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SYSTEM ENGINEERING

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CHAPTER 1
INTRODUCTION

1–1. Purpose and Scope

a. This manual describes a system engineering process and presents guidelines for system engineering management which will satisfy those regulations, directives, and standards which contain policy for the application of system engineering. System engineering is performed for projects, systems, or items designated a major program under the provisions of AR 70–1. The process is consistent with and complementary to DA Pam 11–25, Life Cycle System Management Model for Army Systems. It may be performed for nonmajor programs, based on the expected complexity of the program or weapon system interfaces. The manual presents a means for integrating the efforts of each technical and managerial specialist in the design and development of a total, balanced system. It contains guidelines for the identification of tasks and responsibilities for implementing the system engineering process. It provides doctrine for the education of Army personnel in the concept of system engineering and its management. It is not the purpose of this manual to prescribe or imply the organizational structure, management methodology, procedures, or form of documentation used to implement system engineering.

b. The system engineering methodology described herein is provided for use by all agencies concerned with the conception, development, acquisition, fielding, and modification of both project-managed and nonproject-managed Army materiel systems and end items. New programs requiring design effort and full integration of technical/scientific disciplines will benefit by following the guidelines within this manual for arriving at engineering decisions. Managers of ongoing programs with unacceptable cost, performance, or schedule status will find that the techniques, rigor, and formats of this manual can serve as a diagnostic tool for exposing causes of deficiencies and provide a data base for engineering and management decisions.

c. This manual provides guidance for in-house system engineering. Where used, the term "contractor" also means Government agency when system engineering is performed in-house. This manual may be made available to contractors to help them understand Army system engineering; however, this manual may not be used as the basis for any contractual requirement or action.

d. The language used in this manual is not intended to discriminate on the basis of sex when the words "he" or "she" appear; they are intended to include both the masculine and feminine genders.

1–2. Historical Perspective

a. When weapon development programs were relatively simple to manage, engineering effort could be directed by a few top managers. Communications between participants were uncomplicated; functions and responsibilities were easily stated; and decision-making in regard to cost, performance, and schedule goals were fairly straightforward. User needs were adequately covered in a one-volume model specification and a one-volume contract. As state-of-the-art advanced, science and engineering expanded along highly specialized functional lines, acquired increased importance and complexity, and required more sophisticated management.

b. The problems of communication, coordination, direction, and control of these specialties and among geographically separated personnel have become increasingly severe. Some specialists are grouped into "functional" organizations to coordinate the state-of-the-art across more than one program and to time-share between programs. In other instances, specialists are divided into program-oriented organizations, or a compromise bilateral organization may be adopted, i.e., vertical program and horizontal function. With advanced and increasingly complex new programs, there is need for increased rigor in the following technical and managerial activities:

(1) Control of the design interfaces among systems, equipment, personnel, facilities, and computer programs.

(2) Use of trade-off analysis techniques in allocation of functions, selection among design approaches, and resolution of conflicting design objectives and constraints.

(3) Assurance that the performance specifications, detail design, and production data packages are consistent with the fundamental mission require-

ments and with balanced consideration of such factors as producibility, operability, supportability, reliability, safety, and compatibility with interfacing systems, equipment, personnel, facilities, and computer programs.

c. The development of solutions to the problems of communications, direction, and control requires methodical, analytical approaches to the development of total systems. These approaches are termed system engineering. The sequential and iterative method for top-down development of a product and its technical program task elements is known as the system engineering process. The total management effort is termed system engineering management. These may be defined as follows:

(1) *System engineering.* The transforming of an operational need into a description of system performance parameters and a system configuration.

(2) *System engineering process.* The repetitive four-step method for developing program and design requirements.

(3) *System engineering management.* The management process of coordinating the engineering and technical effort within a project or program.

d. The total design process encompasses system analysis, definition and synthesis of requirements, preliminary design, and detail design. System analysis is the analysis and transformation of materiel requirements into a theoretical model with quantitative terms, and the manipulation of the model in simulation of the operational environment. Definition and synthesis of requirements is the translation of performance objectives of a selected system approach into design criteria (design-to requirements) for the individual elements which will comprise that system. Preliminary design develops the design approach for the system and its elements based upon the criteria provided by definition and synthesis of requirements. Detail design translates the design approach into a manufacturing configuration which can be produced and supported within the state of existing or economically achievable manufacturing technology and support capability. System engineering integrates the engineering effort throughout the design process.

1–3. Objectives

The objectives of the system engineering process and the system engineering guidelines presented in this manual are to—

a. Ensure that the engineering effort is fully integrated, and to reflect adequate and timely consideration of design, test and demonstration, production, operation, and support of the system/equipment.

b. Ensure that the definition and design of the system or equipment item are conducted on a total system basis, reflecting equipment, facilities, personnel data, computer programs, and support requirements to achieve the required effectiveness in acceptable risk, cost, and schedule considerations.

c. Integrate the design requirements and related efforts of reliability, maintainability, integrated logistics support, human factors engineering, health, safety, and other specialties with respect to each other as well as into the engineering effort.

d. Ensure compatibility of all interfaces within the system, including the necessary supporting equipment and facilities; and to ensure the compatibility and proper interface of the system with other systems and equipment that will be present in the operational environment.

e. Establish, control, and maintain an effective work breakdown structure throughout the life of the system/project in accordance with applicable directives.

f. Evaluate effects of changes on overall system performance, effectiveness, schedule, and cost; and to ensure that all affected activities participate in the evaluation of changes.

g. Provide a framework of coherent system requirements to be used as performance, design, and test criteria; and to provide source data for development plans, contract work statements, specifications, test plans, design drawings, and other engineering documentation.

h. Measure and judge technical performance for the timely identification of high risk areas and other

i. Document major technical decisions made during the course of the program.

1–4. Implementation

The following factors should be considered in implementation of system engineering:

a. System engineering requires mutual understanding and support among the system engineers, senior management, and higher authority. The rigor, documentation, and integration may require substantial procedural changes.

b. Implementators of system engineering should have diversified backgrounds of engineering experience and an understanding of the relationship of the engineering specialty program to the design process.

c. Without expertise in system engineering, formal training of personnel is essential prior to implementation. Improper or poorly founded implementation may be expensive and reduced in effectiveness.

1–5. Executive Overview

Executives of Army organizations involved in the development of materiel systems and end items may gain a general understanding of system engineering theory and management practice through reading chapters 1 through 3 of this manual. In addition to the first three chapters, project and journeyman engineering personnel should be familiar with chapter 4 and appendix B.

1–6. Publication Improvements

Reporting of errors, omissions, and recommendations by the individual user for improving this publication is encouraged. Reports should be made on DA Form 2028 (Recommended Changes to Publications) and forwarded direct to Commandant, US Army Logistics Management Center, ATTN: DRXMC-SLS-EDD, Fort Lee, Virginia 23801.

CHAPTER 2
THE SYSTEM ENGINEERING PROCESS

2–1. General

a. A system may be defined as a composite of elements capable of performing and/or supporting an operational role. The definition is insensitive to system size or complexity; it applies equally well to a large weapons system or a simple personnel/machine system. The five possible elements which may comprise the system are equipment, facilities, personnel, procedural data, and computer programs. Not every system has all of these elements, but every system consists of a combination of some or all of them. The individual system elements are described more fully in paragraph 2–4.

b. No two systems are alike in their developmental requirements. Regardless of system size or complexity, however, there is a uniform and logical process for arriving at engineering decisions. The process converts input requirements (user need) into output information which describes the optimal combination of system elements which will satisfy that need. The overall process is described in the balance of this paragraph. Subsequent paragraphs develop this description in terms of input requirements, functional areas, steps of the process, and system elements.

c. The system engineering process is a network of actions with very close interrelationships. As illustrated in figure 2–1, these actions are grouped into the four steps: (1) Function analysis, which includes the determination of functions and their function performance requirements for accomplishing mission objectives; (2) Synthesis of combinations of system elements to fulfill the function performance requirements; (3) Evaluation of the synthesis in terms of time, life cycle costs, and performance, resulting in a decision as to the preferred combination of system elements and (4) Description of each element in the combination selected. The steps of the process and figure 2–1 are described in detail in paragraph 2–3.

d. As shown in figure 2–2, every system must be produced, tested, and deployed, following which it is operated and provided logistics support. All function performance requirements, therefore, are derived from the needs of these functional areas. It follows logically that the system elements are identified and developed to meet the performance requirements derived from the functional areas of operations, logistics support, test, production, and deployment. For example, the functions which must be accomplished for successful performance of the mission (operations functions) generate the requirements for operations equipment, facilities, computer programs, personnel, and procedural data. Each of the other functional areas generates requirements for their respective system elements.

e. Figure 2–3 shows the system engineering process iteratively applied to the interrelated functional areas of operation, logistics support, test, production, and deployment. These functional areas are described

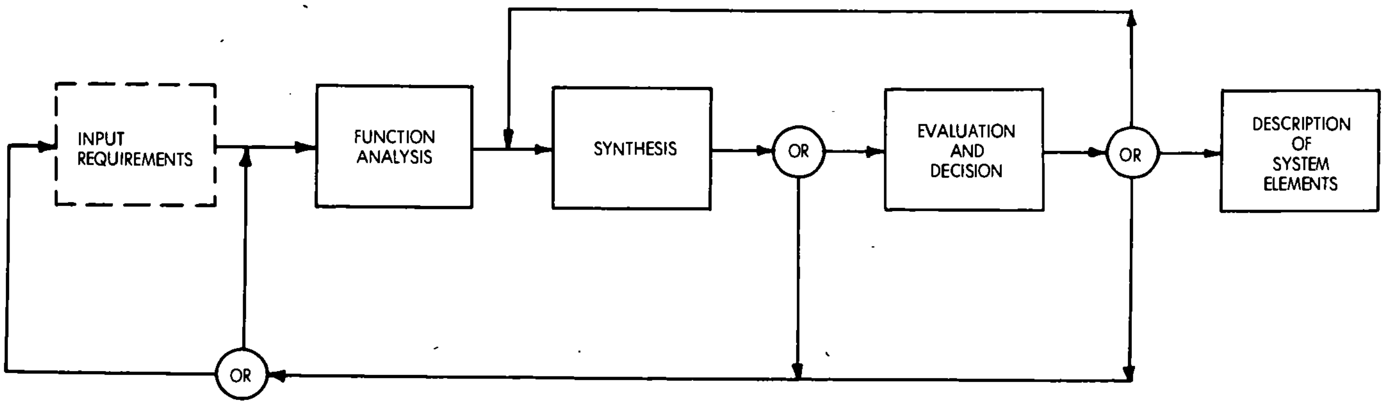


Figure 2–1. The system engineering process.

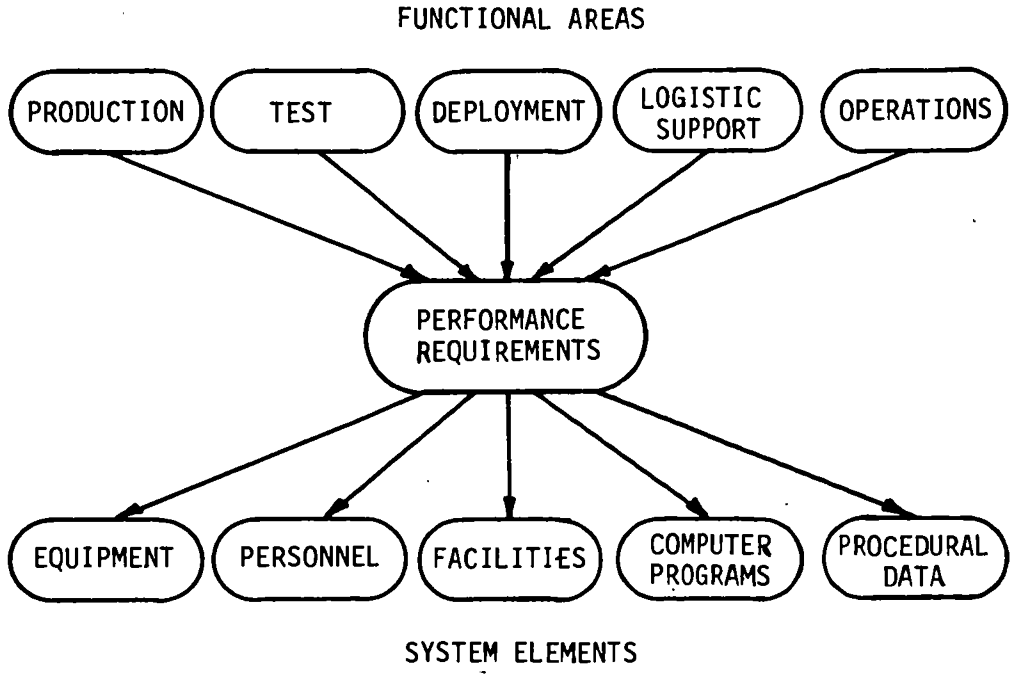


Figure 2-2. Sources of requirements for system elements.

in paragraph 2-5. Each of these applications of the process is accomplished to define and optimize the combination of system elements needed to satisfy the requirements of that functional area. These applications of the process are functional cycles. The initial application of the process is addressed to the operations requirements of the system. The inputs to this "operations" cycle are the mission requirements, operational environment, system constraints, and measures of effectiveness which have been initially established by prior systems analysis. The output of this cycle consists of the description of an optimized combination of system elements for the performance of operational functions. This description is complete only when the inputs from all engineering disciplines and specialty programs have been integrated.

f. In the subsequent functional cycles shown in figure 2-3, the system engineering process is applied to the logistics support, test, production, and deployment requirements imposed by the selected combination of system elements. The production and logistics support cycles are concerned with the requirement to produce and maintain equipment and facilities. The test and deployment cycles, however, are concerned with the requirements imposed by all of the system elements. For example, personnel, computer programs, and procedural data, as well as the equipment and facilities, require testing. The outputs of these cycles of the process are the descriptions of the logistics support, test, productin, and deployment elements.

g. Although the functional requirements that are analyzed in the succeeding cycles are based upon the characteristics of the operational elements, this does not imply that the operation cycle is completed to the ultimate detail level of description before the other cycles are initiated. At each level of definition from the system level down to the component level, the requirements imposed by logistics support, test, production, and deployment are considered in system optimization. At each level, the process is accomplished for each of the functional cycles to the extent necessary to identify risks, achieve delineation of system elements and product elements of the work breakdown structure, and to validate the decisions which must be made at that level. Appendix B describes the iterations of the system engineering process as applied to the various functional areas during each of the life cycle phases of a typical operational systems development program.

2-2. Input Requirements

a. Introduction. Effective application of the system engineering process is dependent upon complete and clearly stated input information. This information is a product of systems analyses and various studies which establish the objectives and major characteristics and constraints of the system. In early stages of the program, the input information is normally at a gross level; it is expanded and refined as the system engineering process is applied to definitize requirements. This may create demands for additional input

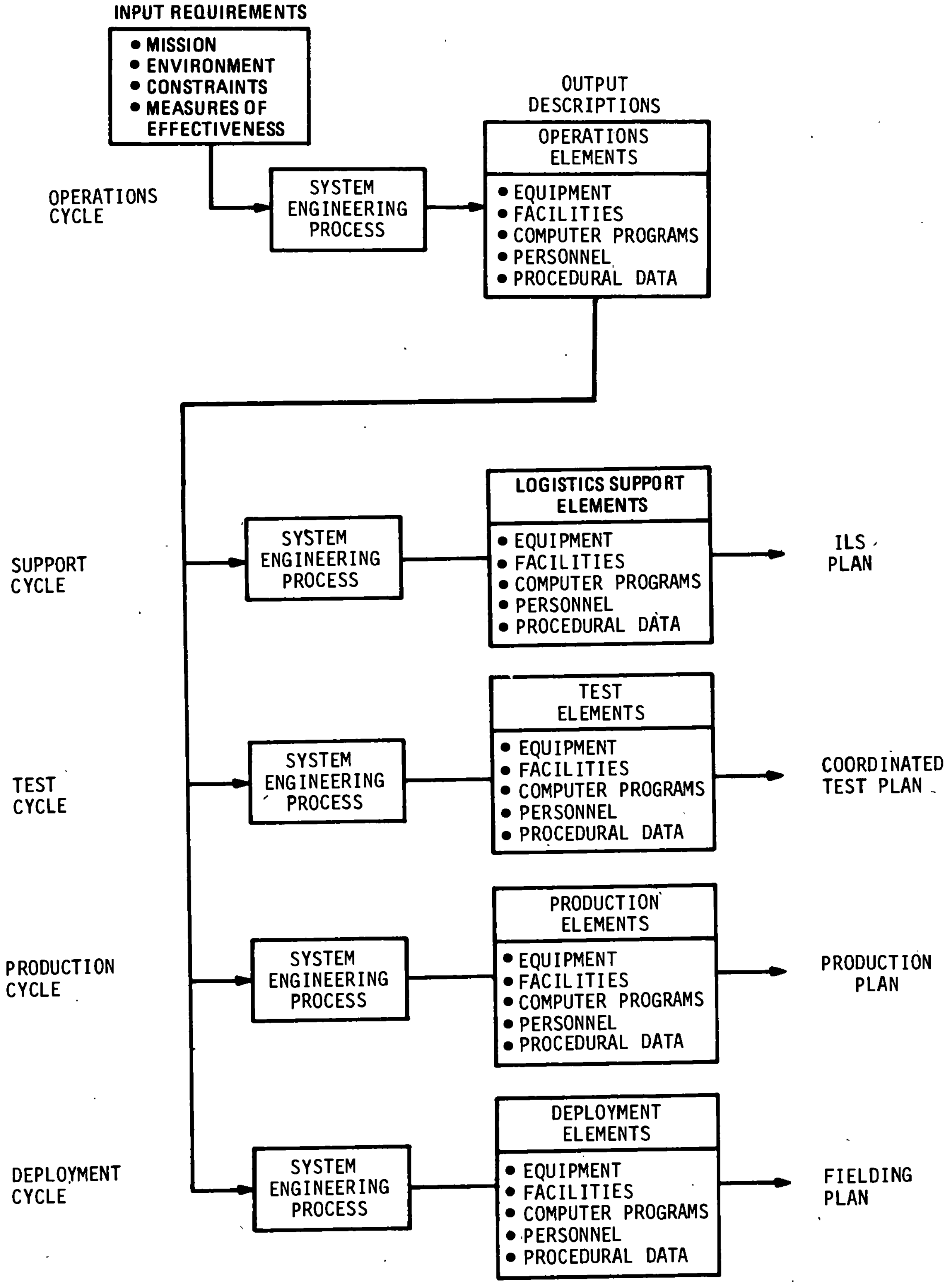


Figure 2–3. The application of system engineering process to functional areas.

from various concept sources. Close liaison between the materiel developer and the using/support agencies is necessary to ensure adequacy of input. Inadequacies which detract from the potential usefulness of the system increase cost and delay deployment. The four initial inputs to the system engineering process are mission, operational environment, system constraints, and measures of effectiveness.

b. Mission. Input information describing the operational mission must be sufficient to permit recognition of major functions and functional requirements to be met by the system. Where multiple missions are to be performed, each is described and anticipated mission mixes are stated. The prime missions are those which justify acquisition of the system. There will also be specified ancillary missions such as the training missions which the system is to fulfill to maintain a high state of operational readiness in peacetime. Such missions should be so specified that their impact on design must be considered in the application of the system engineering process. For example, during a period of 10 years in a cold war training environment, combat equipment may participate in regular training and field exercises to the extent that much of it may be processed through several overhaul cycles. Analysis could indicate that training demands exceed design requirements imposed by operational mission profiles. Under these circumstances, the impact of training will be of the greatest significance, and could result in selection of entirely different approaches. Input information should be screened rigorously to ensure that the total system objective is adequately defined and is consistent with the system identification and interface information. To ensure proper delegation of system engineering work, the nature of interfaces at the boundaries of the system must be identified early in the process. Detailed definition of functional and physical interfaces are quantified later in the routine of the system engineering process. Input information describing the operational mission is contained in the Mission Element Need Statement (MENS), the Letter of Agreement (LOA), and the Required Operational Capability (ROC)/Letter Requirement (LR).

c. Operational Environment. The system performs under both internal and external environmental conditions. The internal conditions are self-induced, e.g., electronic compartment temperatures. The factors related to these conditions are derived with the system engineering process. External environmental factors derive from the external universe in which the system must perform. These factors must be furnished as input information. Generalized statements, such as "all-weather capability" or "hostile environment", are not adequate. Specific values are necessary for each pertinent parameter of natural physical environment, such as temperature, humidity, vibration frequency, radiation, light, wind, and geography. Parameters which describe operational environments, e.g., enemy threat levels, must also be stated in specific values.

d. System Constraints. System constraints originate from policy, experience, budget limitation, and prior analysis. These constraints usually affect the characteristics and composition of the system as its elements are being derived in the synthesis portion of the system engineering process. Examples include the use of Government-furnished equipment, adherence to established logistics support concepts, conformity to current skill codes, specified system life, or the stipulation that certain types of equipments must not be used. Most of the hardware-oriented military specifications and standards contain constraints which are input information to the system engineering process at the time of synthesis. In addition, there are definite constraints on the employment of personnel within a system based on safety engineering, the limits of human performance, and the availability of certain skills in the Army manpower pool. Constraints upon other system elements are generated whenever personnel/machine interfaces are introduced in the system. Identification of these constraints and their potential impact on system design require early input from human factors engineering.

e. Measures of Effectiveness.

(1) Each decision made within the system engineering process must be guided by the standards of measurment for evaluation of the various parameters involved in the decision. To provide these standards, measures of effectiveness are established for the system. All requirements stated for the system should be related to some measure of effectiveness.

(2) A measure of effectiveness is a particular value of system effectiveness pertinent to one or more mission objectives. A measure of effectiveness is related to the inherent value or utility of the system; it may or may not involve cost-effectiveness. In military systems, the measures of effectiveness should be based upon the mission objectives. They may be related to any or all of the effectiveness factors of availability, dependability, and capability. To be useful in decision making, a measure of effectiveness must be either quantitative, e.g., the maximum attainable speed under stated conditions, or probabilistic, e.g., the probability that a system can respond to and accomplish a specific mission objective.

(3) The basis for optimizing decisions changes as a project progresses through its life cycle phases.

During the Alternative Systems Concept Phase, the purpose of analysis and decision is to select two or more cost-effective technical approaches to accomplish stated objectives and to select broad logistics support concepts. Cost-effectiveness analyses must consider both acquisition and operating costs. In the Demonstration and Validation Phase, with the technical approaches and the basic logistics support concepts established, decisions are concerned with allocation of performance capability to individual elements of the systems, optimization of specific parameters within the systems, and selection of the optimal system. In the Full-Scale Engineering Development Phase, with a cost a fixed factor, the bases for optimization become producibility and contract incentives (when applicable). Measures of effectiveness may change with the life cycle phases.

2-3. System Engineering Process Steps

a. Process Steps. The system engineering process steps of function analysis, snythesis, evaluation and decision, and description are described separately in the following paragraphs. In application, however, these steps are interacting and interdependent. Figure 2-1 shows the relationship and interaction of the system engineering process steps. Function analysis (Block 1), for example, cannot be performed beyond the level of gross functions without considering the synthesis of system elements (Block 2) or alternative system elements, and verifying their capability of accomplishing the assigned functions; therefore, function analysis and synthesis are performed virtually in concert. At each level, however, the synthesis must be responsive to functional requirements. A good deal of evaluation in the form of analytical and engineering judgment is involved in the combined function analysis/synthesis activity in selection of the technically feasible design alternatives. The evaluation and decision activity shown as Block 3 in figure 2-1 ultimately results in selection of the preferred combination of system elements. Prior to final decision, the evaluation performed in Block 3, to include an analysis of risk, may require that new functional approaches be examined, additinal design approaches be synthesized, or changes to the input requirements be considered by the using agency.

b. Function Analysis. After verification of the adequacy of initial input information, the first step in the system engineering process is function analysis. The objective of this step is to define a baseline of functions and function performance requirements which must be met in order to adequately accomplish the operation, logistics support, test, production, and deployment requirements of the system, and to identify those functions where system life cycle costs are expected to be sensitive to incremental changes in the performance requirements. These functions and their performance requirements provide a common denominator of selection and design criteria for the system elements, and initially identify areas where trade-offs between input requirements and engineering development require future consideration. The function analysis step consists of three interrelated activities, described as follows:

(1) *Function identification.* System objectives are analyzed to identify those functions which must be performed to satisfy the objectives of each functional area. Each function, i.e., characteristic action, of the system is identified for all specified modes of usage in all specified environments. No-go, emergency, and consequent alternative functions are also identified. Each function of the system is described, including a statement of beginning and ending conditions, i.e., inputs, outputs, and interface requirements (both intrasystem and intersystem), and whether associated life cycle costs are expected to be sensitive to incremental changes in the performance requirements. Functions are indentured and identified from top down so that subfunctions are recognized as part of larger functions. Functions are arranged in their logical sequence so that any specified operational usage of the system can be traced in an end-to-end or closed-loop path. Paths which are operational alternatives are identified. When more than one candidate functional arrangement is under evaluation, (i.e., subject to subsequent selection), each is depicted and identified. Records are maintained in order to document the rationale for acceptance or rejection of each alternative, and for the identification of a function as having an expected sensitivity to system life cycle cost for incremental changes in the system performance requirements. Similar functions are suitably cross-referenced to assist in the recognition of a common synthesis solution. Subfunctions also are derived in an iterative process, together with the determination of performance requirements and the synthesis of progressively lower level system elements. At any level of detail, a function must be stated in purely functional, i.e., action, terms, and must not be stated in terms of its design solution at the same level. For example, if propellant must be transferred, the function is expressed as TRANSFER PROPELLANT. It is not good practice to express the function as PROVIDE A PROPELLANT PUMP which presupposes the means of accomplishing the action; however, it is often desirable to express the function in terms of the synthesis corresponding to a higher level function, e.g., in the case above, the function TRANSFER PROPELLANT is based upon the prior synthesis decision to use a liquid propellant.

(2) *Function performance requirements analysis.* A set of performance requirements is developed for each function. These requirements represent the acceptable level of performance for the accomplishment of that function. Function performance require ments are derived in an iterative process with the development of the functions, synthesis of the system design, and evaluation performed through trade-off studies and application of established measures of effectiveness for the system. Function performance requirements are continually reviewed against the original requirements established for the system to ensure that system requirements are adequately fulfilled. All function performance requirements are stated in sufficient detail for direct use as criteria for hardware design as well as for equipment operation, personnel skills and tasks, facility operation, computer programing, display of procedural instructions-/data, and logistics support. The requirements are functionally oriented, and should not presuppose hardware or other elements which might be developed subsequently. Performance requirements define the input and output status of the function sufficiently to ensure end-to-end or closed-loop compatibililty of functional behavior. Requirements are dimensioned in measurable terms and/or stated in go/no-go criteria which can be verified by analysis, test, and/or demonstration. Performance requirements must be traceable to the analysis by which they were derived and to the higher order of functions. In allocating the requirements to lower level functions and subsequent equipment design, activities performing function requirements analysis should effect integration and optimization to achieve completeness and compatibility of all engineering efforts.

(3) *Time requirements analysis.* An analysis is performed to determine the time requirements of functions or functional sequences in which time is critical to mission success, safety, utilization of resources, minimization of downtime, and/or increasing availability. Not all functional sequences require time analysis—only those sequences in which time is a critical factor. The following are some examples of the types of functions and functional sequences that are time critical:

(*a*) Functions affecting system reaction time.

