I-10 Integrated Corridor Management

Systems Engineering Management Plan

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LIST OF ACRONYMS

ADOT – Arizona Department of Transportation
AMS – Analysis, Modeling and Simulation
CD – Compact Disc
ConOps – Concept of Operations
FHWA – Federal Highways Administration
ICM – Integrated Corridor Management
IT – Information Technology
ITS – Intelligent Transportation Systems
KH – Kimley-Horn
MAG – Maricopa Association of Governments
PIO – Public Information Officer
PM – Project Manager
PMP – Project Management Plan
RADS – Regional Archived Data System
SEMP – Systems Engineering Management Plan
USDOT – United States Department of Transportation

REVISION HISTORY

Filename	Version	Date	Comment
I-10 ICM SEMP (Draft)	Draft	12/1/2015	Draft for review
Final I-10 ICM SEMP_12 31 2015.docx	1.0	12/31/2015	Final submitted to MAG

1 PURPOSE OF THE DOCUMENT

The Systems Engineering Management Plan (SEMP) was prepared in support of the I-10 Integrated Corridor Management (ICM) project that includes development of an ICM solution concept and system requirements to help advance the implementation of ICM along the I-10 corridor in the Phoenix metropolitan area. This project is being conducted by a team led by Kimley-Horn (KH) for the Maricopa Association of Governments (MAG). This document describes the systems engineering process that will be carried out in the development of the ICM solution concept. The SEMP identifies what items are to be developed, delivered, integrated, installed, verified, and supported. It identifies when these tasks will be done, who will do them, and how the products will be accepted and managed. Its purpose is to detail out those engineering tasks and to provide specific information on the processes to be used. Finally, it defines the technical processes to be used to produce each of the project's products.

A Project Management Plan (PMP) was developed which details the project-level activities that will be conducted in parallel with the systems engineering activities. The SEMP is cross-referenced with the PMP.

1.1 Overview of the SEMP

The SEMP focuses on the technical planning of the project and the systems engineering processes to be used to develop the Concept of Operations (ConOps) and System Requirements for the I-10 ICM project. The SEMP outlines engineering tasks and provides detailed information on the processes to be used.

Developing an ICM solution concept and system requirements as part of this project will address steps two through four of the Systems Engineering development process, as shown in **Figure 1**. It is highly likely that this project will involve multiple iterations of the Systems Engineering Process; ICM in the MAG region is both an incremental and an evolutionary process.

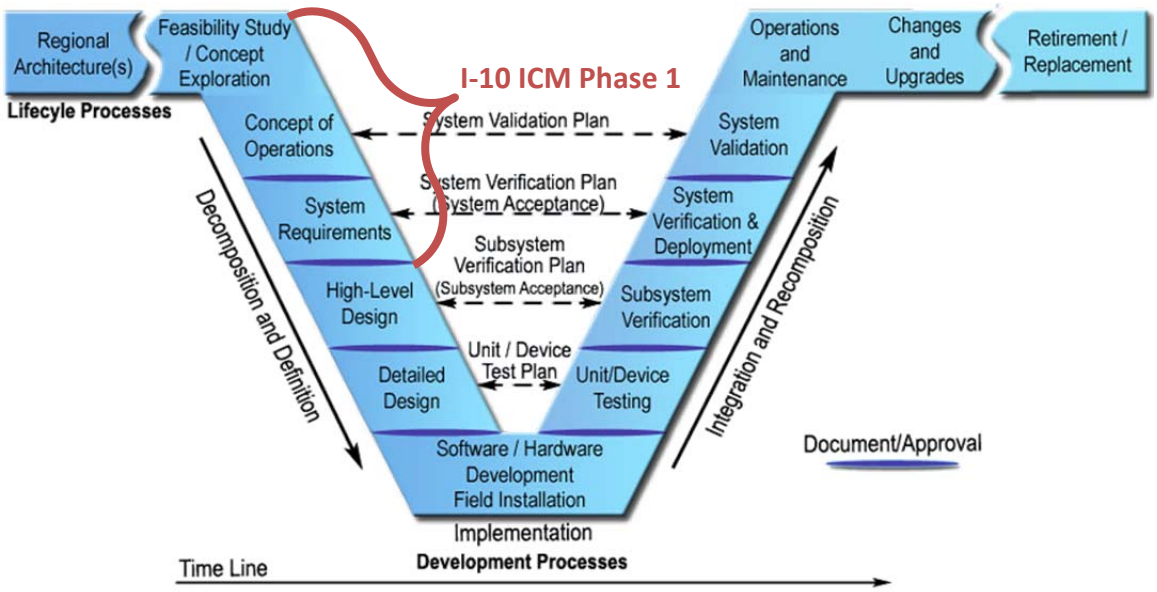
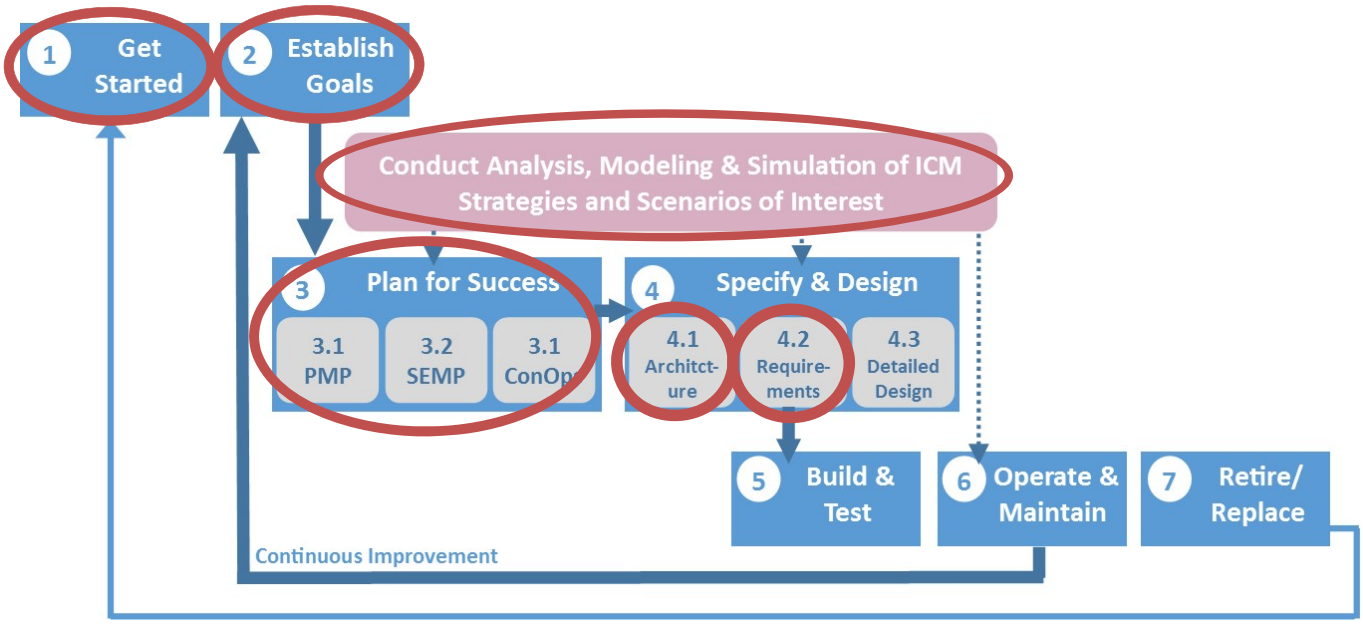


