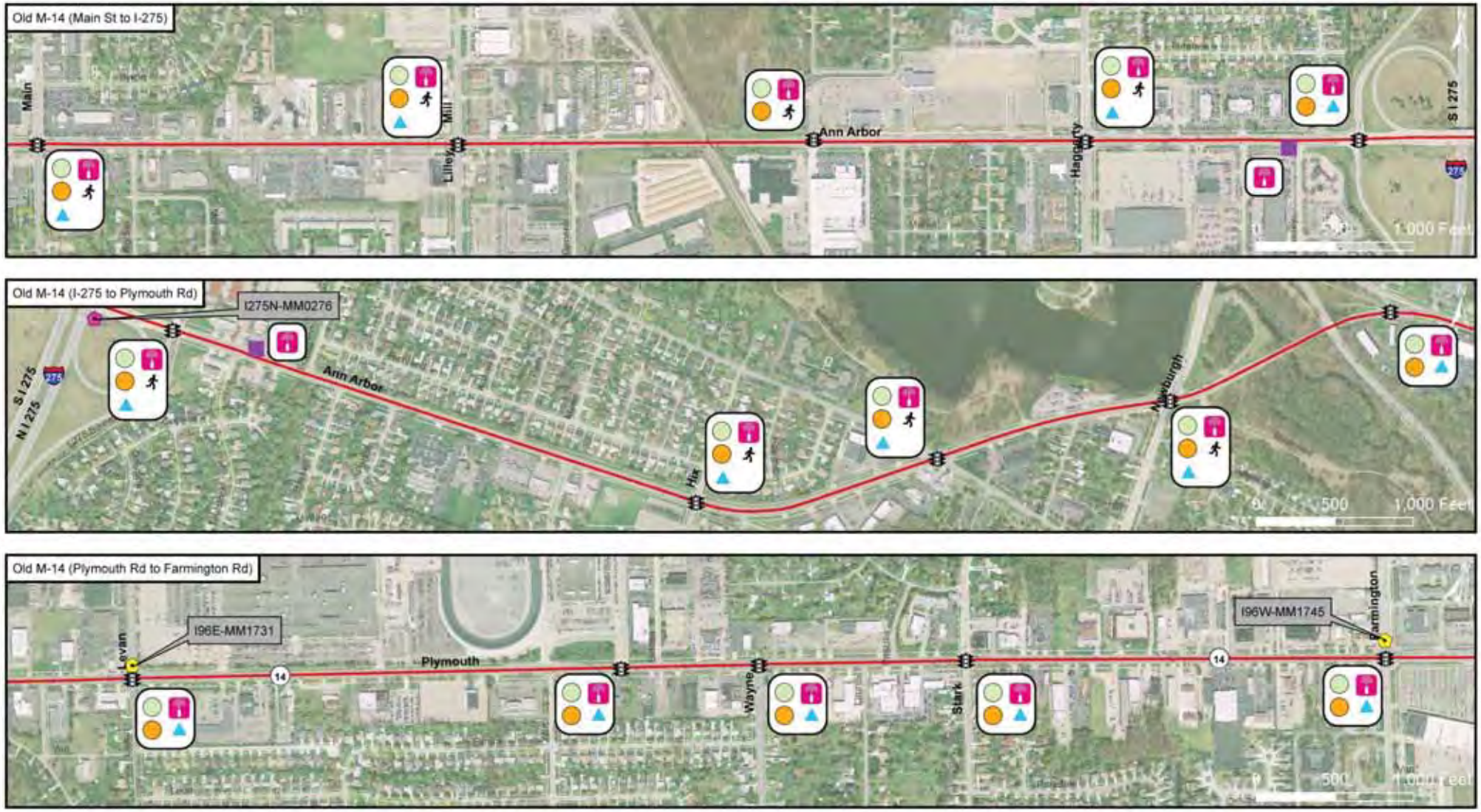

Legend

- Old M-14 Corridor
- Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio

Main St | I-275 | Plymouth | Farmington | Old M-14 | Middlebelt | US-24

Schematic Corridor Overview

Metro Region AMS Corridor Plan

Old M-14 (Plymouth Ave)
Main St to US-24
Sheet 1 of 2

MDOT

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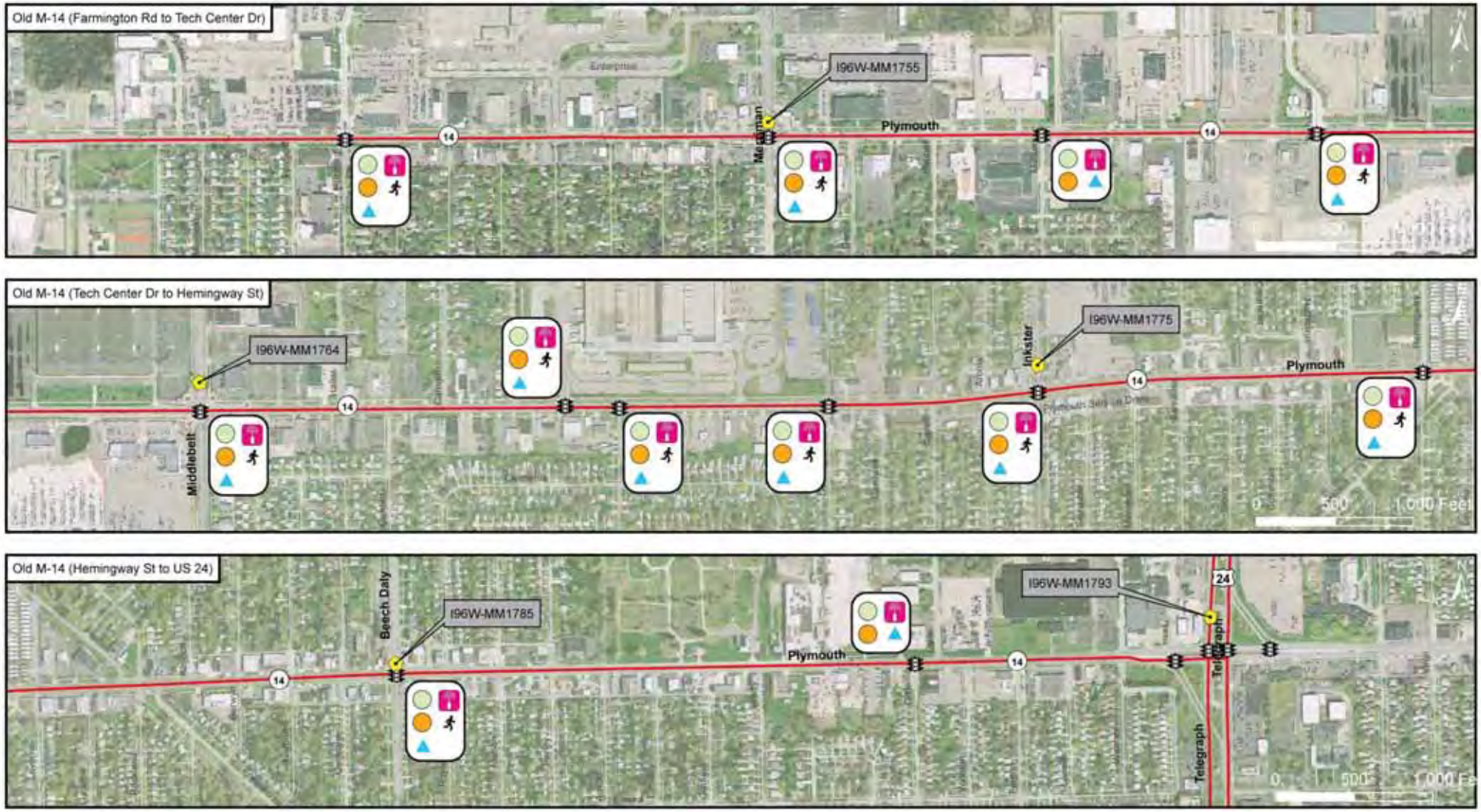

