City of Dubuque: Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Final Report

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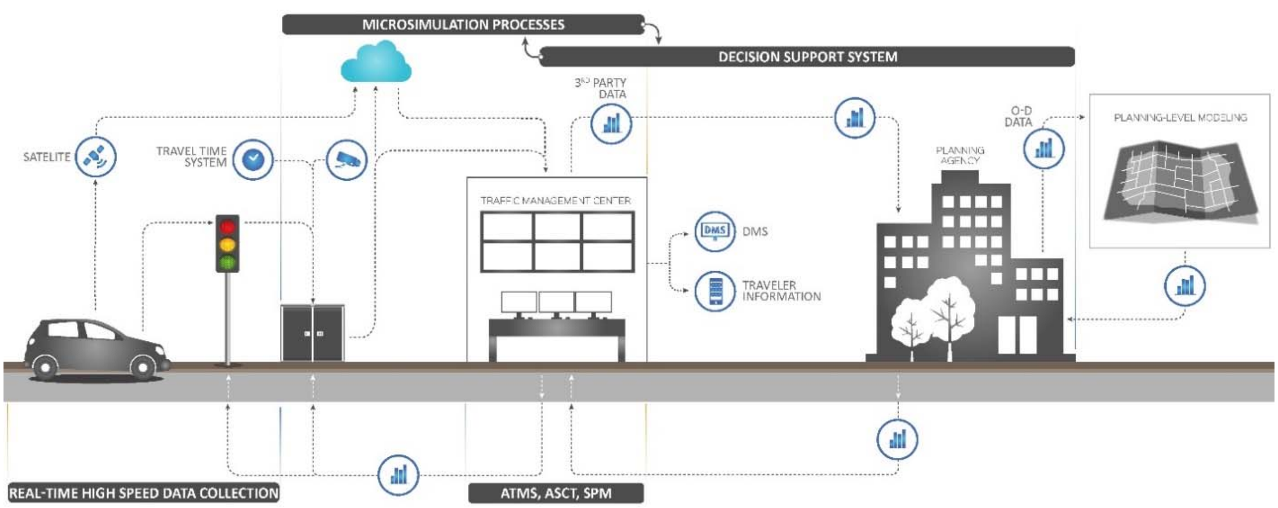
EXECUTIVE SUMMARY

The City of Dubuque is a leader in the use of traffic signal systems and field hardware to manage and operate a sophisticated and advanced signal network that benefits the road-users that live within, that work within, visit within or just pass through the Dubuque region. These devices have served to reduce delay and improve safety for these road-users. This includes adjusting signal timings based on the traditional study of traffic conditions. Staff has used the camera system to support Dubuque Police in identifying wrong way traffic or other crash information. Much of this effort is placed upon a small number of traffic engineers and technicians within the City. With the advent of new technology and integration, with terms like; advanced analytics, “deep learning”, smart cities, artificial intelligence throughout our society and within the transportation industry, the opportunity to “do more with our technology” was discussed and planned for in the Dubuque region. Area leaders, planners and administrators came together to describe a future smart traffic signal system that leverages the advances in technology. The vision is to create the next generation of integrated traffic signal system that includes rapid simulation of future traffic conditions based on real-time data collection. It also includes communicating the modeled changes to road-users before they leave and in route to balance delay and reduce congestion. The dynamic rerouting of traffic to balance road-user delay is also expected to have safety benefits with a reduction in crashes and pollutants. The interaction of sub-system components is illustrated in **Executive Summary (ES) Figure 1.**

This future enhanced smart traffic system for the Dubuque region has been given that name: **Smart Traffic Routing with Efficient & Effective Traffic System (STREETS).**

ES Figure 1 – STREETS Components Interaction

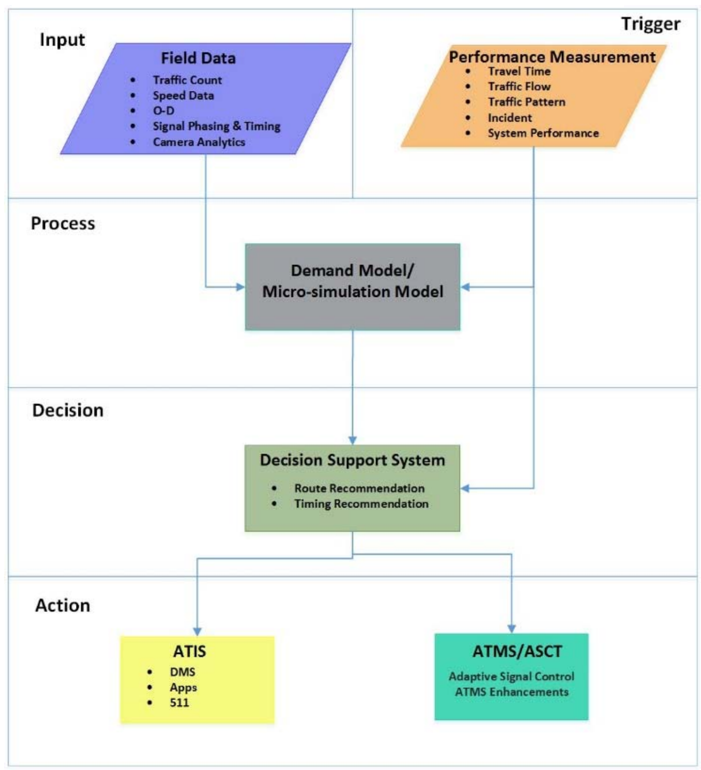


The Dubuque STREETS project has taken the next step from a future project described within the Dubuque Metropolitan Area Transportation Study (DMATS) to the completion of system engineering documents that are consistent with Federal Highway Administration (FHWA) processes and guidelines for the deployment of Intelligent Transportation System (ITS) projects. The documents include:

- System Engineering Management Plan (SEMP)
- Concept of Operations (Con Ops)
- Preliminary Requirements and Verification Plan

These documents provide the required planning and design as the project moves towards future design phases and ultimately deployment. These documents will provide the supporting materials for the lead agency to submit the STREETS project for additional grants and funding opportunities. There is no guarantee of funding but the System Engineering documents satisfy Federal Requirements to be able to submit the applications.

ES Figure 2 – STREETS Management and Control System



The East Central Intergovernmental Association (ECIA), City of Dubuque, Dubuque Metropolitan Area Transportation Study (DMATS) and the Iowa Department of Transportation (Iowa DOT) partnered together to develop the Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) project. The goal of the STREETS project is to develop a smart, next generation, traffic management and control system, **ES Figure 2** Shows the expected flow of data through the STREETS system. In addition to providing sound information to the stakeholders, this project will serve as a framework, nationally, for deployment of similar systems in small urban areas with populations under 100,000.

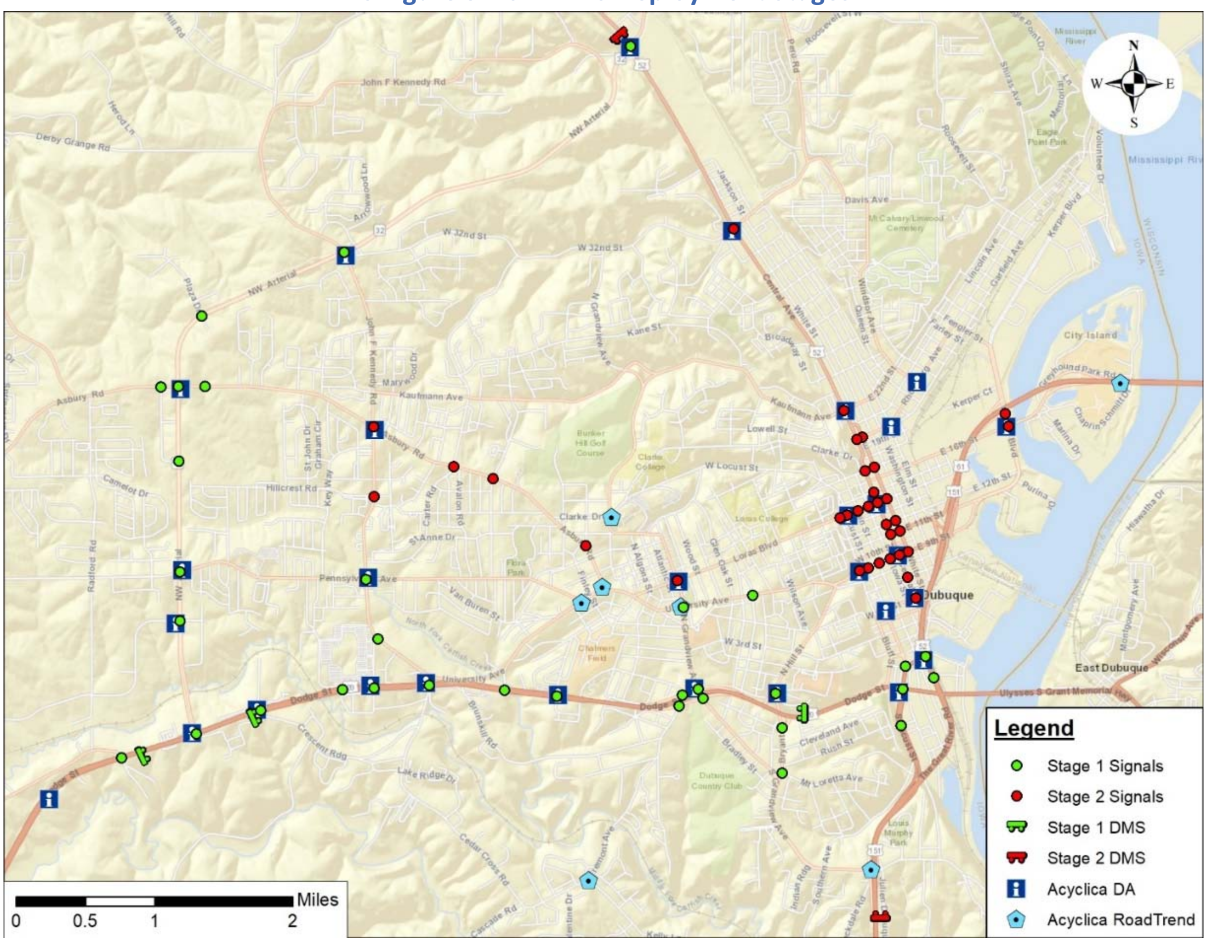
The STREETS project will use traffic control strategies to enable dynamic traffic routing to maximize the use of existing roadway capacities in the Dubuque metropolitan area. The ultimate deployment of STREETS will cover nine (9) corridors with 57 signalized intersections within the City of Dubuque. The STREETS project will use advanced traffic control strategies to enable dynamic traffic routing to maximize the use of existing roadway capacities in the Dubuque metropolitan area. Some benefits from implementation of the STREETS includes:

- Reducing wear and tear on major corridors
- Reduced congestion

- Improved travel times
- Improved safety
- Reduced emissions
- Enhanced system monitoring capabilities

The proposed STREETS project is expected to dynamically react to congestion detected/predicted by the Micro-simulation model, and proactively change signal timing based on predicted traffic flow data while disseminating congestion and alternate route information for motorists. This requires existing signal system and ITS infrastructure to be improved to meet the operational requirements of STREETS. **ES Figure 3** shows the intersections by Stage and locations where existing travel-time and data collection devices are present.

ES Figure 3 – STREETS Deployment Stages



Opinion of Probable Cost (OPC) was also developed to summarize the estimated costs to construct the STREETS based what has been identified by the stakeholders. Looking at potential funding the project was broken into two deployment stages. Stage 1 will include the integration and deployment of the STREETS software, servers, camera analytics and traffic signal enhancements at 33 intersections. Stage 2 would expand the system to adding another 24 intersections. The estimated cost of Stage I is slightly more than $3,365,000, with an overall project estimate $5,060,000. This includes estimated engineering services to support the development of the final RFP and appropriate plan packages for signal enhancements. It also includes a 15% contingency at this time due to the unknown sub-system component costs.

The completion of Phase 1 of the System Engineering Process, which serves as a guide for future phases of the project by defining the roles and responsibilities of the stakeholders involved, as well as the requirements of the system. The project now moves into the next phase, which is the completion of additional design of the system and preparation of a Request for Proposal (RFP). Based on the current status of the industry, the design team recommends completing a Request for Information (RFI) before finalizing requirements and preparing the RFP. Although sub-system components are mature, the rapid micro-simulation modeling of real-time traffic characteristics with camera analytics and other decision-making has not been completed within the signal system industry. The RFI will allow signal system vendors to team up with micro-simulation, with camera analytics and advanced traveler information systems to present preliminary solutions and project specific challenges for the ultimate deployment of the STREETS project. The result of the RFI will allow the design team to improve the project requirements and RFP resulting in a better final project.

STREETS FINAL REPORT

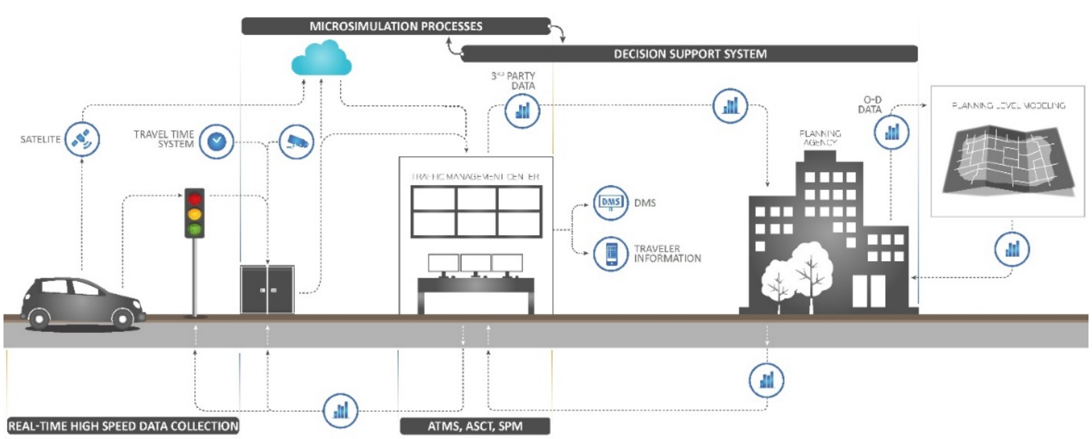
1 INTRODUCTION

The City of Dubuque, Dubuque Metropolitan Area Transportation Study (DMATS) and the Iowa Department of Transportation (Iowa DOT) partnered together to develop the Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) project. The goal of the STREETS project is to develop a smart, next generation, traffic management and control system. The STREETS project will use traffic control strategies to enable dynamic traffic routing to maximize the use of existing roadway capacities in the Dubuque metropolitan area.

The initial deployment of STREETS covers nine (9) corridors with 57 signalized intersections within the City of Dubuque. The STREETS project will use advanced traffic control strategies to enable dynamic traffic routing to maximize the use of existing roadway capacities in the Dubuque metropolitan area. The STREETS project seeks to employ Active Transportation and Demand Management (ATDM) strategies which will require a suite of modeling tools and methods that will enable the City of Dubuque to evaluate the potential benefits of implementing ATDM strategies in a dynamic and proactive fashion using both real-time and historic data.

The STREETS includes the following major components: 1) Travel Demand Model (TDM); 2) Microsimulation Traffic Model (MTM); 3) Adaptive Signal Control Technology (ASCT); 4) Decision Support System (DSS). The STREETS will also interface with other components include, but not limited to, Advanced Traffic Management System (ATMS), Advanced Traveler Information System (ATIS), and third-party data source (i.e., Waze). The TDM will be utilized to estimate the origin/destination (O/D) and other necessary data for the microsimulation traffic model. The MTM is to represent the current roadway network and be capable of executing traffic assignment (dynamic traffic routing) based on estimated/measured traffic impedances of the network links. The ASCT will develop optimized signal timing in real time after changes of traffic conditions are determined by STREETS. The DSS is to function as a core model which communicates with TDM, MTM, ASCT and other components, provide data exchange, dynamic routing strategy generation and integrate all components into a complete STREETS. The interaction of these components is illustrated in **Figure 1.**

Figure 2 – STREETS Components Interaction



The City expects the STREETS will facilitate dynamic routing of traffic to maximize the use of existing roadway capacities in the project area. Some benefits from implementation of the STREETS includes:

- Reducing wear and tear on major corridors
- Reduced congestion
- Improved travel times
- Improved safety
- Enhanced system monitoring capabilities

Based on the goals, a set of objectives, in the context of addressing the City of Dubuque's issue, is established as shown in **Table 1**.

Table 1 – STREETS Goals and Objectives

GOALS	OBJECTIVES
Improve Mobility	• Reduce travel time for commuters within the corridor • Increase person and vehicle throughput on the corridor • Reduce delay time for corridor travel on the corridor's networks • Detour/reroute traffic among corridors to balance the capacity usage
Reduce Congestion	• Improve intersection operation • Reduce delay at intersections • Reduce incident detection time
Improve Safety	• Reduce incident rate • Reduce injury rate • Reduce fatality rate • Reduce roadway hazards
Information for Travelers	• Improve collection and dissemination of road network information • Collect and process data on the operational condition/status of all corridor networks, including o Comparative travel times between major origins and destinations o Construction, detours, and other planned road work o Occurrence and location of incidents o Expected delays • Disseminate comprehensive, real-time, and accurate information to travelers within the corridor by means of multiple media (e.g., phone, computer, PDA/Blackberry, CMSs, 511 App) • Make available archived historical data to travelers

Currently, the City of Dubuque operates all traffic signals and other ITS devices within City limits (including state highways). The current signal system in Dubuque includes 115 traffic signals. Most of the signal controllers are M50 Siemens controller with EPAC firmware and some are EPAC 300. The signal cabinets are NEMA TS-1 or TS-2. Approximately 80% of the system is connected to a fiber optic communication system which is comprised of a minimum of 24 multi-mode and 48 single mode fibers. The City currently uses Siemens' TACTICS central management software to communicate with the traffic signal system. The City currently uses various types of vehicle detection, including Wavetronix and inductive loop. The City has a small number of travel-time measurement systems. Currently the City has 31 Acyclica devices installed throughout the City, which is expected to grow. The City has an extensive network of CCTV and the video detection cameras which are both used for traffic surveillance and post-event investigation of the events that affect safety and security of the travelers. In addition to the existing ITS devices, the City has undertaken an aggressive program to expand ITS deployment within the City including fiber optic conduit, fiber Optic Loop, Dynamic Message Sign (DMS), Smart Sensor, Traffic Camera, and wireless communication. All these will become part of future STREETS and play roles in dynamic routing. The STREETS project intends to deliver an automatic system that gives the City staff the ability to monitor traffic operations and intervene as necessary but does not require constant or significant manual operations.

Built on the existing and near future ITS to be deployed, implementation of the STREETS may require City investment in other physical infrastructure such as data collection and performance measurement systems, processing and dissemination systems, control algorithms, and signal systems that will provide the following upgraded systems and equipment:

- A high speed, reliable communications system
- A highly accurate, reliable detection system
- Improved traffic signal controllers
- A high speed, reliable series of servers and databases
- An automated process to transfer data
- An automated process to analyze traffic conditions
- An automated, highly accurate means to communicate traffic conditions to the traveling public.

1.1 Document Overview

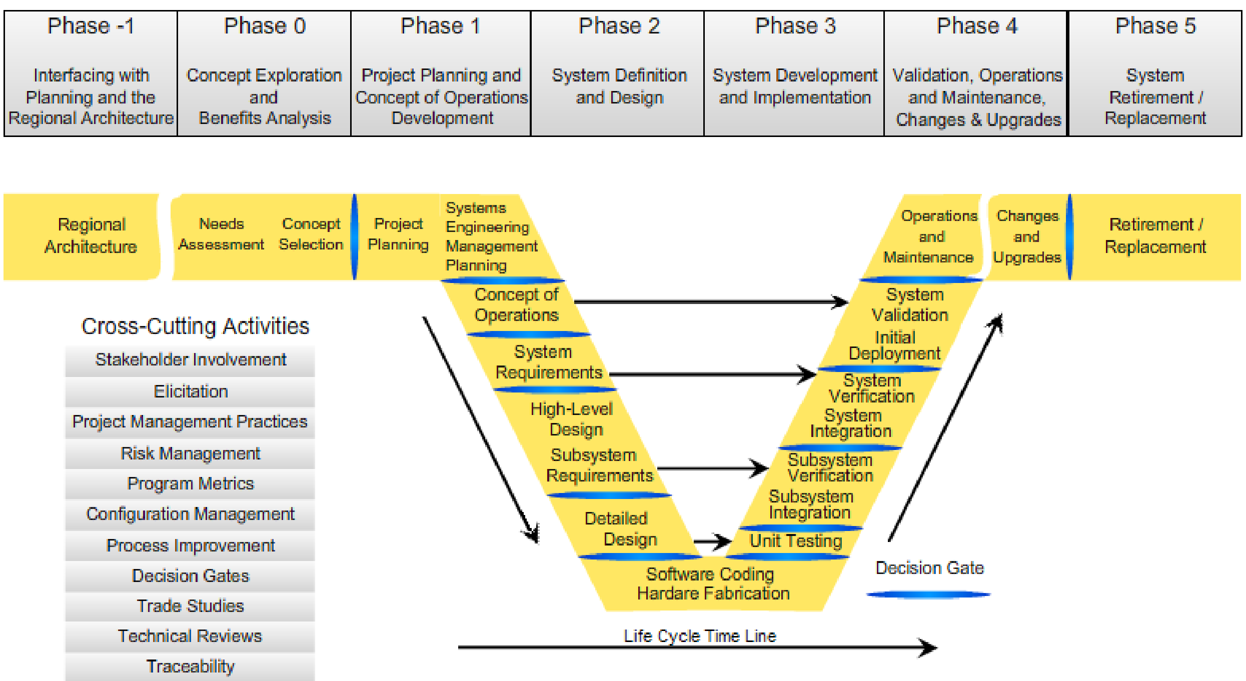
The STREETS Final Report provides a high-level overview of the System Engineering documents that have been completed to date. This Final Report summarizes Phase 1 of the Systems Engineering Process, as illustrated in **Figure 1**. The System Engineering documents produced as part of Phase 1 will guide the STREETS project from conception to operations and maintenance in a systematic way.

The Systems Engineering for the STREETS project worked through the identification of stakeholder needs, project requirements, and verification procedures. Following the FHWA Systems Engineering process (V Diagram in **Figure 2**), the Systems Engineering Management Plan (SEMP), Concept of Operations (ConOps), System Requirements and Verification Plan are key deliverables that are part of the systems engineering work for STREETS. These System Engineering documents are evolving documents that will need to be updated as the STREETS project progresses through the phases of the System Engineering Process.

The Final Report contains the following sections:

Section 2.0 STREETS Planning Process provides a high-level summary, as well as the recommendations, of the three system engineering documents listed above as the subsections within Section 2.0. Section 3.0 STREETS OPC Costs summarizes the estimated OPC Costs to construct the STREETS based what has been identified from the planning processes that have been completed as part of Phase 1 of the System Engineering Process. The final section, 4.0 Next Steps, summarizes the recommendations and actions that should be taken next as identified from Phase 1 of the System Engineering Process, as well as provides an overview of what Phase 2 of the process will include.

Figure 2 – Systems Engineering Process "V" Diagram



2 STREETS PLANNING PROCESS

The following sections provide a high level overview and summary of the System Engineering documents that have been produced as part of Phase 1 of the System Engineering Process for the STREETS project.

2.1 Systems Engineering Management Plan (SEMP)

2.1.1 SEMP Overview

The Systems Engineering Management Plan (SEMP) for the STREETS project provides a high-level plan for the management of Systems Engineering in compliance with the Federal Highway Administration (FHWA) Federal Rule 23 CFR 940.11 and Systems Engineering Guidelines. At this stage of the systems engineering the process is evolving, this SEMP will need to be revisited again at key milestones as the project progresses through procurement, deployment, integration, and testing.

2.1.2 SEMP Summary

SEMP details the technical tasks and systems engineering processes that should be followed to develop and implement a next-generation traffic management system in the Dubuque metro area. The SEMP identifies project elements that must be designed, procured, integrated, verified and maintained as the deployment occurs. The SEMP also identifies a realistic project schedule so that consistent expectations are developed early-on among project stakeholders with regard to deployment of the system. Development of the SEMP considered the region's planning process and other project technical needs and dependencies that could impact the planning, design and deployment schedule for the system. Key details defined in the SEMP include:

- Project Management and Control
- Traceability and Technical Review
    - Procurement Management
    - Change Management
    - Quality Management
    - System Acceptance
    - Operations, Maintenance, Upgrade and Retirement

For more detailed information about the above, refer to the *Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Systems Engineering Management Plan (SEMP)* document.

The System Engineering Process and deliverables that will be completed as part of the STREETS project, as identified in the SEMP, are shown in **Table 2**. These contain important descriptions of stakeholders, systems, and operational practices that support the systems engineering for the STREETS project.