Figure 1 – Systems Engineering 'Vee' Diagram

This SEMP identifies the processes within later steps of the Systems Engineering process, including design, testing, validation and operations and maintenance that will be required when the ICM solution concept is further defined in later phases of the project. Additionally, this SEMP document will be updated throughout the project process to reflect developments in the concept as they occur. There are several sections in the current document that follow the required SEMP format, but are described in high-level terms. Stakeholders have not yet agreed that a system will be the result of the ConOps. As planning decisions are made and documented, these will provide input to the SEMP updates.

MAG applied for and received federal funding to develop a PMP, SEMP, Concept of Operations, System Requirements, and to develop an Analysis, Modeling and Simulation Plan. Funding for subsequent phases is not yet identified; later sections of this document refer to design, verification, implementation and other tasks that are not part of the Phase 1 effort.

Figure 2 provides an overview of the implementation phases for ICM strategies and how they align with the Systems Engineering process. Phase 1 of this ICM project addresses the first three steps of the process (Get Started; Establish Goals, Plan for Success), as well as the Analysis Modeling and Simulation component and steps 4.1 Architecture and 4.2 Requirements.



Adapted from: http://www.its.dot.gov/icms/images/icm_lifecycle.jpg

Figure 2 – The ICM Lifecycle within the Systems Engineering Process

2 PROGRAM OVERVIEW

2.1 Project Purpose and Approach

The I-10 ICM project is the result of an ongoing effort by local and regional agencies along the study area to support steps towards implementation of ICM strategies during incidents and other special events that impact the freeway. Stakeholders identified a key need for improved response and coordination processes during incidents to help reduce impact on the traveling public and freight operators. MAG applied for and received federal funding through the United States Department of Transportation (USDOT) ICM Deployment Planning Grant to begin developing an ICM concept.

This project is developing a feasible concept for implementing ICM along a portion of I-10 within the Phoenix metropolitan area. Initial ICM planning activities will focus on more on improving operations and strategies for major incidents and closures on I-10 including:

- Implementing technologies and systems that will support enhanced real-time monitoring and agency communications;
- Supporting proactive freeway-arterial coordination and operations strategies; and
- Informing travelers of conditions through a variety of means to support en-route decision making and traveler route decisions.

The I-10 ICM project will involve two phases of work. Phase 1 involves the development of the ICM solution concept, system requirements and Analysis, Modeling and Simulation Plan. The objective of the first phase of the project is to identify the needs for the I-10 corridor in relation to incident management; this will be completed over a 24-month period. Based on the outcomes of the first phase and based on funding availability, subsequent phases develop, procure and deploy technologies, systems or processes that are recommended in the first phase.

2.2 Assumptions and Constraints

The I-10 ICM project is being developed under the following assumptions:

- There is existing infrastructure along the freeway and some arterials to support ICM; and
- The agencies along the corridor will not accept full system integration as a viable recommendation from this project. A solution needs to complement, not disrupt, current agency systems and processes.

The following items are seen as existing constraints to the development of the I-10 ICM project:

- There are multiple systems used for traffic operations and management within the study area;
- Along portions of the study area, there is insufficient roadway infrastructure to accommodate increased traffic volumes as a result of ICM strategies (such as diverting traffic to arterials); and
- There is limited interagency coordination capability after-hours, as Arizona Department of Transportation (ADOT) is currently the only agency with 24-hour traffic operations and management center capabilities. Arrangements are being formalized to allow for after-hours coordination and traffic management between ADOT, MCDOT and the City of Phoenix as part of additional ICM-related discussions.

2.3 Performance Targets

Performance targets related to the project process for the planning phase are presented and described in the PMP (Section 7.3). A set of performance metrics related to the performance of the ultimate ICM solution concept for I-10 will be identified and described in the ConOps.