Legend

- Old M-14 Corridor
- Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio

Schematic Corridor Overview: Main St | I-275 | Plymouth | Farmington | Old M-14 | Middlebelt | US-24

Metro Region AMS Corridor Plan

Old M-14 (Plymouth Ave)
Main St to US-24
Sheet 2 of 2

MDOT

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Legend

- M-39 Corridor
- Other Route

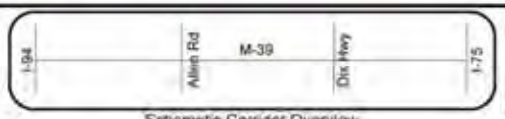
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-39 (Southfield Road)
I-94 to I-75
Sheet 1 of 1

MDOT

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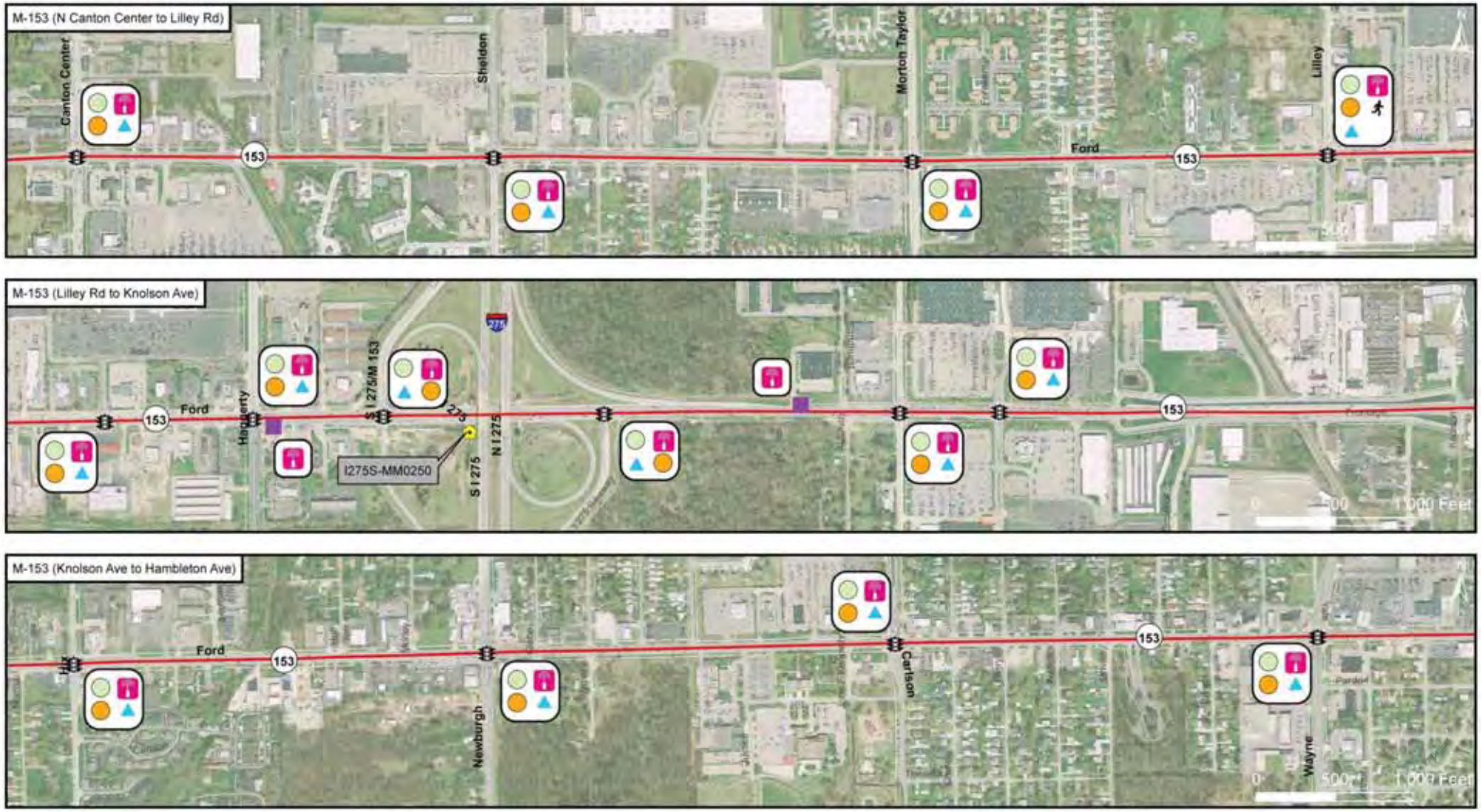


