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MIL-STD-499B
(Date)

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(Project MISC-0151)

Superseding
MIL-STD-499A
1 May 1974

DRAFT

MILITARY STANDARD

SYSTEMS ENGINEERING

DRAFT

MIL-STD-499B
Joint OSD/Services/Industry Working Group
7 Sept 93

AMSC
Mil-Std-499B 2.50T

AREA MISC

FOREWORD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense and may be used by other government and commercial organizations.

2. Send comments and pertinent data for improving this standard to HQ AFMC/EN, 4375 Chidlaw Rd Suite 6, WPAFB OH 45433-5006. A self-addressed Standardization Document Improvement Proposal (DD Form 1426) appears at the end of this standard. (## ADD DD Form 1426)

3. The intent of this standard is to assist in defining, performing, managing, and evaluating systems engineering efforts in defense system acquisitions and technology developments. The scope and requirements of systems engineering are defined in terms of what should be done, not how to do it. As a result, the systems engineering activities to manage are defined, not how to manage them.

4. This standard defines an executable systems engineering process and required systems engineering efforts. In doing this, it implements DoD policy on systems engineering to: apply systems engineering throughout the system life cycle; provide a comprehensive, iterative technical process as the basis for integration of all technical efforts; and, meet cost, schedule and performance objectives with an optimal system solution encompassing both products and processes. The process is applicable in any phase of an effort and for any size or complexity of an effort.

5. This standard provides the technical foundation for integrating product and process development by requiring: the simultaneous development of system products and life-cycle processes to satisfy user needs; multidisciplinary teamwork; and a systems engineering approach. The Systems Engineering Management Plan (SEMP) describes the implementation of these by each organization with technical responsibilities. The intended use of the SEMP is to coordinate and integrate all technical plans and planning, by developing and formalizing the SEMP prior to technical effort execution, using the SEMP in executing the effort, and maintaining the SEMP for the duration of the effort. The SEMP is structured to facilitate its application contractually as an alternative to placing this standard on contract as a means to execute systems engineering. This approach is in concert with DoD acquisition streamlining policy.

6. This standard provides the process to leverage development techniques including streamlined management approaches (e.g., use of Non-Developmental and Military or Commercial Off-The-Shelf items) and commercial leveraging options (e.g., Dual Use Technologies). These leveraged approaches are enabled by emphasizing a performance-based approach to system requirements and then identifying/defining/designing candidate solution alternatives that best satisfy those requirements. Preferred solutions are identified based on cost, schedule, performance, and risk.

7. This standard governs the conduct of a complete, integrated technical effort (systems engineering), not the organizational entity or method of implementation. The organization of resources employed to implement this standard is expected to vary from one program implementation to another.

8. This standard integrates the entire technical effort represented by the set of required standards, but does not replace them. Each program implementation will employ other standards to satisfy program requirements and to comply with DoD policy. It is the Program Manager's responsibility to select and tailor those standards which are necessary to execute the program successfully.

9. This standard must be conscientiously tailored to ensure that only necessary and appropriate requirements are cited in defense solicitations and contracts. Tailoring guidance can be found in MIL-HDBK-248, Acquisition Streamlining, and in paragraph 6.3 of this document.

CONTENTS

1. SCOPE

This standard defines a total system approach for the development of defense systems. The standard requires: establishing and implementing a structured, disciplined, and documented systems engineering effort incorporating the systems engineering process; multidisciplinary teamwork; and the simultaneous development of the products and processes needed to satisfy operational needs. The systems engineering process is defined generically to facilitate broad application. Additionally, this standard defines the requirements for technical reviews. The tasks in this standard provide a methodology for evaluating progress in achieving system objectives.

This standard applies to all acquisition and support phases to provide a comprehensive, structured, and disciplined approach to new system product and process developments, to upgrades, to modifications, and to engineering efforts conducted to resolve problems in fielded systems. This standard is applicable to technical efforts in support of the advancement and development of new technologies and their application. It applies to large and small scale systems; to single or multiple procurements; and to the replacement of current products and processes. The standard is applicable to both hardware and software dominant systems. This document should be tailored for effective and efficient program implementation.

1.1 Background. The systems engineering process is applied iteratively throughout the system life cycle to translate stated problems into design requirements, providing an integrated system solution consisting of people, products, and processes that provides a capability to satisfy customer needs (see Figure 1). Problems are normally expressed in terms of needs for new developments and modifications or, as deficiencies in operating, supporting, or providing training for, already-fielded items. Performance-based requirements and alternative solutions to problems are iteratively defined and refined. Solutions may employ existing, limited development, or emerging technologies transitioned from the technology base to product and process applications. Where needed, a technology transition approach is established, implemented and controlled. Transition criteria and implementation methods (what, when, to whom, by whom) are defined cooperatively by the tasking and performing activities (see 1.2.2) and include definition of an acceptable level of maturity for all life cycle products and processes. Selection of preferred solutions is based on cost, schedule, performance, and risk. Technical risk management is integral to the process and includes the identification, quantification, impact assessment, and implementation of mitigation measures throughout the acquisition cycle. A comprehensive, responsive verification effort is implemented to ensure that designs satisfy requirements. Progressive verification from individual pieces of the solution (system elements) up through the total system is required. This structured and disciplined process is applied across the eight primary system functions (characteristic actions spanning life cycle requirements) to define and select solutions that optimally solve the problem from a life-cycle perspective, that is, life-cycle-balanced solutions (see Figure 2).

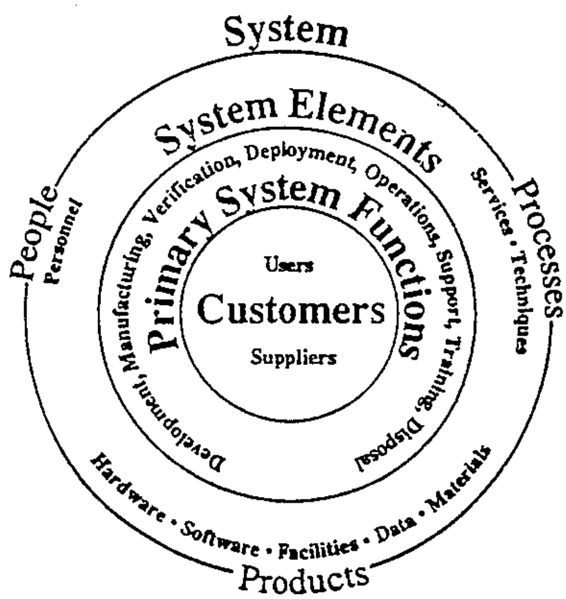

FIGURE 1. Key Terms

1.2 Application Guidance. This standard applies to pre-milestone 0 activities, Concept Exploration and Definition, Demonstration and Validation, Engineering and Manufacturing Development, Production and Deployment, and Operations and Support acquisition phases. This standard applies to all tasking and performing activities. It can be used by the tasking activity to assist in systems engineering planning (in terms of the required systems engineering efforts), as well as the performing activity's planning function (in terms of a responsive proposal and implementation plan).

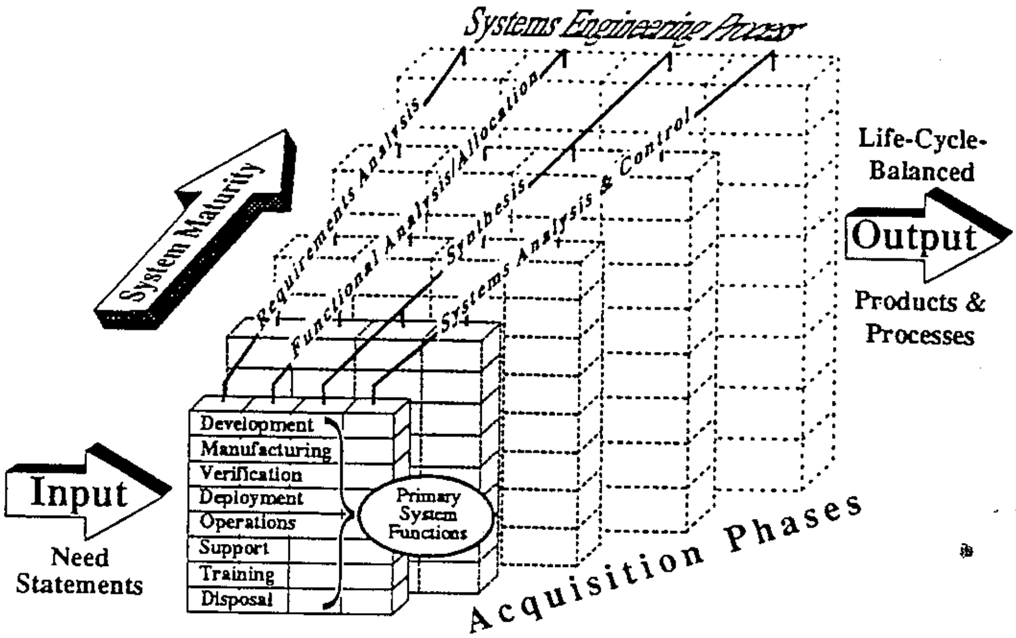

FIGURE 2. Systems Engineering Life-Cycle Application

1.2.1 Usage of "configuration item". Throughout this standard, the term configuration item (CI) refers to any type of configuration item (hardware, firmware, software, their aggregation, or any discrete portions). When a requirement applies to a specific type of CI, the limiting designation is used (e.g., computer software configuration item or CSCI).

1.2.2 Usage of "Tasking and Performing Activities". Throughout this standard, the term "tasking activity" refers to the organization requiring the technical effort. The term "performing activity" refers to that organization doing the technical effort.

1.2.3 Usage of "program". Throughout this standard, the term "program" is used generically to include programs or projects for which systems engineering is tasked or performed.

1.3 Order of Precedence. Application of this document integrates the entire technical effort. In the event of a conflict between the requirements of this standard and other applicable standardization documents, the conflict must be resolved. Figures in this standard are for example only. If there is a conflict between the text and the figures, the text applies.

2. APPLICABLE DOCUMENTS

This section is not applicable to this standard (no documents are referenced in Sections 3, 4, or 5).

3. DEFINITIONS

A glossary of essential definitions for systems engineering is contained in Appendix A.

4. GENERAL REQUIREMENTS

This section defines the systems engineering tasks that are generally applicable throughout the system life cycle for any program, new development, upgrade, modification, resolution of deficiencies, or development and exploitation of technology.

4.1 Systems Engineering Planning Implementation. For each application of this standard:

a. All technical execution and management efforts shall be integrated in conformance with the systems engineering process. Technical tasks, including task requirements of other standardization documents cited for contractual application, shall be integrated to yield a single and complete process that focuses all activities on the common objective. The planning and execution of required tasks shall demonstrate multidisciplinary teamwork whereby all appropriate technical disciplines are applied to satisfy identified needs. The integrated technical effort shall be reflected in the Systems Engineering Management Plan (SEMP), the Systems Engineering Master Schedule (SEMS), and the Systems Engineering Detailed Schedule (SEDS).

b. The performing activity shall develop a SEMP representing the agreed-to tailoring of this standard that describes required systems engineering tasks and the plans for their execution. The performing activity shall execute the systems engineering effort in accordance with the contractual SEMP. The performing activity shall maintain and update the SEMP.

c. The performing activity shall develop a SEMS for contractual implementation.

d. The performing activity shall develop a SEDS to support the SEMS. The performing activity shall maintain the SEDS for currency as detailed, time dependent tasks evolve and to support changes in the SEMS. Changes to the SEDS shall be within the current scope of the SEMS. Normally, an initial version of the SEDS accompanies the performing activity's proposal and it is finalized and maintained during contract execution. (see 6.2)

e. The performing activity shall extend the Work Breakdown Structure (WBS) developed by the tasking activity to the level necessary to complete contractual requirements. The performing activity has the flexibility to extend the contract WBS (derived from the tasking activity-developed program WBS) below the reporting requirement to reflect how the work is to be accomplished consistent with program risk.

4.2 Systems Engineering Input. The process input is the set of information necessary to support initiation of a new phase of technical effort (includes new or updated customer needs, technology base data, outputs from a previous phase, and program constraints). The performing activity shall notify the tasking activity of needed technical input information, why it is needed, and when it is needed. The tasking activity will inform the performing activity which information will not be provided, and must therefore be generated in the phase.

4.2.1 Technical Objectives. When lacking sufficient data to establish requirements, technical objectives shall be used to provide a basis for defining and trading off relationships among need, urgency, costs, risks, and worth. Technical objectives identified should assist in converging on a system solution, focus on factors critical to success, and offer substantial capability payoffs for resources expended. The performing activity shall:

a. identify needed technical objectives, with rationale;

b. develop metrics and success criteria to ensure that increases in system capabilities are cost effective when technical objectives are established for capabilities beyond requirements; and

c. use critical technical objectives in technical performance measurement.

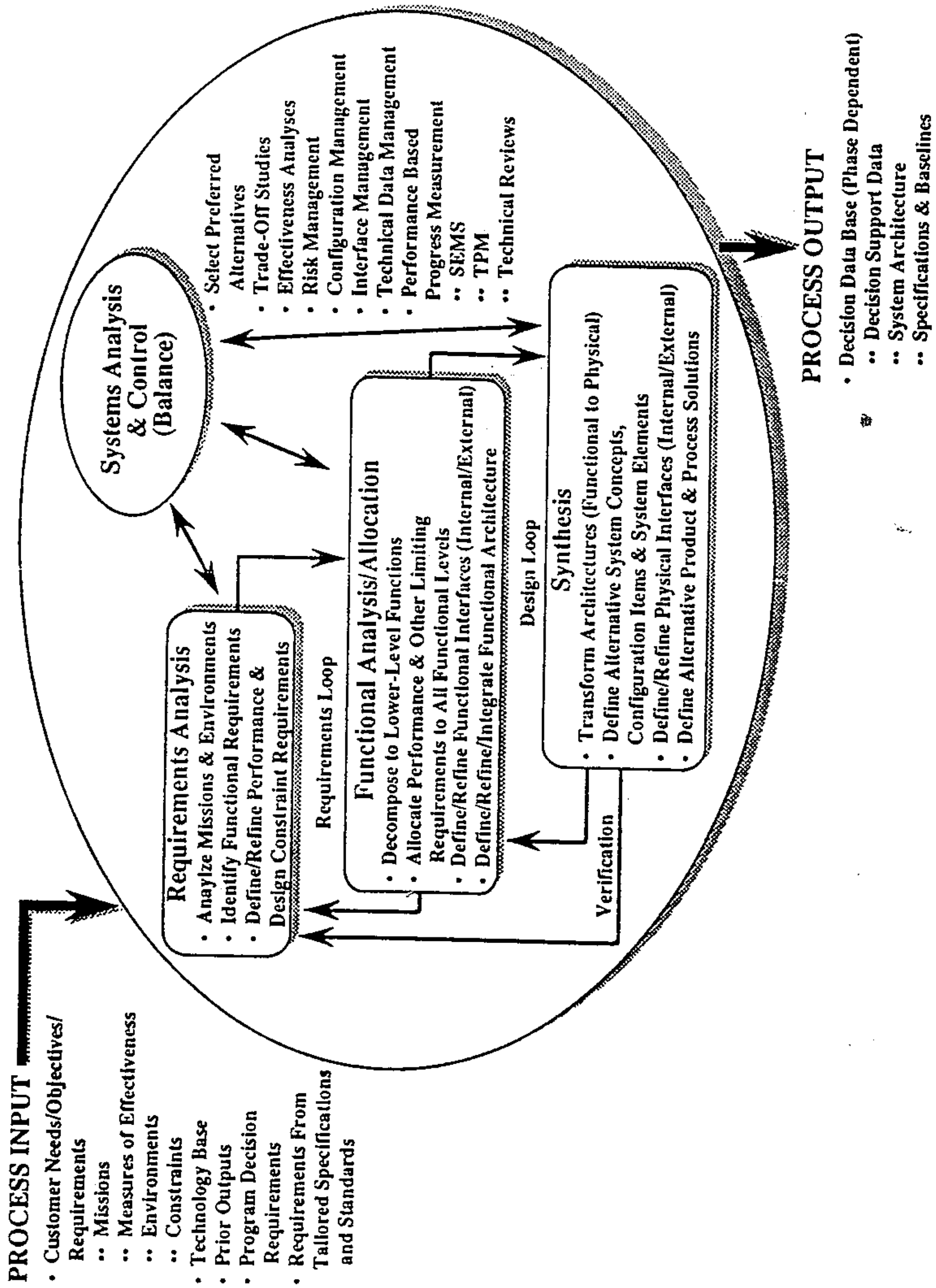

FIGURE 3. The Systems Engineering Process

4.3 Systems Engineering Process Requirements. The performing activity shall employ the systems engineering process of requirements analysis, functional analysis/allocation, synthesis, and systems analysis and control (Figure 3) progressively throughout the effort to achieve contractual objectives and to define requirements, designs, and solutions for the system life cycle.

4.3.1 Requirements Analysis. The performing activity shall analyze customer needs, objectives, and requirements in the context of customer missions, utilization environments, and identified system characteristics to determine functional and performance requirements for each primary system function. Prior analyses shall be reviewed and updated, refining mission and environment definitions to support system definition. Requirements analysis shall be conducted iteratively with functional analysis to develop requirements that depend on additional system definition (e.g., other system items, performance requirements for identified functions) and verify that people, product, and process solutions (from synthesis) can satisfy customer requirements. In conducting requirements analysis, the performing activity shall:

a. assist in refining customer objectives and requirements;
b. define initial performance objectives and refine them into requirements;
c. identify and define constraints that limit solutions (e.g., missions and utilization environments or adverse impacts on natural and human environments); and
d. define functional and performance requirements based on customer provided measures of effectiveness. When measures of effectiveness are not provided at the level of detail needed, the performing activity shall develop and use a set of measures of effectiveness relating to customer missions; utilization environments; needs, requirements, and objectives; and design constraints.

4.3.1.1 Requirements. Functional requirements identified in requirements analysis and as process inputs shall be used as the top-level functions for functional analysis. Performance requirements shall be:

a. interactively developed across all identified functions based on system life cycle factors; and
b. characterized in terms of the degree of certainty in their estimate, the degree of criticality to system success, and their relationship to other requirements.

4.3.2 Functional Analysis/Allocation. The performing activity shall define and integrate a functional architecture to the depth needed to support synthesis of solutions for people, products, and processes and management of risk. Functional analysis/allocation shall be conducted iteratively:

a. to define successively lower-level functions required to satisfy higher level functional requirements and to define alternative sets of functional requirements;
b. with requirements analysis to define mission and environment driven performance and to determine that higher level requirements are satisfied;
c. to flowdown performance requirements and design constraints; and
d. with synthesis to define and refine feasible solution alternatives which meet requirements and to place derived requirements into the functional architecture.

4.3.2.1 Functional Analysis. Identified functional requirements shall be analyzed to determine the lower level functions required to accomplish the parent requirement. All specified usage modes shall be included in the analysis. Functional requirements shall be arranged so that lower level functional requirements are recognized as part of higher level requirements. When time is critical to performance or sequencing of functions a time-line analysis shall be conducted. Functional requirements shall be logically sequenced; with input, output, and functional interface (internal and external) requirements defined; and be traceable from beginning to end conditions, and across their interfaces.

4.3.2.2 Allocation. The performing activity shall successively (highest to lowest level) establish performance requirements for each functional requirement and interface. Time requirements that are prerequisite for a function or set of functions shall be determined and allocated. The resulting set of requirements shall be defined in measurable terms, applicable go/no-go criteria, and in sufficient detail for use as design criteria. Performance requirements shall be traceable throughout the functional architecture, through the analysis by which they were allocated, to the higher-level requirement they are intended to fulfill.

4.3.3 **Synthesis.** The performing activity shall define and design solutions for each logical set of functional and performance requirements in the functional architecture and integrate them as a physical architecture. The performing activity shall conduct synthesis iteratively with functional analysis/ allocation to define a complete set of functional and performance requirements necessary for the level of design output required. Requirements analysis shall be used to verify that solution outputs can satisfy customer input requirements. The performing activity shall:

a. determine the completeness of functional and performance requirements for the design and derive any additional requirements needed for completeness in terms of function and performance;
b. define internal and external physical interfaces including required function and performance and ensure that requirements are integrated and verifiable across interfaces;
c. identify critical parameters, analyze their variability and solution sensitivity to the variability;
d. define people, product, and processes alternatives (including the concepts, techniques, and procedural data applicable to each of the primary system functions) as well as required allowances for tolerances and variabilities for those alternatives;
e. define system, configuration item, and system element solutions to a level of detail that enables verification that required accomplishments have been met; and
f. translate the architecture into a work breakdown structure, specification tree, specifications, and configuration baselines.

4.3.3.1 **Design.** The outputs from synthesis shall describe the complete system, including the interfaces and relationships between internal and external items. The performing activity shall:

a. develop the information for establishing and updating applicable functional, allocated, and product baselines; system, CI, process, and material specifications including commercial item descriptions; drawings and lists; interface control documentation; technical plans; life cycle resource requirements; procedural handbooks and instructional materials; and documentation of personnel task loading;
b. apply design simplicity concepts, evaluating alternatives for factors such as ease of access, ready disassembly, common and non-complex tools, decreased parts counts, modularity, producibility (e.g., ready assembly), standardization, and less demanding cognitive skills;
c. demonstrate design consistency with results from risk reduction efforts; and
d. establish and control correlation among interdependent and functionally related elements.

4.3.3.2 **Design Verification.** The performing activity shall progressively verify that product and process designs satisfy their requirements (including interfaces) from the lowest level of the current physical architecture up to the total system and can be implemented.

4.3.4 **Systems Analysis and Control.** The performing activity shall measure progress, evaluate alternatives, select preferred alternatives, and document data and decisions used and generated. Systems analyses shall include trade-off studies, effectiveness analyses and assessments, and design analyses to determine progress in satisfying technical requirements and program objectives, and to provide a rigorous quantitative basis for performance, functional, and design requirements. Control mechanisms shall include risk management, configuration management, data management, and performance-based progress measurement including the SEMS, Technical Performance Measurement (TPM), and technical reviews. The performing activity shall implement systems analysis and control to ensure that:

a. decisions on solution alternatives are made only after evaluating their impact on system effectiveness, life cycle resources, risk, and customer requirements. The performing activity shall identify those alternatives which would provide improved system effectiveness or costs when compared with those based on contract requirements;
b. technical decisions and system-unique specification requirements are based on systems engineering outputs and results of decisions documented;
c. traceability from process inputs to outputs is maintained, including changes in requirements;
d. schedules for the development and delivery of products and processes are mutually supportive;
e. technical disciplines and disciplinary efforts are integrated into the systems engineering effort;
f. impacts of customer requirements on resulting functional and performance requirements are examined for validity, consistency, desirability, and attainability with respect to technology availability, physical and human resources, human performance capabilities, life cycle costs,

schedule, risk, applicable statutes, contractually designated hazardous material lists, and other identified constraints. This examination shall either confirm existing requirements or require the determination of more appropriate requirements for the system; and

g. product and process design requirements shall be directly traceable to the functional and performance requirements they were designed to fulfill, and vice versa.