(*b*) Time critical activities during mission.

(*c*) Mission "turn-around" time

(*d*) Time countdown activites.

(*e*) Functions requiring time analysis to determine optimum equipment and personnel utilization.

For time critical function sequences, the time requirements are specified with tolerances. Times should then be allocated to subfunctions so as to determine that sequential and concurrent actions will collectively meet the time criteria requirements of the total functional sequence. Time analyses performed on time critical functions should determine whether automatic or manual methods are essential; human performance may or may not be involved. These analyses are used to derive time constraints application to performance and design requirements. They also become a factor in trade-off decisions where time is an important factor.

c. Synthesis.

(1) Synthesis is conceptual design. It is the point in the system engineering process at which engineering creativity and technology are brought to bear in the creation of a system or design concept to meet stated requirements. One of the main objectives of the system engineering process is to ensure that design concept includes full cognizance of function performance requirements, system constraints, and effectiveness criteria, and that system elements are given proper consideration in arriving at a design concept.

(2) Synthesis is performed initially to postulate possible technical approaches and, supporting each technical approach, one or more system concepts (arrangements of system elements which will satisfy the function performance requirements). Later, during successive iterations of the system engineering process, one or more design concepts will be synthesized for each system concept. The configuration and arrangement of system elements and the techniques for their use are portrayed in any suitable form, such as schematic block diagrams. The purposes of such portrayals are to depict a complete response to the functional need which meets the initial input requirements, to depict compatibility between the elements of the system and interfacing system, to permit traceability between the elements and their functional origin in the operational usage, and to ensure complete and comprehensive change control.

(3) Synthesis must, therefore, consider the results of various technical and design studies as well as the requirements delineated by function analysis. Since synthesis involves all system elements (not merely equipment), it requires the inputs or participation of all the technologies and disciplines that have a bearing on the system or design concept. Engineering creativity is a key factor in the accomplishment of effective synthesis. Exploration of alternative approaches which are beyond the obvious can be particularly rewarding. Synthesized solutions should take into cognizance the latest technological developments in the areas of design, manufacturing, and support methods.

(4) Within each synthesized solution, characteristics of the equipment, facilities, personnel, and proce-

dural data are balanced in accordance with the established measures of effectiveness. In effecting this balance, it is necessary to interrelate the characteristics of system elements in terms of technical performance and effectiveness parameters. As subsystems develop and performance/design requirements are allocated to system elements, data is developed and retained to show the parametric interrelationship between subsystems within the system; between various system parameters or constraints, such as reliabilty, maintainability, supportability, weight, operating cost, and downtime, and the relation of each to total system and mission requirements.

(5) Portrayal of the synthesized system in terms of its elements will, after selection has been made by the evaluation and decision step, provide a source of data for equipment design documentation; interface control documentation; consolidated facility requirements; contents of procedural handbooks, placards, and similar forms of instruction/data; task loading of personnel; consolidated computer programs; the specification tree and product elements of the work breakdown structure.

d. Evaluation and Decision.

(1) Evaluation is continual in order to select the best combination of system elements to meet the mission objectives and support requirements. To aid in risk assessment, and to avoid undue engineering sophistication, each decision should have as its objectives a balance among performance, schedule, and total system life cycle cost.

(2) Evaluation and decision are always required to establish that a feasible and adequate design concept has been synthesized. Whenever alternate functions and/or synthesis solutions are evolved, evaluation and decision are accomplished through the conduct of trade-off studies. This step cannot be completed until the synthesis and functional analysis of each alternative are reconciled.

(3) An effectiveness model may be developed to relate design parameters to established measures of effectiveness. The outputs of such a model can provide assistance in choosing one of several synthesized combinations of system elements, and can facilitate investigation of the effects of parameter changes on the overall system effectiveness.

(4) Evaluation leads to a decision which selects a recommended system design concept; determines that additional analysis, synthesis, and/or trade-off studies are required to make a selection; or establishes that the state-of-the-art in technology does not provide an acceptable solution.

e. Description.

(1) The description step produces engineering data that defines the configuration, arrangement, and usage of all system elements, and their effectiveness in achieving functional performance. The description of the system and its individual elements becomes progressively more definitive as the program proceeds through the life cycle phases. At the beginning of each phase, the descriptions must be sufficient to provide the proper baseline for technical decisions and contracting purposes. These descriptions define the product elements of the work breakdown structure.

(2) The engineering data which describes the individual elements must be such that it controls the design, development, test, production, and deployment of equipment and facilities; the selection and training of personnel; and the development of procedural data and computer programs. The description data may be in such form as specifications, design descriptions, schematics, layouts, detailed drawings, personnel and training requirements data, and engineering reports. It may also include physical and mathematical models and computer programs.

(3) It is not possible to specify precisely the depth of data detail required for any phase of a project. In the early phases, however, the description data shold be confined to performance requirements so as not to constrain creative design unduly, but to allow subsequent engineering activities as much flexibility as the program objectives will permit.

2–4. System Elements

The elements of a system are identified as equipment, facilities, personnel, procedural data, and computer programs. This means that any item required to produce, test, deploy, operate, and support the system can be categorized as one of these system elements. Such categorization provides a logical and convenient boundary for the structure or constitution of the system. Employment of some combination of these elements in accordance with established doctrine is the only means whereby the mission objectives can be accomplished. While every system may not contain all five elements, all systems are made up of a combination of some or all of them. The following (*a* through *e* below) describe the system elements and discuss the role of system engineering process in defining the requirements for each element.

a. Equipment.

(1) This includes all equipment items required by the system. In addition to the basic operational equipment required to perform the assigned mission, it includes operational and maintenance support equipment; test equipment required by test programs; any special equipment (such as special transportation or installation and checkout equipment) required to deploy the system; any special, unique, or long lead time equipment (such as factory tooling)

required to produce the deliverable equipment; and special trainers or training aids required to train personnel in the operation and support of the system and its equipment.

(2) The system engineering process is used to define the design requirements for all items of equipment needed by the system. The function performance characteristics which each equipment item must have are developed by function analysis. During synthesis, the function performance requirements and all other design requirements and constraints that are imposed on the system or developed by engineering analyses are integrated to provide a complete set of "design-to" requirements for each equipment item. These equipment items are identified as the product elements of the work breakdown structure.

b. Personnel.

(1) All systems involve the interaction of trained personnel with equipment. In certain systems, such as HAWK, specially trained personnel, identified by systems peculiar military occupational specialty (MOS), are an integral part of the operational system. These personnel are specialists who are selected, trained, classified, and assigned as "components" of the system. On the other hand, many weapons/equipment systems developed for both tactical and nontactical units are used by personnel already trained in the use and maintenance of various other items of materiel; an example is the SHERIDAN/SHILLELAGH weapon system. This required the development or modification of doctrinal concepts for employment of the total system. The identification of the various changes to procedural data, training courses, MOS, and quantitative personnel requirements necessitated by the introduction of the new equipment was part of the development process. It is also a major interface among the materiel developer, the combat developer, and the training developer/trainer. Maintenance and support personnel may include Department of the Army civilians (DAC) or contractor as well as military persons.

(2) In the development of completely new systems or new materiel items to be added to existing systems, system engineering, together with integrated logistics support and human factors engineering, is concerned with identifying the tasks, skills, training, and numbers of personnel required to operate, maintain, support, test, and deploy the system or equipment items. In the application of the system engineering process, the tasks and skill requirements related to the individual functions involved in operation, logistics support, test and deployment are identified. The human performance tasks are formulated into task groups, and task groups into duty positions, and the duty positions into MOS's. The resultant MOS's provide the basis for selection of personnel and the determination of training requirements. This task grouping is an activity of the human factors engineering specialty and provides the personnel element input to conceptual design.

c. Facilities.

(1) These include Government buildings and other structures (landing pads, launch pads, control center, etc.) required to operate, maintain, and, in some instances, produce the system and to conduct Government testing that is specifically oriented to the system. Many Army systems do not have fixed operational facilities, but most systems and materiel items have requirements for maintenance and support facilities.

(2) It is normal practice that the design and construction or modification of Government facilities is accomplished under the cognizance of the Army Corps of Engineers. However, identification of the requirements for new facilities or facility modifications imposed by a new system or equipment item is the responsibility of the system or equipment developer. System engineering is concerned with the identification of these requirements. During the synthesis step of the system engineering process, the facility characteristics necessary for the performance of functions and the facility requirements imposed by the system equipment and personnel are identified. These characteristics and requirements provide criteria to the Corps of Engineers for the design of new or modified facilities.

d. Procedural Data. These data include all forms of instructional material to be used by personnel in producing, testing, deploying, operating, and maintaining the system or equipment item. The material may consist of field manuals, technical manuals, test procedures manuals, associated lists, drawings, diagnostic schematics, production process specifications, and various display media. The system engineering process defines the tasks which personnel must perform in accomplishing the system functions and the procedures for performing the tasks. The functionally oriented instructional material and those pertaining to support are developed as part of the integrated logistics support activity based upon the tasks/procedures defined by the system engineering process. Guidance for total system application within the conceptual and doctrinal employment envisaged by the combat developer is normally defined in organizationally oriented doctrinal and training literature or in field manuals specifically addressing the system.

e. Computer Programs. Whenever computer programs are required for production, test, operation, or logistics support of the system, the system engineering process defines the capabilities and input and output requirements of such programs. Mandatory procedures for development and documentation of ADP system specifications are described in AR 18–1. Computer resources, to include software, are included as elements within subsystems of the work breakdown structure; their requirements validation, risk analysis, configuration management, life cycle planning, milestone definition, demonstration criteria, contract deliverables, and post deployment support are as prescribed in DODD 5000.29.

2–5. Functional Areas

The system engineering process is applied iteratively to the functional areas of mission operation, logistics support, test, production, and deployment. The mission operation and logistics support functional requirements generate the need for all of the system elements that will constitute the delivered system. The functions involved in the other areas generate the requirements for the additional elements needed to produce, test, and deploy the system.

a. Mission Operations Functions. These repetitive actions performed on and by a system that has been turned over to the user and that are required to accomplish the given mission objectives and support the system in operation. Examples of mission operations functions for a deployed system would include receiving alert indications, positioning or transporting the equipment, checking out the system, launching or firing operations, and accomplishing other mission operations, including target acquisition and identification and data reduction necessary to accomplish the basic mission. Examples of mission support functions are fueling and supplying of ammunition and other consumables.

b. Logistics Support Functions. These are actions necessary to ensure continuing normal system readiness (preventive maintenance functions), or to return a failed system element to readiness (corrective maintenance functions). They include actions such as transport between maintenance activites and storage of unserviceable and repaired equipment, resupply of repair parts, calibration of test equipment, and resupply of ammunition and other consumables. Preventive maintenance includes scheduled inspection, maintenance, and those servicing functions (lubrication, refueling, time-phased parts replacement, and others) described in AR 310–25. Corrective maintenance includes such functions as fault isolation, repair, adjust, and overhaul, at all maintenance levels. Logistics support functions are integrated into the design effort in accordance with AR 700–127, Integrated Logistics Support.

c. Test Functions. These are actions necessary to determine to what extent the system and/or system elements are capable of performing basic mission/performance/support requirements and to determine product conformation to specification and technical requirements. Such functions include test requirement determination, testing, test support, and test result evaluation during all life cycle phases. These include test and evaluation during research and development of materiel (AR 70–10), quality assurance during product acquisition (AR 702–9 and AR 702–10), user field tests, experiments and evaluations (AR 71–3), and operational tests and evaluations (OTE) (AR 71–3). Test procedures must conform to the Single Integrated Development Test Cycle policy, under which the developer, contractor, test agencies, and evaluators share data, thus reducing redundant testing.

d. Production Functions. These are actions necessary to transform design into a capability for efficient and economical production of equipment and facility elements of the system. The functions include such actions as materials ordering, materials handling, fabrication, processing, process control, assembly, inspection, test, preservation, packaging, storage, shipping, and disposition of scrap, salvage, and waste materials.

e. Deployment Functions. These are fielding actions necessary to initially transport, receive, deprocess, install, test, checkout, provide logistics support for, and, as required, emplace, house, or store a system or system element at the user location. Materiel fielding concepts are described in AR 700–127.

CHAPTER 3
SYSTEM ENGINEERING MANAGEMENT

3-1. General

a. The term "System Engineering Management (SEM)" as used in this manual encompasses the management of the system engineering process (SEP) and the integration of all engineering activities and technical aspects of the system/project from receipt of a Mission Element Need Statement (MENS) through delivery of the system or item to the operational inventory. It includes management of the system engineering process, described in Chapter 2, as well as management of preliminary and detail design activities and planning of the test program and of system performance evaluation. This chapter does not prescribe to managers the methods by which they will manage their projects or programs; rather, it points out the salient features of system engineering management and presents a perspective of the role of system engineering management within the total spectrum of system/project management.

b. System engineering management is one of the major functions of project management. It is closely interrelated with configuration management, integrated logistics support, and cost/schedule planning and control. There are various levels of system engineering management, ranging from the top level management exercised by the materiel developer to the most detailed level to which the performance and design requirements of system elements are controlled by the contractor or equivalent Government agency. The levels of system engineering management responsibility for any specific project are defined by the contract work breakdown structure and contract work statements. They are organized along lines of the basic managerial functions of planning, organizing, and controlling, and conclude with a discussion of the relationship of system engineering to configuration management, integrated logistics support, engineering specialty programs, and cost/schedule control mechanisms.

3-2. Planning the System Engineering Effort

a. Tailoring.

(1) The basic system engineering process described in chapter 2 is applicable to any development project, regardless of size or complexity. Appendix B describes the application of this process to the type of project depicted in the life cycle system management model. System engineering must be tailored or modified for application to projects which deviate from that depicted in the model.

(2) Tailoring is performed to both breadth and depth. Tailoring in breadth includes the elimination or addition of system elements, particular system engineering activities, functional areas, and/or life cycle phases. Tailoring in depth involves decisions concerning the level of detail required to identify, describe, and specify the "design to" requirements. The depth of system engineering varies from project to project in relationship to complexity, uncertainty, project urgency, and the willingness to accept risk.

(3) One example of tailoring could involve the addition of a functional area. In a system that requires continual, intensive training to maintain a high state of readiness, training functions and the impact of their performance requirements on design become extremely significant. Decisions based on life cycle costs and effectiveness may be required to provide the best balance between the use of operational equipment for training or the development of specific training devices. Such considerations may not be limited to the training of operation and support personnel in the usual sense, but may need to take into account the impact of maneuvers and field training exercises that are required to train commanders and their staffs. For such a system, it may be that training requirements will be sufficiently important to justify the application of the system engineering process to the functional area of training.

(4) The breadth of the system engineering effort for systems which do not require computer programs or facilities would be limited or tailored, as necessary.

(5) A combat vehicle or aircraft system development program which specifies the use of an existing engine would be modified or tailored in depth. Detailed consideration of the functions concerned with providing primary power would normally not be required. The system engineering process would be utilized in the area of power only to the depth necessary to define functional and physical interfaces

with the balance of the system. It will also verify that the specified engine meets all of the loading conditions required by the mission profile of the new system. If loading conditions are not met, or should system performance be determined to be marginal, then a complete application of the process to develop an alternative engine would be in order. The scope of the system engineering process to be applied (i.e., tailoring) is determined by the levels of risk, the complexity of the decisions required, the state-of-the-art, and other critical areas. Persons directing the application of system engineering must be willing to accept proven design procedures evolved from past experience; otherwise, duplication, through system engineering, may produce costly work which makes no further contribution to the development effort.

b. Cost-Effective Application of System Engineering.

(1) On almost any project, there are technical areas which have varying degrees of potential performance and/or cost benefit. Resources should be expended on those areas where the payoff potential is the highest. The specific areas will depend upon the characteristics of the system, but are usually associated with such features as the uniqueness of the program, the criticality to mission success, the degree of technical risk involved, or the possibility of either increasing performance capability or reducing operating and/or maintenance cost.

(2) In applying system engineering to a specific project, a major consideration should be the benefits to be expected in terms of cost. The cost of system engineering and its management should be considered relative to their potential payoff to the system and the project. This applies both to the types of procedures to be used and the depth of detail to which the process is carried and managed. Neither the rigor nor the depth of the procedure used should be greater than their worth to the project. For example, the cost of conducting a trade-off study between two alternative design approaches may be greater than the potential value differential of the alternatives. When such is the case, conducting a trade-off study would not be cost-effective provided both alternatives fulfill the performance requirements of the system. Similarly, the relationship between expenditure of engineering analysis time or testing and level of confidence is usually nonlinear; and, in many instances, the potential value of increased confidence beyond a certain level would not warrant the added expenditure.

c. System Engineering Management Plan (SEMP)

(1) SEMP is prepared by each Army development/production agency directed to accomplish system engineering as part of a development project and by each contractor whose statement of work calls for system engineering. A contractor's SEMP is submitted as a part of the proposal in response to a request for proposal.

(2) The SEMP is a concise top level management plan for the integration of all system activities. Its purpose is to make visible the organization, direction and control mechanisms, and personnel for the attainment of cost, performance, and schedule objectives. The who, what, when, where, how, and why of the evaluation and decision-making authority and relevant interfaces must be clearly delineated. The level of detail presented in the SEMP should be appropriate to the system life cycle status and degree of system complexity. Use of the SEMP as a management tool must be emphasized; it should reflect good management judgment with minimum documentation. Consideration of data reporting, data retrieval, data utilization, and data visibility is essential.

(3) The SEMP defines and describes the type and degree of system engineering management, the system engineering process, and the integration of related engineering programs. The plan contains identification of organizational responsibilities, authority for system engineering management, levels of control for performance and design requirements, control methods to be used, technical program assurance methods, control procedures to ensure integration of requirements and constraints, and schedules for design and technical program reviews. The plan also contains a detailed description of the system engineering process to be used, including specific tailoring to requirements of the system, in-house documentation, trade-off study methodology, and types of mathematical and/or simulation models to be used for system and cost-effectiveness evaluations.

(4) The three parts of the SEMP are concerned with system engineering management, the system engineering process, and engineering specialty integration. Description of parts one and two are shown in figure 3-1. References which describe many specialities are shown in the same figure.

(5) Depending upon system peculiarities, the plan should also delineate the special or intensive management aspects of functions and activities critical to the system objectives. These might include, for example, risk analysis and assessment, resource allocation,

(Locate fig. 3-1, a fold-in, at the end of this manual.)

work elements, trade-offs, program assurance, and many other specialties. As a top management tool, the SEMP must present the system engineering management and system engineering process, and relate these to the engineering specialties, activities, and functions as an integrated plan, rather than as a composite or summary of discrete subplans.

3–3. Assignment of Responsibility and Delegation of Authority.

Organizational responsibilities for system engineering management must be established, and functions and lines of communication defined, which will enable those responsible to control the application of resources and make the decisions necessary to accomplish system engineering in keeping with the project directive or the statement of work. For Army agencies engaged in development/production programs, the organization, responsibilities, and authority are established by Government regulations and directives. Contractors will specify in the SEMP the organization of their own choosing for the conduct and management of system engineering.

3–4. System Engineering Management Control Methods

a. Design Reviews.

(1) System engineering and design efforts directed to a product element of the work breakdown structure are reviewed to gain visibility and to determine their technical adequacy in meeting system requirements. As the system engineering and design effort proceeds through the life cycle phases, the reviews become more detailed and definitive. Starting with the review of system and function performance requirements, the reviews progressively consider conceptual designs, preliminary designs, and detail designs. The reviews encompass requirements reviews, system design reviews, design characteristics reviews, functional configuration audit, physical configuration audit, configuration item verification, and other design reviews that may be required. The schedule and procedures for the conduct of design reviews are included in the system engineering management plan.

(2) Design reviews include the following:

(*a*) The system requirement review (SRR) ensures that development effort is proceeding toward the objectives in a logical manner and should ensure that adequate consideration has been given to the test, production, deployment, and logistics support constraints.

(*b*) The system design review (SDR) ensures that design approaches are responsive to system performance objectives established in the system specifications. The SRR and SDR are accomplished in the Demonstration and Validation Phase.

(c) The preliminary design characteristics review (PDCR) ensures that the preliminary design approved in terms of equipment, facilities, personnel, procedural data, and computer programs is an acceptable design solution to total system and configuration item requirements.

(*d*) The design characteristics review (DCR) determines that detail design solutions satisfy the requirements and design constraints of the development specification.

(*e*) The functional configuration audit (FCA) is the formal examination of functional characteristics test data for a configuration item, prior to acceptance of the prototype, to verify that the item has achieved the performance specified in its functional or allocated configuration identification. The PDCR, DCR, and FCA are accomplished in the Full-Scale Engineering Development Phase.

(*f*) The physician configuration audit (PCA) is the formal examination of the "as-built" configuration of an LRIP unit of a configuration item against its technical documentation and functional requirements in order to establish the configuration item initial product configuration identification. Configuration item is defined in appendix C (Glossary).

(*g*) The configuration item verification review (CIVR) is the formal examination (technical audit) of the production item to verify conformance to configuration identification (technical data) and performance interfaces within the system. The PCA and the CIVR are accomplished in the Production and Deployment Phase.

(3) Design reviews consider all aspects of system engineering and the design that are relevant to the progress of the particular phase of the design. They include technical performance measurement and program review functions, as appropriate. They cover all performance requirements, the estimated effects of incremental change in the requirements on life cycle costs, technical performance measurements to date, and engineering specialties, such as reliability, maintainability, safety, human factors engineering, survivability/vulnerability, electromagnetic interference, standardization, test engineering, quality engineering and security engineering. Special attention is accorded the design integration, engineering specialty integration, and coordination with other program management functions. These design reviews include, but are not necessarily limited, to the following:

(*a*) Statement of requirements and/or allocated requirements.

(*b*) Design synthesis and evidence of meeting the requirements.

(*c*) Drawings, schematic diagrams, models, and other data.

(*d*) Development and qualification testing progress and data.

(*e*) Cost and schedule status, as reflected, or cost and schedule measurements for all tasks contributing to completion of the design phase.

(*f*) Problem analyses, anticipated changes, and corrective action plans for deficiencies.

b. Technical Program Reviews.

(1) In addition to design reviews, periodic reviews are conducted for the purpose of determining whether the planned technical program should be altered as uncertainties are disclosed, eliminated, or reduced during the progression of the technical program. For in-house projects, these reviews are the equivalent of a quarterly Review and Analysis (R&A). These reviews are a planned part of the system engineering management effort, not a reaction to program exigencies. They are used to seek opportunities to reduce or redirect program effort to effect economies in budget and time as well as requirements to increase or redirect program effort to overcome weaknesses which may develop in the planned program.

(2) Technical program reviews are concerned with task elements of the work breakdown structure (WBS). They may be scheduled to coincide with the design reviews or technical performance measurement events for the corresponding product elements of the WBS. Performance measurement seeks to estimate, measure, and forecast actual design and system performance against planned values. Program reviews seek warranted changes to the planned technical program effort, but not to design requirements or characteristics except where the design reviews have indicated favorable trade-offs between the performance requirements and estimated life cycle costs.

c. Technical Performance Measurement.

(1) Technical performance measurement (TPM) is defined as the product design assessment which estimates through engineering analyses, or measures through tests, the values of essential performance parameters of the current design of WBS product elements. It forecasts the values to be achieved through the planned technical program effort, measures differences between achieved values and those allocated to the product element by the system engineering process, and determines the impact on system effectiveness. Technical performance measurement is initiated during the Demonstration and Validation Phase after design-to requirements of the product elements have been defined. It continues throughout the Full-Scale Engineering Development Phase, and into the Production and Deployment Phase whenever design and development are being carried out for product improvement changes or modifications.

(2) Planning for technical performance measurement is included in the assessment plan which is referenced in the system engineering management plan. The assessment plan establishes how product assessments will be accomplished. It describes the scheduled times at which assessments will be performed, the objectives of each assessment, selection of performance parameters to be measured and tracked, forecasts of the parameter values to be attained through the planned technical program, planned methods of assessing the achievement of planned performance parameters in the product design through engineering analysis and/or testing, identification of the data required to conduct such assessments, and the acquisition of the required data from tests or analysis. For each assessment, the plan specifies the conditions under which tests or other evaluations will be conducted, expected results expressed quantitatively, and methods of evaluation employed.

(3) The technical parameters to be reported and tracked are determined through the identification of technically critical areas from review of performance specification requirements and performance incentives and their relationship to system measures of effectiveness. System elements and their performance parameters to be tracked by the contractor or the procuring activity are identified in the contract. In addition, the contractor is obligated to provide visibility of all design deficiencies that effect system performance whether or not the parameters are identified for tracking. At the completion of each evaluation, results are recorded for comparison with planned values. Variances of results from planned values are analyzed. The analysis will include evaluation of the impact of variances on the technical program, on schedule, and on cost. System effectiveness and summary performance status reports are prepared from the basic parameter status data provided by technical performance measurements. Figure 3-2 illustrates the information flow for technical performance measurement and system effectivenss assessment. It includes TPM work breakdown elements, master parameter list, planned parameter profiles, summation models, parameter status tracking and forecast, records of achieved parameter profiles, system effectivenss and summary performance status report, and problem analysis and corrective action. The first four items are the outputs of planning and replanning efforts. They form the inputs to technical performance measurements and assessments. These items can be initially accomplished during the Demonstration and Validation Phase of

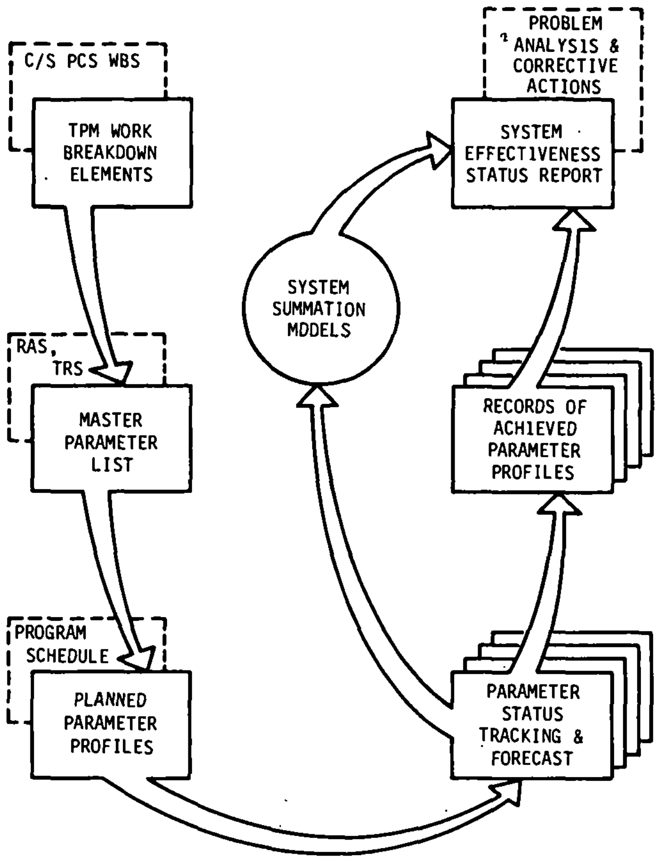


Figure 3–2. Technical performance measurement and system effectiveness assessment information flow.

the program. Interfaces with other pertinent management procedures are shown on the figure. The last four items are the outputs of technical performance measurements and assessments. These elements are described in (4) through (11) below.