3 TECHNICAL PLANNING AND CONTROL

3.1 Technical Project Summary and Schedule

The first phase of the project will occur over a 24-month period between October 2015 and September 2017. A detailed project schedule is provided in the PMP (Section 3.1). Each deliverable will be provided to the project planning partners for review. The project schedule includes review time for stakeholders as well as revisions by the project team to incorporate comments.

The list below provides a high-level technical schedule for the project and associated stakeholder involvement as each relates to the Systems Engineering process for stakeholder input. Timeframes correspond to developing the PMP and SEMP documents, Concept of Operations, Requirements, and Analysis, Modeling and Simulation Plan

Phase 1

- Project Management
    - Kick-off Workshop (November 2015) – review and discuss Project Management Plan, Systems Engineering Management Plan, and Project Schedule.
    - December 2015 – review and refine Project Management Plan and Systems Engineering Management Plan.
- Develop Concept of Operations (ConOps)
    - Workshop #1 (February 2016) – introduction to project for new stakeholders; discussion about corridor gaps and needs and overarching solution concepts.
    - Workshop #2 (March 2016) – discussion about ICM solutions relative to Segment 1 of the I-10 corridor study area.
    - Workshop #3 (April 2016) – discussion about ICM solutions relative to Segment 2 of the I-10 corridor study area.
    - Workshop #4 (May 2016) – discussion about ICM solutions relative to Segment 3 of the I-10 corridor study area; introduction to the Develop Analysis, Modeling and Simulation (AMS) Plan and how it will support concept development and validation.
    - Workshop #5 (June 2016) – walkthrough Draft Concept of Operations and provide input.
    - June 2016 – review and refine draft Concept of Operations.
    - September 2016 – review and submit final Concept; include submission to Federal Highway Administration (FHWA) and presentation to agency executive management teams for approval.
- Develop System Requirements
    - Workshop #1 (October 2016) – discussion about operational requirements of the solution concepts; AMS plan check-in.
    - Workshop #2 (November 2016) – discussion about technical requirements of the solution concepts; AMS plan check-in.
    - Workshop #3 (February 2017) – confirm requirements decisions and discussion about draft requirements; AMS plan check-in.
    - March 2017 – review and refine System Requirements.

    - June 2017 – review and submit final System Requirements.
- Develop Analysis, Modeling and Simulation (AMS) Plan
    - Workshop (May 2016) – introduction to AMS Plan concurrently with ConOps Workshop #4 to support ConOps development and concept validation.
    - AMS Plan check-in at each System Requirements workshop.
    - Workshop (February 2017) – walkthrough and provide input on draft AMS Plan.
    - May 2017 – review and refine AMS Plan.
    - August 2017 – review and submit final AMS Plan.
- Develop Final Report
    - September 2017 – review all deliverables, update as necessary and submit Final Report.

An Intelligent Transportation System (ITS) Life Cycle Process is defined by the FHWA California Division Systems Engineering Guidebook Version 3.0 2009. Phase 1 of this project as defined above will address the ITS Life Cycle Process Phases -1, 0, 1, and a portion of 2 (requirements development). If successful in Phase 1, subsequent phases would plan to address the ITS Life Cycle Process Phases 2 (design), 3, and 4. ITS Life Cycle Process phases are defined below for reference:

- Phase [-1]: Regional Architecture and interfacing it with systems development;
- Phase 0, Concept Exploration: Concept exploration and benefits analysis;
- Phase 1, Planning & Concept of Operations: project planning, systems engineering management planning, and concept of operations;
- Phase 2, Systems Definition: requirements development, high level design, and component level detailed design;
- Phase 3, Systems Development and Implementation: hardware & software development, integration, verification, and initial deployment;
- Phase 4, Operations & Maintenance: Validation, operations & maintenance, changes & upgrades; and
- Phase 5, Retirement and/or Replacement of the system or major sub-systems.

3.2 Stakeholder Involvement

Stakeholders are integral to the project development process to identify collaborative opportunities and ground the analysis in a needs-based foundation. Key points are defined throughout the project to solicit stakeholder input for the ICM solution concept so that the concept has agency support and will be able to be easily integrated into existing systems and/or processes. Agency stakeholders will collaborate on concepts ideas and recommendations.

Table 1 identifies the stakeholders and managers that will be involved in the project development as well as their roles and responsibilities and key involvement points in the project. The PMP also identifies communication strategies between MAG, Kimley-Horn, Planning Partners and all stakeholders during the project. An important goal of this project is to ensure buy-in and enhanced communication between agencies along the corridor.

Table 1 – Stakeholder Involvement Summary

Group	Description	Roles and Responsibilities	Timing of Involvement
Kimley-Horn and Associates Team	Consultant project management working directly with MAG and other team partners throughout the project.	Lead and manage project; Work with MAG to establish deliverable drafts for distribution and review; Solicit stakeholder input at key milestones in project; and Finalize deliverables and incorporate into final product.	Ongoing
Maricopa Association of Governments Team	MAG project management working directly with Kimley-Horn throughout project.	Identify and provide input to project deliverables; Support coordination of stakeholder involvement efforts; and Support development of AMS plan.	Ongoing
Planning Partners	Key representatives involved in I-10 operations and management from agencies along the corridor.	Participate in stakeholder group activities and provide input into deliverables; and Provide review of deliverables.	All workshops Project deliverable review
Additional Stakeholders	Agency stakeholders beyond those involved in operations, such as Information Technology (IT) or Public Information Officers (PIOs), will be involved at strategic points throughout the process to make sure that a complete agency perspective is captured.	Provide input into ConOps and Requirements; and Review relevant deliverables.	Specific workshops Deliverable review