4.3.4.1 **Trade-off Studies.** Desirable and practical trade-offs among user requirements, technical objectives, design, program schedule, functional and performance requirements, and life cycle costs shall be identified and conducted. Trade-off studies shall be defined, conducted, and documented at the various levels of the functional or physical architecture in enough detail to support decision making. The level of detail of each study shall be commensurate with cost, schedule, performance, and risk impacts.

4.3.4.1.1 **Requirements Analysis Trade-off Studies.** The performing activity shall conduct requirements analysis trade-off studies to establish alternative performance and functional requirements to both resolve conflicts with and satisfy customer requirements.

4.3.4.1.2 **Functional Analysis/Allocation Trade-off Studies.** The performing activity shall conduct trade-off studies within and across functions to:

a. support functional analyses and allocation of performance requirements;
b. define a preferred set of performance requirements satisfying identified functional interfaces;
c. determine performance requirements for lower-level functions when higher level performance and functional requirements can not be readily resolved to the lower-level; and
d. evaluate alternative functional architectures.

4.3.4.1.3 **Synthesis Trade-off Studies.** The performing activity shall conduct synthesis trade-off studies to:

a. support decisions for new products and process developments versus non-developmental products and processes (see 5.3);
b. establish system/CI configuration(s);
c. assist in selecting system concepts, designs, and solutions (include people, parts, and materials availability);
d. support materials selection and make-or-buy, process, rate, and location decisions;
e. examine proposed changes;
f. examine alternative technologies to satisfy functional/design requirements including alternatives for moderate to high risk technologies;
g. evaluate environmental and cost impacts of materials and processes;
h. evaluate alternative physical architectures to select preferred products and processes; and
i. select standard components, techniques, services, and facilities that reduce system life-cycle cost and meet system effectiveness requirements (force structure and infrastructure impacts that emphasize supportability, producibility, training, deployment, and interoperability must be considered). Government and commercial data bases should be utilized to provide historical information used in evaluation decisions.

4.3.4.2 **System/Cost Effectiveness Analysis.** The performing activity shall plan and implement a systems analysis effort as an integral part of the systems engineering process. The performing activity shall develop, document, implement, control, and maintain a method to control analytic relationships and measures of effectiveness. Critical measures of effectiveness used for decision making should be identified for technical performance measurement. System/cost effectiveness assessments shall be used to support risk impact assessments. The performing activity shall analyze each primary system function to:

a. support the identification and definition of performance and functional requirements for the primary system functions to which system solutions must be responsive; and
b. support the selection of preferred product and process design requirements that satisfy those performance and functional requirements.

4.3.4.3 **Risk Management.** The performing activity shall establish and implement a risk management program. Risks shall be assessed for products, processes (e.g. process variability) and their interrelationships. Risk shall also be assessed for contractually identified variations, uncertainties, and evolutions in system environments. The risk management program shall be conducted to:

a. identify potential sources of technical risk including critical parameters that can be risk drivers;
b. quantify risks, including risk levels, and their impacts on cost (including life cycle costs), schedule, and performance. Include design, cost, and schedule uncertainties and sensitivity to program, product, and process assumptions;
c. determine sensitivity of interrelated risks;
d. determine alternative approaches to handle moderate and high risks;
e take actions to avoid, control, or assume each risk and adjusting the SEMP as necessary; and
f. ensure risk is factored into decisions on selection of specification requirements, and design and solution alternatives.

4.3.4.4 Configuration Management. The performing activity shall manage the configuration of identified system products and processes. This effort shall include configuration:

a. identification, including the selection of the documents to comprise the baseline for the system and CIs involved and the numbers and other identifiers affixed to the items and the documents;
b. control, including the systematic proposal, justification, evaluation, coordination, approval or disapproval of all proposed changes to the configuration of CIs after establishment of the baseline(s) for the CI;
c. status accounting, including the recording and reporting of the information needed to manage configuration items; and
d. audits, including verification that the CI conforms to its current approved configuration documentation.

4.3.4.5 Interface Management. The performing activity shall manage the internal interfaces within their contractual responsibility. The performing activity shall support activities established to ensure that external interfaces are managed and controlled. The performing activity shall delineate the design compatibility of external and internal engineering interfaces as interface requirements in their specifications. Interface controls shall be established, coordinated, and maintained for interface requirements, documents, and drawings, and include all applicable performing activity, vendor, and subcontractor contract items and tasking activity furnished equipments, computer programs, facilities, and data. Interfaces shall be controlled to ensure accountability and timely dissemination of changes.

4.3.4.6 Data Management. The performing activity shall establish and maintain an integrated data management system for the decision data base to:

a. capture and organize all inputs as well as current, intermediate, and final outputs;
b. provide data correlation and traceability among requirements, designs, solutions, decisions, and rationale;
c. document engineering decisions, including procedures, methods, results, and analyses;
d. be responsive to established configuration management procedures;
e. function as a reference and support tool for the systems engineering effort; and
f. make data available and sharable as called out in the contract.

4.3.4.7 Systems Engineering Master Schedule (SEMS). The performing activity shall implement the SEMS for top-level process control and progress measurement to: ensure completion of required accomplishments; demonstrate progressive system and development achievements and maturity; ensure that integrated, multidisciplinary information is available for decision and demonstration events; provide an event-based, accomplishment-oriented framework for measuring progress; and demonstrate control of cost, schedule, and performance risks in satisfying accomplishments, requirements, and objectives. SEMS accomplishments with their supporting criteria shall be devised and structured to ensure that:

a. critical technical inputs and decision data is available for technical and program decision points, demonstrations, reviews and other identified events;
b. required progress and system maturity is demonstrated prior to continuing technical efforts dependent on that progress and maturity; and
c. demonstration of all accomplishment criteria identified for a SEMS accomplishment completes that accomplishment.

4.3.4.8 Technical Performance Measurement (TPM). The performing activity shall establish and implement TPM to evaluate the adequacy of evolving solutions and to identify deficiencies impacting the ability of the system to satisfy a performance requirement. Actions taken to redress deficiencies depend on whether the technical parameter is a requirement or an objective. TPM level of detail and documentation shall be commensurate with the impact on cost, schedule, performance, and risk.

4.3.4.8.1 Implementation of TPM. The performing activity shall determine the achievement-to-date for each technical parameter. Technical progress shall be assessed in terms of both allowed variation and the trend in achievement-to-date compared with the planned value profile. When progress in the technical effort supports revision of the current estimate, a new profile and current estimate shall be developed. Risk assessments and analyses shall be updated to reflect changes in planned value profiles and current estimates, and impacts on related parameters.

4.3.4.8.2 TPM on Requirements. For identified deficiencies, analyses shall be performed to determine the cause(s) and to assess the impacts on higher-level parameters, interfaces, and system cost effectiveness. Alternative recovery plans shall be developed with cost, schedule, performance, and risk impacts fully explored. For performance in excess of requirements, the marginal cost benefits and opportunities for reallocation of requirements and resources shall be assessed and an appropriate course of action defined.

4.3.4.8.3 TPM on Objectives or Decision Criteria. The performing activity shall perform TPM on objectives and decision criteria as delineated in the SEMP.

4.3.4.9 Technical Reviews. The performing activity shall plan and conduct the technical reviews necessary to demonstrate that required accomplishments have been successfully completed before proceeding beyond critical events and key program milestones. Technical reviews shall be conducted for the system and contractually identified configuration items. Technical reviews shall occur at key events identified in the SEMS when the performing activity is ready to demonstrate completion of all the SEMS accomplishments associated with the event, as measured by their associated criteria.

4.3.4.9.1 Technical Review Content. System and CI technical reviews shall be integrated reviews including all the disciplines, all the primary system functions, and all the products and processes of the item being reviewed. Reviews shall be structured within the total system context to:

a. confirm that the effects of technical risk on cost, schedule, and performance, as well as risk reduction measures, rationale, and assumptions made in quantifying the risks have been addressed;

b. demonstrate that the relationships, interactions, interdependencies, and interfaces between required items and externally interfacing items, system functions, subsystems, configuration items, and system elements, as appropriate, have been addressed; and

c. ensure performance, functional, design, cost, and schedule requirements and objectives, technical performance measurements and technical plans are being tracked, are on schedule, and are achievable within existing programmatic constraints.

4.3.4.10 Response to Change The performing activity shall define total program impact of identified changes to technical requirements with respect to cost, schedule, performance, and risk. Technical, cost, and schedule problems shall be diagnosed and their impacts determined. The impacts of collateral effects induced by solutions and solution alternatives on the technical program, including interfaces, shall be determined. The performing activity shall inform the tasking activity of changes in cost, schedule, performance and risk that impact the executability (on time, within budget, meets requirements) of the program. The performing activity shall process all resulting changes to contract requirements and configuration baselines in accordance with established change control procedures. The performing activity shall ensure that all supporting and related data is accessible to the tasking activity and documented in the decision data base.

4.4 Systems Engineering Output. Outputs of the systems engineering effort are acquisition phase dependent. The performing activity shall develop and implement a decision data base that:

a. Documents and organizes data used and generated by the systems engineering effort.

b. Provides an audit trail of results and rationale from identified needs to verified solutions for traceability of requirements, designs, decisions, and solutions.

4.4.1 Specifications and Baselines. The performing activity shall generate required system and configuration item (CI) unique documentation. General criteria include the following.

a. Documentation used to establish configuration baselines (Functional, Allocated, Product) shall be developed progressively.
b. Specifications shall be formalized to establish configuration baselines commensurate with the contracted effort.
c. Configuration baselines shall be documented, controlled, and audited in accordance with contractual configuration management practices.
d. Requirements included in specifications shall be verifiable.
e. Specifications will not be approved by the tasking activity until:
   (1) their completeness and design attainability have been verified;
   (2) item costs have been determined and those costs satisfy established design-to-cost targets or other prescribed affordability limits; and
   (3) the cost, schedule and performance risks associated with the item and its processes have been determined and the risk levels are acceptable.
f. Essential process requirements shall be included in item specifications.
g. System functional and CI development specifications shall be performance based.

4.4.2 Life Cycle Support Data. The preparing activity shall identify, annotate, and track those elements in the decision data base necessary for the life cycle management of the system.

5. DETAILED REQUIREMENTS

This section describes systems engineering tasks that shall be evaluated/tailored for integrating product and process development as applied to a specific program and phase. Tailored requirements for program specific tasks will be provided by the tasking activity in solicitations or suggested by the performing activity through procedures such as responses to draft request for proposals.

5.1 Systems Engineering Planning. The systems engineering process shall be applied to system objectives and requirements, forming the basis for the development function. This application shall define and plan the necessary technical program tasks including the Statement of Work (SOW), SEMP, SEMS, SEDS, and other technical plans identified in the contract.

5.1.1 Systems Engineering Management Plan (SEMP). The performing activity shall determine how a fully integrated technical effort will be conducted in compliance with this standard. The performing activity shall define the implementation of the systems engineering process including how all of the outputs are entered into the decision data base as well as how they are used interactively with, and as inputs for subsequent applications of, the process. Each task in the SEMP shall be traceable to the system definition. The SEMP developed by the performing activity (see 4.1.b) shall provide a summary, with reference to the detailed plan, for all technical plans required by the CDRLs of the contract.

5.1.1.1 Technical Performance Measurement (TPM) Planning. The performing activity shall plan a TPM effort that is responsive to tasking activity requirements and the SEMS. When not otherwise provided , the performing activity shall establish TPM update frequencies, tracking depth, and response time to generate recovery plans and planned profile revisions. Achievement-to-date assessments should be planned to support cost reporting (such as the cost performance report and cost/schedule status report) and the SEMS. Technical parameters selected for tracking shall be critical indicators of technical progress and achievement and shall include either system parameters, CI parameters, or both. Parameter descriptions shall include identification of related risks. The relationships between selected parameters and lower-level component parameters that must also be measured shall be determined. Each parameter identified shall be correlated with a specific Contract Work Breakdown Structure (CWBS) element.

5.1.1.2 Technical Review Planning. The performing activity shall devise and plan a structured review process to demonstrate and confirm completion of required accomplishments and accomplishment criteria in the SEMS. All reviews necessary to demonstrate, confirm, and coordinate progress shall be incorporated into overall review planning. Reviews include structured meetings on progress toward satisfying SEMS events. The performing activity shall define the tasks associated with the conduct of each review, including responsibilities of personnel involved, review site(s), and necessary procedures (e.g., action item close-out), entry criteria, and all required accomplishments. The performing activity shall describe the success criteria for review accomplishments, how compliance with requirements and criteria will be determined, and how discrepancies identified will be handled. Overall review planning, as well as the plan for the conduct of each review, shall be contained in the SEMP.

5.1.1.3 Technical Integration Planning. Plans to define and implement system functionality shall be integrated into the SEMP. How multidisciplinary teamwork is to be implemented shall be defined including how the performing activity's organizational structure supports the time-phased needs of the technical effort. The performing activity shall describe the organizational responsibilities and authority for the systems engineering effort, including control of subcontracted technical efforts.

5.1.1.4 Technology Transition Planning. The performing activity shall establish, implement, and control a technology transition approach for identifying and applying relevant available and emerging technologies to program specific efforts. The activities and the criteria for assessing, validating, and transitioning critical technologies from technology development and demonstration programs, including commercially developed technologies, shall be determined. This shall include methods to identify alternatives and selection criteria used to determine when and which alternatives will be incorporated into people, product, and process solutions. This approach shall be responsive to transition methods and criteria required by the tasking activity.

a. Performance requirements for technologies critical to system success shall be monitored via TPM.

b. When technologies required to meet requirements can not be effectively transitioned, or when the requirements can only be generally defined, opportunities for preplanned product improvement or evolutionary acquisition strategy alternatives shall be identified and documented.
c. Criteria for validation shall include maturity in performance, sustainability, and affordability.

5.1.1.5 Relating TPM, SEMS, and SEDS to Cost and Schedule Performance Measurement. The performing activity shall determine and define a means to relate TPM, the SEMS and the SEDS to cost and schedule performance measurement. Cost, schedule, and technical performance measurement shall be made against common elements of the CWBS or as specified in the contract. The performing activity shall integrate this approach into risk management efforts.

5.1.2 Systems Engineering Master Schedule. The SEMS developed by the performing activity shall identify the significant accomplishments that must be achieved by established contract events for the complete technical effort. The performing activity shall include events, associated accomplishments, and success criteria identified by the tasking activity. The SEMS shall reflect the integration of the efforts necessary to satisfy required accomplishments. Events, accomplishments, and accomplishment criteria shall directly relate to WBS elements.

a. Accomplishments required to transition moderate to high risk technologies shall be incorporated into the SEMS along with their success criteria.
b. Events should be identified in the format of entry and exit events (Initiate Preliminary Design Review (PDR) and Complete PDR) or use entry and exit accomplishments for each event.
c. All SEMS accomplishments shall be event related, not time coincidental or driven. SEMS accomplishments shall have one or more of the following characteristics:
   (1) Define a desired result at a specified event that indicates design maturity or progress directly related to each product and process;
   (2) Define completion of a discrete step in the progress of the planned development; and
   (3) Describe disciplinary and functional activities that directly related to the product.
   (3) Describe activities to provide functionality directly related to the product.
d. SEMS accomplishment criteria shall be measurable. SEMS accomplishment criteria shall provide a definitive measure or indicator that the required level of maturity or progress has been achieved.
e. The tasking activity should identify critical TPM parameters to be used as accomplishment criteria for identified milestones. In addition to selecting parameters based on risk, the tasking activity should select parameters that directly relate to the program's Acquisition Program Baseline.

5.1.3 Systems Engineering Detailed Schedule (SEDS). The performing activity shall develop a time-based schedule (SEDS) based on the work efforts required to support the events, accomplishments, and accomplishment criteria identified in the SEMS. The SEDS shall outline the tasks and calendar dates necessary to show how and when each accomplishment criteria will be met. The performing activity shall maintain the SEDS to keep the schedule and tasks current.

5.1.4 Work Breakdown Structure (WBS). The performing activity shall analyze the system requirements generated and translate them into a structure of the products and services which comprise the entire work effort commensurate with the acquisition phase and contract requirements.

5.2 Functional Tasks. The tasks listed below do not preclude or supersede tasks applied from other standardization documents. Sources for tailoring these tasks, and additional tasks necessary to the specific application of this standard, can be found in section 6, Table I. The performing activity shall ensure that the following tasks are incorporated into the systems engineering process. These tasks shall be included in the requirements analysis, functional analysis/allocation, synthesis, and systems analysis and control and their impact shall be included in system life cycle cost estimates. These tasks reflect important areas in system development. Satisfying total system cost, schedule, and performance requirements and objectives, at an acceptable level of risk, shall be the determining factor of the degree of performance required.

5.2.1 Reliability and Maintainability. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements to ensure that items are reliable and maintainable. Emphasis shall be on:

a. Determining requirements based on the user's system readiness and mission performance requirements, physical environments, and resources available to support the mission.
b. Managing the contributions to system reliability and maintainability made by system elements.
c. Preventing design deficiencies (including single point failures), precluding the selection of unsuitable parts and materials, and minimizing variability effects in manufacturing processes.
d. Developing robust systems, acceptable under specified adverse environments experienced throughout the system's life cycle and repairable under adverse conditions.
e. Developing items that have low impact on support resources including time, people, money, parts, tools, storage, and transportation assets.

5.2.2 Survivability. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements to ensure that items are survivable when those items must perform critical functions in a man-made hostile environment. Survivability from all threats found in specified levels of conflict shall be analyzed. Threats to be considered include conventional, electronic, nuclear, biological, chemical, high power microwave, kinetic energy weapons, directed energy weapons, and terrorism or sabotage. Critical survivability characteristics shall be identified, assessed, and evaluated for their impact on system effectiveness.

For items hardened in order to meet a survivability requirement, hardness assurance, hardness maintenance, and hardness surveillance programs shall be developed to identify and correct procedures in manufacture, repair, spare parts procurement, and maintenance or repair activities that may degrade item hardness during the system's life cycle.

5.2.3 Electromagnetic Compatibility and Radio Frequency Management. The performing activity shall identify and define functional and performance requirements, and derive solution-dependent requirements, to ensure system solutions employing electric and electronic items can achieve necessary performance in intended environments. The performing activity shall ensure electric and electronic items comply with applicable DoD, national, and international electromagnetic compatibility requirements. The performing activity shall ensure that intentional radiators or receptors of radio frequency energy comply with DoD, national, and applicable international policies for radio frequency spectrum management.

5.2.4 Human Factors. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements to ensure that human factors are integrated into product and processes designs. Objectives shall include balance of system performance and cost of ownership by ensuring that item designs are compatible with the capabilities and limitation of the personnel who will operate, maintain, transport, supply, control, and dispose of the items. Requirements and designs shall minimize characteristics that require extensive cognitive, physical, or sensory skills; require the performance of unnecessarily complex tasks; require tasks that unacceptably impact manpower or training resources; or result in frequent, repetitive, or critical errors.

5.2.5 System Safety and Health Hazard. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements consistent with higher-level and mission requirements as well as cost effectiveness to effect safe use of system items and to control hazards associated with system items. The total system of people, products, and processes, including verification, manufacture, support, and disposal activities, shall be analyzed to identify potential hazards for the projected life cycle. Identified hazards associated with use of system end items shall be documented to establish criteria for mitigating or defining and categorizing high and serious risks. Materials categorized as having high and serious risks shall be characterized in terms of the risks related to producing, deploying, operating, supporting, training with, and disposing of system end items using such materials. Use of materials which present a known hazard to people of the environment shall be avoided to the extent practical. If use of hazardous materials is an essential element of the solution, a containment program, including procedures for safe use and disposal, shall be developed and implemented. This program shall include eventual substitution for hazardous materials except for those explicitly accepted by the tasking activity for the specific application. Handling and disposal of hazardous material shall be included in life cycle cost estimates.

5.2.6 System Security. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements to eliminate or contain vulnerabilities to known or postulated security threats (documented for contractual use). Item, information, and data base susceptibility to damage, compromise, or destruction shall be identified and reduced. Control of compromising emanations (TEMPEST) shall be explicitly addressed early in the acquisition of items that have a potential to emanate sensitive information. All items and their processes, including system information flows, shall be evaluated for known or potential vulnerabilities for the entire life cycle. The tasking activity will establish the level to which the vulnerability shall be controlled.

5.2.7 Producibility. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements for producibility. The performing activity shall employ multidisciplinary teamwork to ensure that items are producible and to generate simple designs and stable manufacturing processes to reduce risk, manufacturing cost, lead time, and cycle time; and that minimize use of strategic and critical materials. As part of system design, manufacturing methods, processes, and process controls shall be defined, evaluated, and selected based on total system cost, schedule, performance, and risk.

a. Prior to full rate production, the performing activity shall ensure that the product design has stabilized, the manufacturing processes and process controls have been proven, and rate production facilities, equipment, capability, and capacity are in place (or are about to be put in place) to support the approved schedule.
b. The performing activity shall use value engineering concepts to assist in the identification of requirements that add cost to the system, but add little or no value to the users.

5.2.8 Integrated Logistics Support (ILS). The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements to ensure that items are supportable. The performing activity shall:

a. ensure requirements are related consistently to readiness objectives, to design, and to each other;
b. integrate support factors into item and system element design interactively with the design of support products and processes;
c. identify cost-effective approaches to supporting an item when deployed/installed;
d. identify and define requirements for support structure elements so that the item is both supportable and supported when deployed/installed; and
e. plan for post-production support to ensure continued, economic logistics support.

5.2.9 Test and Evaluation. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements to ensure that all required item characteristics are verifiable. Verification of the acceptability and compatibility of human performance requirements, personnel selection, training, and man-machine interfaces of system procedural data shall be integrated into the system test program. The objectives, scope, and type of system test and evaluation shall reflect an integrated approach for functionality verification to conserve resources. Test and evaluation planning shall address performance, functional, and design requirements with appropriate quantitative criteria, test events or scenario descriptions, resource requirements (e.g., test range, special test facilities), and test limitations. Wherever practicable, tests for different objectives shall be combined. Test and evaluation efforts shall be structured to:

a. provide information for assessment of technical risks and for decision making;
b. generate information to determine whether items have met technical performance requirements, specifications, and objectives;
c. verify that items are operationally effective and suitable for intended use;
d. verify the critical assumptions, data, and methods used to derive critical item requirements (e.g., safety, survivability, electromagnetic compatibility); and
e. verify the critical assumptions, data, and methods used in the verification of item performance.