(4) The work breakdown elements for technical performance measurement are selected from the contract WBS. The WBS is developed as indicated in MIL-STD-881A and AR 70–32. TPM elements are primarily product oriented. Each selected element must possess measurable technical characteristics that contribute significantly to the technical performance or effectiveness of the total system. Since the project WBS is a combination of deliverable configuration items and task elements, it is sometimes difficult to associate measurable technical performance with each one of the WBS elements. Although it may be possible to make the TPM elements identical with those of the project WBS product elements, it would often result in duplication of parameters to be tracked and reported on the same subsystems and configuration items. It is, therefore, logical to combine some WBS elements and work packages into a specification tree-like structure of elements for the purpose of technical performance measurement. Figure 3–3 illustrates a typical project WBS for a development program. Numbering of components and their associated drawings is most commonly done as illustrated, although the MIL-STD-482 procedure may be used. Figure 3–4 schematically portrays the combination of WBS elements into TPM elements.

(5) The master parameter list is established prior to the design of performance tracking and status reporting procedures. A technical performance parameter is a characteristic of an element representing how well it must perform its intended function. It is determined on the basis of sensitivity of each parameter. The technical parameters which are selected for tracking and status reporting must be meaningful and measurable through application of the system effectivness model. The identification of parameters is closely related to requirements allocation, and can be accomplished with formulation of requirements allocation sheets (RAS) or test requirements sheets (TRS). Parameters of an element selected are those directly contributing to selected parameters of a higher level element, or which represent the overall contract requirement for the element. Examples of the former group of parameters are component weights, hydraulic power demand in units per minute and electric power demand in watts, a drift rate of an inertial guidance unit, and computer accuracy. Examples of the latter group of parameters are the gross weight, engine power, system reliability, range, and reaction time. The mast parameter list contains all measurable technical performance parameters for each of the elements. It is usually arranged in accordance with the WBS.

(6) A planned parameter profile is the time-phased goals of the parameter values of a WBS element. These goals are the expected achievements of the development efforts on the element. A planned parameter profile may be a constant value which was used as the design criterion as a result of the requirment allocation. In this case, the planned parameter profile would appear as a horizontal line against time. Other performance characteristics may trend upward or downward. Figure 3–5 illustrates two planned parameter profiles of contract specification requirements or allocated requirements. The planned goals may have to undergo revisions from time to time as the development progresses. The original planned goal should be retained as a reference. If not retained as a goal after replanning, the value should be retained for variance analyses and revised goals should be traceable to it. Examination of the work progress should ensure that contract objectives are met.

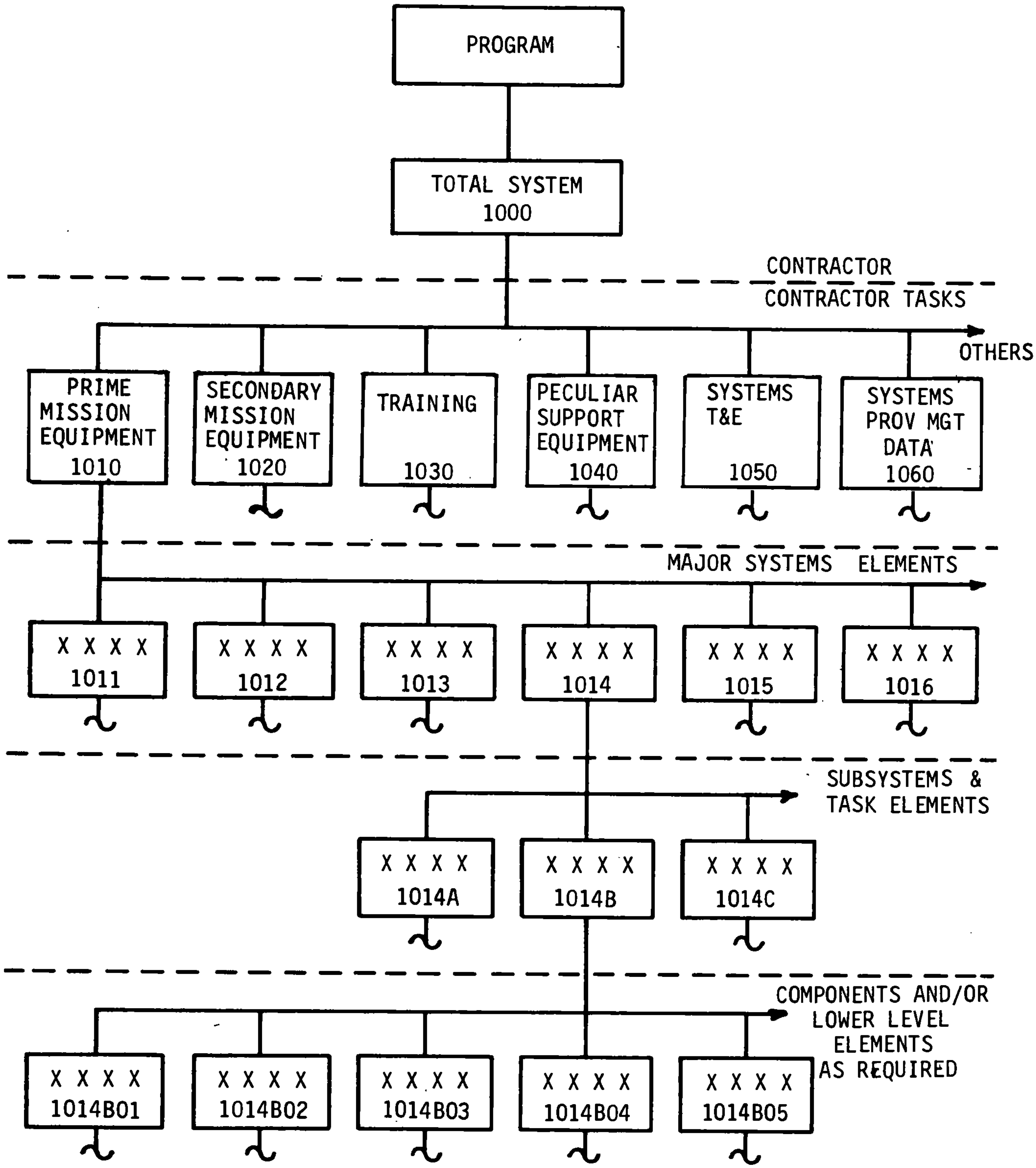


Figure 3–3. Typical work breakdown structure.

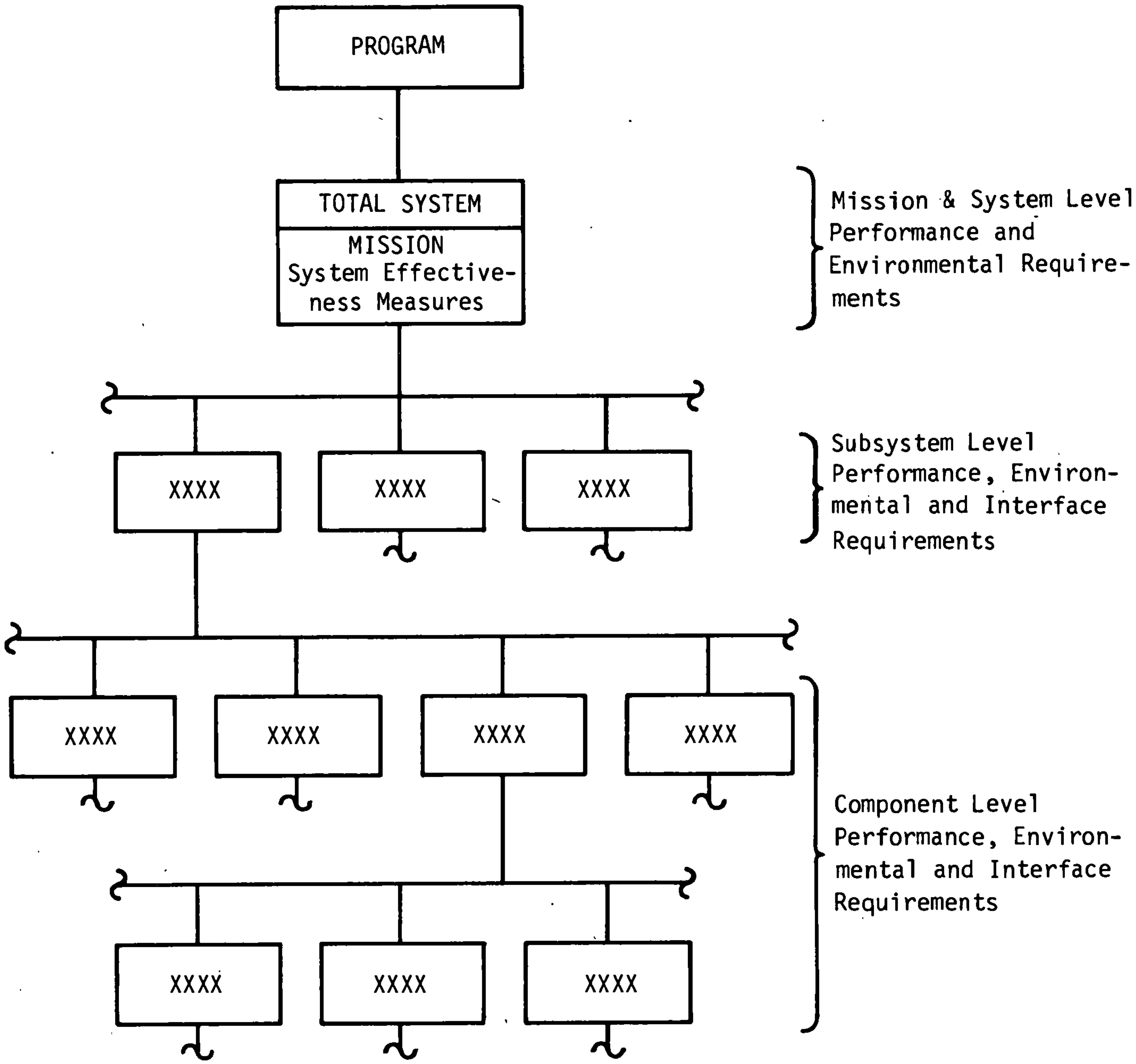


Figure 3–4. Typical work breakdown elements for TPM.

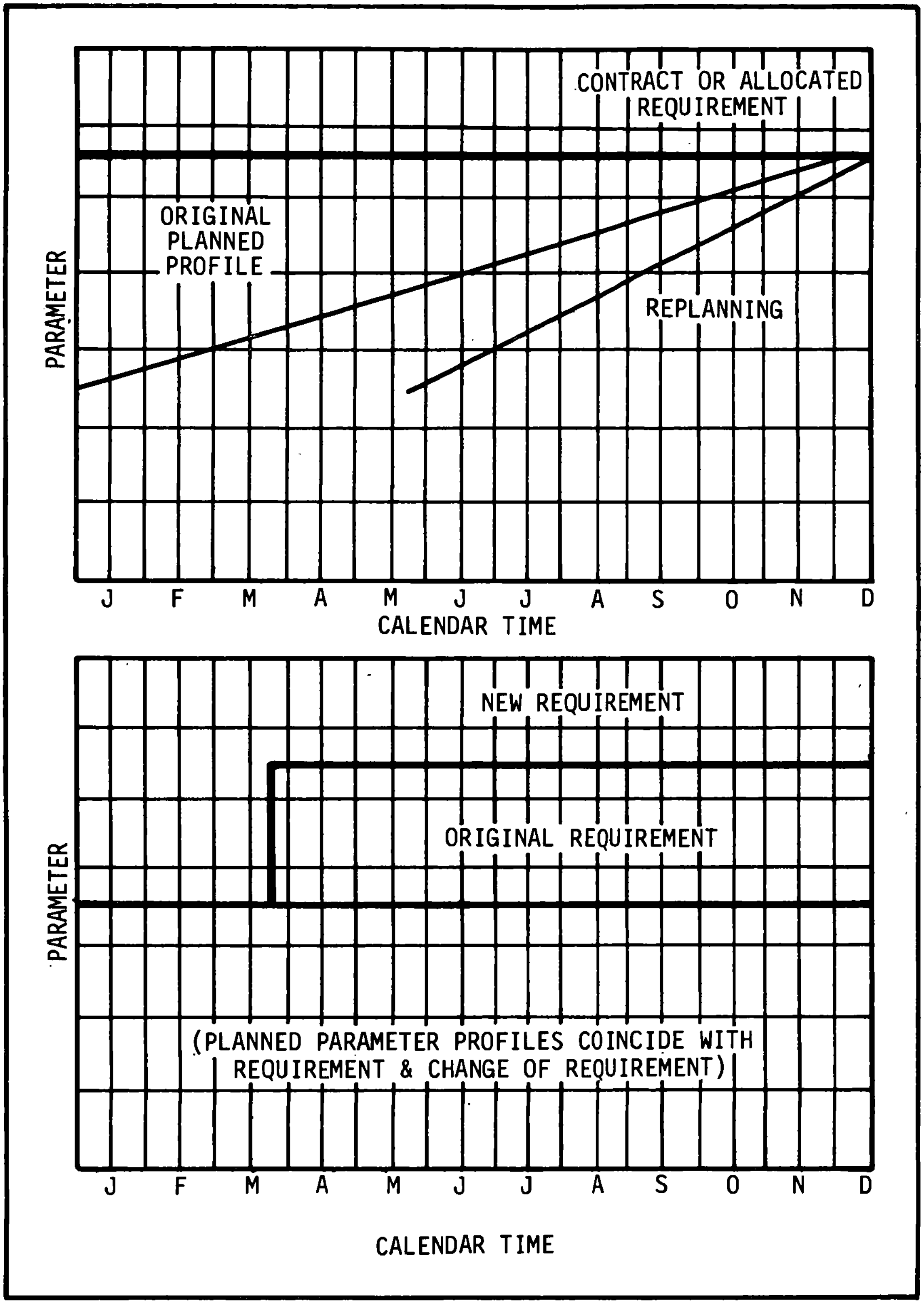


Figure 3-5. Planned parameter profile.

SECTION I. System Designation

SECTION II. System Effectiveness Summary

a. Narrative

b. Summary Chart (Figure 3-8)

SECTION III. System Effectiveness Analysis Plan

a. Mission

b. System Description

1. General Configuration
2. System Block Diagram
3. Mission Profile
4. Mission Outcome (s)

c. Definition of Characteristics/Master Parameter List

d. System Effectiveness Model/System Summation Models

e. System Effectiveness and Performance Parameter Requirements

SECTION IV. Parameter Matrices and Achieved Parameter Profiles

a. Availability

1. Requirements Narrative
2. Status Narrative
3. Matrix Chart/Profile

b. Dependability (Mission Reliability)

1. Requirements Narrative
2. Status Narrative
3. Matrix Chart/Profile

c. Capability (Kill Probability)

1. Requirements Narrative
2. Status Narrative
3. Matrix Chart/Profile

SECTION V. Summary of Significant Changes, Problems and Corrective Actions

Figure 3-7. System effectiveness status report—topical outline.

SYSTEM EFFECTIVENESS AND SUMMARY PERFORMANCE STATUS REPORT									
RESPONSIBLE ACTIVITY			DATE						
IDENTIFICATION	CHARACTERISTICS	REQUIREMENTS		STATUS			VARIANCE		
WORK TPM ELEMENTS	PRIMARY PERFORMANCE CHARACTERISTICS OR PERFORMANCE PARAMETER	ESSENTIAL ROC/LR REQUIREMENT	a. SPECIFICATION REQUIREMENTS	b. STATUS BASED ON PREDICTION	c. STATUS BASED ON TEST RESULTS	d. STATUS BASED ON OPERATIONAL USE	a - b	a - c	a - d
NOTES:									

Figure 3–8. System effectiveness and summary performance status report.

(7) The work breakdown structure described above is a framework for technical performance allocation from which performance standards are established for each element in order to achieve total system performance requirements specified in the contract. The summation models established during the planning process are used with the current estimate or measurement of the technical parameter values to compute the total system performance estimate at each reporting period. Through these summary level reports, both the procuring agency and contractor management may quickly identify deviations from the planned parameter profile. A simplified example of this process can be described by the parameter of weight. It is obvious that if weight is a parameter at the top summary level, a simple arithmetic summation of the actual weight of every part of the total system must not exceed the total allowable weight for the system being developed. Each work breakdown structure element would be allocated a specific or maximum weight. During the design, development, and test phases, the weight of each WBS element would be reported and accumulated through the summation model to arrive at a total system weight. It is not necessary that the planned weight parameter be constant over development time to meet the guaranteed or required weight of the total system. Management may recognize that weight historically increases during the system life cycle, and planning may allocate a lesser value to permit growth during system design, development, and test. Other parameters will require much more complex summation models. For instance, reliability and maintainability summation models utilize information on mean time beteen failure and mean time to repair of subsystems and components, typical mission profiles, intended mission mix, and maintenance man-hours per operation hour. Techniques for developing these models have been formulated in the respective engineering specialty areas.

(8) The fundamental effort of technical performance measurement is tracking the status of performance parameters at the summary level and in terms of system effectiveness for additional analysis. This data must originate from the organizations responsible for the design or test of each of the WBS elements. Status of the parameters for each element may be established by credible design analysis, simulation, environmental test, prototype test, engineering test, service test, or field test. Periodic status information of the accomplished parameter values are submitted to the appropriate management organization for analysis and reporting. At this location, raw data may be grouped according to parameters, elements, systems, and organizations. Figure 3–6 shows examples of parameter status tracking reports of two parameters of a typical system. Periodic technical performance summary reports which compare actual to planned technical performance will provide a record of the degree of technical success of the WBS elements. Although only summary data is submitted to the procuring agency, traceable technical performance data for work breakdown structure elements may be requested if required for additional analysis. This data will provide system management with visibility by which they may forecast system progress and possible trouble areas. It would also provide a record for predicting changes in the planned TPM baselines as additional trade-offs are made during evolution of the design.

(9) The accumulation of performance parameter status data over a period of time constitutes the acheived parameter profile. Many parameter profiles for lower level elements may be constructed directly from the status data; others, for higher level elements, can be derived through appropriate summation models from parameter values of lower elements. Most of the technical performance parameters for the overall system cannot be measured directly until the system tests are conducted. Achieved parameter profiles may be added to the planned parameter profile charts as illustrated in figure 3–6.

(10) System effectiveness status reports and summary performance status reports can be assembled from the basic parameter status data and arranged according to the needs of recipients. This data can be sorted according to the performance parameters at the system level, parameters which contribute to system level performance, elements of other levels, or responsible engineering organizations. System effectiveness and summary performance status reports that are required by the procuring agency shall be as stated in the contract. Figure 3–7 is a sample format for this report. Figure 3–8 is a sample format for either summary performance or system effectiveness status reporting.

(11) Reporting is required periodically, generally at higher levels of the WBS. It is a requirement that the contractor utilize this system in the performance of his technical management, and records of his internal actions should be maintained within the contractors facility. Whenever a plan is changed, or deviation from planned technical performance values is reported, traceable records will be maintained. The procuring agency may require the contractor to discuss the records and technical performance measurement reports at levels of the work breakdown structure within the TPM lower than the reporting levels. The capability for examination on an exception

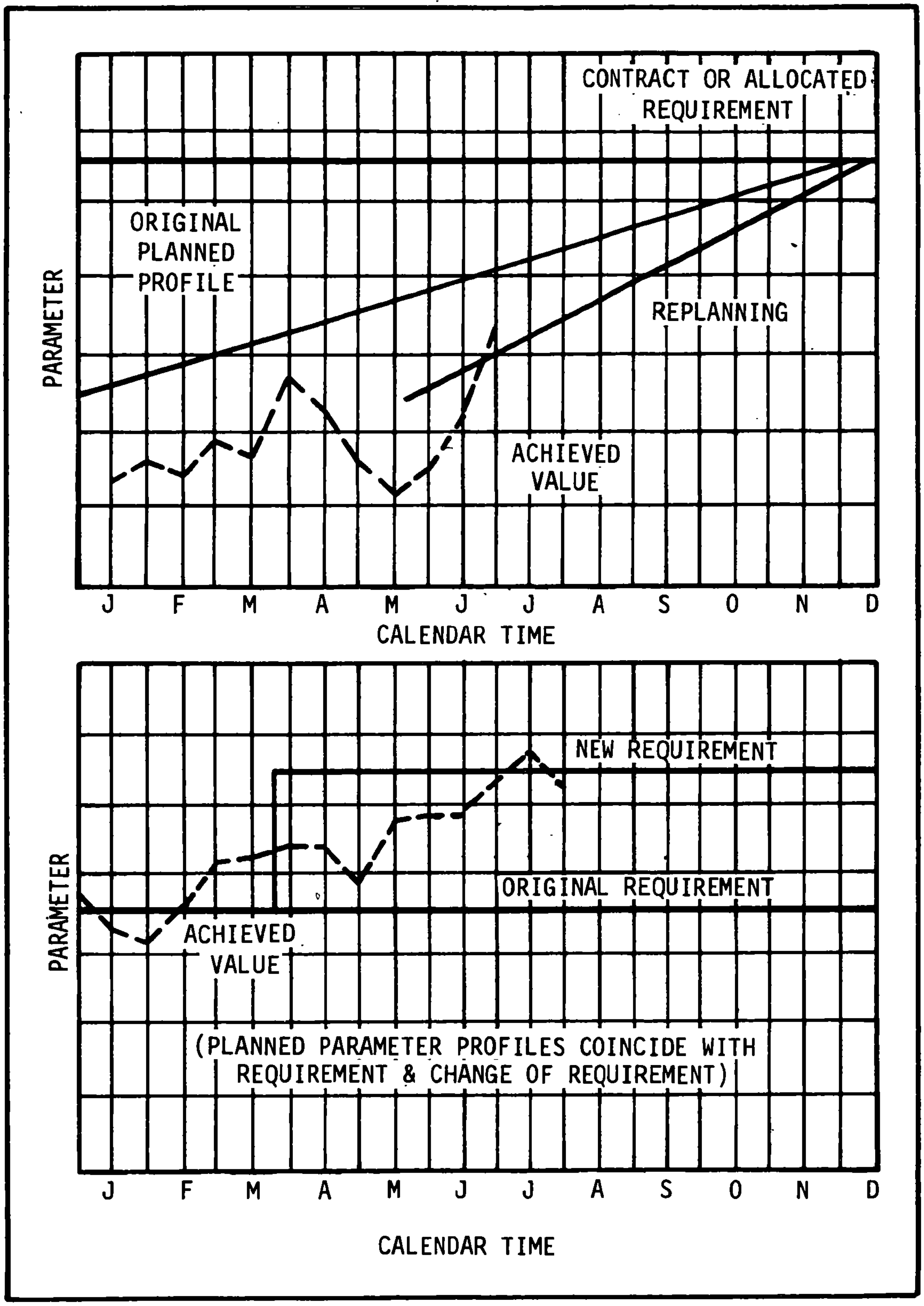


Figure 3-6. Achieved parameter profiles.

basis by the procuring activity of lower work breakdown structure elements will give the contracting activity knowledge of the WBS elements which cause the technical performance deviation. This assurance of visibility will give the procuring activity confidence in the reprogramming necessary to meet the contract requirements. Development of the technical performance measurement and assessment system is required during the Demonstration and Validation Phase of the system life cycle. The contractor may propose an internal technical performance measurement system, or use the technical performance measurement procedure set forth in this manual. During evaluation of the contractors proposal, the procurement agency will evaluate the technical performance measurement and assessment system and ensure that it possesses the capabilities set forth in the contract.

3-5. Relationships

a. Relationship of System Engineering Process to Configuration Management.

(1) A fundamental concept associated with system/project development is the use of three baselines to ensure an orderly transition from one major decision point to the next in the system life cycle. This concept is illusrated in figure 3-9. The system engineering process interfaces with configuration management through technical data. An output of the system engineering process is technical data which establishes baselines to which configuration management procedures are applied throughout the life cycle. This is done by established procedures which identify the complete technical description of the system as it evolves, control the documents that provide this identification, and continually update the documentation to reflect the approved configuration of the system. The output of the system engineering process in the Alternative Systems Concept Phase provides the functional configuration identification (FCI). This identification translates the LOA into performance and design requirements, design constraints, inter- and intrasystem interfaces, test and evaluation requirements, and functional areas of the system which are documented in the system specification at the end of the phase. During the Demonstration and Validation Phase, the system engineering process provides the allocated configuration identification (ACI), which consists of a series of development specifications that define the functional and test requirements for each major configuration item. These development specifications will be used to specify requirements for the design, development,

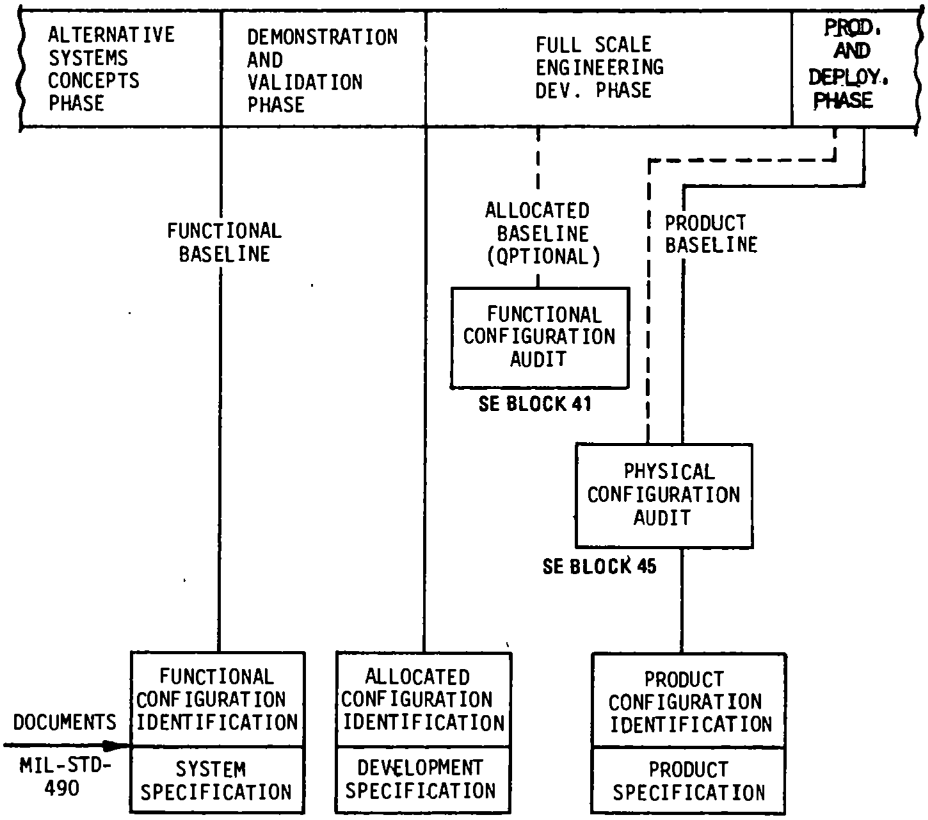


Figure 3-9. Configuration management as related to life cycle.

test, and evaluation of the equipment and facility elements of the system. The requirements stated in the development specifications encompass the total system requirements as stated in the system specification. During the Full-Scale Engineering Development Phase, the system engineering process provides the product configuration identification (PCI), which includes product specifications.

(2) System engineering develops three configuration management baselines during the life cycle.

(*a*) *Functional baseline*. The functional baseline is established at the end of the Alternative Systems Concepts Phase, and normally is concurrent with approval to initiate engineering development or operational system development. It is established by approval and release of the system specification which delineates the system functional requirements. It is prepared in accordance with MIL-STD-490.

