CHAPTER 3

SYSTEMS ENGINEERING PROCESS OVERVIEW

3.1 THE PROCESS

The Systems Engineering Process (SEP) is a comprehensive, iterative and recursive problem solving process, applied sequentially top-down by integrated teams. It transforms needs and requirements into a set of system product and process descriptions, generate information for decision makers, and provides input for the next level of development. The process is applied sequentially, one level at a time, adding additional detail and definition with each level of development. As shown by Figure 3-1, the process includes: inputs and outputs; requirements analysis; functional analysis and allocation; requirements loop; synthesis; design loop; verification; and system analysis and control.

Systems Engineering Process Inputs

Inputs consist primarily of the customer's needs, objectives, requirements and project constraints.

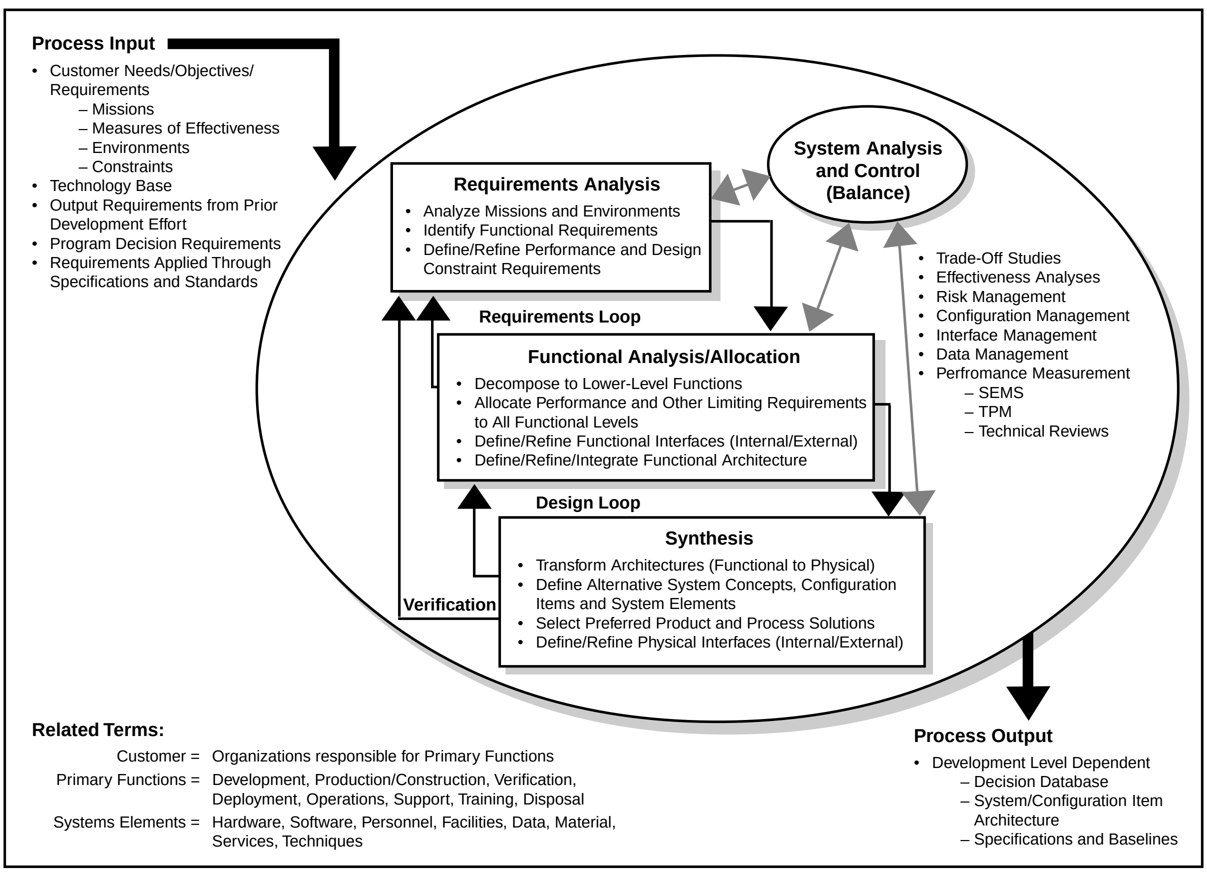

Figure 3-1. The Systems Engineering Process

Inputs can include, but are not restricted to, missions, measures of effectiveness, environments, available technology base, output requirements from prior application of the systems engineering process, program decision requirements, and requirements based on "corporate knowledge."

