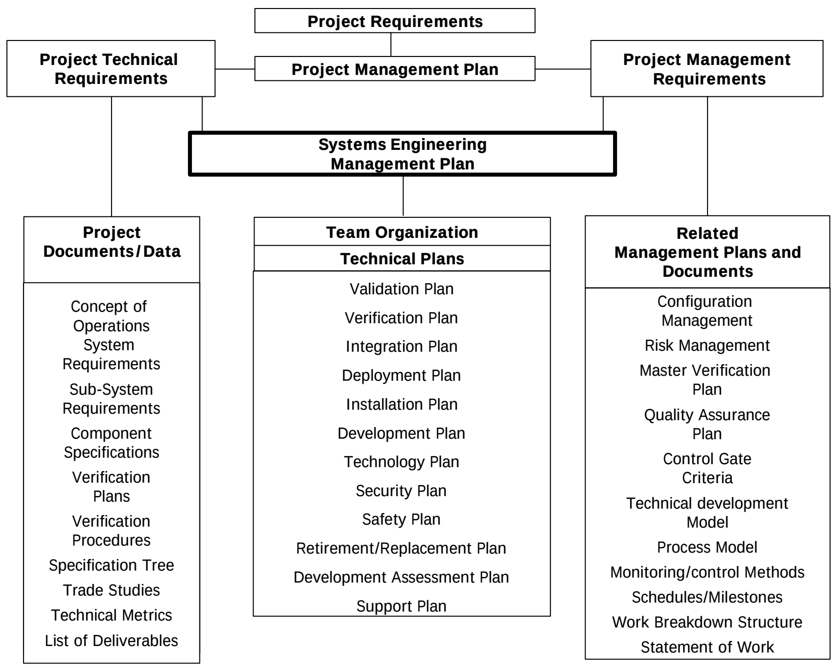
Exhibit 12-E
Systems Engineering Management Plan (SEMP) Guidelines

INTRODUCTION

The Systems Engineering Management Plan (SEMP) is the primary, top-level technical management document that defines and describes the systems engineering management, the tailored systems engineering process, and how the technical disciplines will be integrated for the life of a transportation project. This document establishes the technical program organization, direction, and control mechanisms for the project to meet its cost, schedule, and performance objectives. The SEMP is the foundation for all engineering activities during the entire project.



The SEMP applies to all team personnel and all technical activities conducted in the fulfillment of the project. It applies to all processes and products that are deemed necessary for accomplishing the project, whether or not they are required under contract.

A SEMP should be developed for every project that includes software development or software/hardware integration. The SEMP should be tailored to project size and complexity, yet cover all development phases. The SEMP is not necessarily a long document. For some projects, it could be few pages long and for others it could be hundreds of pages long. The plan needs to be specific to the needs of the particular project.

The SEMP is a living document and as a result additions, deletions, and modifications will occur as it is utilized. It will be updated as the development work proceeds and systems engineering process products are produced. All updates must be reviewed and approved by the Transportation Agency project manager.

The SEMP will be prepared in two stages. The first stage is a framework (or scope) for the SEMP established by the Transportation Agency. The second stage is the completion of the SEMP by the Developer (system manager and/or integrator) before software detailed design and software/hardware integration begin.

The Transportation Agency, in conjunction with any directed systems engineering management working group(s), establishes a framework for the SEMP by stating project goals and organizational management and establishing requirements for what should be in it. This takes the form of a *Draft Scope* (typically the first section of the SEMP) and can be useful for project management decisions and contract RFP scope developments.

The Developer will provide complete SEMP content in the second stage. This content will be addressed as a part of the contract proposal and finalized in technical documents that are approved before software component detailed design begins. With the Developer's input, the SEMP becomes the control document for work to be performed for the life of the project.

In the sections that follow, an example format and description of the SEMP is presented.