(*b*) *Allocated baseline*. The allocated baseline is established at the end of demonstration and validation. This optional baseline, when used, will govern the development of selected configuration items that are part of a higher level configuration item. It consists of development specifications which result from application of the system engineering process during demonstration and validation. When combined, the development specifications must meet criteria established in the system specification. Approval and release of these development specifications establishes this baseline.

(*c*) *Product baseline*. The product baseline is established at the completion of the physical configuration audit (PCA). This baseline consists of product specifications, process specifications, and material specifications. Additionally, system engineering provides engineering drawings and related data to provide a set of documents adequate for the procurement, production, test, evaluation, and acceptance of an item.

(3) The above baselines serve as system engineering management reference points. They represent the progressive development of specifications, drawings, and associated data. These technical data progress from general requirements to detail requirements. They provide a level of control which is initially a broad scope. Eventually, they are narrowed to be more restrictive as the design becomes more definitive. A constant closed-loop relationship must be maintained between established design requirements and design effort, thereby ensuring that the design effort is at all times directed to meet, rather than exceed or fall short of, total system requirements. The baselines also represent the progressive and evolutionary development of system documentation. System elements developed by the system engineering process and described in the baselines define product elements of the work breakdown structure.

b. Relationship With Integrated Logistics Support (ILS).

(1) Guidance and procedures to be used in the application of ILS are covered in AR 700–127, TM 38–710, and TM 38–715. These documents define the concept of ILS planning and describe the actions and judgments necessary to insure the orderly and systematic initiation, development, and monitoring of support planning and implementation of plans for end items or systems.

(2) ILS includes that planning required for the technical management elements and tangible support elements which are required for logistics support of an equipment item or system. The three technical management elements are the engineering element, logistics support resource funds, and logistics support management information. The elements provide input for the system engineering process. The tangible support elements receive output from the system engineering process as follows: support and test equipment; supply support (repair parts and spares); transportation and handling; technical data; facilities; and personnel and training. The ILS concept embodies an anaylsis of equipment design with the following objectives:

(*a*) Earlier consideration of support requirements in design and developmnent of new materiel.

(*b*) Improved maintenance support and reduced skill requirements.

(*c*) Optimum balance among support elements achieved by considering possible trade-offs.

(*d*) All support elements on hand, when required.

(*e*) Minimum life cycle cost for support.

(3) Interface:

(*a*) System engineering procedures enable determination of system logistics support elements to the degree of detail appropriate to given points in the life cycle. ILS covers the multitude of detailed actions to be accomplished and procedures to be followed to ensure preparation of detailed management support plans and development of total support requirements.

(*b*) There must be a flow of information between the two activities at various points in the life cycle. Certain outputs of ILS activities provide inputs to the system engineering process. Certain outputs of the system engineering process provide input to ILS. The primary medium for transfer of this input-output information data is the Logistics Support Analysis Records (LSAR) input data sheets and output summary reports.

(*c*) Logistics support concepts for the system are developed based upon experience, requirements documents, and documentation derived from similar systems. These concepts must interface with the guidance provided by concept and doctrinal studies, and furnish early and continuing inputs to system engineering.

(*d*) The system engineering process provides the operational data upon which the logistics support analysis is based. These data provide the engineering derived information required in the LSAR sheets which are used by the logistics support manager to accomplish integration with system engineering. The LSAR data is, in turn, used by the system engineering process to provide or revise requirements for equipment, personnel, facilities, procedural data, and computer programs in appropriate functional areas.

(*e*) Based upon analysis of the design characteristics of proposed system equipment and facility elements and upon logistics support concepts, the system engineering process is employed to define the requirements for and provide descriptions of operations and maintenance elements.

(*f*) Based upon LSAR data and description of the proposed maintenance elements provided by the system engineering process, ILS updates the Plan for Logistics Support (Section VI) (OAP/AP) to provide technical direction and management to the ILS effort. These plans become progressively more definitive as the design and logistics support analysis of equipment and facility elements of the system evolve.

(*g*) In developing the logistics support elements in system engineering, consideration is given to the impact of integrated logistics support upon equipment design and upon system effectiveness and cost-effectiveness.

c. System Engineering/Specialist Interrelationship.

(1) Integration of engineering specialties into the total engineering program is a major objective of system engineering management. In the earlier stages of a program, system engineers work in conjunction with operations research and operations analysis specialists to establish appropriate measures of effectiveness. System effectiveness is normally influenced by factors of reliability, maintainability, and other parameters of total system performance. Thus, reliability, maintainability, and other specialty programs are incorproated into the system engineering process at logical and pertinent points in time with sufficient applicable input data. As the concept grows, contributions of additional engineering specialties are brought into the design of the system, specialists can identify the processes of their professions in terms of input and output, and the points of their linkage with the system engineering process data flow are apparent. Thereafter, with properly implemented procedures, the rigor of the system engineering process insures participation of the specialist at the pertinent points in decision making.

(2) As depicted in figure 3–10, system engineering and specialty program interrelationships may be represented by three imaginary round tables. At the first table, system engineering is concerned with conceptual analysis. The specialists in this group contribute candidate concepts which are subject either to acceptance, rejection, or trade-off study analyses for resolution.

(3) As data emerges from the first table in the form of system engineering documentation, it is reviewed at the second table for disciplinary constraints and expansion of requirements. Often, the action at the second table will override the action at the first. In this case, the data is returned to the first group for rework. Material which pases through the first two groups goes to the third for execution of downstream responsibilities. It is interesting to note that specialists at the second table are identified with plans, all drafted in conjunction with the activity of the system engineering process. Some of the specialists shown may have little or no participation in the Alternative System Concepts Phase, but the network is designed to include them later at the appropriate times. A very important participant in all phases in the designer at the third table who produces configurations, layouts, and trade-off study data. The designer is linked very closely with the conceptual specialists from the earliest part of the effort, and in later phases, executes the detail design for production. At this time, the designer is supported and audited by the specialists who earlier prescribed "design-to" requirements.

d. Relationship of System Engineering to Cost and Schedule Control Mechanisms.

(1) Cost is a major consideration every time an engineer or designer conceives possible alternative solutions to solving an operational problem. In the system engineering process, life cycle costs are considered along with the design constraints, reliability, maintainability, safety, and other parameters and engineering specialties.

(2) The use of the work breakdown structure (WBS) as a framework for visibility provides a means of identifying the small pieces (detail system elements) to which life cycle costs are assigned. Cost control and prevention of cost escalation are directly tied to constraining the design by identifying the risks and life cycle cost implications every time synthesis of alternatives is accomplished. As each design alternative is considered, including those alternatives based on incremental changes in the func-

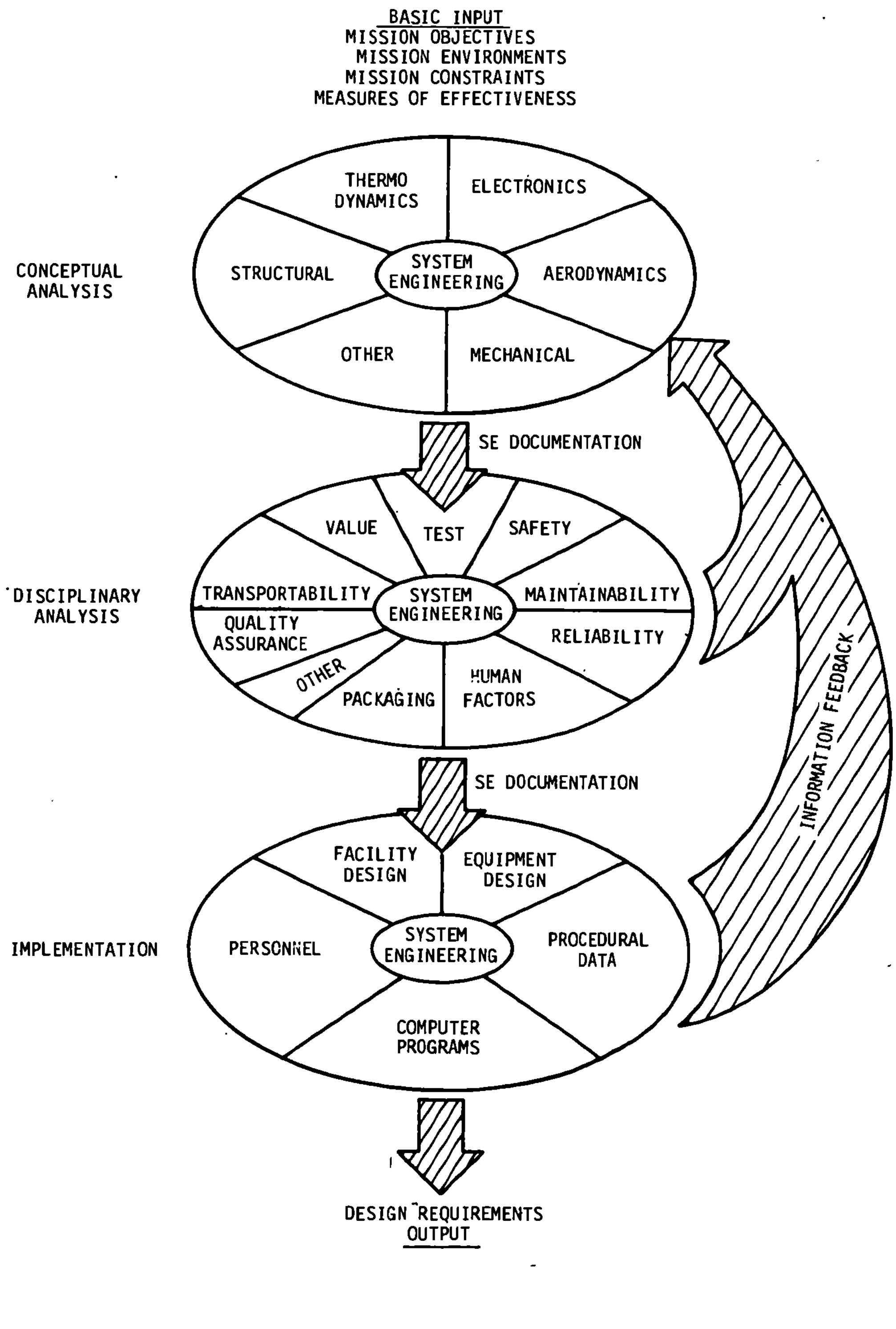


Figure 3–10 System engineering/specialist interrelationships.

tion performance requirements for functions where system life cycle costs are expected to be sensitive to the requirements, the most cost-effective alternative is identified and selection justification is included in the trade-off studies prior to the decision to select a particular conceptual design.

(3) Among the interrelationships of management systems and system engineering, one of the most important is that associated with cost/schedule planning and control. The product and service segments of a system are related by system engineering for any specific project and are defined by the contract work breakdown structure and contract work statements. As shown in figure 3–3, the definition and identification of lower indenture levels, through application of system engineering and the system engineering process, provide the details to which are applied various management and control systems and criteria in order to achieve firm, fixed, credible estimates of costs. Some of these are Cost/Schedule Control System Criteria (C/SCSC), Contract Cost Data Reporting (CCDR), Cost Performance Report (CPR), and Cost/Schedule Status Report (C/SSR).

(4) System engineering provides an achievable technical foundation upon which costs can be based. Application of system engineering produces the engineering data that describes all system elements. As the program proceeds through the life cycle phases, one of the major constraints is the limitation of available funds. This constraint impacts in all areas of preliminary design. System engineering identifies the product and service segments of the work breakdown structure (WBS). WBS provides the visible framework for cost estimates. It is the summation of costs applied to the identified segments and components of the WBS that provide firm estimates of the system cost. The balance achieved among system performance, cost, and schedules is documented, and its traceability is available for consideration of the program manager on demand at scheduled reviews.

(5) Cost and schedule performance measurement is accomplished through contractor management control systems which meet the DOD Cost/Schedule Control Systems Criteria. These criteria require contractors to measure cost performance in terms of the work accomplished compared to the resources used. They also ensure that contractors are using cost and schedule control systems which provide both contractor and the Government with adequate visibility and control at all levels of management, using data from the same source.

(6) The Cost Performance Report (CPR) provides cost and related data for measuring a contractor's cost and schedule performance against selected WBS elements (MIL-STD-881A), and provides a similar measurement by functional (organizational) cost element. There is also a part of the CPR for identifying changes to the cost baseline and projecting the time phasing on the planned cost. Also provided is a manpower loading report which permits measurement of personnel utilization against the budgeted plan. The CPR includes a narrative which identifies significant problems, explains major cost and schedule variances, and addresses their impact and the corrective action taken on proposals. This information assists the project manager in making necessary decisions regarding the project. Using selected WBS elements, the contractor reports planned costs for the work performed versus actual costs for that work. This information is then used to update projected costs at completion of the program. The projections provide an early indication of the cost trend, thereby identifying potential overruns promptly enough to permit the project manager to take effective corrective action. The information contained in the Cost Performance Report is also required by DOD components in completing the Selected Acquisition Reports (SAR), an internal requirement which provides program performance measurement information to the Secretary of Defense and the Congress.

(7) The Cost/Schedule Status Report (C/SSR) provides cost and related data for measuring contractor cost and schedule performance against selected WBS elements, and includes a narrative which identifies significant problems, explains major cost and schedule variances, and addresses the corrective action taken or proposed. The C/SSR is a scaled-down version of the CPR for use on nonmajor contracts. Where the CPR is used with the C/SCSC, the C/SSR does not require cost performance reporting on a functional basis, nor on manpower or baseline reporting. The C/SSR does not give the contractor greater flexibility in the selection of internal cost performance measurement techniques, but assists the Government manager in understanding the derivation and meaning of the reported data.

(8) The Contractor Cost Data Reporting (CCDR) Plan is used to specify requirements for the collection of cost data on selected WBS elements for cost analysis purposes. It identifies proposed cost information coverage for selected contractors and in-house Army activities engaged in the development and production of the system. This cost data is required by the Army to accomplish its cost estimating and analysis functions. The relationship that exists between CCDR and system engineering is that the WBS results from the application of system engineering. Thus, system engineering again contributes to cost control mechanisms.

e. Relationship of System Engineering to Cost and Technical Performance Measurement.

(1) System engineering employs engineering analysis, test, and evaluation to make periodic assessments of the status of the technical program in achieving the performance parameters it has established for the product system. These technical assessments resulting from TPM, when correlated to cost and schedule reports, provide the complete status of the project. They serve to identify any engineering or other technical problems requiring management attention and to forecast the impact on program (project) cost, schedule, and utlimate performance of any out-of-tolerance conditions.

(2) Technical performance measurement (TPM) supports cost/schedule performance measurement by providing confidence that established milestones have been successfully met, that expenditure of resources has accomplished the objective for which they were allocated, and by predicting technical problems that can cause program (project) cost and schedule variances by triggering action to reduce these variances before they result in cost and schedule overruns.

(3) System engineering provides the technical basis for allocating funds to program tasks against time; and for relating earned value of cost schedule control systems to demonsrated values of performance parameters. The information generated by this interrelationship enables the manager to efficiently plan and control the technical program for the design, development, test, and evaluation of the system.

CHAPTER 4
A SYSTEM ENGINEERING IMPLEMENTATION METHOD

4-1. General

a. Implementation. This chapter describes a method and a set of documentation tools for implementing the system engineering process. The procedures and documentation described here have been utilized effectively in a board variety of programs; however, other procedures and documentation may be used as long as the prescribed objectives of system engineering are attained. System engineering documentation is controlled in a manner similar to that used for a set of engineering drawings..

b. Concept of Minimum Documentation. Because of the iterative nature of the system engineering process, it is necessary that documentation be held to a minimum. This concept recognizes that excessive amounts of formal paper to identify, define, and describe the system requirements and solutions will inhibit timely and conscientious use of the system engineering discipline. The minimum documentation concept emphasizes creative aspects, but is not intended to discourage the use of specialized forms and working paper where a clear need exists.

c. Documentation and Document Relationship.

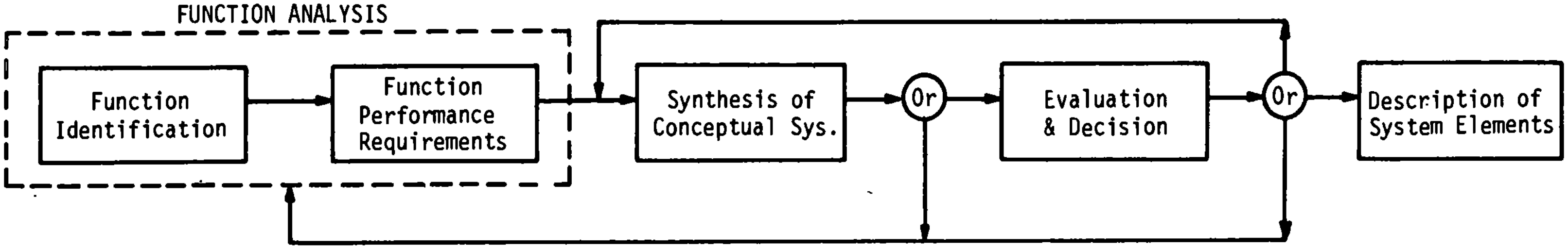
(1) Internal documentation is derived from the system engineering process itself. The four system engineering steps (function analysis, synthesis, evaluation and decision, and description) are applied to the five system functional areas (operation, logistics support, test, production, and deployment) in order to define the requirements and develop criteria for selection and design of the five system elements (equipment, personnel, facilities, computer programs, and procedural data).

(2) System engineering documentation provides analytical tools for the process steps as applied to the functional areas. The documents include the minimum information required at each step of the process to perform that step and to define the system elements. The basic documentation is the most frequently used, is most adaptable, and will in many cases fulfill all documentation requirements. The special purpose documentation is given as examples of variations on the basic documents and may be used when they serve a need.

(a) *Function identification.* In the planned operation of a potential system there are a large number of possible functions and functional sequences. The nature of these functions is dependent upon the mission objectives and varies from system to system. For the accomplishment of function identification in the operation and deployment cycles, the basic analytical tool is the functional flow block diagram (FFBD). This format allows for a broad selection of functions, and provides a means for depicting functional sequences and relationships. On the other hand, in the functional areas of maintenance, test, and production, there is a smaller number of possible functions, and the functional requirements are dependent upon the design configuration of the system equipment. For the identification of logistics support, test, and production functions in their respective cycles of the process, the following forms are provided, and may be used to correlate functions to equipment end items, subassemblies and components: end item maintenance sheet (EIMS), test requirements sheet (TRS), and production sheet (PS). Functional flow block diagrams may also be used in these cycles if the sequence and relaionship of functions has a bearing on the function analysis.

(b) *Function performance requirements analysis.* In all of the functional cycles of the process, the requirements allocation sheet (RAS) is used as the primary analytical tool in conjunction with functional flow block diagrams and the special purpose documents such as end item maintenance sheets, test requirements sheets, and production sheets. The RAS serves three purposes in documenting the system engineering process: initially, it is used to record the performance requirements established for each function; during synthesis, it is used to show the allocation of the function performance requirements to individual system elements or combination of elements; following evaluation and decision, the RAS provides the functionally oriented data required for description of the system elements.

(c) *Time requirements analysis.* The time line sheet (TLS) is used to perform and record the analysis of time-critical functions and functional se-



FUNCTIONAL FLOW BLOCK DIAGRAMS (FFBD)* END ITEM MAINTENANCE SHEETS (EIMS)** TEST REQUIREMENTS SHEET (TRS)** PRODUCTION SHEET(PS)**	REQUIREMENTS ALLOCATION SHEETS (RAS)* TIME-LINE SHEETS (TLS)*	CONCEPT DESCRIPTION SHEETS (CDS)* SCHEMATIC BLOCK DIAGRAMS (SBD)*	TRADE-OFF STUDY REPORTS (TSR)*	DESIGN SHEETS (DS)* FACILITY INTERFACE SHEETS (FIS)**
<u>FFBD</u>* IDENTIFY AND SEQUENCE FUNCTIONS THAT MUST BE ACCOMPLISHED TO ACHIEVE SYSTEM OR PROJECT OBJECTIVES. DEVELOP THE BASIS FOR ESTABLISHING INTER-SYSTEM FUNCTIONAL INTERFACES AND IDENTIFY SYSTEM RELATIONSHIPS. <u>EIMS/TRS/PS/</u> LSAR ** IDENTIFY MAINTENANCE, TEST AND PRODUCTION FUNCTIONS ON A SPECIFIC END ITEM, SUB-ASSEMBLY AND COMPONENT BASIS	<u>RAS</u>* DEFINE THE REQUIREMENTS AND CONSTRAINTS FOR EACH OF THE FUNCTIONS AND RELATE EACH REQMT TO THE SYSTEM ELEMENTS OF a. EQUIPMENT b. FACILITIES c. PERSONNEL d. PROCEDURAL DATA e. COMPUTER PROGRAMS <u>TLS</u>* PRESENT CRITICAL FUNCTIONS AGAINST A TIME BASE IN THE REQUIRED SEQUENCE OF ACCOMPLISHMENT	<u>CDS</u>* CONSTRAIN THE DESIGNER TO STOP AT A POINT IN THE CYCLE AND CREATE AT THE GROSS LEVEL A DESIGN OR SYNTHESIS MEETING THE FFBD, RAS, TLS REQUIREMENTS AND CONSTRAINTS. <u>SBD</u>* DEVELOP AND PORTRAY SCHEMATIC ARRANGEMENT OF SYSTEM ELEMENTS TO SATISFY SYSTEM REQMTS.	<u>TSR</u>* SELECT, EVALUATE AND OPTIMIZE PROMISING OR ATTRACTIVE CONCEPTS AND DOCUMENT THE TRADE-OFF AND SUPPORTING RATIONALE. CONSIDERS ALL POSSIBLE SOLUTIONS WITHIN THE FRAMEWORK OF REQMTS.	<u>DS</u>* DEFINE, DESCRIBE AND SPECIFY PERFORMANCE, DESIGN AND TEST CRITERIA FOR THE SYSTEM ELEMENTS, a. EQUIPMENT b. FACILITIES c. PERSONNEL d. PROCEDURAL DATA e. COMPUTER PROGRAMS <u>FIS</u>** IDENTIFY ENVIRONMENTAL AND PHYSICAL INTERFACES BETWEEN EQUIPMENT AND FACILITIES ON AN END ITEM BASIS.

INDENTURE IS CARRIED TO THE LEVEL REQUIRED FOR THE SELECTED LEVEL OF ENGINEERING TO IDENTIFY. DESCRIBE AND SPECIFY.

* BASIC DOCUMENTATION
** SPECIAL DOCUMENTATION

Figure 4-1. Basic and special purpose documentation for system engineering.

quences. In performing time requirements analysis for complex functional sequences, additional tools, such as mathematical models or computer simulation, may be needed. Time requirements analysis is performed in any or all of the functional cycles of the process to determine whether time is a critical factor.

(*d*) *Synthesis*. Two documentation tools accomplish and record the synthesis of design approaches or alternative approaches. The concept description sheet (CDS) is used to collect the performance requirements and constraints as delineated by function analysis that apply to an individual subsystem or end item, and to describe at the gross level a design approach for meeting the requirements. The schemaic block diagram (SBD) is used to develop and portray the conceptual schematic arrangement of system elements to meet system or subsystem requirements. The CDS and SBD are both applicable to all functional cycles and, following evaluation and decision, will provide the basis for development of descriptions of system elements.

(*e*) *Evaluation and decision*. Since program risk and cost are dependent on practical trade-offs between stated operating requirements and engineering design, trade-offs must be considered not only at the beginning of the program but continually throughout development. The trade study report (TSR) is used to correlate characteristics of alternative solutions to the requirements and constraints which establish the selection criteria for a specific trade-off study area. The report also documents the rationale used in the decision process and should present risk assessment and risk avoidance considerations. Other tools, such as analytical or mathematical models or computer simulation, may be needed and used in accomplishing the evaluation and decision process.

(*f*) *Description*. Two forms are provided to describe system elements. The design sheet is used to establish and describe the performance, design, and test requirements for equipment end items, critical components, and for computer programs. The facility interface sheet (FIS) is used to identify the environmental requirements and interface design requirements imposed upon facilities by the functional and design characteristics of equipment end items. The design sheet and FIS provide the basis for the formal identification required for configuration management.

d. Traceability in Documentation.

(1) The system engineering process provides traceability which, in turn, ensures technical integrity in application of the system engineering process. Technical integrity ensures that the design requirements for the system elements reflect the function performance requirements, that all function performance requirements are satisfied by the combined system elements, and that such requirements are optimized against system performance requirements and constraints.

(2) The system engineering documentation described in this chapter provides the audit trail for traceability. Figure 4–2 portrays an example of the mechanics used to provide traceability within the system engineering documentation. Prior to synthesis, all requirements and other analytical data are oriented to functions and are identified by the function number to which they pertain. During synthesis, system elements or candidate elements are identified to satisfy the function performance requirements. After synthesis, all requirements and other design data are oriented to system elements, and are identified by the appropriate configuration item (CI) number (or similar identification for other elements).

e. Relation of System Engineering Documentation to Other Technical Data.

(1) The documentation described in this chapter provides the data required for implementation of the system engineering process. This documentation is considered internal to the system engineering process. Most of the data developed by the process is required by other activities engaged in the development project. Figure 4–3 illustrates in matrix form the multiple application of the data elements contained in the system engineering documentation for a theoretical system. Note that each of the activities marked have a need for the information generated for the delineation of the data elements. As systems vary and activities in individual plants may or may not have need of data, the entries in the matrix would change accordingly. The decision to use data is that of the manager. It is to be noted that without the single source of identifiable data elements as shown in the column on the left, each of the activities would generate the necessasry data based on its interpretation of the requirements. This could lead to significant differences in interpretation and to unrelated requirements.