Legend

M-153 Corridor

Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

Potential Fiber-Optic Communication Linkage Point

Potential Wireless Communication Linkage Point

Proposed Detection:

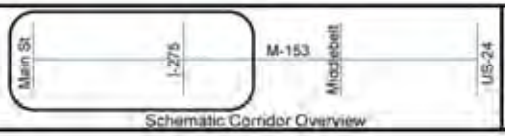
Side Street Stop Bar

Mainline System

Communication Radio

Main Line Stop Bar

Pedestrian



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-153 (Ford Road)
N Canton Center to US-24
Sheet 1 of 2

MDOT

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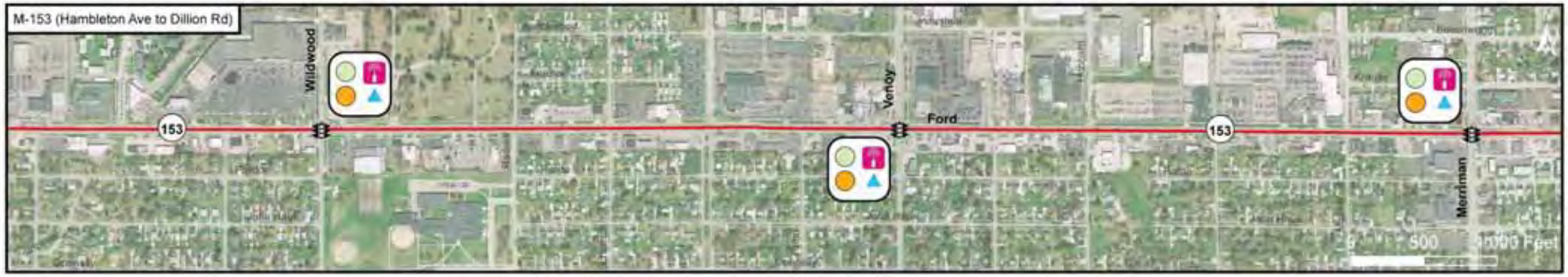
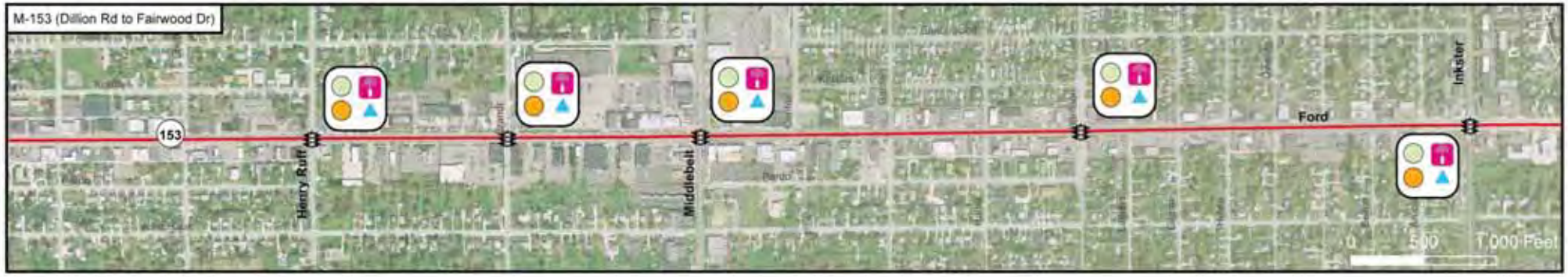




Legend

M-153 Corridor

Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

Potential Fiber-Optic Communication Linkage Point

Potential Wireless Communication Linkage Point

Proposed Detection:

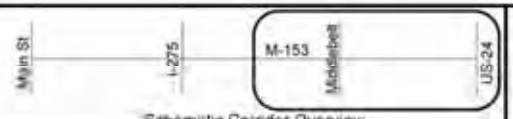
Side Street Stop Bar

Mainline System

Communication Radio

Main Line Stop Bar

Pedestrian



Schematic Corridor Overview

Metro Region AMS Corridor Plan

M-153 (Ford Road)
N Canton Center to US-24
Sheet 2 of 2

MDOT

PARSONS BRINCKERHOFF

Legend

- US-12 Corridor
- Other Route

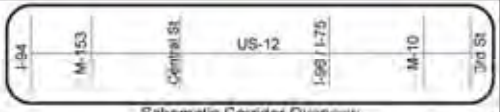
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



