U.S. Department of Transportation

Federal Highway Administration

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SYSTEMS ENGINEERING FOR: REGIONAL ADAPTIVE SIGNAL CONTROL TECHNOLOGY (ASCT)

- Systems Engineering Management Plan

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1.0 INTRODUCTION

The Metropolitan Area Planning Agency (MAPA) has commissioned the development of system engineering documents for the deployment of adaptive signal control technology (ASCT) systems throughout the region. This Systems Engineering Management Plan (SEMP) represents a portion of the systems engineering deliverables and provides a high-level plan for MAPA and other stakeholder's management of the systems engineering process in compliance with the Federal Highway Administration (FHWA) Federal Rule 23 CFR 940.11 and Systems Engineering Guidelines.

The MAPA System Engineering for Regional ASCT project will work through the identification of stakeholder needs assessment, project requirements and verification procedures. The project will blend the project deliverables identified by the FHWA Local office which include the Project Plan, SEMP (this document), Concept of Operations, Requirements and Verification Plan, with the FHWA ASCT Model Documents (FHWA Model Systems Engineering Document for ASCT, Draft – Guidance Document, FHWA-HOP-11-027, August 2011). The Model Systems Engineering Documents for Adaptive Signal Control Technology systems offer guidance and associated templates that will be used to support the creation of regional and corridor specific planning and design documents. A primary goal for using this FHWA model document is to streamline the documentation and evaluation of stakeholder needs and to prepare requirements that can successfully procure and implement an ASCT corridor within the region. Subsequent to the project scoping and initiation, FHWA provided updated Guidance Documents in September, 2012. While the newer documents provide a significant information update three months after project startup, a majority of these templates are being utilized to help streamline agency review.

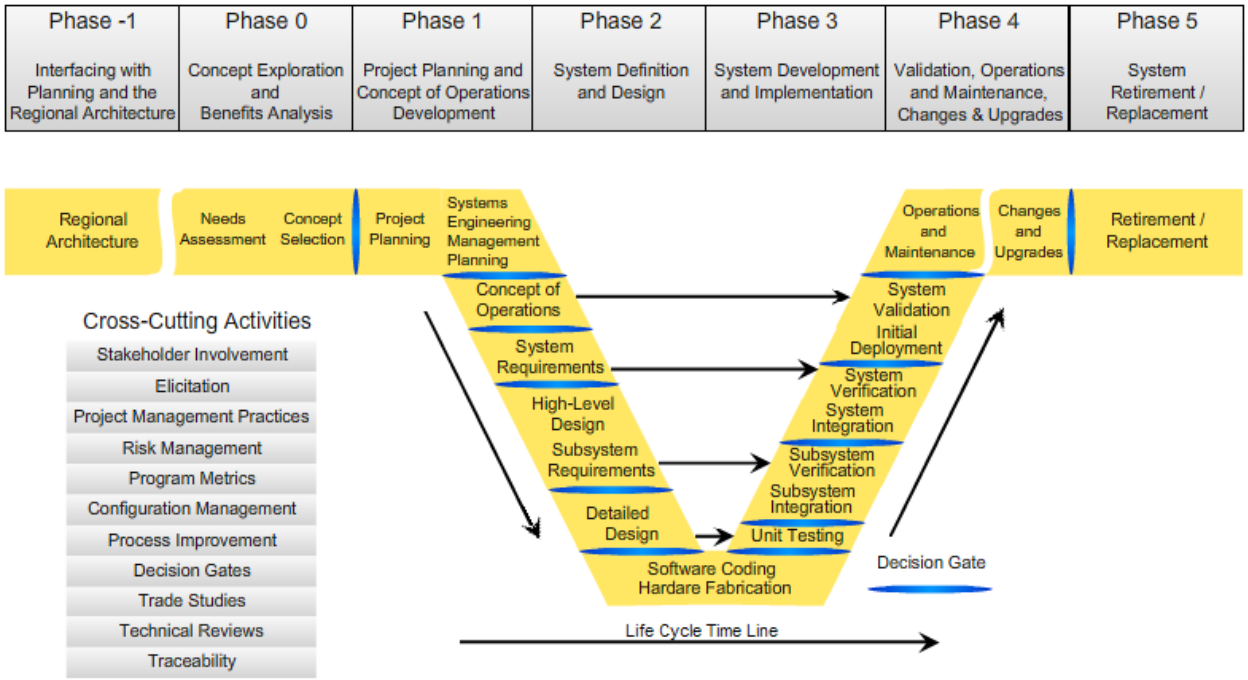
This systems engineering documentation that will be conducted as part of this project and potential future deployment projects relate directly to Congestion Management and Safety/Incident Management components identified in the MAPA ITS Architecture for key, congested corridors in the MAPA region.