3.3 Technical Reviews and Decision Gates

This section describes the activities and plans that will act as controls on the project's systems engineering activities that involve producing deliverables, conducting meetings and workshops, and soliciting reviews. The list of decision gates identifies the activities that will control the satisfactory completion of the activity. Phase 1 of the I-10 ICM project involves the following technical tasks:

- Develop a PMP and SEMP
    - Inputs: Grant application; identification of the overall project goal by all Stakeholders, MAG team input; Planning partners input, key stakeholder identification,

commitment from each stakeholder agency for time and personnel, identification of performance measures, Kimley-Horn systems engineering experience.
    - Deliverables: 1) PMP; 2) SEMP
    - Decision Gates: Project goal, project performance measures, stakeholder commitments, MAG team review; planning partner review; Kimley-Horn update based on input and reviews.
- Develop a ConOps for an ICM solution concept
    - Inputs: Existing knowledge of ITS/communication systems, devices and processes; travel information data; planned improvements; traffic forecasts; identification of best practices from other agencies; key agency representative knowledge; inputs from workshops; review of draft and final document.
    - Deliverables: 1) Draft ConOps 2) Final ConOps
    - Decision Gates: MAG team review; planning partner review; Kimley-Horn update based on input and reviews; results of AMS activities; approval and agreements on concept(s) from regional and agency executive teams.
- Develop System Requirements for the ICM solution concept
    - Inputs: Final ConOps document; key stakeholder knowledge and input on existing systems, requirements and policies; travel information data; planned improvements; traffic forecasts; best practices studies from other agencies; discussions with software and/or technology vendors, workshop to walk through draft Requirements with planning partners; review of Requirements.
    - Deliverables: 1) System Requirements
    - Decision Gates: MAG team review; planning partner review; Kimley-Horn update based on reviews and new knowledge that emerges; FHWA buy-off of solution concept after the AMS plan is completed and results are validated; technical agency support (IT).
- Develop an AMS plan
    - Inputs: ConOps identified alternatives; System Requirements; performance measures; MAG experience and knowledge; input from planning partners; MAG traffic projection data.
    - Deliverables: 1) AMS Plan
    - Decision Gates: output of analysis tools to identify required changes to concept or requirements; MAG team review; Planning partners review; Kimley-Horn review; MAG updated based on input and review.

3.4 Systems Integration

3.4.1 Validation

Validation, or acceptance testing, consists of testing the system against the requirements and making sure that the system is functioning as it was originally intended. If a software system is developed as a result of the planning phase of the ICM project, a Software Test Plan will be developed in a subsequent phase. This test plan will describe the environment in which the delivered system will be tested and eventually accepted. The Software Test Plan will include detailed written procedures outline the steps

for testing the system to determine if it works in a manner that meets all of the functional and performance requirements. Software validation should include positive and negative test cases to identify bugs or issues.

System acceptance will be documented based on traceability back to the requirements, which is discussed later in this document. The acceptance testing will be carried out by MAG and other entities (including representatives from the Planning Partners), to observe the testing for test failures, deviations or anomalies. The Software Test Plan will test each of the requirements to determine the final system performs in accordance with the written requirements.

The Software Test Plan will include further detail of the following:

Test Item#	Requirement	Test Procedure	Expected Results	PASS/FAIL	Comments

3.4.2 Verification

The systems acceptance process is critical because this is where the agency chosen to house the new system, which will be identified in the ConOps, becomes responsible for the continued maintenance and management of the systems, products, and processes delivered. Test cases for each of the system requirements will be developed to detail the test procedure to verify that the overall system requirements are satisfied. The result of the test cases will be documented as PASS or FAIL during the final acceptance test.

3.4.3 Integration

If a new system is recommended from Phase 1, subsequent phases will require the development of a plan for Future System Integration Opportunities and Future System Needs. With the unique operating environments of each of the partnering agencies, a direct focus on future integration requirements is imperative. The long-term success of an ICM system will need to factor in potential near-term changes to agency systems or technologies, as well as new data sources or new operational priorities. The deliverable from this final task will be a document summarizing future integration opportunities and considerations while factoring in planned agency system enhancements, integration requirements, and a future level of integration of the system within each of the agency systems. As part of subsequent phases, the future system integration opportunities and needs, along with a proposed timeline and resource estimate, will be documented in a technical memorandum and will be shared and review with the project stakeholders.

3.4.4 Operations and Maintenance

Along with the Integration Plan, an Operations and Maintenance Plan will be required for the resulting technologies, devices or systems that are recommended in the ConOps. This document would be developed in a subsequent phase and would take the ConOps and create a more detailed plan that includes procedures and requirements for operating the ICM solution concept from the perspective of each of the agencies. The plan will also identify maintenance requirements, including system upgrades, that will be required.

3.5 Configuration Management

Configuration management is a cross-cutting activity in the Systems Engineering process that ensures that the integrity of the system is maintained throughout the project lifecycle. The goal of configuration management is to ensure that the resulting system does not deviate from the expected functionalities, characteristics, or requirements prescribed in the system documentation. The configuration management plan described in this section details the control process and procedures to ensure that the configuration of the software components of the system is maintained closely throughout the project.

3.5.1 Configuration Identification

The following items will be managed under the configuration management process:

- Systems engineering documents – PMP, SEMP, ConOps, System Requirements;
- System prototype development (if applicable);
- Baseline acceptance test procedures and results (if applicable);
- Operations and maintenance documentation (including standard operating procedures as documented in the Software Operations and Maintenance Manual); and
- Documentation of future Integration Requirements and future system needs.

3.5.2 Change Management Board

A Change Management Board will be designated as oversight and approval method for which all changes, updates, additions to the ICM system will be discussed and managed. The Change Management Board will have at least five representatives.

