SUPPLEMENT A

A PROCEDURE FOR REQUIREMENTS ANALYSIS

The following section provides a list of tasks that represents a plan to analyze requirements. Part of this notional process is based on the 15 requirements analysis tasks listed in IEEE P1220. This industry standard and others should be consulted when preparing engineering activities to help identify and structure appropriate activities.

As with all techniques, the student should be careful to tailor; that is, add or subtract, as suits the particular system being developed. Additionally, these tasks, though they build on each other, should not be considered purely sequential. Every task contributes understanding that may cause a need to revisit previous task decisions. This is the nature of all System Engineering activities.

Preparation: Establish and Maintain Decision Database

When beginning a systems engineering process, be sure that a system is in place to record and manage the decision database. The decision database is a historical database of technical decisions and requirements for future reference. It is the primary means for maintaining requirements traceability. This database decision management system must be developed or the existing system must be reviewed and upgraded as necessary to accommodate the new stage of product development. A key part of this database management system is a Requirements Traceability Matrix that maps requirements to subsystems, configuration items, and functional areas.

This must be developed, updated, and reissued on a regular basis. All requirements must be recorded. ***Remember: If it is not recorded, it cannot be an approved requirement!***

The Fifteen Tasks of IEEE P1220

The IEEE Systems Engineering Standard offers a process for performing Requirements Analysis that comprehensively identifies the important tasks that must be performed. These fifteen task areas to be analyzed follow and are shown in Figure 4-3.

1. Customer expectations
2. Project and enterprise constraints
3. External constraints
4. Operational scenarios
5. Measures of Effectiveness (MOEs)
6. System boundaries
7. Interfaces
8. Utilization environments
9. Life cycle process concepts
10. Functional requirements
11. Performance requirements
12. Modes of operation
13. Technical performance measures
14. Physical characteristics
15. Human systems integration

Figure 4-3. IEEE P1220 Requirements Analysis Task Areas

Task 1. Customer Expectations

Define and quantify customer expectations. They may come from any of the eight primary functions, operational requirements documents, mission needs, technology-based opportunity, direct communications with customer, or requirements from a higher system level. The purpose of this task is to determine what the customer wants the system to accomplish, and how well each function must be accomplished. This should include natural and induced environments in which the product(s) of the system must operate or be used, and constraints (e.g. funding, cost, or price objectives, schedule, technology, non-developmental and reusable items, physical characteristics, hours of operation per day, on-off sequences, etc.).

Task 2. Project and Enterprise Constraints

Identify and define constraints impacting design solutions. Project specific constraints can include:

- Approved specifications and baselines developed from prior applications of the Systems Engineering Process,
- Costs,
- Updated technical and project plans,
- Team assignments and structure,
- Control mechanisms, and
- Required metrics for measuring progress.

Enterprise constraints can include:

- Management decisions from a preceding technical review,
- Enterprise general specifications,
- Standards or guidelines,
- Policies and procedures,
- Domain technologies, and
- Physical, financial, and human resource allocations to the project.

Task 3. External Constraints

Identify and define external constraints impacting design solutions or implementation of the Systems Engineering Process activities. External constraints can include:

- Public and international laws and regulations,
- Technology base,
- Compliance requirements: Industry, international, and other general specifications, standards, and guidelines which require compliance for legal, interoperability, or other reasons,
- Threat system capabilities, and
- Capabilities of interfacing systems.

Task 4. Operational Scenarios

Identify and define operational scenarios that scope the anticipated uses of system product(s). For each operational scenario, define expected:

- Interactions with the environment and other systems, and
- Physical interconnectivities with interfacing systems, platforms, or products.

Task 5. Measures of Effectiveness and Suitability (MOE/MOS)

Identify and define systems effectiveness measures that reflect overall customer expectations and satisfaction. MOEs are related to how well the system must perform the customer's mission. Key MOEs include mission performance, safety, operability, reliability, etc. MOSs are related to how well the system performs in its intended environment and includes measures of supportability, maintainability, ease of use, etc.