Format and Description of SEMP:

Title Page

The title page should follow the Transportation Agency procedures or style guide as applicable. It shall contain the following information (not in order):

- SYSTEMS ENGINEERING MANAGEMENT PLAN FOR THE *Name of Project*, AND *Transportation Agency*
- Contract Number
- Date the document was formally approved
- The organization responsible for 'preparing' the document
- Internal Document Control Number, if available
- Revision version

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1. SCOPE

Transportation Agency - *"What is the project goal and what is expected from the Developer?"*

Developer - *"What is proposed and how will it be delivered?"*

The *Scope* shall identify the specific project and its purpose, to include complexities and challenges that will be addressed by the technical development effort. It will specify the systems engineering process (see Fig. 1 next page) to be used for the system's design, development, test, and evaluation. Overall organizational structure and technical, direction and control for the project should be summarized. This includes management work groups and multi-disciplinary technical teams that are critical to reaching successful system deployment.

The *Scope* will summarize all associated planning, technical, and management activities described in the SEMP sections that follow. This information will be provided from two perspectives, the Transportation Agency in the form of a *Draft Scope*, and the Developer as a part of the contract proposal and completed in the final SEMP delivered for approval.

From the perspective of the Transportation Agency, the *Draft Scope* will state project goals and organizational management and summarize the minimum requirements expected of the Developer. Drawing upon the details presented in the following Sections of this SEMP guidance, these agency expectations can be documented. This will be useful for project management decisions and contract RFP scope developments.

The Developer completes the *Scope* content in stages, as a part of the contract proposal and as technical documents are finalized and approved before the Component Detailed Design phase begins (see Figure 1). The Developer will provide the necessary details in the other sections of this SEMP guidance. The content of the *Scope* has similarity to an Executive Summary.

The VEE life-cycle technical development model should be specified by the Transportation Agency in the *Draft Scope* to represent the overlying systems engineering process for analysis. See Figure 1. Other models may be used to supplement the analysis.

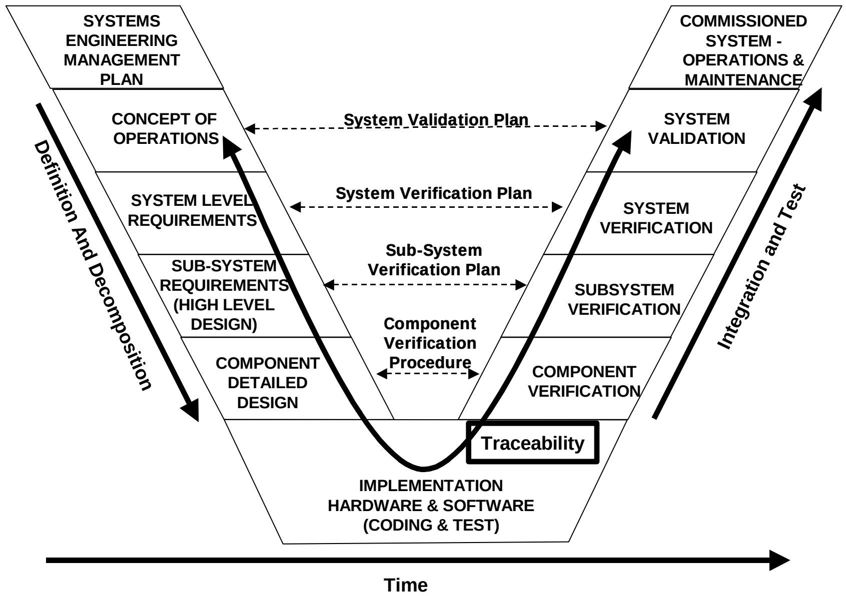

Figure 1. VEE Systems Engineering Technical Model

The level of detail at each of the phases of the analysis should be on a scale commensurate with the project scope. The details of this tailoring will be summarized in the *Scope* by the Developer and described in full in SEMP Section 3 entitled *Systems Engineering Process*.

The Transportation Agency shall state in the *Scope* that the Federal Regulation 23 CFR 940, *Intelligent Transportation Systems (ITS) Architecture and Standards*, *Final Rule* will be satisfied. 23 CFR 940 states, “All ITS projects funded with highway trust funds shall be based on a systems engineering analysis.” The project implementation requirements specified in 23 CFR 940.11 are as follows:

- Identification of portions of the Regional ITS Architecture being implemented or if a Regional ITS Architecture does not exist, the applicable portions of the National ITS Architecture,
- Identification of participating agencies and their roles and responsibilities,
- Requirements definitions,
- Analysis of alternative system configurations and technology options to meet requirements,
- Procurement options,
- Identification of applicable ITS standards and testing procedures, and
- Procedures and resources necessary for operation and management of the system.