Table 2 – City of Dubuque STREETS Process Documentation

SYSTEMS ENGINEERING PROCESSES	STATUS	DESCRIPTION	DELIVERABLES
Systems Engineering Management Plan	Complete; update as needed during future phases.	The Systems Engineering Management Plan provides project managers and stakeholders an overview of how the systems engineering activities and the subsequent components of the STREETS will follow and be integrated with the systems engineering processes.	Draft and Final Systems Engineering Management Plan
Concept of Operations	Completed.	The Concept of Operations identifies the needs as well as roles and responsibilities of all stakeholders identified in the SEMP as it relates to the STREETS. The Concept of Operations defines what the STREETS will look like and how it will operate based on discussion of operational scenarios and alternative concepts.	Draft and Final Concept of Operations
Requirements	Preliminary Completed. To be refined after RFI.	This document describes what needs to be achieved by the proposed STREETS. The requirements will be traced back to the stakeholder needs that were identified in the Concept of Operations. Each need will have at least one requirement. The requirements will be either mandatory or secondary based on the stakeholder needs. The System Requirements determine what the system must do. A Verification Plan will be prepared as part of this project that addresses the expected process to determine that the requirements are satisfied during the deployment of the STREETS components.	Preliminary, Revised and Final Requirements

SYSTEMS ENGINEERING PROCESSES	STATUS	DESCRIPTION	DELIVERABLES
Verification Plan	Draft Completed	This document describes how the system will be tested, ensuring that the mandatory and possibly desirable requirements are satisfied. It will lay out a template plan for the vendor & City to conduct the verification effort.	Draft and Final Verification Report
Travel Demand Forecast Model (Enhanced Existing or New)	Not started. To be started in the next phase of the project.	The existing Travel Demand Forecast Model will be evaluated to determine how well it can perform in estimating the O/D and other necessary data for the microsimulation traffic model. If the existing Travel Demand Forecast Model cannot perform satisfactorily, then either it may be enhanced or a new model may need to be procured in the next phase of the project.	The draft and final requirements related to the Travel Demand Forecast Model. In the next phase of the project, either the model may need to be enhanced or a new model may need to be procured.
Microsimulation Traffic Model' – Data (New)	Not started. To be started in the next phase of the project.	Based on the system requirements, the existing microsimulation model will be evaluated to determine whether it can satisfy the data requirements. If the existing model cannot satisfy the requirement, then either it may be enhanced or a new microsimulation traffic model representing the existing traffic conditions in the Dubuque metro area may need to be procured. in the next phase of the project.	The draft and final requirements related to the microsimulation model. In the next phase of the project, either the existing model may need to be enhanced or a new model may need to be procured.
Adaptive Signal Control Technology (ASCT) (New)	Not Started. To be completed in the next phase of the project.	An adaptive signal control technology system will be procured in the next phase of the project. The ASCT system will be selected based on the system requirements.	The draft and final requirements related to the ASCT system. In the future phases of the project, the ASCT system will be procured.

SYSTEMS ENGINEERING PROCESSES	STATUS	DESCRIPTION	DELIVERABLES
System Integration	Not started. To be completed in the next phase of the project.	In future phases of the project, a detailed plan of integrating the existing data sources to the STREETS will be developed. The plan will identify the available data sources, indicate which data sources will be utilized as input to the microsimulation model, which data sources will be used for model calibration and validation, provide the approach of handling missing data and identify necessary tools and features such as third party Speed Data Collection/ Performance Management system to monitor the STREETS.	The draft and final data requirements related to data sharing and integration. In a future phase of the project, the system integration plan identifying how to meet the data requirements will be developed. The high level data requirements will be included in the requirements in this phase of the project.

The most significant objective of the SEMP was to ensure that a deployment strategy is identified that meets the Region's short- and long-term needs in a logical, sequential manner. Adherence to the defined process will ensure that all relevant concerns have been included in the overall design process. The SEMP serves as a guide the STREETS project from conception to operations to maintenance in a systematic way. The SEMP is an evolving document that will be updated as the STREETS project progresses through future phases.

2.2 Concept of Operations (ConOps)

2.2.1 ConOps Overview

The Concept of Operations (ConOps) is a document that describes the expected operations of the system from the user's viewpoint and provides documentation in compliance with FHWA Rule 23 CFR 940.11 and Systems Engineering Guidelines. The objective of this task was to develop a ConOps for a traffic management solution in the Dubuque metro area that identifies (confirms) project stakeholders, defines system needs and expectations, explores the adaptive/dynamic environment that is envisioned (including user and/or operational scenarios) develops high-level requirements and identifies institutional issues or constraints that would impact project design, deployment, operations or maintenance. Key aspects of the ConOps included the needs assessment, review of current systems, defining roles and responsibilities of the project stakeholders and necessary resources for the operations and maintenance of the desired traffic management system. This task explored the necessary integration that must exist between system components (signal system, communications, field devices, microsimulation models, performance measurement platform, etc.) to provide the desired STREETS functionality. The ConOps answers the following set of core questions:

- Why: Justification for the system, identifying what the corridors currently lack, and what the system will provide
- What: Currently known elements and the high-level capabilities of the system
- Where: Geographical and physical extents of the system
- Who: Stakeholders involved with the system and their respective responsibilities
- When: Time sequence of activities that will be performed
- How: Resources needed to design, build, operate, and maintain the system

2.2.2 ConOps Summary

The ConOps is the second document of the various systems engineering deliverables identified for this project. The purpose of the ConOps document is to communicate overall qualitative system characteristics to the City of Dubuque and other involved stakeholders. The ConOps document lays out the STREETS concept, explains how things are expected to work once it is in operation, and identifies the roles and responsibilities of the various stakeholders to make this happen. The Concept of Operations documents, at a high-level, the expected plan for:

- **Operations** – This includes a high-level summary of the staffing needs to operate the STREETS and the roles and responsibilities for the selected system operation, management, information sharing and reporting.
- **Maintenance** – This included the staffing needed to maintain system software, hardware and communications.
- **Upgrade** – This will include opportunities to upgrade hardware, software and communications. The City of Dubuque and DMATS will use potential upgrade options to develop a strategy for budgeting and performing system upgrades.
- **Retirement** – This will include estimates for software, hardware and communications replacement. This will be based on industry trends and the City of Dubuque and DMATS' vision for future systems.

The plan for the operations, maintenance, upgrade and retirement of the STREETS and its components was documented in the ConOps. The details for these plans were summarized in the following sections of the ConOps:

- Operational Needs
- Proposed Operations
- Operational Scenarios
- Summary of Impact
- Next Steps

For more detailed information about the above, refer to the *Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Concept of Operations (ConOps)* document.

The operational needs assessment process was conducted to identify the stakeholder needs, based on the proposed operations, which must be satisfied in order for the City of Dubuque to meet its goals and objectives relative to developing the STREETS. This process included a Needs Assessment Workshop with stakeholders, as well as additional follow-up meetings with key stakeholders, that included various operational scenarios to identify stakeholder roles and responsibilities, equipment (such as hardware, software, and communications), staffing, and traffic management needs for both existing and future conditions. This process resulted in the identification of eight needs, which included:

1. Data Collection
2. Performance Measurement System
3. Traffic Modeling
4. Decision Support System
5. Traffic Signal System
6. Communication System
7. ATIS
8. Operations and Maintenance

Through discussion and further evaluation of the needs identified during stakeholder workshops, more detailed needs were identified based on various operational scenarios. After the needs were defined, a preliminary list of performance measures was identified to support the evaluation of the goals and objectives by defining the system requirements. These needs and associated requirements are further documented and traced in the requirements and verification plan.

2.3 Requirements and Verification Plan

2.3.1 Requirements and Verification Plan Overview

The Requirements and verification Plan will be used to guide the City of Dubuque staff and the System Vendors through different components of the STREETS during the deployment. The Requirements and Verification Plan traceability from each requirement to the original needs identified in the ConOps, as well as to the testing and acceptance procedures identified in the Verification Plan. The verification plan will serve as the foundation for the creation of a detailed acceptance test plan for the STREETS.

2.3.2 Requirements and Verification Plan Summary

The requirements are based on user needs determined in the Concept of Operations document. These needs were gathered directly through meetings with stakeholders and walking-through various operational scenarios. The STREETS requirements and verification are discussed in detail in the following sections of the Requirements and Verification Plan:

- Verification Approach
- Verification Review and Testing
- System Requirements.

For more detailed information about the specific details of the Requirements and Verification Plan, refer to the *Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Requirements and Verification Plan* document.

A preliminary set of detailed requirements were evaluated and determined to be Mandatory or Secondary. Secondary requirements are features that provide benefit but are not mandatory, as the execution of the project deployment can be accomplished without these STREETS requirements. As an example, the selected ASCT system of STREETS does not need the ability to access and modify settings on an adjacent controller at a near-by intersection. The City might consider this a favorable solution but not a solution at the expense of other mandatory requirements. Therefore, it is written as a Secondary requirement.

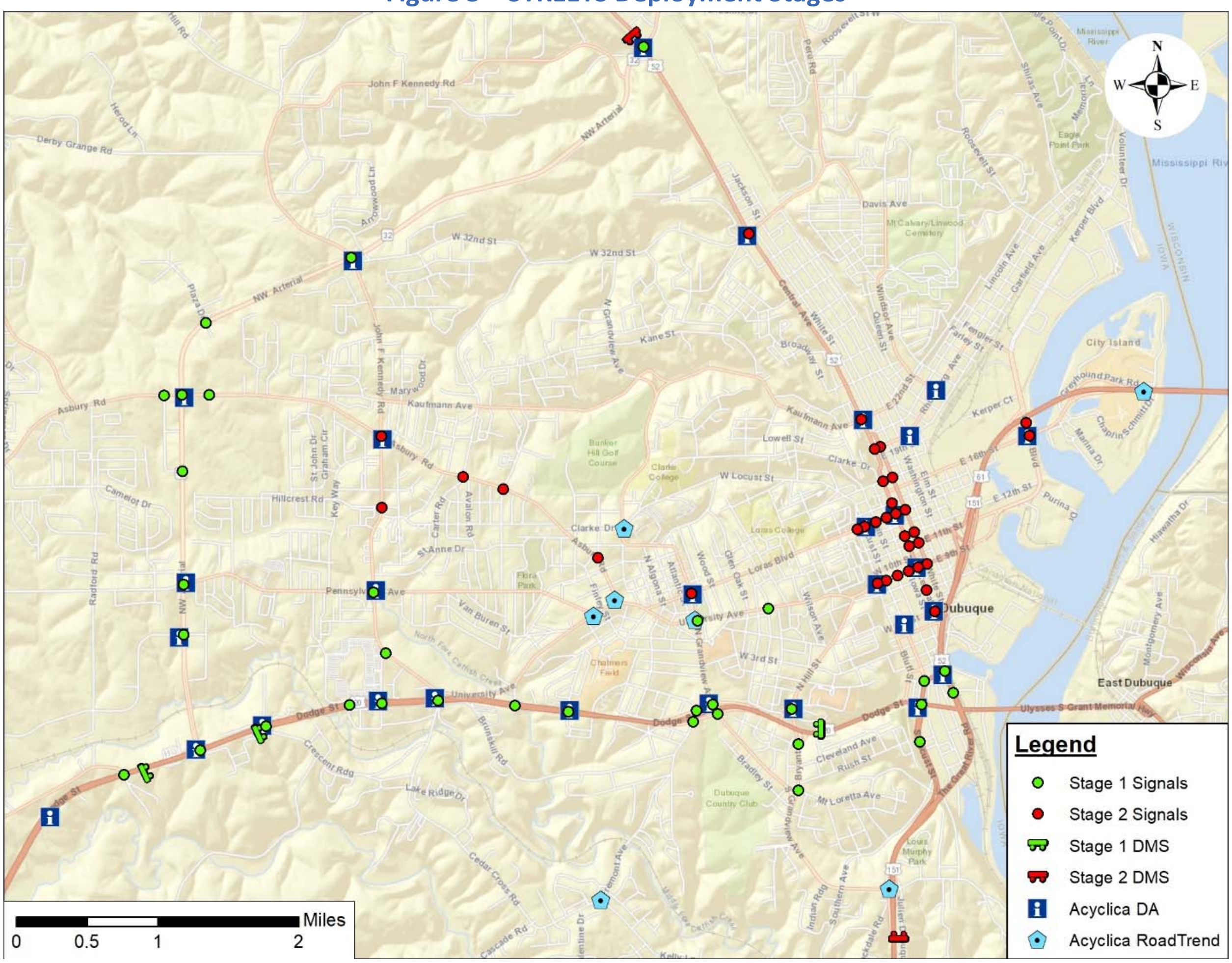
The Final verification procedures will be developed by the System Vendors of the STREETS project based on actual sub-systems selected and the materials provided in the RFP. These acceptance procedures will require the approval from lead agency and the City of Dubuque traffic engineering staff. All verifications shall be conducted in the presence of the City of Dubuque staff. Final verification and formal system acceptance will be provided by the City of Dubuque's Project Manager. The Project Manager will control the schedule and acceptance of the tests, but will also work with the System Vendors to clarify the verification procedures and acceptance tests.

The verification and acceptance testing will be accomplished at approved City of Dubuque locations and at specific field locations within the City. All acceptance test procedures shall conform to the approved acceptance test plans. These tests will be completed and documented by the System Vendors and supervised by the City of Dubuque Project Manager. Operational documentation of the field components is expected to be completed with a laptop, internet connection and associated cabling. The System Vendors will need to provide multiple staff in the field and at the TOC to document certain acceptance tests.

3 STREETS OPINION OF PROBABLE COST

As part the Phase 1 of the STREETS project, an Opinion of Probable Cost (OPC) was developed for the STREETS components, as well as the annual support and fine-tuning. The items that were included in the OPC were identified throughout the project, including during the stakeholder workshops, as being necessary to obtain the required system functionality needed to obtain the proposed operations. The OPC was separated into two stages. Stage 1 is the cost required to equip the primary corridor intersections and one primary alternate route. It also includes the majority of the software, central network and integration. Stage 2 is the completion of the system and additional of the remaining alternate routes. **Figure 3** shows the intersection locations by Stage and locations where existing travel-time and data collection devices are present.

Figure 3 – STREETS Deployment Stages



Stage 1 includes 33 intersections with the purchase, development and integration of the necessary sub-systems to meet the project requirements and operational goals. The construction is expected to include integration of:

- Camera Analytics
- Acyclica Travel-Time Data
- 3rd Party Travel-Time Data
- Advanced Traffic Management System (ATMS) Enhancements
- Adaptive Signal Control Technology (ASCT)
- Additional Detection
- Micro-Simulation
- Signal Performance Measures (SPM)
- Decision Support System (DSS)
- Dynamic Message Signs (DMS)
- Advanced Traveler Information Systems (ATIS)

The software and central network will be sized for the future build-out and additional stages such that the effort to expand the system will require field hardware such as controller, detection and communication upgrades. The DSS system will likely need expansion as new corridors are monitored and available for dynamic rerouting. For planning purposes the project is broken into two Stages to support funding, deployment and acceptance testing. The component and support costs for Stage 1, Stage 2 and the Total of both phases is shown in **Table 3**, while the detailed OPC for each of the phases is located in **Appendix A**.

Table 3 – Opinion of Probable Cost (OPC) for the STREETS Project

STAGE	COMPONENTS COST	SUPPORT COSTS	TOTAL COSTS
Stage 1	$3,366,250	$101,200	$3,467,450
Stage 2	$1,696,250	$101,200	$1,797,450
Total	$5,062,500	$202,400	$5,264,900

4 NEXT STEPS

With the completion of Phase 1 of the System Engineering Process, which serves as a guide for future phases of the project by defining the roles and responsibilities of the stakeholders involved, as well as the requirements of the system, the project now moves into Phase 2 of the Design Process, which will include the detailed design, revision of requirements and then preparation of an RFP to select the STREETS Vendor.

As of the spring of 2018, numerous components of the STREETS can be described by the industry as “in development.” It is anticipated that multiple vendors will need to team together to provide a STREETS solution. To better refine the requirements for this system, an RFI is recommended to have vendors organize teams and describe potential solutions. Through this process the agencies will gather additional information to expand the requirements and move the project closer to procurement.

The agencies have discussed the selection process that would likely consist of one RFP and include all components for deployment including field hardware, video analytics, simulation models, the ASCT system, the DSS and the ATIS systems as necessary to meet the requirements. Such a selection process would help reduce the potential finger-pointing of multiple contracts and extended project support.

Staged deployment is recommended for this project to support funding, to manage construction, configure and test the system.

APPENDIX A – DETAILED STREETS OPC BY STAGE

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City of Dubuque: Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Concept of Operations

FINAL| version 1.1

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IOWA DOT

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Concept of Operations – Draft Submittal	02/02/2018	1.0
Concept of Operations – Final Submittal	05/11/2018	1.1

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1 SCOPE OF THE PROJECT

1.1 System Overview

The City of Dubuque, Dubuque Metropolitan Area Transportation Study (DMATS) and the Iowa Department of Transportation (Iowa DOT) partnered together to develop the Concept of Operations (ConOps) for the Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) project. The purpose of this project is to develop a smart, next generation, traffic management and control system. The City expects the STREETS will facilitate dynamic routing of traffic to maximize the use of existing roadway capacities in the project area.

The initial deployment of STREETS covers nine (9) corridors with 57 signalized intersections within the city of Dubuque. The STREETS project will use advanced traffic control strategies to enable dynamic traffic routing to maximize the use of existing roadway capacities in the Dubuque metropolitan area. The STREETS project seeks to employ Active Transportation and Demand Management (ATDM) strategies which will require a suite of modeling tools and methods that will enable the City of Dubuque to evaluate the potential benefits of implementing ATDM strategies in a dynamic and proactive fashion using both real-time and historic data.

The STREETS system includes the following major components: 1) Travel Demand Model (TDM); 2) Microsimulation Traffic Model (MTM); 3) Adaptive Signal Control Technology (ASCT); 4) Decision Support System (DSS). The STREETS will also interface with other components include, but not limited to, Advanced Traffic Management System (ATMS), Advanced Traveler Information System (ATIS), and third party data source (i.e., Waze). The TDM will be utilized to estimate the O/D and other necessary data for the microsimulation traffic model. The MTM is to represent the current roadway network and be capable of executing traffic assignment (dynamic traffic routing) based on estimated/measured traffic impedances of the network links. The existing systems and real-time traffic characteristics are expected to come from multiple sources: City-owned field data (Acyclica, other sensors), and INRIX Travel-Time data. The ASCT will develop optimized signal timing in real time after changes of traffic conditions are determined by STREETS. The DSS is to function as a core model which communicates with TDM, MTM, ASCT and other components, provide data exchange, dynamic routing strategy generation and integrate all components into a complete STREETS system.

Currently, the City of Dubuque operates all traffic signals and other ITS devices within City limits (including state highways). The current signal system in Dubuque includes 115 traffic signals. Most of the signal controllers are M50 Siemens controller with EPAC firmware and some are EPAC 300. The signal cabinets are NEMA TS-1 or TS-2. Approximately 80% of the system is connected to a fiber optic communication system which is comprised of a minimum of 24 multi-mode and 48 single mode fibers. The City currently uses Siemens' TACTICS central management software to communicate with the traffic signal system. Currently, there are 31 Acyclica travel-time measurement systems installed in the City's roadway network. By the end of 2018, another 4-6 Acyclica systems will be deployed in the City's road network. The City has an extensive network of CCTV and the video detection cameras which are both used for traffic surveillance and post-event investigation of the events that affect safety and security of the travelers. In addition to the existing ITS devices, the City has undertaken an aggressive program to expand ITS deployment within the city including fiber optic conduit, fiber Optic Loop, Dynamic Message Sign (DMS), Smart Sensor, Traffic Camera, and wireless communication. All these will become part of future STREETS system and play roles in dynamic routing. The STREETS project intends to deliver an automatic system that gives the City staff the ability to monitor traffic operations and intervene as necessary, but does not require constant or significant manual operations.

Built on the existing and near future ITS to be deployed, implementation of the STREETS may require City investment in other physical infrastructure such as data collection and performance measurement systems, processing and dissemination systems, control algorithms, and signal systems that will provide the following upgraded systems and equipment:

- A high speed, reliable communications system.
- A highly accurate, reliable detection system.
- Improved traffic signal controllers
- A high speed, reliable series of servers and databases.
- An automated process to transfer data.
- An automated process to analyze traffic conditions.
- An automated, highly accurate means to communicate traffic conditions to the traveling public.

1.2 Document Overview

The Concept of Operations (ConOps) is a document that describes the expected operations of the system from the user's viewpoint and provides documentation in compliance with FHWA Rule 23 CFR 940.11 and Systems Engineering Guidelines. The ConOps is the second document of the various systems engineering deliverables identified for this project and consists of:

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

The purpose of the ConOps document is to communicate overall qualitative system characteristics to the City of Dubuque and other involved stakeholders. The ConOps document lays out the STREETS concept, explains how things are expected to work once it is in operation, and identifies the roles and responsibilities of the various stakeholders to make this happen. The ConOps answers the following set of core questions:

- Why: Justification for the system, identifying what the corridors currently lack, and what the system will provide
- What: Currently known elements and the high-level capabilities of the system
- Where: Geographical and physical extents of the system
- Who: Stakeholders involved with the system and their respective responsibilities
- When: Time sequence of activities that will be performed
- How: Resources needed to design, build, operate, and maintain the system

1.3 Goals and Objectives

The overall purpose of the project is to develop a smart, next-generation, traffic management and control system that will use traffic control strategies to enable dynamic traffic routing to maximize the use of existing roadway capacities in the Dubuque metro area. This is intended to create an even distribution of traffic on the roadways and the goals of implementing STREETS include:

- Improve Mobility
- Reduce Congestion
- Improve Safety
- Providing Information for Travelers

Based on the goals, a set of objectives, in the context of addressing the City of Dubuque's issue, is established. (**Table 1**)

Table 1 – STREETS Goals and Objectives

GOALS	OBJECTIVES
Improve Mobility	• Reduce travel time for commuters within the corridor • Increase person and vehicle throughput on the corridor • Reduce delay time for corridor travel on the corridor's networks • Detour/Reroute traffic among corridors to balance the capacity usage
Reduce Congestion	• Improve Intersection Operation • Reduce Delay at Intersections • Reduce Incident Detection Time
Improve Safety	• Reduce incident rate • Reduce injury rate • Reduce fatality rate • Reduce roadway hazards
Information for Travelers	• Improve collection and dissemination of road network information • Collect and process data on the operational condition/status of all corridor networks, including o Comparative travel times between major origins and destinations o Construction, detours, and other planned road work o Occurrence and location of incidents o Expected delays • Disseminate comprehensive, real-time, and accurate information to travelers within the corridor by means of multiple media (e.g., phone, computer, PDA/Blackberry, CMSs, 511 App) • Make available archived historical data to travelers

The project is needed as it has the potential to alleviate some of the existing traffic operational issues in the City of Dubuque metropolitan area. Congestion occurs on the US 20 and on the NW Arterial because of many residential and retail areas along these corridors. Congestion also appears at the Pennsylvania Ave & NW Arterial intersection in the mornings and early afternoons because of high traffic demand from the nearby high school. Similar traffic problems are observed at the NW Arterial and Asbury Rd intersection. Locust Street & the Mississippi River Bridge on US 20 are also heavily congested. STREETS could alleviate this congestion by diverting traffic to other less congested corridors.

2 REFERENCE DOCUMENTS

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

- **Dubuque Metropolitan Area Transportation Study (DMATS)/ Regional Planning Affiliation (RPA) 8 Regional ITS Architecture –** A regional ITS architecture describes the "big picture" for regional ITS deployment in terms of individual components (i.e. subsystems) that will perform the functions necessary to deliver the desired ITS needs. This document is a roadmap for transportation systems deployment and integration in the Dubuque metropolitan area and the adjacent six counties (Clinton, Delaware, Dubuque, Jackson, Jo Daviess, and Grant).
- **FHWA Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems –** This document is a resource for the stakeholders to follow during the development of the ASCT Systems Engineering documents.
- **Dubuque Metropolitan Area Transportation Study, Travel Demand Model,** June 2016**.**
- **Intelligent Transportation System Plan, Iowa Department of Transportation.**
- **East-West Corridor Connectivity Study, City of Dubuque and City of Ashbury -** This document describes the result of a study that was conducted to analyze east-west traffic flow in the City and identify corridor improvements or modifications needed to support growing demands along the U.S. 20 corridor.
- **DMATS Long Range Transportation Plan 2045** (adopted October 13, 2016 and amended January 12, 2017).
- **Smarter Travel – Identifying Options for Commuters in the Region**, July 14, 2017.
- **Future Conditions Analysis, Traffic Operations Study, Northwest Arterial (US 20 to US 52)**, Iowa Department of Transportation.
- **Traffic Incident Management Book**, Dubuque County.
- **Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Project Proposal,** They city of Dubuque, May 1, 2017.
- **City of Dubuque: Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Systems Engineering Management Plan,** November 6, 2017.

3 CURRENT SITUATION

The proposed STREETS system consists of various components including Demand Modeling, Microsimulation, Traffic Signal System, ITS, ATIS, ATMS, and performance measurement system. The project team collected comprehensive data of the existing assets and systems. Some of the existing assets can be directly included as part of proposed STREETS and some may require upgrading. This section describes the roadway network to be initially encompassed by the STREETS and the existing assets present in the network that will be evaluated during the design, construction and deployment phases of the STREETS. Understanding of the existing assets helps to realize the gaps between the capabilities of the existing transportation system and the capabilities of the future transportation system with the STREETS. These gaps will help identifying the required technical, operational and institutional changes necessary to achieve the goals of the STREETS project.