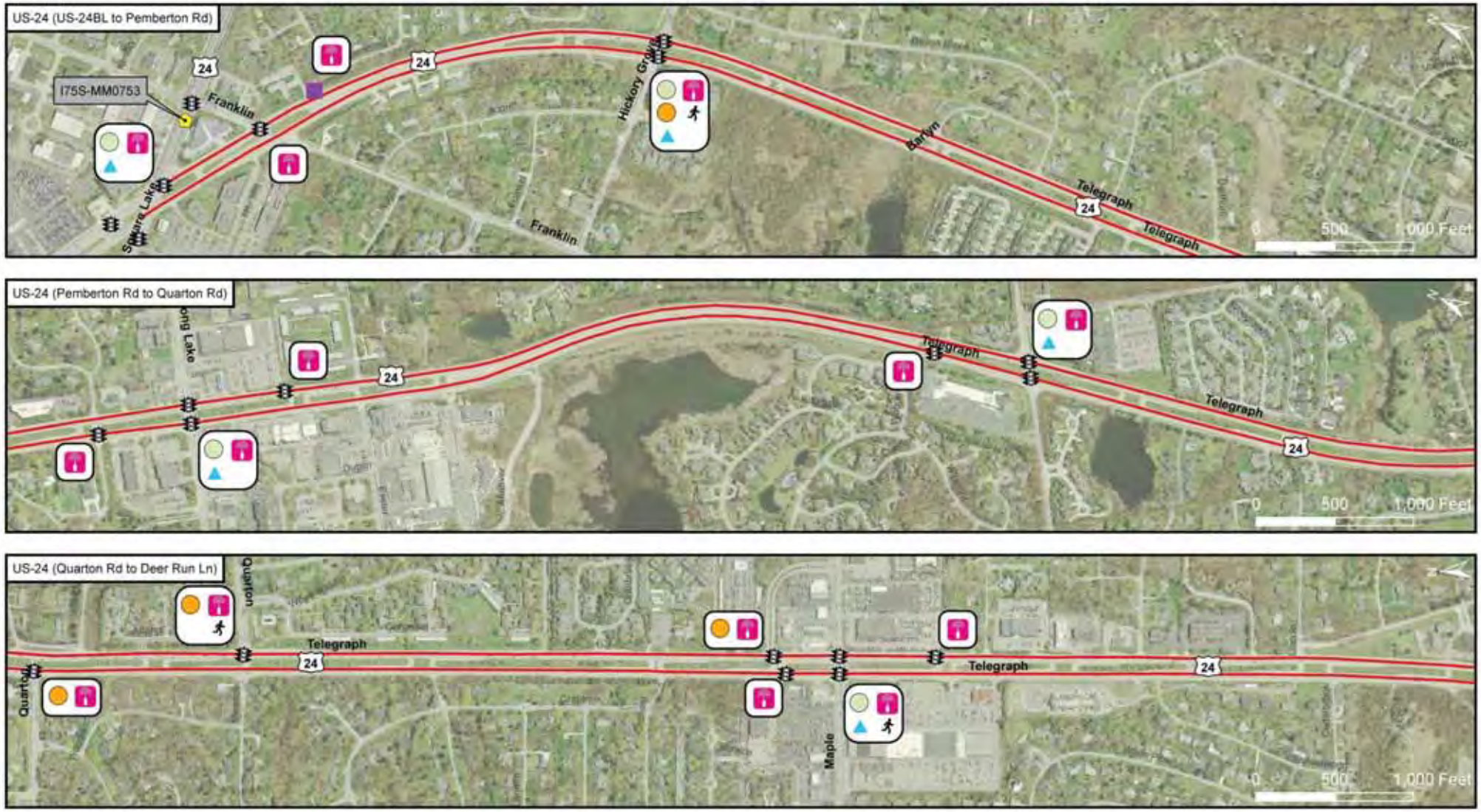
Schematic Corridor Overview

Metro Region AMS Corridor Plan

US-12 (Michigan Ave)
I-94 to 3rd Street
Sheet 1 of 1

MDOT

PARSONS BRINCKERHOFF



Legend

- US-24 Corridor
- Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio

US-24BL | Quarton Rd | US-24 | 1/2 Mile | I-696

Schematic Corridor Overview

Metro Region AMS Corridor Plan

US-24 (Telegraph Road)
US-24BL to I-696
Sheet 1 of 2

MDOT

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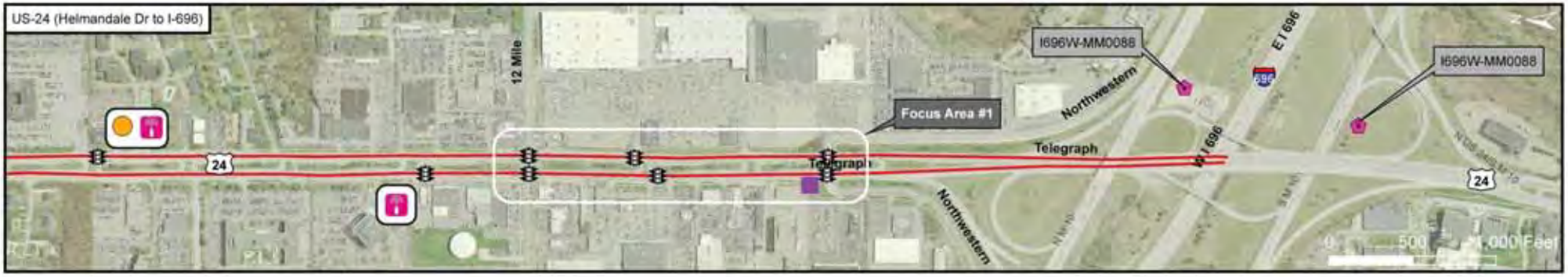


Legend

- US-24 Corridor
- Other Route

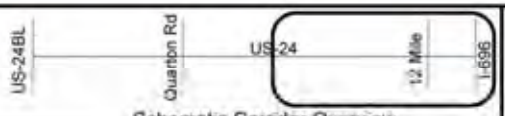
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



