1 INTRODUCTION

The System Engineering Manual (SEM) is a "how to" guidebook. The SEM defines major System Engineering (SE) elements and establishes best practices regarding application of these elements to the National Airspace System (NAS). The SEM is a selected compilation of those proven practices within the SE domain that are deemed most appropriate to analysis, planning, design, acquisition, lifecycle support, and management of Federal Aviation Administration (FAA) programs.

There are many definitions of SE in textbooks, professional journals, and classrooms. The following definition has been selected for the SEM:

> *SE is a discipline that concentrates on the design and application of the whole (system) as distinct from the parts. It involves looking at a problem in its entirety, taking into account all the facets and all the variables and relating the social to the technical aspects.*

SE addresses translation of stakeholder needs into system requirements and facilitates the process by which the specification of systems and/or components satisfies those requirements. Although programs differ in underlying requirements, SE provides a logical sequence of steps toward deriving good requirements and transforming them into solutions regardless of the program's size or complexity. These steps generate a series of work products that specify characteristics of systems (at any level), demonstrate and document traceability to stakeholder needs (expressed or implied), and define how the requirements are validated and the systems (and associated components) are verified. To maximize effectiveness, SE commences before any significant product development activities and continues throughout the program's lifecycle. When performed correctly, SE helps to ensure that program execution is right from the start. Any problems are detected and resolved early. This process reduces program cost and risk.

1.1 Purpose

The primary purposes of this manual are to:

- Define the FAA's integrated practice of SE to be used by any engineer or group performing a task requiring an SE approach; by design, this practice is compatible with all components of the agency and consistent with sound government and industry best policies and guidelines
- Provide methods and tools that result in effective and consistent SE
- Identify competency areas for the effective practice of SE
- Supply detailed information on work products of SE activities that are needed to ensure uniform and consistent high-quality products
- Enable SE to participate in and support Program Management and its needs

1.2 Scope

The SEM describes 12 major SE elements as they are applied within the FAA. The SEM supports the Acquisition Management System (AMS) by identifying the proper application of SE elements in the AMS decision and acquisition processes. Figure 1.2-1 shows the 12 SE elements. A 13th element can be considered to be "Maintain Systems Engineering."