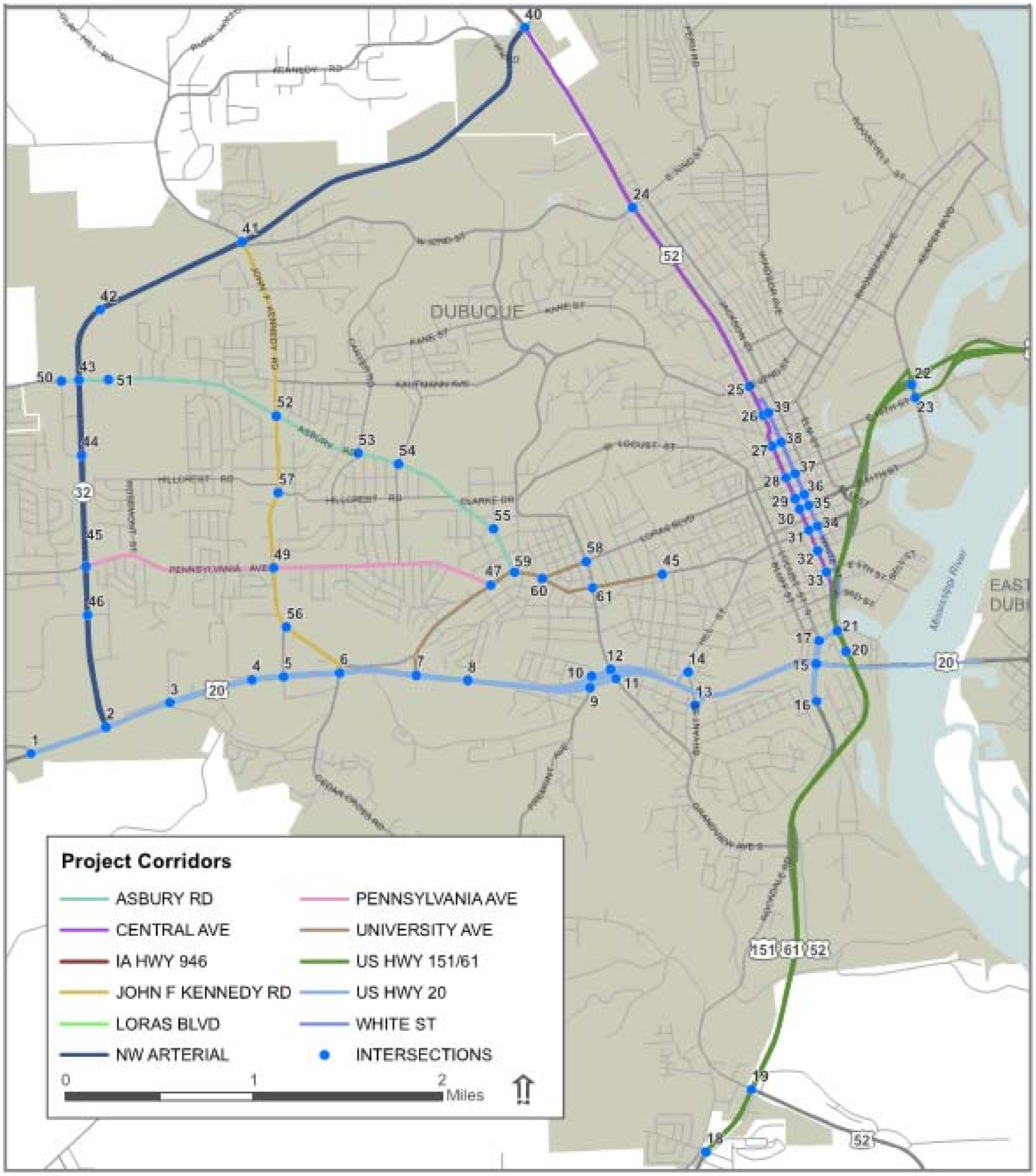
3.1 Existing Roadway Network

The initial deployment of STREETS is to cover nine (9) corridors with 57 signalized intersections within the City of Dubuque. **Figure 1** illustrates the existing roadway network. Five of the nine corridors are Principal Arterials accommodating 46 signals and the rest are Minor Arterials accommodating 11 signals. **Table 2** lists all corridors, the limits of each corridor and the number of signalized intersections.

Table 2 – STREETS Project Corridors

NAME	FUNCTIONAL CLASS	FROM	TO	# OF INTERSECTIONS
US Highway 20	Principal	Old Highway Rd	Locust St Connector	17
US Highway 151/61	Principal	Maquoketa Dr	E 16th St Exd	6
Central Ave/US 52 N	Principal	Northwest Arterial	E 5th St	10
White St/US 52 N	Principal	E 20th St	E 9th St	6
Northwest Arterial	Principal	US 20	US 52	7
Asbury Rd	Minor	Holiday Dr	University Ave	6
Pennsylvania Ave	Minor	Northwest Arterial	University Ave	2
John F Kennedy Rd	Minor	US 20	Northwest Arterial	1
University Ave	Minor	US 20	Nevada St	2

Figure 1– Existing Roadway Network



The level of service in 2010 is shown in **Figure 2** and the 2045 forecasted level of service is shown in **Figure 3** for the corridors included in the initial network of STREETS based on the DMATS Travel Demand Model.

Based on the recent operational analysis, some corridors in the study area are expected to reach beyond LOS E in near future. DMATS Travel Demand Model forecasts that the most of the project corridors are projected to attain level of service E and F by 2045. The Travel Demand Model also shows the "imbalanced" traffic flow on different corridors within the network. With several corridors reaching LOS F, some corridors show available capacity. This indicated the potential of encouraging traffic rerouting to further reassign traffic to utilize the "unused" capacity. This is even more beneficial during non-recurring congestion (i.e., incidents and special events) on certain corridors while others remain free flow.

Figure 2– 2010 Level of Service

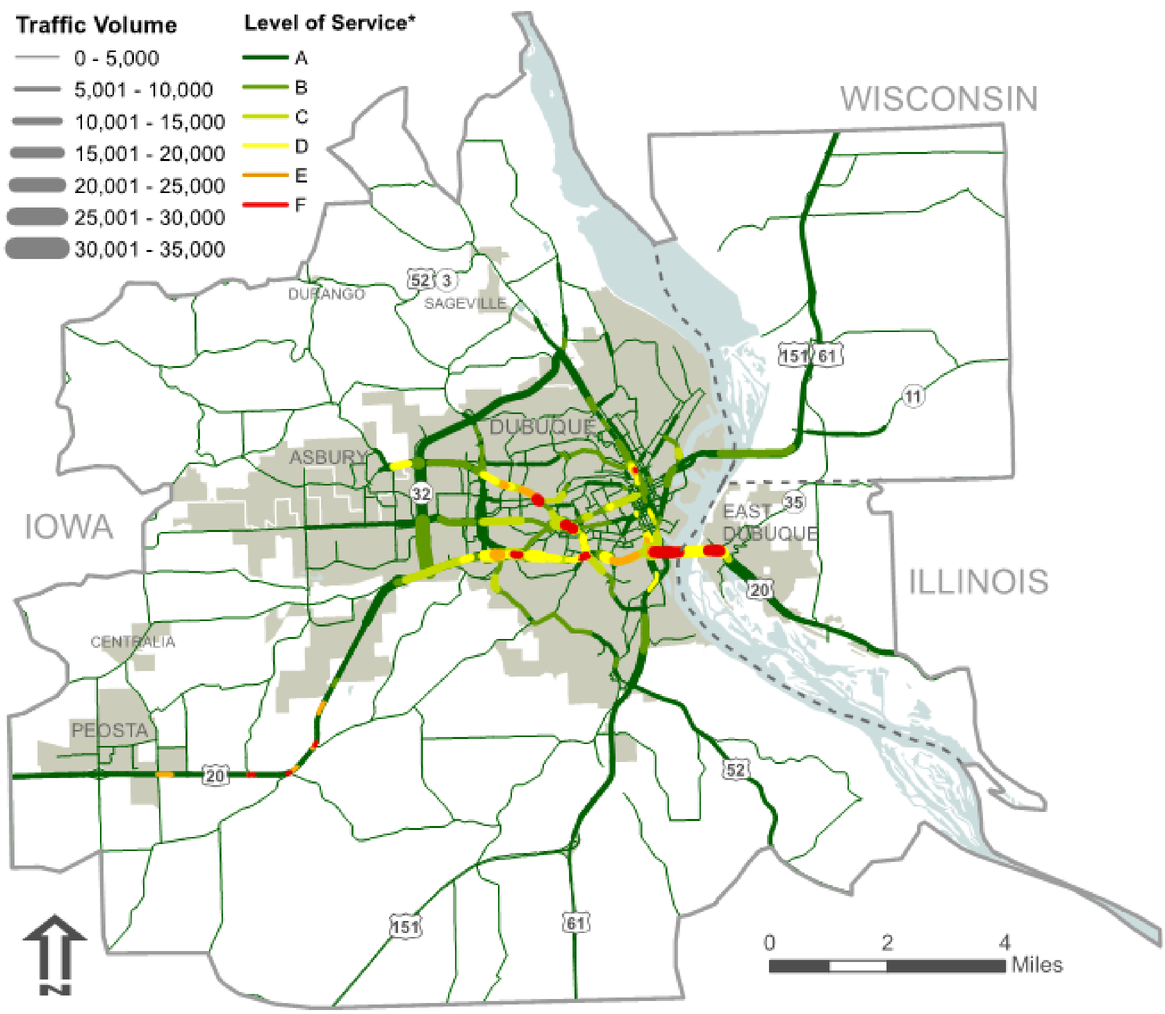
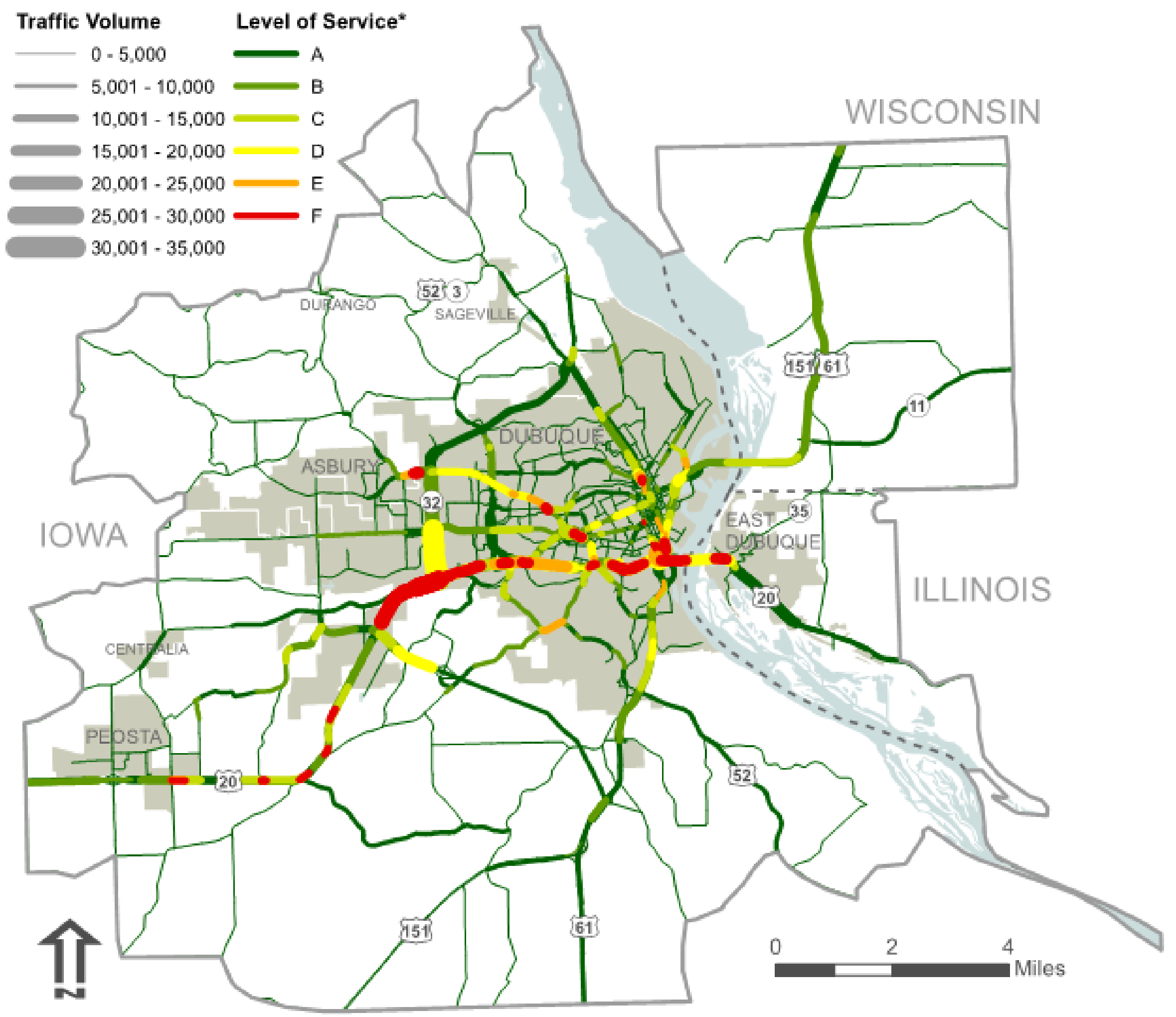


Figure 3– 2045 Level of Service



3.2 Existing Operation Issues

Some of the existing characteristics of traffic behavior are worsening the current operation of the roadways within the studied scope and these include:

- Drivers are sometimes very slow to pull off from the standing queue at signalized intersections. Therefore, headways between vehicles are longer resulting in lower saturation flow rates. This can impact efficiency of the green times.
- Drivers tend to be very aware of the necessary lane changes well ahead of the merging/diverging times and this sometimes creates an issue because uneven utilization of the lanes on some of the roads.
- There is a lot of truck traffic throughout the network which can contribute to traffic issues due to the amount of uphill in the project area. Very often signals that are timed to provide good coordination for truck traffic may not be ideal for light vehicles (they get to the next signal too soon in some cases). Future development of the STREETS system should take this problem in consideration and propose how existing (e.g. video surveillance) or new technologies can be integrated in STREETS to avoid these

very inefficient and sometimes unsafe traffic occurrences.

There are also observed congestion on the corridors and intersections included in this project and these include:

- US 20 is the most problematic and has a significant amount of congestion. Emergency pre-emptions / pedestrian crossings and coordination changes frequently disrupt the flow along US 20. One of the main goals of this project is to reduce such congestion and distribute it more evenly across the other roads in the network.
- Intersection of NW Arterial and US 20
- Pennsylvania Ave & NW Arterial has a nearby high school that generates high traffic demand and pedestrian movements in the mornings and early afternoons. Similar traffic problems are observed at NW Arterial and Asbury Rd.
- Intersection of Hwy 61/151 and US 52
- Asbury is also a heavily utilized corridor and the most congested intersections are Asbury and JFK road and NW Arterial and JFK Rd
- Chavenelle Rd & NW Arterial can be a heavily congested intersection – operating near capacity in peak periods
- There are many residential and retail areas along NW Arterial which create congestion problems.

3.3 Existing Travel Demand Modeling

There is an existing travel demand model in place managed by The Dubuque Metropolitan Area Transportation Study (DMATS). This DMATS travel model is used to analyze the highway transportation system of the metropolitan planning area located in the tristate area encompassing Dubuque (IA), Asbury (IA), Peosta (IA), East Dubuque (IL), and Kieler (WI). The model was also expanded to include Galena (IL) and Platteville (WI). The primary purpose of the travel model is to support the development of the MPO's long-range transportation plan. The travel model can also be used to test specific land use or roadway changes in the short-term or long-term. The model has a base year of 2010, interim years of 2015, 2020, 2025, 2030, 2035, 2040, and a horizon year of 2045.

The DMATS travel model is based on the traditional four-step modeling process. The model is developed using person trips, includes a truck sub-model based on procedures from the Quick Response Freight Manual (QRFM), time of day component, and procedures to account for unique characteristics or special generators such as travel to and from the different states (k-factors) and the colleges and universities in the area. The model includes procedures to post -process the model volumes and provides updated Level of Service (LOS), Vehicles Miles of Travel (VMT), and Vehicle Hours of Travel (VHT). The model run process has been automated using the TransCAD programming language GISDK. The model run scenarios can be executed and managed using a TransCAD model file and integrated scenario manager.

As the requirements to be developed in the next step of the project, the current DMATS travel model needs to be evaluated to determine how well it can perform in estimating the O/D and other necessary data for the microsimulation traffic model. If the current model cannot perform satisfactorily, it shall be modified/enhanced to be functional and included in the future STREETS system, or a new Demand Model shall be developed.

3.4 Existing Micro-simulation Model

Currently there is no city wide Micro-simulation model for City of Dubuque suitable for STREETS deployment. A Micro-simulation model representing the existing traffic conditions in the Dubuque metro area shall be procured in the next phase of the project. This Micro-simulation model shall be capable of receiving input (i.e., O/D) from travel demand modeling, simulating recurring and non-recurring congestion, providing rerouting options and updating traffic flow data for signal timing optimization at intersections.

3.5 Existing Signal and ITS Assets

The proposed STREETS system is expected to dynamically react to congestion detected/predicted by the Micro-simulation model, and proactively change signal timing based on predicted traffic flow data while disseminating congestion information and/or route selection for motorists. This requires existing signal system and ITS infrastructure to be improved to meet the operational requirements of STREETS, which will be developed in the next phase of the project. This section describes the existing signal and ITS assets of City of Dubuque.

3.5.1 Traffic Signals

The City of Dubuque is the only entity that has a signal system within the Dubuque Metro area. The City of Dubuque network has 60 signalized intersections excluding the Central Business District (CBD) of which approximately 80% are connected. Most of these signals are equipped with M50 Siemens controllers with EPAC firmware. The City also uses Siemens' TACTICS central management software, which currently does not meet all of the City's needs for management of traffic signals. The City is equally open to consider STREETS solutions which propose use of the existing or installation of new traffic signal/controller equipment.

In the Central Business District (CBD) of Dubuque the City operates 45-50 signals with fixed timings where minimum detection is present. Those signals are usually well coordinated due to a proper combination of cycle lengths, block lengths, and the fact that several streets in CBD are one-way streets etc. Therefore, if the STREETS is implemented through multiple phases, the CBD will likely be the last area where STREETS is deployed.

To create a robust and reliable traffic signal system, the City of Dubuque has developed new traffic signal standards that include: emergency generator connection ports and battery back-up systems for power failures occur throughout the City as well as network gear and monitoring equipment that ties signals back to the Traffic Operations Center (TOC) through an IP-based network.

3.5.2 Detection

Detection at the signalized intersections within the City is usually implemented through Wavetronix Matrix units which are installed both on the main roads and side streets. There are almost no intersections which operate in semi-actuated mode (no detection on the main street). Some of the Wavetronix detectors are HDS (Wavetronix Advanced Detection) but most of them are Matrix units.

The second most deployed detection technology within the City is the inductive loop. There are few intersections that are equipped with video detection systems, but the City is not interested in video detection due to its performance during winter conditions. Some of the intersections also have advanced (dilemma-zone) loops and these are usually Wavetronix advanced detectors located about 600 ft. ahead of the intersection. Six intersections currently have advance detection. It is anticipated that additional advance detection will be needed to accurately collect traffic data from the field.

3.5.3 Video Surveillance

The City has an extensive network of CCTV and the video detection cameras which are both used for traffic surveillance and post-event investigation of the events that affect safety and security of the travelers. These cameras are backed up with a powerful recording, archiving and reviewing software (Milestone) which gives the City staff opportunity to quickly and conveniently review the cameras' video footage. Once videos are recorded (24/7) they are stored on the City's database for 30 days before being discarded. Recordings of some very important events can be archived permanently. The City staff feels that these video capabilities are not leveraged enough for traffic management purposes. Therefore, the City encourages proposed STREETS solutions which will leverage and expand the City's video capabilities. The City would like to use video analytics to detect incidents along key corridors. Currently, the City does not have an automatic procedure to extract any traffic-related metrics from the video footage recorded by its cameras.

3.5.4 Performance Measurement System

The City has also deployed a number of travel-time measurement systems. Currently the City has thirty-one (31) Acyclica devices installed on its roadway network. The City plans to install 30 more such devices within the City. There are also 5 City owned and two state owned Wavetronix HD units located through City. It is expected that the number of these or similar devices will grow in the near future. The City budget for ITS equipment allows a full upgrade of 2-3 signalized intersections per year. Also, some of the funding from recently increased gas tax may improve future funding of ITS equipment and solutions.

3.5.5 Communication Infrastructure

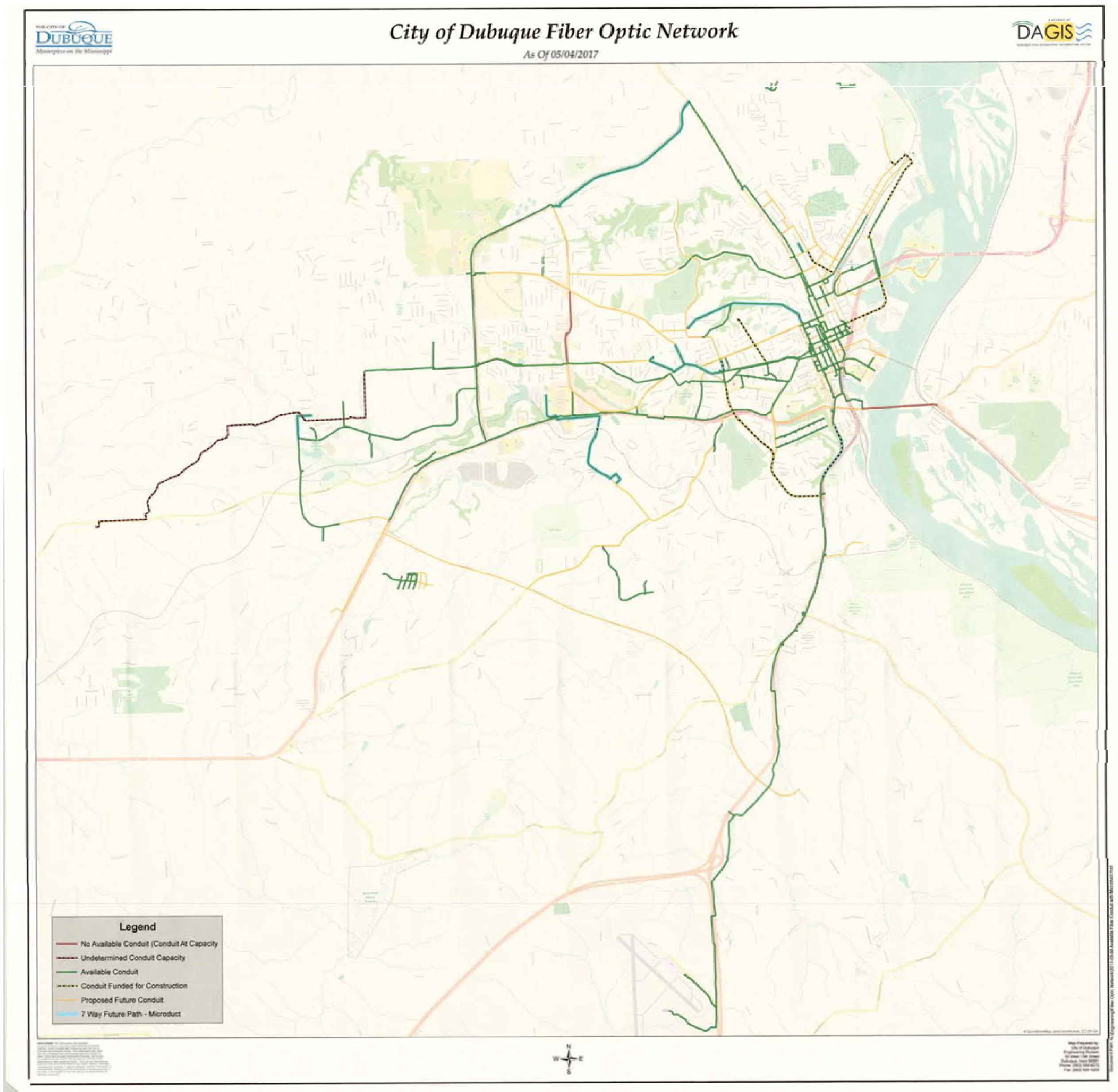
The City of Dubuque and Iowa DOT are committed to improving traffic flow within the Dubuque metro area by incorporating ITS assets where necessary. The STREETS project requires high speed and reliable fiber connectivity throughout the metropolitan area to be successful. The investment that the City has made over the last ten years in fiber optic conduit and cabling connecting public buildings, traffic and security cameras and traffic signal intersections has created a platform for the STREETS project.

The City of Dubuque Traffic Engineering also received $500,000 from DMATS to provide fiber connectivity and upgrade signal systems at Asbury/Chaney and Asbury/Carter intersections as part of the overall project as these improvements are necessary to prepare the system for the STREETS project implementation. **Figure 4** maps the City of Dubuque's fiber Network.

All corridors to be included in the initial deployment of STREETS have either existing active fiber or planned fiber. Among them, US 52 and Central Ave have full coverage of active fiber; US 20, NW Arterial, US 151/61 and University Ave have partial coverage of active fiber; the rest of the corridors have small portion of fiber coverage and there are planned fiber installations along the corridors.

90% of the intersections covered in this project has CCTV cameras installed, which provides additional infrastructures for STREETS. Considering the future need of monitoring traffic and adaptive signal control, the city has been installing HDPE 7-way Multi-duct conduit under new roadways to accommodate future fiber optic communications cable.

Figure 4 – City of Dubuque FOC Network



3.6 Existing Transportation System Operation and Management

3.6.1 Facilities and Staff

All staff that conducts work related to the ITS is a part of the Street/Sewer Maintenance Division, which is located within the Public Work Department. **Figure 5** illustrates the organizational structure of the Public Works Department.

The Public Works Department has engineering, maintenance, technician, and administrative staff that are responsible for traffic signals, traffic signs and markings, and street lighting.

For the future STREETS system, the City of Dubuque Traffic Engineer will work with the City of Dubuque Project Manager to provide input for the development of the Travel Demand Forecast Model, the Microsimulation Traffic Model, and third-party Speed Data Collection/ Performance Management system requirements. The Traffic Engineer will also provide input related to the identification of the existing data sources for input to the model and for recalibrating and validating the model. Coordinating with the City of Dubuque Project Manager, East Central Intergovernmental Association (ECIA), and other City staff, Quality Control Test Manager and the System Vendors, the Traffic Engineer will ensure that the traffic assignments provided by the traffic model are accurate relative to the field conditions. Also, ensuring that the third-party Performance Management system accurately monitor and measure the transportation system's performance is the City of Dubuque Traffic Engineer's responsibility.