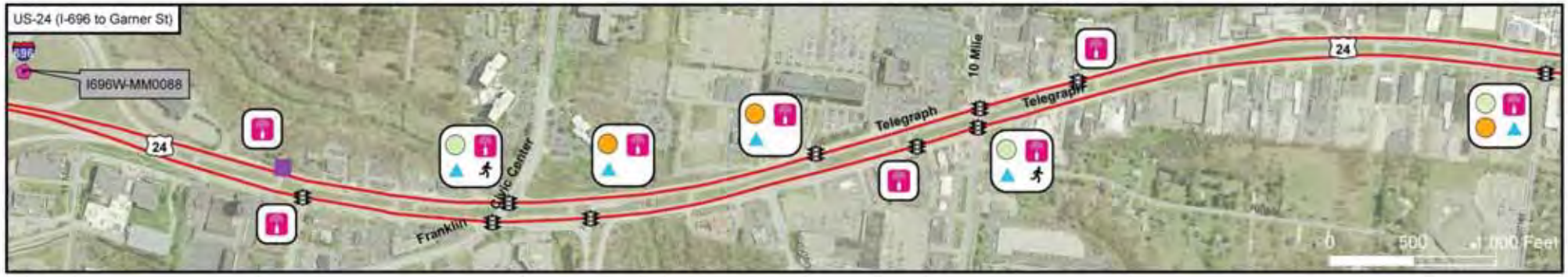
Schematic Corridor Overview

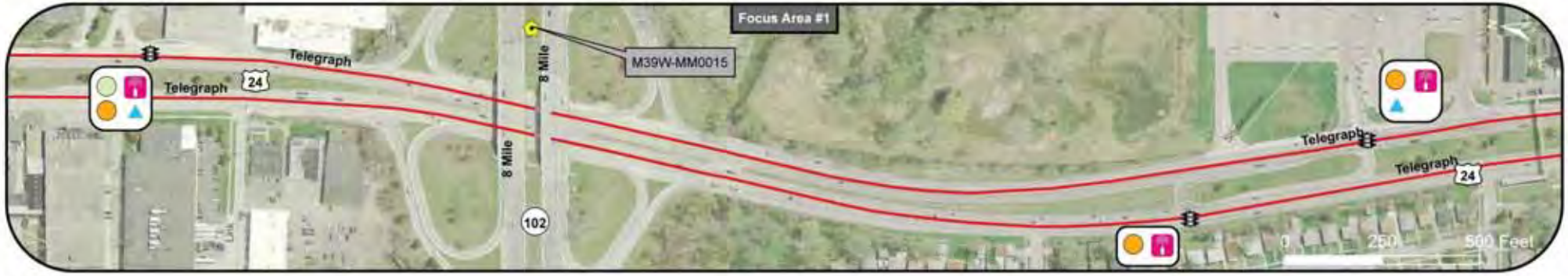
Metro Region AMS Corridor Plan

US-24 (Telegraph Road)
US-24BL to I-696
Sheet 2 of 2

MDOT

PARSONS BRINCKERHOFF





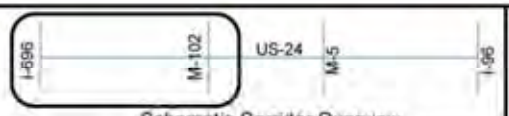
Legend

US-24 Corridor
Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV
Potential Fiber-Optic Communication Linkage Point
Potential Wireless Communication Linkage Point

Proposed Detection:
Side Street Stop Bar
Mainline System
Communication Radio
Main Line Stop Bar
Pedestrian

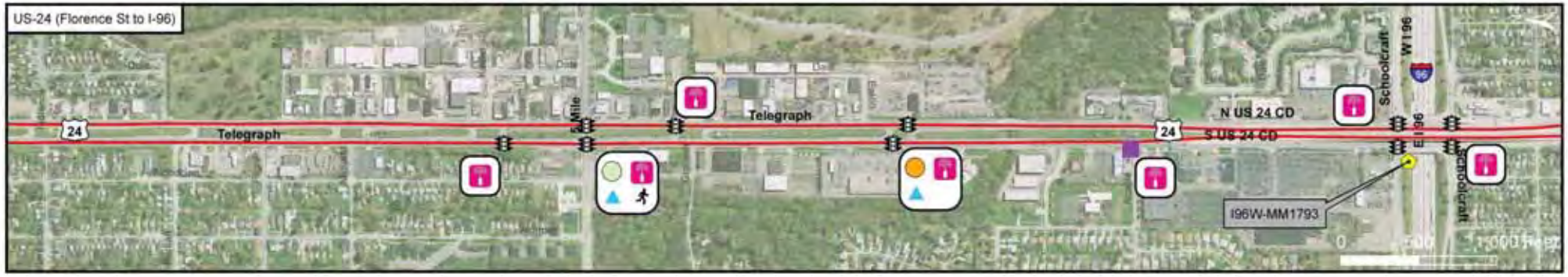


Schematic Corridor Overview

Metro Region AMS Corridor Plan

US-24 (Telegraph Road)
I-696 to I-96
Sheet 1 of 2

MDOT
PARSONS BRINCKERHOFF



Legend

US-24 Corridor
Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV
Potential Fiber-Optic Communication Linkage Point
Potential Wireless Communication Linkage Point

Proposed Detection:
Side Street Stop Bar
Mainline System
Communication Radio
Main Line Stop Bar
Pedestrian

I-696 | M-102 | US-24 | M-5 | I-96

Schematic Corridor Overview

Metro Region AMS Corridor Plan

US-24 (Telegraph Road)
I-696 to I-96
Sheet 2 of 2

MDOT
PARSONS BRINCKERHOFF

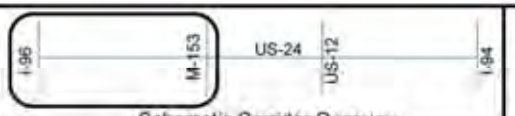
Legend

US-24 Corridor
Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV
Potential Fiber-Optic Communication Linkage Point
Potential Wireless Communication Linkage Point

Proposed Detection:
Side Street Stop Bar
Mainline System
Communication Radio
Main Line Stop Bar
Pedestrian

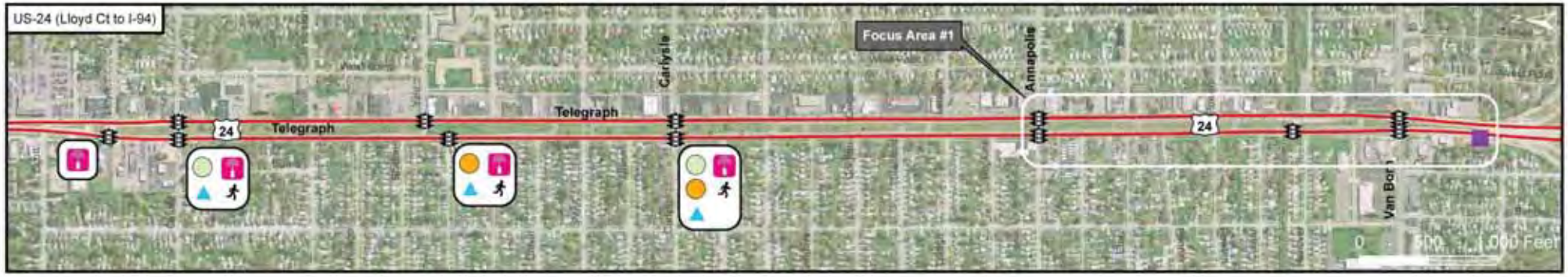


Schematic Corridor Overview

Metro Region AMS Corridor Plan

US-24 (Telegraph Road)
I-96 to I-94
Sheet 1 of 2

MDOT
PARSONS BRINCKERHOFF



Legend

- US-24 Corridor
- Other Route

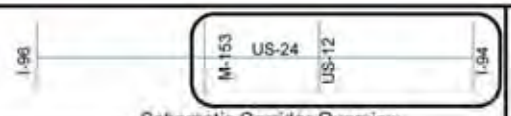
Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV

- Potential Fiber-Optic Communication Linkage Point
- Potential Wireless Communication Linkage Point

Proposed Detection:

- Side Street Stop Bar
- Main Line Stop Bar
- Mainline System
- Pedestrian
- Communication Radio



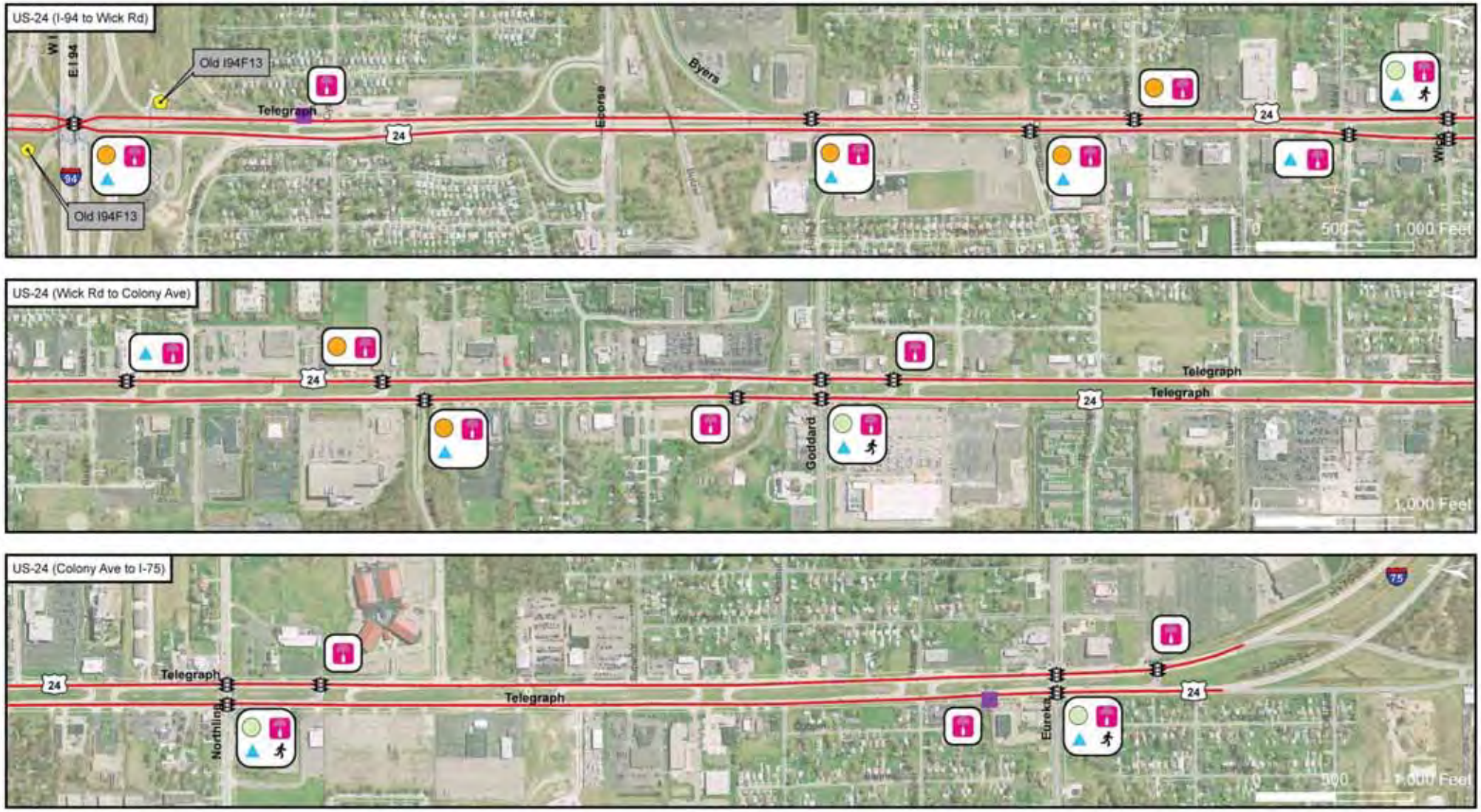
Schematic Corridor Overview

Metro Region AMS Corridor Plan

US-24 (Telegraph Road)
I-96 to I-94
Sheet 2 of 2

MDOT

PARSONS BRINCKERHOFF



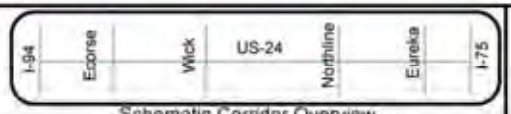
Legend

US-24 Corridor
Other Route

Existing Devices: Traffic Signal

Proposed ITS Devices: DMS, CCTV
Potential Fiber-Optic Communication Linkage Point
Potential Wireless Communication Linkage Point

Proposed Detection:
Side Street Stop Bar
Main Line Stop Bar
Mainline System
Pedestrian
Communication Radio