Any new scenario developed or a change to an existing scenario needs to be approved by the Change Management Board and will need to be run in Test Mode and verified through reports/data prior to implementation. No changes are allowed to any of the configuration items without the approval of the Change Management Board.

3.5.3 Configuration General Control Process

The configuration control process consists of a sequence of steps to prevent unilateral decisions that could have negative or unforeseen consequences. A control process ensures the entire project team is aware of a change being implemented and that an evaluation is performed to understand the potential risks, costs and impacts of that action. **Figure 3** illustrates the steps in the process.

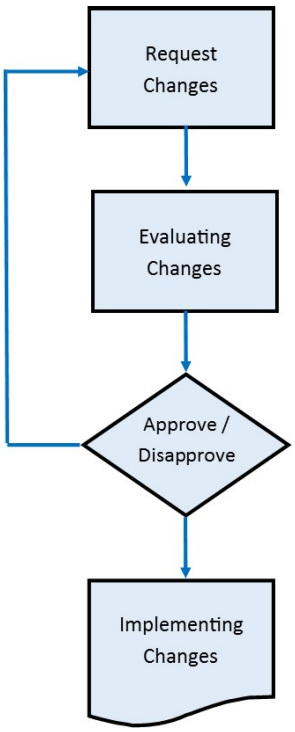


Figure 3 – Configuration Control Process

All requests will be written when submitted and subsequently documented how they are addressed. A low level priority may require only a verbal request/approval. Higher levels of change control that might have a critical impact on configuration items will require the review of a Change Management Board.

3.5.4 Configuration Item and Rationale

After the development of the ConOps and system requirements, a list of items will be identified that represent those that need to be tracked from the project inception to delivery and maintenance. The Configuration Item and Rational table shown below will be used to identify those elements that the software team will have to use and track throughout the project.

Table 2 – Configuration Item and Rationale

Configuration Item	Description	Rationale	Volatility	Impact Severity
ConOps Description	ConOps of the new system defined.	This document describes the ConOps and is volatile early on.	Very High early	Changes here will affect all documents

3.5.5 Configuration Change Management

All feature requests are to be submitted in the form of a scope. As soon as the scope has been received and notice to proceed accepted, the team may begin to analyze the required changes. After the appropriate design elements have been updated, the features are entered into the system management tool and prioritized by the project manager and development team. Each feature is

checked into subversion revision control with an ID from the management tool and a comment that notifies the Quality Control/Quality Assurance Team where this feature originated and how it evolved.

Similar to features, all issues are entered into the system management tool. The defects are prioritized based on their level of criticality and fixed. Each entry into subversion revision control requires an ID from the management tool as well as a comment, so the tester may understand how the issue originated.

3.6 Data Management

The development of new software as part of a potential ICM solution will involve obtaining, sharing and storing a significant amount of data. In order to manage this data, a Data Management Plan will be developed and will describe how and which data will be controlled, the methods of documentation, and where the responsibilities for these processes reside. Based on the ICM solution that is developed in the ConOps, the Data Management Plan will need to address some or all of the following considerations:

- Types of data that will be collected by the solution ;
- Types of data to be available by each agency;
- Data quality and frequency considerations;
- Data privacy and security;
- Information access, archiving and storage.

Additionally, it may be necessary for each agency to make a commitment to work internally to both provide the agreed upon data and information and verify that the agency's operating environment is compatible with the solution. This acknowledgment of commitment might take the form of an IGA or other multi-agency agreement.

3.7 Risk Management

There are risks involved in the development of this project as well as risks involved in the ultimate integration of the system into each of the partnering agency's unique operating systems and environments. These risks have been defined as part of this SEMP and will be referred to and updated by the team throughout the project.

The PMP identifies the process for risk identification and mitigation. Associated with each risk is a mitigation strategy, responsible party to mitigate the risk, and a timeline associated with action on the risk. As the project moves forward, this SEMP will be updated to track and discuss the risks at monthly team meetings. Risks are evaluated throughout a project's life cycle, as risks may change during the course of the project.

In addition to process risks, there are also technical risks for the I-10 ICM project. Strategies for mitigating and controlling these risks will be included in the development of the ConOps and during project workshops. At the end of Phase 1, it will also be important for the Planning Partners to understand and convey any remaining risks and mitigation strategies while communicating with their senior executives within their agency.

Technical risks include:

- System interoperability between the stakeholder agencies;

- Compatibility of new systems/technologies with life cycle stage and limits of the existing systems;
- Speed of technology innovation and life cycle;
- Need for periodic system maintenance and upgrades;
- Longevity of regional commitment to system due to the dynamic ICM environment in the region;
- Ability to obtain support and commitment from agencies for the establishment and maintenance of systems/technology;
- Ability to provide periodic staff training; and
- Ability to provide technical staff continuity.

3.8 Procurement Management

Based on the outcomes of Phase 1 and the identification of the ICM solution concept, a Procurement Management Plan will be developed that provides a list of items and resources that need to be procured, procured as well as documents and development artifacts that need to be tracked with version management. A more detailed discussion about procurement management is in the PMP (Section 6).

3.9 Systems Security and Recovery

A plan for ensuring system security as well as for system recovery in the event that there is a system breach or failure will have to be developed as part of subsequent phases of the project. The integrity of a regional system is a top priority, and a well thought out and comprehensive plan will need to be developed by the contractor and the participating agencies to set up proper security designs and protocols as well as contingency plans.