5.2.10 Integrated Diagnostics. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements to incorporate diagnostics which provide unambiguous detection and isolation of faults which occur when system end items are in use. Factors to be considered in developing requirements include embedded testability; built-in-test;

automatic, semi-automatic, and manual testing; common test data; technical information; consistent detection and isolation; and training.

5.2.11 Transportability. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements to ensure that items are transportable. The performing activity shall identify the limiting characteristics of transportation systems, as they apply to item requirements, designs, and development. The performing activity shall use this data to derive and refine item requirements and designs, and impact associated packaging, handling, storage, and transportation solutions. The performing activity shall address transportability in the development of new, modified, and non-developmental items and in developing integrated logistics support for items.

5.2.12 Infrastructure Support. The performing activity shall identify and define functional and performance requirements and derive solution-dependent requirements for a compatible interface with the infrastructure supporting the system, to identify unique infrastructure support requirements, and to ensure timely planning to provide needed infrastructure support. The performing activity shall assess each item for its interaction with and integration into the command, control, communications, and intelligence structure. The performing activity shall identify the support that the system will require from other support agencies and commands (e.g., mapping, charting, geodesy, and meteorology).

5.2.13 Other Functional Areas. The preceding paragraphs do not obviate the need for addressing all pertinent functions. The performing activity shall identify and define other areas of the system's functionality to derive and define additional system requirements needed to satisfy higher level requirements. As the functionality of the system is defined during execution of the systems engineering process, additional functional tasks may also be identified. An example is resource conservation (e.g., life cycle resources, energy consumption, preservation of material for recycling).

5.3 Leveraged Options. The following options offer the potential for reduced risk and cost in many systems. The preparing activity shall ensure the identification of solution alternatives which facilitate the use of these options. As candidates for a particular application, they shall be assessed for use as appropriate in system solutions. (Note: When structuring physical architecture alternatives, solution viability may depend on the application order of non-developmental items (NDIs) and open system architectures (OSAs) versus new development items and technologies. For example, employing new development items and technologies first may preclude application of NDIs and OSAs. Employing NDIs and OSAs first, may export higher risks to remaining items requiring new development.)

5.3.1 Non-Developmental Items (NDI). The performing activity shall identify and evaluate NDIs, including commercial and military off-the-shelf items, for use in system solutions. NDIs shall be used where practical when they meet requirements and are cost-effective over the entire life cycle.

5.3.2 Open System Architectures (OSA). The performing activity shall identify and evaluate OSAs for use in system solutions. These shall be evaluated for applications in systems employing pre-planned product improvement or evolutionary acquisition strategies; when required solution functionality and mission application is expected to vary; and in circumstances where technologies are changing rapidly. Additionally, OSAs shall be evaluated for application to effect required system interoperability and use of solutions across multiple items. OSAs shall be used where practical when they meet requirements and are cost-effective over the entire life cycle.

5.3.3 Re-Use. The performing activity shall identify opportunities for designing items for re-use and multiple application and evaluate the benefits and costs of those opportunities. Opportunities providing cost-benefit and that are compatible with program objectives shall be identified to the tasking activity.

5.3.4 Dual Use Technologies. The performing activity shall identify and evaluate the application of dual use technologies in system solutions. Dual use technologies shall be employed where practical when they meet requirements and are cost-effective over the entire life cycle.

5.4 Pervasive Development Considerations. The following tasks, as selected and tailored for the particular program application, shall be integrated into the systems engineering process.

5.4.1 Computer Resources. The performing activity shall manage computer resource development for system end items as an integral part of overall system development. The performing activity shall not finalize computer hardware resource decisions until the software design demonstrates a maturity that minimizes the risk of inadequate processor throughput and memory. Similarly, software design decisions shall not be finalized until computer hardware resource designs demonstrate a maturity that minimizes the risk of incompatibility.

a. The performing activity shall address the requirements for software development tools and the software development, integration, and test environments.
b. The performing activity shall ensure that software development is disciplined and an integrated part of systems engineering activities.

5.4.2 Materials, Processes, and Parts Control. The performing activity shall establish, implement, and control a materials, processes, and parts control program. This program shall focus on standardization of parts, materials, and processes. The program shall addresses the design, procurement, and availability of parts through the expected life of each item, the environment that the item is required to operate in, and account for life cycle support costs. The program shall emphasize reducing the variety of parts, variability in processes, and associated documents used with items.

5.4.3 Prototyping. The performing activity shall evaluate whether prototyping should be used to assist in identifying and reducing risks associated with integrating available and emerging technologies into an item's design for satisfying requirements. When employed, prototyping shall address all aspects of the emerging technology which bear upon its successful application, to include, for example, hardware, software, and manufacturing processes. Prototyping (experimental, rapid, or developmental) shall be used to provide timely assessment of item testability to identify the need for new or modified test capabilities. The performing activity shall conduct the same type of evaluations, and for the same purpose, when supporting product improvements and modifications to fielded (operational) systems.

5.4.4 Simulation. The performing activity shall evaluate the extent of simulation application to refine requirements and designs, and to evaluate solutions for people, products, and processes by simulating their interaction with their environment. Additionally, simulation application shall be evaluated as an adjunct to prototyping. The performing activity shall employ simulation where cost-effective.

5.4.5 Digital Data. The performing activity shall evaluate the use of integrated computer aided engineering, design, manufacturing, test, and support methods to support design integration through shared product and process models and data bases. When cost effective over the system life cycle, documentation of accomplishments and exchange of product and process infomation shall be consistent with standard interchange formats such as Computer Aided Acquisition and Logistics Support (CALS) or as contractually defined.

5.4.6 Quality. The tasking activity and performing activity shall apply the systems engineering process to ensure that quality is an integral part of all technical elements and activities of the program to focus on preventing defects rather than detecting and correcting them.

5.5 System/Cost Effectiveness. Systems/cost effectiveness analysis and assessment tasks shall be integrated into the systems engineering process to support development of life cycle balanced products and processes. These tasks do not preclude or supersede tasks applied from other standardization documents. Sources for tailoring these tasks, and additional tasks necessary to the specific program application of this standard can be found in section 6, Table I. Critical requirements and verifications identified by analyses of each primary system function shall serve as constraints on other items and areas they impact. These constraints shall be included in requirements documentation and specifications for impacted items and areas.

a. The performing activity shall conduct system/cost effectiveness analyses and assessments to:
   (1) support the identification of mission and performance objectives and requirements;
   (2) support the allocation of performance to functions;
   (3) provide criteria for the selection of solution alternatives;
   (4) provide analytic confirmation that designs satisfy customer requirements; and
   (5) support verifications of people, product, and process solutions.

b. The performing activity shall identify those parameters that drive solutions and establish their sensitivity to uncertainties in input data and assumptions.

c. When another system has comparable characteristics, it shall be included as a baseline system to support the determination, completeness, and achievability of requirements.

5.5.1 Manufacturing Analysis and Assessment. The performing activity shall conduct manufacturing analyses and assessments to support the development of people, product, and process requirements and solutions necessary to produce system end items. Manufacturing analyses shall include producibility analyses and manufacturing and production inputs to system effectiveness, trade-off studies, and life cycle cost analyses. Alternative designs and capabilities of manufacturing shall be evaluated. Long lead time items, material source limitations, availability of materials and manufacturing resources, and production cost shall be identified, assessed, and documented. Manufacturing-critical characteristics of people, product, and process solutions shall be identified and their risks included in risk management efforts. Results of these activities and solution alternatives shall be assessed interactively with other system solution alternatives.

5.5.2 Verification Analysis and Assessment. The performing activity shall conduct verification analyses and assessments to support the development of people, product, and process solutions necessary to verify that system end-items satisfy their requirements. Verification analyses shall address verification requirements and criteria for solution alternatives; definition of verifications to demonstrate proof of concept; and development, qualification, acceptance, pertinent operational, and other testing. Life cycle requirements for test consistency in and across the solution set shall be determined These analyses shall address the requirements and procedures needed to verify critical verification methods and processes (such as key methods, assumptions, and data used in verifications by analysis). Verification-critical characteristics of people, product, and process solutions shall be identified and their risks included in risk management efforts. Results of these activities and solution alternatives shall be assessed interactively with other system solution alternatives.

5.5.3 Deployment Analysis and Assessment. The performing activity shall conduct deployment analyses and assessments to support the development of people, product, and process solutions necessary to deploy system end-items. Deployment analyses and assessments shall address:

- **a.** Factors for site/host selection and activation/installation requirements including identification of site-unique hazard classification and explosive ordnance disposal requirements;
- **b.** Operational and maintenance facilities and equipment requirements;
- **c.** Compatibility with existing infrastructure (e.g., computer-communication systems);
- **d.** Determination of environmental impacts and constraints (environment impacts on the system and system impacts on the environment) at deployment sites as defined by the environmental analysis and impact assessment task (see 5.5.8);
- **e.** Early deployment of training items and personnel;
- **f.** Initial provisioning and spares;
- **g.** Packaging, handling, storage, and transportation; and
- **h.** Site transition requirements.

Deployment-critical characteristics of people, product, and process solutions shall be identified and their risks included in risk management efforts. Results of these activities and solution alternatives shall be assessed interactively with other system solution alternatives.

5.5.4 Operational Analysis and Assessment. The performing activity shall conduct operational analyses and assessments to support the development of people, product, and process solutions necessary to satisfy operational requirements for system end-items. The performing activity shall analyze and assess the operational use of alternative solutions addressing interactively:

- **a.** the way the solutions will be used to accomplish required tasks in their intended environments;
- **b.** interfacing systems required to execute operational functions in the intended use environment;
- **c.** required joint and combined operations; and
- **d.** identified modes of operational deployment and employment.

Operations-critical characteristics of people, product, and process solutions shall be identified and their risks included in risk management efforts. Results of these activities and solution alternatives shall be assessed interactively with other system solution alternatives.

5.5.5 Supportability Analysis and Assessment. The performing activity shall conduct supportability analyses and assessments to assist in the development of people, product, and process solutions to support system end-items. Supportability analyses shall be used to assist in the identification of data and procedures needed in specifications and other development documentation to provide system life cycle support (e.g., additional interface information and verification requirements for utilization of "used" parts). Supportability analyses shall address:

a. All contractually specified levels of operation, maintenance, and training for system end-items.
b. The planned life cycle to ensure that system end-items satisfy their intended use.
c. Identification of supportability-related design factors.
d. The development of an integrated support structure (people, products, and processes).
e. Support resource needs including parts, people, facilities, and materials.

Supportability-critical characteristics of people, product, and process solutions shall be identified and their risks included in risk management efforts. Results of these activities and solution alternatives shall be assessed interactively with other system solution alternatives.

5.5.6 Training Analysis and Assessment. The performing activity shall conduct training analyses and assessments to support development of people, product, and process solutions to train users of system end-items. Training analysis shall include the development of personnel capabilities and proficiencies to accomplish tasks at any point in the system life cycle to the level they are tasked. These analyses shall address initial and follow-on training necessary to execute required tasks associated with system end-item use. Training-critical characteristics of people, product, and process solutions shall be identified and their risks included in risk management efforts. Results of these activities and solution alternatives shall be considered assessed with other system solution alternatives.

5.5.7 Disposal Analysis and Assessment. The performing activity shall conduct disposal analyses and assessments to support development of people, product, and process solutions to dispose of products and by-products. Environmental factors for process wastes and outputs as well as used products and components shall be included. Alternative disposal methods for system parts and materials shall be evaluated and requirements for new or modified methods determined. Methods addressed should include storage, dismantling, demilitarization, reusing, recycling, and destruction. Costs, sites, responsible agencies, handling and shipping, supporting items, and applicable federal, state, local, and host nation regulations shall be factors in the analyses. Disposal-critical characteristics of people, product, and process solutions shall be identified and their risks included in risk management efforts. Results of these activities and solution alternatives shall be assessed interactively with other system solution alternatives.

5.5.8 Environmental Analysis and Impact Assessment. The performing activity shall adhere to all applicable statutes and to contractually designated hazardous material lists. Environmental analysis limited to the above shall be performed to determine the impact on and by each system product and process alternative on factors such as noise pollution, quantities and types of hazardous materials used, hazardous waste disposal and other defined environmental requirements as applicable. Methods to mitigate problems identified from this analysis shall be defined and an assessment of impacts made. Results of these assessments shall be factored into effectiveness analyses as well as system definition, design, and verifications. Analysis output will be documented appropriate to the acquisition phase and used in conjunction with cost and performance analyses outputs to support acquisition phase exit criteria. Environmental-critical characteristics of people, product, and process solutions shall be identified and their risks included in risk management efforts.

5.5.9 Life Cycle Cost Analysis and Assessment. Life cycle cost analyses and estimates, including the cost of development, acquisition, ownership, and disposal, shall be conducted and updated as designated in the contract to support decisions, assessments of system cost effectiveness, and trade-off studies. This effort shall identify the economic consequences of solution alternatives. These analyses shall develop the requisite cost information to support decisions on alternative people, product, and process solutions and risk assessments. These analyses shall include established design-to-cost targets, a current estimate of these costs, and known uncertainties in these costs.

5.5.10 Models. Effectiveness models, including simulations, shall be used when they contribute to decision process. The models shall allow parameters to be varied so that their relative, individual effect on total system performance and life cycle cost can be determined. Performance characteristics allocated to system functions shall correlate to parameters in the models. The models, data files, and their documentation shall be maintained, updated, and modified as required. Each version of a model or data file that impacts requirements, designs, or decisions shall be entered into the decision data base.

5.6 Systems Engineering Implementation Tasks. The performing activity shall conduct the following tasks, interactively with the systems engineering process, as needed to satisfy contract requirements:

a. Conduct developmental test and evaluation to validate technologies for application to system solutions, acquire definition information to support synthesis, and acquire verification information to support assessments in systems analysis and control.
b. Implement engineering test models, and other related items needed to conduct developmental test and evaluation. This does not include items for those tests conducted on low-rate or full rate production hardware, unless specified in the SOW.
c. Generate software, from design, for system end-items.
d. Provide sustaining engineering and problem solution support.

5.6.1 Verification. The performing activity shall verify people, product, and process solutions by design analysis, design simulation, inspection, demonstration, or test. Required performance of all critical characteristics shall be verified by demonstration and test. Design analysis and simulation shall be used to complement, not replace, demonstration and test. Tests shall include system effectiveness evaluations and manufacturing process proofing. Where total verification by test is not feasible, testing shall be used to verify key characteristics and assumptions used in the design analysis or simulation. Commensurate with the contractual effort, the performing activity shall:

a. conduct verification of the physical architecture (including interfaces) from the lowest level up to the total system to ensure that functional and performance requirements are satisfied;
b. generate evidence necessary to confirm that configuration items meet their requirements;
c. validate technologies for use in people, product, and process solutions considering cost, schedule, performance, and risk using established criteria; and
d. verify that materials employed in system solutions can be disposed of in a safe, environmentally compliant manner.

5.7 Technical Reviews. The performing activity shall conduct reviews in accordance with the SEMP. Typically, reviews are co-chaired by the tasking and performing activities and participants are those who have a stake in the objectives of the review.

5.7.1 Review Responsibilities. At each review, the performing activity shall:

a. be able to substantiate trade-off decisions with technical details and associated rationale;
b. ensure appropriate participation including that of subcontractors, vendors, and suppliers;
c. host the review at an appropriate site (or sites);
d. provide information and items necessary to demonstrate and confirm that the SEMS accomplishments associated with the review event have been satisfied;
e. provide administrative support (e.g., resources, materials, meeting rooms, security, clerical);
f. provide other information and items necessary, including agendas and plans; and
g. document the proceedings including key points, decisions, and issues with associated rationale; open and unresolved items with their closure requirements and responsibilities.

5.7.2 Structuring Reviews. The structured review process shall provide needed demonstrations and confirmations of SEMS accomplishments at the level suited to: ensure orderly progress of the technical effort; confirm functional integration; ensure resolution of issues at the earliest time and lowest level; support event-based decisions; and control risk. This process must be balanced, that is, as unobtrusive as possible but as rigorous as necessary. The primary categories of reviews to meet the objectives are major reviews and incremental reviews.

5.7.2.1 Major Reviews. The performing activity shall plan and conduct the following major technical reviews as designated in the SOW: Alternative System Review, System Requirements Review, System Functional Review, system Preliminary Design Review, system Critical Design Review, System Verification Review, and system Physical Configuration Audit. These reviews reflect major system development milestones, each traceable to the preceding. Major review shall have well defined entry and exit criteria. Although called an audit, the system Physical Configuration Audit shall utilize the same concept of identifying accomplishments and success criteria. Incremental reviews facilitate conduct of major reviews as system demonstration and confirmation events.

5.7.2.2 Incremental Reviews. There are three types of Incremental Reviews: Subsystem Reviews, Interim System Reviews, and Functional Reviews. Only the subsystem review has a scope that is less than system-wide. The Functional Reviews examine an aspect of the system's functionality across the entire system and with a multidisciplinary focus. These reviews are part of an overall strategy of getting issues identified and resolved prior to initiating a major review.

5.7.3 Alternative System Review (ASR). ASR shall be conducted to demonstrate that the preferred system concept: provides a cost effective, operationally effective and suitable solution to identified needs; meets established affordability criteria; and can be developed to provide a timely solution to need at an acceptable level of risk. ASR shall demonstrate, for the preferred system concept, that:

a. it is traceable to and can satisfy mission needs and other identified customer requirements;
b. life cycle resource requirements, significant potential environmental consequences, timing to need, and other factors designated by the tasking activity, have been identified;
c. it is documented and defines scope, cost, schedule, and performance objectives and thresholds;
d. pertinent technologies (product and process) have been identified and the approach to their validation, including prototyping and simulation, and transition is defined;
e. risks and risk drivers have been identified, quantified, prioritized, and that an effective and implementable risk management approach is defined;
f. the critical accomplishments, success criteria, and metrics have been defined for the next acquisition phase or continued technical effort including technical exit criteria; and
g. a draft specification tree and planned program work breakdown structure for the next phase of technical effort are defined and traceable to the physical architecture.

5.7.4 System Requirements Review (SRR). SRR shall be conducted to demonstrate progress in converging on viable, traceable system requirements that are balanced with cost, schedule, and risk by confirming that:

a. customer requirements (including environments, usage modes, and other pertinent factors) were analyzed and translated into system-specific functional and performance requirements;
b. technology validation and demonstration plans are complete and closure plans on technical demonstrations and maturations are achieving required progress;
c. critical technologies for people, product, and process solutions have been identified and assessed;
d. risks are identified and quantified, and risk mitigation actions are achieving required progress; and
e. the total system approach to satisfying requirements (including interfaces) for the primary system functions has been identified (draft system and initial development specifications).

5.7.5 System Functional Review (SFR). SFR shall be conducted to demonstrate convergence on and achievability of system requirements and readiness to initiate preliminary design by confirming that:

a. system functional and performance requirements have converged and characterize a system design approach that satisfies established customer needs and requirements;
b. the system's physical architecture and draft allocated configuration documentation establish the adequacy, completeness, and achievability of functional and performance requirements (sufficient design and systems analyses including assessment and quantification of cost, schedule, and risk);
c. critical technologies for people, product, and process solutions have been verified for availability, achievability, needed performance, and readiness for transition;
d. the process completely defined system functional and performance requirements including that
    (1) system solutions for people, products, and processes satisfy all primary system functions,
    (2) an audit trail from SRR is established with changes substantiated,

(3) risks are mitigated and remaining risks acceptable, and
(4) the system functional baseline can be established;

e. the draft specification tree has been assessed (based on the physical architecture) for the next phase or engineering effort to include any effect on the planned or approved PWBS;
f. planned CWBSs for the next phase or technical effort have been assessed based on planned or approved PWBS;
g. risk handling approach defined for the next phase or technical effort;
h. pre-planned product and process improvement and evolutionary acquisition requirements and plans have been defined;
i. implementation requirements for technology transition have been defined; and
j. The critical accomplishments, success criteria, and metrics have been defined for the next acquisition phase or continued technical effort.

5.7.6 **Preliminary Design Review (PDR).** PDR shall be conducted to confirm that the total system detailed design approach (as an integrated composite of people, product, and process solutions) satisfies the functional baseline; risks are mitigated with closure plans for remaining risks demonstrating required progress; and the total system is ready for detailed design. PDR shall confirm that:

a. the process completely defined system requirements for design including that
   (1) the design approach is balanced for the life cycle, cost, schedule, performance, and risk,
   (2) the system physical architecture is an integrated detailed design approach for people, products, and processes to satisfy requirements, including interoperability and interfaces,
   (3) an audit trail from SFR is established with changes substantiated,
   (4) the system design approach is consistent with available DT&E results,
   (5) risks are mitigated and remaining risks acceptable, and
   (6) the allocated baselines for system CIs are defined;
b. issues for system CIs, functional areas, and subsystems are resolved;
c. sufficient detailed design has been accomplished to verify the completeness and achievability of defined requirements;
d. the risk handling approach is refined for the next phase or technical effort;
e. pre-planned product and process improvement and evolutionary acquisition requirements and plans have been refined; and
f. critical accomplishments, success criteria, and metrics are valid for continued technical effort.

5.7.7 **Critical Design Review(CDR).** CDR shall be conducted to demonstrate that the total system detailed design (as an integrated composite of people, product and process solutions) is complete, meets requirements, and that the total system is ready for manufacturing and coding. CDR shall confirm:

a. that issues for the system, functional areas, and subsystems are resolved;
b. the process completely defined system design requirements including that
   (1) the design is balanced for the life cycle, cost, schedule, performance, and risk,
   (2) the system physical architecture is an integrated detailed design for people, products, and processes to satisfy requirements, including interoperability and interfaces,
   (3) an audit trail from PDR is established with changes substantiated;
   (4) allocated baselines for system CIs are refined
c. the system design compatibility with external interfaces (people, products, and processes);
d. system design and interface requirements and design constraints are consistent with DT&E results;
e. DT&E results support critical system design and interface requirements and design constraints;
f. the risk handling approach is refined for the next phase or technical effort;
g. pre-planned product and process improvement and evolutionary acquisition requirements and plans have been refined; and
h. the critical accomplishments, success criteria, and metrics are valid for continued technical effort.