Schematic Corridor Overview

Metro Region AMS Corridor Plan

US-24 (Telegraph Road)
I-94 to I-75
Sheet 1 of 1

MDOT
PARSONS BRINCKERHOFF

APPENDIX D

CONCEPTUAL DEPLOYMENT PLAN COST ESTIMATES

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	M-1 (Woodward Ave)	County:	Wayne	
Bounds:	8 Mile Rd to US-24BL	Length:	13 miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	28	$8,000.00	$224,000.00	Wireless in pavement detection
Pedestrian Detection	23	$4,000.00	$92,000.00	Pedestrian Push Buttons for crossing the primary road. Includes new devices only. It is assumed the existing push buttons will not need upgrades.
Close Circuit Television Camera	19	$10,000.00	$190,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Wireless Communication			$200,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet and controller upgrades	18	$25,000.00	$450,000.00	Assume 50% of the cabinets would require upgrades, including controllers
Controller upgrades	18	$5,000.00	$90,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	52	$7,000.00	$364,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	6	$5,000.00	$30,000.00	Assume new service for each DMS sign
Removals and MISC Work	26	$1,000.00	$26,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$1,676,000.00**	
System Integration and testing	5% of total cost		$83,800.00	
Design Engineering	15% of total cost		$251,400.00	
Construction Engineering	10% of total cost		$167,600.00	
Mobilization	7% of total cost		$117,320.00	
MOT	7% of total cost		$117,320.00	
Contingency	10% of total cost		$167,600.00	
Grand Total			**$2,581,040.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	M-1 (Woodward Ave)	County:	Wayne	
Bounds:	Grand Blvd to 8 Mile Rd	Length:	5.9 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	29	$8,000.00	$232,000.00	Wireless in pavement detection
Pedestrian Detection	22	$4,000.00	$88,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	3	$10,000.00	$30,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Wireless Communication			$125,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet and controller upgrades	15	$25,000.00	$375,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	15	$5,000.00	$75,000.00	Assume Remaining (50%) of controllers will require upgrades
Cabinet Electronics	16	$7,000.00	$112,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	2	$5,000.00	$10,000.00	Assume new service for each DMS sign
Removals and MISC Work	16	$1,000.00	$16,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$1,073,000.00**	
System Integration and testing	5% of total cost		$53,650.00	
Design Engineering	15% of total cost		$160,950.00	
Construction Engineering	10% of total cost		$107,300.00	
Mobilization	7% of total cost		$75,110.00	
MOT	7% of total cost		$75,110.00	
Contingency	10% of total cost		$107,300.00	
Grand Total			**$1,652,420.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	M-3 (Gratiot Ave)	County:	Wayne	
Bounds:	I-375 to 8 Mile Rd	Length:	8.4 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	34	$8,000.00	$272,000.00	Wireless in pavement detection
Pedestrian Detection	1	$4,000.00	$4,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	24	$10,000.00	$240,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	3	$5,000.00	$15,000.00	
Wireless Communication			$180,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet and controller upgrades	17	$25,000.00	$425,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	17	$5,000.00	$85,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	31	$7,000.00	$217,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	3	$5,000.00	$15,000.00	Assume new service for each DMS sign
Removals and MISC Work	30	$1,000.00	$30,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
			$1,483,000.00	
System Integration and testing	5% of total cost		$74,150.00	
Design Engineering	15% of total cost		$222,450.00	
Construction Engineering	10% of total cost		$148,300.00	
Mobilization	7% of total cost		$103,810.00	
MOT	7% of total cost		$103,810.00	
Contingency	10% of total cost		$148,300.00	
Grand Total			**$2,283,820.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	M-8 (Davison Ave)	County:	Wayne	
Bounds:	I-96 to M-10	Length:	2.1 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	11	$8,000.00	$88,000.00	Wireless in pavement detection
Pedestrian Detection	3	$4,000.00	$12,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	7	$10,000.00	$70,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	1	$5,000.00	$5,000.00	
Wireless Communication			$48,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet and controller upgrades	5	$25,000.00	$125,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	5	$5,000.00	$25,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	11	$7,000.00	$77,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	1	$5,000.00	$5,000.00	Assume new service for each DMS sign
Removals and MISC Work	11	$1,000.00	$11,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$466,000.00**	
System Integration and testing	5% of total cost		$23,300.00	
Design Engineering	15% of total cost		$69,900.00	
Construction Engineering	10% of total cost		$46,600.00	
Mobilization	7% of total cost		$32,620.00	
MOT	7% of total cost		$32,620.00	
Contingency	10% of total cost		$46,600.00	
Grand Total			**$717,640.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	Old M-14 (Plymouth Rd)	County:	Oakland	
Bounds:	Downtown Plymouth to US-24	Length:	10.1 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	28	$8,000.00	$224,000.00	Wireless in pavement detection
Pedestrian Detection	18	$4,000.00	$72,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	27	$10,000.00	$270,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Wireless Communication			$190,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet and controller upgrades	14	$25,000.00	$350,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	14	$5,000.00	$70,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	14	$7,000.00	$98,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	2	$5,000.00	$10,000.00	Assume new service for each DMS sign
Removals and MISC Work	29	$1,000.00	$29,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$1,323,000.00**	
System Integration and testing	5% of total cost		$66,150.00	
Design Engineering	15% of total cost		$198,450.00	
Construction Engineering	10% of total cost		$132,300.00	
Mobilization	7% of total cost		$92,610.00	
MOT	7% of total cost		$92,610.00	
Contingency	10% of total cost		$132,300.00	
Grand Total			**$2,037,420.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	M-39 (Southfield Road)	County:	Wayne	
Bounds:	I-94 to I-75	Length:	2.0 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	12	$8,000.00	$96,000.00	Wireless in pavement detection
Pedestrian Detection	0	$4,000.00	$0.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	1	$10,000.00	$10,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Wireless Communication			$69,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet and controller upgrades	8	$25,000.00	$200,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	8	$5,000.00	$40,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	14	$7,000.00	$98,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	3	$5,000.00	$15,000.00	Assume new service for each DMS sign
Removals and MISC Work	14	$1,000.00	$14,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$552,000.00**	
System Integration and testing	5% of total cost		$27,600.00	
Design Engineering	15% of total cost		$82,800.00	
Construction Engineering	10% of total cost		$55,200.00	
Mobilization	7% of total cost		$38,640.00	
MOT	7% of total cost		$38,640.00	
Contingency	10% of total cost		$55,200.00	
Grand Total			**$850,080.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	M-153 (Ford Rd)	County:	Wayne	
Bounds:	Canton Center to US-24	Length:	11.0 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	29	$8,000.00	$232,000.00	Wireless in pavement detection
Pedestrian Detection	1	$4,000.00	$4,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	27	$10,000.00	$270,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Cabinet and controller upgrades			$195,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet upgrades	13	$25,000.00	$325,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	13	$5,000.00	$65,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	14	$7,000.00	$98,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	2	$5,000.00	$10,000.00	Assume new service for each DMS sign
Removals and MISC Work	29	$1,000.00	$29,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$1,238,000.00**	
System Integration and testing	5% of total cost		$61,900.00	
Design Engineering	15% of total cost		$185,700.00	
Construction Engineering	10% of total cost		$123,800.00	
Mobilization	7% of total cost		$86,660.00	
MOT	7% of total cost		$86,660.00	
Contingency	10% of total cost		$123,800.00	
Grand Total			**$1,906,520.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	US-12 (Michgan Ave)	County:	Wayne	
Bounds:	I-94 to Third Street	Length:	5.3 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	21	$8,000.00	$168,000.00	Wireless in pavement detection
Pedestrian Detection	6	$4,000.00	$24,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	16	$10,000.00	$160,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Wireless Communication			$90,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet and controller upgrades	10	$25,000.00	$250,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	10	$5,000.00	$50,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	18	$7,000.00	$126,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	2	$5,000.00	$10,000.00	Assume new service for each DMS sign
Removals and MISC Work	21	$1,000.00	$21,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$909,000.00**	
System Integration and testing	5% of total cost		$45,450.00	
Design Engineering	15% of total cost		$136,350.00	
Construction Engineering	10% of total cost		$90,900.00	
Mobilization	7% of total cost		$63,630.00	
MOT	7% of total cost		$63,630.00	
Contingency	10% of total cost		$90,900.00	
Grand Total			**$1,399,860.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	US-24 (Telegraph Rd)	County:	Oakland	
Bounds:	I-696 to I-75 (via US-24 BL)	Length:	8.4 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	15	$8,000.00	$120,000.00	Wireless in pavement detection
Pedestrian Detection	3	$4,000.00	$12,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	9	$10,000.00	$90,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	3	$5,000.00	$15,000.00	
Wireless Communication			$98,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet and controller upgrades	12	$25,000.00	$300,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	12	$5,000.00	$60,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	12	$7,000.00	$84,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	3	$5,000.00	$15,000.00	Assume new service for each DMS sign
Removals and MISC Work	26	$1,000.00	$26,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$820,000.00**	
System Integration and testing	5% of total cost		$41,000.00	
Design Engineering	15% of total cost		$123,000.00	
Construction Engineering	10% of total cost		$82,000.00	
Mobilization	7% of total cost		$57,400.00	
MOT	7% of total cost		$57,400.00	
Contingency	10% of total cost		$82,000.00	
Grand Total			**$1,262,800.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	US-24 (Telegraph Rd)	County:	Wayne/Oakland	
Bounds:	I-96 to I-696	Length:	7.3 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	15	$8,000.00	$120,000.00	Wireless in pavement detection
Pedestrian Detection	7	$4,000.00	$28,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	13	$10,000.00	$130,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Cabinet and controller upgrades			$145,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet upgrades	7	$25,000.00	$175,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	7	$5,000.00	$35,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	13	$7,000.00	$91,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	2	$5,000.00	$10,000.00	Assume new service for each DMS sign
Removals and MISC Work	26	$1,000.00	$26,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$770,000.00**	
System Integration and testing	5% of total cost		$38,500.00	
Design Engineering	15% of total cost		$115,500.00	
Construction Engineering	10% of total cost		$77,000.00	
Mobilization	7% of total cost		$53,900.00	
MOT	7% of total cost		$53,900.00	
Contingency	10% of total cost		$77,000.00	
Grand Total			**$1,185,800.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	US-24 (Telegraph Rd)	County:	Wayne	
Bounds:	I-94 to I-96	Length:	8.1 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	15	$8,000.00	$120,000.00	Wireless in pavement detection
Pedestrian Detection	15	$4,000.00	$60,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	13	$10,000.00	$130,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Cabinet and controller upgrades			$190,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet upgrades	12	$25,000.00	$300,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	12	$5,000.00	$60,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	14	$7,000.00	$98,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	2	$5,000.00	$10,000.00	Assume new service for each DMS sign
Removals and MISC Work	28	$1,000.00	$28,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$1,006,000.00**	
System Integration and testing	5% of total cost		$50,300.00	
Design Engineering	15% of total cost		$150,900.00	
Construction Engineering	10% of total cost		$100,600.00	
Mobilization	7% of total cost		$70,420.00	
MOT	7% of total cost		$70,420.00	
Contingency	10% of total cost		$100,600.00	
Grand Total			**$1,549,240.00**	