4 SYSTEMS ENGINEERING PROCESS

Emphasis in this SEMP is placed on stakeholder involvement in the entire project life cycle and depends on feedback from the stakeholders at key points. Much emphasis is placed on gathering user needs at the beginning of the project as the foundation for the ConOps process, where those needs will be refined into a consensus agreement among the stakeholders for the ICM solution's top-level requirements. As those requirements are translated into system functional and performance requirements, frequent reviews with the stakeholders will help refine the interpretation and understanding of the requirements in the context of the system as a whole. During the technical development phase, early demonstrations at stakeholder workshops of system functionality will be used to confirm that the requirements were clearly understood and properly interpreted. The SEMP provides a process to identify and correct deficiencies, and incorporate improvements while supporting the system's operation throughout its life cycle.

System development cannot be defined until after the development of the ConOps, and the actual development would not occur until later phases of the project. Regardless, the spiral model project management methodology will be used for the system development portion of this project. Spiral project management involves prototyping with an iterative approach of system development. The spiral model utilizes a combination of the waterfall and agile methodologies in order to define project schedule milestones while being able to adapt to changing requirements throughout the course of the project. Setting project objectives, project risk management, and project planning are key to spiral model development and the user is able to test some of the functionality before the entire system is completed. The specific tasks associated with later phases of the project will be determined upon completion of Phase 1.

4.1 Systems Engineering Planning Process

This section describes the intended execution of the systems engineering processes used to develop the project. The FHWA's Final Rule (23 CFR Part 940 part 11) places requirements on the minimum description of the systems engineering analysis for projects with federal funding.

Previous efforts in the development and updating of the MAG ITS Architecture addressed the first task of the Systems Engineering "Vee" Diagram, Regional Architectures. Phase 1 of the I-10 ICM project addresses steps two through four of the Systems Engineering process. Additionally, this SEMP identifies where later steps in the Systems Engineering process will be addressed after the I-10 ICM solution concept is defined in the ConOps and during later phases where there is funding identified for the development and deployment of the concept.

4.2 Relationship to Regional ITS Architecture

In order to receive federal funding for ITS projects, the functionality defined by this project must be included in the Regional ITS Architecture. For this project, the MAG Regional ITS Architecture is the relevant ITS Architecture that should be considered when developing and ultimately implementing this project. ADOT has a Statewide ITS Architecture that also should be reviewed for changes.

As part of the regional architecture, the following functional needs are known and are anticipated to be included in the functionality of the ICM solution concept:

- Disseminate more timely incident information;
- Improve information exchange;
- Improve interagency coordination;
- Improve incident response and management;
- Improve traveler information during incidents;
- Improve work zone and safety; and
- Up-to-date information to review closures, congestion, incidents, etc.

The ICM solution concept is also expected to have a combination of freeway functions and arterial functions with the primary focus on incident management, but a secondary and day-to-day focus on congestion management. Therefore, the following service packages have been identified by the MAG ITS Architecture that represent functions provided by ADOT and by the local cities along the I-10 corridor:

ADOT:

- AD1-1 – ITS Data Mart – ADOT Archive
- AD2-1 – ITS Data Warehouse – AZTech Regional Archived Data System (RADS)
- ATIS01-1 – Broadcast Traveler Information – ADOT Highway Conditions Reporting System (Inputs)
- ATMS01-01 – Network Surveillance – ADOT
- ATMS03-15 – Traffic Signal Control – ADOT
- ATMS06-01 – Traffic Information Dissemination – ADOT
- ATMS08-01 – Traffic Incident Management System – ADOT (Traffic Management to Emergency Management)
- MC03 – Road Weather Data Collection
- MC04 – Weather Information Processing and Distribution
- MC07 – Roadway Maintenance and Construction
- MC08 – Work Zone Management
- MC10 – Maintenance and Construction Activity Coordination

Cities of Phoenix, Tempe, and Chandler:

- AD1-3 – ITS Data Mart – Local Archives
- AD2-1 – ITS Data Warehouse – AZTech RADS
- ATMS01 – Network Surveillance – all cities
- ATMS03 – Traffic Signal Control – all cities
- ATMS06 – Traffic Information Dissemination – all cities
- MC07 – Roadway Maintenance and Construction – all cities
- MC10-3 – Maintenance and Construction Activity Coordination – all cities

After the development of the ConOps, where the ICM solution will be defined and developed, changes or updates that will be required for the MAG Regional ITS Architecture will be identified and described. MAG plans to update the Regional ITS Architecture in 2016; ICM concepts will not be finalized in 2016,

but the team will track potential ICM-related updates for future inclusion in the Regional ITS Architecture. Updates that may be required would include addition of a centralized system that manages infrastructure or additional integration with transit.

4.3 List of Systems Engineering Documents

The following describes the Systems Engineering documentation that will likely be developed for this project in addition to the PMP and SEMP:

- **ConOps** – The document provides an easy to understand view of how the ICM solution will work from the perspective of the operating agencies and external stakeholders. The ConOps lists the stakeholders and their roles and responsibilities and describes brief operational scenarios for the basic functions of the systems.
- **System Requirements** – The document will be developed using the ConOps and the SEMP to provide traceability throughout the system development. It will have a list of functional (what the system is supposed to do) and performance requirements (how well the system does in its functions). The requirements will cover the scope of work for the project.
- **Configuration Management Plan** – A configuration management plan will be developed after the completion of the ConOps that describes how the project team will maintain consistency with the requirements baseline throughout the project. The guidelines identify items under change management and the process for accepting, implementing and documenting change requests that deviate from the requirements.
- **Software Test Plan** (if applicable) – The document will describe the sequence of activities to verify that the system functions and performs according to the system requirements. The plan will organize the requirements into test cases and include specific steps for carrying out a list of procedures to test each requirement.
- **Software Integration and Future Upgrade Plan** (if applicable) – A plan for implementing the system requirements in the system development will be developed after the development of the ConOps. The SEMP will be revised as the plan is developed from the System Requirements. The plan will describe the sequence of activities for integrating the different software subsystems into a complete and functioning system.