Some specific objectives, not listed in any particular order, include:

- Decreased number of crashes (primary and secondary)
- Improved level of service
- Reduced congestion
- Reduced queuing
- Reduced emissions
- Better responsiveness to fluctuating traffic demands
- Improved travel time reliability
- Public acceptance and support
- Ability to deploy with existing or planned staffing levels

The SEMP describes how the project will follow the Systems Engineering Process illustrated in **Figure 1** on the following page. The SEMP will guide the project from conception to operations and maintenance in a systematic way. The SEMP is an evolving document that will be updated as the project progresses.

FIGURE 1: SYSTEMS ENGINEERING PROCESS "V" DIAGRAM



2.0 PROJECT OVERVIEW

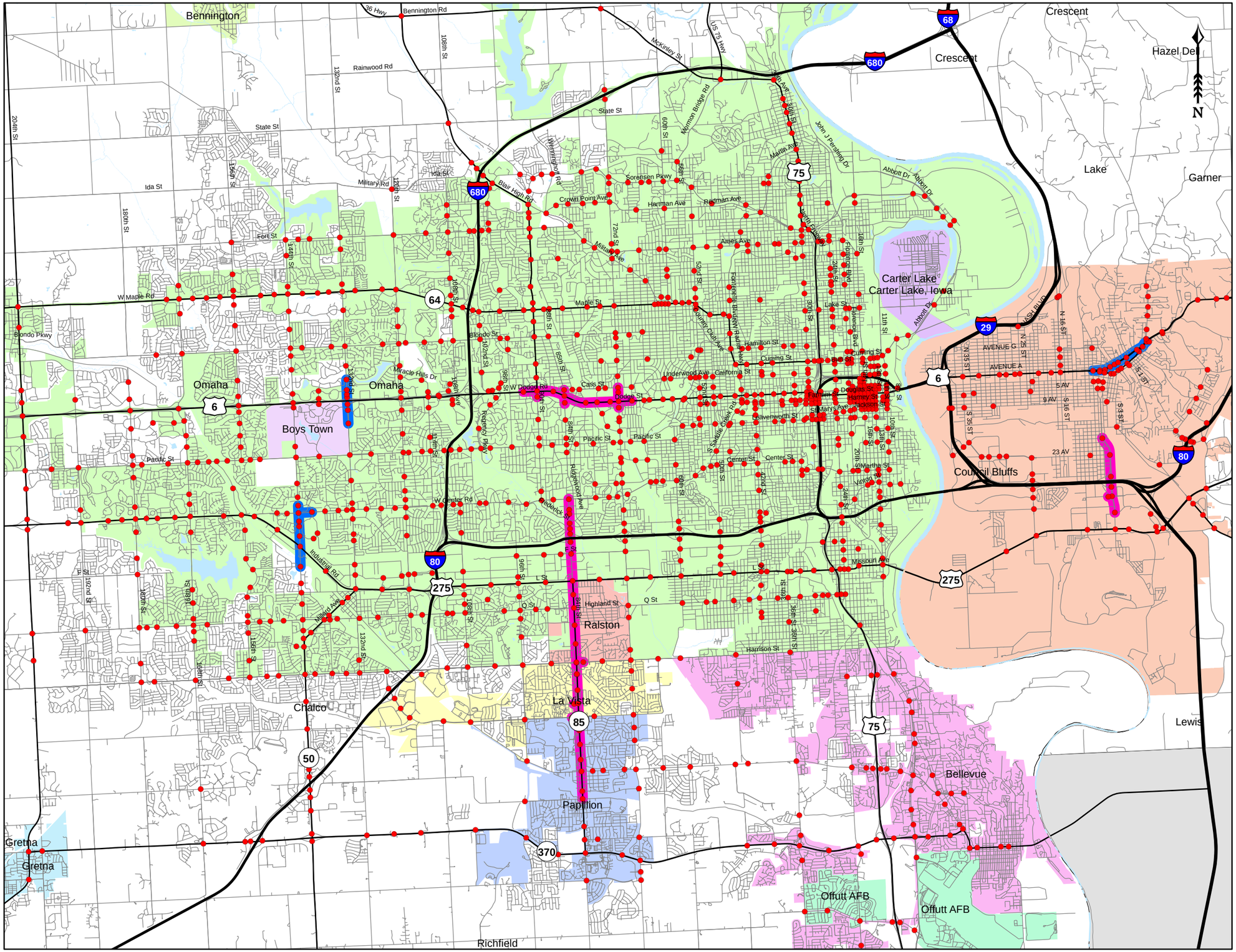
ASCT system projects have been constructed throughout North America to manage congested corridors and locations with varying peak directions and side streets. Some of these projects are now 30 years old. Many initial deployments struggled with the ability to collect the necessary real-time information on the approaches, communicate consistently to the controller and the adjacent intersections in real-time to achieve the performance that the traffic engineering community and traveling public expected. The amount of maintenance and calibration was more than anticipated. Additional struggles were due to lack of systems engineering, lack of critical stakeholder involvement, and systems not being configured to address the problems that needed to be solved. Ultimately many were turned off. The performance of systems engineering, as well as the improvement in communications infrastructure, ATMS control software, controller firmware, and sensor accuracy has allowed for ASCT projects to be successful for many agencies. This has led to a wide variety of ASCT systems all claiming to satisfy every agency need.