5.7.8 **System Verification Review (SVR).** SVR shall be conducted to demonstrate that the total system (people, products, and processes) was verified to satisfy requirements in the functional and allocated configuration documentation, and to confirm readiness for production, support, training, deployment, operations, continuing verifications, continuing development (if any), and disposal. SVR shall confirm the completion of all incremental accomplishments for system verification (e.g., Test Readiness Reviews, CI and system Functional Configuration Audits) and confirm that:

a. issues for the system, functional areas, and subsystems are resolved;
b. system and CI verification procedures were completed and accurate (including verification by test and demonstration of critical parameters as well as key assumptions and methods used in verifications by analytic models and simulations);
c. the system and CIs were confirmed ready for verification;
d. verifications were conducted in accordance with established procedures; were completed for people, products, and processes; and system processes are current, executable, and meet the need;
e. an audit trail from CDR is established with changes substantiated and the system and CIs verified;
f. the risk handling approach is refined for the next phase or technical effort;
g. pre-planned product and process improvement and evolutionary acquisition requirements and plans have been refined;
h. planning is complete and procedures, resources, and other requisite people, products, and processes are available (or programmed to be available) to initiate operations, support, training, production, deployment, disposal, and continuing verifications and development (if any); and
i. the critical accomplishments, success criteria and metrics have been refined and validated for the next acquisition phase or continued technical effort.

5.7.9 Physical Configuration Audit (PCA). A system PCA shall be conducted to confirm that: all CI PCAs have been satisfactorily completed; the CIs on which PCAs have been conducted sum to a system; the current state of the decision data base is valid and represents the system; items (including processes) that can be baselined only at the system-level have been baselined; required changes to previously completed baselines have been completed (e.g., deficiencies discovered during testing have been resolved and implemented); and system processes are current, can be executed, and meet the need. A system PCA can be conducted after a full set of production representative CIs has been baselined. This review shall be conducted in accordance with contractually established configuration management procedures.

5.7.10 Subsystem Reviews. The performing activity shall conduct subsystem reviews to assure that the requirements (including interface requirements) for the subsystem have been identified, balanced across its segments and interfaces, documented, and met. These reviews shall address issues and assess progress of a subsystem and ensure that the subsystem is developed in a life cycle context (development through disposal). Each review shall focus on required accomplishments for the SEMS event the review supports as well as upcoming system reviews. The subsystem review shall address impacts on and by interfaces with other subsystems and systems, documentation, risk, and to the extent they apply, designs, verification readiness, and documentation. Generally, the subsystem review shall confirm that the specifications required for the CI, it materials, and its processes are defined adequately to ensure that at:

a. Subsystem requirements reviews, the requirements allocated to the CI are complete and incorporated into the specification and that pertinent interface control documentation has been established; and
b. Subsystem design reviews, the requirements allocated to the CI are viable and necessary process and material specifications have been developed.

5.7.10.1 Software Specification Review (SSR). SSRs shall be conducted to demonstrate convergence on computer software configuration item (CSCI) requirements as an integrated part of system and CI requirements, and readiness to initiate preliminary design for the CSCI, by confirming that:

a. subsystem and functional issues have been resolved;
b. the system physical architecture has converged on, and characterizes, a software design approach that includes design allocation of functional and performance requirements, interface requirements, and constraints to the CSCI as well as derived requirements for the CSCI;
c. CSCI requirements are traceable to higher-level requirements and that the set of requirements incorporates the functionality that must be implemented in the CSCI;
d. the relationship between the CSCI and associated computer hardware requirements has been identified and the design compatibility between the hardware and software has been established;

e. CSCI requirements, needed to ensure that its performance and system compatibility satisfy higher-level and interfacing requirements, have been captured in a completed Software Requirements Specification and, if applicable, completed Interface Requirements Specification;
f. cost, schedule, and performance risks have been identified, quantified, and prioritized;
g. risks are acceptable and risk management planning for the CSCI has been incorporated into overall technical risk management; and
h. CSCI life cycle resource requirements are compatible with, and incorporated into, the system life cycle resource requirements.

5.7.10.2 Preliminary Design Review (Subsystem). Subsystem PDRs shall be conducted to confirm that the CI's detailed design approach (as an integrated composite of applicable people, product, and process solutions) provides required functionality; risks are mitigated with closure plans for remaining risks demonstrating required progress; and the CI is ready for detailed design. PDR shall confirm that:
a. subsystem and functional issues have been resolved;
b. the process completely defined CI requirements for design including that
(1) the design approach is balanced for the life cycle, cost, schedule, performance, and risk,
(2) the CI physical architecture is an integrated detailed design approach for applicable people, products, and processes to satisfy requirements, including interoperability and interfaces,
(3) an audit trail from SFR is established with changes substantiated,
(4) the CI design approach is consistent with available DT&E results,
(5) risks are mitigated and remaining risks acceptable, and
(6) the allocated baseline for the CI is defined;
c. sufficient detailed design has been accomplished to verify the completeness and achievability of defined requirements;
d. the risk handling approach is refined for the next phase or technical effort;
e. applicable pre-planned product and process improvement and evolutionary acquisition requirements and plans have been refined; and
f. critical accomplishments, success criteria, and metrics are valid for continued technical effort.

5.7.10.3 Critical Design Review (Subsystem). Subsystem CDRs shall be conducted to demonstrate that the CI detailed design (as an integrated composite of applicable people, product and process solutions) is complete, meets requirements, and the CI is ready for fabrication, coding, assembly, and integration of qualification units. CDR shall confirm that:
a. subsystem and functional issues have been resolved;
b. the process completely defined CI design requirements including that
(1) the design is balanced for the life cycle, cost, schedule, performance, and risk,
(2) the CI physical architecture is an integrated detailed design for applicable people, products, and processes to satisfy requirements, including interoperability and interfaces,
(3) an audit trail from CI PDR is established with changes substantiated,
(4) allocated baseline(s) for the CI are refined;
c. the CI design compatibility with external interfaces (people, products, and processes);
d. CI design and interface requirements and design constraints are consistent with DT&E results;
e. DT&E results support critical CI design and interface requirements and design constraints;
f. the risk handling approach is refined for the next phase or technical effort;
g. pre-planned product and process improvement and evolutionary acquisition requirements and plans have been refined; and
h. critical accomplishments, success criteria, and metrics are valid for continued technical effort.

5.7.10.4 Test Readiness Reviews (TRR). TRRs shall be conducted, as needed, for each CI to confirm completeness of test procedures, to assure that the CI is ready for testing, and to assure that the performing activity is prepared for formal testing. TRR shall confirm that:
a. test procedures comply with test plans and descriptions, demonstrate adequacy to accomplish test requirements, and satisfy CI specification requirements for verifications;
b. pre-test predictions and informal test results (if any) indicate testing will confirm necessary performance;

c. new or modified test support equipment, facilities, and procedure manuals required to accomplish planned DT&E and OT&E are available and satisfy their requirements; and
d. required operation and support documents are complete and accurate.

5.7.10.5 Functional Configuration Audit (Subsystem FCA). Subsystem FCAs shall be conducted to verify a CI's performance against its configuration documentation. This review shall be conducted in accordance with contractually established configuration management procedures.

5.7.10.6 Physical Configuration Audit (Subsystem PCA). Subsystem PCAs shall be conducted on the as-built version of a CI against its design documentation. PCAs are normally conducted when production representative articles are available and establish or verify the product baseline for the CI. PCAs shall be conducted in accordance with contractually established configuration management procedures.

5.7.11 Functional Reviews. Integrated, multidisciplinary functional reviews shall be conducted across the system to demonstrate:

a. progress in defining requirements for the system's functionality;
b. vertical traceability of the functionality from needs/customer requirements to solutions;
c. integration and balance of the functionality across interfaces; and
d. progress in converging on design solutions that provide the required functionality.

With this perspective, these reviews shall be conducted to assist in the identification and resolution of issues; support the identification of alternatives to satisfy higher level requirements; and support technical plan development ensuring that product plans are functionally integrated system-wide.

5.7.12 Interim System Reviews. Interim system reviews shall be conducted across the system, as needed between major reviews, to:

a. provide system status toward satisfying the SEMS for the next major review;
b. ensure that closure plans are defined and implemented for subsystem and functional issues;
c. confirm incremental progress toward meeting system-level SEMS accomplishments; and
d. confirm that system maturity, including risk mitigation, is achieving needed progress.

5.8 Systems Engineering Capability Assessment. The tasking activity may the assess performing activity's capability to satisfy contractual requirements for systems engineering. Upon request of the tasking activity, the performing activity should make available for tasking activity review additional systems engineering procedures and data. The review consists of a combined demonstration and analysis of features in the performing activity's procedures, data, facilities, personnel, and tools that are key to the satisfaction of contract requirements. Prior to contract award, this review is used by the tasking activity to assist in identifying the risk in achieving required accomplishments. During the contracted period, the review may be conducted to evaluate the cause of not meeting contractual requirements and to evaluate the viability of "get well" actions, if developed.

6. NOTES

(This section contains information that may be helpful, but it is not mandatory.)

6.1 Intended Use. This standard is to be used when a program involves the development or upgrade of a system, segment, configuration item, or set of configuration items. It applies equally to any performing activity, whether a government or industry operation. For programs where a government activity plays a "contractor" role, that activity should implement this standard under a "contract" to the tasking government activity. A single, integrated set of technical tasks should be developed. This can be accomplished by integrating all the tasks in the SOW, tailoring this document to include tasks from other standards selected for contractual application, complete execution of the integrated task set via the performing-activity prepared SEMP or some appropriate combination of these alternatives. Regardless of the approach taken to place the tasks of this standard on contract, the SEMP should be the single integrated technical planning document. Table I identifies some of the related standardization documents that should be considered for tailored incorporation in the SOW and/or SEMP.

6.2 Data Requirements. The following Data Item Descriptions (DID's) must be listed, as applicable, on the Contract Data Requirements List (DD Form 1423) when this standard is applied on a contract, in order to obtain the data, except where DoD FAR Supplement 227.405-70, Data Requirements, exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title
4.1.b	TBD	Systems Engineering Management Plan
4.1.d	TBD	Systems Engineering Detailed Schedule

The above DID's were those cleared as of the date of this standard. The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.3 Tailoring Guidance. This standard is applied at the discretion of the Government tasking activity. In each application, this standard should be tailored to the specific requirements of a particular program, program phase, or contractual structure. Care should be taken to eliminate tasks which add unnecessary costs, data and any factors which do not add value to the process or product. Tailoring takes the form of deletion (removal of tasks not applicable), alteration (modifying tasks to more explicitly reflect the application to a particular effort), or addition (adding tasks to satisfy program requirements). Tailoring specific tasks requires definition of the depth of detail, level of effort required, and the data expected. Tailoring is performed to both breadth and depth. Tailoring in breadth of application is based on the program and program phase (e.g., types and numbers of systems impacted by the development of a new general application subsystem, the numbers and types of assessments, numbers and types of reviews). Tailoring in depth involves decisions concerning the level of detail needed to generate and substantiate the outputs required to satisfy contractual objectives. The depth that the systems engineering effort should take will vary from program to program in relationship to complexity, uncertainty, urgency, and the willingness to accept risk. MIL-HDBK-248 provides additional tailoring guidance. Selected and tailored requirements and task statements may be used by program managers in preparing solicitation documents and by offerors in response to a draft Request for Proposal.

6.3.1 Tailoring Considerations. The objectives of the contract effort and the inputs to the systems engineering process scope the breadth and depth of application. To assist in defining the depth of application and level of effort required, the following inputs should be identified for any application of this document.

a. The level of detail in system definition required from the contracted effort. For example, during conceptual investigations a complete functional decomposition of the system for each system alternative is not always necessary. However, sufficient depth is necessary to provide confidence in cost, schedule, and performance objectives and related risks estimates. Different depths may be identified for areas in relationship to the application of new technologies.

b. Tasking activity directions and limitations including willingness to accept risk.

c. The scenarios and missions to be examined for each primary system function.

AREA	REFERENCE	
Automated Information Systems	MIL-STD-7935	
Configuration Management & Audits	MIL-STD-973	
Climatic information	MIL-STD-210	
Computer aided acquisition and logistics support	MIL-STD-1840	MIL-HDBK-59
Corrosion prevention and control	MIL-STD-1250	MIL-STD-1568
Data Management	DoD-STD-1700	
Design to Cost	MIL-STD-337	MIL-HDBK-766
Drawing practices	MIL-STD-100	
Environmental analysis (operating environments)	MIL-STD-810	
Electromagnetic compatibility	MIL-STD-461, 462, 1795, 1818 MIL-E-6051	 MIL-HDBK-237
Electrostatic discharge	MIL-STD-1686	MIL-HDBK-263
Human factors	MIL-STD-1472, 1794, 1800 MIL-H-46855	 DoD-HDBK-763
Integrated Diagnostics	MIL-STD-1814	
Maintainability	MIL-STD-470, 1843, 2165, 2184 MIL-HDBK-472	 DoD-HDBK-791
Manufacturing	MIL-STD-1528	
Non-destructive inspection	MIL-HDBK-728, 731	MIL-I-6870
Nuclear hardness and survivability	DoD-STD-1766	
Parts, materials, and processes control	MIL-STD-965	MIL-HDBK-402
Producibility	MIL-HDBK-727	
Quality	MIL-Q-9858	MIL-I-45208
Reliability/durability	MIL-STD-785, 1530, 1543, 1783, 1798, 2164	
Software	DoD-STD-2167 MIL-STD-1803, 1815	MIL-HDBK-287
Software quality assurance	DoD-STD-2168	MIL-HDBK-286
Specification Practices	MIL-STD-490, 961	
Statement of Work Preparation	MIL-HDBK-245	
Supportability	MIL-STD-1388, 1839	
Survivability	MIL-STD-1799, 2069	MIL-HDBK-336
System safety	MIL-STD-882	
System security	MIL-STD-1785	
Tailoring	DoD-HDBK-248	
Technical Data Package	MIL-T-31000	
Technical Reviews	MIL-STD-1521	
Telecommunications	MIL-STD-188-xxx	
Testability	MIL-STD-2165	
Thermal design/analysis	MIL-HDBK-251	
Training	MIL-STD-1379	
Transportability	MIL-STD-1367	MIL-HDBK-157
Value engineering	MIL-STD-1771	
Work Breakdown Structure	MIL-STD-881	

TABLE I. Related Standardization Documents

d. A set of measures of effectiveness organized hierarchically. The relative importance of all metrics at the top-level in the hierarchy should also be identified.

e Known constraints and requirements for establishing constraints in areas where they are likely to exist but quantitative data is not available (or determine these internally).

f. The technology base data including identification of key technologies, performance, maturity, cost, risks, and any limiting criteria on the use of technologies.
g. The factors essential to system success, including those factors related to major risk areas (e.g., budget, resources and threat)

6.3.2 General Guidance (Section 4). The basic systems engineering process described in section 4 can be applied to any development effort (including new developments, modifications, and products improvements), regardless of size or complexity. Attention to scope of the effort and level of output expected is, however, essential. Additionally, there are some tasks that may require specific tailoring.

a. For example, an unprecedented, new system development in concept exploration phase is not likely to require configuration management audits or formal change control mechanisms. However, conceptual exploration investigation of modifications to an existing or foreign developed system may need this type of activity (for example to verify interface constraints).
b. TPM in concept exploration phase may be reduced to tracking critical technical objectives or decision metrics related to validated needs. A technology program may not require the execution of any TPM tasks although some top-level tracking of key success metrics is recommended. If just top-level tracking is desired, tailor 4.3.4.8 (e.g., delete 4.3.4.8.2).

6.3.3 In Depth Considerations. The level of detail expected from the end-products of the technical effort must be identified as this scopes the depth to which the systems engineering process must be executed. For example, functional analysis and synthesis should be conducted to a sufficiently detailed depth to identify areas of technical risk appropriate for consideration for the acquisition phase or effort.

The term "sufficiently detailed" is determined based on the objectives of the contracted effort and can be characterized by the information content expected from the physical architecture. For example, during Concept Exploration and Definition the physical architecture should describe the system concept. During Demonstration and Validation, the physical architecture should describe the system in terms of its specifications and the concept of the CIs that make up the system. By the end of Engineering and Manufacturing Development (EMD), the physical architecture should provide the detailed design requirements for all system elements and the drawings for the system CIs. Throughout acquisition, the level of detail may vary since the baseline system may be at one level of detail and product or process improvements or other modifications may be at a different level of detail. Note that level of detail needed from the technical effort to ensure adequacy of technical definition, design, and development is not synonymous with the level of detail expected for management control and reporting (e.g., cost performance reports). Reporting for management control is normally to WBS level 3, except where high-cost or high-risk elements necessitate additional, lower-level visibility for effective management control.

6.3.4 General Guidance (Section 5). Many of the tasks in section 5 are phase dependent. Some tasks are not applicable to every program. Some tasks may need to be expanded as other standardization documents are applied. Figure 4 depicts an example life cycle for an unprecedented system. It illustrates the application of the systems engineering process across a system's life cycle and specific products and activities associated with application of this standard to an acquisition phase. Specific technology base development and modification activities are not identified in this figure. General guidance for application and tailoring considerations for technical reviews is contained in Appendix C.

6.3.4.1 Systems Engineering Implementation Tasks. The tasks identified are general systems engineering tasks that will require explicit tailoring (by expansion) to scope the technical effort. Task selection is program and phase dependent.

6.3.4.2 Systems Engineering Management Plan. The specific content requirements for the SEMP may vary for each application. Tailor the SEMP to define the specific content requirements for the intended application of this document. For example, if TPM were not implemented on a technology program delete the requirements for this type of planning from the SEMP. If there are no technology insertion efforts being considered, delete those requirements.

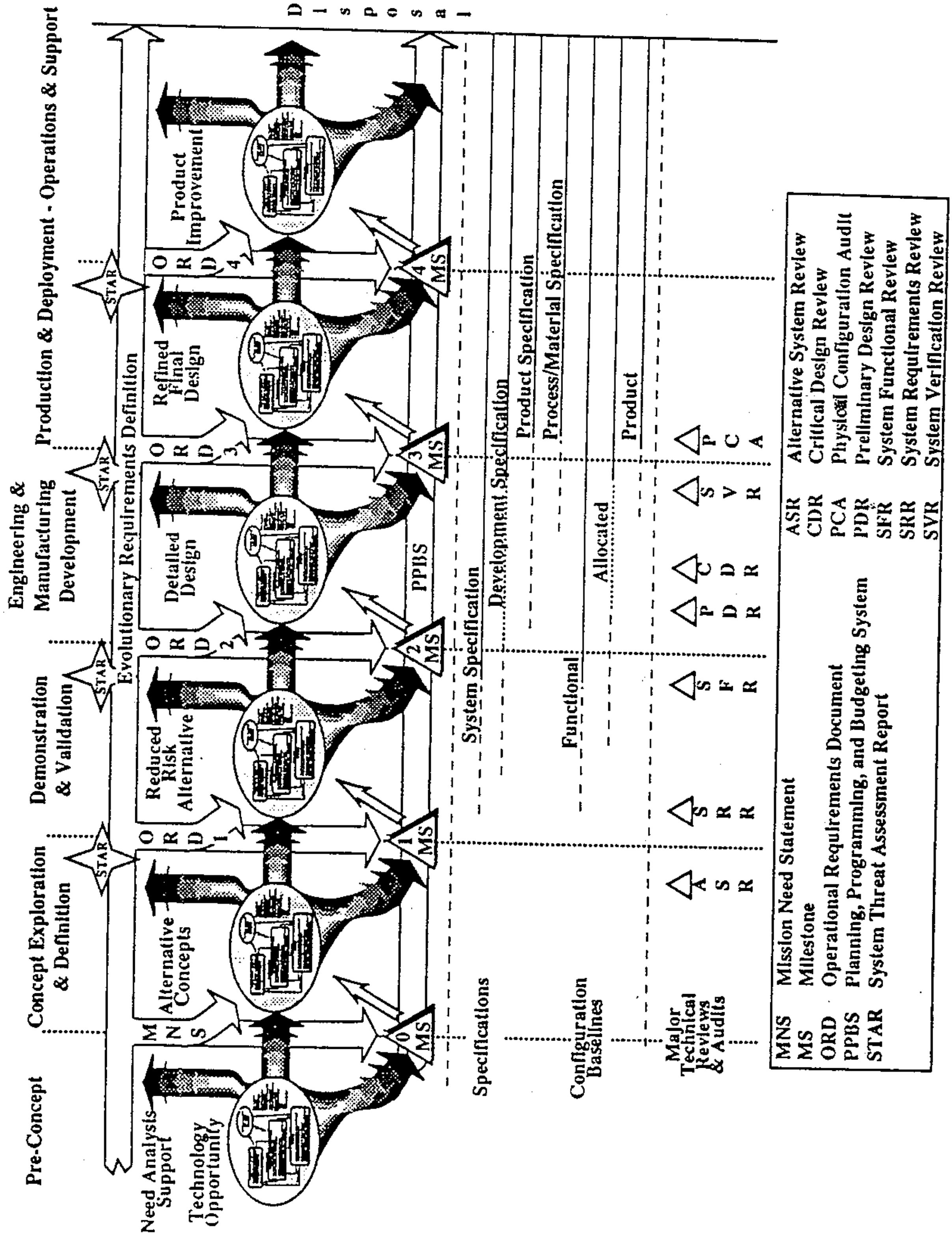

FIGURE 4. Example of a System Life Cycle

6.3.4.3 Functional Tasks. The tasks in 5.2 are intended to be integrated into the systems engineering process. Generally, the need (and subsequent tailoring guidance) results from customer inputs and systems engineering process outputs. The tasks identified represent some of the critical disciplinary considerations to be examined in development. As requirements are made definitive, tasks from appropriate standardization documents should be examined, selected and integrated into planned systems engineering process activities. Some tasks (e.g., ILS) are applicable throughout acquisition generally because support is always a factor. The tailoring of these tasks is expected to vary by application and program complexity. Depending on the specific program , some or even most of the tasks could be deleted. Also, the engineering specialties personnel needed to execute these tasks may be integral members (either as core or extended members) of the multidisciplinary teams assigned to subsystem developments, commensurate with the system and acquisition phase.

6.3.5 Tailoring Documentation. Tasking activity tailoring is included in the tasking activity SEMP and RFP/SOW. Performing activity tailoring recommendations are included in their proposal as inputs to the SOW and the SEMP.

6.3.6 Potential Environmental Concerns. When making a solicitation for work to be contracted, the tasking activity must examine not only the existing laws and agreements pertaining to control of hazardous materials, and the lists which define those materials, but also the pending extensions of those agreements and lists which could affect the program in its later phases.