4.4 Concept of Operations

The beginning processes for conducting Systems Engineering involves establishing needs of the stakeholders, relationships to other projects/programs, and identifying how the system will operate, before moving into steps toward designing the product – all of which are captured in a Concept of Operations. The ConOps document will describe the functionality of the ICM solution from a customer and stakeholder perspective.

A draft ConOps will be distributed to stakeholders for review and a workshop will be scheduled to discuss concepts with stakeholders and elicit input. Stakeholders in this task will include operations and maintenance representatives as well as agency IT staff, as IT policies may drive several of the ultimate design decisions. The draft ConOps will be updated and circulated for a final review by stakeholders prior to commencing with requirements development. The ConOps document will be refined during the course of this project to support the design and development of the solution.

4.5 Systems Requirements Analysis

Formal system requirements will be defined after the development of the ConOps and represents the first step in the design and development of the ICM solution. There are multiple inputs that are necessary to understand and identify system requirements that will be needed. Inputs into the ConOps include:

- The existing devices and infrastructure used for operations, information collection and dissemination and incident management within the ICM study area;
- Existing systems, requirements policies and procedures used for operations and management of roadways within the study area by partner agencies;
- Existing roadway network, roadway capacity, future planned developments, and traveler information;
- Funding mechanisms, agency preferences;
- Needs and goals identified by partner agencies for each segment of the corridor; and
- Past and current ICM and traffic management-related projects and initiatives in and around the study area.

Additionally, the following steps and strategies will be used to define requirements during the process of developing the ConOps:

- Using graphics to communicate functionality;
- Using matrices to number and track requirements against original objectives;
- Creating operational scenarios to describe the functionality of the proposed solution; and
- Ensuring configuration management amongst the project team, including decisions on documentation procedures, product format, and procedure for submitting and finalizing deliverables.
    - Any software deliverables will be delivered via Compact Disc (CD); and
    - Formal drafts of documents that are submitted for review will be formatted appropriately and labeled as 'Draft' with the appropriate draft number and data. Any final deliverables will be labeled as 'Final' and will include the date.

During requirements development, a series of workshops will be conducted to discuss operational and technical requirements for the solution. A Draft Requirements document will be distributed to stakeholders for review and a workshop will be scheduled to directly present the requirements to stakeholders and elicit input. Stakeholders in this task will include operations and maintenance representatives as well as agency IT staff, as IT policies may drive several of the ultimate design decisions. The draft requirements will be updated and circulated for a final review by stakeholders prior to commencing with any software development.

Technical objectives for this project which will be managed and carefully considered throughout the course of development include:

- Defining the system from a need- and user-based standpoint;
- Designing any software to ensure compatibility with all existing systems and all known, future changes and upgrades;

- Designing any software to ensure that new functionality (device types, expansion, etc.) can be accommodated at a later date without requiring complete replacement of the system; and
- Identifying risks and mitigation strategies associated with manual or automated features of the system

To ensure that each of the specified needs put forth in the ConOps and stakeholder input obtained through workshops is incorporated into the final system, a set of requirements will be developed that will guide the system development process. The matrix in **Table 3** will be used to help trace each specified need that was identified in the ConOps and identify necessary subcomponent requirements that are derived from those needs. It also provides a schedule of completion for each identified requirement.

Table 3 – Requirements Traceability Matrix

User Need ID	User Need Description	Requirement ID	Requirement Description
USER NEED CATEGORY 1			
USER NEED CATEGORY 2			
USER NEED CATEGORY 3			

This matrix enables the traceability of operational needs (as identified in the ConOps) to system requirements. All requirements are to be written in the form of 'shall' statements. Determination of the requirements is critical for system interface design. This traceability approach is consistent with the system engineering approach, where only user needs drive the requirements. The draft of the System Requirements will be distributed to stakeholders for review. This Requirements Traceability Matrix will be used to map verification methods to system requirements.

4.6 System Design and Development

The SEMP assumes that a system will be developed for this project. The User Interface of the system will be defined through the ConOps and System Requirements task of the project as the first step in the design and development of the system.

4.6.1 System Analysis

System analysis, including trade-off studies and risk mitigation, will occur in subsequent phases within the process of prototype design and development. Design alternatives will likely be necessary to ensure that the system is compatible with the operating systems and IT policies for each of the stakeholder agencies. The study alternatives will be evaluated using the identified performance measures, cost, schedule, technical criteria and additional comparative indices developed during the ConOps and System Requirements tasks. Additionally, identification of risks involved with each alternative and the process to mitigate risks will be documented during the alternative analyses.

4.6.2 Sub-System Analysis

Sub-systems will be identified and defined based on the outputs of the ConOps and the System Requirements tasks. At a minimum, the following sub-systems will be necessary as part of the development of the overall platform:

- User interface - how users will interact with the system how and when alerts and notifications are issued, and how they are presented to users;
- Data exchanges and interfaces - how the system will extract and integrate data from a variety of sources;
- Operating platform - how the system will be accessed, including unique requirements of workstation and mobile environments;
- Operation decision support - how strategies are formulated and suggested to users based on current conditions and established thresholds;
- Functional elements - including how communications and coordination among users is facilitated, how operational decisions are supported, and how historical information is captured;
- System management - how data archiving is handled, how system updates are handled, and how overall system management and maintenance is accomplished; and
- System end of life-cycle management - how the system will be upgraded or replaced at the end of its life-cycle. Where will the data be stored, and for how long should any data with this system be stored.

The process of defining and allocating specific requirements to the appropriate sub-system will occur during the design and development of the system prototype in subsequent phases of the project.