The City of Omaha Traffic Engineering Division requested Safety Funds from the Nebraska Department of Road Safety Committee to complete traffic signal improvements and implement an ASCT solution along West Dodge Road from 69th Street to 93rd Street. The City has tried different traffic management options along this congested corridor which has varied land uses including commercial, educational, and retail activity. Prior to moving forward with plans and construction, FHWA, MAPA, NDOR, and Iowa DOT recognized that the variety of ASCT systems would require a detailed evaluation and documentation of the needs of the region. Additionally, they recognized the new ASCT Model Documents provided a significant new resource to support the planning and design of the system on both a regional and corridor specific level.

MAPA prepared a scope of work that organizes the stakeholders in the region (Nebraska and Iowa agencies) to prepare an ASCT strategy and System Engineering documents for the region. In addition to providing sound information to regional stakeholders, the scope includes the evaluation of three specific corridors including:

- Dodge Street / West Dodge Road from 69th Street to 93rd Street in Omaha, Nebraska
- 84th Street from West Center Road to Lincoln Street in Omaha, Ralston, La Vista, and Papillion, Nebraska
- South Expressway from 19th Avenue to 35th Avenue in Council Bluffs, Iowa

In addition to these primary corridors, **Figure 2** illustrates the MAPA region and other preliminary locations that the MAPA stakeholders are considering for ASCT systems.



Legend

- Traffic Signals
- Primary Corridors
- Secondary Corridors

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Figure 2

Proposed Corridors for Adaptive Signal Control Technology (ASCT)

2.1 Project Purpose

The goal of the project is to evaluate the potential deployment of adaptive signal control technology in the MAPA region. This includes the development of Systems Engineering documentation that will support and facilitate deployment of ASCT, if it is deemed an appropriate traffic control solution for the region. Overarching objectives include developing traffic management solutions that provide value, improve safety, improve operations and have broad support from regional agencies and stakeholders. Traffic signal system improvements must be compatible with the needs of multiple jurisdictions that are responsible for traffic management in the greater Omaha metropolitan area, and must be scalable and expandable to meet future system needs.

2.2 Project Scope and Schedule

Table 1 summarizes the project scope and key schedule dates. For each task, the table briefly describes the effort, team members involved, and expected deliverables. Dates of draft deliverables are approximate and subject to change based on meetings and stakeholder review.