The relationships of these seven bullets from 23 CFR 940 to the recommended VEE technical model phases are depicted in Figure 2. In the process phases leading up to Component Detailed Design, these seven regulatory requirements will be addressed. The Developer shall acknowledge in the *Scope*, as a part of the contract proposal that these will be addressed in the systems engineering analysis and any associated process tailoring detailed in Section 3, *Systems Engineering Process*.

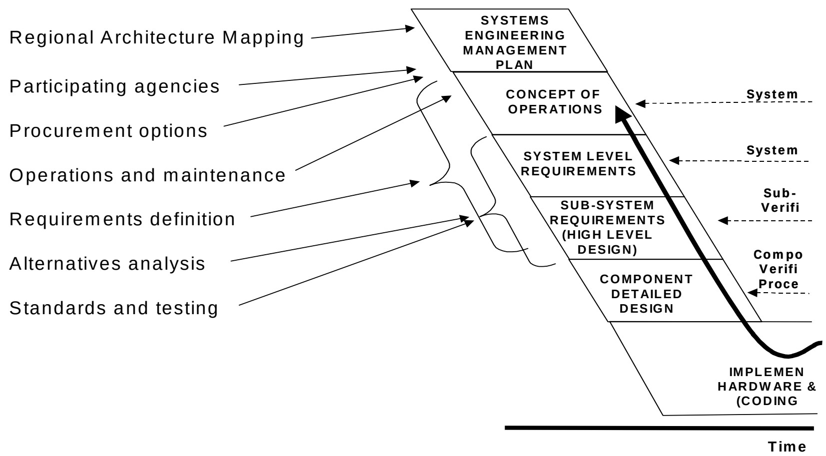

Figure 2. Relationship between 23 CFR 940.11 and the VEE

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2. TECHNICAL PLANNING AND CONTROL

"What needs to be documented, and how will the development be managed?"

Technical Planning and Control contains the core systems engineering planning information that the Developer will convey within a contract proposal and provide during the system design development. *Technical Planning and Control* identifies overall organizational structure and responsibilities for systems engineering activities during the total system life cycle. The section will detail the technical direction and control of contracted, and subcontracted engineering tasks. It applies to all technical activities conducted, and to all processes and products that are deemed necessary for accomplishing the project.

Technical Planning and Control defines the project's interaction with all internal and external organizations involved in performing technical work (i.e., teammates, subcontractors, and vendors). Multi-disciplinary teams that are critical to reaching successful system deployment will be formed. Multi-disciplinary teams will be discussed in detail in Section 4, *Integration of the Systems Engineering Effort.*

The Transportation Agency should specify in the *Draft Scope* the planning activities important to the success of the project. A final decision will be made through consultation with the Developer at time of contract proposal approval. The planning activities important to most system developments consist of the following:

- Major decision deliverables – produce the requirements databases, specifications, and baselines.
- Process inputs - identify source material for the deliverables noted above, which includes the SOW and the specification from the RFP, and previously developed specifications for similar systems.

- Technical objectives – include success criteria defining when the design is done. May be a source document for deliverables noted above. Could be part of a Concept of Operations.
- Contract Work Breakdown Structure (WBS) - defines the tasks in the Systems Engineering Master Schedule and the milestones of the Systems Engineering Detailed Schedule. The Detailed Schedule may or may not be an expectation at the contract proposal phase.
- Training – planned for agency staff to operate the system and for contract staff on the basis of the requirements of the RFP/SOW, with associated scheduling.
- Standards and procedures – identify within the Developer company those that are applicable, such as workmanship, quality assurance, engineering policies and procedures, and time charging practices, etc.
- Resource allocation – identifies resource requirements (capital equipment, software, personnel, agency-furnished equipment and information, and time-phased needs), procedures for resource control, and reallocation procedures (workarounds).
- Constraints - identify source, e.g., RFP, system concept, technology availability, availability of required resources, funding, facilities, etc.
- Work authorization – describes process for handling requests for work (e.g., task orders), or changes to existing tasking; especially important with subcontractors.
- Test and Evaluation – acknowledge that a Testability Plan be prepared. See description of Testability Plan below.