4.6.3 Design Synthesis

Detailed functional requirements serve as the technical special provisions in the development of any software. Design synthesis describes the process or methods that will be used to translate the system requirements into software design. To support this process in Phase 1, a series of workshops will be conducted to review the draft and final ConOps before any system requirements are developed. This will ensure intended functionality of any system meets the intended needs and objectives. System requirements will be developed only after the ConOps is finalized.

It is suggested that the software development process for subsequent phases of this project include the following methods:

- Developing a functional design prototype to allow stakeholders an opportunity to fine tune the look and feel of the system and its capabilities;
- Holding a series of stakeholder workshops to incrementally offer opportunities to comment on the functional design as it is being developed, rather than after it has already been developed. This process is integral to designing a system that meets the intended purpose that the ConOps has defined; and
- Incrementally updating the functional design and functional specifications based on stakeholder input will fine tune the functional design into a final version that can then be taken to develop the software to match the design.

Detailed functional requirements are referred to as the "functional specifications" and will serve as the technical special provisions in the software development. System prototypes and functional requirements will be distributed to stakeholders for review and a series of technical walk-through workshops will be scheduled to directly present the requirements and prototype to stakeholders and elicit input. The prototype and requirements will be updated and circulated for a final review by stakeholders prior to commencing with any software development.

4.7 Transitioning Critical Technologies

This section describes the processes that will be used in subsequent phases of the I-10 ICM project to support the Systems Engineering process for system development and deployment.

4.7.1 Trade-Off Studies and Gap Analyses

As a formal decision analysis method, trade-off studies are used in situations where more than one alternative exists for a given product, system, or technology. Alternative analysis will be used during the system design and development to ensure that all softwar developed is compatible with the existing systems of each of the stakeholder agencies while still meeting the needs and goals that are identified by stakeholders.

Gaps that might exist between existing system capabilities and the desired system to be developed will be identified during the ConOps development in Phase 1. These tasks are designed to ensure there is a clear understanding of the existing systems, processes, environments and devices in each agency to ensure that any future systems are compatible with the unique systems that exist. The needs and goals that are identified will be translated into system requirements, which are presented to stakeholders for review and feedback.

Because these system requirements ultimately guide the development of software, any potential gaps between existing and desired capabilities are identified and addressed before software development occurs.

4.7.2 Technology Assessments and Selection

In order to create the environment that is described in the ConOps, specific functionalities will be needed. The appropriate technology to provide these functionalities will need to be identified. During the process of developing and designing the system, a methodology will be established to identify, evaluate, select, and incorporate critical technologies into the system design. The identification of

candidate technologies hinges on a broad knowledge of the technologies and knowledge of each technology's status and maturity. The project team will perform substantial research on best-practices and will engage all necessary stakeholders from within the study corridor as well as other software development firms who have done similar work throughout the country.

Technologies that are identified as promising will be evaluated for inclusion by considering some of the following criteria:

- Cost of the technology;
- The technology's ability to address or comply with system requirements;
- The effort and time that would be necessary to develop and/or incorporate the technology;
- Trade-offs that may be necessary in order to include the technology;
- The level of management and maintenance that is needed for the technology; and
- The perceived sustainability of the technology (how long is the technology perceived to stay relevant).

Similarly, a process to analyze the risks and benefits of each technology will be put in place as part of the vetting process for any technologies that are identified.

The processes for identifying, assessing and ultimately including desirable technologies will be defined in subsequent phases.

4.7.3 Life-Cycle Management

In addition to the technology assessments, a Life-cycle Management Plan will be developed in subsequent phases for the technologies and software-related components of the ICM solution. With the current technology environment changing so rapidly with respect to devices and systems, it will be important to have a plan to periodically revisit the system and its components identify and updates or replacements that might be necessary due to either age or compatibility with current systems and technologies. The Life-cycle Management Plan will also be used to help identify upgrades or enhancements for the system that might be needed to maintain adequate system functionality within a constantly changing operating environment. The Life Cycle Management Plan will also help plan for funding requests to support the upgrades that are identified and allow for adequate time to identify and secure necessary funding.

4.8 System Performance Monitoring

A set of performance metrics by which to evaluate the system and its outcomes will be developed as part of the ConOps. These performance measures will include those that measure how well the system is functioning (amount of system down time, number of times an agencies interfaces with the system, etc.) as well as how effective the system is in producing the desired results.

These metrics, which will be identified and defined based on input from MAG and Planning Partners, will allow MAG to monitor system functions and functionality over time. As part of Phase 1 of the project, a plan for performance measurement and reporting will be discussed and identified, and this plan will be updated, as necessary during subsequent phases as the system is deployed. The regular collection and reporting of performance measures will help MAG and planning partners identify flaws or issues with the system so that proper reconciliation can be made to make sure that the system is

operating as put forth in the system requirements. Measuring performance can also help identify where system upgrades or enhancements might be needed over time. Finally, performance tracking can help highlight the benefits of the system and the efforts that went into this project. It could provide justification to the FHWA, State or local officials, or agency upper management for providing support and/or funding for future studies or investments in ICM and similar initiatives within the region.

4.9 Identification of Other Important Plans

A number of additional planning documents have been identified in this SEMP with the understanding that they will need to be developed during this project. However, additional plans that should be completed or processes that should be followed may be identified during ConOps and System Requirements tasks of Phase 1 of the project. Examples of such a plan could be a Human Factors plan or a System Safety plan. Any additional plans or procedures that are identified during the ConOps or System Requirements phases of the project will be included in the updated SEMP document prior to the delivery of the Final Report. The SEMP will provide a description of the required plan and the timeline at which the plan should be developed.