6.4 Application Guidance.

6.4.1 Integrated Planning. When technical efforts are large and complex, they normally require the successful intermeshing of activities conducted by more than one organization. Furthermore, the technical effort may be a part of a larger, program-wide effort. Overall technical planning should be integrated across all activities having systems engineering responsibilities. The program manager should have visibility into how all related technical efforts are integrated. Thus, systems engineering management planning for the tasking activity should have clear, well defined interfaces to the systems engineering management planning conducted under contract to each performing activity, including event/accomplishment-based schedules and time-based schedules. Finally, many programs implement integrated program-wide plans, event/accomplishment-based schedules, and time-based scheduling. In these circumstances, each SEMP, SEMS, and SEDS should be integrated into their program-wide counterparts. Where this is done, and contractual implementation and maintenance is accomplished such as described in this standard, separately delivered technical planning is not needed except to satisfy higher-level requirements.

6.4.2 Tasking activity SEMP and SEMS. It is recommended that the tasking activity develop a SEMP and a SEMS to support its planning requirements. The tasking activity may elect to provide its SEMP and SEMS in part or total to the performing activity for use in proposal preparation. When provided, the tasking activity SEMP and SEMS is for guidance only. The tasking activity SEMS should provide top-level events, accomplishments, and accomplishment criteria throughout the entire program. The tasking activity SEMP and SEMS should provide detailed information for the next acquisition phase and/or engineering effort to identify specific events, accomplishments, and criteria necessary to satisfy planned and required technical exit criteria. The tasking activity SEMP should contain:

a. A general life cycle roadmap of the key systems engineering activities to be accomplished in the next acquisition phase and who (tasking activity or performing activity) will be responsible for their accomplishment. The tailoring approach for this standard and other applicable standards for contractual application should be included.

b. The concept to effect multidisciplinary teamwork for the tasking activity technical effort and specific responsibilities.

c. The plans and criteria for transitioning critical product and process technologies.

d. Identification of key trade-off studies, the scope and depth of systems effectiveness assessments, the current measures of effectiveness hierarchy, technical risk management plans, critical technical parameters, and tracking requirements for those parameters.

e. Identification of existing simulations which should be made available to the performing activity.

6.4.3 Performing activity Systems Engineering Management Plan. The SEMP, prepared by each performing activity, describes how the systems engineering will be implemented and controlled. It is recommended that the SEMP become the contractual application vehicle for implementation of this standard. To be effective, the SEMP must be contractually binding. However, it also must be recognized that the SEMP reflects a best estimate of how the activities will happen at a particular point in time. It is expected that the SEMP will need to change to meet contract requirements as the performing activity encounters unplanned events. A flexible contract implementation approach is necessary. An approach that balances the needed flexibility with the necessary implementation discipline is to require, in the RFP, development of the SEMP and delivery with the proposal. The SEMP, and requirements for review and approval of updates (included on the DD 1423), would then be negotiated as part of the Contract Data Requirements List (CDRL). The SEMP is then approved by the tasking activity prior to or concurrent with the issuance of a contract or change order. Changes to the SEMP can be made by mutual agreement between the respective tasking activity and performing activity program managers via the CDRL.

6.4.4 Performing Activity Systems Engineering Master Schedule. As the key control element of the systems engineering process, the SEMS should be contractually implemented in a manner that requires a contract change proposal to modify the SEMS. The Instructions to Offeror should contain requirements for the performing activity to develop the SEMS as part of the proposal. The negotiated SEMS is to be placed on contract. Demonstration milestones should be incorporated in Section H. The full SEMS should be an attachment to the SOW. The SOW must require that progress be tracked in accordance with the SEMS and reported at both incremental (functional, subsystem, and interim system) reviews and major reviews. The SEMS can be used as the basis for quantitative requirements for award fees. The SEDS (normally a deliverable item) provides a calendar based, detailed listing of the tasks required to satisfy the tasks in the SEMS. During phases with specifications on contract, the linkage between the specification requirements, the WBS, the SOW, TPM, the SEMS, and the SEDS provides a significant risk management tool that provides specific insights on the relationships between cost, schedule and performance risks. This relationship allows all items to be tracked to the same WBS element. This relationship is shown in Figure 5 for the EMD phase. For systems engineering efforts prior to the Demonstration and Validation phase, the specification tree may not be available. The draft Program or Contract WBS would be used to guide development of the SOW, SEMS, and SEDS, in this case.

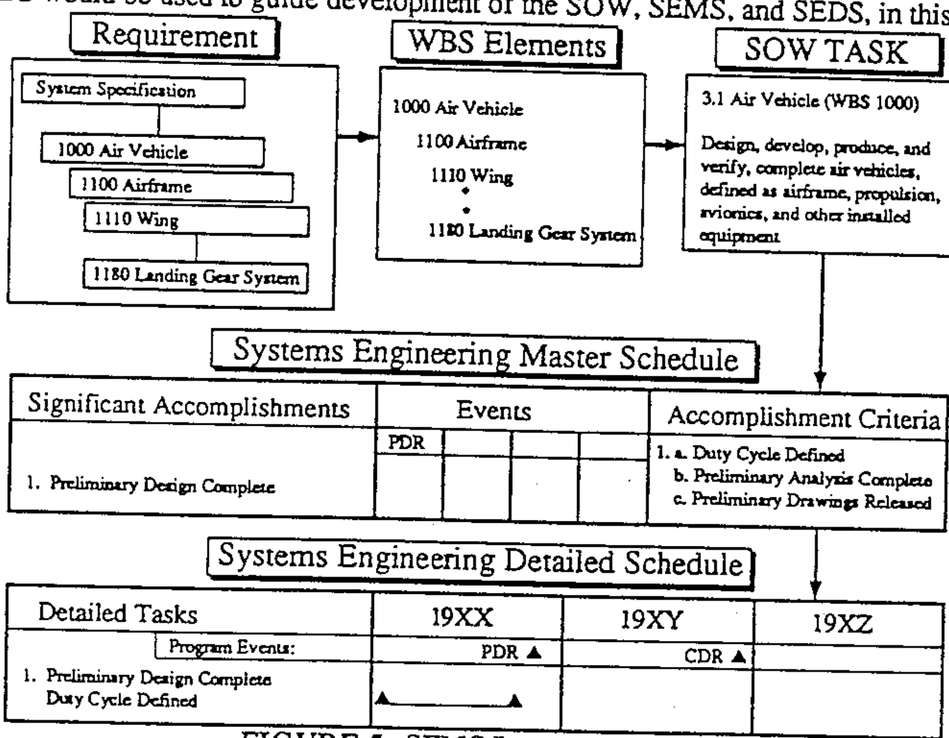

FIGURE 5. SEMS Interrelationships

6.4.5 Decision Data Base. This is a repository of information used and generated by the systems engineering process, at the appropriate level of detail for the acquisition phase. The intent of the decision data base is that when, properly structured, it provides access to all of the technical information, decisions, and rationale that describe the current state of system development and its evolution. For example, the decision data base is intended to:

a. illustrate intrasystem, intersystem and item interfaces;
b. permit traceability between the elements at various levels of system detail;
c. provide means for complete and comprehensive change control;
d. include the techniques and procedural data for development, manufacturing, verification, deployment, operation, support, training, and disposal;
e. provide data to verify the adequacy of design development;
f. provide data for trade-offs and assessments of an item's capability to satisfy objectives; and
g. provide complete documentation of the design (products and processes) to support progressive system development and subsequent iterations of the systems engineering process.

The decision data base may be on electronic media as provided by the statement of work. The specific format and structure of the data base may be defined by the tasking activity or left open for performing activity definition. Standardization of its format and structure, however, should be an issue during early acquisition phases, or during an upgrade or modification effort, to document and maintain the necessary audit trail. Computer system independence should be maximized to facilitate transition and translation of system data. When multiple cooperative or associate contracts are executed, a common format and interface should be agreed upon by all participants. Performing activities should be accountable for compatibility of system data from their subcontractors. The form, depth, and frequency of tasking activity access to the data base should be defined in contract requirements.

6.4.6 Automated Tools. Performing activity-owned, off-the-shelf automated tools for data maintenance and transfer are generally preferred over the use of new tools requiring a development effort. Their selection for use, particularly for data transfer, may be predicated on their ability to satisfy prescribed security and data interchange (e.g., American National Standards Institute - ANSI X-12) requirements. Development requirements for new tools are acceptable, if pragmatic life cycle management benefits can be realized. In circumstances where multiple performing activities are supporting the same overall development effort, the tasking activity should consider the requirement that each performing activity use the same automated tools to facilitate transition and translation of system data, and provide a common format and interface among all participants. The performing activity should justify, on the basis of life cycle cost effectiveness, the selection and use of test equipment, software, and documentation tools that differ from the installed tool set at projected maintenance facilities. When cost effective, tools should be selected from those considered to be "industry standards".

6.4.7 Relationship of Technical Planning to Cost and Schedule Performance. Planning of technical tasks provides the foundation for cost and schedule planning. It forms the basis for allocating resources, scheduling task elements, assigning authority and responsibility, and integrating all aspects of the technical program. Technical planning is carried out to meet contractual requirements and is integrated with the cost and schedule control system at the appropriate level. The allocated resources form the performance measurement baseline for integrated cost, schedule and technical management. This relationship pertains both to the initial program definition and to the redefinition which is part of the decision and control process.

6.4.8 Relationships of Technical Performance Measurement (TPM) to Cost and Schedule Performance Measurement. The purpose of performance measurement is to provide contractor and Government program managers with accurate data to monitor execution of their programs. Performance measurement provides a basis for responsible decision making by both contractor and DoD Component managers by requiring that contractors' internal management control systems produce data that:

a. indicate work progress;
b. properly relate cost, schedule, and technical accomplishment;
c. are valid, timely, and able to be audited; and
d. provide DoD Component managers with information at a practical level of summarization.

TPM assesses the technical characteristics of the system and identifies problems through engineering analyses or tests which indicate performance being achieved for comparison with performance values allocated or specified in contractual documents. Cost/schedule performance measurement assesses the program effort from the point of view of the schedule of increments of work and the cost of accomplishing those increments. By comparing the value of work accomplished with its planned value and with the actual cost of work performed, variances are identified that quantify the effects of problems being experienced. In addition to problems due to unrealistic cost and schedule planning, cost/schedule performance measurement may show up technical inadequacies, just as technical problems identified through TPM surface inadequacies in budget of time or dollars. TPM and cost/schedule performance measurement are complementary functions. Further, by assessing progress toward design objectives, TPM can provide a basis to assess the adequacy of remaining cost performance budgets and to revise cost and schedule projections as necessary. TPM assessment points should be planned to coincide with cost reporting as well as the planned completion of significant design and development tasks, or aggregation of tasks. This facilitates the verification of the results achieved in the completed task in terms of its technical requirements and the verification that technical work still to be accomplished is within established budgets. Thus, TPM and cost/schedule performance measurement must be integrated both in task planning and in contract reviews to achieve the ultimate goal of effective cost, schedule and technical performance management.

6.4.9 System Configuration. This section presents, as an example, the configuration of a generic system. The system configuration consists of the system's elements and the linkages among them. An element of the configuration, when identified and designated for configuration control, is called a configuration item (CI). A CI which contains hardware is termed a configuration item (designated a CI) and may include equipments, computers, materiel, software, facilities, etc. A CI which consists only of software is termed a computer software configuration item (CSCI). As these CIs and their constituents are identified and developed, the interfaces between them are also identified and developed. Figure 6 shows how a system may be partitioned into its CIs and their components and how CSCIs would appear in this partitioning (a top-down process).

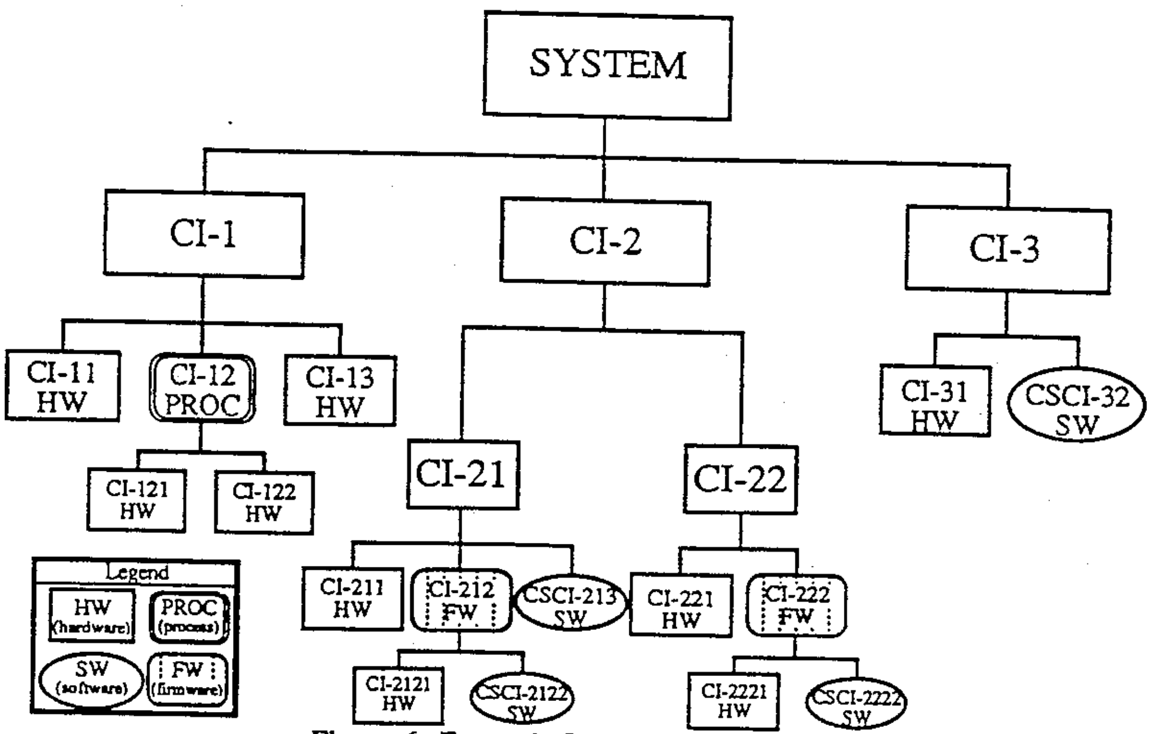

Figure 6. Example System Configuration

The system shown in Figure 6 is partitioned into three subsystems:

(1) CI-1 consisting of three items of equipments with a process but no computers;
(2) CI-2 consisting of two CIs each having hardware with embedded processors or firmware; and
(3) CI-3 consisting of a digital computer and the software it uses to achieve necessary functionality.

CI-1 is partitioned into CI-11, CI-12 (process driven CI such as training), and CI-13 (CI for materiel). CI-12 is further partitioned into the hardware elements of the process (such as courseware and manuals).
CI-2 is partitioned into CI-21 and CI-22. CI-22 is further partitioned into CI-221, a hardware item and CI-222, a firmware item. CI-222 is made up of CI-2221 (CI for the hardware portion of the firmware) and CI-2222 (CSCI for the software portion of the firmware). These "lower-level" CIs may be partitioned further into less complex components until they are suitable for individual treatment.
CI-3 is partitioned into CI-31 and CSCI-32. These "lower-level" CIs may be partitioned further into components until they are suitable for individual treatment.

Note that physical integration of components and CIs is achieved bottom-up.

6.5 Subject term (key word) listing.

Multidisciplinary Teamwork
Primary System Functions
System
System Elements
Systems Engineering
Technical Reviews
Systems Engineering Detailed Schedule
Systems Engineering Master Schedule
Systems Engineering Management Plan
Systems Engineering Process
Technical Performance Measurement

6.6 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

APPENDIX A

GLOSSARY

A1. Scope. This Appendix provides definitions of essential terms used in the standard. This Appendix is a mandatory part of the standard. The information contained herein is intended for compliance.

A2. Applicable Documents. This section is not applicable to this appendix.

A3. Definitions.

Allocated Baseline. The initially approved documentation describing a configuration item's (CI) functional, performance, interoperability, and interface requirements that are allocated from those of the system or a higher level CI; interface requirements with interfacing CIs; design constraints; derived requirements (functional and performance); and verification requirements and methods to demonstrate the achievement of those requirements and constraints. Generally, there is an allocated baseline for each CI to be developed.

Compatibility. The capability of two or more items, components of equipment, or material, to exist or function in the same system or environment without mutual interference.

Configuration Baseline. The configuration documentation formally designated by the Government at a specific time during a system's or configuration item's life cycle. Configuration baselines, plus approved changes from those baselines, constitute the current configuration documentation. There are three formally designated configuration baselines, namely the functional, allocated, and product baselines.

Configuration Item (CI). An aggregation of hardware, firmware, or computer software or any of their discrete portions, which satisfies an end use function and is designated by the Government for separate configuration management. Configuration items may vary widely in complexity, size, and type, from an aircraft, electronic, or ship system to a test meter or round of ammunition. Any item required for logistic support and designated for separate procurement is a configuration item. (Note: In this standard, the term configuration item (CI) means any type of CI. When a requirement is limited to a specific type of CI, the limiting designation is used such as, computer software configuration item or CSCI.)

Cost Objectives. Financial thresholds and targets established for relevant life cycle cost elements and subelements consistent with the ability to control and influence the element (see Figure 7).

Customers. Users and suppliers of system end items.

Customer Requirements. Statements of fact and assumptions that define the expectations of the system in terms of mission or objectives, environment, constraints, and measures of effectiveness. These requirements are defined from a validated needs statement (Mission Needs Statement), from acquisition and program decision documentation, and from mission analyses of each of the primary system life-cycle functions.

Decision Data Base. The organized collection of data (inputs, as well as intermediate and final outputs) that provides the audit trail of decisions and rationale from initially stated needs and requirements to the current description of system people,

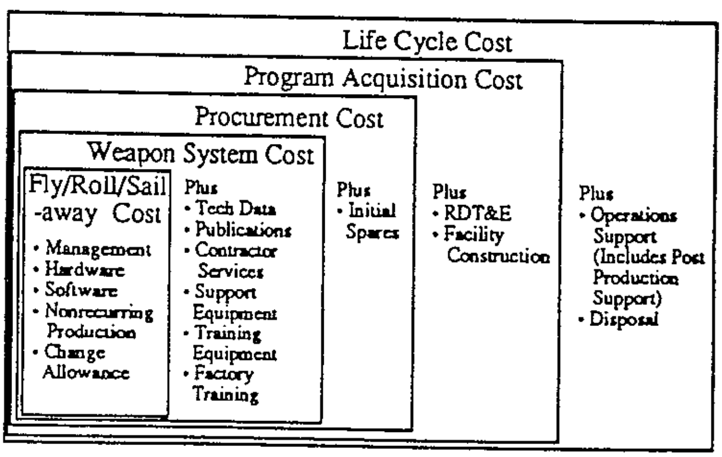

FIGURE 7. Factors in Program Cost Categories

product and process solutions. It includes information such as functional and physical architectures, specifications, baselines, plans, test results, models (e.g., finite element, simulation), drawings, and layouts.

Demilitarization. The disposal resources, processes, procedures, design considerations, and methods required to ensure that military-peculiar attributes of system end items (such as explosives, whether in warheads or employed to effect performance of an item) can be deactivated (rendered harmless) or otherwise disposed of in an environmentally responsible manner.

Deployment Function. Tasks, actions, and activities to be performed with required resources to bring a system, or upgrades to the system into a state of full operational capability. The function encompasses transport, receive, process, assemble, install, test, checkout, operate and, as required, emplace, house, store, or field types of activities.

Derived Requirements. Characteristics needed to complete the requirements set for item design that are dependent on the nature of the item solution for their initial identification. These are typically identified during synthesis of preliminary product and process solutions, related trade-off studies and verifications.

Design. (verb) The process of defining, selecting, and describing solutions to requirements in terms of products and processes. (noun) The product of the process of designing that describes the solution (either conceptual, preliminary, or detailed) of the system, system elements or system end-items.

Design Constraints. The boundary conditions within which the developer must remain while allocating performance requirements and/or synthesizing system elements. These design constraints may be externally imposed (e.g., safety, environmental) or internally imposed as a result of prior decisions which limit subsequent design alternatives. Examples of these constraints include: form, fit, function, interface, technology, material, standardization, cost, and time.

Design Requirements. That set of characteristics defining solution specific implementation ranging from solution boundary conditions (e.g., form and fit) to detailed design including "build to", "code to", and "buy to" requirements for products and "how to execute" requirements for processes.

Design-To-Cost. An acquisition management technique to achieve system designs that meet stated cost objectives. The technique embodies early establishment of realistic but rigorous cost targets and a determined effort to achieve them.

Development Function. Tasks, actions, and activities to be performed with required resources to evolve the system from customer needs to system product and process solutions. The function encompasses the planning and execution of the definition, design, design implementation, integration, analyses, and control types of activities. Development applies to new developments, product improvements, and modifications, as well as any assessments needed to determine a preferred course of action for material solutions to identified needs, deficiencies, or problem reports.

Disposal Function. Tasks, actions, and activities to be performed with required resources to ensure that disposition of products and by-products that are no longer needed, no longer useful, or no longer fit for use, complies with applicable classified and environmental regulations and directives. The function encompasses the short and long term impact to the environment and health hazards to humans and animals as well as recycling, material recovery, salvage for reutilization, demilitarization, and disposal of by-products across the life cycle.

Effectiveness Analysis. An analytical approach used to determine how well a system performs in its intended utilization environment.

Environment. The natural and induced conditions experienced by the system including its people, products, and processes. The natural environment (weather, climate, ocean conditions, terrain, vegetation, space conditions); combat environment (dust, fog, smoke, nuclear-chemical-biological); threat environment (effects of existing and potential threat systems to include electronic warfare and communications interception); operations environment (thermal, shock, vibration, power variations);

transportation and storage environment; maintenance environment; test environments; manufacturing environments (critical process conditions, clean room, stress) and other environments (e.g. software engineering environment, electromagnetic) related to system utilization.

Environmental Requirements. The requirements that characterize the impact of the environment on the system/configuration item (CI) as well as the system/CI's impact on the natural environment.

Evolutionary Acquisition. An adaptive and incremental strategy applicable to high technology and software intensive systems when requirements beyond a core capability can generally, but not specifically, be defined.

Exit Criteria. Specific accomplishments or conditions that must be satisfactorily demonstrated before an effort can progress further in the current acquisition phase or transition to the next acquisition phase.

Function. A task, action or activity performed to achieve a desired outcome.