(2) Data elements included in system engineering documentation generated by the system engineering process are said to be source data; other program documentation, based upon this source data, is said to be derived documentation. Thus, system engineering data, in addition to its internal use, provides inputs to external documentation. Figure 4–4 shows the relationship of the basic system engineering documenttion to the system engineering process and to typical derived documentation. The system engineering process may be depicted as a 5 x 5 x 5 with three axes; the process steps, the function areas, and the system

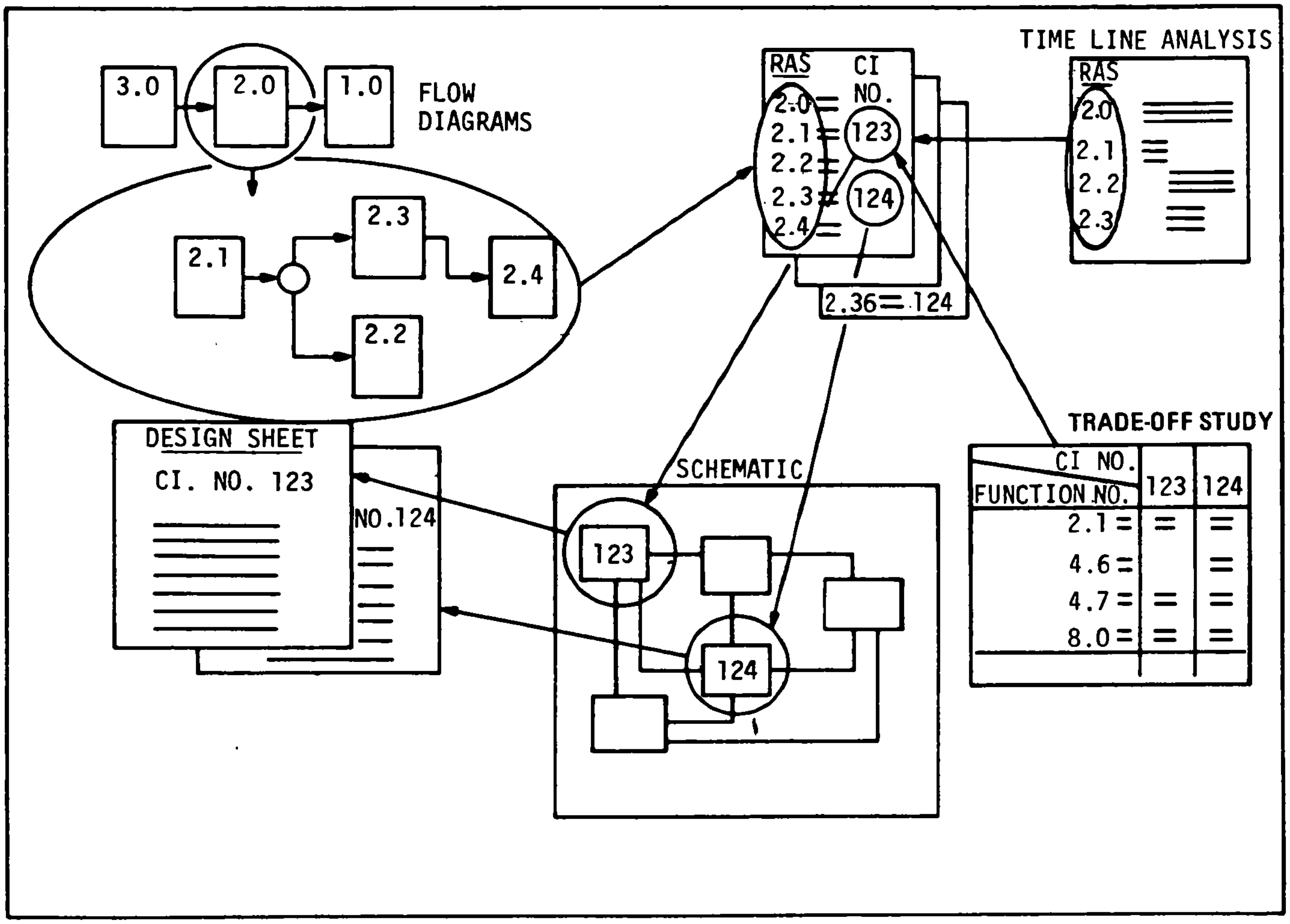


Figure 4-2. Traceability in system engineering documentation.

elements. The system engineering documents are shown opposite the process steps during which they are generated. The derived documents noted on the illustration are typical examples.

4-2. System Engineering Documentation

Detailed descriptions of the system engineering documentation items:

a. Functional Flow Block Diagrams (FFBD) (fig. 4-5). The initial step in the system engineering process formulates a functional description of the system. Functional flow block diagrams are developed for the primary purpose of structuring system requirements in functional terms; the main emphasis is on accuracy and completeness rather than upon format. As an aid in developing, interpreting, and providing standardization necessary to control interfaces, certain basic rules and symbols have been developed and are followed in the physical layout of the functional diagrams. These requirements are described in subsequent paragraphs. The general format and basic symbols for functional diagrams are illustrated in figure 4-5.

(1) *Level designation and scope notes.* Functional flow block diagrams are designated as top level, first level, second level, and so on. The top level functional flow block diagram describes the gross operational functions. The subsequent level diagrams represent progressive expansions of individual functions of the preceding level. Each functional flow block diagram contains a "scope notes" area. On top level diagrams, this area contains the formal name of the system and its objectives, a brief description of the scope of the programs, and comments such as the limitations of the analysis. On lower level diagrams, the scope note is used to describe the relationship of the data covered on the diagram with data covered in other diagrams. It should briefly summarize the condition that exists at the starting and ending point of the drawing and the general purpose and scope of the functions covered in the diagrams. Normally, the materiel developer prepares functional flow block

OUTPUT DATA FOR PLANS AND ACTIVITIES

Plans and activities shown here are typical examples, and may vary with different projects.

PROGRAM PLANS AND ACTIVITIES

SYSTEM ENGINEERING DATA ELEMENTS	DESIGN	DEVELOPMENT	PRODUCTION	PRODUCT ASSURANCE	FACILITIES CONSTR.	TEST & EVALUATION	TRAINING	RELIABILITY	DEPLOYMENT	OPERATIONAL	DEPOT MAINTENANCE	MAINTENANCE (LSAR)	LOGISTIC SUPPORT (ILS)	PRODUCT IMPROVEMENT
Operational Functions/Rqmts	X	X		X	X	X		X		X			X	X
Log Spt Functions Rqmts	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Reliability/Maint/Rqmts	X	X		X	X			X	X			X	X	X
Equipment Design Criteria	X	X	X		X	X	X	X		X	X	X	X	X
Equipment Design Solutions	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Facilities Requirements	X	X		X		X	X		X			X	X	X
Function Performance Times		X			X	X	X		X	X		X	X	X
Task Description/Skill Rqmts				X	X	X	X	X				X	X	X
Operating Procedures		X		X	X	X	X	X	X	X			X	

AND OTHERS,

E.G., MIS

Figure 4–3. Multiple application of SE data elements.

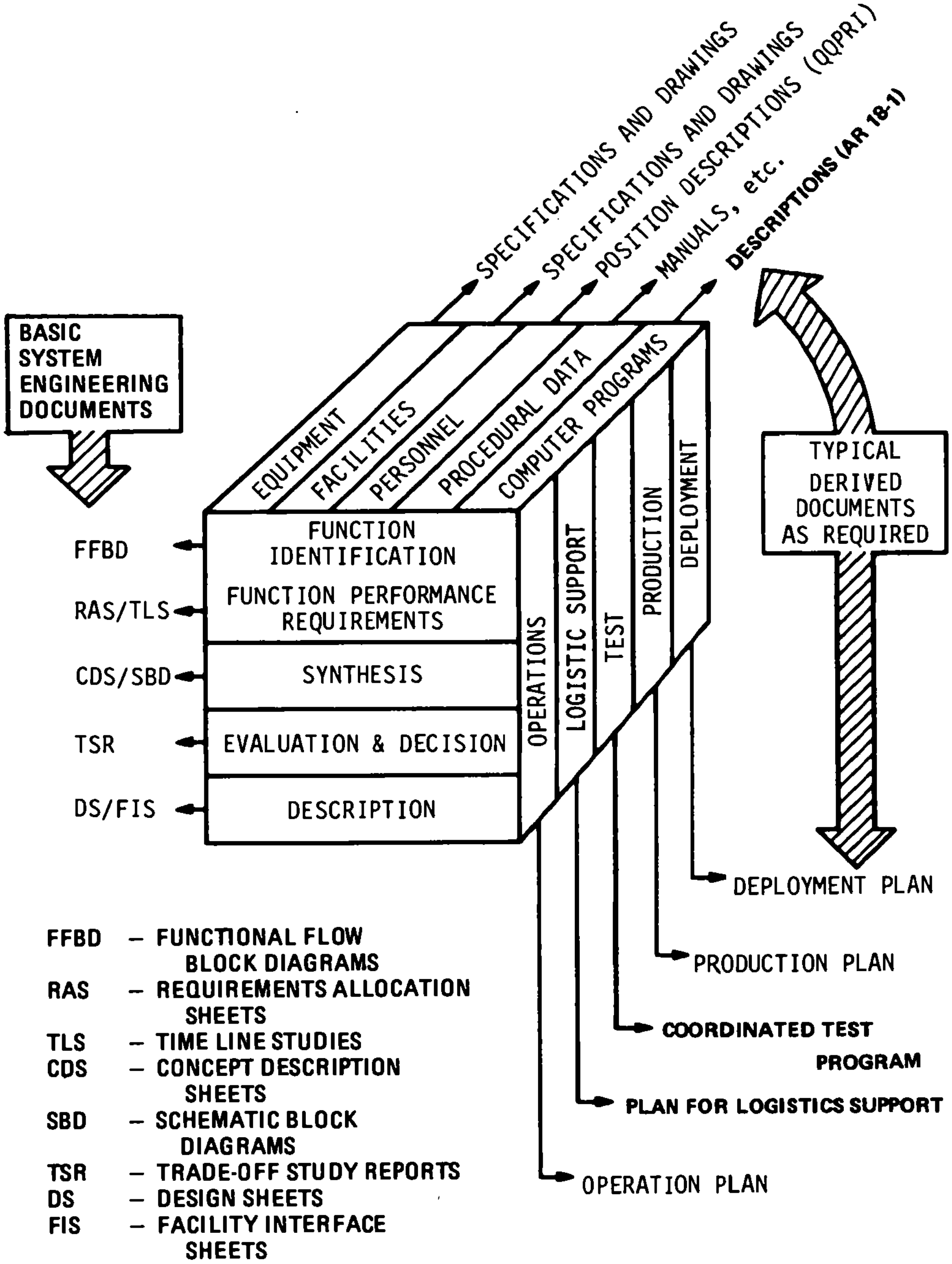


Figure 4–4. Relationship of basic to derived documentation for system engineering.

diagrams down to the level necessary to establish the parameters of the major subsystems. The system contractor then prepares the lower level functional flow block diagrams to the level necessary for program definition and identification of technically critical areas.

(2) *Function numbering.* Functions identified on the diagrams at each level are numbered in a manner which preserves the continuity of functions and provides information with respect to function origin throughout the system. The indenture numbering related to flow diagram level is illustrated in figure 4–6. Functions which further indenture these top functions contain the same parent identifier and coded at the next decimal level for each indenture. For example, if more than one function is required to amplify function 1.0 at the first level of indenture, the sequence will be 1.1, 1.2, 1.3, . . ., 1.n. In expanding function 1.2 at the second level, the numbering will be 1.2.1, 1.2.2, . . ., 1.2n. Where several levels of indentures appear on a single functional diagram, the same pattern is maintained. While the basic ground rule is to maintain a minimum level of indentures on any one particular flow, it may become necessary to

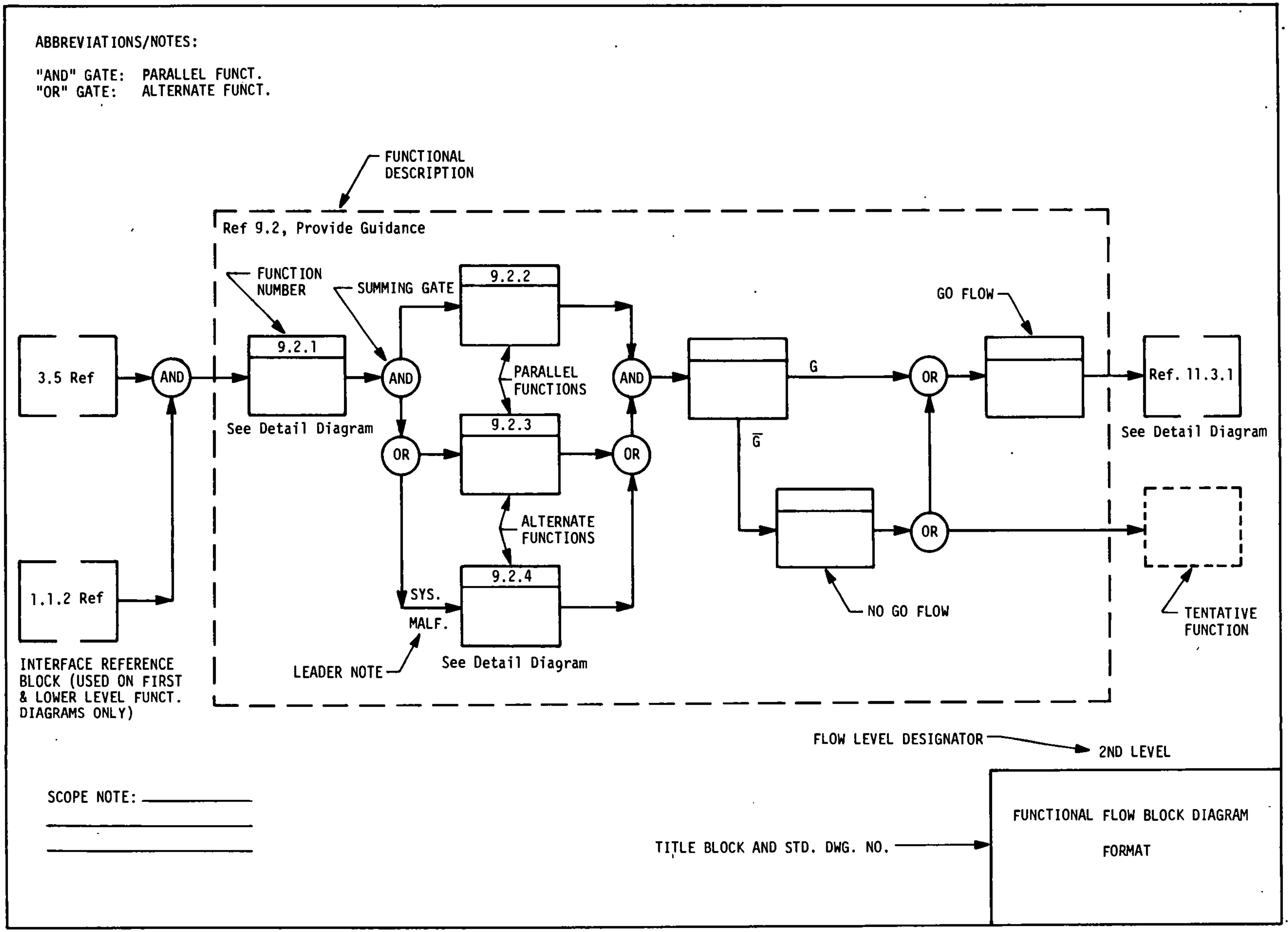


Figure 4–5. Functional flow block diagram general format and symbols.

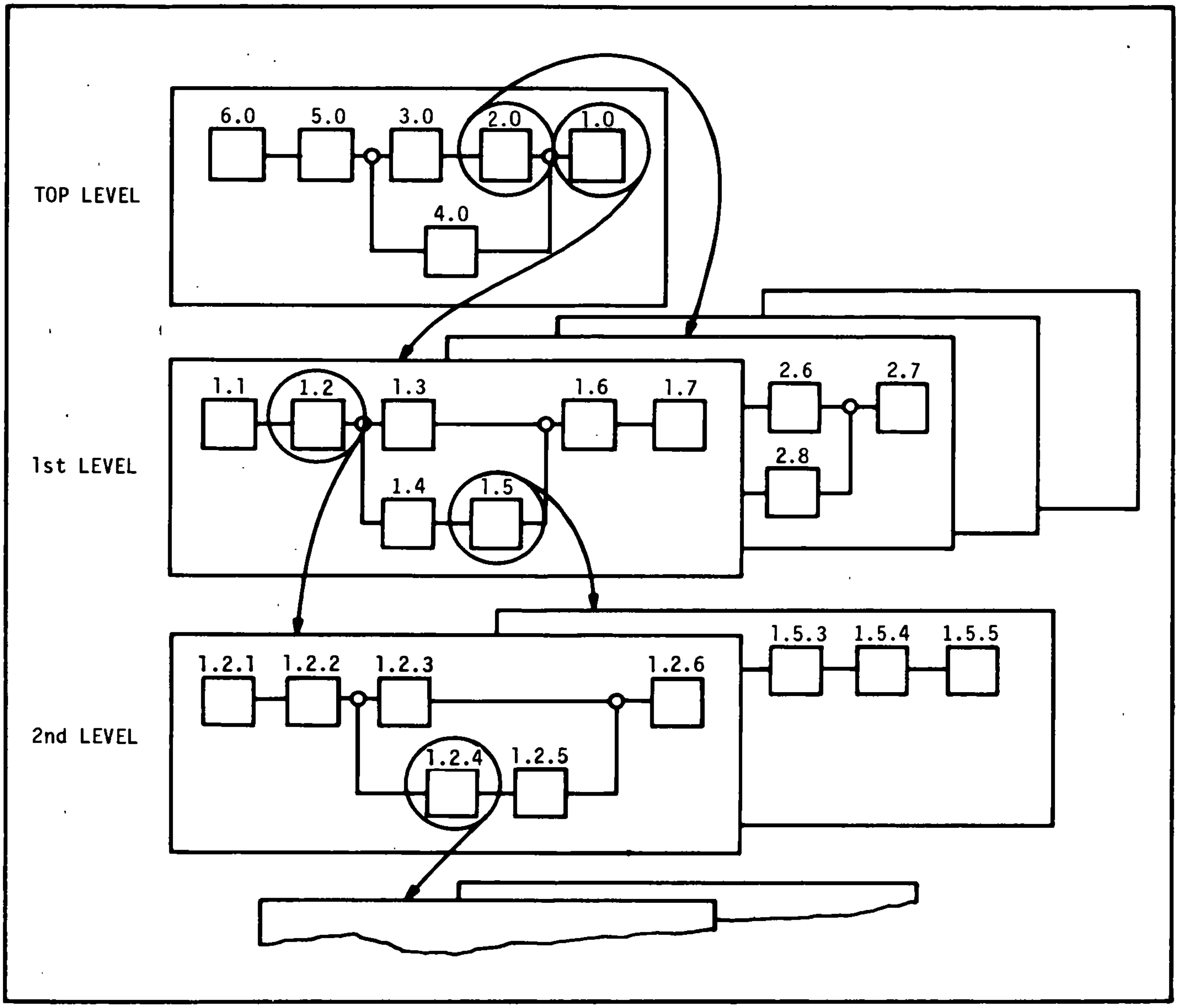


Figure 4-6. Indenture levels and traceability.

include several levels to preserve the continuity of functions and to minimize the number of flows required to functionally depict the system. The general criteria for the number of functions and level of indentures appearing on any particular flow are accuracy, traceability, and clarity of presentation.

(3) *Function block.* Each separate function on a functional flow block diagram is presented in a single box enclosed by a solid line. Blocks used for references to other forms are indicated as partially enclosed boxes labeled "Ref" and bearing its own number. Each function may be as gross or as detailed as required by the level of the diagram on which it appears, but it will stand for a discrete action to be accomplished. Trade-off studies which have a determining effect on the selection of functions and functional paths are referenced on the diagrams. This is accomplished by a flag noting the functional path involved showing the applicable trade study numbers. Corresponding flag notes are continued in the "Notes" section of the diagram.

(4) *Flow connection.* Lines connecting functions indicate only the functional flow, and represent neither a lapse in time nor any intermediate activity. In indicating the flow, vertical and horizontal lines between blocks indicate that all functions so interrelated must be performed in either a parallel or series sequence as indicated.

(5) *Flow direction.* Functional flow block diagrams are drawn so that the functional flow is from

left to right and the reverse flow, as in the case of a functional loop or servo system, from right to left. Primary input lines enter the function block from the left side; the primary output or "GO" line exits from the right; and the "NO GO" line from the bottom of the box. However, where other considerations dictate a different arrangement to highlight a physical area, level of maintenance, or other significant consideration, a different arrangement might be employed.

(6) *Summing gates.* A circle is used to depict a summing gate. As in the case of functional blocks, lines enter and/or exit the summing gate as appropriate. The summing gate is used to indicate the convergence and/or divergence of parallel or alternate functional paths and is annotated with the terms "AND" or "OR" respectively. The term "AND" is used to indicate that parallel functions leading into the gate must be accomplished before proceeding into the next function, or that paths emerging from the "AND" gate must be accomplished after the preceding function. The "OR" gate indicates that alternative paths may lead to or follow a particular function. The term "OR" is used to indicate that any of several alternative paths (alternative functions) converge to or diverge from the "OR" gate. An "AND" gate may have multiple inputs and multiple outputs. All of the input functions must be completed prior to passage through the gate. An "OR"gate may have multiple inputs or multiple outputs, but not both. The summing gate which preceds parallel and alternative functional paths is repeated at the end of those functional paths when this redundancy increases the clarity of the diagram..

(7) *GO/NO-GO paths.* The symbols "G" and "Ḡ" are used to indicate "GO" and "NO-GO" paths. The symbols are entered adjacent to the line(s) leaving a particular function block to indicate alternative functional paths (fig. 4–5).

(8) *Numbering procedures for changes to functional flow block diagrams.* In order to provide a rapid means for changing flows without causing extensive or chain reaction revision of numbering, addition of functions to existing data is accomplished by locating the new function in its correct position without regard to subsequence of numbering. The new function is numbered using the first unused number at the level of indenture appropriate for the new function, as in figure 4–7.

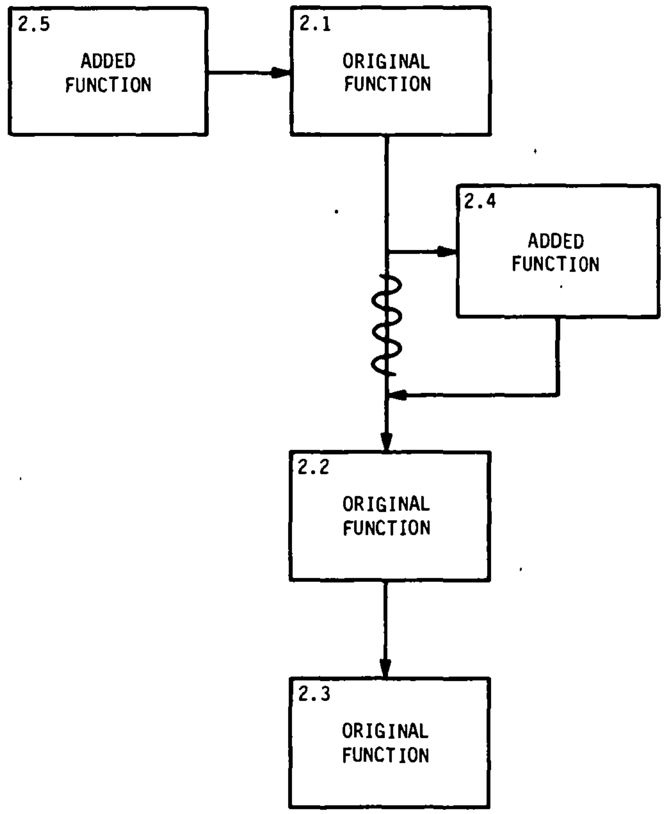


Figure 4–7. Addition of functions.

When previously established functions must be redelegated to a different functional string, the function to be moved is considered retired and the new location of that function is considered as a new addition to the acquiring strings and is treated as shown in figure 4-8.

(9) *Abbreviations, notes, and leader notes.* Abbreviations are used in flow blocks to increase the understandability of functional flow block diagrams and to reduce the space required. Generally, these abbreviations are restricted to those commonly understood in the program. Functional diagrams, while logically aranged, are not logic networks in the mathematical sense, and gates alone are not adequate to avoid ambiguity in all cases. To minimize the problem, leader notes are used for clarification. Leader notes are placed near a line entering or leaving a function when additional clarification is required. Leader notes are used particularly in conjunction with "OR" gates to indicate criteria of selection. Leader note examples: NO-GO, system malfunction, operational launch, gravity mode. In any event, all abbreviations and any notes used on the drawing to simplify or clarify the meaning are listed in this area of the drawing. Definition and descriptions should be complete and accurate.

(10) *Title block.* A title block is placed in the lower right corner of the drawing. The title block contains the title of the functional diagram, the functional diagram number, and the appropriate signatures, approvals, and dates. The formal title for top level diagrams is "Top Level Functional Diagram . . . System." The title for lower level diagrams is the same as the title of the reference block, i.e., the function being detailed. A level designator is placed directly above the title block to indicate flow level.

(11) *Revision block.* A revision block is located in an appropriate area. The revision block contains the revision symbol, the revision date, and the appropriate approval signatures. Each revision is described on

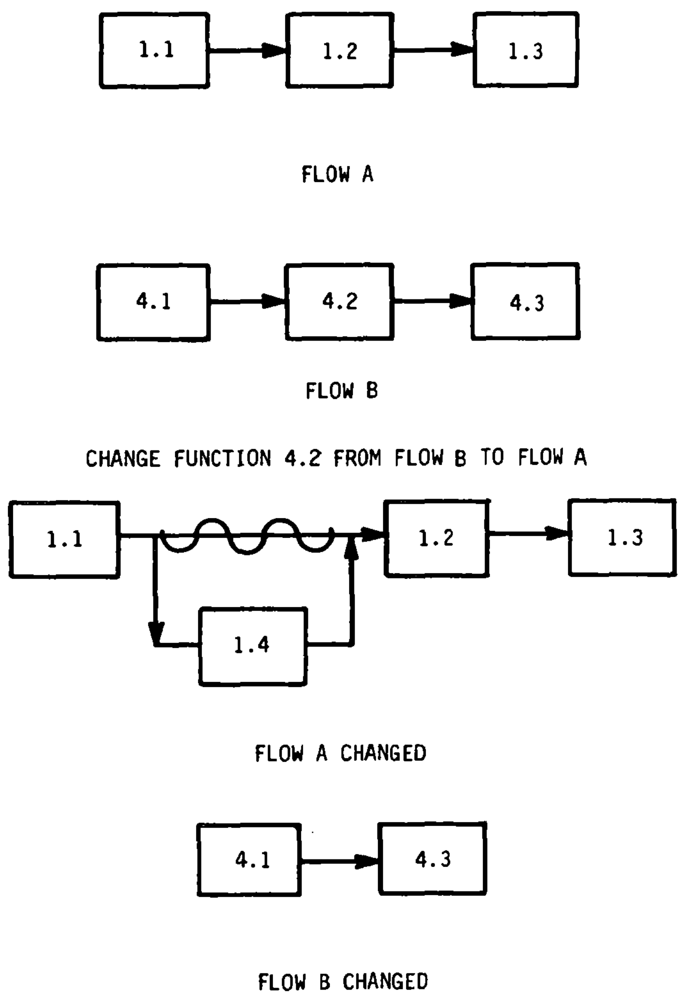


Figure 4-8. Redelegation of functions to different functional string.

the revision page of the document containing the functional diagrams.

(12) *Detail reference.* A function block which has a lower level breakout will have the note "See Detail Diagram" inside or below that block.

b. End Item Maintenance Sheet (EIMS) (fig. 4-9). The end item maintenance sheet is a special purpose form which may be used to identify maintenance function requirements on a specific configuration item, subassembly, and component basis. When both system engineering and LSAR documentation requirements are specified on the project, it will be advantageous to use LSAR input data sheets for recording maintenance engineering analysis data.

(1) *Use of LSAR data sheets.* LSAR sheets are completed manually or by other appropriate means to provide the nomenclature, Government-type model and series designation, as applicable, or the major end items or systems, and/or commercial type, model, and series designation in the space provided.

(2) *Use of end item maintenance sheet.* The EIMS may be used if LSAR documentation is not required on the project. While its use may not be generally applied, the EIMS is included in this manual to demonstrate the traceability and correlation required for compatibility with other system engineering basic documentation. EIM's are prepared in the format presented in figure 4-9 as follows:

(*a*) *Column A*—Enter the contract control number. This number identifies the procuring military service or agency, the fiscal year, last four digits of the contract number, and identification of exhibits and modifications incorporated into the contract by finalized supplemental agreement.

(*b*) *Column B*—Enter the letter "A" for addition, "C" for change, and "D" for deletion, as applicable to column A. A number following the letter shall be entered to indicate the numbered change or addition, e.g., "C2" would be change 2.