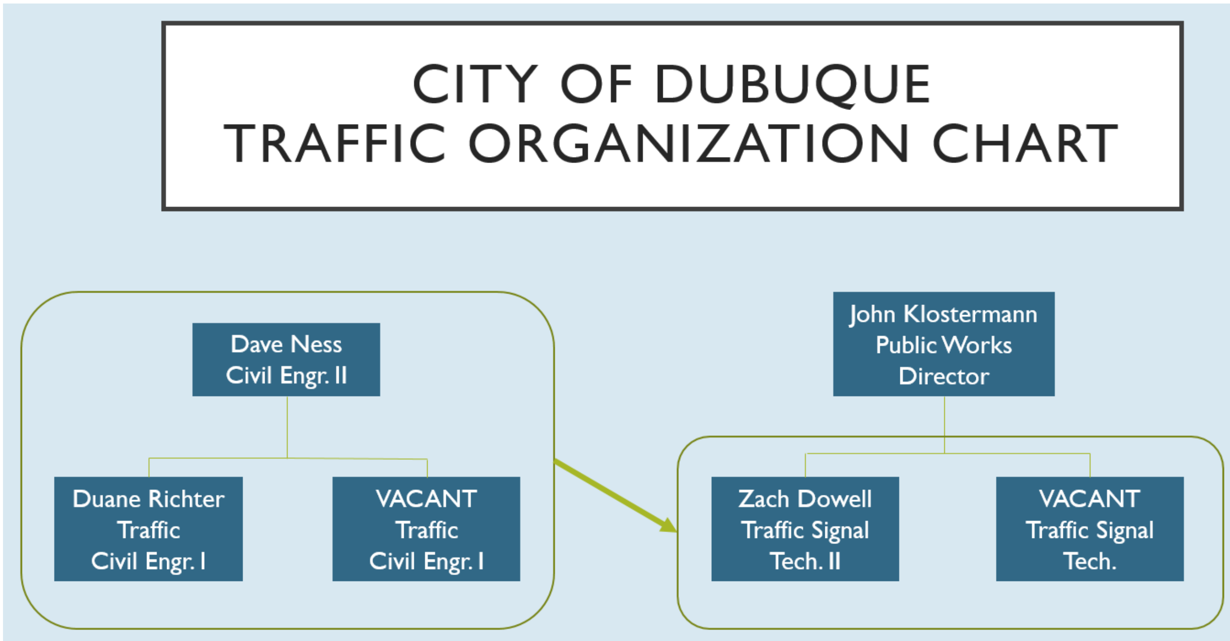
The City of Dubuque Signal Design Engineer will be responsible for working with the City of Dubuque Traffic Engineer and the Traffic Signal Technician Supervisor. The Signal Design Engineer will provide technical support to the City of Dubuque Traffic Engineer and Project Support Consultants/Contractors.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

The City of Dubuque Traffic Signal Supervisor will be responsible for working with the City of Dubuque Project Manager to provide input for the development of the ASCT system requirements. The Supervisor will also be responsible for ensuring projects are constructed or installed in accordance with the plans, specifications, and requirements, and managing and assigning field staff during deployment. The Traffic Signal Supervisor will also work as the liaison between the System Contractor and the City of Dubuque staff during installation.

3.6.2 Traffic Operations Center (TOC)

The City of Dubuque has a Traffic Operation Center (TOC). TOC provides the City staff with the ability to monitor traffic conditions and make necessary adjustments to the signal operations to provide the most efficient operation during special or unusual conditions.

Figure 5 – Organization Chart for the Public Works Department



3.6.3 Traffic Signal Timing

Traffic signal timing at all traffic signals is conducted by the Principal Traffic Engineer. This includes basic timing (e.g., yellow-change and all-red clearance intervals, pedestrian walk and clearance intervals) and coordination parameters (cycle lengths, splits, and offsets), as well as responding to timing-related citizen complaints. From the TOC the engineer can communicate with signals and can get some alerts from the signal controller, and upload signal timing data. Traffic maintenance staff is also responsible for delivering updated timing sheets to the cabinets. The engineer is also responsible for creating and maintaining the traffic signal system model for capacity analysis and optimization.

3.6.4 Incident Management

Incident management includes various activities that help mitigate non-recurring congestion, such as rapid detection and response to accidents and stalled vehicles, provision of congestion-related information to drivers, management of construction and maintenance activities, and management of traffic for special events. Currently the City has a Traffic Incident Management Book prepared by The Dubuque County Multi-Disciplinary Safety Team (MDST), which serves as a guideline for incident management for incidents occurring on major roadway network within the City of Dubuque. This book, defines the communication protocol and contact list, and provides detour route for an incident per incident location. The corridors for STREETS deployment are included in this book. This book should provide insight for traffic diversion strategy development in the next phase of STREETS development.

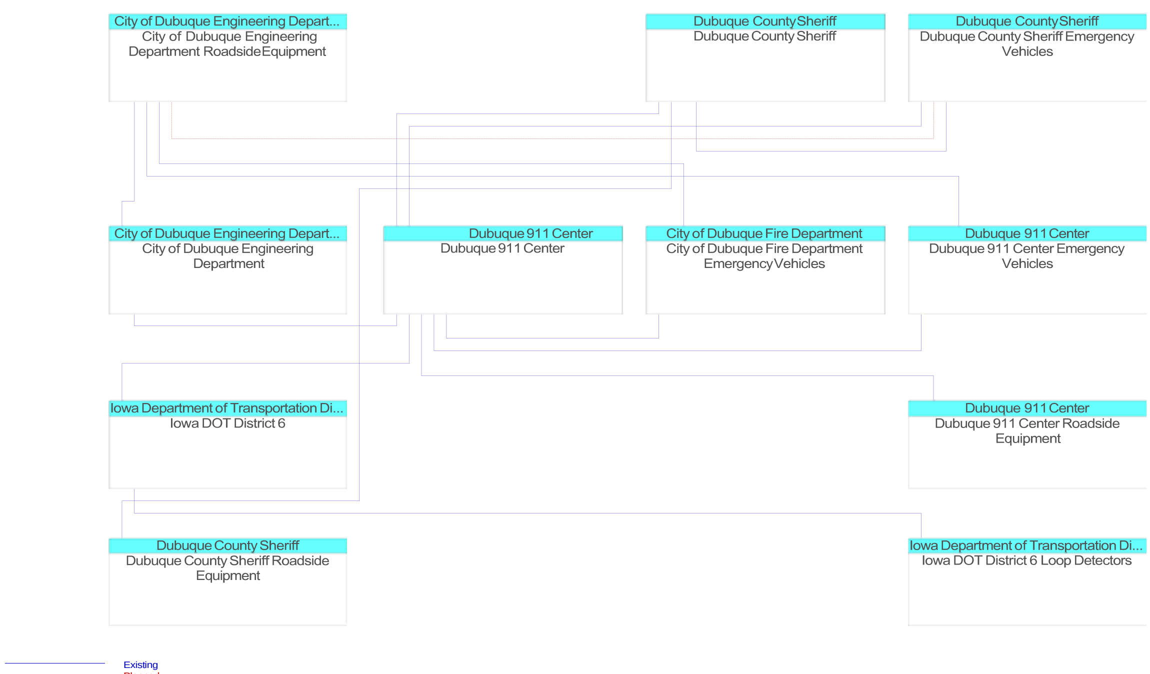
3.7 Existing Regional ITS Architecture

A regional Intelligent Transportation Systems (ITS) architecture describes the "big picture" for regional ITS deployment in terms of individual components (i.e. subsystems) that will perform the functions necessary to fulfill the desired needs. It does not describe exact technology that is to be deployed, but how those systems are to be deployed. Currently there is an existing regional ITS architecture that covers the City of Dubuque. **Figure 7** shows the interconnect diagram of Dubuque County Area Traffic Management under this regional ITS Architecture.

The DMATS/Regional Planning Affiliation (RPA) 8 Regional ITS Architecture is a roadmap for transportation systems deployment and integration in Dubuque metropolitan area and the adjacent six counties (Clinton, Delaware, Dubuque, Jackson, Jo Daviess, and Grant). The architecture has been developed through a cooperative effort by the region's transportation and emergency management agencies, covering all modes and all roads in the region. The architecture represents a shared vision of how each agency's systems will work together in the future, sharing information and resources to provide a safer, more efficient, and more effective transportation system for travelers in the region.

The proposed STREETS system is considered a "project architecture" under the DMATS/RPA regional ITS architecture. The development of STREETS operations (and architecture) will, therefore, be compatible and consistent with this regional ITS architecture; this requires an understanding of the various attributes that comprise the regional architecture and the associated management functions. The regional architecture should be updated with this project, including systems and data flows based on the current maintenance schedule.

Figure 6 – Dubuque County Area Traffic Management Interconnect Diagram



3.8 Near Future Signal/ITS Deployment

The City of Dubuque has an existing ITS deployment plan in place. This plan identifies ITS deployment in the prioritized corridors primarily based on congestion and operational needs. There is also near future deployment of components pertaining to the STREETS based on the communication with the stakeholders. The near future deployment of signal and ITS system must be considered as part of the base for the future deployment of STREETS. This section describes these deployments.

3.8.1 Intelligent Transportation Systems (ITS) Devices

ITS technology will provide the continuous collection of traffic volume data, intersection reports, failure/malfunction notifications, video monitoring, overall control for signal timing and ability to redirect traffic. The proposed equipment will focus on implementing technology so that the corridor can be continuously monitored and managed. The City of Dubuque is to install and implement the following ITS device/system.

<u>Overhead Dynamic Message Sign (DMS)</u>

Overhead DMS is an effective ATIS device to inform motorists in advance of a situation by notifying motorists of issues or events occurring within the City of Dubuque. This type of device is typically integrated and accessible by the Iowa Department of Transportation. It can communicate a wide range of alerts to the public, such as:

- Traffic Alerts
- Incidents
- Planned Construction Activities
- Weather Alerts and Road Closures
- Special Events (which generate excess traffic flow)
- Maintenance Crew Activities
- AMBER Alerts
- National Security Information

<u>Side-Mount Dynamic Message Sign (DMS)</u>

Side-Mount DMS will provide some of the same functions as the Overhead DMS, however the side-mount DMS will primarily serve to divert traffic at locations along the primary roadway.

<u>Smart Sensor</u>

Smart Sensor measures up to eight lanes of traffic simultaneously using microwave technology and records the following:

- Vehicle Volume
- Vehicle Occupancy
- Vehicle Speed
- Vehicle Classification
- Provides an Accurate Traffic Count versus Manual Traffic Count

- Daily Timing Patterns (for signal progression)
- Information gathered from the smart sensors is used to create daily traffic patterns which are programmed into the traffic signals.

Traffic Cameras

Traffic Cameras provide the following functions:

- Show Traffic Congestion
- Give Real-Time Road Up-Dates
- Gather Data on Traffic Snarls and Patterns (used for daily management of the system)
- Data collection for traffic timing studies.

City of Dubuque Fiber Optics Ring Network

To provide redundant back-up to the communications path, fiber optics rings are provided to the traffic center. The existing rings are bi-directionally redundant for the benefit that if a network switch or a section of fiber failed, communications to all other points in the system would still be maintained.

Fiber Optic Communications (FOC)

The City of Dubuque has been aggressively installing fiber optics throughout the city for future traffic signal communications and to aid other city entities. To provide a robust and reliable FOC system while taking into account the future development, the City has developed the following standards:

- Hybrid single-mode 72 and 144 strands/multi-mode fiber optic cable in dedicated conduit paths
- FuturePath 7-way Multi-duct conduit
- Pre-cast concrete vaults with cast iron manhole lids at approximately 500 foot spacing

These fiber optic lines are installed along roadways and are terminated at traffic control devices along the route (traffic signals, smart sensors, video Detection, PTZ cameras, DMS boards, etc.). Once tied into the fiber optics, these devices are all connected and interact with equipment back at the TOC. The cost to install fiber varies from location to location; urban installations are typically more costly than rural installations.

Gigabyte Network Backbone

This equipment consists of fiber optics, switching gear and other standard networking equipment used to communicate with traffic control/ITS equipment. This form of communication replaces older, slower proprietary equipment that was the standard years ago. This fiber network backbone uses a recognized standard communications protocol just like the network found in most IT departments. Using this form of communication also allows for a scalable system that is easily expanded or modified.

Wireless Communication

The ultimate goal of the ITS network is to be able to connect information to laptop computers located in City of Dubuque vehicles or cell phones located on city personnel to inform of events that require immediate attention. Wireless communication is typically utilized to connect ITS devices to the network when fiber is not present or difficult/costly to install. The City of Dubuque is in the process of negotiating 5G service for the region as part of a public/private partnership.

3.8.2 Prioritized Corridor ITS Deployment

To avoid duplication of effort towards ITS implementation and provide adequate ITS infrastructure for future projects such as STREETS, the City of Dubuque has prioritized the ITS deployment per corridor. **Table 3** shows the prioritized corridor with future ITS deployment with the number of unit per ITS device category. The planned deployment shall be part of future STREETS system.

Attachment 1 includes the location map of the corridors with ITS to be deployed in the near future.

Table 3 – Prioritized Corridors for ITS Deployment

PRIORITY*	ROADWAY	FROM	TO	DMS (L)	DMS (S)	SMART SENSOR	CCTV	FOC
1	US 20	Cousins Rd	Julien Dubuque Bridge	1	3	4	1	1
2	US 151/61	Grandview Ave	N. of Jones St.	0	2	3	3	1.75
3	US 52	4th St	32nd St	0	0	2	5	2.2
4	US 151/61 Interchange	N/A	N/A	2	0	3	1	4.4
5	IA32 and US 52	JFK Rd	32nd St	0	1	2	2	3.1
7	US 151/61	Wisconsin Bridge	Wisconsin Bridge	1	0	1	4	1
8	US 20	Julien Dubuque Bridge	Julien Dubuque Bridge	1	0	0	0	0
9	SW Arterial	US 20	US 61	0	6	3	9	7

*Priority 6 – Signal Upgrading described in 3.8.3

3.8.3 Signal Control System

The City regularly maintains and upgrades the signal system. Every year, maintenance programs provide enhancements to select signalized intersections. Additionally, the City studies the traffic characteristics at intersections and evaluates the ability to install a roundabout as an alternate to signal enhancements. During each phase of the STREETS project the actual number of intersections that require upgrades may vary from preliminary planning.

The City is currently planning the following facility changes:

- Intersection of University Ave and Asbury Rd, University Ave and Loras Blvd, and University Ave and Pennsylvania Ave will be converted to roundabouts
- Intersection of University Ave and Grandview Ave will be converted from a 4-way stop intersection to a roundabout.
- Enhancements to the Southwest Arterial

3.9 Roles and Responsibilities

There are numerous stakeholders with interest in the STREETS system deployment. **Table 4** summarizes the ITS System stakeholders and their roles.

Table 4 – Stakeholders Roles for the STREETS

STAKEHOLDER	ROLE
City of Dubuque	Budgeting and project programming Manage, procure and oversee STREETS project development Operate, maintain and upgrade STREETS
Dubuque County	Manages municipal facilities
ECIA	Transportation planning, distribute federal funding, project programming, and maintain regional ITS architecture for Des Moines area
Iowa Department of Transportation (Iowa DOT)	Operations and maintenance of the freeway system Operations and maintenance of ATIS on freeway as part of STREET system
Iowa Motor Truck Association (IMTA)	User of STREETS
Federal Highway Administration (FHWA) Iowa Division	Oversight of projects
Dubuque School District	User of STREETS
Dubuque County Emergency Management	Regional safety management
Dubuque Community School District	User of STREETS
Dubuque County Sheriff’s Department	Public safety
Iowa State Highway Patrol	Public safety
Dubuque Fire Department	Public safety for the City
Travelling Public	Make travel decisions, users of STREETS

4 OPERATIONAL NEEDS

4.1 Operational Needs

Given the evaluation of the existing conditions described in Section 3, the operational needs assessment process is conducted to identify the stakeholder needs that must be satisfied in order for the City of Dubuque to meet its goals and objectives relative to developing STREETS system. The primary focus of this section is on documenting the needs that were described at a high-level and adding detail to create operational needs that can be used to build an action plan and more detailed requirements. Once the needs are described, a preliminary list of performance measures was identified to support the evaluation of the goals and objectives.

The needs identified in this section were gathered through a Needs Assessment Workshop with stakeholders, as well as additional follow-up meetings with key stakeholders, that included various operational scenarios to identify stakeholder roles and responsibilities, equipment (such as hardware, software, and communications), staffing, and traffic management needs for both existing and future conditions.

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

1. Data Collection
    - Collect Origin and Destination Data
    - Make full use of City-owned travel time data
    - Provide traffic real time volume data
    - Incorporate Signal Phasing and Timing data into STREETS
    - Collect Roadway Geometry Data

2. Performance Measurement System
    - Expand existing performance measurement system (Acyclica and DA-300’s)
    - Incorporate third party data when possible
    - Determine Traffic State and provide trigger for STREETS
    - Monitor Real time Incident/Event
    - Monitor system asset

3. Traffic Modeling
    - Enhance regional demand modeling
    - Enhance Micro-simulation modeling
    - Generate performance measures (i.e. delay and travel time) used as comparison

4. Decision Support System
    - Provide a User Interface (UI) to monitor STREETS operation
    - Allow data Management
    - Develop comparative rules for rerouting and timing plan evaluation
    - Provide and recommend rerouting strategy

5. Traffic Signal System
    - Improve and upgrade to advanced traffic signal controllers
    - Provide Adaptive Signal Control Technology (ASCT)

6. Communication System
    - Improve and upgrade existing FOC network
    - Realize communication to traffic signal controller
    - Evaluate future connected vehicle needs

7. ATIS
    - Improve operations for drivers by providing pre-trip and en-route information
    - Enhance traveler information system and use various media (e.g., text alerts, DMS, Smart Phone Apps) for delivering alerts and notification
    - Enhance traveler information system and use various media (e.g., text alerts, DMS, Smart Phone Apps) for route choice

8. Operations and Maintenance
    - Reduce staffing needs for system operation
    - Allow System Management

Through discussion and further evaluation of the needs identified during stakeholder workshops, more detailed needs were identified based on various operational scenarios that are further described in the next section. These needs and associated requirements are further documented and traced in the requirements and verification plan. **Table 5** summarizes the needs:

Table 5 – Operational Needs of the STREETS

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS
1.0	DATA COLLECTION
1.1	Collect O/D data from various sources (i.e., IBM)
1.2	Prioritize usage of City owned data
1.3	Collect real time traffic data
1.4	Incorporate signal phasing and timing data
1.5	Include Roadway geometry data
1.6	Evaluate vehicle to infrastructure (V2I) communications systems
2.0	PERFORMANCE MEASUREMENT SYSTEM
2.1	Provide travel time measurement system
2.2	Explore usage of the 3rd party data (i.e. Waze)
2.3	Determine Traffic State and Trigger STREETS operation
2.4	Monitor Real Time Incident/Event
2.5	Monitor System Assets State
2.6	Calculate System Performance Metrics

NO.	NEEDS, CONSTRAINTS, AND EXPECTATIONS
3.0	TRAFFIC MODELING
3.1	Develop Traffic Demand Model to estimate O/D and other necessary data for Micro-simulation Model
3.2	Provide Simulation model covering minimum 9 key corridors
3.3	Provide Simulation model capable of performing traffic route assignment
3.4	Provide Simulation model capable of interacting with DSS
3.5	Provide Simulation model capable of replicating controller functions
4.0	DECISION SUPPORT SYSTEM
4.1	Provide a User Interface (UI) for data display and manual operation
4.2	Provide a system allowing data management
4.3	Generate response plan (Rerouting and Signal Timing)
4.4	Evaluate response plan (Rerouting and Signal Timing)
4.5	Recommend optimum response plan
5.0	SIGNAL SYSTEMS
5.1	Evaluate and Upgrade local controllers
5.2	Evaluate and Upgrade ATMS software
5.3	Provide Adaptive Signal Control Technology (ASCT) System
6.0	COMMUNICATIONS SYSTEMS
6.1	Increase speed, bandwidth, and reliability of center to field communications
6.2	Provide communication among each STREETS module
6.3	Develop and implement network security protocols
6.4	Evaluate future connected vehicle communications system
7.0	ATIS
7.1	Enhance and develop traveler information delivery media (i.e., DMS, 511, Smart Phone App)
7.2	Develop procedures to automate information retrieving and Alarm/Notification distribution
7.3	Disseminate accurate and real-time congestion-related information to travelers
8.0	MAINTENANCE AND OPERATIONS
8.1	Automate STREETS system operation to reduce staff needs
8.2	Allow system management
8.3	Develop MOU for STREETS maintenance between the City and ECIA
8.4	Provide adequate staff training for the City, ECIA, and other stakeholders

4.2 Performance Measures

This section identifies the performance measures and targets that will be used to evaluate STREETS system operation. The information herein should address how the performance measures are related to the STREETS goals and objectives, which is described in section 1.3.

Based on the goals and objectives, the performance measure outlined in the following table, **Table 6,** can be established:

Table 6 – Performance Measures for the STREETS

GOALS	PERFORMANCE MEASURES

Improve Mobility	• Average travel time per trip for the corridor and each network
	• Average delay per trip (for the corridor and each network)
	• Travel time reliability measures
	  o Travel time index (ratio of peak period travel times to free-flow travel time
	  o Buffer index: extra time needed to be on-time 95% of the time
	• Person and vehicle throughput
	• Vehicle hours traveled
	• # of rerouting events
	• # of automatic retiming due to STREETS system

Reduce Congestion	• Intersection LOS • Freeway LOS • Arterial LOS • Volume/Capacity Ratios

Improve Safety	• Incident rate
	  o # of Secondary Accidents
	• Accident rate
	  o Injury
	  o Fatality

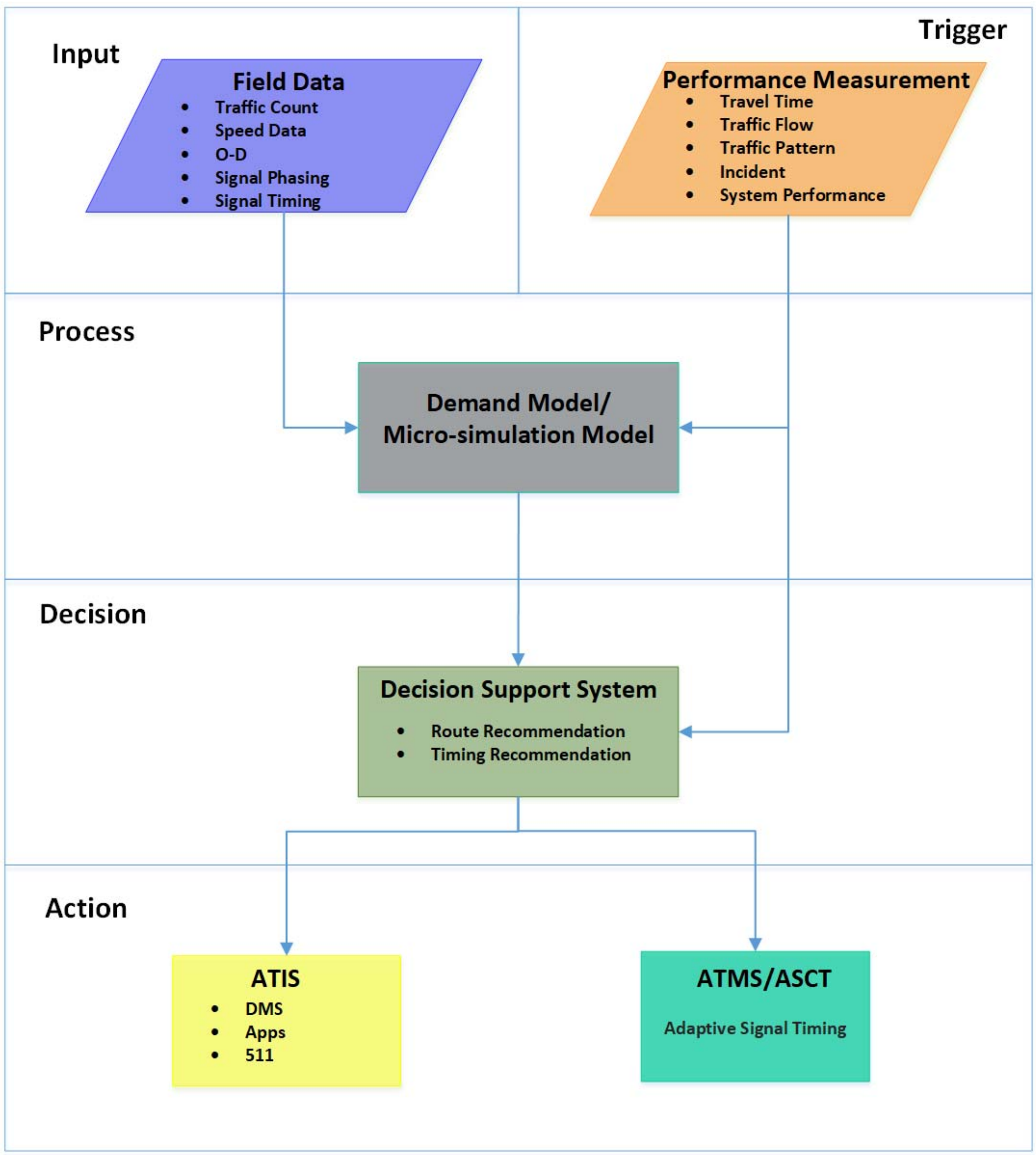
Information for Travelers	• # of events disseminated (i.e., travel time information)
	  o Per O/D pair
	  o Construction
	  o Incidents
	  o Special Event
	• System Availability
	  o Device up-time
	• 511 Usage
	  o Number of Subscribers

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

5 PROPOSED OPERATIONS

The concept of the STREETS was established through coordination with multiple stakeholders to address the needs identified in Section 4.0. The proposed STREETS System concept is illustrated in **Figure 7** and described in the following section.