As part of *Technical Planning and Control*, (1) technical documents, and (2) related project management plans applicable to the project, are identified. The Transportation Agency will give initial indication in the *Draft Scope* of those technical documents they desire to see developed, and specify project management plan requirements that relate to this development that they already have in place. A final decision will be made through consultation with the Developer at time of contract proposal approval. The Developer will describe the associated technical management aspects for this development in the final SEMP.

The technical documents include both schedules and plans. Each schedule and plan is designed to interact with other project plans to provide complete coverage of the engineering effort and ensure continuity of management control. Typical technical documents (schedules and plans) include:

- Systems Engineering Master Schedule – top-level process control and progress measurement tool to ensure completion of identified accomplishments.
- Systems Engineering Detailed Schedule – reflects the detailed work efforts required to support critical events and tasks. May be required by the RFP.
- Software Development Plan – describes organizational structure of the effort, facilities and engineering environment, management techniques to maintain control over development activities.
- Hardware Development Plan – describes organizational structure of the effort, procedures, facilities and engineering environment, management techniques to maintain control over development activities.

- Interface Control Plan – Identifies and defines physical, electronic, content characteristics of all system internal and external interfaces, and communications links. Includes interfaces with people as well as hardware and software.
- System Installation Plan – describes in detail planned step-by-step activities on site-by-site basis for the release, both physical installation as well as electronic updating, also organizational structure.
- System Integration Plan – identifies organizational structure, optimal sequence for incremental delivery, assembly, and activation of the various components into operational system. Addresses factors to minimize assembly difficulties and cost/schedule impact.

- Testability Plan – basic tool to establish and execute a test program. Emphasizes: integration with other design requirements, consistency with end product requirements, identifies guides, analysis models, and procedures, planning for review and use of data submissions, how/when tasks to be done and how results are to be used, physical and personnel resources and overall testing schedule.
- Technical Review Plan – lists technical reviews to be conducted and describes associated tasks for each contract phase, methods to solve problems during reviews, information needed as prerequisite, and schedule. A listing of life cycle phase technical reviews can be found in EIA/IS 632, Annex E.

- Technology Plan – describes evolution to identify, assess, and applies emerging technology, activities and criteria for transitioning from development and demonstration, addresses selection criteria for alternative technologies.

The above list is not meant to be exhaustive. Other test plans will be called for in transportation projects, such as Verification Plans, Validation Plans, and Test Plans for which much of the information in the Testability Plan would be included. Other technical plans that may be appropriate include: Quality Assurance Plan, Maintenance Plan, and Human Factors Plan. For smaller, less complex projects, several of these plans could be combined and some may not be necessary at all.

In addition to the technical plans, certain project management plans will be prescribed for the development. Project management plans include at a minimum

Configuration Management Plan – describes Developer approach and methods to manage configuration of system products and processes. Describes change control procedures and baseline management.

- Data Management Plan – describe how and which data will be controlled, method of documentation, and responsibilities. Describes control systems in place, company procedures, and recent practices on similar programs.
- Risk Management Plan – addresses risk identification, assessment, mitigation, and monitoring activities associated with development, test and evaluation requirements. Also addresses roles and responsibilities of all organizations.

For small, less complex projects, the configuration and data management plans could be combined. Other management plans that may be appropriate include: System Safety Plan, System Security Plan, and Resource Management Plan.

A complete list of enabling content that the Developer should consider for these plans, which are applicable, follows:

- Statement of Work
- Work Breakdown Structure
- Activity Breakdown Structure
- Computerized Resource Tracking (Resources Loaded Network)
- Glossary of terms
- Schedule
- Technical milestones
- Project team organization
- Project control method
- Process models
- Management plans (configuration management, interface, risk, training, etc)
- List all deliverables
- Technical metrics
- Systems Engineering life cycle model
- Gate and exit criteria (decision points)
- Technical plans (integration, installation, etc.)
- System description
- Specification tree
- Trade studies

A final decision by the Transportation Agency project manager on selected documentation will occur with contract proposal approval. Plans, as they are completed during development, must be reviewed and approved by the Transportation Agency project manager.