(*c*) *Column C*—Enter the relative position of the item within the group assembly hardware breakdown starting with identure "A." This would identify the highest level of a given item of hardware to be produced or furnished as an entity by the Government and would progress in order through B, C, D, etc., in accordance with the mechanical disassembly relationship of the parts being analyzed.

(*d*) *Column D*—Enter the nomenclature, manufacturer's part number, and national stock number (NSN), if available, for the corresponding equipment indenture.

(*e*) *Column E*—Subsequent to the establishment of the product baseline, engineering change requests (ECR's) will require that the first item which incorporates the change be specifically identified and noted opposite the applicable equipment entry. The serial number(s) of the next higher end item are used when there is a possibility of hardware differences within a given part number. Where configuration differences exist within the next higher item or assembly that would affect the maintenance of the item under analysis, the lowest and highest serial number of the next higher item or assembly are shown. In cases where the specific item under analysis applies to all serial numbers of the end item, insert

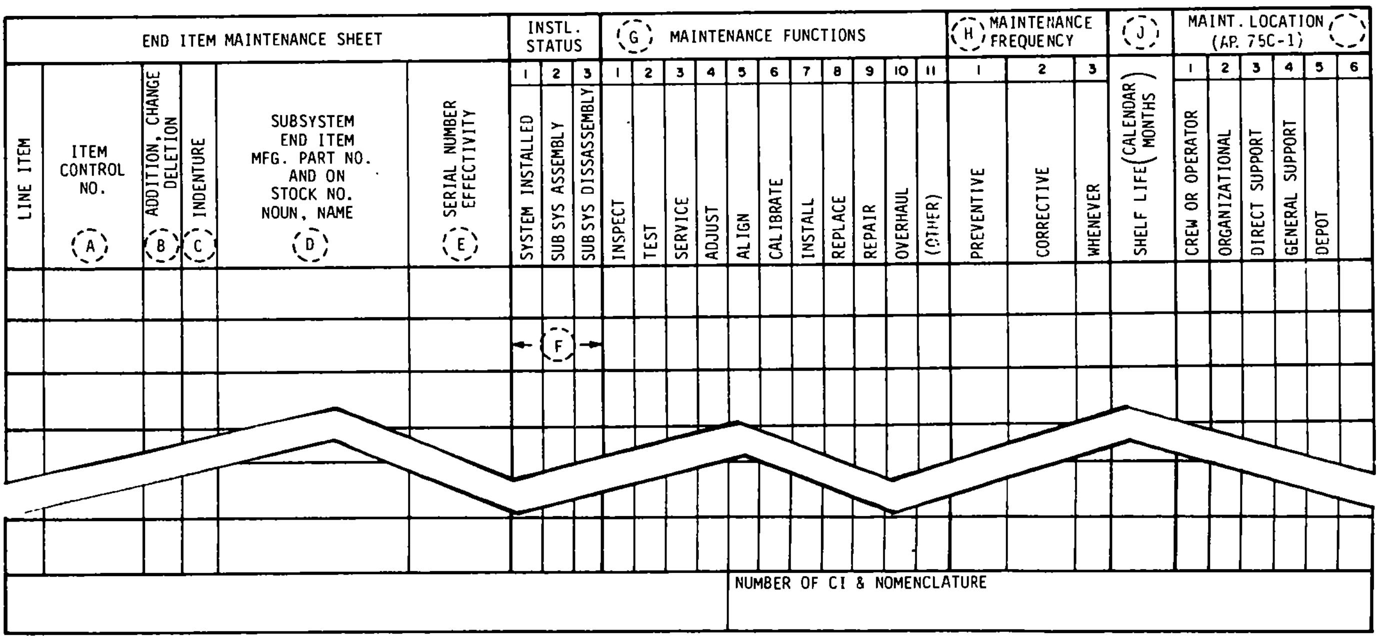


Figure 4-9. End item maintenance sheet.

the lowest serial number and "and subsequent." End items for which there is no higher end item reflect only their own serial numbers.

(*f*) *Column F*—Identify the installation status of equipment at the time the maintenance function in column G is accomplished. No entry is to be made for "whenever" or "as required" maintenance actions.

(*g*) *Subcolumn F1*—Enter an "X" to indicate that the preventive or corrective maintenance function indicated on that line is performed while the equipment is installed in its normal operating configuration.

(*h*) *Subcolumn F2*—Enter an "X" to denote that the maintenance function is performed on a subsystem or module that has been removed from the system, but has not been disassembled.

(*i*) *Subcolumn F3*—Entry of "X" in this column denotes reparable equipment that can be removed and installed only on a disassembled subsystem or major assembly.

(*j*) *Column G*—Enter identification of the maintenance functions required on equipment listed under column D. Subcolumns 1 through 10 identify basic maintenace functions which may apply to the equipment entered in column D. Refer to AR 310–3 for definitions of these maintenance functions. Only one function entry is made per line item. As each entry is made in column G, the preventive and corrective maintenance frequency of that function is entered in the appropriate subcolumn of column H. Each major assembly is analyzed as a complete assembly for maintenance functions and maintenance frequency: (1) In a system installed; (2) For subsystem-assembled configuration; and (3) As an end item, whether it is a primary or secondary item. After analysis as an end item, the major assembly is broken down in a logical order of disassembly on successive lines. The lower indenture items identified thereon are subjected to analysis as performed on higher level equipment.

(*k*) *Column H*—This column is subdivided into three subcolumns within which are recorded the manufacturer's frequency recommendation relevant to the requirements for preventive maintenance. Also recorded is the estimated frequency of corrective maintenance for each applicable function identified in column G. If a specific function occurs at two different frequencies, a separate line is used for each frequency at which the function is accomplished. Entries made in this column are recorded as follows:

(*l*) *Subcolumn H1*—This subcolumn is used to indicate the calendar and/or operating time cycles that may be accumulated on the item under analysis prior to requiring accomplishment of the maintenance function indicated on the same line to keep the item in the ready status. Frequencies of functions identifying operating or calendar time are entered as a number followed by one of these letter codes: D = Days, M = Months, S = Seconds, H = Hours, C = Cycles. Reasons for the frequency selection are narrated on the RAS in the "Design Requirements" column to substantiate both the need for the function and its frequency. If the maintenance function is scheduled but not on the basis of time (operating or calendar), the requirement is entered under the preventive column using the following codes when applicable:

1. PI—This code identifies a maintenance function required PRIOR TO INSTALLATION in the equipment configuration for which it is intended.

2. R—This code identifies a maintenance function required upon RECEIPT from the factory/depot.

3. PM—This code identifies a maintenance function required PRIOR TO MISSION accomplishment.

4. POM—This code identifies a maintenance function required after every POST MISSION or post start period. Post start would include an aborted mission condition.

5. PU—This code identifies a maintenance function required PRIOR TO USE of the item.

(*m*) *Subcolumn H2*—This entry identifies the estimated frequency for corrective maintenance functions. The failure rate is identified in the terms of number of failures per item per month. The code designating the time unit and the quantity is entered in the same manner as subcolumn H1 entries.

(*n*) *Subcolumn H3*—When accomplishment of a particular function requires that additional functions be performed, an "X" is entered in subcolumn H3.

(*o*) *Column J*—This column identifies the period of time, expressed in calendar months, when an item may remain in serviceable stock for issue. Enter calendar months in this subcolumn or "IND" if the item has an indefinite shelf life.

(*p*) *Column K*—This column is used to correlate levels of maintenance to be accomplished with maintenance locations. The column may be divided into subcolumns for identifying the gross maintenance locales of the system. Each horizontal line entry identified by a maintenance function in column G is coded with an indicator in the appropriate subcolumn of K as to the specific level recommended for performance.

(3) *Identifying information*. Appropriate identifying information including the revision letter, date, approval, document number, and page number are entered at the bottom of the sheet.

c. Test Requirement Sheet (TRS) (fig. 4–10). The test requirement sheet serves several purposes in the system engineering process. It identifies all the requirements called out in section 3 of the System Design Sheet which must be demonstrated or verified during the life cycle testing. It serves as a tool for management check whether appropriate provisions have been made for verification of all performance/design requirements. It also provides for the identification of test functions for the test cycle of the system engineering process. The TRS is used to describe test requirements of the overall system. By appropriate repetition, the TRS is indentured to the level desired, e.g., end item, assembly, subassembly, or component.

(1) Preparation.

(*a*) *Block A*—Title of sheet.

(*b*) *Block B*—Name here the system, item, or assembly to which this sheet applies. Use official nomenclature, if possible, or the accepted name assigned during development.

(*c*) *Block C*—When available, enter the manufacturer's part number, detail specification number, or other appropriate identification.

(*d*) *Block D*—This block gives the legend for the codes used in columns 2 and 3 of Block E for verification method and type of test which will be used to demonstrate that the requirement identified in column 1 has been met.

(*e*) *Block E*—Contains four columns which form the matrix for requirement identification, verification method, test type, and verification requirement.

1. Column 1—Enter in column 1 the paragraph number from the system development or product specification (or Design Sheet) which states a requirement subject to verification.

2. Column 2—Enter the verification method(s) per legend in Block D which will be used to confirm that the requirement is being fulfilled.

3. Column 3—Enter the test type(s) per legend in Block D which will be conducted to accomplish verification that the requirement has been fulfilled.

4. Column 4—Enter the paragraph number from the system development or product specification (or Design Sheet) which states the verification requirement.

(2) For each system, end item, assembly, subassembly, or component for which the verification method is designated in column 2, function analysis using Requirements Allocation Sheets, Functional Flow Block Diagrams, Time Line Sheets, synthesis using Schematic Block Diagrams and Concept Description Sheets, evaluation and decision using Trade-Off Study Reports, and description using Design Sheets are required in order to ensure the timely availability of the test elements. Test elements stated in section 4 of the Design Sheet or appropriate specification are the source of performance requirements for test functions. Test equipment, facilities, personnel, computer programs, and procedural data to satisfy these requirements are derived from the test cycle of system engineering.

d. Production Sheet. A production sheet may be developed for each end item of operations and maintenance equipment which imposes unique or critical production problems. The criticality may be caused by new processes required, high production rates, or high production costs. No standard format has been developed for the production sheet. The sheet should be designed by the user to fit the specific production problem. In general, the sheet should correlate production functions to indenture levels of the equipment end item in a manner similar to the end item maintenance sheet. Only production-critical indenture levels, functions, and factors should be included.

e. Requirements Allocation Sheet (RAS) (fig. 4–11).

(1) The requirements allocation sheet is initially used to document the performance requirements for each function or group of functions depicted in the Functional Flow Block Diagram, End Item Maintenance Sheet, Test Requirement Sheet, and Production Sheet. Where feasible, performance requirements are stated in terms of purpose of the function; performance parameters; design constraints; and requirements for reliability, human performance, safety, operability, maintainability, and transportability. Following synthesis, the RAS is used to allocate function performance requirements to individual system elements or combination of elements.

(2) The RAS is prepared in accordance with the description given below. General format is indicated in figure 4–11. The physical format of the RAS is highly flexible. It can be expanded and contracted both vertically and horizontally, as required.

(*a*) *Block A—Functional diagram title and number.* This block contains a reference to the title and number of the drawing containing the functional diagram or identification of the End Item Maintenance Sheets, Trade-Off Study Reports, or Production Sheets from which the function being analyzed originated. When the RAS's are used to document the analysis of functions on the end item maintenance sheets, enter the nomenclature and number of the configuration item (CI).

(*b*) *Column B—Function name and number.* The name and number of each block on the referenced functional flow block diagram or other source is

TEST REQUIREMENT SHEET (A)	NOMENCLATURE (B)	CI NO. DETAIL SPEC. NO. (OR OTHER IDENTIFICATION) (C)

METHOD LEGEND (D)

NA NOT APPLICABLE 1. EXAMINATION 2. REVIEW OF ANALYTICAL DATA 3. DEMONSTRATION 4. TEST

TEST TYPE LEGEND

COORDINATED TEST PROGRAM (AR 70-10)

A. ENGINEERING DESIGN TEST
B. DEVELOPMENT TEST I
C. OPERATIONAL TEST I
D. DEVELOPMENT TEST II
E. OPERATIONAL TEST II
F. DEVELOPMENT TEST III
G. OPERATIONAL TEST III
H. PRODUCT IMPROVEMENT PROPOSAL TEST
I. TECHNICAL FEASIBILITY TEST

PRODUCTION & POST-PRODUCTION TESTING

AR 702-9

J. FIRST ARTICLES TESTING
K. COMPARISON TEST
L. QUALITY CONFORM. ACCEPT. INSP.
M. INTERCHANGEABILITY TEST

AR 702-10

N. RECONDITIONING
O. INT. MAINTENANCE SHOP TEST
P. SURVEILLANCE TEST

USER TEST (AR 71-3)

Q. FORCE DEVELOPMENT TEST AND EXPERIMENTATION
R. OPERATIONAL FEASIBILITY TEST
S. ON-SITE USER TEST

REQUIREMENT REFERENCE PER SECTION 3 OF SPECS (1)	VERIFICATION METHOD (2)					(3) COORDINATED TEST PROGRAM									PROD AND POST PROD							USER TEST			VERIFICATION REQUIREMENTS PER SECTION 4 OF OF SPECIFICATION(S) (4)
	NA	1	2	3	4	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	
(E)											CONTINUATION SHEETS AS REQUIRED														

Figure 4–10. Test requirement sheet.

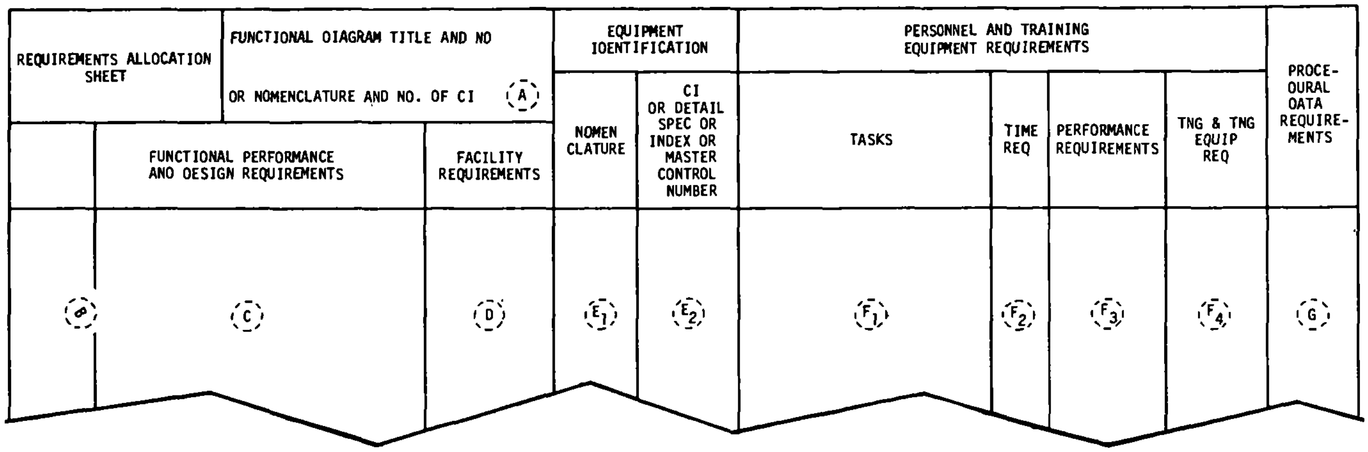


Figure 4-11. Requirements allocation sheet.

entered in sequence. Subfunctions which evolve as a product of the RAS analysis, but which are not identified as discrete functions as the functional flow block diagram or other source, may be identified in the column to minimize unnecessary diagram expansion. Functions are expanded by listing these subfunctions only when additional performance requirements are generated. When the RAS is used to document the analysis of the functions on the end item maintenance sheet, the EIMS line number and maintenance function identification is entered in column B.

(c) *Column C—Functional performance and design requirements.* This column contains the qualitative and quantitative performance requirements which result from analysis of the function identified in column B. These requirements are developed and expanded in detail to provide criteria for synthesizing and evaluating methods of satisfying each functional requirement in terms of combinations of equipment, facilities, and personnel. This column also contains any design requirements and/or constraints that apply to the equipment that may be selected to perform the function. These requirements are developed in equal depth for maintenance, test and production functions reflected on the appropriate sheet, as well as operational and deployment functions identified in functional flow block diagrams. The objectives of the performance and design requirements entries are to establish functional and design requirements for inclusion in the design sheet and, subsequently, into the requirements section of the development specification; initiate recognition of intrasystem and intersystem interface requirements and facility requirements; and initiate recognition of personnel requirements. Performance and design requirement entries include—

1. Description of the function including the "why" and "what" of the function, i.e., answering the questions: Why is the function necessary? Why should the functions be accomplished at this point in the sequence of activities? What engineering characteristics of this function are related to engineering characteristics of another function?

2. Specific design characteristics created by the function, i.e., input, output, performance values, and allowable quantitative tolerances include applicable maintenance constraints, such as checkout limit, calibration limitations and requirements, accessibility requirements, limiting prerequisites, including identification of pressurized and toxic environments, and critical disassembly requirements. Detail should be sufficient for direct use as criteria which initiate and control the system and system equipment design. Include sufficient technical detail to extract portions of one or more RAS's and, in conjunction with schematics, assemble them into the design sheet as integrated design requirements.

3. Requirements which constrain or have significant influence on design, such as power, physical dimension and weight, controlled and natural environment, and human performance capabilities and limitations. Time constraints either created by or constraining the function shall be identified. Illustration of such constraints might be computation times, countdown or availability, or effectivensss studies.

4. Requirements for reliability, safety, maintainability, and transportability.

5. Functional and technical interface requirements evolving from analysis of the function are separately identified to facilitate interface surveillance and collection. The requirements describing the interface are specific and quantified. Where intersystem interface is specified, the configuration of that system is specified together with the technical characteristics of the interface. When any of the above entries are products of trade-off study reports, other backup studies, specifications, or other sources, a specific reference to the applicable source is made.

(*d*) *Column D—Facility requirements*. This column contains the facility requirements imposed by the performance and design requirements in column C. The entries identify—

1. Controlled and natural environmental requirements, e.g., temperature and humditiy ranges, illumination and noise levels, wind and snow loading, precipitation, penetration and abrasion effect, and atmospheric pressure. This entry identifies facilities which must be developed or scheduled on a long lead basis to provide or test the system capability to withstand specific environments.

2. Utility requirements, e.g., power (electrical, hydraulic, etc.), air conditioning, ventilation, and heating to be satisfied by the facility.

(*j*) *Column F2—Time required*. Enter the elapsed time required to accomplish the task in seconds, minutes, hours, or days to the first decimal; use S = sec., M = min., H = hour, D = day; e.g., 3.5 S means 3.5 seconds.

(*k*) *Column F3—Performance requirements*. For those task requirements outlined in F1, the following entries, as appropriate, are used:

1. Crew coordination, i.e., if the task requires more than one person, define the coordination requirement including the communications necessary and number of personnel involved.

2. Job knowledge, i.e., state whether or not theory of operation is required or just an understanding of the procedures necessary to accomplish the task.

3. Making decisions, i.e., if the task requires judgment of decision, summarize action and the criteria which control that action.

4. Safety procedures, i.e., if the task requires more than normal caution to prevent injury to personnel or equipment malfunction, summarize the procedural criteria which will minimize risk.

5. Performance under stress, i.e., if the personnel actions are to be performed under time or technical stress, summarize the significant conditions under which stress occurs.

6. Skill demands for critical tasks, i.e., define perceptual, judgmental, and motor demands.

7. Define sustenance and other life support requirements imposed by the functions and design requirements.

(*l*) *Column F4—Training and training equipment requirements*. Enter training and training equipment requirements to indicate the extent of training required and whether training equipment or aids are required, as well as the recommended type for the functions and tasks identified in columns B and F1. The following codes are used to indicate the extent of training required:

1. X—requires no training.

2. A—requires a general familiarization through discussion and/or demonstration.

3. B—requires a briefing on the knowledge or job task to meet the job requirements; does not need to apply the information received.

4. C—requires a briefing on the knowledge or job task to meet the job requirements; needs to apply the information received in a nonjob-like situation, such as written test or verbal problem-solving situations.

5. D—requires a briefing on the knowledge or job task; needs to perform or apply representative portions of the job task or knowledge in a job-like situation, either on actual equipment or trainers.

6. E—requires a briefing on the knowledge or job task; needs to perform the complete job task or apply the knowledge in a job-like situation on actual equipment or trainers.

7. F—same as E, but performed a sufficient number of times to ensure proficiency in all phases of performance.

The training equipment or aids recommended may be mission simulators, part-task trainers, training attachments, animated panels, cutaways, exploded or site display, training films, and charts and transparencies. For training equipment end items, the CI number or applicable specification number is entered in this column, as appropriate.

(*m*) *Column G—Procedural data requirements*. Functions which produce complicated or hazardous requirements involving personnel will generally dictate the need for procedural information. Column G provides the means for ensuring that the developer has considered available data, and where not available, has programed development of the procedural data. Entry in this column is in all cases specific. For engineering development programs, enter the nomenclature, number, and type of procedural data available or to be established (test directives, test procedures, specific equipment procedures). Where the requirements are applicable to operational military programs, include the technical manual number in existence or to be established; include the technical manual preparation specification against each type of data to be prepared. Commercially available publications may be applicable to higher development engineering efforts or operational military supplier. In any category previously described, changes required to make existing procedural data suitable for the technical requirement involved are noted by a parenthetical (c) following document number, i.e., Speery Gyro 25656 G (c) or T.M. (c).

3. Civil/structural/architectural requirements. Requirements for structures are stated in terms of functional requirements, induced environment, and minimum dimensions. Requirements for space, access, and monitoring in new or existing structures are described in terms of minimum dimensions necessary to accommodate the equipment.

4. Facility equipment, if identified earlier in the system engineering process.

(*e*) *Column E—Equipment identification.*

(*f*) *Column E1—Nomenclature.* Enter the short form nomenclature of the end item(s) of equipment, which has been selected to satisfy the functional performance requirement. Once nomenclature is used against a given function or within a given function, the item may be identified thereafter by number.

(*g*) *Column E2—CI identification.* Enter the CI identification number. This may be the manufacturer's part number, specification number, or NSN.

(*h*) *Column F—Personnel and training equipment requirements.* For functions that are to be completely automated and will not involve personnel, this column may be eliminated. For these functions, a separate sheet may be used with columns B, C, D, and E, only.

(*i*) *Column F1—Tasks.* Enter the human performance task requirements which are involved in performance of the functions identified in column B. These task requirements are specified to the level of technical depth that will facilitate identification of personnel requirements and procedure development. Detail task identification and analysis (when required) is a separate but correlated effort. Procedural instructions are not included. A task is defined as a concise statement of a unit of work that has an identifiable starting and ending point, is measurable, and cannot be reduced to two or more significant parts. If a breakdown of a statement would result in stating obvious activities such as "Bolt in Place" or "Open Access Door," the breakdown is not to be considered significant. If a unit of work to be performed by equipment, facilities, personnel, or some combination thereof, can be broken into two or more significant parts, it is a function; for example, "Install Communication Equipment" can be broken into at least two significant parts: "Install Transmitting Equipment" and "Install Receiving Equipment." Task requirements are identified by alphanumeric extensions of the function number in column B; for example, function 3.1.2 would have corresponding tasks numbered 3.1.2a, 3.1.2b, . . . 3.1.2n with task breakdown numbered 3.1.2.a.1, 3.1.2.b.2, and so on.

(3) Appropriate identifying information including the revision letter, date approval, document number, and page number, are entered on the bottom of the sheet.

f. Time Line Sheets (TLS) (fig. 4-12).

(1) Time line sheets are used to support the development of design requirements for the operation, test, and maintenance functions. They depict concurrency, overlap, and sequential relationship of functions and related tasks and identify the time-critical functions. Time-critical functions are those that affect reaction time, downtime, or availability.

(2) Time line sheets may be prepared in the format shown in figure 4-12 in accordance with the following requirements:

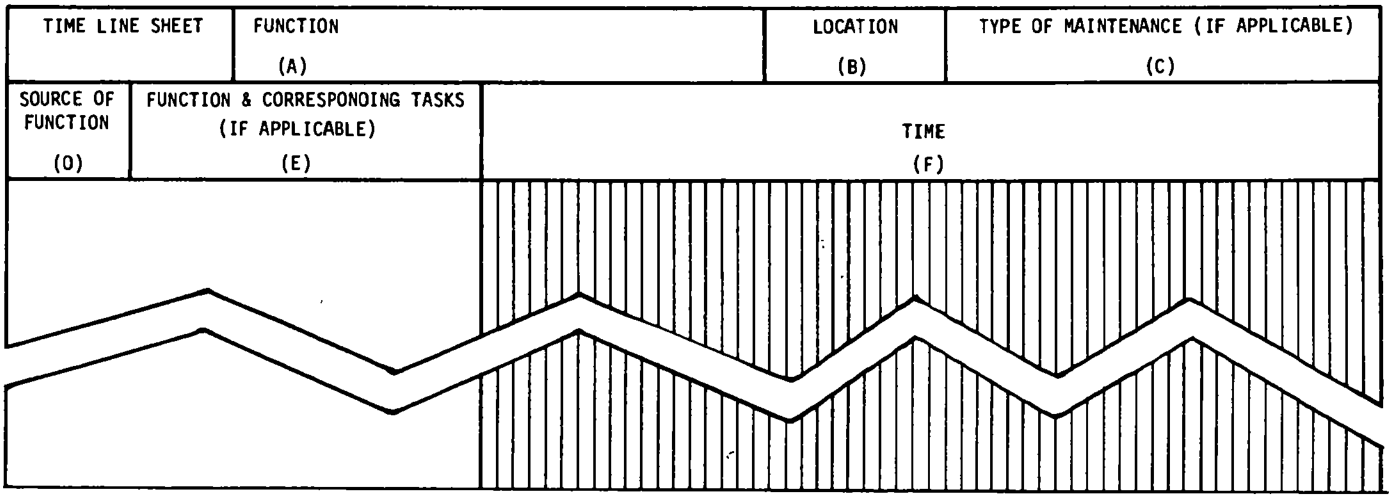


Figure 4-12. Time line sheet.

(*a*) *Block A*—Enter the title of the time-critical functions appearing on the functional flow diagram.

(*b*) *Block B*—Enter the location where the functions and corresponding tasks are to be performed.

(*c*) *Block C*—This entry is applicable only for functions involving maintenance. When applicable, indicate preventive or corrective maintenance.

(*d*) *Column D*—Enter the functional diagram drawing number, function block number, and document number of the Requirements Allocation Sheet. Enter identifying information (control number nomenclature) from End Item Maintenance Summary and End Item Code, whenever the function has been derived from the End Item Maintenance Summary or LSAR.

(*e*) *Column E*—Enter the functions and corresponding personnel tasks contained on Requirements Allocation Sheets. Corresponding tasks will not be applicable for all time-critical functions. For time-critical functions involving human engineering, identify Military Occupational Specialty.

(*f*) *Column F*—Enter the elapsed time estimated to accomplish functions and corresponding task, if applicable, in seconds, minutes, hours, or days to the first decimal, in bar chart manner. the total time in days, hours, minutes, and/or seconds is entered at the end of each time bar; use S = seconds, M = minutes, H = hour, D = day, e.g., 3.5 S means 3.5 seconds.