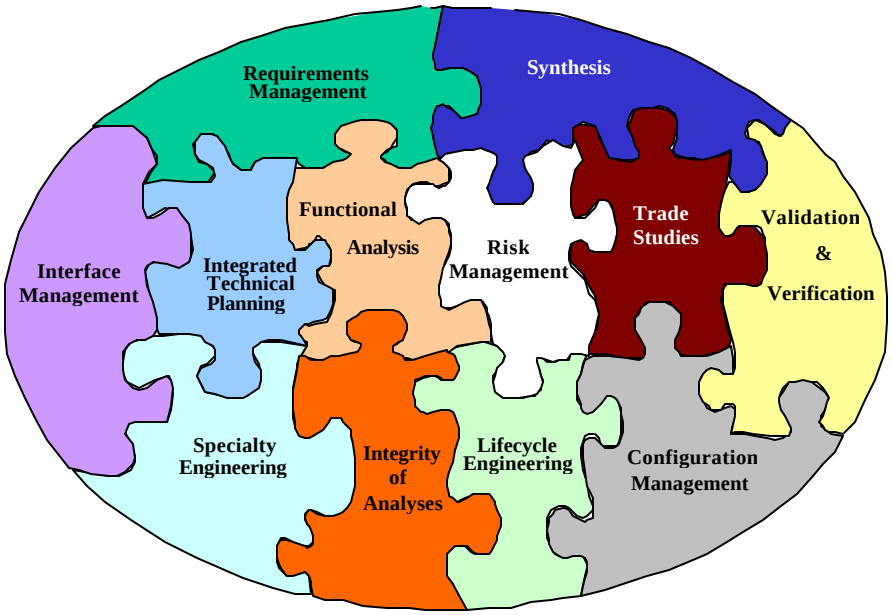

Figure 1.2-1. FAA System Engineering Elements

As a "how to" manual for SE, the SEM defines the constituent SE elements to be performed throughout the program lifecycle. The term "program" is intended to mean projects of all sizes and complexity, ranging from the National Airspace System (NAS) to individual parts. While the SEM is primarily directed at NAS modernization, it is recommended that individual programs tailor the application of processes, tools, and techniques according to program requirements. Further, implementation of these processes is to be directed by the appropriate program or SE management authority designated in the NAS System Engineering Management Plan (SEMP). The SEM includes guidance on tailoring (see Section 4.14, System Engineering Process Management).

The SEM defines the FAA SE elements as well as the work products generated from each SE element. The 12 (actually 13) elements appear in Table 1.2-1 along with each element's purpose or function. The 13th element listed provides for process management and maintenance of the other 12 elements.

Table 1.2-1. System Engineering Elements

System Engineering	Abbrev.	Purpose of Element
Integrated Technical Planning	ITP	Plans the SE efforts and products.
Requirements Management	RM	Identifies and manages the requirements that describe the desired characteristics of the system.
Functional Analysis	FA	Describes the functional characteristics (what the system needs to do) that are used to derive requirements.
Synthesis	SYN	Transforms requirements into physical solutions.
Trade Studies	TS	Assists decision making by analyzing and selecting the best-balanced solutions to requirements.
Interface Management	IM	Identifies and manages the interactions between segments within a system or interactions with other peer systems.
Specialty Engineering	SpecEng	Analyzes the system, requirements, functions, solutions, and/or interfaces using specialized skills and tools. Assists in derivation of requirements, synthesis of solutions, selection of alternatives, and validation and verification of requirements.
Integrity of Analyses	IA	Ensures that analyses provide the required level of fidelity and accuracy.
Risk Management	RSK	Identifies, analyzes, and manages the uncertainties of achieving program requirements by developing strategies to reduce the severity or likelihood of those uncertainties.
Configuration Management	CM	Establishes and maintains consistency and manages change in the system performance, functional, and physical attributes.
Validation and Verification	V&V	Validation determines if system requirements are correct. Verification determines that the solution meets the validated requirements.
Lifecycle Engineering	LCE	Identifies and manages requirements for system lifecycle attributes, including real estate management, deployment and transition, integrated logistics support, sustainment/technology evolution, and disposal.
Maintain System Engineering Process	MSE	Manages and maintains SE processes to meet FAA goals. Gains agency-wide skill and standardization by continuously improving the effectiveness and efficiency of SE processes and tools.

1.3 Organization of the Manual

In addition to the purpose, scope, and manual organization, Chapter 1 discusses the relationship between the SEM and SEMP, SE process descriptions, and the interaction between SE elements. Chapter 2 discusses the historical background and context for the practice of SE. Chapter 3 describes the relationship between the SEM and each phase of the FAA AMS. Chapter 4 contains individual sections that discuss in detail each major SE element and interrelationships among the elements. Also included is a correlation between each SE element (with its associated Chapter 4 paragraph number) and the reference to the associated section of the FAA integrated Capability Maturity Model (iCMM) (e.g., SEM 4.12; iCMM PA 08) and/or Electronics Industries Alliance (EIA)-731.1 (e.g., SEM 4.2; EIA-731 Functional Area 2.1).

The following appendices are included:

- Appendix A: Acronyms and Abbreviations
- Appendix B: System Engineering Manual Glossary
- Appendix C: System Engineering Technical Reviews and Associated Checklists
- Appendix D: Concerns and Issues
- Appendix E: Integrated Technical Planning Details
- Appendix F: Enterprise Architecture and Associated System Engineering Processes and Products

1.4 Relationship Between the SEM and the SEMP

The SEM and SEMP are designed to work together. The SEM answers SE questions related to what, how, and when, while the SEMP answers SE questions related to what, who, when, and why (i.e., why a particular organization or program is implementing or not implementing a particular SE element versus the SEM discussion regarding an SE element's purpose). The "what," or products and activities of SE, directly connects the SEM and SEMP, and the "when" provides a secondary correlation. Figure 1.4-1 portrays this relationship between the SEM and SEMP.