Table 1: Preliminary Project Tasks and Schedule

Tasks and Deliverables	Key Team Members	Start Date	Completion Date
1. Project Management and Stakeholder Coordination	- Iteris (Lead) - HDR - MAPA	July, 2012	Dec., 2012
2. Data Collection and Review of Existing Information	- Iteris (Lead) - HDR - MAPA	July, 2012	Aug., 2012
3. Project Plan Verification	- MAPA (Lead) - Iteris - HDR	July, 2012	Aug., 2012
4. Systems Engineering Management Plan	- Iteris (Lead) - HDR - MAPA	Aug., 2012	Oct., 2012
5. Concept of Operations	- HDR (Lead) - Iteris - MAPA	Sept., 2012	June, 2013
6. Requirements and Verification Plan	- Iteris (Lead) - HDR - MAPA	Oct., 2012	July, 2013
7. Design Phase(s)*	- City of Omaha (Lead)	Aug., 2013	Oct., 2013
8. Construction Phase(s)*	- City of Omaha (Lead)	Oct., 2013	Dec., 2013

**Assumes final design and construction/deployment commences immediately following approval of the Systems Engineering for ASCT project.*

2.3 STAKEHOLDERS

Project Stakeholders for the deployment of Regional ASCT systems include:

- MAPA
- FHWA
- City of Omaha, NE
- City of Council Bluffs, IA
- NDOR
- Iowa DOT
- Metro Transit
- Other Local Agencies
- Traveling Public

2.4 RELEVANT PROJECT DOCUMENTATION

The concept of adding ASCT solutions to select corridors has been discussed between stakeholders and planned by agencies for a number of years.

The following Statewide and Regional planning-level documents are relevant to this project because they identify the need for the ASCT solutions.

1. *NDOR Statewide ITS Architecture* – Traffic signal control is covered for all Districts within NDOR and specifically District 2 in the MAPA region.
2. *MAPA Regional ITS Architecture* – The Metropolitan Area Planning Agency (MAPA) Regional ITS Architecture was completed in 2005. MAPA has recently contracted to update the ITS Regional Architecture and it will include ASCT systems. .
3. *Omaha Traffic Signal System Master Plan* – Omaha completed this comprehensive master plan including SE documents in 2012. The system engineering documents identify the need and high-level requirements to include ASCT projects on select corridors during the traffic signal system upgrades and ATMS software deployment and integration.
4. *FHWA Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems* - This document is a resource for the stakeholders and consultant team to follow during the development of the ASCT System Engineering documents.
5. *Nebraska 2012-2016 Strategic Highway Safety Plan* - This plan outlines strategies for reducing the number of fatalities in Nebraska, including those at signalized intersections.

3.0 PROJECT AND SYSTEMS ENGINEERING DOCUMENTATION

Table 2 on the following page lists the documents and processes that contain important descriptions of stakeholders, systems, and operational practice that support the systems engineering for proposed regional ASCT systems. The table describes the documents and deliverables, and their relevance to the systems engineering process.

TABLE 2: MAPA REGIONAL ASCT SYSTEMS DOCUMENTATION

Systems Engineering Docs / Processes	Status	Description	Deliverables
1. Project Plan	Complete	This document will provide project managers and stakeholders an overview of the project, magnitude of the project, proposed process, schedule, and expected budget for the project.	Draft & Final Project Plan
2. System Engineering Management Plan	Complete	This document utilizes the project plan, goals & objectives, and agency capabilities to assess project management activities and define needed SE processes and resources.	Draft & Final SEMP
3. Concept of Operations	Complete	This document is written from the system operator perspective and defines the needs and objectives of stakeholders to determine desirable functions of the proposed ASCT system.	Draft & Final Concept of Operations
4. Requirements	Draft Complete	This document describes what needs to be achieved by the system. Each requirement is traced to a need described in the ConOps, and it provides a basis for verifying the systems when delivered.	Draft & Final High Level Requirements
5. Verification Plan	Draft Complete	This document describes how the system will be tested, ensuring that the desired requirements are satisfied. It will lay out a template plan for the vendor & agency to conduct the verification effort.	Draft Verification Plan & template information for use in the verification effort.
6. Validation Plan	Not started To be completed under next phases	This document describes how the performance of the system will be measured to determine if the needs in the ConOps have been satisfied. Can include initial validation plan, user's manuals, and report on validation results	Validation Plan