Functional Analysis and Allocation. Examination of a defined function to identify all the subfunctions necessary to the accomplishment of that function; identification of functional relationships and interfaces (internal and external) and capturing these in a functional architecture; and, flow down of upper-level performance requirements and assignment of these to lower-level subfunctions.

Functional Architecture. The hierarchical arrangement of functions, their internal and external (external to the aggregation itself) functional interfaces and external physical interfaces, their respective functional and performance requirements, and the design constraints.

Functional Baseline. The initially approved documentation describing a system's or item's functional, performance, interoperability, and interface requirements and the verification required to demonstrate the achievement of those specified requirements.

Functional Requirement. The necessary task, action, or activity that must be accomplished.

Functional Review. An incremental review conducted across the system to address progress and issues for an area of the system's functionality.

Interface Requirement. The functional and physical requirements and constraints at a common boundary between two (or more) functions or items. Interfaces result from the interaction between functions, items, products of an item, or collateral effects of operating an item. Functional interfaces are the relationships between characteristic actions (internal or external). Physical interfaces are the relationships between internal parts of the solution as well as between the solution and external elements.

Interim System Review. A review conducted across the entire system, between major reviews, to address progress and issues.

Item. A non-specific term used to denote any product, including systems, subsystems, assemblies, subassemblies, units, sets, parts, accessories, computer programs, or computer software. In this standard, it also denotes any process that includes a series of actions, changes, or functions to achieve an end or result.

Life Cycle Resources. All resources (e.g., time, money, people, materials, facilities) required to accomplish the primary system functions for an item throughout its life cycle.

Major Review. A formal demonstration and confirmation across the system that supports or constitutes a program milestone event. Major reviews mark significant progress in system maturity and have key accomplishments and success criteria that directly relate to established phase exit criteria for the program.

Manufacturing Function. Tasks, actions, and activities to be performed with required resources to convert raw materials and components into a product. It provides for: definition of manufacturing designs (including manufacturing layouts), methods, and processes; and fabrication, assembly, and checkout of component elements (including test equipment, tooling, and machinery).

Measure of Effectiveness (MOE). A metric used to quantify the performance of system products and processes in terms that describe the utility or value when executing customer missions. Systems engineering uses MOEs in a variety of ways including decision metrics, performance requirements, and in assessments of expected performance. MOEs can include cost effectiveness metrics.

Measure of Effectiveness Hierarchy. A top-down set of measures of effectiveness that establishes a relationship from customer needs, requirements and objectives to design criteria. The Measure of Effectiveness hierarchy assists in the selection of requirements and in analytic estimates and verifications that product and process solutions satisfy customer needs, objectives, and requirements.

Metrics. Measures used to indicate progress or achievement.

Multidisciplinary Teamwork. The timely and cooperative application of all appropriate disciplines in an open-communication, shared-information environment to effect people functioning as a team to achieve optimum solutions to problems regardless of the actual organizational structure employed.

Need. A user-related capability shortfall (such as those documented in a Mission Need Statement, field deficiency report, or engineering change proposal), or an opportunity to satisfy a capability requirement because of a new technology application or breakthrough, or to reduce costs. Can also apply to a shortfall in capability to accomplish supplier-related primary system functions (e.g. disposal).

Non-Developmental Item (NDI).

a. Any item of supply that is available in the commercial marketplace (including Commercial-off-the-Shelf);
b. Any previously developed item of supply that is in use by a department or agency of the United States, a State or local government, or a foreign government with which the United States has a mutual defense cooperation agreement;
c. Any item of supply described in definition a or b, above, that requires only minor modification in order to meet the requirements of the procuring agency; or
d. Any item of supply that is currently being produced that does not meet the requirements of definition a., b., or c., above, solely because the item is not yet in use or is not yet available in the commercial marketplace.

Open System Architecture. A logical, physical structure implemented via well defined, widely used, publicly-maintained, non-proprietary specifications for interfaces, services, and supporting formats to accomplish system functionality, thereby enabling the use of properly engineered components across a wide range of systems with minimal changes.

Operational Effectiveness. The overall degree of mission accomplishment of a system when used by representative personnel in the environment planned or expected (e.g., natural, electronic, threat) for operational employment of the system considering organization, doctrine, tactics, survivability, vulnerability, and threat (including countermeasures, initial nuclear weapons effects, nuclear, biological and chemical contamination threats). Frequently used as an operational test and evaluation metric.

Operational Suitability. The degree to which a system can be placed satisfactorily in field use with consideration given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, natural environmental effects and impacts, documentation, and training requirements. Frequently used as an operational test and evaluation metric.

Operations Function. Tasks, actions, and activities to be performed with required resources to accomplish defined mission objectives and tasks in the peacetime and wartime environments planned or expected.

Performance. A quantitative measure characterizing a physical or functional attribute relating to the execution of a mission or function. Performance attributes include quantity (how many or how much), quality (how well), coverage (how much area, how far), timeliness (how responsive, how frequent), and readiness (availability, mission readiness). Performance is an attribute for all system personnel, products, and processes including those for development, production, verification, deployment, operations, support, training and disposal. Thus, supportability parameters, manufacturing process variability, reliability, and so forth, are all performance measures.

Performance Requirement. The extent to which a mission or function must be executed, generally measured in terms of quantity, quality, coverage, timeliness, or readiness.

Physical Architecture. The hierarchical arrangement of people, product, and process solutions, their functional and performance requirements; their internal and external (external to the aggregation itself) functional and physical interfaces and requirements, and the physical constraints that form the basis of design requirements. The physical architecture provides the basis for system/CI baselines as a function of the acquisition phase. It documents designs for people, products (such as hardware, software, facilities), and processes required to:

a. accomplish effectiveness analysis, risk analysis, and technology transition planning;
b. establish the feasibility of physically realizing the functional architecture;
c. identify manufacturing verification, support and training requirements;
d. document the configuration of prototypes and other test articles, and
e. define in increasing detail the solution to identified needs.

Preplanned Product Improvement. The conscious, considered strategy which involves deferring the development of necessary performance capabilities associated with elements having significant risks or delays so that the system can be fielded while the deferred element is developed in a parallel or subsequent effort. Provisions, interfaces, and accessibility are integrated into the system design so that the deferred element can be incorporated in a cost effective manner when available. The concept also applies to process improvements.

Primary System Functions. Those essential tasks, actions, or activities that must be accomplished to ensure that the system will satisfy customer needs from a system life-cycle perspective. The eight primary system functions are development, manufacturing, verification, deployment, operations, support, training, and disposal. Also referred to as primary (or system) functions, and system life-cycle functions.

Producibility. The attributes of a design that allow it to be produced economically with consistent quality.

Product Baseline. The initially approved documentation describing all of the necessary functional, performance, and physical requirements of the configuration item (CI); the functional and physical requirements designated for production acceptance testing; and tests necessary for deployment, support, training and disposal of the CI. In addition to the documentation, the product baseline of a configuration item may consist of the actual equipment and software. There is a product baseline for each CI.

Requirements. Characteristics that identify the accomplishment levels needed to achieve specific objectives for a given set of conditions.

Requirements Analysis. The determination of system specific performance and functional characteristics based on analyses of customer needs, requirements, and objectives; missions; projected utilization environments for people, products, and processes; constraints; and measures of effectiveness. The bridge between customer requirements and system specific requirements from which solutions can be generated for the primary system functions.

Risk. A measure of the uncertainty of attaining a goal, objective, or requirement pertaining to technical performance, cost, and schedule. Risk level is categorized by the probability of occurrence and the consequences of occurrence. Risk is assessed for program, product, and process aspects of the system. This includes the adverse consequences of process variability. The sources of risk include technical (e.g., feasibility, operability, producibility, testability, and systems effectiveness); cost (e.g., estimates, goals); schedule (e.g., technology/material availability, technical achievements, milestones); and programmatic (e.g., resources, contractual).

Risk Management. An organized, analytic process to identify what can go wrong, to quantify and assess associated risks, and to implement/control the appropriate approach for preventing or handling each risk identified.

Risk Management Plan. Description of the risk management program that describes the approach and activities for risk management. The technical risk management plan is an essential part of the Systems Engineering Management Plan (SEMP).

Schedule Requirements. Progress characteristics imposed in terms of operational capability, production and surge rates, production and repair cycle times, or other development time constraints.

Segment. A generic term for a portion (and all its constituent parts) of a system. Can be a single CI.

Specification. A description of the essential technical requirements for items, materials, and services that includes the verification criteria for determining whether these requirements are met. A specification supports the acquisition and life cycle management of the item, material, and service described.

Specification Tree. The hierarchical depiction of all the specifications needed to control the development, manufacture and integration of items in the transition from customer needs to the complete set of system products and processes that satisfy those needs.

Subsystem. A grouping of items satisfying a logical group of functions within a particular system.

Subsystem Review. An incremental review conducted for a configuration item (CI) or aggregate of CI's to assess subsystem development risks, issues, and progress. Subsystem reviews can be formal (review of a single CI as part of a preliminary design review (PDR)) or informal (a working group meeting assessing progress and actions required to meet future required accomplishments).

Suppliers. The development, manufacturing, verification, and deployment personnel that define, design, code, fabricate, assemble, integrate, verify, test, deliver and/or install system end items, and safely dispose of the by-products of their activities.

Support Function. Tasks, actions, and activities to be performed with required resources to provide support for operations, maintenance, logistics, field performance information feedback, training, and materiel management. The function encompasses the definition of tasks, equipment, skills, personnel, facilities, materials, publications, data, services, supplies, and procedures required to ensure the proper supply, storage, and maintenance of a system end item.

Synthesis. The translation of input requirements (including performance, function, and interface) into possible solutions (resources and techniques) satisfying those inputs. Defines a physical architecture of people, product, and process solutions for logical groupings of requirements (performance, function, and interface) and then designs those solutions.

System. An integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective.

System Effectiveness. A quantitative measure of the extent to which a system can be expected to satisfy customer needs and requirements. System effectiveness is a function of suitability, dependability and capability. System effectiveness and its components are systems engineering metrics. They can be used as decision criteria and the values can be used as requirements.

Capability. A measure of the system's ability to achieve the mission objectives, given that the system is dependable and suitable.

Dependability. A measure of the degree to which an item is operable and capable of performing its required function at any (random) time, given its suitability for the mission and whether the system will be available and operate when, as many times, and as long as needed.

Suitability. A measure of the degree to which a system is appropriate for its intended use with respect to non-operational factors such as man-machine interface, training, safety, documentation, producibility, testability, transportability, maintainability, manpower availability, supportability, and disposability.

System Elements. The basic constituents (personnel, hardware, software, facilities, data, materials, services, techniques) of a system that satisfy one or more requirements in the lowest levels of the functional architecture.

System End Item. A deployed system product and/or process that is ready for its intended use.

System Life Cycle. The period extending from inception of development activities, based on an identified need or objective, through decommissioning and disposal of the system.

Systems Analysis and Control. The imposition of structure and discipline into system evolution by: measuring progress based on demonstrated performance; identifying, developing, and examining alternatives; making decisions based on cost, schedule, performance, and risk to effect balanced results; documenting the evolution and rationale; and controlling resulting configurations.

Systems Engineering. An interdisciplinary approach encompassing the entire technical effort to evolve and verify an integrated and life-cycle balanced set of system product and process solutions that satisfy customer needs. Systems engineering encompasses:

a. the development, manufacturing, verification, deployment, operations, support, disposal of, and user training for, system products and processes;
b. the management of the system configuration;
c. the translation of system definition into work breakdown structures; and
d. development of information for management decision making.

Systems Engineering Detailed Schedule (SEDS). The detailed, time dependent, task-oriented schedule of the work efforts required to support the events and tasks identified in the Systems Engineering Master Schedule (SEMS). The SEDS is used to track day-to-day progress and includes the continual assessment of the technical parameters required to support each SEMS task/event.

Systems Engineering Management Plan (SEMP). The plan for the conduct of the fully integrated technical effort necessary to satisfy the general and detailed requirements of MIL-STD-499B.

Systems Engineering Master Schedule (SEMS). A compilation of key accomplishments, each with measurable criteria, requiring successful completion to pass identified events. Events include technical reviews and audits, demonstration milestones, and decision points. Accomplishments include major and critical tasks, activities, and demonstrations. Accomplishment criteria are measurable indicators of successful completion of the associated accomplishment and can include completed work efforts and demonstrations of technical performance. The SEMS is event based, not calendar based.

Systems Engineering Process. A comprehensive, iterative, problem-solving process that:

a. transforms validated customer needs and requirements into a description of a life-cycle balanced solution set of people, products and processes;
b. generates information for decision makers; and
c. provides information for follow-on technical efforts (see also Figure 3).

Tailoring. The process by which individual task statements (sections, paragraphs, or sentences) of specifications, standards, and related documents are evaluated to determine the extent to which they are most suitable for a specific system and equipment acquisition and the modification of these requirements to ensure that each achieves an optimal balance between operational needs and cost. The tailoring of data product standards and DID's is limited to the exclusion of information requirement provisions. (Tailoring standards by adding tasks to satisfy program requirements is permitted except for data product standards.)

Technical Data. Scientific or technical information recorded in any form or medium (such as manuals and drawings). Computer programs and related software are not technical data; documentation of computer programs and related software are. Also excluded are financial data or other information related to contract administration.

Technical Data Package. A technical description of an item (product and process) adequate for supporting an acquisition strategy, production, engineering, and logistics support. The description defines the required design configuration and procedures to ensure adequacy of item performance. It consists of all applicable technical data such as drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, and packaging details.

Technical Effort. Any scientific, engineering, or related activity that influences or is influenced by, the primary system functions.

Technical Objectives. Target values used when insufficient data are available for stating binding requirements or, when opportunities are identified for substantial increases in effectiveness, decreases in cost, or additional flexibility (such as utilization in environments different from baseline conditions). Includes cost, schedule, and performance attributes.

Technical Parameters. A selected subset of the system's technical metrics tracked in Technical Performance Measurement (TPM). Critical technical parameters (products and processes) relate to critical system characteristics and are identified from risk analyses and contract specifications. Examples of Technical Parameters include:

a. Specification Requirements.
b. Metrics associated with technical objectives and other key decision metrics used to guide and control progressive development.
c. Design-to-cost targets.
d. Parameters identified in the acquisition program baseline or user requirements documentation.

Technical Performance Measurement (TPM). The continuing verification of the degree of anticipated and actual achievement for technical parameters. Confirms progress and identifies deficiencies that might jeopardize meeting a system requirement. Assessed values falling outside established tolerances indicate a need for evaluation and corrective action (see Figure 8).

a. **Achievement-to-Date.** Present assessed value of the technical parameter.
b. **Current Estimate.** The technical parameter value predicted to be achieved by the end of the contract with remaining resources (including schedule and budget).
c. **Technical Milestone.** A point where a TPM evaluation is accomplished or reported.
d. **Planned Value.** Technical parameter value based on the planned value profile.
e. **Planned Value Profile.** Projected time-phased achievement of a technical parameter.
f. **Tolerance Band.** Alert envelope around the planned value profile indicating allowed variation and projected estimating error.
g. **Threshold.** The limiting acceptable value of a technical parameter.
h. **Variation.** Difference between the planned value and the achievement-to-date value.

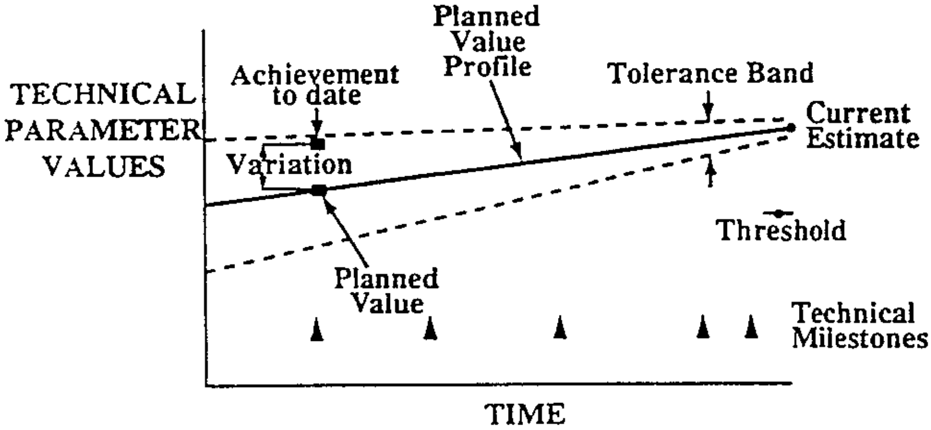

FIGURE 8. Example Technical Performance Measurement Profile

Technical Reviews. A series of systems engineering activities by which the technical progress of a program is assessed relative to its technical or contractual requirements. Conducted at logical transition points in the development effort to reduce risk by identifying and correcting problems/issues resulting from the work completed before the program is disrupted or delayed. Provide a method for the performing activity and tasking activity to determine that the development of a system and/or configuration item and its documentation have met contract requirements. Includes incremental reviews (functional, subsystem, and interim system) and major system technical reviews.

Time Requirements. Required functional capabilities dependent on accomplishing an action within an opportunity window (e.g., a target is vulnerable for a certain time period). Frequently defined for mission success, safety, system resource availability, and production and manufacturing capabilities.

Time Line Analysis. Analytical task conducted to determine the time sequencing between two or more events and to define any resulting time requirements. Can include task/time-line analysis. Examples:

a. A schedule line showing key dates and planned events
b. An engagement profile detailing time based position changes between a weapon and its target.
c. The interaction of a crew member with one or more subsystems.

Trade-off Study. An objective evaluation of alternative requirements, architectures, design approaches, or solutions using identical ground rules and criteria.

Training Function. Tasks, actions, and activities to be performed with required resources to achieve and maintain the knowledge and skill levels necessary to perform operations and support functions efficiently and effectively.

Users. The operators and supporters of system end items, and the trainers that train the operations and support personnel. Users execute the operations, support, training, and some disposal functions associated with system end items.

Verification Function. Tasks, actions, and activities to be performed with required resources to evaluate progress and effectiveness of evolving system products and processes and to measure compliance with requirements. Analysis (including simulation), demonstration, test, and inspection are verification approaches used to evaluate: risk, product and process capabilities, compliance with requirements, and proof of concept. The function encompasses all Test and Evaluation including Developmental Test and Evaluation activities such as technology validation, manufacturing process proofing, quality assurance and acceptance, as well as Operational Test and Evaluation.

Work Breakdown Structure (WBS). A product-oriented family tree composed of hardware, software, services, data, and facilities which result from systems engineering efforts during the development and production of a defense materiel item, and which completely defines the program. Displays and defines the product(s) to be developed or produced, and relates the elements of work to be accomplished to each other and to the end product.

APPENDIX B

LIST OF ACRONYMS AND ABBREVIATIONS

B1. Scope. This appendix provides a list of all acronyms and abbreviations used in this standard, with associated meaning. This appendix is not a mandatory part of this standard. The information contained herein is intended for guidance only.

B2. Applicable Documents. This section is not applicable to this appendix.

B3. Acronyms and Abbreviations.

ASR	-	Alternative System Review
CDR	-	Critical Design Review
CDRL	-	Contract Data Requirements List
CI	-	Configuration Item
CSCI	-	Computer Software Configuration Item
CWBS	-	Contract Work Breakdown Structure
DID	-	Data Item Description
DoD	-	Department of Defense
DT&E	-	Developmental Test and Evaluation
EMD	-	Engineering and Manufacturing Development
FCA	-	Functional Configuration Audit
HDBK	-	Handbook
ICD	-	Interface Control Document
ILS	-	Integrated Logistics Support
MOE	-	Measure of Effectiveness
NDI	-	Non-Developmental Item
OSA	-	Open System Architecture
OT&E	-	Operational Test & Evaluation
PCA	-	Physical Configuration Audit
PDR	-	Preliminary Design Review
PWBS	-	Program Work Breakdown Structure
RDT&E	-	Research, Development, Test & Evaluation
RFP	-	Request for Proposal
SFR	-	System Functional Review
SEDS	-	Systems Engineering Detailed Schedule
SEMP	-	Systems Engineering Management Plan
SEMS	-	Systems Engineering Master Schedule
SOW	-	Statement of Work
SRR	-	System Requirements Review
SSR	-	Software Specification Review
SVR	-	System Verification Review
TPM	-	Technical Performance Measurement
TRR	-	Test Readiness Review
WBS	-	Work Breakdown Structure

APPENDIX C

GENERAL GUIDANCE ON THE CONDUCT OF TECHNICAL REVIEWS

C1. Scope. This appendix provides general guidance for the conduct of technical reviews to assist in tailoring review tasks in this standard and MIL-STD-1521. This appendix is not a mandatory part of this standard. The material contained herein is intended for guidance only. This appendix provides interim guidance pending the publication of MIL-HDBK-499-4 on technical reviews and the resulting supersession of MIL-STD-1521. MIL-STD-1521 will be used as interim guidance and tailored as necessary to satisfy the requirements of MIL-STD-499.

C2. Applicable Documents.

C2.1 Government Documents. The following military standards are referenced for guidance. The issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

MIL-STD-973 - Configuration Management
MIL-STD-1521 - Technical Reviews and Audits for Systems, Equipments, and Computer Software

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

C3. Definitions. (see Appendix A)

C3.1 Acronyms and Abbreviations. (see Appendix B)

C4. Technical Reviews Overview. Technical reviews are used to demonstrate progress, ensure issues have been resolved, verify the expected maturity of solutions and confirm that risks are acceptable. Reviews require thorough up-front planning, since they are event-driven, not held on a certain date, and scheduling must account for the uncertainty in completion of all entry criteria as well as for potential conflicts across events with common needs. Planned, formalized Incremental Reviews should be used as a means to evaluate progress and resolve technical issues without reliance on technical interchange meetings, organizationally-oriented reviews, working groups or committees, and program management reviews . Meetings of any kind should have well defined objectives , a multidisciplinary approach, and a formalized format that documents proceedings (decisions, accomplishments, closures, etc.). This is necessary to assure that any requirement/design change recommendations resulting from these meetings have been examined across all the functionality of the people, products, and processes being impacted.

Major reviews should not be viewed as a single point in time event. They culminate a period of careful, disciplined technical effort, marking progress toward the end objective. Each major review has required accomplishments (integrated across all technical areas) and measurable criteria to determine if each accomplishment is done. The accomplishments and criteria are contained in the SEMS. The event-based SEMS provides focus and objectives for the in-between smaller reviews and meetings. Formal reviews focus on demonstrating and confirming progress. A review is not complete until all its SEMS accomplishments are done.