Figure 7 – STREETS Concept



As shown in the concept chart, the STREETS system include six functional models. The following list provides a brief description of each module:

5.1 Data Input

The module defines the data needs for STREETS system. This module gathers data from various data sources, compile them and feed the data into Micro-Simulation Model. O/D data can be collected from traditional survey and smart phone as well. The O/D data, traffic counts for both roadway segment and intersection turning movement, signal timing data, roadway improvement (i.e., adding a travel lane) are fed into Micro-Simulation Model to simulate existing roadway network operation and used to conduct evaluation for various operation scenarios such as normal daily operation, incident, planned or unplanned events.

5.2 Performance Measurement

The module includes various field devices, and/or third party applications (i.e. Waze, Google) that can provide real time data to represent traffic operation and system performance. Firstly, this module is to constantly monitor traffic operation within the roadway network and detect any traffic pattern change or capacity reduction which causes unbalanced traffic assignment within the network. The field devices for traffic monitoring include CCTVs for traffic surveillance, travel time and delay evaluation system (i.e. Acyclica), and other selected technologies during system design. This module shall contain a defined process to detect, identify and verify incident, and methodology to identify potential unbalanced traffic assignment within the network (i.e., significant variation in travel time/delay for a roadway segment or unusual disparity in travel time/delay among roadways). This module can also utilize third party applications to retrieve existing information such as verified incidents, lane closure and delay and feed these data into the STREETS to trigger traffic reassignment evaluation. For example, STREETS may exchange data with Waze Connected Citizens Program (CCP) to receive real-time incident information to trigger route reassignment, and use Waze to inform drivers of major events and other roadway insights such as detouring thought the app. Secondly, this module also interacts with DSS module to provide system performance data for system reporting. Performance data such as travel time, delay, incident clearance was fed to STREETS. These data can be retrieved in various reports over time to indicate the effectiveness of STREETS system and for future system enhancement.

5.3 Traffic Modeling

The module defines the process of STREETS system. The STREETS system requires both Travel Demand Modeling (TDM) and Micro-simulation model to mimic the roadway network to be included in the system.

<u>Travel Demand Modeling</u>

The module contains an existing or modified regional TDM. The model provides highway passenger car and truck origin-destination trip matrices needed in development of the Micro-simulation model. The regional model highway network is used as basis for developing the Micro-simulation network.

Micro-simulation Modeling

STREETS system requires the development of a microsimulation traffic model of the Dubuque metro area (including all relevant roads and all of the signalized intersections) to represent existing traffic conditions. The model will be capable of replicating signal operations from the field and it will produce truthful outputs of the field traffic conditions (travel times, delays, etc.) so that following traffic assignments/routing can be executed based on verified data. The model will execute traffic assignments (reroute vehicles) based on the estimated/measured traffic impedances of the network links when traffic pattern, or traffic status change is identified. Prior to integration in the STREETS system, the model will be calibrated and validated to confirm that field data (e.g. travel times between signalized intersections, intersection approach delays, average phase times) are matched properly. Under STREETS operation, a traffic status change or capacity change (i.e., verified incident, planned special events, construction actives, etc.) will trigger the running of this model. This model is utilized to run and test re-routing alternatives and validate the proposed detour routes based on the field conditions (e.g., major road work or lane closures; test the same scenario in the model and confirm that the assignment can reflect conditions observed in the field). The modeling results include traffic detour, simulated traffic flow on selected corridors after reassignment of traffic among network. Then the model will feed the information to DSS module.

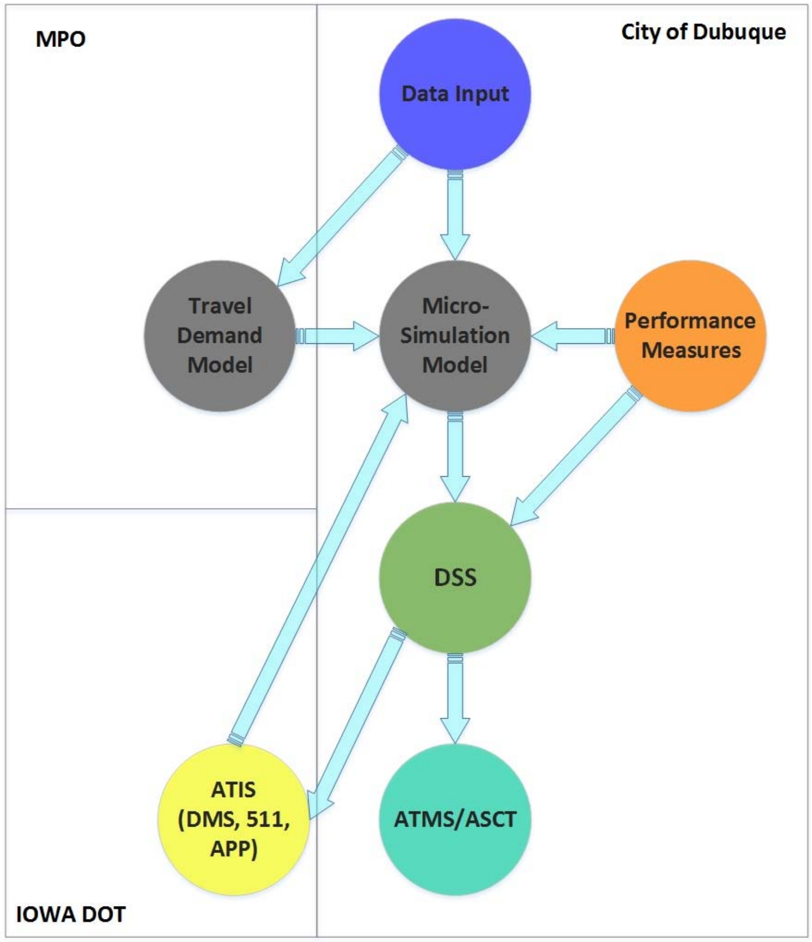
5.4 Decision Support System (DSS)

The DSS is a core module of the STREETS system which integrates other modules and contains functionalities that do not exist today. This module interacts with many other modules, allows for data exchange, handle data formatting/processing, detect congestion, recommend rerouting strategy, and receive feedback from other modules. **Figure 8** presents the data flow to/from DSS to all other modules of the STREETS system.

The DSS provides the following functionalities in STREETS system:

- Interface the user for STREETS operation with displayed inputs and outputs and allow manual intervention as necessary
- Gather, categorize, format and compile input data from other modules
- Handle erroneous and missing data
- Store and maintain a library of pre-defined timing constraints under a variety of traffic flow
- Allows special events scheduled in STREETS system to trigger new timing plan assignment
- Receive, evaluate and recommend rerouting strategy developed by Simulation Model
- Interface with ASCT to request timing change and receive feedback
- Interface with ATIS to request dissemination of traveling information such as alternative route
- Interface with Performance Measures System to validate system performance
- Conduct system performance reporting

Figure 8 – STREETS Module and Data Flow



5.5 Advanced Traveler Information System (ATIS)

ATIS is an essential component of the STREETS system. ATIS provides the users of the transportation system with real-time information that could be used to make decisions about route choices, estimate travel times, and to avoid congestion. Existing and proposed DMS, a traffic website (i.e. 511) and a smart phone application are envisioned to provide this data to the users.

- Dynamic Message Signs (DMS) – DMS provides en-route information to drivers regarding traffic and roadway conditions such a travel time and recommended alternative routes.
- Smart Phone App – A free smart phone App for STREETS operation is to be included in STREETS to provide alternative route information and verify motorist's adoption of suggested route.
- 511 – Existing or enhanced 511 system is used for dissemination of travel time and traffic route recommendation by STREETS.
- Future in-car Information dissemination system

5.6 Adaptive Signal Control Technology (ASCT)

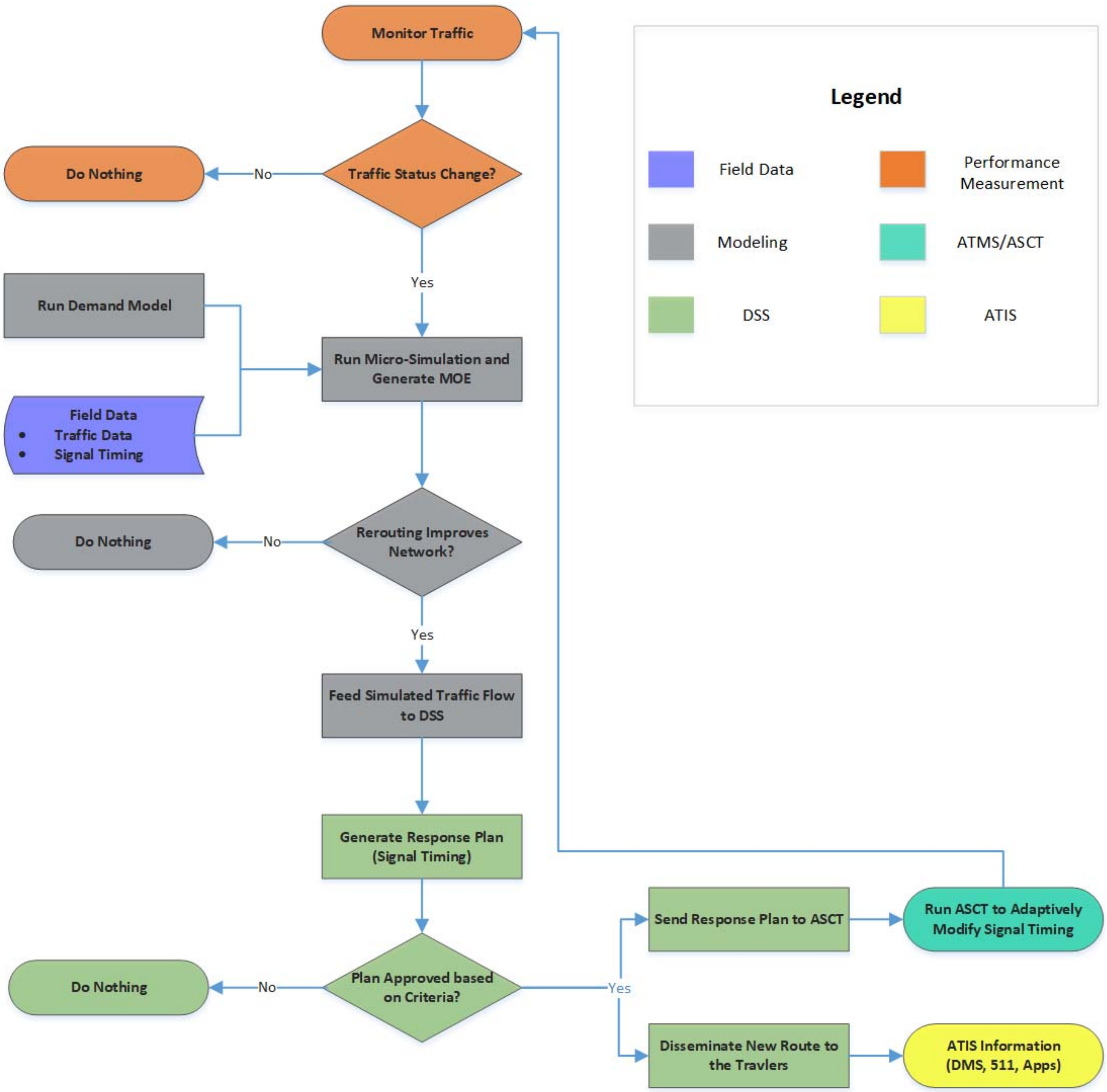
The STREETS system contains an ASCT system to dynamically change signal timing based on observed and predicted congestion as estimated by the Micro Simulation Model. The ASCT is expected to be fed by DSS with recommended timing plans which is triggered only after optimal traffic flows are determined through a traffic assignment procedure. The ASCT then take control and utilizes it is own adaptive algorithm to adjust signal timing in a partial and progressive fashion while confirming that the proposed routing changes are implemented in the field.

Most of the existing ASCT systems require extensive vehicular detection. The ASCT deployed under STREETS shall work with both field detection data and data fed by DSS. The proposed ASCT must be integrated in the STREETS properly to enable signal timing changes to be made in real time without creating disruptions to the field operations. The ASCT shall also have a Software-in-the-Loop (SIL) capability which is compatible with the field traffic controllers. Changes made in the SIL database of the ASCT need to be seamlessly transferrable to the field controllers. The ASCT shall also contain a feedback loop which suggests signal timing changes. The adopted ASCT only implements full signal timing change for optimal traffic rerouting after the assurance from the field that the drivers are adopting/following on the suggested routing options. In case the STREETS system is malfunctioning such as no DSS not feeding data to ASCT, the ASCT shall still work individually as an independent system for its deployed corridor.

5.7 STREETS Logical Process

The STREETS project intends to deliver an automatic system that gives the City staff the ability to monitor traffic operations and intervene as necessary, but does not require constant or significant manual operations. Ideally, if no significant traffic disturbance events occur, STREETS will run 24/7 without requiring operators to interfere manually with traffic operations. System shall use CCTV with analytical capability or other performance measurement system automatically capture traffic change and trigger STREETS process. The project will reduce equipment costs at individual intersections by providing signal timings through a centralized Adaptive (Dynamic) Control Traffic System. The project will help the MPO measure the performance of the system by providing 24/7 traffic volumes and delays at all major corridors and intersections. **Figure 9** describes the logical process of the proposed STREETS system.

Figure 9 – STREETS System Process



6 OPERATIONAL SCENARIOS

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

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

The operational scenarios include the following:

- Scenario 1: Traffic Monitoring & Operations - Recurrent Congestion
- Scenario 2: Traffic Monitoring & Operations - Unplanned Event
- Scenario 3: Traffic Monitoring & Operations - Planned Event
- Scenario 4: Traffic Monitoring & Operations - Maintenance

The scenarios listed above are detailed below for the proposed system. Note that the Micro-simulation Model is calibrated and ready for use prior to testing/applying any operational scenarios.

6.1 Scenario 1: Traffic Monitoring & Operations - Recurrent Congestion

Recurrent congestion represents a normal day to day operational scenario. Under this scenario, each corridor experiences its daily traffic variation depending on time of day and there is no drastic disparity in terms of congestion level among corridors and traffic flow is assumed to be naturally assigned within the network based on impedance perceived by travelers. The ASCT shall be well calibrated based on the traffic characteristic of each corridor and function independently per corridor to adaptively optimize signal timing plan progressively based on traffic variation. The performance measurement module is constantly monitor traffic, however, no drastic traffic change over historical pattern is observed and performance data are archived by the individual component (i.e., Acyclic, CCTV data storage). No Micro-simulation model run is expected.

6.2 Scenario 2: Traffic Monitoring & Operations - Unplanned Event

This scenario represents a typical STREET operation when traffic re-routing is needed. Under this scenario, the performance measurement model constantly monitors traffic status, an unplanned event, typically a crash, is reported either by third party data, or by established incident detection algorithm (i.e. unusual travel time or delay). This triggers STREETS to run Micro-simulation Model to estimate the impact of this event. Event location (i.e., mile post of the corridor) and severity (i.e., # of lane closure) is verified via CCTV, which is entered into the simulation model. The model run is performed to reassign traffic among the roadway network. This results in simulated performance measurements and a new set of traffic flow on affected corridors. The simulated traffic flow data is fed into the DSS module. The DSS compares the simulated traffic flow and field traffic flow, with a set of predetermined criteria, it then selects new timing plans for each intersection among the impacted corridors. Presumably the intersections on corridor where the event occurs will receive more relaxed signal timing plans whereas those on corridors where traffic is reassigned to will receive a more restrictive timing plans. Before sending these plans to the ASCT system, the DSS will also examine other conditions such as truck route, school zone which may restrict or limit the deployment of new plans. Once approved, the new plans are forwarded to the ASCT system. At the same time, the DSS disseminates the recommended route information to the ATIS module such as DMS, 511 and mobile apps to inform the motorist and encourage detour. The ASCT receives the recommended timing plans and deploy them within its system, then operates based on its own adaptive algorithm to adjust timing based on varying traffic.

6.3 Scenario 3: Traffic Monitoring & Operations - Planned Event

This scenario represents another typical STREET operation when traffic reassignment is needed. Under this scenario, a planned event such as a game, is scheduled ahead. The city staff shall use historical data to estimate the impact of the scheduled event and new O/D trip patterns for use in Micro-simulation Model to predict the increased traffic demand on the roadway network. Prior to the planned event, STREETS runs Micro- Simulation Model with recommended O/D pairs, predict traffic flow based on field data while the performance measurement module constantly monitors traffic status. The simulation model then feed the simulated traffic flow data into the DSS module. The DSS compares the simulated traffic flow and field traffic flow, with a set of predetermined criteria, it then selects new timing plans for each intersection among the impacted corridors. Presumably the intersections on corridor where the planned event occurs will receive more relaxed signal timing plans whereas those on corridors where traffic is reassigned to will receive a more restrictive timing plans. Before sending these plans to the ASCT system, the DSS will also examine other conditions such as truck route, school zone which may restrict or limit the deployment of new plans. One approved, the new plans are forwarded to the ASCT system. At the same time, the DSS disseminates the recommended route and special event information to the ATIS module such as DMS, 511 and mobile apps to inform the motorists. The ASCT receives the recommended timing plans and deploy them within its system, then operates based on its own adaptive algorithm to adjust timing based on varying traffic.

6.4 Scenario 4: Traffic Monitoring & Operations - Maintenance

This scenario represents another typical STREET operation when traffic reassignment is needed. Maintenance can be scheduled routine preventive maintenance and emergency maintenance.

For routine maintenance, a series of activities should be pre-evaluated using Micro-simulation model such as duration of maintenance, number of lane blockage and scheduled Maintenance of Traffic (MOT). The results should be a set of traffic flow variation. Prior to the scheduled maintenance, STREETS runs Micro-simulation model based on field data to verify with pre-evaluation. It then feeds DSS with simulated traffic flow. The DSS receives the new traffic flow, generates response plan, and then alerts the ASCT to modify signal timing and prompt ATIS to disseminate the new routes and event information. The routine maintenance shall be scheduled in DSS. Once the maintenance activity is completed and verified, the City staff shall command STREETS to end maintenance scenario and resume normal operation. STREETS will utilize performance data and CCTV data to verify the recovery of traffic status before commanding the system to a “normal” operation scenario.

For emergence maintenance, STREETS treats it in the same manner as an unplanned event. Under this scenario, STREETs triggers Micro-simulation Model to predict the increased traffic demand among the roadway network. Verified with field data, then feed the simulated traffic flow data into the DSS module. The DSS compares the simulated traffic flow and field traffic flow, with a set of predetermined criteria, it will then select new timing plans for each intersection along the impacted corridors. Before sending these plans to the ASCT system, the DSS will also examine other conditions such as truck route, school zone which may restrict or limit the deployment of new plans. One approved, the new plans are forwarded to the ASCT system. At the same time, the DSS disseminates the recommended route and special event information to the ATIS module such as DMS, 511 and mobile apps to inform the motorists. The ASCT receives the recommended timing plans and deploy them within its system, then operates based on its own adaptive algorithm to adjust timing based on varying traffic. Once the maintenance activity is completed and verified, the City staff shall command STREETS to end maintenance scenario and resume normal operation. STREETS will utilize performance data and CCTV data to verify the recovery of traffic status before commanding the system to a “normal” operation scenario.

7 SUMMARY OF IMPACTS

7.1 Operational Impacts

The implementation of the elements identified in the STREETS System concept will allow for significant operational improvements. To effectively impact the traffic flow through the signalized intersections of the STREETS deployment, the subsystems of data collection, traffic modeling, performance measurement, decision support, advanced traveler information and signal timing will need to be completed in less than two minutes. Preferably these subsystems will be completed in less than one minute. The system will allow staff to monitor, manage and maintain the system automatically. The following summarizes the operational impacts in regards to the nine categories of operational needs discussed in Section 4.0.

1. Data Collection – The STREETS will allow for the ability to gather and integrate a variety of field data from various data resources, and to categorize and format them to be utilized in different modules of STREETS. STREETS intends to interact with third party data such as Google and Waze. Existing travel time and traffic signal characteristics are summarized via Acyclica and DA300's. STREETS takes advantage of existing verified information such as incident and delay from such resources and utilizes them as trigger of traffic assignment.

2. Traffic Signal Systems – The STREETS system concept will develop a new ACTS that changes signal timing based on predicted traffic condition. This will greatly enhance the City's ability to manage traffic dynamically and proactively.

3. Communications System – The proposed system will bring all signals online and significantly improve the communications system to provide near real-time remote monitoring and management of the system.

4. Traffic Modeling – The STREETS system will provide the City with the ability to analyze traffic operations within the key corridors, evaluate the impact of both recurring and non-reoccurring congestion to the roadway network, and develop incident management strategies (i.e., rerouting of traffic to corridors with existing capacity).

5. Performance Measurement System – The STREETS system will expand current city owned Performance Measurement System and potentially incorporate the 3rd party data (i.e., Waze). This will improve the City's ability to monitor the performance of the transportation infrastructure, to evaluate the progress towards their objectives, and to assess the effectiveness of the transportation management strategy such as traffic rerouting. The STREETS system will need to incorporate Signal Phasing and Timing (SPaT) data from each controller.

6. Decision Support System (DSS) – The STREETS system will add a new DSS module to provide additional features to monitor congestion management. This will provide the City the ability to gather specific, necessary field and simulation data, and translate the data into a congestion management strategy. Additionally, the DSS will serve as a trigger for corridor and individual signal timing modifications and provide recommendations on route assignments for incident management, congestion management and connect traffic modeling with ATIS and Signal system operation.

7. Data Exchange and Archiving - The STREETS system will enhance the City's ability to gather, exchange, archive data generated and collected by the proposed system.

8. Traveler Information Systems – The STREETS system will improve operations for travelers by providing pre-trip and en-route information. It will improve incident management through improved notification of incidents, the ability to monitor incidents, the ability to manage the system, and the ability to disseminate traveler information.

9. Maintenance and Operations – The STREET system will improve the efficiency of city staff by automate the operation process. The added module, device, firmware and software will require additional maintenance needs, which should be further evaluated in the next phase of the project.

7.2 Organizational Impacts

The implementation of the STREETS system may require additional work for the City of Dubuque staff. The system will improve some efficiencies in maintaining and operating the system; however, with the additional devices such as DMS, detector, ASCT, and potentially firmware/software for data and DSS, the staff will have additional roles and responsibilities to manage and maintain the system. This may require additional resources or the reallocation of resources.

7.3 Potential Risks

The risk associated with this project will be discussed with City staff, DMATS and other stakeholders. Project needs will be discussed to reduce the amount of risk in the project. Areas of risk include:

- Travel Demand Forecast model not estimating the O/D data with acceptable level of accuracy
- Microsimulation Traffic model not producing representative outputs of field traffic conditions data
- Traffic model requires frequent calibration
- Keeping backup timings current in the event of all possible system failures
- Extensive system oversight during construction
- STREETS Process takes too long to provide near real-time signal timing modifications
- Maintaining a trained staff on the Adaptive Signal Control Technology (ASCT)
- Corridors require significant intersection enhancements prior to deployment
- Corridors require significant communications upgrades prior to deployment
- Inability to remotely monitor and trouble-shoot the ASCT system
- Project Delays based on integration or project approvals
- System not providing meaningful measurement against clearly stated performance objectives
- Measures do not directly map to specific functions of the adaptive algorithm
- Not properly identifying needs and requirements to address the City of Dubuque area

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

8 NEXT STEPS

The project team will develop high-level system requirements and a preliminary verification plan consistent with this Concept of Operations for the Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) project. As of the spring of 2018, numerous components of the STREETS system can be described by the industry as “in development.” It is anticipated that multiple firms will need to team together to provide a STREETS solution. To better refine the requirements for this system, an RFI is recommended to have vendors organize teams and describe potential solutions. Through this process the agencies will gather additional information to expand the requirements and move the project closer to procurement.

Phased deployment is expected for this project to construct, configure and test the system. Concept design information (phasing by corridor, and preliminary equipment requirements) and concept-level cost estimates will be prepared to illustrate the recommended implementation plan.