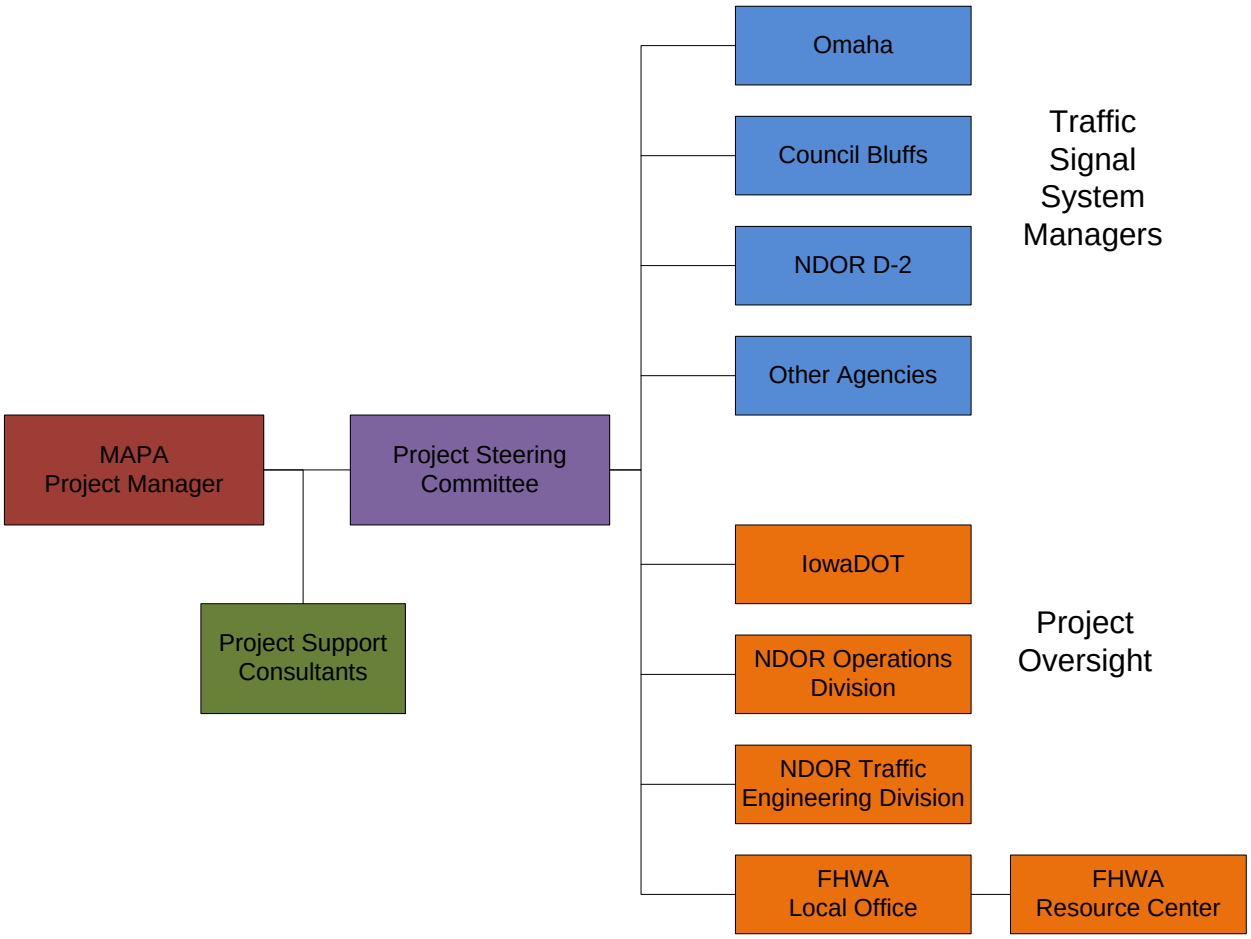
Systems Engineering Docs / Processes	Status	Description	Deliverables
7. Detailed Design, Requirements, and Procurement documents	Not started To be completed under next phases	Final plans and specifications will be prepared as needed. Detailed requirements traceability spreadsheet based on the system requirements and the detailed design. Procurement plan process finalized.	Final Plans & Specifications, Detailed Project Requirements, and procurement docs
8. Technical Reviews	Portions of this effort will be completed with this project and future phases.	Throughout the project, agency staff will perform technical reviews of the consultant & contractor deliverables. The frequency and thoroughness of the technical reviews determined by agency.	Progress Meeting Minutes & Documents. Subsequent design review info and procurement docs review.
9. Testing, Integration and Acceptance	Not started To be completed under next phases	This process will summarize the expected testing associated with the project and will build on the Draft Verification Plan. The documentation of the test is expected to include inspection, demonstration and execution of systems. Once the Contractor is selected, the Contractor will be responsible for review and submittal of an Acceptance Test that describes the anticipated schedule and potential modifications to the Acceptance Test. The Contractor will be responsible for performing and documenting all testing with agency or its representatives present to observe and verify the results.	Final Acceptance Test Plans

As illustrated in Table 2 above, items 1 through 5 are included in the current scope of work as part of the MAPA Systems Engineering effort for Regional ASCT. The follow on items (illustrated after the dashed line) will need to be completed as part of next phases of the project deployments.