3. SYSTEMS ENGINEERING PROCESS

How will the development be done?"

Systems Engineering Process will convey how the Developer executes the development of the system. The VEE life-cycle technical development model will be specified by the Transportation Agency in the *Draft Scope* to represent the overlying systems engineering process for analysis. See Figure 1. Other models may be used to supplement the analysis, e.g., the Spiral risk-mitigation model.

Systems Engineering Process will describe all tailoring of the systems engineering process requirements. Tailoring is the modification of any process requirements – managerial or technical. The details of this tailoring will be summarized in the *Scope* by the Developer and described in full in this Section. To further describe these tailoring activities, they are categorized as:

- System Requirements Analysis
- Sub-System (Functional) Analysis
- Design Synthesis
- System Analysis

System Requirements Analysis

Describes approach and methods for analyzing and defining the concept of operation and top-level system requirements. These evolve iteratively. The concept of operations approval results from peer reviews, working groups, scenario studies, simulation, and/or demonstrations, as necessary. Requirements are analyzed for development, deployment, verification, operations, support, and training.

Sub-System (Functional) Analysis

Describes approach and methods to allocate requirements to lower-level functions; defines functional interfaces; and defines the functional architecture. This is not practical during a proposal effort for each and every system requirement. This can be managed through the use of risk analysis, with high-risk requirements in terms of likelihood and severity being defined in some detail, while low-risk requirements are included in an overall general scope of analysis. For items defined in detail, the SEMP should include consideration of type of analysis, tools, schedule and budget constraints, and the completion criterion. From the systems engineering perspective, address the "illities".

Design Synthesis

Describe approach and methods to transform the functional architecture into a physical architecture; to define alternative system concepts; to define physical interfaces, and to select preferred product and process solutions. Also describe how requirements are transformed into detailed system design specifications.

System Analysis

Describe approach and methods to undertake trade-off studies, system/cost effectiveness analysis, and risk analysis. The results of these analyses should provide: (1) rigorous basis for technical decision-making, (2) quantifiable basis for decision-making ensuring that cost, schedule, and performance are addressed, and (3) support for risk strategy development and management.

Developers (systems managers and integrators) are accustomed to these processes and should be able to scale the tailoring for small, less complex, projects. Each process of the VEE technical model should be addressed, though, whether categorized as above or in another format.

As a part of the tailoring discussion, the Developer should explain the established relationship of the requirements from 23 CFR 940 with the tailored processes of the VEE technical model. The project implementation requirements specified in 23 CFR 940.11 are as follows: (See also Figure 2)

- Identification of portions of the Regional ITS Architecture being implemented or if a Regional ITS Architecture does not exist, the applicable portions of the National ITS Architecture,
- Identification of participating agencies and their roles and responsibilities,
- Requirements definitions,
- Analysis of alternative system configurations and technology options to meet requirements,
- Identification of applicable ITS standards and testing procedures, and
- Procedures and resources necessary for operation and management of the system.

4. Transitional Critical Technologies

"How do I avoid obsolescence?"

This section describes key technologies, the approach for transitioning those technologies into the project system development, and their associated risk. This includes the activities and criteria for assessing and transitioning critical technologies from their development and demonstration programs into the project system development.

Transitioning critical technologies should be done as a part of the risk management. It is called separately here for special emphasis. Identify what technologies are critical and follow the steps outlined for risk management. This will establish which alternative and when an alternative is incorporated into the project to meet performance and functional requirements. As a separate section of the SEMP, reference to the work that will be done to address critical technologies will be incorporated here as a part of the proposal submittal.

The ability to evolve the technologies employed in a system hinges on several factors: knowledge of the technologies, knowledge of technology status (e.g., mature, leading edge, bleeding edge, etc.), and use of an open architecture strategy in the system design. A system design based upon an open architecture is necessary to be able to easily take advantage of newer and better technologies.