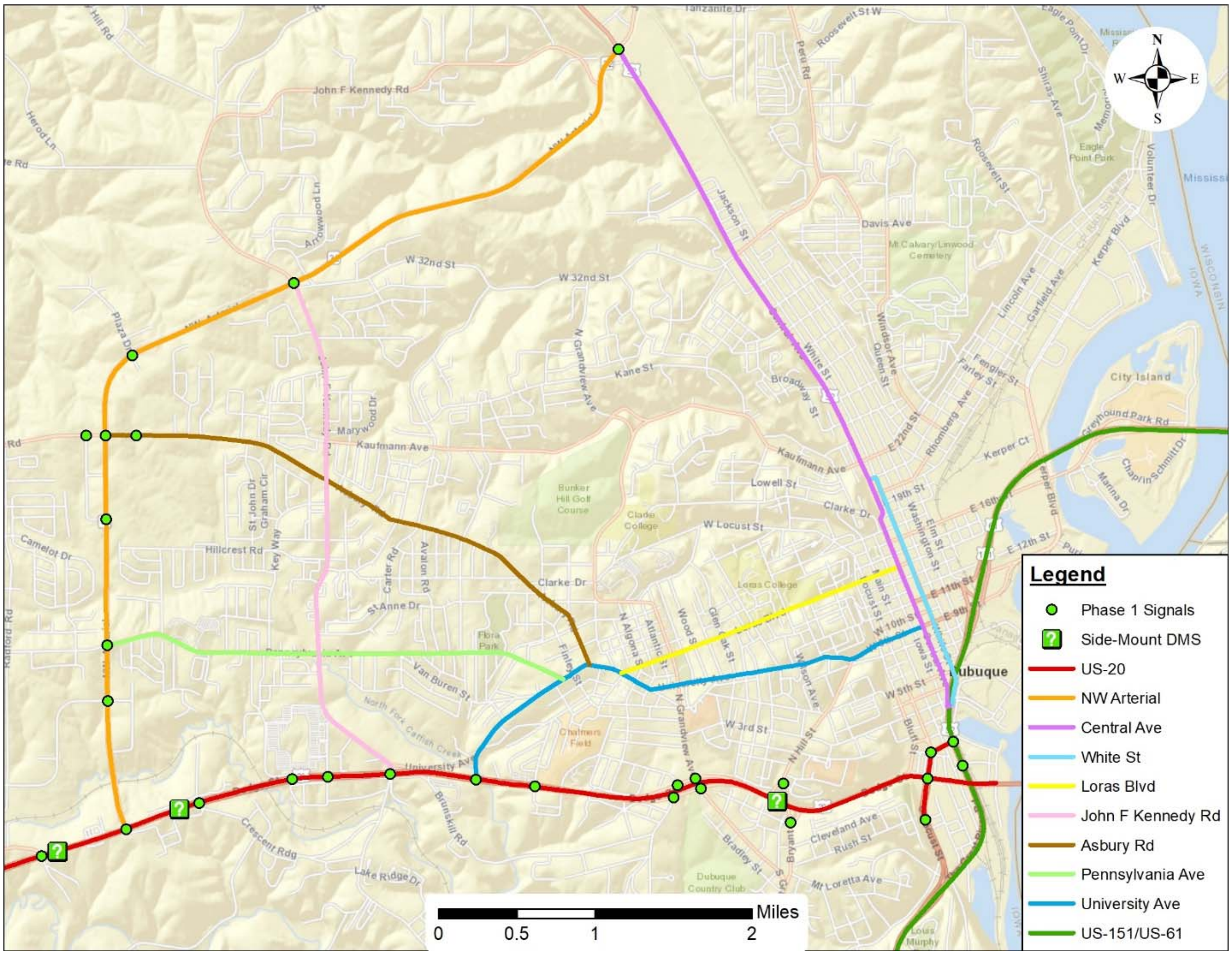
The City of Dubuque or their representatives will track and amend the verification plan, specifications and requirements after the RFI process is complete. Once the revisions to the Concept of Operations, requirements and verification plan are complete, the designated agency could determine if the timing was right for an RFP for phased deployment. The agencies have discussed the selection process that would likely consist of one RFP and include all components for deployment including field hardware, video analytics, simulation models, the ASCT system, the DSS and the ATIS systems. Such a selection process would help reduce the potential finger-pointing of multiple contracts and extended project support.

The current responsibility to manage the project will be the City of Dubuque Project Manager. Changes will need to be documented in the System Engineering documents, the acceptance testing and verification procedures, as well as in the As-Built information. To provide support for the project, it is recommended that a System Manager provide support through deployment and acceptance testing.

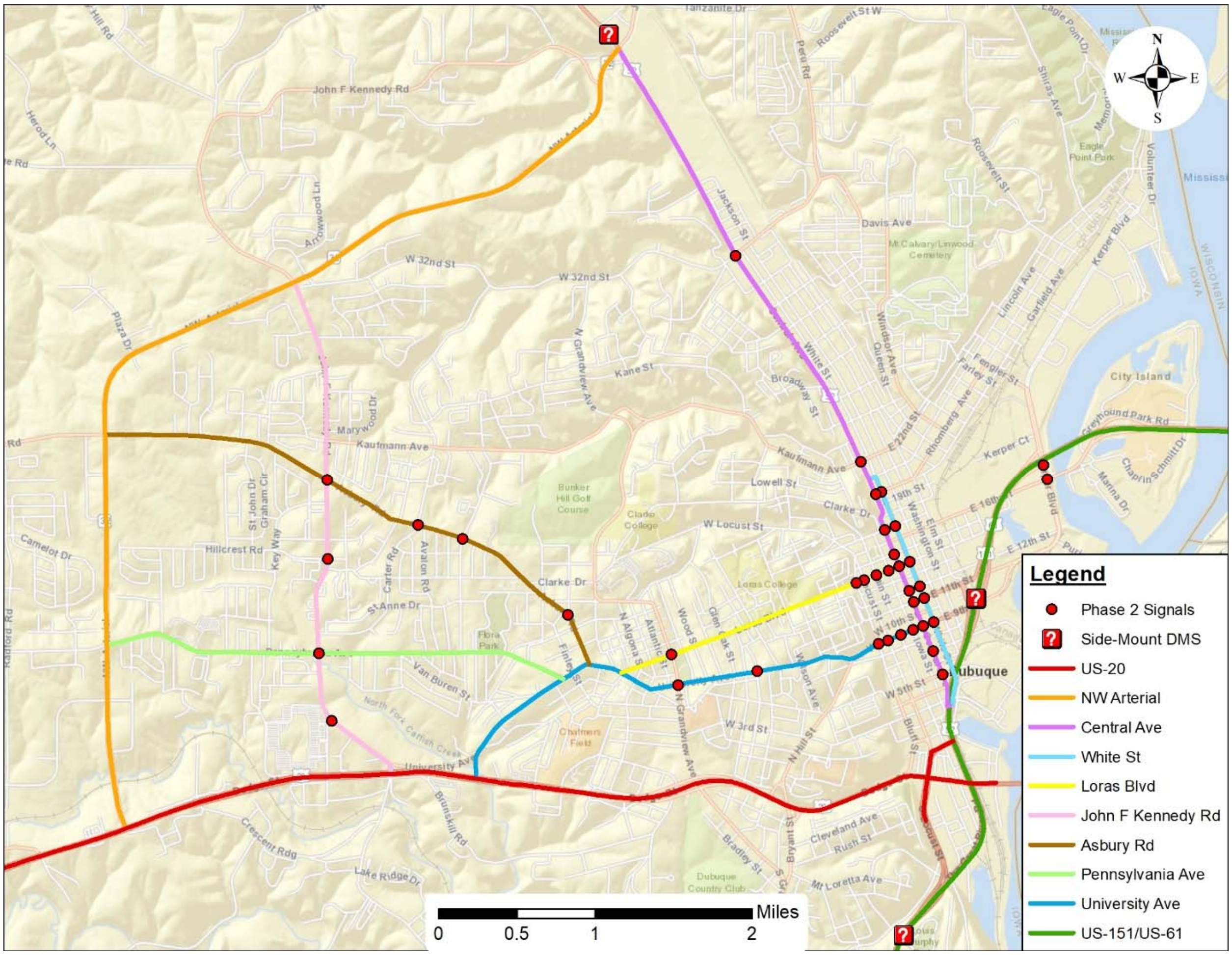
ATTACHMENT 1 – PROPOSED ITS DEPLOYMENT MAP

- STREETS System – Phase 1
- STREETS System – Phase 2

STREETS System – Phase 1



STREETS System – Phase 2



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CITY OF DUBUQUE
SMART TRAFFIC ROUTING WITH EFFICIENT & EFFECTIVE TRAFFIC SYSTEM (STREETS)
Final Requirements and Verification Plan| version 1.1

May 11, 2018

U.S. Department of Transportation
Federal Highway Administration

IOWADOT

Submitted to:

ECIA

17J18-0640 | Prepared by **Iteris, Inc.**

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DOCUMENT VERSION CONTROL

DOCUMENT NAME	SUBMITTAL DATE	VERSION NO.
Draft Requirements and Verification Plan for the Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Project	March 29. 2018	1.0
Final Requirements and Verification Plan for the Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Project	May 10, 2018	1.1

TABLE OF CONTENTS

1 PURPOSE OF DOCUMENT

The purpose of this document is to present the requirements and verification plan for the proposed Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) deployment in the City of Dubuque. The City of Dubuque, Dubuque Metropolitan Area Transportation Study (DMATS) and the Iowa Department of Transportation (Iowa DOT) partnered to develop a smart, next generation, traffic management and control system. The City expects the STREETS will facilitate dynamic routing of traffic to maximize the use of existing roadway capacities in the project area. The City, DMATS and Iowa DOT have developed Systems Engineering documents for the STREETS system. This Requirements and Verification Plan document is developed to select and deploy the different components of the STREETS system in the initial nine (9) corridors with 57 signalized intersections within the city of Dubuque area. It describes the scope of the project; the referenced documents that were used to prepare the verification plan; details on the actual execution of verification; and provides a list of the verification cases and corresponding system requirements to be tested.

The following stakeholders of the STREETS system were included in the process to develop the final requirements, and verification plan:

- City of Dubuque
- Dubuque County
- ECIA
- Iowa DOT
- Iowa Motor Truck Association (IMTA)
- Federal Highway Administration (FHWA) Iowa Division
- Dubuque School District
- Dubuque County Emergency Management
- Dubuque Community School District
- Dubuque County Sheriff's Department
- Iowa State Highway Patrol
- Dubuque Fire Department
- Traveling Public.

This document will be used to guide the City of Dubuque staff and the System Vendors through different components of the STREETS system during the deployment. This document and all considerations contained herein are provided with the understanding that the project requirements and the verification plan will guide the installation, integration, and testing of the STREETS system.

2 SCOPE OF PROJECT

The scope of this project is to deploy the STREETS system along nine (9) corridors with 57 signalized intersections within the city of Dubuque. The STREETS project will use advanced traffic control strategies to enable dynamic traffic routing to maximize the use of existing roadway capacities in the Dubuque metropolitan area. The STREETS project seeks to employ Active Transportation and Demand Management (ATDM) strategies which will require a suite of modeling tools and methods. These strategies, tools and methods will enable the City of Dubuque to evaluate the potential benefits of implementing ATDM strategies in a dynamic and proactive fashion using both real-time and historic data.

The STREETS system shall include the following major components:

1) Travel Demand Model (TDM)
2) Microsimulation Traffic Model (MTM)
3) Adaptive Signal Control Technology (ASCT)
4) Decision Support System (DSS).

The STREETS will also interface with other components including, but not limited to, Advanced Traffic Management System (ATMS), Advanced Traveler Information System (ATIS), and third party data source (i.e., Waze). The TDM will be utilized to estimate the O/D and other necessary data for the microsimulation traffic model. The MTM is to represent the current roadway network and be capable of executing traffic assignment (dynamic traffic routing) based on estimated/measured traffic impedances of the network links. The ASCT will develop optimized signal timing in real time after changes of traffic conditions are determined by STREETS. The DSS is to function as a core model which communicates with TDM, MTM, ASCT and other components, provides data exchange, dynamic routing strategy generation and integrates all components into a complete STREETS system.

The existing traffic signal system includes over 100 traffic signals and other ITS devices. About 80% of the signals are connected to a fiber optic communication system. While the existing system is functional, stakeholders have identified needs that cannot be met with the current traffic management system. Below are the high-level needs that cannot be fulfilled by the existing system.

- Inefficient use of green times due to drivers' slow pull off from standing queue at signalized intersections.
- Uneven utilization of particular road lanes because some drivers, cognizant of the necessity of lane changes, change lanes well advance before merging/diverging times.
- Signal timings that provide good coordination for truck traffic along certain corridors with hilly terrain are not suitable for light vehicles.
- Reducing congestions from a number of heavily congested corridors such as Hwy 20, Pennsylvania Ave., NW Arterial, Asbury by distributing the traffic more evenly across the other roads in the network.
- Recognizing the onset of peak periods.
- Detecting and responding to unexpected changes in traffic demand as a result of incidents, work zones, weather, etc.
- Managing the fluctuations of traffic along Pennsylvania Ave & NW Arterial because of nearby high school in mornings and early afternoon hours.

The STREETS system will allow the City to proactively manage traffic, enhance operations, increase mobility and reduce congestion along the congested corridors.

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

- Traffic signal controllers and controller local software
- Advanced Traffic Management System (ATMS)
- Cabinets
- Detection devices (inductive loops, video and microwave)
- Emergency vehicle preemption (EVP) devices
- Communications
  - Media (including twisted pair copper, wireless radio, fiber optic)
  - Hardware (switches, transceivers, modems, etc.)
- CCTV

- Travel time measurement system (Acyclica)

Systems engineering analysis for the STREETS is on-going; City, DMATS, Iowa DOT and FHWA will review the systems engineering documents. Once these documents are approved, the City will develop and publish the RFP to procure the different components of STREETS. Iowa DOT and FHWA will contribute to selecting the format of the RFP and also will participate in selecting the STREETS system.

3 REFERENCE DOCUMENTS

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

- Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Project Proposal, City of Dubuque, May 1, 2017.
- City of Dubuque: Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Systems Engineering Management Plan (Draft), November 6, 2017.
- City of Dubuque: Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Stakeholder Workshop, November 14, 2017.
- City of Dubuque: Smart Traffic Routing with Efficient & Effective Traffic System (STREETS) Concept of Operations (Draft), February 2, 2018.
- Dubuque Metropolitan Area Transportation Study (DMATS)/ Regional Planning Affiliation (RPA) 8 Regional ITS Architecture.
- Dubuque Metropolitan Area Transportation Study, Travel Demand Model, June 2016.
- Intelligent Transportation System Plan, Iowa Department of Transportation.
- East-West Corridor Connectivity Study, City of Dubuque and City of Ashbury
- DMATS Long Range Transportation Plan 2045 (adopted October 13, 2016 and amended January 12, 2017).
- Smarter Travel – Identifying Options for Commuters in the Region, July 14, 2017.
- Future Conditions Analysis, Traffic Operations Study, Northwest Arterial (US 20 to US 52), Iowa Department of Transportation.
- Traffic Incident Management Book, Dubuque County.
- *Model Systems Engineering Documents for Adaptive Signal Control Technology Systems – Guidance Document, FHWA, Report No. FHWA –HOP- 11- 027.*
- *Systems Engineering Guidebook for ITS, California Department of Transportation, Division of Research & Innovation, Version 3.0 - http://www.fhwa.dot.gov/cadiv/segb/*

Select documents provide the policy guidance while specific texts are the Dubuque area future transportation systems' planning documents. Additional documents report the conclusions of discussions, workshops and other research used to define the needs of the project and subsequently identify STREETS requirements.

4 STREETS REQUIREMENTS

Appendix A identifies detailed requirements for the STREETS. These requirements are based on user needs determined in the Concept of Operations document. These needs were gathered directly through meetings with stakeholders and walking-through various operational scenarios. The Concept of Operations document describes these operational scenarios and documents these needs in detail.

Detailed requirements were evaluated and determined to be Mandatory or Secondary. Secondary requirements are features that provide benefit but are not mandatory, as the execution of the project deployment can be accomplished without these STREETS requirements. As an example, the selected ASCT system of STREETS does not need the ability to access and modify settings on an adjacent controller at a near-by intersection. The City might consider this a favorable solution but not a solution at the expense of other mandatory requirements. Therefore, it is written as a Secondary requirement.

5 VERIFICATION APPROACH

The final verification procedures will be developed and conducted by the System Vendors of the STREETS with approval from Iowa DOT in partnership with the City of Dubuque. All verifications shall be conducted in the presence of the City of Dubuque staff. Final verification and formal system acceptance will be provided by the City of Dubuque's Project Manager. The Project Manager will control the plan and tests, but will also work with the System Vendors to clarify the verification procedures and acceptance tests.

The System Vendors will be responsible for providing all materials, equipment and staff to complete the testing. A list of all hardware, software and special equipment utilized in the testing shall be provided prior to testing. The System Vendors shall produce and maintain a schedule for the City of Dubuque that details all proposed dates and time of all acceptance testing activities. The City of Dubuque Project Manager, will review and notify Iowa DOT of the schedule. The City of Dubuque Project Manager will approve the schedule of the acceptance testing activities.

The System Vendors shall conduct the verification tests with deployed hardware and software. The verification table indicates where the test should be conducted (see attached Requirements with Verification Methods). The Vendor shall coordinate with the City of Dubuque Project Manager to schedule the testing time periods consistent with the test schedule. The City of Dubuque Project Manager will notify Iowa DOT of the testing time periods.

Acceptance testing will be a critical part of implementation, including one-day acceptance and 30-day reliability tests. The acceptance test is expected to consist of a one-day test of the STREETS components as described above. This testing will take place in the field at selected locations and at the traffic operations center (TOC) for complete end-to-end system verification. If there are verification tests that result in failure, then the verification could take longer than one day. A 30-day reliability test for each component installed as part of the project will also be documented. The 30-day test is expected to document the verification of daily operation. At the end of the 30-day reliability test, the System may need to be fine-tuned to meet the operational need(s) of the corridor. The System Vendor(s) will coordinate with the City of Dubuque Project Manager to schedule the fine-tuning of the system. City will notify Iowa DOT of this schedule.

Any failure to meet the stated system requirements shall be immediately recorded as a System Variance and the System Vendors shall prepare a report stating why the system requirement was not met. It is the responsibility of the System Vendors to complete, track, and resolve each variance to the satisfaction of the Project Manager. The Variance Form shall include a proposed solution to resolve the deficiency and shall be submitted to the Project Manager within seven (7) days of the date the failure is discovered. Upon any failed verification, the System Manager and the City of Dubuque Project Manager will complete a Variance Form and also decide if all testing should stop until correction is made. A failure with a select system requirement such as upload/download data to the controller will likely cause all testing to halt. Other functional requirement failures, that do not directly impact system functions, may not necessitate a halt to system verification.

If the System Vendor is not able to meet a system requirement that was included in the contract, the System Vendor shall prepare a report documenting the failure and develop a plan to provide similar performance operation or correction to the failure. Upon completion of all required verification testing, the System Vendors shall prepare a final Verification Report which will contain all critical information regarding testing conducted including both failures and successes. Resolution of the cause of failures should also be detailed.

6 VERIFICATION REVIEW AND TESTING

This section identifies specific verification reviews and acceptance testing for the STREETS deployment. The acceptance test is expected to include multiple reviews and will include one or more of the following elements:

- Demonstration of integration of the STREETS' different software modules
- Demonstration of automated data (volume, SPaT) input to the Micro-Simulation Model
- Demonstration of receiving data (volume, SPaT) automatically from the Micro-Simulation Model
- Demonstration of Traffic Demand Modeling data (O-D) output
- Demonstration of the Micro-Simulation Model's data accuracy
- Demonstration of Performance Measurement System's data output
- Demonstration of transmitting SPaT data to the Decision Support System(DSS)
- Demonstrations of the Decision Support System (DSS)
- Demonstration of the Advanced Traveler Information System (ATIS)
- Field demonstrations of detection system's data accuracy
- Demonstration of City's existing Video Data Analytics system's data accuracy
- Demonstration of the STREETS system's full functionalities on hand-held devices (smart phone, tablet etc.) for the STREETS system operator
- Demonstration of the STREETS system's full functionalities on hand-held devices (smart phone, tablet etc.) for traveler
- Demonstration of the existing City owned travel time system (Acyclica) data accuracy
- Demonstration of archiving data (volume, SPaT) sent to the Microsimulation Model on both local and cloud based storage
- Demonstration of archiving data (volume, SPaT) output from the Microsimulation Model on both local and cloud based storage
- Monitoring queue management at user-specified locations
- TOC test of communications
- Remote monitoring and control of the ASCT and other components of the STREETS
- Review training materials

The verification and acceptance testing will be accomplished at approved City of Dubuque locations and at specific field locations within the City. All acceptance test procedures shall conform to the approved acceptance test plans. These tests will be completed and documented by the System Vendors and supervised by the City of Dubuque Project Manager. Operational documentation of the field components is expected to be completed with a laptop, internet connection and associated cabling. The System Vendors will need to provide multiple staff in the field and at the TOC to document certain acceptance tests.

A verification test case is a logical grouping of functions and performance criteria that are to be verified together. Each test case should contain the following:

- Name and reference number
- Objective (from requirements)
- List of requirements to be verified or traced
- Data to be recorded or noted during verification, such as expected results
- Statement of requirements met, partially met, or not met
- Comments on how requirements are met, and proposed action if only partially met or not met.

The following preliminary test cases have been identified:

1. Local Controller Configuration
2. Upload and Download from Central Database
3. Alarms & Notifications
4. Default Settings
5. Remote Access and Operation
6. Data input to/output from Micro-Simulation Model
7. Data input to/output from DSS
8. Data output from Performance Measurement System
9. Comparison of Traffic Demand Model output and Field Traffic Data
10. Comparison of estimated traffic assignment of the Micro-Simulation Model and DSS
11. Comparison of traffic assignment from DSS and field traffic data
12. Queue Management
13. Verification of STREETS system travel time data
14. Data Archiving.

Once a specific system component of STREETS is procured, additional and final test case instructions will be developed in conjunction with the System Vendor to confirm that all necessary software demonstration procedures are adjusted accordingly.

APPENDIX A – REQUIREMENTS WITH VERIFICATION METHODS

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City of Dubuque| Smart Traffic Routing with Efficient & Effective Traffic System (STREETS)

Final Requirements

Document Versions Control

Document Name	Submittal Date	Version No.
STREETS Requirements	3/22/2018	1
STREETS Requirement	3/30/2018	1.1
STREETS Requirement	5/11/2018	1.2

City of Dubuque| Smart Traffic Routing with Efficient & Effective Traffic System (STREETS)

Final Data Collection Requirements

Data Collection Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
1.1	Collect O/D data from various sources				
		1.1.1	The STREETS shall allow using O/D data from traditional survey	M	
		1.1.2	The STREETS shall allow using City's existing (IBM) data as O/D data source	M	
		1.1.3	The STREETS shall allow using O/D data from smart phone		S
		1.1.4	The STREETS shall allow using exsiting City-owned systems	M	
		1.1.5	The STREETS shall allow using O/D data from 3rd- Party Sources		S
1.2	Prioritize usage of City owned data				
		1.2.1	The STREETS shall prioritize using City owned travel time data	M	
		1.2.2	The STREETS shall prioritize using City owned detector data	M	
		1.2.3	The STREETS shall prioritize using City owned CCTV surveillance data	M	
		1.2.4	The STREETS shall allow automated input from existing Travel Time Information	M	
		1.2.5	The STREETS shall allow automated input of data from Acyclica and EDI DA300s	M	
1.3	Collect real time traffic data				
		1.3.1	The STREETS shall collect real time traffic data for roadway segment	M	
		1.3.1.1	Speed	M	
		1.3.1.2	Traffic Count	M	
		1.3.2	The STREETS shall collect real time traffic data for intersection	M	
		1.3.2.1	Turning Movement Count	M	
		1.3.3	System shall automate the process of traffic data feed into micro-simulation model		S
1.4	Incorporate Signal Phasing and Timing data				
		1.4.1	The STREETS shall collect signal phasing data in user defined interval (1/10th of a second to 300 seconds)	M	
		1.4.2	The STREETS shall collect signal timing data (1/10th of a second to 300 seconds)	M	
		1.4.3	The STREETS shall automatically transfer data at a user definded rate to the Micro-simulation model	M	
		1.4.4	The STREETS shall automate the process of signal data feed into micro-simulation model	M	
1.5	Include Roadway geometry data				
		1.5.1	The STREETS shall collect roadway geometry change data (i.e., adding a travel lane)	M	
		1.5.2	The STREETS shall be checked periodically for roadway geometry change and allow update of micro-simulation model	M	
1.6	Evaluate Vehicle to Infrastructure (V2I) Communications System				
		1.6.1	The Deployment System shall determine if V2I infrastructure is necessary to provide real-time information to drivers		S
		1.6.2	Traffic Signal Controller shall be capable of supporting V2I communications		S

City of Dubuque| Smart Traffic Routing with Efficient & Effective Traffic System (STREETS)

Final Performance Measurement System Requirements

Performance Measurement System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
2.1	Provide travel time measurement system				
		2.1.1	The STREETS shall expand current Acyclica system.	M	
		2.1.2	The STREETS shall evaluate/deploy other travel time measurement system (i.e. Bluetooth).		S
		2.1.3	Travel time measurement system shall calculate real time travel time on each corridors.	M	
		2.1.4	Travel time measurement system shall flag unusual travel time on each corridors .	M	
2.2	Explore usage of the 3rd party data				
		2.2.1	The STREETS shall be capable of receiving real time data representing traffic operation (i.e., incident) from Waze.	M	
		2.2.2	The STREETS shall be capable of receiving real time data representing traffic operation (i.e., incident) from google.		S
2.3	Determine Traffic State and Trigger STREETS operation				
		2.3.1	The performance measurement system shall constantly monitor traffic characteristics, which include but not limited to the following:		
			a travel time	M	
			b approach delay	M	
			c traffic queues	M	
			d Phase Failures	M	
			e Controller delay	M	
		2.3.2	The system shall be able to detect traffic pattern change/capacity reduction via travel time data.	M	
		2.3.3	The system shall be able to detect incident/event via CCTV surveillance cameras.	M	
		2.3.4	The system shall receive the status of the road network, including current incident information, roadway maintenance actions, and closures.	M	
		2.3.4	The System shall have rules and parameters for incident detection that can be adjusted ("fine-tuned") to minimize false alerts.		S
		2.3.5	The system shall trigger STREETS run based on detected/received traffic state change.	M	
2.4	Monitor Real Time Incident/Event				
		2.4.1	The system shall be capable of incident and event verfication via CCTV surveillance cameras.	M	
		2.4.2	The system shall maintain a list of active incidents and events affecting network operations.	M	
		2.4.3	The system shall be capable of monitoring active incident and events via CCTV surveillance cameras.		
		2.4.4	The system shall be capable of confirm the clearance of active incident and events via CCTV surveillance cameras.	M	
2.5	Monitor System Assets State				
		2.5.1	The system shall continuously assess the health status of devices used to monitor traffic conditions.	M	
		2.5.1.1	Monitor fault and error message of individual travel time measurement devices.	M	
		2.5.1.2	Check whether CCTV cameras are providing video feeds.	M	
		2.5.1.3	Monitor fault and error message of individual traffic detection devices (i.e. traffic detection) if included in STREETS.		S
		2.5.2	The system shall continuously assess the health status of devices used to control traffic conditions.	M	
		2.5.2.1	Monitor fault and error message of individual traffic signal controller.	M	
		2.5.2.2	Monitor fault and error message of ASCT system.	M	
		2.5.3	The system shall continuously assess the health status of devices used to disseminate traffic conditions.	M	
		2.5.3.1	Monitor fault and error message of individual CMS.	M	
		2.5.3.2	Monitor fault and error message of 511 system.	M	
		2.5.3.3	Monitor fault and error message of STREETS mobile app.		S
2.6	Provide System Performance Metrics				
		2.6.1	Explore usage of Signal Performance Measure (SPM) data to calculate Signal Performance Metrics.	M	
		2.6.2	The System shall calculate and store metrics summarizing overall network performance.	M	
		2.6.3	The System shall calculate and store metrics summarizing each corridor.	M	
		2.6.4	The System shall calculate and store metrics summarizing each intersection.	M	