4.0 PROJECT MANAGEMENT AND CONTROL

Figure 3 shows the organizational structure for the MAPA Regional ASCT Project. Following the chart is a brief description of the project roles.

FIGURE 3: MAPA REGIONAL ASCT SYSTEM ENGINEERING PROJECT ORGANIZATIONAL CHART



MAPA Project Manager – The MAPA Project Manager will be responsible for the management of this project and the acceptance of the final SE documents.

The MAPA Project Manager will be responsible for the following:

- Managing the consultant throughout the project
- Monitoring project progress and approving or denying any changes to the scope
- Delegating roles for specific efforts throughout the project
- Ensuring the project is completed as agreed upon, that the system meets its goals and objectives, and that the project is properly documented

Project Steering Committee – The Project Steering Committee (PSC) will provide input at key stages of the project to guide the documentation and prioritization of the regional needs and requirements of the ASCT system. They will support the identification of the preliminary corridors for ASCT system evaluation.

Project Support Consultant – The Project Support Consultant will provide technical support to the MAPA Project Manager and all stakeholders throughout the duration of the project. In that role, the Consultant will ensure the project is consistent with systems engineering processes and that all systems engineering documentation is produced. With future design contracts, the Project Support Consultant will finalize the requirements, plans, specifications and estimates. The Consultant may support the project in reviewing the efforts of the Contractor and supporting testing.

Traffic Signal System Managers – The Traffic Signal System Managers will provide input to the needs and requirements on a regional level. Additionally, these representatives will provide detailed information regarding the existing signal systems and agency specific needs for specific corridors. They are expected to have a significant role in all phases of the creation of the draft and final System Engineering documents.

As the ASCT projects move from preliminary design to final design plan preparation and development of specifications and more detailed requirements, these agencies will need to provide further input, and additional information including as-built information etc. for the selected corridors.

Project Oversight Agencies – These agencies will play a key role in the management and planning of ASCT on a high level for the MAPA region. Additionally, FHWA Resource Center will provide a review of the System Engineering documents relative to the use of the Model ASCT documents.

Beyond the MAPA ASCT System Engineering project, the plan is to move forward with deployment of three corridors. MAPA staff will not be the contracting agency for the specific corridor deployments - that is expected to be the responsibility of the agency or multiple agencies that control the traffic signal system along each corridor. The organizational structure for these next steps will be out lined in the Verification Plan, as the deployment approach and available staff could vary based on each agency.

4.1 Procurement Management

The lead agencies currently have several options for the procurement of equipment, software, and professional services. Typically each community has the following options:

Equipment and Software

For procurements under an established threshold, vendors and/or contractors may submit price quotes. The agency may select based on a "lowest and best" provision, which means the lowest bidder that complies with the specifications by the issuing department is selected and issued a purchase order.

For procurements over the established threshold, a bid package is prepared. The lowest responding bidder, pending approval by agency, is awarded the contract. For federal-aid projects in Nebraska, the bid must be let by NDOR using its specifications (with the agency specs as special provisions).

Procurements for maintenance follow a similar low-bid process.

As discussed at the Project Steering Committee on January 18, 2013, NDOR will allow the City of Omaha to procure the system as long as all federal procurement regulations are followed, NDOR and FHWA approve the process, and NDOR is on the selection committee. FHWA has agreed to this arrangement.

Currently, most agencies have a list of approved products and vendors for certain traffic signal system components such as, inductive loops, traffic signal detector cards, video detection cameras, emergency vehicle preemption, signal heads and pedestrian signals, wireless interconnect radios, service disconnect pedestals, fiber communication equipment etc.

Professional Services

For services involving federal-aid funds, the agencies must follow state and federal requirements. In Nebraska, agencies can utilize the NDOR On-Call ITS Consultant contract (at the discretion of NDOR).