C4.1 Structuring the Reviews. Technical interchange meetings, independent, organizationally-oriented reviews, working groups, committees and program management reviews are replaced in this standard by the Subsystem, Functional and Interim System Reviews. The intent is not to turn every review into a fully formal review, but to incorporate planning for all reviews (formal and informal) into the overall process. Every review has some degree of formality, even if it is nothing more than to record the activities and agreements made amongst participants. Reviews are formal only to the extent necessary to document agreements, issues, and to demonstrate (or confirm) SEMS accomplishment criteria. For example, informal subsystem reviews may focus on work activities leading to demonstration that required accomplishments in the SEMS for an upcoming formal review are done. Multidisciplinary teamwork is expected at reviews and meetings. Reviews are selected and held incrementally based on the complexity of the program and phase of development (or modification). Large, formal reviews involving personnel with little or no involvement in the work efforts should be avoided, since they are costly and inhibit effective exchange of substantive information. An incremental review process provides a smaller forum for efficient exchange of information. There may still be a need for one-on-one or few-on-few technical interchange meetings to discuss a specific problem, however changes to requirements or designs, in terms of either the approach to be taken or the agreed-to "numbers" must be made in a multidisciplinary environment. Typically, participants in a review include the tasking and performing activity personnel responsible for the item or area being reviewed, key representatives for lower level items, and other personnel who have a stake in the specific objectives of the review.

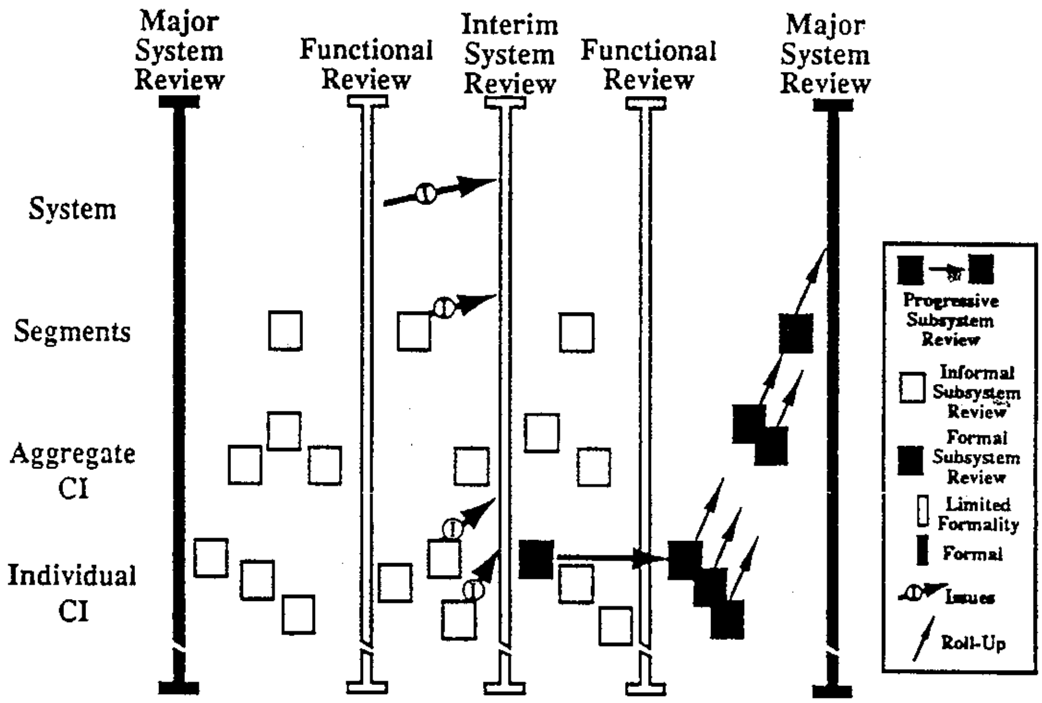

FIGURE 9. Illustration of Review Process

This review process is shown conceptually in Figure 9. The solid bars and boxes identify the formal reviews, such as major system reviews. The hollow boxes and bars would be formal only to the extent needed to demonstrate required progress. These can be viewed as working meetings. For a "subsystem", the meeting represents all the disciplines (people) functioning as a team to define, design, etc., the subsystem. The term subsystem has a broad span, from a single component or CI to aggregates of CIs to all the CIs satisfying a segmented portion of the system's requirements. In preparation for a major system review, a roll-up of subsystems reviews is done. Key concerns (such as risk and outstanding issues), findings, summaries, and so forth are presented at the next higher level in the system hierarchy. Each such review demonstrates or confirms that required progress has been achieved. The traditional review work (i.e., evaluation of data) has already been done at the appropriate level by the people actually working on the subsystem. Demonstration and confirmation results are integrated at progressively higher levels. Finally, when there is joint agreement (i.e. the SEMS) on what must be done to achieve success, there is consensus on both when it is time, and when it is not time, to conduct a review.

In addition to the subsystem reviews, Figure 9 also depicts functional and interim system reviews. These reviews need not be held separate from other program-wide reviews.

C4.2 Tasking activity Responsibilities at Reviews. General tasking activity responsibilities include:

a. Assure that the review process will confirm that the requirements set (tasking activity responsibility) is balanced against the current design (performing activity responsibility). These objectives need to be well defined, reflected in tasking activity systems engineering plans/planning, and communicated to the performing activity in the RFP to accurately scope accomplishments that must be demonstrated in each acquisition phase.

b. Determine the degree to which the objectives of the review have been satisfied. This can be done during the course of the review when demonstrating (or confirming) that the exit accomplishments of the review have been satisfactorily completed as measured by defined criteria in the SEMS. At the end of the formal review, the tasking activity summarizes the results by notification of: approval (review was satisfactorily completed — all accomplishments demonstrated/confirmed as measured by defined criteria in the SEMS), contingent approval (review is not considered complete until the satisfactory completion of resulting action items to satisfy SEMS exit accomplishments for the review), or disapproval (the review was inadequately executed or planned accomplishments were not complete).
c. Ensure that action plans have been established to satisfy all accomplishments and criteria not demonstrated or confirmed so that the review can be completed when all action plans have been successfully executed. Action plans may be generated against both tasking activity and performing activity responsibilities.
d. Ensure the formation of a properly prepared tasking activity review team. This includes ensuring that team members understand their role, responsibilities, and the specific objectives of the review. Training and pre-briefings may be necessary. Formal reviews are focused on issues and on confirmation of required accomplishments in the SEMS building upon the in-depth review of the analyses, requirements, and solutions done before the formal review started.
e. Serve as co-chair for formal reviews.
f. Provide formal acknowledgment to the performing activity of review accomplishment when proceedings are published.
g. Provide administrative information to the host such as the name, organization, security clearance, and so forth for each tasking activity participant prior to the review.
h. Ensure that all significant inputs have been included in the proceedings during or at the conclusion of the review.

C5. Major Reviews. At a major review, subsystem leaders, with key support staff, demonstrate that the accomplishments and criteria for that review have been met. They will confirm that issues and concerns addressed during previous reviews have been satisfactorily resolved. Major reviews demonstrate that risk levels are acceptable and provide an opportunity to modify program emphasis for the next phase or effort. Proper integration and management of the interim, subsystem, and functional reviews (as delineated in the SEMP) should make a detailed total evaluation unnecessary. Only those areas requiring close scrutiny should be addressed in detail. Such areas will be designated based on the results of the most recent interim system review.

Prior to Engineering and Manufacturing Development (EMD) phase, the focus of reviews is on process, system concepts, system requirements, and interface requirements. During EMD the focus is on system designs. Prior to rate production, the product (and process) documentation is baselined at the Physical Configuration Audit. Throughout the remaining system life cycle, major reviews are conducted to demonstrate system maturity during modification efforts. Major reviews are typically culminating events for one or more incremental reviews to confirm resolution of issues and demonstrate progress. The last subsystem review, prior to a major review, for each CI is normally formal. The major review is a formal system review to demonstrate system readiness to proceed with follow-on technical efforts.

The following paragraphs describe major reviews and outline when they typically occur. Each major review must demonstrate that there is an audit trail from the exit conditions of the previous review to the current conditions with changes substantiated as appropriate. A simple, illustrative example set of SEMS accomplishments is provided for each review. These accomplishments are generally oriented toward an unprecedented new development.

C5.1 Alternative System Review (ASR). The ASR normally occurs in concept exploration and definition phase for new developments. It is used as a phase exit review to ensure that all necessary efforts have converged on the information necessary to support a Milestone I decision. The ASR focuses on confirmation that: a preferred system concept with cost, schedule, and performance objectives has been defined; and that an executable development and risk management approach (including technology transitions, verifications, prototyping, and risk reduction efforts) has been defined to reduce the risk of the preferred system concept to a point where commitment to a system specification is appropriate.

Review increments may include an interim system review to assess the scope of the alternatives considered and to surface interface and interoperability issues. Functional reviews may be considered to surface issues and to support system planning. Modification programs should consider subsystem reviews to assess impacts of technology application.

Program specific phase exit criteria should be incorporated into the SEMS for demonstration/confirmation at the ASR. SEMS entry accomplishments for the ASR include:

a. Concept study complete.
b. System architecture for the concept complete.
c. Analytic assessments that the concept meets established needs, requirements, and/or objectives complete.
d. Cost, schedule, and performance objectives and threshold estimates for the system concept complete.
e. Product and process technology verification requirements for future development efforts identified.
f. Product and process risks identified and a risk management approach complete.

Exit accomplishments for the ASR should include:

a. Draft specification tree and program work breakdown structure for Demonstration and Validation Phase complete.
b. Set of technical exit criteria for Demonstration and Validation phase defined.
c. Action plan closure documentation complete.

C5.2 **System Requirements Review (SRR).** Normally a SRR is held early in Demonstration and Validation phase for new developments. This review is also held in Production and Deployment or in Operations and Support phases for modifications, upgrades and product and process improvements. Its purpose is to ensure that a balance has been struck between requirements and solution approach risk — that there has been convergence on a system solution that has acceptable risk and that system requirements satisfy customer requirements. SEMS entry accomplishments for the SRR include:

a. Draft system specification complete.
b. Draft system architecture complete.
c. Technology maturity status established for each candidate technology.

Exit accomplishment for the SRR should include:

a. Performing activity understanding of customer requirements established.
b. Draft functional baseline complete.
c. Action plan closure documentation complete.

C5.3 **System Functional Review (SFR).** This review refocuses what was called the System Design Review in MIL-STD-1521. Many activities associated with a System Design Review are still pertinent, however the fundamental objective is to establish and verify an appropriate set of functional and performance requirements for the system. Particular attention should be paid to the results of trade-off studies which were conducted to define requirements in areas which have moderate-to-high risk. This review is normally held during:

a. Demonstration and Validation phase for new developments requiring technology validation prior to establishing a functional baseline.
b. During Engineering and Manufacturing Development for systems utilizing sufficiently mature technologies that did not require a Demonstration and Validation phase.
c. During Production and Deployment or in Operations and Support phases for modifications, upgrades and product and process improvements.

SEMS entry accomplishments for the SFR include:

a. All scheduled subsystem, functional, and interim system reviews complete; previously unresolved issues documented with action plans, closed.
b. Definition of functional and performance requirements for system development, manufacturing, verification, deployment, operations, support, training, and disposal complete.
c. System trade-off studies complete.
d. Trade-off studies needed to support the identification of CIs complete.
e. System architecture complete to _______ (identify measurable and demonstrable level).

f. Specification tree complete to _______ (identify measurable and demonstrable level).
g. Draft CI architecture complete to _______ (identify measurable and demonstrable level).
h. Draft CI development specifications complete for _____ (specify number) levels below the system specification.
i. Effectiveness assessments (to support specifications) complete.
j. Establishment of configuration management program complete.

(Note: The depth and completeness of architecture and draft specifications is determined based on cost requirements and the need to provide confidence in the completeness and achievability for parameters to be established in the functional baseline.)

Exit accomplishments for the SFR should include:
a. System Specification complete.
b. Functional baseline for products and processes complete.
c. Draft performing activity allocated CI baselines complete.
d. Draft ICD (functional and physical interface) requirements complete.
e. Proposed program and contract work breakdown structures for Engineering and Manufacturing Development Phase complete.
f. Pre-planned product and process improvement or evolutionary acquisition strategies complete.
g. Risk handling approach for Engineering and Manufacturing Development Phase complete.
h. Action plan closure documentation complete.

C5.4 Preliminary Design Review (PDR). A series of PDRs are normally held in Engineering and Manufacturing Development phase for new developments and can be held in Demonstration and Validation phase for major prototyping activities. PDRs are also held in Production and Deployment or in Operations and Support phases for modifications, upgrades and product and process improvements. A PDR is held for each CI or aggregation of CIs in the specification tree. Individual CI PDRs should ensure that a preliminary CI architecture is complete; a CI development specification is complete, or development specification approved; and that a preliminary allocated baseline is complete, or allocated baseline approved. A system PDR is held after completion of all CI and aggregate of CIs PDRs. SEMS entry accomplishments for the system PDR include:
a. All scheduled subsystem, functional, and interim system reviews complete; previously unresolved issues documented with action plans, closed.
b. System architecture update complete.
c. Preliminary CI architecture complete.
d. Preliminary designs complete.
e. All functional and physical interface requirements established.
f. Design implementation trade-off studies complete.
g. Make/buy decisions defined.
h. Compatibility among all interfacing CIs established.
i. Allocated configuration documentation complete.

Exit accomplishments for the system PDR should include:
a. Verification that the functional and performance requirements of each CI, as confirmed by the subsystem PDR for each CI, satisfy the functional baseline.
b. Updated pre-planned product and process improvement, or evolutionary acquisition plan, complete.
c. Agreement that requirements for all CIs and the system are satisfied by the design approach.
d. All draft functional and physical interface ICDs (documents) complete.
e. Allocated baseline complete (Note: or approved based on specification control concept employed on the program) for each CI.
f. Action plan closure documentation complete.

C5.5 Critical Design Review (CDR). A series of CDRs are normally held in Engineering and Manufacturing Development phase for new developments and can be held in Demonstration and Validation phase for major prototyping activities. CDRs are also held in Production and Deployment or in Operations and Support phases for modifications, upgrades, and product and process improvements. A

CDR is held for each CI and aggregation of CIs in the specification tree. A system CDR is held after completion of all CI or aggregation of CI CDRs.

Even when the Government elects not to bring the allocated baseline under configuration control by the time of this review, an assessment of the flowdown of requirements from the functional baseline to the lowest level CI for each item in the specification tree should be included in the review. Any changes in the performing activity's draft allocated configuration documentation since the PDR are reviewed by the tasking activity and their impact on the functional baseline assessed and validated. SEMS entry accomplishments for the system CDR should include:

a. All scheduled subsystem, functional, and interim system reviews complete; previously unresolved issues documented with action plans, closed.
b. System architecture update complete.
c. Update of system specification complete.
d. Update of functional baseline complete.
e. Make/buy decisions finalized.
f. All CI architectures complete.
g. Allocated configuration documentation complete.
h. Detailed designs complete.
i. All ICDs (documents and drawings) complete.
j. All CI draft product specifications complete.
k. All CI draft product baselines complete.

Exit accomplishments for the system CDR should include:

a. Verification that the functional and performance requirements and the detailed design of each CI, as confirmed by the CDR for each CI, satisfy the functional baseline.
b. Update (or approval) of allocated baseline complete for each CI.
c. Assessments confirm that CI and the system requirements are satisfied by the design.
d. Qualification test articles ready for fabrication/coding.
e. Action plan closure documentation complete.

C5.6 System Verification Review (SVR). This review represents the culmination of incremental reviews supporting a decision that the total system (as represented by all of its people, products, and processes), is ready to enter the Production and Deployment Phase. The accomplishments formally confirmed at the culmination of SVR need to be incrementally demonstrated as part of system verification throughout the period between CDR and the conclusion of SVR. These accomplishments should be defined for subsystem or interim system reviews (events) to ensure a logical, progressive, and comprehensive verification of system performance and function as well as to ensure total system readiness to enter the production and deployment phase. SVR is normally held in Engineering and Manufacturing Development phase for new developments, but is also held in Production and Deployment or in Operations and Support phases for modifications, upgrades and product and process improvements. If a system FCA is planned, it may be held in conjunction with the SVR. Special attention is critical for systems that have a degree of concurrency in development and production. Those systems with development continued into production phase may need to plan and conduct SVR as two separate reviews. The first addresses all verification and readiness requirements to satisfy the Engineering and Manufacturing Development Phase exit criteria supporting a Milestone III decision (or similar decision for smaller programs). The second addresses the completion of all activities necessary for full production release in Production and Deployment Phase.

SEMS entry accomplishments for the SVR include:

a. All scheduled subsystem, functional, and interim system reviews complete; previously unresolved issues documented with action plans, closed.
b. Verification procedures for CIs and the system completed
c. CI and system ready for verification
d. All specification Part 4 verification tasks against Part 3 requirements complete
e. Verifications conducted in accordance with established procedures
f. Confirmation that each verified item conforms to its design
g. FCAs for each CI complete

h. Update of system and CI architectures complete.
i. Update of system specifications and CI development specifications complete.
j. Update of draft CI product specifications complete.
k. Update of functional baseline and allocated baselines complete.
l. Update of draft product baseline complete.
m. Verification or proofing of manufacturing, support, training, and pertinent deployment processes complete.
n. Product and process designs stabilized.
o. Verification of the availability, capability, and capacity of manufacturing, support, training, deployment, operations, continued verification, continued development and disposal elements complete.

The exit accomplishments for the SVR should include:
a. Verification of the functional characteristics of all products and processes complete.
b. Approval of all CI allocated baselines complete.
c. Definition of the program WBS and contract WBSs for production and deployment complete.
d. Confirmation of system readiness for production and deployment phase.
e. Action plan closure documentation complete.

C5.7 Physical Configuration Audits (PCA). A series of PCAs are normally held in Production and Deployment phase for each CI in a new developments and can also be held in Operations and Support phases for modifications, upgrades and product and process improvements. Specific tasks for this review are contained in MIL-STD-973, Configuration Management. The entry and exit accomplishments for this review and any other pertinent critical accomplishment and associated success criteria are to be included in the SEMS. As a major demonstration/confirmation event, there are typically additional, program specific accomplishments that should be incorporated into the SEMS for the PCA event. These may include accomplishments related to resolving design issues uncovered during continuing verification efforts (including Operational Test and Evaluation).

SEMS entry accomplishments for a CI PCA include:
a. Update of all specification and design documentation complete.
b. All manufacturing process requirements and documentation finalized.
c. Product specifications finalized.

The exit accomplishments for the CI PCA include:
a. Verification of the as-built or as-coded version of the CI against their design documentation.
b. Government approval of CI product specifications.
c. All acceptance test requirements complete and approved by the Government.
d. Government approval of the PCA.
e. Establishment of the CI product baseline.

SEMS entry accomplishments for a system PCA include:
a. PCA for each CI complete.

The exit accomplishments for a system PCA include:
a. Verification that the technical data package for the system as built by the specified manufacturing processes is an accurate representation of the configuration documentation of the system.
b. Action plan closure documentation complete.

C6. Subsystem Reviews. Subsystem reviews are multidisciplinary formal and informal reviews to assess progress in defining (e.g., derived requirements) and satisfying subsystem requirements. Initially, subsystem reviews focus on process and requirements in examining alternative solutions (e.g., design approaches) for performance and functional requirements to establish requirements feasibility and risk in the solution. As the system matures, emphasis shifts to solution approach, design, design implementation, and finally confirmation that the solution satisfies requirements. At a subsystem review, all functional areas and technical disciplines needed to address life cycle requirements and actions to satisfy those requirements and all elements of that subsystem participate. This includes user, supplier, performing activity, and subcontractor organizations needed to confirm and demonstrate progress. The main thrust of any given subsystem review is on pertinent subsystem accomplishments and criteria defined in the SEMS and the risk associated with the development of the subsystem. The formality of these reviews is dependent on content. Most can be held as working meetings. Some, such as the Preliminary Design Review of a configuration item, or the Software Specification Review for a computer software configuration item will be formal demonstrations and confirmations of the accomplishments and criteria identified in the SEMS pertinent to that review. Subsystem reviews should replace some of the numerous, informal, technical interchange meetings, and other working group meetings that normally occur during a program. Subsystem reviews below the CI level on contract may not require tasking activity oversight.

C6.1 Functional Configuration Audits (FCA). A series of FCAs are normally held in Engineering and Manufacturing Development phase for each CI in a new developments and can also be held in Production and Deployment or in Operations and Support phases for modifications, upgrades and product and process improvements. Specific tasks for this review are contained in MIL-STD-973, Configuration Management. The entry and exit accomplishments for this review and any other pertinent critical accomplishment and associated success criteria are to be included in the SEMS. FCAs are an incremental part of the SVR.

SEMS entry accomplishments for a CI FCA include:
a. All CI development specification Part 4 verification tasks against Part 3 requirements complete.
b. Update of all development and design documentation complete.

The exit accomplishments for the CI FCA include:
a. Government approval of FCA.
b. Action plan closure documentation complete.

C7. Functional Reviews. These reviews are conducted across the system by representatives from all involved disciplines to address progress and issues associated with one functional area or like group of functional areas. These reviews are structured to assess (and confirm) that the functionality of the system, within the area being reviewed, is traceable throughout the architecture from top-level customer needs and requirements to solutions. Functional reviews are an examination of an area of the system's functionality. While they do not have to start at the top of the system architecture, they address that functionality from the start point all the way to the bottom. In a systems engineering environment, solutions are effected by integrated consideration of total product/process functionality and not a single area. Functional reviews focus on problem identification, confirmation of functionality implementation, and assist in identifying alternatives. By examining the functionality throughout the architecture, progress and issues with both vertical (needs/ requirements to solutions) and horizontal (integration of the functionality across all interfacing items) traceability can be determined. Functional reviews focus on progress in satisfying the accomplishments and criteria associated with the functional area at the next formal review. Within this overall perspective, functional reviews also support the functional integration of product planning across the system. The following paragraphs identify some of the possible functional reviews. They are formatted as task statements to facilitate contractual application.

C7.1 Support Reviews. These reviews shall be conducted to evaluate support requirements integration. These reviews shall assess support status and issues related to meeting system requirements with functional alternatives and solution alternatives such as, new or modified support equipment, facilities, integrated diagnostics, technical orders/manuals, and skill levels. In addition, interface issues and the consistency and validity of support concepts for the system shall be addressed.

C7.2 Training Reviews. These reviews shall be conducted to evaluate training requirements integration, interface issues, and the consistency and validity of training concepts for the system. These reviews shall assess training status and issues related to meeting system requirements with functional alternatives and solution alternatives such as new or modified training equipment, facilities, training manuals and materials, and training of the trainers.