The result of this activity is to establish and maintain a viable technological baseline during project development.

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5. Integration of the Systems Engineering Effort

"How will the process activities be brought together to assure an operational system?"

This section describes the planned integration activities leading to final project implementation. In illustration, this Section concentrates on what is needed to climb the right side of the VEE methodology (See Figure 1).

Integration is planned for and supported from the early concept phase of the systems engineering process with the formation of multi-disciplinary teams, described below. Application of the schedules and integration technical plans described in *2. Technical Planning and Control* will be described here.

An integrated team approach is critical to successful integration of products and other inputs (e.g., test plans) into a coordinated systems engineering effort that meets cost, schedule, and performance objectives. The steps toward ultimate system implementation include:

- Multi-disciplinary team organization
- Technology verifications
- Development test and evaluation
- Implementation of software designs for system end items
- Operations & maintenance sustainability and user training development

Multi-disciplinary team organization

Teamwork is the key! Multi-disciplinary teams are an integrated set of cross-functional teams (an overall team comprised of many smaller teams) given the appropriate resources and charged with the responsibility to define, develop, produce, and support a product and/or service. A basic principle is to get all disciplines involved at the beginning of the development process to ensure that requirements are completely stated and understood for the full life cycle. By using multi-disciplinary teams, the systems engineers still lead the requirements development process, but now more (all) disciplines participate in it. This includes the software designers and software/hardware component integrators if contracted separately by the Transportation Agency.

The Developer will describe how their organizational structure will support team formation, the composition of functional and subsystem teams, and the products each subsystem and higher-level team will support (e.g., teams organized to support a specific product in the Work Breakdown Structure). This team approach will address assessment and review of progress, traceability of technical changes, integration of data, configuration management, and risk management. Depending on the complexity of the project, this can mean a hierarchy of teams to address product development, product integration, and umbrella system integration and program issues.

The multi-disciplinary teams are partnerships between the agency stakeholders, the Developer and any sub-contractors or other contractors, and key areas of experts. They should be end-item oriented. In other words team members must focus on the overall project performance as well as the performance of their particular team.

For small, less complex projects, the entire staff constitutes a single team. In such cases, tailor this section to reflect that there is only one team for the project. The Developer's organizational structure should be able to bring together representatives from all relevant disciplines to one or more teams for the duration of their need.

Technology verifications

Technology solutions are verified using design analysis, design simulation, inspection, demonstration, and/or test. Required performance of all critical characteristics is verified by demonstration and test. Design analysis and simulation are used to complement, not replace demonstration and test.

Development test and evaluation

After completion of the total system, a formal system verification review is held by the agency stakeholders. The purpose of this review is to demonstrate that the total system has been verified to be compliant with the requirements in the configuration baselines. System verification testing is conducted following completion of integration testing.

Operations & maintenance sustainability and user training development

Consideration should be given to ongoing support to an existing system, preplanned system improvement, evolutionary development, or to support the developed system after it has been fielded. Describe how system faults will be addressed, user requests for support, and the level of support and resources to be provided.

6. Applicable Documents

This section will identify all the applicable and referenced documents that are required for the specific project. Referenced documents are those standards, specifications, and technical documents that are external to the project statement of work.

List by title, version number, and issue date. The order of precedence and availability of the documents should be stated. For example:

- *EIA Standard 632, Processes for Engineering a System, Version 1.0, April 28, 1998.*
- *In the event of conflict between this document and the contents of the project SOW, SOW shall be considered a superseding requirement. The document is available for purchase on the Internet at http://www.global.ihs.com.*

This will include the list of documents from the Request for Proposal. Identify any contractual and noncontractual provisions. This includes any international or American national standards, and government and industry directive documents applicable to the conduct of the tasks within the SEMP.

When the rest of the SEMP has been completed, go back to this section and cross off the documents that are not referenced in your SEMP, and add any documents referenced in your SEMP that weren't already on the list.

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7. Notes

(Background Information, Acronyms, abbreviations, glossary)

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