City of Dubuque| Smart Traffic Routing with Efficient & Effective Traffic System (STREETS)

Final Traffic Modeling Requirements

Traffic Modeling Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
3.1	Develop Travel Demand Model to estimate O/D and other necessary data for Micro/Meso-simulation Model				
		3.1.1	The DMATS model shall be required to develop AM peak period, PM peak period, and daily O/D's available to import into the micro-simulation model.	M	
		3.1.2			
3.2	Provide Simulation model capable of performing traffic route assignment				
		3.2.1	The model shall be Citywide in nature and will also include other relevant regional roadways that carry traffic to, from and through the City.	M	
		3.2.2	The model requires travel demand model outputs to run. This includes link flow demand along major arterials and collector roadways that typically carry through traffic.	M	
		3.2.3	The model shall include up-to-date traffic signal timing for every signalized intersection, including peak period patterns, coordination, priority, and any other special timing elements necessary to operate the signals, collected directly from real-time data collection.	M	
		3.2.4	The model shall include existing turning movement counts, speeds, and volumes at all intersections and for corridor segments, updated regularly as part of real-time data collection.	M	
		3.2.5	The model shall be provided by scenarios such as construction-related detours, collision-related capacity changes, and special events information.	M	
		3.2.6	The model shall estimate changes to delay, speed, volume, and other MOES without adjustments due to the tested scenario.	M	
		3.2.7	The model shall then iteratively test changes to network to provide optimal solution for scenario.	M	
		3.2.8	The model shall identify preferred detour routing, timing pattern(s) for corridor/network area in question, and duration of change from normal operations for DSS integration. Timing pattern for adaptive system shall implement constraints and parameters that ensure scenario/event implementation and associated traffic detours are prioritized.	M	
		3.2.9	The model shall replicate the algorithms of the ASCT system to calculate and simulate the adaptive traffic operations.	M	
3.3	Provide Micro-simulation model covering up to X City-identified key corridors				
		3.3.1	If necessary, micro-simulation modeling shall be used to validate and verify effects to network and corridors based on change implemented.	M	
		3.3.2	The models will be capable of importing origin/destination data for peak periods stratified into 15 minute intervals.	M	
		3.3.3	The microsimulation models shall incorporate recent turning movement counts, signal timing sheets, volume inputs, and other vehicular/roadway behaviors per corridor.	M	
		3.3.4	The microsimulation models shall rely on volumes, travel times, speeds, queues, and other measures of effectiveness (MOEs) that describe the current operating conditions of the corridors.	M	
		3.3.5	The microsimulation models shall be calibrated/validated to FHWA criteria for vehicular volumes, travel times, queues, and delays for each corridor.	M	
		3.3.6	The models will evaluate behavior changes to network based on testing from 3.2, including but not exclusive to local travel behaviors such as merging, weaving, parallel corridor operation effects, and queuing changes.	M	
		3.3.7	The models shall be compared with the validated travel demand model for count/volume comparisons and O/D data.	M	
3.4	Provide Simulation model capable of interacting with DSS				
		3.4.1	Outputs from identified optimal or preferred scenario solution for meso-simulation shall be implemented for use by the DSS.	M	
3.5	Provide simulation model capable of replicating controller functions	3.5.1	The simulation model shall be capable of replicating controller feature as described in 5.1.4 and 5.1.5	M	

City of Dubuque| Smart Traffic Routing with Efficient & Effective Traffic System (STREETS)

Final Decision Support System Requirements

Decision Support System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
4.1	Provide a User Interface (UI) for data display and manual operation			M	
		4.1.1	The DSS shall include a user interface to create, view, update, and delete asset inventory data.	M	
		4.1.2	The DSS shall include a user interface to view and update asset health information.	M	
		4.1.3	The DSS shall include a user interface to view and update asset availability.	M	
		4.1.4	The DSS shall include a user interface to view and update asset state.	M	
		4.1.5	The DSS shall include a user interface to create, view, update, and delete incident/event information.	M	
		4.1.6	The DSS shall include a user interface to view response plan.	M	
		4.1.7	The DSS shall include a user interface allowing users to submit requests for specific actions to be included in a response plan.		S
		4.1.8	The DSS shall include a user interface allowing users to manually specify whether specific assets can be used for the generation of a response plan.		S
		4.1.9	The DSS shall include a user interface for directing the implementation of an approved response plan.	M	
		4.1.10	The DSS shall include a user interface for termination of an approved response plan.	M	
		4.1.11	The DSS shall include a user interface allowing standard and customized reporting capabilities.	M	
		4.1.11	The DSS shall include a user interface to interface with school dispatch system.	M	
4.2	Provide a system allowing data management				
		4.2.1	Provide a system to format and compile input data using standard protocols.	M	
		4.2.2	Provide a system capable of handling erroneous/missing data.	M	
		4.2.3	Provide hierarchy of log in and password for data archiving.	M	
		4.2.4	Provide a system capable of understanding and exchanging data among different modules.	M	
		4.2.5	Provide hardware for STREETS historical data archiving and storage.	M	
		4.2.6	Provide mechanism for STREETS historical data archiving and storage.	M	
		4.2.7	The system shall archive the STREETS operation information.	M	
		4.2.7.1	Time stamps and traffic data to trigger of STREETS response	M	
		4.2.7.2	Time stamps and results of STREETS simulation run	M	
		4.2.7.3	Time stamps and STREETS DSS response plan taken - reroute	M	
		4.2.7.4	Time stamps and STREETS DSS response plan taken - signal timing change	M	
		4.2.8	Provide reporting of historical data.	M	
4.3	Generate response plan (Rerouting and Signal Timing)				
		4.3.1	The DSS shall be capable of receiving performance measurements (i.e. traffic flow) from micro-simulation model.	M	
		4.3.2	The DSS shall be capable of receiving rerouting from micro-simulation model.	M	
		4.3.3	The DSS shall allow scheduling planned special events (i.e., game, concert).	M	
		4.3.4	The DSS shall allow scheduling planned maintenance events (i.e. lane closure).	M	
		4.3.5	The DSS shall contain a user defined rules to modify traffic patterns (i.e., change of corridor flow).		S
		4.3.6	The DSS shall maintain a library of pre-defined timing plans under a various of traffic pattern change.		S
		4.3.7	The DSS shall generate response plans based on defined rules per corridor.		S

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Final Decision Support System Requirements

Decision Support System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
4.4	Evaluate response plan (Rerouting and Signal Timing)				
		4.6.1	The DSS shall contain a defined rules to evaluate the response plan generated.	M	
		4.6.2	The DSS shall consider a “Do Nothing” scenario as a potential recommendation.	M	
		4.6.3	The DSS shall rank all developed response plans based on their ability to improve corridor operations within the identified zone of influence of the incident or event that triggered the response planning.	M	
		4.6.4	The DSS shall contain a defined rules that limit the deployment of developed response plan.	M	
		4.6.4.1	Truck Route	M	
		4.6.4.2	School Zone	M	
		4.6.4	The DSS shall determine the optimum response plan	M	
4.5	Implement response plan (Rerouting and Signal Timing)				
		4.7.1	The DSS shall determine the order and proper time at which control actions should be sent to individual controller.		S
		4.7.2	The DSS shall send response plan instructions to individual controller.		S
		4.7.3	The DSS shall verify that controller have the correct response plan.		S
		4.7.4	The DSS shall send detour instructions to individual CMS.		S
		4.7.5	The DSS shall verify that CMS have the correct detour information.		S
		4.7.6	The DSS shall send incidents and events to individual CMS.		S
		4.7.7	The DSS shall verify that CMS have the correct incidents and events.	M	
		4.7.8	The DSS shall send detour instructions to truck fleet dispatchers and/or truck operators.	M	
		4.7.9	The DSS shall verify that truck fleet dispatchers and/or truck operators have the correct detour information.	M	
		4.7.10	The DSS shall send incidents and events to truck fleet dispatchers and/or truck operators.	M	
		4.7.11	The DSS shall verify that truck fleet dispatchers and/or truck operators have the correct incidents and events.	M	
		4.7.12	The DSS shall send detour instructions to school bus dispatchers.	M	
		4.7.13	The DSS shall verify that school bus dispatchers have the correct detour information.	M	
		4.7.14	The DSS shall send incidents and events to school bus dispatchers.	M	
		4.7.15	The DSS shall verify that school bus dispatchers have the correct incidents and events.	M	
		4.7.16	The DSS shall send detour instructions to 511.		S
		4.7.17	The DSS shall verify that 511 have the correct detour information.		S
		4.7.18	The DSS shall send incidents and events to 511.		S
		4.7.19	The DSS shall verify that 511 have the correct incidents and events.		S
		4.7.20	The DSS shall send detour instructions to STREETS app.		S
		4.7.21	The DSS shall verify that STREETS app have the correct detour information.		S
		4.7.22	The DSS shall send incidents and events to STREETS app.		S
		4.7.23	The DSS shall verify that STREETS app have the correct incidents and events.		S

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Final Signal System Requirements

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
5.1	Evaluate and Upgrade local controllers				
		5.1.1	The STREETS shall evaluate existing local controllers to ensure they can be integrated with selected ASCT system.	M	
		5.1.2	The STREETS shall upgrade existing local controllers to ensure they can be integrated with selected ASCT system.	M	
		5.1.3	The controller shall have access control settings with privileges based on user credentials (i.e., passcode).	M	
		5.1.4	The controller shall have minimum phase requirements as follows:	M	
		5.1.4.1	Minimum of 16 volume/density vehicle phases.	M	
		5.1.4.2	Minimum of 8 pedestrian phases.	M	
		5.1.4.3	Minimum of 8 overlap phases.	M	
		5.1.4.4	Minimum of 16 phase sequence options.	M	
		5.1.4.5	Minimum of 4 NEMA concurrent phase timing rings.	M	
		5.1.5	Controller shall have minimum coordination requirements:	M	
		5.1.5.1	Minimum of 64 coordination plans	M	
		5.1.5.2	Automatic permissive during coordination	M	
		5.1.5.3	Fixed force offs	M	
		5.1.5.4	Floating force offs	M	
		5.1.5.5	Variable offset reference - beginning or end of sync phase green, beginning of FDW	M	
		5.1.5.6	Vehicular phase re-service (Conditional Service)	M	
		5.1.5.7	Pedestrian phase re-service	M	
		5.1.5.8	Adaptive split timing adjustment capable	M	
		5.1.5.9	Controller shall have a default "Free" timing plan	M	
		5.1.5.10	Controller shall have a "Flash" timing plan	M	
		5.1.5.11	Coordination plan shall provide "Coordinated phase split extension"	M	
		5.1.5.12	Coordinator shall provide a minimum of three options for transition	M	
		5.1.5.13	Rest-in-walk option for designated coordination phase(s)	M	
		5.1.5.14	Stop-in-walk option for coordination.	M	
		5.1.5.15	Variable phase sequences	M	
		5.1.6	Controller shall have minimum detection requirements:	M	
		5.1.6.1	Handles a minimum of 64 detectors	M	
		5.1.6.2	Phase assignments configurable for each detector	M	
		5.1.6.3	multiple phases can be assigned to each detector	M	
		5.1.6.4	detection assignable to vehicle overlaps	M	
		5.1.6.5	delay functionality assignable to each detector	M	
		5.1.6.6	carryover functionality assignable to each detector	M	
		5.1.6.7	detection diagnostics with automatic "fail" recall	M	
		5.1.6.8	Shall be capable of configuring detector input functionality types:	M	
		5.1.6.8.1	Standard Detector	M	
		5.1.6.8.2	Type III - Disconnect detector	M	
		5.1.6.8.3	Call Only Detector	M	
		5.1.6.8.4	Extension (pulse) Detector	M	

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Final Signal System Requirements

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.1.6.8.5	Bicycle detector	M	
		5.1.6.8.6	System Detector	M	
		5.1.7	Controller shall have minimum scheduler requirements:	M	
		5.1.7.1	Minimum 32 Schedules	M	
		5.1.7.2	Minimum 16 day plans	M	
		5.1.7.3	Minimum of 32 events to select coordination patterns, special functions, etc.	M	
		5.1.7.4	automatic daylight savings time adjustment	M	
		5.1.7.5	Minimum of 16 holiday or exception schedules which override the normal day program	M	
		5.1.8	Controller shall have the following minimum operational functionality:	M	
		5.1.8.1	Protected/permissive left-turn operation with trap prevention	M	
		5.1.8.2	Bicycle minimum green timing independent of vehicular phase timing	M	
		5.1.8.3	Minimum of two "Walk" timing interval parameters	M	
		5.1.8.4	Minimum of two Pedestrian Clearance timing intervals	M	
		5.1.8.5	Minimum of three Maximum Green timing intervals	M	
		5.1.8.6	Volume / Density timing capability	M	
		5.1.8.7	"Add per vehicle" Functionality for each phase	M	
		5.1.8.8	"Maximum Initial" interval for each phase	M	
		5.1.8.9	"Dynamic Max" functionality where Maximum timer extends automatically	M	
		5.1.8.10	Exclusive Phase functionality for all phases.	M	
		5.1.8.11	Dual Entry functionality	M	
		5.1.8.12	Overlap Pedestrian Phase Functionality	M	
		5.1.8.13	Leading pedestrian phase (pedestrian phase starts x seconds before corresponding vehicle phase)	M	
		5.1.8.14	Operate up to four flashing beacon units	M	
		5.1.8.15	Operate up to four advance warning flasher units	M	
		5.1.8.16	Overlap phase green shall be programmable to start at a user specified time interval prior to the parent phase green start.	M	
		5.1.8.17	Selectable overlap Phases	M	
		5.1.8.18	Flashing Yellow Arrow	M	
		5.1.9	Controller shall have minimum communications requirements:	M	
		5.1.9.1	Accommodates Ethernet communication	M	
		5.1.9.2	Accommodates Serial communication	M	
		5.1.9.3	Programmable for IP address, network mask, and gateway parameters	M	
		5.1.9.4	Serial Communication - Programmable for address, baud rate, parity, and stop bits	M	
		5.1.9.5	Data validation during remote data download	M	
		5.1.9.6	The controller local software shall provide the ability to monitor traffic controllers at adjacent signals in real time.	M	
		5.1.9.7	The controller local software shall provide for peer-to-peer communications between adjacent controllers.	M	
		5.1.10	Controller shall have transit priority requirements:	M	
		5.1.10.1	Minimum of 4 priority routines	M	
		5.1.10.2	Minimum of 6 priority strategies selectable by TOD schedule	M	

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Final Signal System Requirements

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.1.10.3	Priority call shall be configurable for a 6.25 Hz input or a solid input.	M	
		5.1.10.4	Queue jump functionality	M	
		5.1.10.5	Dynamic phase time adjustment based on transit vehicle arrival	M	
		5.1.10.6	Provides green extend / early green / green "hold" functionality during priority	M	
		5.1.10.7	Priority shall have a "re-service" time that prevents excessive utilization of priority calls.	M	
		5.1.10.8	Priority shall provide for a "check-in" functionality to initiate priority calls.	M	
		5.1.10.9	Priority shall provide for a "check-out" functionality to terminate priority calls.	M	
		5.1.11	The controller shall log all events and alarms to be stored locally in the controller memory. All logged events and alarms shall be time and date stamped. When queried by the ATMS, the log shall be viewable and be able to be uploaded for storage at the ATMS.	M	
		5.1.12	The controller shall be able to store on the local controller memory up to 6000 of the controller's most recent events. The controller, through the controller front panel interface, shall allow these events to be viewed and queried.	M	
		5.1.13	The controller shall be able to store on the local controller memory up to 6000 of the controller's most recent events. When queried by the ATMS, the log shall be viewable and be able to be uploaded for storage at the ATMS.	M	
		5.1.14	Events logged by the controller shall include cabinet door open, conflict flash, watchdog timer, controller power off, controller power on, and conflict monitor fault.	M	
		5.1.15	Events logged by the controller shall include preempt number/approach, preempt start, preempt end, and local controller status at preempt end.	M	
		5.1.16	Events logged by the controller shall include priority request, priority number/approach, priority granted, priority denied, priority start, priority end, and local controller status at priority end.	M	
		5.1.17	Events logged by the controller shall include coordination status, cycle length/split/offset in use, change in pattern, start of transition, end of transition, and control mode.	M	
		5.1.18	Events logged by the controller shall include database access request, passcode used during access request, and database change.	M	
		5.1.19	Events logged by the controller shall include detector channel failure, constant call, no activity, transit check-in fault, and transit check-out fault.	M	
		5.1.20	The controller shall allow user programmable thresholds to prompt an automatic alarm from the controller.	M	
		5.1.21	The controller shall have user programmable parameters to turn on, turn off, and schedule when detector count and occupancy data are collected for individual detectors.	M	
		5.1.22	The controller shall have the capability to store detector count and occupancy data for all individual detector inputs into the controller.	M	
		5.1.23	The controller shall have the capability to collect and store detector count and occupancy data based on user-defined time intervals for any detector input into the controller.	M	
		5.1.24	The user-defined time interval shall be selectable from 0.1 second through 24 hours for any detector input into the controller.	M	
		5.1.25	The controller shall be capable of storing at least 30 days of detector data (volume and occupancy) for at least 16 detector channels at a data collection rate of 15-minute intervals.	M	
		5.1.26	The controller shall log all detector data to be stored locally in the controller memory. All logged detector data shall be time and date stamped. When queried by the ATMS, the detector log shall be viewable and be able to be uploaded for storage at the ATMS.	M	
		5.1.27	The controller shall be able to pass local controller alarm notifications to the ATMS so that the ATMS can issue notifications of these alarms to users and operators.	M	
		5.1.28	The controller shall have programmable configuration, timing, and phase parameters to enable and operate flashing yellow arrow (FYA) operation in compliance with MUTCD requirements.	M	
		5.1.29	The controller shall have programmable configuration, timing, and phase parameters to enable and operate pedestrian hybrid beacon in compliance with MUTCD requirements.	M	

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.1.30	The controller shall have programmable configuration, timing, and phase parameters to enable and operate exclusive pedestrian phases where all intersection pedestrian phases are simultaneously activated and timed.	M	
		5.1.31	The controller shall be capable of operating with accessible pedestrian signals (APS) in compliance with MUTCD requirements.	M	
		5.1.32	The controller shall have programmable configuration, timing, and phase parameters for a minimum of:	M	
		5.1.32.1	two (2) rail preempts,	M	
		5.1.32.2	four (4) emergency vehicle preempts, and	M	
		5.1.32.3	four (4) transit priority sequences.	M	
		5.1.33	The controller shall have programmable parameters to allow a service priority to be assigned to each preempt and priority sequence.	M	
		5.1.34	Each preemption shall provide programmable green, yellow, and red clearance intervals.	M	
		5.1.35	Overlaps shall be controlled independent of the parent phase during preemption.	M	
		5.1.36	Controller shall allow limited service operation for defined phases during the preempt dwell phase.	M	
		5.1.37	Controller shall allow for remapping the Low Priority I/O to provide for signal priority.	M	
		5.1.38	Controller shall allow for remapping the inputs F15to provide for Flashing Yellow Arrow.	M	
		5.1.39	The controller shall have programmable preempt parameters that allows users to establish maximum preempt timer for each preempt routine.	M	
		5.1.40	The controller shall have programmable preempt parameters that allows users to establish a separate pedestrian clearance interval associated with each preempt routine. This parameter shall allow for the pedestrian clearance interval to vary from maintain full normal timing and be reduce to any lower level all the way to zero.	M	
		5.1.41	The controller shall have programmable preempt parameters that allows users to establish an exit routine from preempt.	M	
		5.1.42	The controller shall have the capability to track the active phase in the background cycle during an interruption to coordinated operation caused by a preempt request. The controller shall have programmable preempt parameters that allows users to establish an exit routine from preempt that includes returning to the phase(s) that would normally be active in the background cycle.	M	
		5.1.43	The controller shall have the capability to operate lane use control signals.	M	
		5.1.43.1	Changeable lane assignment signals operation shall be established based on time-of-day schedule consistent with the scheduling requirements in 3.04.	M	
		5.1.43.2	A manual control shall be provided to override automatic operation under the scheduler.	M	
5.2	Evaluate and Upgrade ATMS software				
		5.2.1	The STREETS shall evaluate existing central signal system that can be integrated with selected ASCT system	M	
		5.2.2	The STREETS shall upgrade or provide central signal system that can be integrated with selected ASCT system	M	
		5.2.3	The STREETS shall upgrade or provide central signal system capable of handling all traffic controllers	M	
		5.2.4	The ATMS shall allow all controller settings and parameters to be developed and stored in a central location and be able to download the plans to the local field controllers.	M	
		5.2.5	The ATMS shall support transit signal priority (TSP) while showing the status of the signal to reflect priority operation.	M	
		5.2.6	The ATMS shall be capable of summarizing Signal Phasing and Timing (SPaT) data requests from each controller.	M	
		5.2.7	The ATMS shall be capable of summarizing controller response to Signal Phasing and Timing (SPaT) data.	M	
		5.2.8	The ATMS shall support NTCIP 1211 for Transit Signal Priority.	M	
		5.2.9	The ATMS shall support NTCIP 1203 Object Definitions for DMS.	M	
		5.2.10	The ATMS shall support NTCIP 1205 Object Definitions for CCTV.	M	

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Final Signal System Requirements

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.2.11	The ATMS shall support NTCIP 1212 Object Definitions for Connected Vehicle Environment.	M	
		5.2.12	The ATMS shall allow operators with appropriate privileges to monitor the traffic signal system from remote devices.	M	
		5.2.13	The ATMS shall be modular.	M	
		5.2.13.1	Allow for the addition of DMS management.	M	
		5.2.13.2	Allow for the addition of CCTV management	M	
		5.2.13.3	Allow for the addition of new signalized intersections	M	
		5.2.14	The ATMS shall Provide Alarms and Alerts	M	
		5.2.14.1	To log and report when any timing plan changes have occurred on any controller	M	
		5.2.14.2	To display the status of the system and local detectors in real time.	M	
		5.2.14.3	Allow for the addition of new signalized intersections	M	
		5.2.15	The ATMS shall provide system control capability	M	
		5.2.15.1	The ATMS shall provide functions allowing the users with defined privileges to place a call to a user-defined group of signals.	M	
		5.2.15.2	The ATMS shall provide functions allowing the users with defined privileges to manually implement a timing plan to one or a group of signals.	M	
		5.2.15.3	The time-based clocks for each User's ATMS shall be synchronized with the entire system to coordinate adjacent intersections in different jurisdictions.	M	
		5.2.15.4	The ATMS shall support the output of the off-line preparation of timing plans (using off-line optimization models such as SYNCHRO).	M	
		5.2.15.5	The ATMS shall provide for download/upload capability, allowing the User to perform this function for individual and/or appropriate subsets of controller database parameters at selected schedules, or as desired.	M	
		5.2.15.6	The ATMS shall provide for saved connection paths and IP addressing, file back-up for unexpected system shutdowns, database archiving for corrupted files, and saved system set-up based on restart.	M	
		5.2.16	ATMS shall have a graphic user interface with intuitive functions (hovering, Agency GIS mapping, unique icons, etc.) monitoring of traffic signals and devices.	M	
		5.2.16.1	The ATMS user interface shall be graphics-based, intuitive, and user-friendly. All ATMS user accessible software shall use a graphical user interface (GUI).	M	
		5.2.16.2	The ATMS Users shall be able to pan maps, zoom maps to provide more detailed views, and zoom the map to the full extend possible of the image through the use of a mouse.	M	
		5.2.16.3	The ATMS GUI shall provide Users with drop-down menus for commands to the system and mouse clicking and dragging, text input, button actions, and menu command actions	M	
		5.2.16.4	The ATMS GUI shall provide context sensitive on-line help	M	
		5.2.16.5	The ATMS maps shall allow the display of arterial incidents from 3rd party information.	M	
		5.2.16.6	The ATMS shall display details of coordination at a controller	M	
		5.2.17	ATMS shall provide Upload/Download Features	M	
		5.2.17.1	The ATMS shall allow for the download on a system-wide, section, or intersection basis from the ATMS server to the local controller.	M	
		5.2.17.2	The ATMS shall allow for the upload on a system-wide, section, or intersection basis from the local controller to the ATMS server.	M	
		5.2.17.3	Upload/download commands shall be executed within 5 seconds upon command between the ATMS and the field controllers.	M	
		5.2.17.4	The ATMS controller database shall upload and download the following data (at a minimum):	M	
		5.2.17.4.1	Intersection timing parameters	M	

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Final Signal System Requirements