Requirements Analysis

The first step of the Systems Engineering Process is to analyze the process inputs. Requirements analysis is used to develop functional and performance requirements; that is, customer requirements are translated into a set of requirements that define what the system must do and how well it must perform. The systems engineer must ensure that the requirements are understandable, unambiguous, comprehensive, complete, and concise.

Requirements analysis must clarify and define functional requirements and design constraints. Functional requirements define quantity (how many), quality (how good), coverage (how far), time lines (when and how long), and availability (how often). Design constraints define those factors that limit design flexibility, such as: environmental conditions or limits; defense against internal or external threats; and contract, customer or regulatory standards.

Functional Analysis/Allocation

Functions are analyzed by decomposing higher-level functions identified through requirements analysis into lower-level functions. The performance requirements associated with the higher level are allocated to lower functions. The result is a description of the product or item in terms of what it does logically and in terms of the performance required. This description is often called the functional architecture of the product or item. Functional analysis and allocation allows for a better understanding of what the system has to do, in what ways it can do it, and to some extent, the priorities and conflicts associated with lower-level functions. It provides information essential to optimizing physical solutions. Key tools in functional analysis and allocation are Functional Flow Block Diagrams, Time Line Analysis, and the Requirements Allocation Sheet.

Requirements Loop

Performance of the functional analysis and allocation results in a better understanding of the requirements and should prompt reconsideration of the requirements analysis. Each function identified should be traceable back to a requirement. This iterative process of revisiting requirements analysis as a result of functional analysis and allocation is referred to as the requirements loop.

Design Synthesis

Design synthesis is the process of defining the product or item in terms of the physical and software elements which together make up and define the item. The result is often referred to as the physical architecture. Each part must meet at least one functional requirement, and any part may support many functions. The physical architecture is the basic structure for generating the specifications and baselines.

Design Loop

Similar to the requirements loop described above, the design loop is the process of revisiting the functional architecture to verify that the physical design synthesized can perform the required functions at required levels of performance. The design loop permits reconsideration of how the system will perform its mission, and this helps optimize the synthesized design.

Verification

For each application of the system engineering process, the solution will be compared to the requirements. This part of the process is called the verification loop, or more commonly, Verification. Each requirement at each level of development must be verifiable. Baseline documentation developed during the systems engineering process must establish the method of verification for each requirement.

Appropriate methods of verification include examination, demonstration, analysis (including modeling and simulation), and testing. Formal test and evaluation (both developmental and operational) are important contributors to the verification of systems.

Systems Analysis and Control

Systems Analysis and Control include technical management activities required to measure progress, evaluate and select alternatives, and document data and decisions. These activities apply to all steps of the sysems engineering process.

System analysis activities include trade-off studies, effectiveness analyses, and design analyses. They evaluate alternative approaches to satisfy technical requirements and program objectives, and provide a rigorous quantitative basis for selecting performance, functional, and design requirements. Tools used to provide input to analysis activities include modeling, simulation, experimentation, and test.

Control activities include risk management, configuration management, data management, and performance-based progress measurement including event-based scheduling, Technical Performance Measurement (TPM), and technical reviews.

The purpose of Systems Analysis and Control is to ensure that:

- Solution alternative decisions are made only after evaluating the impact on system effectiveness, life cycle resources, risk, and customer requirements,
- Technical decisions and specification requirements are based on systems engineering outputs,
- Traceability from systems engineering process inputs to outputs is maintained,
- Schedules for development and delivery are mutually supportive,
- Required technical disciplines are integrated into the systems engineering effort,
- Impacts of customer requirements on resulting functional and performance requirements are examined for validity, consistency, desirability, and attainability, and,
- Product and process design requirements are directly traceable to the functional and performance requirements they were designed to fulfill, and vice versa.

Systems Engineering Process Output

Process output is dependent on the level of development. It will include the decision database, the system or configuration item architecture, and the baselines, including specifications, appropriate to the phase of development. In general, it is any data that describes or controls the product configuration or the processes necessary to develop that product.

3.2 SUMMARY POINTS

- The system engineering process is the engine that drives the balanced development of system products and processes applied to each level of development, one level at a time.
- The process provides an increasing level of descriptive detail of products and processes with each system engineering process application. The output of each application is the input to the next process application.