Summary

Several procurement options are available for the deployment of ASCT systems, including: qualifications based (RFP) selection combined with design-bid-build, system manager, and "best value" equipment purchases supported by Systems Engineering documentation. It is envisioned that the following competitive procurement procedure is utilized in Omaha:

1. Use the functional requirements document to generate an RFP specific to the corridor.
2. Use the proposals solicited through the RFP process to create a short-list of three products/vendors.
3. Through a testing and documentation procedure, select the product that demonstrates the "best value" in meeting schedule, cost (from a life-cycle perspective), and quality goals.

The City of Council Bluffs will follow the same procedure in accordance with City or Iowa DOT procurement processes.

Once the stakeholders have worked through the FHWA Model ASCT Documents, the potential exists that a specific corridor may have just one ASCT system that meets the needs for the agency and the corridor. The result could be the need for a sole source justification letter to support the System Engineering documents. This justification letter would need to be approved in accordance with the requirement of 23 CFR 635.411 – Material or Product Selection.

4.2 Risk Management

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

- Keeping backup timings current in the event of all possible system failures
- Extensive system oversight during construction
- Maintaining a trained staff on multiple ASCT systems
- Corridors require significant intersection enhancements prior to deployment
- Corridors require significant communications upgrades prior to deployment
- Regional integration of multiple ASCT systems
- Inability to remotely monitor and trouble-shoot the ASCT systems
- Project Delays based on multiple reviews by multiple agencies
- System not providing meaningful measurement against clearly stated performance objectives, including measures not tied to objectives, too simplistic, and not transparent or verifiable
- Measures do not directly map to specific functions of the adaptive algorithm (eg, travel time, stops, and delays)
- Not properly identifying needs and requirements to address the specific problems on the corridor

These areas will be addressed as specific needs during the remainder of the System Engineering Documentation.

4.3 Change Management

The MAPA Project Manager will be responsible for change management. In this capacity, the MAPAProject Manager will review all proposed project changes and coordinate with the appropriate management for approval or rejection. Proposed changes will be discussed in the project steering committee meetings.

During the deployment phase each lead agency will be responsible for identifying the project manager or designated staff to be responsible for change management for each specific corridor.

4.4 Quality Management

Agency Quality Management practices will be applied to the MAPA ASCT System Engineering project. Due to the technical components of this project, the need for a Traffic Signal Engineer with experience with ASCT systems is important. Additionally, an experienced Project Manager will provide project balance between the technical components and the traditional contracting elements. Finally, a Test Manager that is familiar with the necessary traffic signal enhancements, ASCT systems, communications, sensor placement and system acceptance test procedures will provide the necessary project oversight and lead to improved quality.

4.5 Systems Acceptance

System acceptance is the point at which the local agency accepts and becomes responsible for the corridor specific ASCT deployment. The verification plan will outline the agency organizational chart and the responsibilities of each staff person. The agency is expected to have a Test Manager that will be responsible for taking information provided in the bid documents and creating the final System Acceptance Plan. The Plan will document how the ASCT deployment will function and must be consistent with the agreed-upon requirements.

The Test Manager will be responsible for review and verification of the System Acceptance Plan. Verification by the Test Manager means the acceptance test plan has adequate tests for each system requirement. Once the acceptance test plan has been accepted, the Test Manager will be responsible for conducting or overseeing the performance of the plan. The Test Manager will be responsible for reporting the status of all tests, either in the test plan or a separate report. The agency Project Manager will use this information to make decisions on partial and complete system acceptance.

4.6 Operations and Maintenance, Upgrade and Retirement

Operations and Maintenance, Upgrade and Retirement are dependent upon the technology deployed and the warranty of service provided by the selected ASCT system and contractor. The Concept of Operations should document at the high-level, the expected plan for:

- Operations – This will include a high-level summary of the staffing needs to operate the system, the roles and responsibilities for ASCT operation, management, information sharing and reporting.
- Maintenance – This will include the staff needed to maintain the system, system software, hardware and communications.

- Upgrade – This will include opportunities to upgrade hardware, software and communications. Each agency is expected to use potential upgrade options to develop a strategy for budgeting and performing system upgrades which may include the deployment of additional corridors, the integration of with surrounding entities, and increased dissemination of system data.
- Retirement – This will include estimates for software, hardware and communications replacement. This will be based on industry trends and vision or future systems.