Task 6. System Boundaries

Define system boundaries including:

- Which system elements are under design control of the performing activity and which fall outside of their control, and
- The expected interactions among system elements under design control and external and/or higher-level and interacting systems outside the system boundary (including open systems approaches).

Task 7. Interfaces

Define the functional and physical interfaces to external or higher-level and interacting systems, platforms, and/or products in quantitative terms (include open systems approach). Functional and physical interfaces would include mechanical, electrical, thermal, data, control, procedural, and other interactions. Interfaces may also be considered from an internal/external perspective. Internal interfaces are those that address elements inside the boundaries established for the system addressed. These interfaces are generally identified and controlled by the contractor responsible for developing the system. External interfaces, on the other hand, are those which involve entity relationships outside the established boundaries, and these are typically defined and controlled by the government.

Task 8. Utilization Environments

Define the environments for each operational scenario. All environmental factors (natural or induced) which may impact system performance must be identified and defined. Environmental factors include:

- Weather conditions (e.g. rain, snow, sun, wind, ice, dust, fog),
- Temperature ranges,
- Topologies (e.g. ocean, mountains, deserts, plains, vegetation),
- Biological (e.g. animal, insects, birds, fungi),
- Time (e.g. day, night, dust), and
- Induced (e.g. vibration, electromagnetic, chemical).

Task 9. Life Cycle Process Concepts

Analyze the outputs of tasks 1-8 to define key life cycle process requirements necessary to develop, produce, test, distribute, operate, support, train, and dispose of system products under development. Use integrated teams representing the eight primary functions. Focus should be on the cost drivers and higher risk elements that are anticipated to impact supportability and affordability over the useful life of the system.

Task 10. Functional Requirements

Define what the system must accomplish or must be able to do. Functions identified through requirements analysis will be further decomposed during functional analysis and allocation.

Task 11. Performance Requirements

Define the performance requirements for each higher level function performed by the system. Primary focus should be placed on performance requirements that address the MOEs, and other key performance parameters established in test plans or identified as interest items by oversight authorities.

Task 12. Modes of Operation

Define the various modes of operation for the system products under development. Conditions (e.g. environmental, configuration, operational, etc.) that determine the modes of operation should be included in this definition.

Task 13. Technical Performance Measures (TPMs)

Identify the key indicators of system performance that will be tracked during the design process.

Selection of TPMs should be limited to critical technical thresholds and goals that, if not met, put the project at cost, schedule, or performance risk. TPMs involve tracking the actual versus planned progress of key performance parameters such that the manager can make judgments about technical progress on a by-exception basis. To some extent TPM selection is phase dependent. They must be reconsidered at each systems engineering process step and at the beginning of each phase.

Task 14. Physical Characteristics

Identify and define required physical characteristics (e.g. color, texture, size, weight, buoyancy) for the system products under development. Identify which physical characteristics are true constraints and which can be changed, based on trade studies.

Task 15. Human Factors

Identify and define human factor considerations (e.g. physical space limits, climatic limits, eye movement, reach, ergonomics) which will affect operation of the system products under development. Identify which human systems integration are constraints and which can be changed based on trade studies.

Follow-on Tasks

The follow-on tasks are related to the iterative nature of the Systems Engineering Process:

Integrate Requirements:

Take an integrated team approach to requirements determination so that conflicts among and between requirements are resolved in ways that result in design requirements that are balanced in terms of both risk and affordability.

Validate Requirements:

During Functional Analysis and Allocation, validate that the derived functional and performance can be traced to the operational requirements.

Verify Requirements:

- Coordinate design, manufacturing, deployment and test processes,
- Ensure that requirements are achievable and testable,
- Verify that the design-to-cost goals are achievable, and
- Verify that the functional and physical architectures defined during Functional Analysis/ Allocation and Synthesis meet the integrated technical, cost, and schedule requirements within acceptable levels of risk.