(3) Identifying information. Appropriate identifying information, including dates, approval, and document numbers are entered at the bottom of the page.

g. Concept description sheet (fig. 4-13). The purpose of this document is to signal the designer that he should stop at a point in the system engineering process and create a gross level concept. The concept description sheet may take many forms and may include any indenture. The sheet describes the concept in concise terms that are either within or approach the framework of constraints and requirements described by the earlier FFBD and RAS.

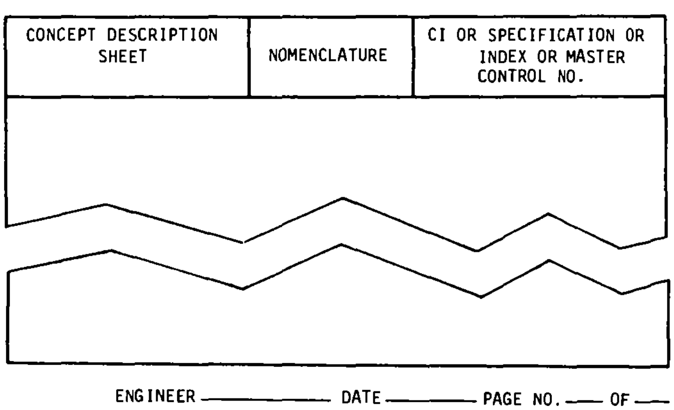


Figure 4-13. Concept description sheet.

h. Schematic Block Diagrams (fig. 4-14).

(1) Schematic block diagrams are used to assemble function performance requirements and criteria, as established and documented in the requirement allocation sheets, into an integrated set of design requirements comprising a system (including interfaces with other systems), an end item, or a group of related end items (subsystem).

(2) Schematics are prepared to identify intersystem relationships, e.g., a command/control system interface with a strategic weapon system; or intrasystem relationships including that between constituent elements of a subsystem, e.g., in communication subsystem interfaces between closed circuit TV, work station intercom, remote site communication and subordinate detailed schematics, as required. The essential characteristics of a schemaic are to delineate by symbols (schematic, architectural,electronic, mathematical, structural, mechanical, or others) the features and relationships of end items, subsystems, components, and parts. Schemaics are structured in a manner that show the functional interfaces and apportionment of requirements between major systems, within the system, among the elements of the system (equipment, personnel, facilities), and between end items; end to end and/or closed-loop relationships; and the maintenance or checkout aspects of the proposed design. The amount of detail shown in the schematic block diagram varies depending upon the point in time that the schematic is prepared, the level of information available in the requirements allocation sheets and trade studies, and the level at which hardware requirements are being described (system, major subsystem, major end item, black box, or other). Sufficient detail is shown to illustrate how the design requirements are to be met.

(3) As system definition progresses, the schematic block diagrams are updated to incorporate new requirements such as maintainability features, self-test capability, read-out indications, monitoring capability, critical pressures, voltages, and other quantitative expressions of system performance. Schematic block diagrams generate a family of lower level diagrams traceable from the top down or from the bottom up, collect and apportion effective RAS requirements or trade-off study requirements against applicable system or subsystem equipment, and identify major intersystem and intrasystem requirements and interrelationships.

(4) The basic technique for developing schematic block diagrams is illustrated in figure 4-14. The first

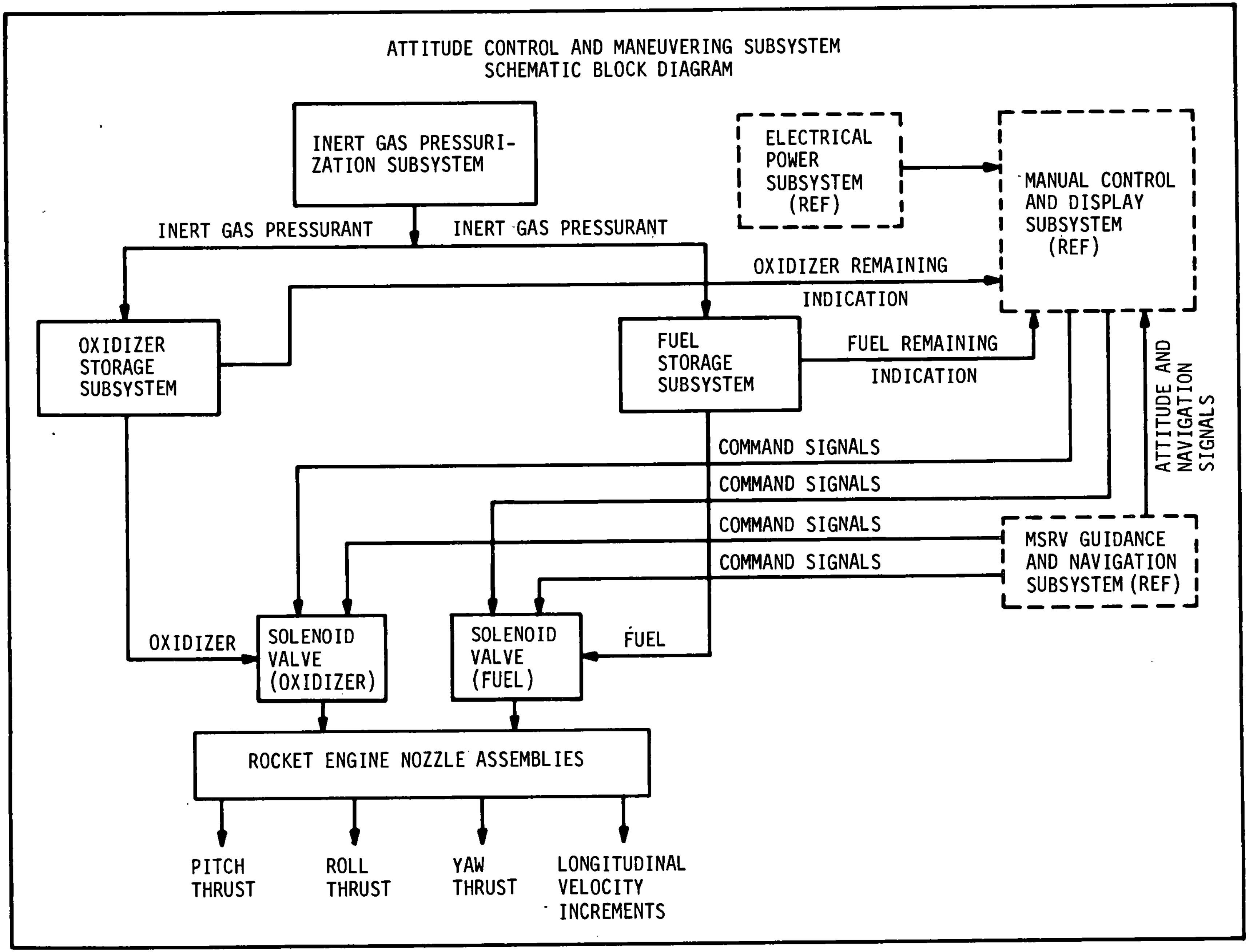


Figure 4–14. Schematic block diagrams.

level schematic diagrams are completed for the system or subsystem being developed. The schematic depicts either a "closed-loop" or end-to-end block description of intrasystem interfaces. Second level detail diagrams are technical expansions of first level diagrams. Input and output expansions are related to the interfaces expressed in the first level diagrams. Third level detail diagrams are organized functionally to define significant end-to-end system logic across all hardware and facility interfaces involved, i.e., power subsystem, launch control, flight sequence, malfunction detection and control, and others. Hardware designators established in first and second level detail schematics are used with logic elements to depict interfaces with facilities and equipment, and to maintain a traceable relationship to the other schematic diagrams. For time-critical functions, time governs the layout of the drawing, i.e., reading from left to right, being with the initial functions and proceed so that the operations sequence of all applicable hardware is shown.

i. Trade-off study report (fig. 4-15).

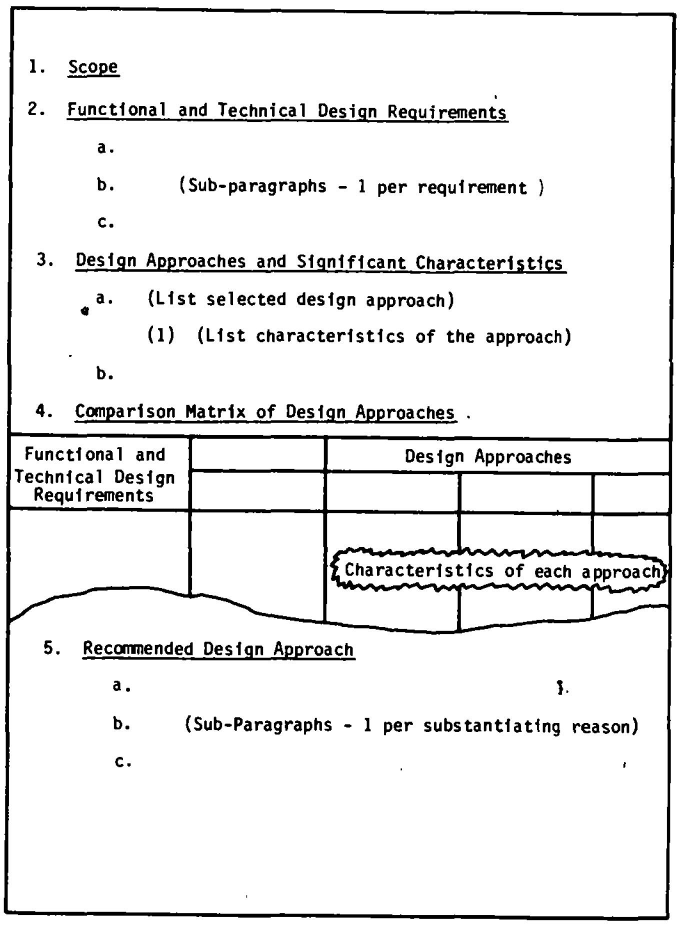


Figure 4-15. Trade-off study report format.

(1) Trade-off study reports provide a systematic assessment of requirements and their alternative solutions. They also help document engineering decisions, providing visibility into the system engineering effort and the reasons for selection of one alternative over another. Selection of the optimum alternative will usually require risk analysis to measure the potential for cost, schedule, and performance deficiencies.

(2) Trade-off study reports are prepared as follows:

(*a*) *Paragraph 1*—State the scope of the report.

(*b*) *Paragraph 2*—Identify and list the functional and technical design requirements which are germane to the trade-off. In each subparagraph, state the functional requirement first and then identify related technical design requirements. Immediately following each requirement (and in the same paragraph), a reference is made which identifies the source of the requirement. This reference consists of the title, file number, date, page number, and paragraph number from which the requirement statement was extracted.

(*c*) *Paragraph 3*—List the possible design approaches and identify the significant characteristics and associated risks of each design approach. Only reasonably attainable design approaches are listed, considering technical capabilities, time schedules, resource limitations, and requirement constraints. Characteristics considered must relate to the attributes of the design approaches bearing most directly on stated requirements. These characteristics should reflect predicted impact on such factors as cost, effectiveness, supportability, personnel selection, training requirements, technical data, schedules, performance, survivability, vulnerability, growth potential, facilities, transportability, and producibility.

(*d*) *Paragraph 4*—Present a comparison matrix of design approaches. The purpose of the matrix is to compare the characteristics for each design approach to determine the degree to which the design approaches satisfy the functional and technical design requirements. The objective is to facilitate rapid comparison and evaluation of potential design approaches and to allow preliminary screening out of those design approaches that are inconsistent with the functional and technical design requirements. Where applicable, include cost-effectiveness models and cost analysis data as enclosures.

(*e*) *Paragraph 5*—Recommend the most promising design approach and provide narrative to substantiate the recommendation. Include schematic drawings, outline drawings, interface details, functional diagrams, reliability data, maintainability data, safety data, statistical inference data, and any other documentation or data deemed necessary to support the recommendation. The narrative must cover the requirements which the recommended approach imposes on other areas of the system.

(3) *Trade-off study report index (fig. 4–16).* The materiel developer prepares and maintains a trade-off study report index. This index identifies by contract or in-house activity identification number all trade-off studies required and those which have been completed.

TRADE-OFF STUDY REPORT INDEX (System Nomenclature)			
REQUIREMENTS		COMPLETED	
CONTRACT OR W/D NR.	TITLE	DATE	FILE LOCATION

Figure 4–16. Trade-off sutdy report index.

j. Design Sheet (fig. 4–17). A design sheet is prepared for each CI, facility CI, and modified inventory equipment item or engineering critical component, but is not required for unmodified inventory equipment items or standard parts. The developer may find it necessary to utilize additional internal documentation to supplement the design sheet in order to establish and maintain control of his design effort. Care must be exercised to ensure that high risk technical areas are identified and that the design is such that the risk has been reduced to an acceptable level. Such supplementary documentation will not be included in the detail specifications.

(1) *Block A*—Enter the short-form nomenclature of the contract item, and abbreviated category of equipment (MIL-STD-881).

(2) *Block B*—Enter the CI or critical component code identification, specification number, or number assigned to the item (MIL-STD-481 and MIL-STD-490).

(3) *Block C*—The design sheet will reflect technical information required by sections 3 and 4 of development specifications, and as specified in configuration management documents.

k. Facility Interface Sheet (fig. 4–18). Facility interface sheets (FIS) are used for recording facility design requirements imposed by operation, logistics support, test, production, and deployment equipment. Entries on these forms will depend upon the extent of definition accomplished for the equipment. The FIS's are used by facility engineers to prepare facility diagrams and drawings. Facility interface sheets are prepared as follows:

(1) *Block A—Nomenclature and CI number.* Enter that nomenclature and identification of the equipment MIL-STD-881) for which the facility requirements are being identified. Identification should include development description numbers, specification numbers, and system identification.

(2) *Block B—Originator.* Enter the identification of the contractor or other agency originating the sheet and the equipment identified in Block A.

(3) *Block C—Site effectivity.* Enter the site, location, or general area of use of the equipment identified in Block A. If the equipment location is fixed within a particular facility area, this area should be identified, along with the major location. If the equipment is portable, state this and identify general area of use, e.g., "portable equipment, missile ready, and maintenance areas." Amplify the location information as necessary in the specific requirements..

(4) *Block D—Reference function.* Enter the function numbers for which the equipment identified in Block A is used, and the appropriate RAS reference numbers where the functions are documented.

(5) *Block E—Environmental requirements.* Using the checklist at the top of the column, enter the requirements data for each checklist heading using the numeric designation from the checklist. These entries are derived from the appropriate sections of the design sheet, e.g., environmental, human performance, safety, and others. Entries are as brief as possible, stressing quantitative values, but complete enough to fully portray the environmental requirements and effects of the equipment as outlined in the description of each heading. When the checklist heading is not applicable to the equipment identified in Block A, indicate this with an "N/A" entry for the corresponding checklist heading number.

(6) *Block F—Interface design requirements.* In a manner similar to Block E, this block and checklist are used to state the design requirements data for the physical interfaces between the equipment identified in Block A and the appropriate facilities. Data for these entries are derived from the design sheet. Information entered in Block F does not replace or substitute for interface control drawings. Depending on the point in the system engineering process, this sheet may be the input to development of the definitive interface control drawings, at which time the drawings become a supplement to the facility

DESIGN SHEET	NOMENCLATURE (BLOCK A)	CI NO. OR CRITICAL COMPONENT CODE IDENTIFICATION ____________ DETAIL SPEC NO. ________ (BLOCK B)
REQUIREMENTS FOR DESIGN AND TEST (BLOCK C)		

REVISION ____________ APPROVAL ____________ DATE ________ PAGE NO.___ OF ___

Figure 4–17. Design sheet.

FACILITY INTERFACE SHEET	NOMENCLATURE AND CI NUMBER (A)	
ORIGINATOR (B)	SITE EFFECTIVITY (C)	REFERENCE FUNCTION (D)

ENVIROMENTAL REQUIREMENTS	INTERFACE DESIGN REQUIREMENTS
SYMBOL/CATEGORY	SYMBOL/CATEGORY
(1) VIBRATION/SHOCK ACOUSTIC LEVEL (2) TEMPERATURE AND HUMIDITY (3) FORCED VENTILATION/AIR CHANGES (4) ILLUMINATION (5) PERSONNEL OCCUPANCY (6) ELECTROMAGNETIC INTERFERENCE/COMPATABILITY (7) CONTAMINATION LEVEL (8) HAZARDS - SAFETY (9) HEAT REJECTION RATE (10) CRITICAL TIME FACTORS (11) OTHER - SPECIAL ENVIRONMENTAL REQ'MTS	(1) ENVELOPE AND WEIGHT (2) MOUNTING PROVISIONS (3) ELECTRIC POWER (4) ELECTRICAL GROUNDING (5) WATER AND GAS SERVICE (6) ACCESS (7) POSITION/LOCATION (8) HANDLING PROVISIONS (9) FIRE/HAZARD PROVISIONS (10) OTHER - SPECIAL INTERFACE CONSIDERATIONS
(E)	(F)

Figure 4–18. Facility interface sheet.

interface sheet to illustrate and detail the physical interface. Where such a drawing has been issued, the appropriate heading entry will refer to this drawing and the drawing appended to the facility interface sheet. Facility interface sheet entries are subject to interaction of the system engineering process. Entries are always made as completely as possible. Where certain information is recognized as a requirement but is not available, the entry indicates the missing but recognized requirement with a blank, e.g., "Required electric power will be 220 ± 18v., 60 ± 10 cps, 3 Phase, __KW, __LL __PF." Subsequent updating of the format continues by the originator until all requirements are stated and blanks filled in. Where a reasonable estimate can be established, it is entered, followed by the designation "(Estimated)" or "(est)." When verified, the "(est)" designation is removed by revision to the facility interface sheet.

l. Identifying Information. Appropriate identifying information, including the revision letter, date, approval, document number, and page number, is entered at the bottom of the sheet. Pages are numbered consecutively for each end item.

APPENDIX A
REFERENCES

A—1. Department of Defense Directives, Instructions, and Guides

DMSSO-GB-1	DOD Specification Development Guide
DODD 4100.35	Development of Integrated Logistics Support for Systems and Equipment
DODD 4120.18	Use of the Metric System of Measurement
DODI 4200.15	Manufacturing Technology Program
DODD 5000.1	Major Systems Acquistion
DODD 5000.2	Major System Acquisition Process
DODD 5000.3	Test and Evaluation
DODD 5010.19	Configuration Management
DODD 5010.20	WBS for Defense Materiel Items
DODD 5000.29	Management of Computer Resources in Major Defense Systems

A–2. Military Standards and Specifications

	Defense Systems
MIL-STD-100A	Engineering Drawing Practices
MIL-STD-100B	Gage Inspection
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipments)
MIL-STD-471	Maintainability Demonstration
MIL-STD-480	Configuration Control—Engineering Changes, Deviations, and Waivers
MIL-STD-481	Configuration Control—Engineering Changes, Deviations, and Waivers (Short Form)
MIL-STD-481A	Configuration Status Accounting—Data Elements and Related Features
MIL-STD-483	Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs
MIL-STD-490	Specification Practices
MIL-STD-499A	System Engineering Management
MIL-STD-721B	Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety
MIL-STD-756A	Reliability Prediction
MIL-STD-781	Reliability Tests, Exponential Distribution
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-881A	Work Breakdown Structures for Defense Materiel Items
MIL-STD-961	Outline of Forms and Instructions for the Preparation of Specifications and Associated Documents
MIL-D-1000A	Drawings, Engineerings, and Associated Data
MIL-STD-1388	Logistics Support Analysis
MIL-STD-1472	Human Engineering Design for Military Systems, Equipment, and Facilities

MIL-STD-1521	Technical Reviews and Audits for Systems, Equipment, and Computer Programs
MIL-Q-9858A	Quality Program Requirements
MIL-D-26239A	Data, Qualitative and Quantitative Personnel Requirements Information (QQPRI)
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities
MIL-S-83490	Specifications, Types, and Forms

A–3. Army Regulations and DA Pamphlets

AR 5–5	The Army Study System
AR 11–13	Army Electromagnetic Capability Program
AR 11–18	The Cost Analysis Program
DA Pam 11–25	Life Cycle System Management Model for Army Systems
AR 11–27	Army Energy Program
AR 11–28	Economic Analysis and Program Evaluation for Resource Management
AR 15–14	Systems Acquisition Review Council Procedures
AR 18–1	Management Information Systems—Policies, Objectives, Procedures, and Responsibilities
AR 34–1	US Participation in NATO Military Standardization, Research, Development, and Logistic Support of Military Equipment
AR 37–40	Army Production Base Support Program Report (RCS-CSGLD-1123)
AR 37–55	Uniform Depot Maintenance Cost Accounting and Production Reporting System
AR 70–1	Army Research, Development, and Acquisition
AR 70–2	Materiel Status Reporting
AR 70–9	Army Research and Development Information System Program Planning and Ongoing Work Reporting
AR 70–10	Test and Evaluation During Development and Acquisition of Materiel
AR 70–15	Product Improvement of Materiel
AR 70–17	System/Project Management
DA Pam 70–21	The Coordinated Test Program (CTP)
AR 70–27	Acquisition Plan/Development Concept Paper/Program Memorandum
AR 70–32	Work Breakdown Structure for Defense Materiel Items
AR 70–35	Advanced Planning for Research and Development
AR 70–37	Configuration Management
AR 70–44	DOD Engineering for Transportability
AR 70–47	Engineering for Transportability
AR 71–3	User Testing
AR 71–5	Introduction of New or Modified Systems/Equipment
AR 71–6	Type Classification/Reclassification of Army Materiel
AR 71–7	Military Training Aids and Training Aids Center
AR 71–9	Materiel Objectives and Requirements
AR 200–1	Environment Protection and Enhancement

AR 310–3	Preparation, Coordination, and Approval of Department of the Army Publications
AR 385–16	System Safety
AR 602–1	Human Factors Engineering Program
AR 611–1	MOS Development and Implementation
AR 700–15	Packaging, Packing, and Marking of Items of Supply
AR 700–18	Provisioning of US Army Equipment
AR 700–47	Defense Standardization Program
AR 700–51	Army Data Management Program
AR 700–82	Use and Application of Uniform Source, Maintenance, and Recoverability Codes
AR 700–90	Army Industrial Preparedness Program
AR 700–127	Integrated Logistics Support
DA Pam 700–XX	Integrated Logistics Support Management Model (ILSMM)
AR 702–3	Army Materiel Reliability, Availability, and Maintainability (RAM)
AR 702–9	Production Testing of Army Materiel
AR 702–10	Post-Production Testing of Army Materiel
AR 715–5	DOD Priorities and Allocations Manual (DODI 4410.1)
AR 715–6	Proposal Evaluation and Source Selection
AR 750–1	Army Materiel Maintenance Concepts and Policies
AR 1000–1	Basic Policies for Systems Acquisition by the Department of the Army

A–4. Technical Manuals

TM 38–710	Integrated Logistics Support Implementation Guide for DOD Systems and Equipment
TM 38–715	Provisioning Requirements for US Army Equipment (PR-1)
TM 38–715–1	Provisioning Techniques

SYSTEM ENGINEERING ACTIVITIES
ALTERNATIVE SYSTEMS CONCEPT PHASE

BLOCK 1.0—ANALYZE BASIC INPUT REQUIREMENTS

RESPONSIBILITY: Special Task Force/Special Study Group (STF/SSG)

DESCRIPTION: Prior to initiating in-house or contractual materiel system planning studies, it is necessary to analyze the nature and objectives of the required mission as stated in or developed from the Mission Element Need Statement (MENS), objectives and justification must establish known requirements and constraints before initial function analysis and synthesis can be undertaken.

REFERENCES: AR 1–1, AR 70–1, AR 71–9, AR 1000–1

BLOCK 2.0—DEVELOPMENT OF ALTERNATIVE TECHNICAL APPROACHES

RESPONSIBILITY: Contractor

DESCRIPTION: The activities in this block represent the initial system engineering effort in support of the materiel concept investigation. The effort begins with receipt of an approved MENS, and leads to alternative approaches that will be presented as technically promising concepts.

BLOCK 2.1—INITIAL FUNCTION ANALYSIS TO FORMULATE ALTERNATIVE TECHNICAL APPROACHES

RESPONSIBILITY: Contractor

DESCRIPTION: The initial system engineering process begins with a detailed analysis of the mission objectives and constraints to achieve complete exposure and detailed amplification of the functions required to achieve the desired capability. This may require the development of a series of models to depict functions of achievable alternative technical approaches for accomplishing the mission. Each of these competing functional approaches is then analyzed in detail to determine the relative probability that performance requirements will be attained. These alternative technical approaches are studied to translate objectives into performance requirements, constraints, and identification of major barrier areas as criteria for conceptual design of the system, subsystems, and segments. The function performance requirements are documented in terms of inputs and outputs, environments, performance, time constraints, and other considerations in sufficient detail to enable synthesis to be accomplished.

FORMS: Functional Flow Block Diagram, Time/Line Sheets, Requirements Allocation Sheets

REFERENCES: AR 70–1, AR 71–9

BLOCK 2.2—SYNTHESIS OF ALTERNATIVE TECHNICAL APPROACHES

RESPONSIBILITY: Contractor

DESCRIPTION: Synthesis is undertaken to evolve alternative conceptual approaches that appear to be technically capalbe of accomplishing the functions necessary to achieve the mission objectives. The outputs of this synthesis are gross descriptions of alternative technical approaches in terms of their system elements. The descriptions are organized so as to compare alternative technical approaches.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 70–1, AR 71–9

BLOCK 2.3—PRELIMINARY EVALUATION OF ALTERNATIVE TECHNICAL APPROACHES

RESPONSIBILITY: STF/SSG

DESCRIPTION: Alternative technical approaches are evaluated to compare functional approaches against the mission requirements, and the relative achievability and potential effectiveness of the alternatives. Evaluations performed are limited by factors such as the depth of available background materiel and limitation in time, money, and study resources.

REFERENCES: AR 70–1, AR 71–9

BLOCK 2.4—TECHNICAL INPUTS TO LOA

RESPONSIBILITY: STF/SSG

DESCRIPTION: Those alternative technical approaches which survive this initial system engineering process are included in the LOA. The technically promising alternative approaches are graphically portrayed using a task analysis diagram supported by brief specific narratives describing work to be done sequentially, work to be done in parallel approaches, major technical barriers, cost estimates, estimated time required to meet objectives (included to complete the documentation and not as a constraint), priorities of approaches, critical performance parameters, probabilities of technical success for each approach, recommended equipment currently available, a range estimate of cost assessment by major cost categories (R&D, investment nonrecurring, investment recurring), and a recommended category (6.2, 6.3, 6.4) of the R&D program to initiate the project.

REFERENCES: AR 70–1, AR 71–5, AR 71–9, AR 700–127, AR 702–3

BLOCK 3.0—FORWARD LOA

RESPONSIBILITY: STF/SSG

DESCRIPTION: The LOA, jointly signed by the combat and material developers, is forwarded to HQ DA (DCSOPS) for review and approval (major systems), or for information (nonmajor systems).

REFERENCES: AR 70–1, AR 71–9

BLOCK 4.0—SYSTEM ENGINEERING OF SELECTED SYSTEM CONCEPTS

RESPONSIBILITY: STF/SSG

DESCRIPTION: This system engineering activity expands the initial technical approaches as to a level sufficient to permit the selection of preferred system concepts from the set of alternative technical approaches considered. The outputs of this iteration are included in the Concept Formulation Package and technical inputs to the Outline Acquisition Plan.