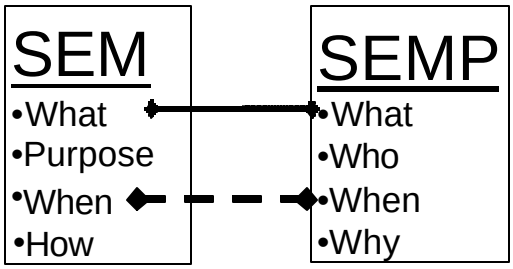

Figure 1.4-1. Relationship Between the SEM and the SEMP

1.5 System Engineering Process Descriptions

The SE process descriptions in Chapter 4 include the following information:

- **Process Definition.** This narrative discusses the function for the process (what to do). The purpose for carrying out the specific SE process and a description of the specific SE process are included. Program implementers may use this information to tailor specific activities to align them with the development events of the program.
- **Process-Based Management (PBM) Charts.** Each SE element section in Chapter 4 uses PBM charts to describe the SE element process. The PBM charts indicate the major steps of the SE process; inputs to the process and associated providers; possible outputs generated; and associated product customers (from an SE view). The SEM also identifies the supplying (inputs) and using (outputs) processes that are used during process implementation to establish program communication, documentation, and review activities.

The granularity of both input and output products depends on the phase of the AMS lifecycle to which the particular SE element being discussed is applied. For example, Synthesis results are emphasized more in Solution Implementation than during Mission Analysis.

The process descriptions consist of all aspects of each SE process, including the need to design for safety, security, affordability, performance, usability, operational suitability, and cost of ownership. On some programs, a given activity may be performed informally (e.g., in an engineer's notebook) or formally with interim products under formal baseline control.

Each SE process includes these major workflow tasks, which are also shown on the PBM charts.

- **How To Do It.** The SEM discusses specific approaches or techniques for implementing each SE process and provides guidance for selecting the right approach for a given program phase. It summarizes the key points, focusing on the "what" and "when," as well as the "how."
- **Inputs.** These include information from external sources or other processes that initiate the process or are received during the conduct of the process.
- **Outputs.** These include information developed during the process and by conducting the process.
- **Beginning Boundary Task (Entrance Criteria).** This is what is required to start the process.
- **Ending Boundary Task (Exit Criteria).** This is what is required to complete the process and allow legitimate exit from the process.
- **Metrics.** These include examples of metrics for measuring the level of performance for the process, as well as the work products generated by the process.
- **Methods/Tools.** This category includes specific tools or methods that are necessary (or desirable) to efficiently implement the process as described. It also lets the user know what is available within the AMS FAA Acquisition System Toolset (http://fast.faa.gov/).
- **Examples.** These include both SE work products and the standard templates for producing the SE work products. Examples may be contained either within a particular section of Chapter 4, an appendix to the SEM, or on the FAA's intranet, in which case a reference Web address is provided.

- **References.** This subsection includes documents from the government, industry, and academia that cover relevant topics regarding that section.

1.6 Process-Based Management and System Engineering

It is very difficult to develop a generic, top-level process model that reflects all interactions among the processes for the SE elements shown in Table 1.2-1 above. The interactions and iterations between the SE elements may be different depending on the program under consideration. Chapter 3 contains a definition of the SE milestones and interactions with each of the major phases of the AMS (i.e., Mission Analysis, Investment Analysis, Solution Implementation, In-service Management, and Disposal). In addition, Chapter 3 Figure 3.1-2, System Engineering Functional N-Squared (N^2) Diagram, contains an N^2 diagram that depicts the interrelationships, inputs, outputs, and products from the related processes.