C7.3 Development Reviews. These reviews shall be conducted to evaluate requirements integration. These reviews shall assess status and issues related to meeting system requirements not addressed in other functional reviews but which are critical to satisfying system requirements such as interoperability, interface management, systems integration, system security, system safety, and computer resources. These reviews shall specifically track critical system parameters including high impact parameters (e.g., survivability) and cost drivers (e.g., reliability).

C7.4 Verification Reviews. These reviews shall be conducted to evaluate verification requirements integration. These reviews shall assess verification status and issues related to meeting system requirements with functional alternatives and solution alternatives such as test and evaluation plans, procedures, equipment, personnel, ranges, special facilities, limitations, and post-test analysis support. In addition, interface issues and the consistency and validity of verification concepts for the system shall be addressed.

C7.5 Manufacturing Reviews. These reviews shall be conducted to evaluate manufacturing requirements integration. They shall assess manufacturing status and issues related to meeting system requirements with functional alternatives and solution alternatives such as high risk/low yield manufacturing processes or materials, manufacturing developments, and planned use of existing manufacturing elements and processes. As the design matures, the reviews shall focus on production planning (identification of special manufacturing processes, process controls, special tooling requirements, layout, and inventory management and material handling requirements); facility needs; producibility changes; fabrication of tools/test equipment/special machines; software requirements; skill levels required; training needs; procedure manuals; and long lead item acquisition. In addition, interface issues and the consistency and viability of manufacturing concepts for the system shall be addressed.

C7.6 Disposal Reviews. These reviews shall be conducted to evaluate disposal requirements integration. They shall assess disposal status and issues related to meeting system requirements and constraints with functional alternatives and solution alternatives such as disposal of system elements including demilitarization, destruction, mothballing, hazardous material containment and substitutions, and recycling for reuse and recovery. Interface issues and the consistency and viability of disposal concepts for the system shall be addressed. Also addressed is integration of requirements resulting from defined hazardous material and environmental impact requirements and constraints.

C8. Interim System Reviews. Interim system reviews are "across the system" reviews held in between major reviews. They provide an avenue to address issues and demonstrate required system-wide progress and maturity. These reviews serve the following purposes:

a. Surface issues and concerns for coordinated senior management action that are not resolvable at the subsystem level. These could include identification of incompatibilities between subsystems or between subsystem and functional approaches that must be resolved to satisfy accomplishments and criteria in the SEMS.
b. Provide a system status on progress toward meeting SEMS accomplishments and criteria for the next major review. Interim system reviews can serve as a stimulator/facilitator to emphasize critical problem areas to help ensure a successful major review.
c. Address progress toward achieving SEMS accomplishments and criteria that can only be demonstrated via a total system look.
d. Integrate progress in contractual efforts to assess status in meeting Government to Government obligations.
e. Provide in-process assessment of system maturity/risk reduction efforts.
f. Action plan closure documentation complete.

Interim system reviews should be planned in advance. Additional interim system reviews should be held when there are one or more issues which threaten the successful completion of an upcoming major review. These reviews occur between major reviews when necessary to address critical risk areas and ensure that SEMS accomplishments are being met. Participants at the interim reviews should be limited to principals. Interim system reviews can be informal or formal depending on the purpose of the review. These reviews may be held concurrently with program management reviews that occur during a program.

Custodians:
Army - MI
Navy - EC
Air Force - 10

Preparing Activity:
Air Force - 10

Agent:
Air Force - 11

(Project No. MISC-0151)

Review Activities:
Army - AR, AT, AV, CE, CR, ER, ET, GL, IE, ME, MI, SC, TM
Navy - AP, AS, CG, EC, MS, NM, OM, OS, SA, SH, TD, YD
Air Force - 11, 12, 13, 17, 19, 27, 70, 71, 79, 80, 82, 84, 85, 99
Marine Corps - MC
DLA - AQCOS, MMS

DATA ITEM DESCRIPTION

Form Approved
OMB No. 0704-0188

1. TITLE

Systems Engineering Detailed Schedule (SEDS)

2. IDENTIFICATION NUMBER

3. DESCRIPTION / PURPOSE

3.1 The SEDS is a detailed schedule of the tasks required to successfully accomplish the contracted effort. It will be used by the contractor and government to monitor progress and manage risk for specific milestones/accomplishments delineated in the Systems Engineering Master Schedule (SEMS).

4. APPROVAL DATE (YYMMDD)

5. OFFICE OF PRIMARY RESPONSIBILITY (OPR)

F/AFMC - ASC/ENS

6a. DTIC APPLICABLE

6b. GIDEP APPLICABLE

7. APPLICATION / INTERRELATIONSHIP

7.1 This Data Item Description contains the format and content preparation instructions for the data product generated by the specific and discrete task requirement as delineated in the MIL-STD-499B, paragraph 4.1.d.

7.2 The primary application of the SEDS is to support the SEMS and risk management of critical program activities.

8. APPROVAL LIMITATION

9a. APPLICABLE FORMS

9b. AMSC NUMBER

10. PREPARATION INSTRUCTIONS

10.1 Reference documents. The applicable issue of the documents cited herin, including their approval dates and dates of any applicable amendments, notices, and revisions, shall be as specified in the contract.

10.2 Format. Contractor format is acceptable, digital format is preferred.

10.2.1 Origin and relationship. The SEDS shall be traceable through the Cost Schedule Control System, Contract Work Breakdown Structure (CWBS), SEMS, and Statement of Work.

10.2.2 Nomenclature. Each schedule activity shall be consistently and clearly described. A list of abbreviations and acronyms shall be provided.

10.2.3 Program milestones and definitions. Key programmatic events defined by the contract through the SEMS shall be the basis for the SEDS. All milestones shall be used in identical terms over all schedules as identified in the SEMS.

11. DISTRIBUTION STATEMENT

10.3 Content. The SEDS shall contain an integrated network based schedule to include program milestones and definitions, logical network based detailed schedules with associated higher order intermediate and summary level schedules, and periodic analysis of progress to date. The SEDS shall be vertically and horizontally traceable, and tied to CWBS work packages. It shall be possible to access the SEDS information either by product/process or along functional organization lines. Descriptions of the key elements are as follows:

10.3.1. Summary master schedules. A graphical display of all top level program activities/events and key milestones, from contract award to the completion of the contract, which depict major work activities in an integrated fashion at the summary level of the WBS.

10.3.2. Intermediate schedules. A graphical display of top level program activities and key milestones which depict major work activities in a WBS element.

10.3.3. Detailed schedules. A graphical display of detailed activities and milestones which depict work activities in a particular WBS element.

10.3.4. Periodic analysis. A brief summary which identifies progress to date, variances to the planned schedule, causes for the variance, potential impacts and recommended corrective action to avoid schedule delays. For each program milestone planned, forecasted and actual completion dates shall be included. The analysis shall also identify potential problems and continuing assessment of the network critical path.

10.3.5. Integrated program network. Logical diagram of all activities in the program. The key elements of the integrated network to be constructed in the diagram are as follows: Events or Time Consuming Activities or Elements, Activity/Event Number, Duration, Target Start, Target Complete, Actual Start, Actual Finish, Early Start, Early Finish, Late Start, Late Finish, Percent Complete, Slack/Float Time. In addition the diagram shall order the Events/Activities to show the logical interrelationship of the activities in a networked fashion This diagram shall be generated by computer-based software capable of highlighting the critical path.

10.3.6. Schedule risk. The schedule shall include a description of the approach that will be taken to limit the schedule risks identified as a result of the contractor's risk assessment. Risk shall be defined considering impact on cost and technical performance and assessing the probability of schedule change.

PROPOSED DRAFT. DO NOT USE FOR ACQUISITION PURPOSES.

DATA ITEM DESCRIPTION

Form Approved
OMB No 0704-0188

Public reporting burden for this collection of information is estimated to average 110 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1 TITLE

SYSTEMS ENGINEERING MANAGEMENT PLAN (SEMP)

2 IDENTIFICATION NUMBER

3 DESCRIPTION/PURPOSE

3.1 The SEMP defines the contractor's plan for the conduct and management of the fully integrated engineering effort.
3.2 The SEMP will be used by the Government to evaluate the contractor's engineering work efforts as part of the contract monitoring process.

4 APPROVAL DATE (YYMMDD)

5. OFFICE OF PRIMARY RESPONSIBILITY (OPR)

F-10

6a DTIC APPLICABLE

6b GIDEP APPLICABLE

7 APPLICATION/INTERRELATIONSHIP

7.1 This Data Item Description (DID) contains the formal and content preparation instructions for the data product generated by the specific and discrete task requirements as delineated in paragraph 4.1.b of MIL-STD-499B.

7.2 This DID supersedes DI-MGMT-81024.

8 APPROVAL LIMITATION

9a APPLICABLE FORMS

9b AMSC NUMBER

10 PREPARATION INSTRUCTIONS

10.1 Reference documents. The applicable issue of the document cited herein, including their approval dates and dates of any applicable amendments, notices, and revisions, shall be specified in the contract.

10.1.1 Content and format instructions. The SEMP shall conform to the content and format requirements described in paragraphs below. The initially used format arrangement shall be used for all subsequent submissions.

10.2 Format.

10.2.1 Response to tailoring instructions. In the event that a paragraph or subparagraph has been tailored out, a statement to that effect shall be added directly following the heading of each such paragraph or subparagraph. If a paragraph and all of its subparagraphs are tailored out, only the highest level paragraph heading need be included.
(continued on Page 2)

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10.2.2 Use of alternative presentation styles. Charts, tables, matrices, or other presentation styles are acceptable when the information required by the paragraphs and subparagraphs of this DID can be made more readable. When the SEMP is a paper product, foldouts are acceptable.

10.2.3 Document control numbers. For printed formats, the SEMP may be printed on one or both sides of each page (single-sided/double-sided). All pages shall contain the document control number and the date of the document. Document control numbers shall include revision and volume identification as applicable.

10.2.4 Page numbering. Each page shall be uniquely numbered in order.

10.2.5 Paragraph numbering. Sections and paragraphs shall be numbered such that the SEMP may be referenced to other documents used by the contractor team in managing their engineering efforts.

10.2.6 General SEMP structure. The contractor should locate information that may be pertinent to multiple topic areas (e.g., methodology descriptions) in appendices and provide a cross reference in the text to the appendix.

a. Cover
b. Title Page
c. Table of Contents
d. Scope
e. Applicable Documents
f. Systems Engineering Process.
g. Transitioning Critical Technologies.
h. Integration of the Systems Engineering Effort
i. Additional Systems Engineering Activities
j. Notes
k. Appendices

10.3 Content. The SEMP shall contain the following parts, unless they have been tailored out by the government. Tailoring out is the only allowed method of tailoring.

10.3.1 Title page. The title page shall contain the words "Systems Engineering Management Plan", the document title, and system. Other information such as contract number, CDRL number, and contracting agency may be added by the preparer.

10.3.2 Table of contents. The SEMP shall contain a table of contents listing the title and page number of each titled paragraph and subparagraph. The table of contents shall then list the title and page number of each figure, table, and appendix, in that order.

10.3.3 Scope. This part of the SEMP shall include a brief description of the purpose of the system to which this SEMP applies and a summarization of the purpose and content of the SEMP. Included in the scope shall be the statement, "Notwithstanding any provision of this SEMP, nothing herein shall relieve the Contractor of meeting the performance, cost and schedule requirements of the Contract."

10.3.3.1 Technical plan summary. This section shall provide an executive summary, with reference to the detailed plan, for all technical plans required by the CDRLs of the contract.

It shall also require a cross reference to appropriate non-technical plans which may interface with the Systems Engineering effort.

10.3.4 Applicable documents. This part of the SEMP shall list the Government documents and non-Government documents, in that order, applicable to SEMP implementation.

10.3.5 Systems engineering process. This part of the SEMP shall describe the contractor's systems engineering process activities as they are to be applied to the contract phase, including:

a. Organizational responsibilities and authority for systems engineering activities, including control of subcontracted engineering;

b. Tasks associated with satisfying each of the accomplishment criteria identified in the contractor's Systems Engineering Master Schedule (SEMS) and the milestones and schedules of the contractor's Systems Engineering Detailed Schedule (SEDS); and,

c. Narratives, supplemented as necessary by graphical presentations, detailing the contractor's plans, processes, and procedures for the execution of the systems engineering process.

10.3.5.1 Systems engineering process planning. This section shall address key program technical objectives, products and results from the process, needed process inputs, and contract work breakdown structure development.

a. Major process products and results. This section shall describe major technical process products and results both to the Government and internal within the contractor program as a result of the systems engineering process activities.

(1) Decision Data Base. This part shall describe the development and implementation of the decision data base.

(2) Specifications and Baselines. This section shall describe the process to generate specifications and baselines.

b. Process inputs. This section shall identify the depth of detailed information needed to be able to accomplish the activities (to the level of effort appropriate to the contract) of the systems engineering process, how needed information will be acquired when not available in Government documents provided, and how conflicts in information provided will be resolved.

c. Technical objectives. This section shall describe the technical objectives related to success of the program, system, and system effectiveness. Technical objectives may include those related to development, manufacturing, verification, deployment, operations, support, training, or disposal.

d. Contract Work Breakdown Structure (CWBS). This section shall describe the development and implementation of the CWBS. (If this information is required elsewhere by the contract, do not duplicate reporting but provide a cross reference to the specific items requested.)

e. Training. This section shall identify both internal and external training for contractor and Government personnel. The plan may include analysis of performance or behavior deficiencies or shortfalls, required training to remedy, and schedules to achieve required proficiencies.

f. Standards and procedures. This section shall describe major standards and procedures that the program will follow and implementation of standardization tasking into the pertinent sections of the systems engineering process.

g. Resource allocation. This section shall describe the technical basis and rationale for resource allocation to program technical tasks. This part may include resource requirements identification, procedures for resource control, and reallocation procedures. (If this information is required elsewhere by the contract, do not duplicate reporting but provide a cross reference to the specific items requested.)

h. Constraints. This section shall describe major constraints on the program. Constraints include those things which impact the technical effort but which the program cannot or will not do. This part may include funding, personnel, facilities, manufacturing capability, critical resources, or other constraints.

i. Work authorization. This section shall describe the method by which work packages are initiated (opened) and the criteria for their closeout as well as the method by which changes to the content of work packages will be authorized. (If this information is required elsewhere by the contract, do not duplicate reporting but provide a cross reference to the specific items requested.)

j. Verification Planning. This section shall describe the verification planning for all requirements. This may include identification and configuration control of verification tools.

k. Subcontractor technical effort. This section shall describe the level of subcontractor participation in the technical effort as well as how vendors and suppliers are selected and controlled.

10.3.5.2 Requirements analysis. This section shall describe the methods and approach to perform requirements analysis. Included shall be a discussion of defining the performance and functional requirements for the following areas. (Note: Some areas may impact requirements analysis only after synthesis efforts identify solution alternatives. As such, some of the descriptive information may be more appropriately covered under other systems engineering process elements).

a. Reliability
b. Maintainability
c. Survivability including Nuclear, Biological and Chemical.
d. Electromagnetic Compatibility, Radio Frequency Management and Electrostatic Discharge
e. Human Engineering and Human Systems Integration
f. Safety, Health Hazards and Environmental Impact
g. System Security.
h. Producibility
i. Supportability and Integrated Logistics Support
j. Test and Evaluation
k. Testability and Integrated Diagnostics
l. Computer Resources

m. Transportability
n. Infrastructure Support.
o. Other Engineering Specialties. This part shall address any other engineering specialties bearing on the determination of performance and functional requirements for the system under contract.

10.3.5.3 Functional analysis/allocation. This section shall describe the methods and approach to perform functional analysis/allocation. Included shall be a discussion on integrating factor dependent approaches and methods for the items identified in DID 10.3.5.2.a thru 10.3.5.2.o into functional analysis/allocation.

10.3.5.4 Synthesis. This section shall describe the methods and approach to perform synthesis. Included shall be a discussion on integrating into synthesis:

a. Factor-dependent approaches and methods for the items identified in DID 10.3.5.2.a thru 10.3.5.2.o ;

b. Nondevelopmental items; and

c. Parts control.

10.3.5.5 Systems analysis and control. This section shall address the approach and methods that the contractor plans to utilize for systems analysis and control. This shall include the integration of factor-dependent approaches and methods for the items identified in DID 10.3.5.2.a thru 10.3.5.2.o into systems analysis and control.

10.3.5.5.1 Systems analysis. This section shall describe the specific systems analysis efforts needed including methodologies and tools necessary for their conduct.

a. Trade studies. This section shall describe planned trade studies, including methods, source data, and tools necessary for their conduct

b. System/cost effectiveness analyses. This section shall describe the system/cost effectiveness analysis effort and its role as an integral part of the systems engineering process. Included shall be a description on how analyses will be partitioned into the various areas, if they cannot be conducted integrally, and how analytic results will be integrated.

c. Risk management. This section shall describe the risk management program. This shall include a description of the method of relating TPM, the SEMS, and the SEDS to cost and schedule performance measurement and the relationship to the Contract Work Breakdown Structure.

10.3.5.5.2 Control. This section of the SEMP shall describe the specific control mechanisms needed included methods and tools.

a. Configuration management (CM). This section shall describe the approach and methods planned to establish and maintain configuration management (when a CM plan is specifically required, reference to the appropriate sections of the plan will suffice).

b. Interface management. This section shall describe the approach and methods planned to establish and maintain interface management.

c. Data management. This section shall describe the approach and methods planned to establish and maintain a data management system (Do not duplicate DID 10.3.5.1.a.(1))

d. Systems Engineering Master Schedule (SEMS). This section shall describe the analysis used to derive the SEMS and the supporting Systems Engineering Detailed Schedule (SEDS) and their structure.

e. Technical Performance Measurement (TPM). This section shall describe the approach and methods planned for establishing, maintaining, and reporting of TPMs which are responsive to requirements, technical parameters identified in the RFP, and requirements in the proposed SEMS. This section shall include the following:

(1) TPM update frequencies, level of tracking depth, and response time to generate recovery plans and planned profile revisions.

(a) Frequency of TPM assessments of the achievement to date should be the same as that used in reporting costs (such as for C/SCSC).

(b) Frequency of TPM assessments should support the SEMS.

(2) Technical parameters selected for tracking which shall include system parameters and CI parameters.

(a) They shall be critical indicators of technical progress (i.e. those with an adverse impact on a system performance requirement if the parameter fails to meet specifications/technical objectives or thresholds).

(b) Parameter descriptions shall include identification of related risks.

(3) Depiction of relationships between the selected critical parameter and those lower-level parameters that must be measured to determine the critical parameter achievement value.

(a) Depiction shall be in the form of tiered dependency trees and reflect the tie in to the related system performance requirement (critical parameter).

(b) Each parameter identified in the dependency tree shall be correlated with a specific Contract Work Breakdown Structure (CWBS) element.

(4) Data for each parameter to be tracked:

(a) Specification threshold, technical objective or requirement, or measure of effectiveness (MOE).

(b) Time-phased planned value profile with a tolerance band (error budget). The planned value profile shall represent the expected trend of the parameter over the CI development life cycle. The boundaries of the tolerance band shall represent estimated inaccuracies at the time of the estimate, and shall indicate the region within which it is expected that the specification requirement will be achieved with allocated resources and SEMS/SEDS events and milestones.

(c) Program events significantly related to the achievement of the planned value profile (e.g., technical reviews).

(d) Conditions of measurement (type of test, simulation, analysis, demonstration, estimate).

f. Technical reviews. This part shall describe the approach and methods planned to establish and conduct technical reviews.

g. Supplier control. This section shall describe the technical management of suppliers and subcontractors including integration of their technical efforts and data into the overall systems engineering effort, and the integration of subcontractor data into the decision data base.

h. Requirements traceability. This section shall describe the approach and methods planned to establish and maintain requirements traceability between systems engineering process activities, work breakdown structures, technical data management system and correlation, as pertinent, with the SEMS and the SEDS.

10.3.6 Transitioning critical technologies. This part of the SEMP shall describe the activities and criteria for assessing and transitioning technologies.

10.3.7 Integration of the Systems Engineering Effort. This part of the SEMP shall describe:

a. How the various inputs into the systems engineering effort will be integrated into a coordinated systems engineering effort that meets cost, schedule and performance objectives, including how the technical effort of subcontractors and vendors is integrated;

b. When the contractor uses a team approach, how the contractor's organizational structure will support team formation; the composition of functional and subsystem teams; and the products each subsystem and higher level team will support;

c. Major responsibilities and authority of the systems engineering team members and technical parties by name, to include present and planned program technical staffing;

d. Planned personnel needs by discipline and performance level, human resource loading, and identification of key personnel;

e. Development and use of simulations including integration laboratories which employ end item hardware and software in the loop;

f. Systems engineering implementation tasks;

g. Use of prototyping (including that by simulation) to assist in identifying and reducing risks

h. Use of integrated computer aided engineering, design, manufacturing, test, and support methods to support design integration; and

10.3.8 Additional systems engineering activities. This part of the SEMP shall describe other areas not specifically included in previous sections but that are essential for a proper understanding of the systems engineering effort and scope of effort planned.

10.3.8.1 Long-lead items. This section shall describe the process by which long-lead items are defined/determined that affect the critical path of the program.

10.3.8.2 Engineering tools. This section shall describe systems engineering tools which will be used on the program as well as the reliance on them and control of them:

a. Analysis tools;
b. Synthesis tools;
c. Control tools;
d. Reference tools;
e. Simulation tools; and
f. Laboratory and other facility tools.

10.3.8.3 Design to cost. This section shall address design to cost with emphasis on how design to cost requirements are allocated to cost elements as well as how compliance is determined and controlled.

10.3.8.4 Value engineering. This section shall describe the value engineering effort and how it will be implemented and administered.

10.3.8.5 System integration. This section shall describe the process by which the system is integrated and assembled with emphasis on risk management and continuing verification of all external and internal interface (physical, functional and logical).

10.3.8.6 Compatibility with associated program activities. This section shall describe compatibility with associated program activities such as production, test, and support.

10.3.8.7 Other methods and controls. This section shall describe any other methods and controls that the contractor systems engineer or system integrator will use in the technical effort.

10.3.9 Notes. This part of the SEMP shall contain:

a. Any general information that aids in understanding the SEMP (e.g., background information, glossary); and

b. An alphabetical listing of all acronyms, abbreviations, and their meanings as used in the SEMP.

10.3.10 Appendixes. Appendixes may be used to provide information published separately for convenience in document maintenance (e.g., charts, classified data). As applicable, each appendix shall be referenced in the main body of the SEMP where the data would normally have been provided.

11. DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.