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.2.17.4.2	Detector data from at least 32 detectors per intersection controller	M	
		5.2.17.4.3	Controller and cabinet alarm data	M	
		5.2.17.4.4	Event data	M	
		5.2.17.4.5	Controller date and time	M	
		5.2.17.4.6	User Specific Notes linked to an intersection	M	
5.3	Provide Adaptive Signal Control Technology (ASCT)				
		5.3.1	Adaptive Strategies shall	M	
		5.3.1.1	Maximize the throughput on coordinated routes	M	
		5.3.1.2	Provide smooth flow along coordinated routes	M	
		5.3.1.3	Distribute phase times in an equitable fashion during special events	M	
		5.3.1.4	Manage the lengths of queues	M	
		5.3.1.5	Manage the locations of queues within the network	M	
		5.3.1.6	Employ a combination of these strategies based on travel-time and other real-time performance measures from multiple corridors	M	
		5.3.2	Network Characteristics	M	
		5.3.2.1	The ASCT shall control a minimum of 2 signals concurrently.	M	
		5.3.2.2	The ASCT shall be able to operate 100 signals adaptively.	M	
		5.3.2.3	The ASCT shall support groups of signals.	M	
		5.3.2.4	The ASCT shall control a minimum of 10 groups of signals.	M	
		5.3.2.5	Each group shall operate independently.	M	
		5.3.2.6	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.		S
		5.3.3	Network and Data Management Interfaces		
		5.3.3.1	The system operator shall prepare an interface control document to describe the following data flows:	M	
		5.3.3.1.1	information layer protocol	M	
		5.3.3.1.2	application layer protocol	M	
		5.3.3.1.3	lower layer protocol	M	
		5.3.3.1.4	data aggregation	M	
		5.3.3.1.5	frequency of storage	M	
		5.3.3.1.6	frequency of reporting	M	
		5.3.3.1.7	duration of storage	M	
		5.3.3.2	The ASCT shall support external interfaces to another system via standard XML data.	M	
		5.3.3.3	The ASCT shall support adaptive coordination on crossing routes.	M	
		5.3.3.4	The ASCT shall alter its operation to minimize interruption of traffic entering the system. (This may be achieved via detection, with no direct connection to the other system.)		S
		5.3.3.5	The ASCT shall conform its operation to an external system's operation (external system could be ATMS, DSS or simulation)	M	
		5.3.3.6	The ASCT shall alter its operation based on data received from another system.	M	
		5.3.4	Security	M	
		5.3.4.1	The system operator shall prepare an interface control document to describe the following data flows:	M	
		5.3.4.1.1	Local access to the ASCT.	M	
		5.3.4.1.2	Remote access to the ASCT.	M	
		5.3.4.1.3	System monitoring.	M	
		5.3.4.1.4	System manual override.	M	
		5.3.4.1.5	Development	M	

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Final Signal System Requirements

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.3.4.1.6	Operations	M	
		5.3.4.1.7	User login	M	
		5.3.4.1.8	User password	M	
		5.3.4.1.9	Administration of the system	M	
		5.3.4.1.10	Signal controller group access	M	
		5.3.4.1.11	Access to classes of equipment	M	
		5.3.4.1.12	Access to equipment by jurisdiction	M	
		5.3.4.1.13	Output activation	M	
		5.3.4.1.14	System parameters	M	
		5.3.4.1.15	Report generation	M	
		5.3.4.1.16	Configuration	M	
		5.3.4.1.17	Security alerts	M	
		5.3.4.1.18	Security logging	M	
		5.3.4.1.19	Security reporting	M	
		5.3.4.1.20	Database	M	
		5.3.4.1.21	Signal controller	M	
		5.3.4.2	The ASCT shall comply with the City of Dubuque's IT security policies	M	
		5.3.5	Queuing interactions	M	
		5.3.5.1	The ASCT shall maintain capacity flow through user-specified bottlenecks.	M	
		5.3.6	Pedestrians	M	
		5.3.6.1	When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.	M	
		5.3.6.2	The ASCT shall execute pedestrian recall on user-defined phases in accordance with a time of day schedule.	M	
		5.3.6.3	When specified by the user, the ASCT shall execute pedestrian recall on pedestrian phase adjacent to coordinated phases.	M	
		5.3.6.4	When the pedestrian phases are on recall, the ASCT shall accommodate pedestrian timing during adaptive operation.	M	
		5.3.6.5	The ASCT shall execute user-specified exclusive pedestrian phases during adaptive operation.	M	
		5.3.7	Non-adaptive situations	M	
		5.3.7.1	The ASCT shall operate non-adaptively during the presence of a defined condition.	M	
		5.3.7.2	The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule.	M	
		5.3.7.3	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals.	M	
		5.3.7.4	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptive operation.	M	
		5.3.8	System responsiveness		
		5.3.8.1	The ASCT shall limit the change in consecutive cycle lengths to be less than a user-specified value.		S
		5.3.8.2	The ASCT shall limit the change in phase times between consecutive cycles to be less than a user-specified value. (This does not apply to early gap-out or actuated phase skipping.)		S
		5.3.8.3	The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.		S
		5.3.8.4	The ASCT shall select cycle length from a list of user-defined cycle lengths.		S
		5.3.8.5	When a large change in traffic demand is detected, the ASCT shall respond more quickly than normal operation, subject to user-specified limits. (2 Cycles)		S
		5.3.9	Complex coordination and controller features		

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Final Signal System Requirements

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.3.9.1	When specified by the user, the ASCT shall serve a vehicle phase more than once for each time the coordinated phase is served.	M	
		5.3.9.2	The ASCT shall provide a minimum of 16 phase overlaps.	M	
		5.3.9.3	The ASCT shall omit a user-specified phase when the cycle length is below a user-specified value.	M	
		5.3.9.4	The ASCT shall omit a user-specified phase according to a time of day schedule.	M	
		5.3.9.5	The ASCT shall omit a user-specified phase based on measured traffic conditions.	M	
		5.3.9.6	The ASCT shall omit a user-specified phase based on the state of a user-specified external input.	M	
		5.3.9.7	The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.	M	
		5.3.9.8	The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.	M	
		5.3.9.9	The ASCT shall prevent skipping a user-specified phase based on the state of a user-specified external input.	M	
		5.3.9.10	The ASCT shall operate adaptively with the following detector logic: ability for left-turn lane detection on 3rd car back from stop bar (not lead veh).	M	
		5.3.9.11	The ASCT shall assign unused time from a preceding phase that terminates early to a user-specified phase as follows:	M	
		5.3.9.11.1	next phase	M	
		5.3.9.11.2	next coordinated phase	M	
		5.3.9.11.3	user-specified phase	M	
		5.3.9.12	The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows:	M	
		5.3.9.12.1	previous phase	M	
		5.3.9.12.2	next phase	M	
		5.3.9.12.3	next coordinated phase	M	
		5.3.9.12.4	user-specified phase	M	
		5.3.9.13	The ASCT shall not prevent the local signal controller from performing actuated phase control using a user-defined number of extension/passage timers as assigned to user-specified vehicle detector input channels in the local controller.	M	
		5.3.9.14	The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.	M	
		5.3.9.15	The ASCT shall operate adaptively using user-specified detector channels.	M	
		5.3.9.16	The ASCT shall have the option for a coordinated phase to be released early based on a user-definable point in the phase or cycle. (User select phase or cycle.)	M	
		5.3.9.17	The ASCT shall begin a non-coordinated phase later than its normal starting point within the cycle when all of the following conditions exist:	M	
		5.3.9.17.1	The user enables this feature,	M	
		5.3.9.17.2	Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent non-coordinated phases before the beginning of the coordinated phase.	M	
		5.3.9.17.3	The phase is called after its normal start time.	M	
		5.3.9.17.4	The associated pedestrian phase is not called.	M	
		5.3.9.18	The ASCT shall not prevent protected/permissive left turn phase operation.	M	
		5.3.9.19	The ASCT shall not prevent the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions.	M	
		5.3.9.20	The ASCT shall not prevent the controller from displaying flashing yellow arrow left turn or right turn.	M	
		5.3.9.21	When adaptive operation is used in conjunction with normal coordination, the ASCT shall not prevent a controller serving a cycle length different from the cycles used at adjacent intersections.		S

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Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.3.9.22	The ASCT shall not inhibit negative vehicle and pedestrian phase timing.	M	
		5.3.10	Monitoring and control	M	
		5.3.10.1	The ASCT shall provide monitoring and control access at the following locations:	M	
		5.3.10.1.1	Agency LAN or WAN	M	
		5.3.10.1.2	Local controller cabinets	M	
		5.3.10.1.3	Remote locations via internet	M	
		5.3.10.2	The ASCT shall not prevent the monitoring of an ASCT controlled intersection with the ATMS software	M	
		5.3.11	Performance reporting	M	
		5.3.11.1	The ASCT shall store results of all signal timing parameter calculations for a minimum of 365 days.	M	
		5.3.11.2	The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of 365 days:	M	
		5.3.11.2.1	volume	M	
		5.3.11.2.2	occupancy	M	
		5.3.11.2.3	queue length	M	
		5.3.11.2.4	phase utilization	M	
		5.3.11.2.5	arrivals in green	M	
		5.3.11.2.6	green band efficiency	M	
		5.3.11.3	The ASCT shall store the following data in 1 minute increments:	M	
		5.3.11.3.1	volume	M	
		5.3.11.3.2	occupancy	M	
		5.3.11.3.3	queue length	M	
		5.3.11.4	The ASCT shall report measures of current traffic conditions on which it bases signal state alterations.	M	
		5.3.11.5	The ASCT shall report all intermediate calculated values that are affected by calibration parameters.	M	
		5.3.11.6	The ASCT shall maintain a log of all signal state alterations directed by the ASCT.	M	
		5.3.11.7	The ATMS system operator shall export operational data and signal timing parameters to the ATMS.	M	
		5.3.11.8	The ASCT shall log the following events:	M	
		5.3.11.8.1	Time-stamped vehicle phase calls	M	
		5.3.11.8.2	Time-stamped pedestrian phase calls	M	
		5.3.11.8.3	Time-stamped emergency vehicle preemption calls	M	
		5.3.11.8.4	Time-stamped transit priority calls	M	
		5.3.11.8.5	Time-stamped railroad preemption calls	M	
		5.3.11.8.6	Time-stamped start and end of each phase	M	
		5.3.11.8.7	Time-stamped controller interval changes	M	
		5.3.11.8.8	Time-stamped start and end of each transition to a new timing plan	M	
		5.3.11.8.9	Time-stamped actuations	M	
		5.3.11.9	The ASCT shall calculate and report relative data quality	M	
		5.3.11.10	The ASCT shall report stored data in a form suitable to provide explanations of system behavior to public and politicians and to troubleshoot the system.	M	
		5.3.11.11	The ASCT log shall include all events directed by the external inputs.	M	
		5.3.11.12	The ASCT log shall include all external output state changes.	M	
		5.3.11.13	The ASCT log shall include all actual parameter values that are subject to user-specified values.	M	
		5.3.11.14	The ASCT shall maintain the records in this ASCT log for a user-specified period.	M	

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Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.3.11.15	The ASCT shall archive the ASCT log in a user-friendly file format/database. (.xls etc.)	M	
		5.3.12	Failure notification	M	
		5.3.12.1	In the event of a detector failure, the ASCT shall issue an alarm to user-specified recipients	M	
		5.3.12.2	In the event of communications failure, the ASCT shall issue an alarm to user-specified recipients	M	
		5.3.12.3	In the event of adaptive processor failure, the ASCT shall issue an alarm to user-specified recipients	M	
		5.3.12.4	The ASCT shall issue an alarm within 5 minutes of a detection failure.	M	
		5.3.12.5	In the event of a failure, the ASCT shall log details of the failure in a permanent log.	M	
		5.3.12.6	The permanent failure log shall be searchable, achievable and exportable.	M	
		5.3.12.7	In the event of a communications failure, the ASCT shall log details of the failure in a permanent log.	M	
		5.3.12.8	The permanent failure log shall be searchable, achievable and exportable.	M	
		5.3.13	Preemption and priority	M	
		5.3.13.1	The ASCT shall resume adaptive control of signal controllers when preemptions are released.	M	
		5.3.13.2	The ASCT shall execute user-specified actions at non-preempted signal controllers during preemption. (E.g., inhibit a phase, activate a sign, display a message on a DMS)	M	
		5.3.13.3	The ASCT shall operate normally at non-preempted signal controllers when special functions are engaged by a preemption event. (Examples of such special functions are a phase omit, a phase maximum recall or a fire route.)	M	
		5.3.13.4	The ASCT shall release user-specified signal controllers to local control when one signal in a group is preempted.	M	
		5.3.13.5	The ASCT shall not prevent the local signal controller from operating in normally detected limited-service actuated mode during preemption.	M	
		5.3.13.6	The ASCT shall maintain adaptive operation at non-preempted intersections during emergency vehicle preemption.	M	
		5.3.13.7	The ASCT shall continue adaptive operations of a group when one of its signal controllers has a transit priority call.	M	
		5.3.13.8	The ASCT shall advance the start of a user-specified green phase in response to a transit priority call.	M	
		5.3.13.9	The advance of start of green phase shall be user-defined.	M	
		5.3.13.10	Adaptive operations shall continue during the advance of the start of green phase.	M	
		5.3.13.11	The ASCT shall delay the end of a green phase, in response to a priority call.	M	
		5.3.13.12	The delay of end of green phase shall be user-defined.	M	
		5.3.13.13	Adaptive operations shall continue during the delay of the end of green phase.	M	
		5.3.13.14	The ASCT shall permit at least 2 exclusive transit phases.	M	
		5.3.13.15	Adaptive operations shall continue when there is an exclusive transit phase call.	M	
		5.3.13.16	The ASCT shall accept a transit priority call from:	M	
		5.3.13.16.1	a signal controller/transit vehicle detector	M	
		5.3.13.16.2	an external system	M	
		5.3.14	Failure and fallback	M	
		5.3.14.1	The ASCT shall switch to the alternate source in real time without operator intervention.	M	
		5.3.14.2	The ASCT shall take user-specified action in the absence of valid detector data from a user-defined number of vehicle detectors within a group.	M	
		5.3.14.3	The ASCT shall release control to ATMS control.	M	
		5.3.14.4	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	M	
		5.3.14.5	The ASCT shall execute user-specified actions when communications to one or more signal controllers fails within a group.	M	

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Final Signal System Requirements

Signal System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
		5.3.14.6	In the event of loss of communication to a user-specified signal controller, the ASCT shall release control of all signal controllers within a user-specified group to local control.	M	
		5.3.14.7	The ASCT shall switch to the alternate operation in real time without operator intervention	M	
		5.3.14.8	The ASCT shall execute user-specified actions when adaptive control fails.	M	
		5.3.14.9	The ASCT shall release control to local operations to operate the local controller under its own time-of-day schedule.	M	
		5.3.14.10	The ASCT shall operate non-adaptively when adaptive control equipment fails.	M	
		5.3.14.11	The ASCT shall operate non-adaptively when a user-specified detector fails.	M	
		5.3.14.12	The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.	M	
		5.3.14.13	The ASCT shall operate non-adaptively when the number of failed detectors in a group exceeds a user-defined value.	M	
		5.3.14.14	The ASCT shall operate non-adaptively when a user-defined communications link fails.	M	
		5.3.14.15	During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.	M	
		5.3.15	Constraints	M	
		5.3.15.1	The ASCT shall fully satisfy all requirements when integrated with detectors of type: Proprietary, Radar and Other Detection (any combination of non-proprietary).	M	
		5.3.15.2	The ASCT shall utilize existing stopbar and advance detection.	M	
		5.3.15.3	The ASCT shall not modify or disable existing detection functionality.	M	
		5.3.15.4	The ASCT shall fully satisfy all requirements when implemented with either fiber optics, twisted- pair copper or wireless communication infrastructure.	M	
		5.3.15.5	The ASCT software shall allow remote operation to turn off adaptive operation and revert to controller settings.	M	
		5.3.16	Training and support	M	
		5.3.16.1	The vendor shall provide training on the operations of the adaptive system.	M	
		5.3.16.2	The vendor shall provide training on troubleshooting the system.	M	
		5.3.16.3	The vendor shall provide training on preventive maintenance and repair of equipment.	M	
		5.3.16.4	The vendor shall provide training on system configuration.	M	
		5.3.16.5	The vendor shall provide training on administration of the system.	M	
		5.3.16.6	The vendor shall provide training on system calibration.	M	
		5.3.16.7	The vendor's training delivery shall include: printed course materials and references, electronic copies of presentations and references.	M	
		5.3.16.8	The vendor's training shall be delivered on-site at City designated facilities.	M	
		5.3.16.9	The vendor shall provide a minimum of 5 days training to a minimum of 15 staff.	M	
		5.3.16.10	The vendor shall provide a minimum of 5, 1-day training sessions.	M	
		5.3.17	External interfaces	M	
		5.3.17.1	The ASCT shall set the state of external input/output states according to a time-of-day schedule.	M	
		5.3.17.2	The ASCT output states shall be settable according to a time-of-day schedule.	M	
		5.3.17.3	The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.	M	
		5.3.17.4	The ASCT shall set a specific state for each special function output based on the current cycle length.	M	
		5.3.17.5	The ASCT shall set a specific state for each special function output based on a time-of-day schedule.	M	
		5.3.18	Maintenance	M	
		5.3.18.1	City of Dubuque shall maintain all necessary parts to maintain the ASCT system.	M	

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Final Communication System Requirements

Communication System Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
6.1	Increase speed, bandwidth, and reliability of center to field communications				
		6.1.1	The project shall provide a 99% level and quality of service on the backbone network.	M	
		6.1.2	The project shall accommodate communication over media including at least the following: Twisted Pair, Wi-Fi, Radio, Cellular, & Fiber Optic	M	
		6.1.3	The project shall deploy a communications system that will allow the transfer of local traffic controller data, traffic cabinet monitoring data and other specific devices from each intersection to a communications Hub cabinet.	M	
		6.1.4	The project shall provide an adequate and scalable communication system that:	M	
		6.1.4.1	Network routers and communication system architecture shall support at a minimum 1 Gigabit Layer III routing topology	M	
		6.1.4.2	Fiber and physical network shall support up to 50 Gigabit capability with future expansion		S
		6.1.5	The project shall accommodate communication to existing signals via at least the following: Twisted Pair, Wi-Fi, Radio, Cellular, & Fiber Optic	M	
		6.1.6	Provide Engineering and maintenance staff wired and wireless communications to the internet to allow VPN and remote management of the ATMS and local controllers.	M	
		6.1.7	The project shall design and deploy an IT network that is scalable and interoperable	M	
		6.1.7.1	Communication network architecture shall be based on established Gigabit Ethernet standards supporting:	M	
		6.1.7.2	All communication network equipment shall be interoperable between vendors	M	
		6.1.7.3	The physical and logical components of the Layer III backbone network shall be constructed to create a mesh / redundant ring topology	M	
		6.1.8	The project shall deploy a Communications system of allowing wireless devices technology.	M	
6.2	Provide communication among each STREETS module				
		6.2.1	Integrate traffic data collection with traffic modeling software	M	
		6.2.2	Integrate traffic modeling software with Performance Measurement System	M	
		6.2.3	The Streets shall establish communication between modeling software and DSS system	M	
		6.2.4	The Streets shall establish communication between DSS and ATMS system	M	
		6.2.5	The Streets shall establish communication between DSS and ATIS system	M	
		6.2.6	The Streets shall establish communication between Performance Measurement System and DSS	M	
		6.2.7	The Streets shall establish communication between ATIS and modeling software system	M	
		6.2.8	The Streets shall establish communication between ASCT and modeling software system	M	
		6.2.9	The Streets shall establish communication between DSS and ASCT system	M	
6.3	Develop and implement network security protocols				
		6.3.1	The project shall design and deploy a network IP management plan to accommodate unique IP addresses for each device.	M	
		6.3.2	The project shall design and deploy a network IP management plan to accommodate the necessary bandwidth for cumulative load of each device at each hub and server location.	M	
6.4	Evaluate future connected vehicle communications system				
		6.4.1	The project shall meet with City representatives to identify future integration and provide scalability of the IT network.	M	

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Final ATIS Requirements

ATIS Requirements				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
7.1	Enhance and develop traveler information delivery media (i.e., DMS, 511, Smart Phone App)				
		7.1.1	The ATIS shall include DMS system for information dissemination.	M	
		7.1.1.1	The ATIS shall provide at least two DMS on each corridor.	M	
		7.1.1.2	The ATIS shall provide at least one DMS per direction of each corridor.	M	
		7.1.1.3	The DMS shall be capable of receiving command from DSS for information dissemination.	M	
		7.1.1.4	The DMS shall be controlled by a central software that can manually controlled by operator.	M	
		7.1.2	The ATIS shall include 511 system for information dissemination.	M	
		7.1.2.1	The ATIS shall provide 511 system for congestion information dissemination.	M	
		7.1.2.2	The 511 system shall be capable of receiving command from DSS for information dissemination.	M	
		7.1.3	The ATIS shall include a mobile APP for information dissemination	M	
		7.1.3.1	The ATIS shall provide A mobile APP for congestion information dissemination.	M	
		7.1.3.2	The APP shall be capable of receiving command from DSS for information dissemination.	M	
		7.1.3.3	The APP shall be capable of disseminating travel information to hand-held (smart phone, tablet etc.) devices.		
		7.1.4	The STREET shall allow congestion information dissemination via the third party providers (Waze, Google, etc.).	M	
		7.1.5	The STREET shall allow congestion information dissemination via in-car Information dissemination system.		S
7.2	Develop procedures to automate information retrieving and Alarm/Notification distribution				
		7.2.1	The STREETS shall automatically send congestion-related information to DMS system.	M	
		7.2.2	The DMS system shall be able to understand and display congestion-related information without operator intervention.	M	
		7.2.1	The STREETS shall automatively send congestion-related information to 511 system.	M	
		7.2.2	The 511 system shall be able to understand and disseminate congestion-related information without operator intervention.	M	
		7.2.1	The STREETS shall automatively send congestion-related information to the mobile APP.	M	
		7.2.2	The APP shall be able to understand and disseminate congestion-related information in a proper format.	M	
7.3	Disseminate accurate and real-time congestion-related information to travelers				
		7.3.1	The STEETS shall inform ATIS for information dissemination in real time.	M	
		7.3.2	The STEETS shall inform ATIS for congestion alarm/notification.	M	
		7.3.2.1	The STREETS shall provide congestion alarm/notification to ATIS based on the information from City's Video Analytic system.		
		7.3.3	The STEETS shall inform ATIS for detour/alternative route information.	M	
		7.3.3	The STEETS shall disseminate travel time and delay information via ATIS.		S
		7.3.4	The STEETS shall inform ATIS for congestion-related information per congestion type.	M	
		7.3.4.1	The STEETS shall inform ATIS for recurring congestion.	M	
		7.3.4.2	The STEETS shall inform ATIS for unplanned events (i.e., roadway incidents).	M	
		7.3.4.3	The STEETS shall inform ATIS for planned events (i.e., game, construction).	M	
		7.3.4.4	The STEETS shall inform ATIS for maintenance.	M	

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Final Maintenance and Operations Requirements

Maintenance & Operations				Requirement Priority	
ConOps Ref #	ConOps Statement	Reqs Ref #	Requirement Statement	Mandatory	Secondary
8.1	Automate STREETS system operation to reduce staff needs				
		8.1.1	The STREETS operation shall be triggered automatically by DSS based on performance measurement module.	M	
		8.1.2	The STREETS shall allow automatically data feed from microsimulation model to DSS system.	M	
		8.1.3	The STREETS shall allow automatically response plan feeding from DSS system to ASCT system.	M	
		8.1.4	The STREETS shall allow automatically congestion information feeding from DSS system to ASCT system.	M	
		8.1.5	The STREETS shall allow automatically congestion information feeding from DSS system to ATIS system.	M	
		8.1.6	The STREETS Shall recognize incident clearance and return to normal operation without operator intervention.	M	
8.2	Allow system management				
		8.2.1	The STREETS shall allow access and maintain a security operation environment.	M	
		8.2.1.1	The STREETS shall grant access for system functionalities to authorized users only.	M	
		8.2.1.2	The STREETS shall allow multiple users to simultaneously access system functionalities from various locations.	M	
		8.2.1.3	The STREETS shall provide a secure means of information transmission.	M	
		8.2.1.4	The STREETS shall provide a secure means for storing information.	M	
		8.2.1.5	The STREETS shall track system access and usage.	M	
		8.2.2	The STREETS shall monitor the health status of its core components.	M	
		8.2.2.1	The STREETS shall include a function to perform self-checks without operator assistance.	M	
		8.2.2.2	The STREETS shall report any identified operational issue with its core components.	M	
		8.2.3	The STREETS shall maintain a measurable level of availability.	M	
		8.2.3.1	The STREETS shall be available 24 hours a day, 7 days a week.	M	
		8.2.3.2	The STREETS shall be available 85% of the time during normal operation, not including routine maintenance and outages due to factors beyond the control of system users.	M	
		8.2.4	The STREETS shall be well maintained.	M	
		8.2.4.1	The STREETS shall maintain a backup of its core operating parameters.	M	
		8.2.4.2	The STREETS shall have a defined maintenance schedule	M	
		8.2.4.3	The STREETS shall revert to TOD plans during system maintenance and upgrades.		
		8.2.4.4	All STREETS assets providing automated data feeds to Decision Support shall be maintained in accordance with the manufacturers' specifications for the assets.	M	
		8.2.4.5	The STREETS shall develop and maintain a list of critical elements that should receive maintenance priority should they fail.		S
		8.2.4.6	The STREETS shall log all received alerts and notifications regarding systems operations.		S
8.3	Develop MOU for STREETS maintenance between the City and ECIA				
		8.3.1	All traffic monitoring devices connected to the STREETS Environment shall be maintained in good operational condition.	M	
		8.3.2	Maintenance of STREETS elements shall be the responsibility of the agency owning/operating each element.	M	
		8.3.3	The STREET shall establish MOU between ECIA and the City of Dubuque for assets maintenance.	M	
8.4	Provide adequate staff training for the City, ECIA, and other stakeholders				
		8.4.1	The STREETS shall have documentation of its operations and maintenance.	M	
		8.4.2	The STREETS shall provide a means for system users to access relevant system documentation when logged into the system.	M	
		8.4.3	The STREETS Manager shall develop a training program for the STREETS Environment and Core System.		S