Metro Arterial Deployment Plan Cost Estimate				
Corridor:	US-24 (Telegraph Rd)	County:	Wayne	
Bounds:	I-75 to I-94	Length:	4.7 Miles	
Item Descritption	Quantity	Unit Price	Total	Assumptions
System Detection	15	$8,000.00	$120,000.00	Wireless in pavement detection
Pedestrian Detection	4	$4,000.00	$16,000.00	Pedestrian Push Buttons for crossing the primary Road
Close Circuit Television Camera	10	$10,000.00	$100,000.00	Includes the camera, DVE , surges and cabling
Dynamic Message Signs	2	$5,000.00	$10,000.00	
Cabinet and controller upgrades			$80,000.00	Includes 900 Mhz, 5 GHz 12 Mbps, 5GHz 36 Mbps and upgrading of the existing backhaul links
Cabinet upgrades	11	$25,000.00	$275,000.00	Assume 50% of the cabinets would require upgrades
Controller upgrades	11	$5,000.00	$55,000.00	Assume 50% of controllers will require upgrades
Cabinet Electronics	8	$7,000.00	$56,000.00	Includes, Field Switch, UPS , POE's, surges and cabling
Power Service	2	$5,000.00	$10,000.00	Assume new service for each DMS sign
Removals and MISC Work	16	$1,000.00	$16,000.00	Includes existing equipment and cable removals, pole fit ups, conduit, handholes
Total			**$738,000.00**	
System Integration and testing	5% of total cost		$36,900.00	
Design Engineering	15% of total cost		$110,700.00	
Construction Engineering	10% of total cost		$73,800.00	
Mobilization	7% of total cost		$51,660.00	
MOT	7% of total cost		$51,660.00	
Contingency	10% of total cost		$73,800.00	
Grand Total			**$1,136,520.00**	