BLOCK 4.1—FUNCTION ANALYSIS OF SELECTED SYSTEM CONCEPTS

RESPONSIBILITY: Contractor

DESCRIPTION: Working from gross description of alternative technical approaches generated in the first iteration (Blocks 2.1, 2.2, 2.3, and 2.4), the system engineering process now can be applied to expand the initial function models by identification and definition of lower indenture functions. Performance requirements are developed for each functional indenture and time requirements analyses performed as required. Functional requirements of each system concept of the alternative technical approaches are depicted for all operational modes of usage in all specified environments. Each function is described with

APPENDIX B
THE SYSTEM ENGINEERING MODEL

B–1. General.

a. This appendix describes a model for application to the five functional areas (operations, logistics support, test, production, and deployment) of the system engineering process described in chapter 2 and the management activities described in chapter 3. Figures B–1, B–2, B–3, and B–4 depict the flow of system engineering activities for the Alternative Systems Concept, Demonstration and Validation, Full-Scale Engineering Development, and Production and Deployment Phases of the life cycle model. Narrative descriptions of each block of the graphic flow of the model are also provided. Together these two parts of the model identify the system engineering documentation and describe the relationships between documentation, engineering, requirements and design reviews, in-process reviews, inputs to configuration management baselines, and inputs to and outputs from the life cycle model.

b. The model dipicts a project managed system from concept to disposal. Since not all projects fall into this category, each system engineering effort must be tailored to the peculiarities of the system and the project. The substance of the activities described in the model must be accomplished at some time during the system life cycle if a balanced, effective system is to be developed.

c. Figures B–1, B–2, B–3, and B–4 show a life cycle activities line, a baseline descriptions line, and a system engineering activities line. Beginning in demonstration and validation, the system engineering activities line is further subdivided into lines for the functional cycles of operations, logistics support, test, production, and deployment. In the earlier applications of the process, the emphasis is primarily upon the operational requirements of the system, but the requirements of all other functional areas are also analyzed to the extent necessary to establish concepts and methodologies, and, in some instances, to identify major system elements related to these functional areas. Dotted lines enclose interations of the system engineering process and other groupings of homogeneous activities. Arrowed lines indicate sequential flow and input and output to and from the life cycle model. Other symbolism is reflected in the legend on each figure.

d. A narrative description of each block in the graphic flow of the model provides additional continuity, comprehension, and clarity to the model. Each description correlates the block number and title with the graphic flow, identifies the agency responsible for coordination of the activity, describes the activity, indicates the system engineering documentation used to accomplish the activity, and lists pertinent references. The inclusion of references to system engineering forms which are described in chapter 4 does not imply that these forms are prescribed, but instead illustrates only one of many ways of presenting data and describing ongoing design activities.

B–2. Alternative System Concepts Phase (fig B–1)

a. The combat developer conducts continuing analyses of mission areas in order to identify those mission elements for which existing or projected capability is deficient and to identify opportunities for capability enhancement through more effective and less costly methods and systems. To define long-range research objectives, the combat developer develops a science and technology objective (STO), which describes scope, background, concepts, desired capabilities, and priority of science and technology objectives. When a mission need is identified, the combat developer documents it in a Mission Element Need Statement (MENS) in terms of the operational task to be accomplished (AR 71–9). Because MENS is not cast in terms of capabilities and characteristics of a hardware of software system, there in no system engineering during the analyses of mission areas.

b. The overall objective of the Alternative System Concepts Phase is to examine the military, economic, and technical bases for a major development program and the alternative systems which warrant going into the next phase. The system engineering starting point in the life cycle of a materiel system is the identification of an operational deficiency, technological opportunity, or approaching obsolensence of exist-

(Locate fig. B–1, a fold-out, at the end of this manual)

ing systems, This need may result from combat development efforts or from field reports of current operating forces. The proponent's need must be evaluated against ongoing or planned developments and concepts, and validated by appropriate studies before conceptual development may begin.

c. Indications of new Army requirements and capabilities are found in the DA, Joint Staff, and national plans and policies; and long-range projections concerning strategic estimates, intelligence estimates, and technological forecasts as described in AR 1–1. The identified requirement initiates an investigation of available technology and proposal of materiel which combines with an operational concept to form the basis for a letter of agreement (LOA). The LOA requires HQDA approval before further development effort is undertaken.

d. The Alternative Systems Concept Phase evolves system concepts for advanced development in the Demonstration and Validation Phase. System engineering activities are less precisely defined and structured in this phase than in later phases. However, the results of early application of the system engineering process are vital since the conditional commitment to enter engineering development or operational system development is made on the basis of the performance, cost, and schedule data developed during the Alternative Systems Concept Phase. System engineering activities are addressed basically to one purpose—demonstration of feasibility. This means that the selected concepts meet validated capability goals, are technically feasible, and provide the basis for selection of a system which can be efficiently and effectively developed, produced, operated, maintained, and supported.

e. The conceptual process leads to completion of the following objectives prior to validation: the technology needed is sufficiently in hand, and primarily engineering rather than exploratory effort is required; the mission and performance envelopes and broad logistics support approaches are defined; the best technical approaches have been selected; thorough trade-off analyses have been made, both of the stated operational requirement against engineering designs and between the design parameters themselves; the cost-effectiveness of competing items on a DOD-wide basis; cost and schedule estimates are credible and acceptable; and the high risks have been identified and plans made to resolve them.

f. Blocks 1.0 through 5.0 describe system engineering activities in the Alternative Systems Concept Phase. This phase is conducted by the Special Task Force/Special Study Group (STF/SSG), with combat, materiel, and training developer members of the STF/SSG providing input as required. Although system engineering support of the task force or study group is done almost exclusively by contract, these activities are described in blocks 1.0 through 5.0 in sufficient detail for in-house accomplishment, should that route be taken.

statements of beginning/ending conditions to include inputs, outputs, and intrasystem/intersystem interface requirements. Functions are defined to ensure indentation as part of the largest function(s) and arranged in their logical sequence so that any specified operational use of the system can be traced within the cycle. Alternative operational cycles are also identified. When more than one system concept is evaluated, each is depicted and identified. Records are kept to reflect the rationale for acceptance or rejection of each alternative. Similar functions are cross-referenced to ensure a common synthesis solution. Gross functions of each system concept are developed in sufficient detail to differentiate those performed by the system from those to be performed by subsystems. During this iteration, all functional cycles (operation, logistics support, test, production, deployment) are considered. While a detailed analysis cannot be made at this time for all functional cycles, concepts for all cycles are identified and described. Initial determination of skill levels and training requirements are identified and described. This effort is based not only on information previously provided, but also continuing Combat Developer inputs which further refine and define mission and performance envelopes and requirements.

FORMS: Functional Flow Block Diagrams, Requirements Allocation Sheet, Time Line Sheet

REFERENCES: AR 70–1, AR 70–27, AR 71–5, AR 71–9, AR 602–1, AR 611–1, AR 750–1

BLOCK 4.2—SYSTHESIS OF SELECTED SYSTEM CONCEPTS

RESPONSIBILITY: Contractor

DESCRIPTION: Synthesis may be performed at any level of functional indenture in order to postulate a design or alternative designs to satisfy the function performance requirements and provide the basis and visibility needed for evaluation and decision. These synthesized solutions should take into consideration the latest technological developments. The arrangement of system elements is portrayed in a suitable form (such as schematic diagrams) to depict a complete response to the functions, to plan compatibility among elements of the system and interfacing subsystems, and to permit traceability between the elements and their functional origin. Expansion of the function into subfunction must recognize the synthesis at the preceding higher level. Cofunctioning equipment, support equipment, personnel, facilities, computer programs, and procedural data are identified and grouped as a system/subsystem corresponding to the function which they collectively accomplish.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 70–1, AR 70–27, AR 71–5, AR 71–9, AR 602–1, AR 750–1

BLOCK 4.3—EVALUATE SYSTEM CONCEPTS

RESPONSIBILITY: STF/SSG

DESCRIPTION: This block represents the detailed analyses performed to compare and evaluate alternative system concepts. Definition of system concepts should not preclude choice in preliminary design above those constraints in the MENS. The number and types of evaluations to be performed may vary with each case. The common factor in each case will be that evaluations conducted are greatly refined over those previously conducted. Trade-off studies can now encompass such factors as man/machine combinations, hardware systems, components, and system support characteristics.

The STF/SSG makes trade-off determinations and analysis. The trade-off studies should insure that the selected system concept represents the best choice possible from a mission standpoint as well as technical risk. Based on results of the trade-off evaluation and other data, including force level planning guidance, the STF/SSG establishes cost and schedule estimates. These estimates of total life cycle costs and schedule must be sufficiently developed to permit joint system merit evaluations (Cost and Operational Effectiveness Analysis (COEA)). The depth of the analytical studies conducted must be sufficient to show clearly that the selected system concepts have a significant advantage over the others in terms of performance, cost, and schedule. It is imperative that these studies include an assessment of technical risk and the consequence of failure.

FORM: Trade-Off Study Reports

REFERENCES: AR 70–1, AR 70–27, AR 71–5, AR 71–9, AR 602–1, AR 702–3, AR 750–1

BLOCK 4.4—FINALIZE CONCEPT FORMULATION PACKAGE

RESPONSIBILITY: STF/SSG

DESCRIPTION: The STF/SSG performs an overall assessment of the combined supporting data for the selected system concept. The assessment is documented in the Concept Formulation Package and included in the Outline Acquisition Plan as evidence that the project is ready to enter advanced development.

REFERENCES: AR 70–27, AR 71–9, AR 611–1, AR 700–127, DA Pam 11–25

BLOCK 5.0—TECHNICAL INPUT TO OUTLINE ACQUISTION PLAN

RESPONSIBILITY: Materiel Developer, in coordination with the Combat Developer, Operational Tester, Trainer, or Logistician

DESCRIPTION: The Outline Acquisition Plan (OAP) is prepared in the format prescribed in AR 70–27. It contains narrative summaries of the technical goals and detailed supporting plans required to outline the proposed program to satisfy the LOA. These detailed supporting plans (i.e., Configuration Management Plan, Coordinated Test Plan, Reliability and Maintainability Plan, Integrated Logistics Support Plan, System Safety Plan, and others) are prepared from the technical data outputs of the Alternative Systems Concept Phase system engineering process and from the various engineering specialties. Much supporting data will be general at this point in the life cycle. However, the OAP must be sufficiently completed at the end of the phase to permit the appropriate management decision to be accomplished. Although no decisions on the method of production and procurement are determined at this early stage, the OAP should address pertinent considerations on advance procurement planning which will affect development.

FORMS: Schematic Block Diagram, Design Sheets, Trade-Off Study Reports, Requirements Allocation Sheets, Time Line Sheets, Facility Interface Sheets, LSAR Records

REFERENCES: AR 18–1, AR 70–1, AR 70–17, AR 70–27, AR 71–5, AR 71–9, AR 385–16, AR 602–1, AR 611–1, AR 702–3, TM 38–703

B–3. The Demonstration and Validation Phase (Fig. B–2)

a. Validation is mandatory for all new developments or major modifications of existing items which are estimated to require cumulative expenditures greater than $75 million in RDTE funds or $300 million in production investment funds, unless specifically waived by Department of the Army. Other projects may be designated for validation by DA or DOD.

b. The degree of technology advancement to be accomplished by the development is limited to that which can be demonstrated quantitatively, by either laboratory or experimental devices, to have a high probability of achievement. If it is necessary to make a forcast of anticipated developmental achievement, the forecast will assume the probability of matching but not exceeding the laboratory results. This assumption is not intended to limit a system development to assembly of off-the-shelf components, but rather to ensure a high level of confidence that every technical requirement can be met.

c. Demonstration and validation is normally performed by two or more contractors in competition under technical direction of the Army. It may, however, be performed by a sole-source contractor, if necessary, or by Army laboratories if they are to peform the engineering development. The system engineering effort contributes to preparation of a Request for Proposal (RFP) to potential contractors; evaluation of contractor proposals for conducting demonstration and validation; selection, negotiation, and award of contracts; preparation of the selected contrators' proposals; submission of contractors' reports, and development engineering or production engineering proposals; evaluation of contractor submissions; selection of the preferred contractor; and negotiation of a definitive development contract with the selected contractor.

d. The ultimate goal of demonstration and validation is to select a system for full-scale engineering development. Subsidiary objectives are to establish firm and realistic performance specifications; precisely define the relationships between, and the responsibilities of all parties to the contract; identify high risk areas; verify technical approaches; establish firm and realistic schedules and cost estimates for engineering development and production; establish schedules and life cycle cost estimates for planning purposes for the total project, including operation, logistics support, test, production, and deployment; and establish requirements for the support plan planning data. The contractor's requirements proposal should include such information as a list of the end items required; performance specifications for each item; a work breakdown structure and a program activities network plan; the principal objectives and features of the overall system design, including recommendations for its operational use; a recommended logistics plan; detained cost estimates and milestone schedules for engineering development or development and production as well as planning estimates and schedules for 5 years beyond; quantitativeive reliability and maintainability specifications and test plans; time/cost/performance trade-off decisions on major alternatives; required new design and technology; forseeable technical problems and proposed solutions; technical specifications and performance specifications for support items for which early engineering development is required; delivery schedules and requirements for data and documentation; and, as required, a proposed schedule of production engineering and production tooling.

e. In the Demonstration and Validation Phase, the system engineering effort is performed indepth to define the performance requirements for all elements of the system. The phase may begin after approval by an IPR for nonmajor systems or after ASARC I/DSARC I approval for major systems, and ends with validation IPR/ASARC II/DSARC II, as appropriate.

f. Blocks 6.0 through 24.0 describe system engineering activities in the Demonstration and Validation Phase.

Locate fig. B–2, a fold-out, at the end of this manual)

SYSTEM ENGINEERING ACTIVITIES DEMONSTRATION AND VALIDATION PHASE

BLOCK 6.0—FUNCTIONAL CONFIGURATION IDENTIFICATION

RESPONSIBILITY: Materiel Developer

DESCRIPTION: The Materiel Developer begins validation upon HQ DA approval of the Outline Acquisition Plan (OAP). OAP update is followed by application of the system engineering process to the system specification (SE Blocks 6.1, 6.2, 6.3, and 6.4) to integrate changes which are directed as conditions of approval and to incorporate new information acquired. The system engineering process is initially applied to the operating function area requirements because selection of operations elements establishes the basic requirements for all other functional areas. Available information concerning all functional areas must be considered, particularly when these areas impose constraints on the total system design. The objective is to create a technically and economically balanced system. A function analysis is conducted for all reasonable alternative approaches to determine performance requirements for each function. Preliminary system design concepts are expanded and synthesized. Trade-off studies are made to support evaluations and decisions. One system design concept is tentatively selected, with possible alternatives, to establish a firm base for expansion of the total system requirements for technical input to a Request for Proposal.

REFERENCES: AR 71–1.

BLOCK 6.1—INITIAL VALIDATION FUNCTION ANALYSIS

RESPONSIBILITY: Materiel Developer

DESCRIPTION: Following approval by HQ DA, the Outline Acquisition Plan is subjected to the system engineering process to reflect changes which may have been directed as conditions of approval, and to incorporate any new information acquired while awaiting approval. The higher level functions in the model are iterated as necessary to firmly establish them as baselines. The initial function analysis performed during the Alternative Systems Concepts Phase is now iterated and expanded to lower levels to reflect new information and directed changes. This analysis includes consideration of operation, logistics support, test, production, and deployment functions to the level necessary to define concepts. A time requirements analysis is performed on time critical functions. Mission objectives and constraints are reviewed and reexamined in relation to higher and lower order systems. A series of preliminary functional models are developed on as many levels as necessary to depict reasonably achievable alternate functional approaches. Each competing functional approach is then examined in detail to determine performance requirements associated with its function and the documenting of these requirements is terms of inputs, outputs, environments, performance constraints, time constraints, and other considerations.

FORMS: Functional Flow Block Diagram, Requirements Allocation Sheet, Time Line Sheet

REFERENCES: AR 70–1, AR 71–1, AR 71–5, AR 356–16, AR 602–1, AR 715–6, AR 750–1

BLOCK 6.2—SYNTHESIS OF PRELIMINARY SYSTEM DESIGN CONCEPTS

RESPONSIBILITY: Materiel Developer

DESCRIPTION: Each of the proposed alternative system concepts in the Outline Acquisition Plan is expanded to acquire further understanding of functions, performance, design requirements, and constraints. The impact of each proposed system concept on other elements of the total system are assessed, and these new concepts used to expand further the functional model to identify lower indentured functions. This synthesis of solutions is accomplished only to the level to which the Government wishes to constrain the competing Demonstration and Validation Phase contractors. Schematics are used as tools in the synthesis process. They provide for visibility, traceability, and communications. They also portray the interfaces among system elements and aid in integratng performance requirements into specific system elements. Facility end items, such as elevators, cranes, ramps, and environmental control systems are identified, particularly in the case of command and control centers, mission installations, fixed repair facilities, and strategic communications systems. The number and kinds of personnel for system operation, logistics support, test, production, and deployment are identified in gross terms. The facilities, personnel, training equipment, procedural data, and periods of time needed for training purposes are identified in gross terms. Government-furnished equipment (GFE), which constitutes constraints upon the system, is identified. In cases where the new system is one which is evolving from a presently installed system, or from a combination of presently installed equipments or systems, the performance requirements may have been generated from a study of existing capabilities. In this case, the scope of the existing system or systems may be fixed by mutual agreement between the developer and the user.

FORMS: Schematic Block Diagrams, Concept Description Sheets

REFERENCES: AR 71–1, AR 71–5, AR 385–16, AR 602–1, AR 715–6, AR 750–1

BLOCK 6.3—EVALUATION AND DECISION

RESPONSIBILITY: Materiel Developer

DESCRIPTION: An evaluation of the various conceptual designs resulting from the expanded function analysis and preliminary system design concepts is conducted in consideration of various personnel/machine/technique combinations, hardware systems, and major components. The performance and design requirements that were defined during concept are updated to incorporate the results of this evaluation. The impact of the various conceptual designs on logistis support, test, production, and deployment, and on costs and schedules are considered at this time. A technical rationale is prepared which summarizes the logic and conclusions reached, and the possible consequences of selecting significant alternative conceptual designs. High risk technical areas, long lead time items, and high cost areas where trade-off studies are to be performed by the validation contractor(s) are identified for inclusion in the Request for Proposal. A conceptual design or possible alternatives are selected for translation into the system specification.

FORM: Trade-off Study Reports

REFERENCES: AR 71–1, AR 385–16, AR 602–1, AR 715–6, AR 750–1

BLOCK 6.4—INITIAL DESCRIPTION OF SYSTEM ELEMENTS

RESPONSIBILITY: Materiel Developer

DESCRIPTION: The system specification presented the basic requirements as defined during concept. By iteration in Blocks 6.1, 6.2, and 6.3, it is expanded to provide a standard base within which competition may freely operate to ultimately produce a technically and economically balanced system over the life cycle of the materiel. The system design and test requirements are defined such that the Request for Proposal(s) will communicate fully the Department of the Army's intent. The description of system elements establishes the criteria for operations, logistics support, test, production, and deployment of the overall system, and reflects the major engineering designs which have been made to date.

FORM: Design Sheets

REFERENCES: AR 11–13, AR 18–1, AR 71–5, AR 71–9, AR 385–16, AR 715–6, AR 750–1

BLOCK 7.0—EXPAND SYSTEM REQUIREMENTS

RESPONSIBILITY: Materiel Developer

DESCRIPTION: The requirements for the total system are established as technical inputs to the Request for Proposal. The requirements are stated in all-inclusive terms, specific as to Government intent, and in such a manner to permit latitude by the offeror to utilize creative ability in submitting meaningful proposals reflecting the offeror's knowledge and experience. Blocks 7.1, 7.2, 7.3, 7.4, 7.5, and 7.6, respectively, describe technical requirements for the system specification, criteria for trade-off studies, and maintenance support, test, production, and deployment plans. The requirements established for the various plans are oriented primarily toward the generation and updating of the plans, and the criteria to be satisfied for each plan. The significance of establishing total system technical requirements as input to the RFP is that these requirements provide the base against which offerors submit proposals. The outputs from the above-cited system engineering blocks are provided in Block 8.0 as technical input to the Request for Proposal.

REFERENCES: AR 34–1, AR 70–1, AR 71–5, AR 71–9, AR 385–16, AR 715–6, AR 750–1

BLOCK 7.1—EXPAND SYSTEM SPECIFICATION

RESPONSIBILITY: Materiel Developer

DESCRIPTION: From the initial description of system elements in Block 6.4, the system specification is expanded for inclusion in the Request for Proposal to amplify the requirements which were identified during the Alternative Systems Concepts Phase. It is expanded in a manner to permit the offeror flexibility in design approaches without compromising basic performance requirements. The system specification must encourage alternatives and stimulate initiative and creativity by the offerors. It must state clearly the performance requirements in definitive terms, but permit exploitation of advances in technology such as use of new materials, automated design, integrated electronics, advanced computer techniques, or unique sources for power or propulsion. Performance requirements will be stated as operationally effective bands which place a limit or limits on acceptable bands of performance.

As required by the Plan for Logistics Support and the several test plans (Blocks 7.3 and 7.4), the system specification requires that design provide for accessibility of test points and any other features necessary to enable performance of maintenance or testing without major disassembly of the equipment or system. It also includes any known maintenance or tests required to operate the system. Included are maintenance and tests necessary to set up or assemble the system, interface it with other systems, or measure particular performance characteristics during operation in order to ensure maximum operating efficiency or performance.

REFERENCES: AR 70–10, AR 71–9, AR 385–16, AR 602–1, AR 715–6, AR 750–1

BLOCK 7.2—DEVELOP CRITERIA FOR TRADE-OFF STUDIES

RESPONSIBILITY: Materiel Developer

DESCRIPTION: Specific operational areas or design features are identified within which, or against which, trade-off studies are to be made by the contractor. Trade-off studies may involve revisions of system functions and performance requirements which could result in revised configurations of the system or specific end items. Criteria for trade-off studies are expressed in terms of resources and system parameters. Examples of resources are funds, time, manpower, and skills. Examples of parameters are weight, mission, length, reliability, maintainability, safety, vulnerability, and survivability. Where possible, criteria for measurement of system effectiveness are stated in quantitative terms. The criteria established for trade-off studies are related to the system measures of effectiveness and the MENS/LOA with particular attention to "essential" characteristics and "desired" characteristics stated therein. Trade-off limitatins are specified in relation to "essential" characteristics and performance requirements for operations, logistics support, test, production, and deployment elements.

All documents which have a direct bearing on the system are identified, reviewed, and selected. The selected documents listed will provide the necessary background information with the Request for Proposal for demonstration and validation. The results of prior studies that provide the base for technical reports prepared during the Alternative System Concepts Phase are of particular importance to this process since they relate to feasibility, cost-effectiveness, major trade-offs, operational analysis, and logistics analysis.

REFERENCES: AR 71–9, AR 385–16, AR 602–1, AR 702–3, AR 715–6, AR 750–1

BLOCK 7.3—UPDATE LOGISTICS SUPPORT PLAN

RESPONSIBILITY: Materiel Developer

DESCRIPTION: The concept for maintaining system equipment, initiated during the Alternative System Concepts Phase and incorporated into the ILS Plan of the Acquisition Plan (Block 5.0), is updated to describe the gross maintenance capabilities and capacity required of using and supporting organizational units. This updated description provides information concerning tactical employment of the system, its bearing on maintenance problems, and any unusual maintenance environment to which the system or its end items may be subjected. It also provides information on mobility considerations as reflected in allowable downtime, equipment availability requirements, and other operations requirements which may have a bearing on the maintenance concept.

The updated Logistics Support Plan includes quantitative reliability and maintainability goals, trade-off limits, demonstration concepts, measure of overall system maintainability, data to be provided by the contractor as a basis for reliability predictions, manpower skills, training requirements, constraints on maintenance, field data to be collected, procedures for feedback of data, data analysis to be conducted, methods/techniques to be used for data analysis, requirements for data utilization for system optimization, and required equipment and facilities. It establishes requirements to determine the most feasible method of supporting the equipment or system, to generate and prepare delivery schedules of procedural data during the entire materiel life cycle phase for implementation of the Logistics Support Plan, and to satisfy Logistics Support Analysis Record (LSAR) requirements.

REFERENCES: AR 71–1, AR 358–16, AR 602–1, AR 700–127, AR 715–6, AR 750–1

BLOCK 7.4—PREPARE INITIAL TEST PROGRAM AND PLANS

RESPONSIBILITY: Materiel Developer/Combat Developer

RESPONSIBILITY: The test program and plans address tests to be performed by both the contractor and the Government. They are the Coordinated Test Program (AR 70–10), Product Assurance Test Plan (AR 702–9), Post-Production Test Plan (AR 702–XX), and User Test Plan (AR 71–3). These plans provide for identification of personnel and materiel support required and for preparation of test specifications. They are structured to ultimately encompass all test requirements for the system, including research, feasibility, development, operational, production, and post-production tests, up to system disposal.

The plans include such general concepts as time schedules, required test facilities, available locations and facilities, planned quantities of items for test, availability of items to be tested, number of items to be tested, training, and planned Government and contractor personnel and materiel support for tests. Environmental tests, safety tests, reliability tests, and others are included as part of each test, as appropriate. For each of the applicable tests, criteria are established for early identification and development of information relative to required special test equipment, special calibration equipment, shop facilities, air and ground vehicles, special fixed and mobile test facilities or sites, personnel skills, and training. Criteria are established for data collection, recording, storage, retrieval, analysis, and feedback of test data and analysis to correct design and achieve system optimization. The plans include requirements for accumulation and use of test data to preclude duplication of tests. In planning the test program, requirements are established for determining mode of equipment transportation and scheduling to test site, and for determining and identifying long lead time areas and access to special facilities.

Requirements for procedural data to be developed and delivered during Demonstration and Validation, Full-Scale Engineering, Development, and Production and Deployment Phases are included in the plans. These plans do not include any tests which are required solely for operation or maintenance of the system. These tests will have been included under Blocks 7.1 and 7.3 respectively.

REFERENCES: AR 70–1, AR 70–10, AR 70–15, AR 71–3, AR 71–9, AR 385–16, AR 700–51, AR 702–9, AR 750–1

BLOCK 7.5—PREPARE INITIAL PRODUCTION PLAN

RESPONSIBILITY: Materiel Developer

DESCRIPTION: At this time, requirements for determining necessary resourses and specifying schedules necessary to produce materiel are established and incorporated into a Production Plan. The requirements for the plan will be included in the Request for Proposal (RFP).

The RFP will require that the contractor formulate general concepts under which the system is to be produced; establish feedback requirements and criteria (plans, methods, techniques of production) to optimize design of the total system; specify contractor claimed rights in data with a plan to minimize the impact of such claims; establish requirements for determining the need for or extent of production engineering establish requirements for management of possible production sources; specify industrial security requirements for production of system elements; establish quantitative production reliability goals, trade-off limits, and production concepts; establish requirements for special facilities, calibration equipment, and manufacturing test and inspection equipment; establish production interfaces with operations, logistics support, test, and deployment elements; formulate initial schedule and quantities of items or systems for limited and continued production; establish requirements, when applicable, for mobilization base planning, and production rates under emergency conditions; require that offerors predict the state of industrial technology against a time base for future production of critical components; establish requirements for identification of high production risk, high production costs, long lead time items; identify unusual production requirements that will provide a basis for system trade-offs; specify a requirement that proposals include recommendations concerning the need for stockpiling and/or research and development to alleviate possible future mobilization problems; determine possible constraints to a short lead time resumption of production after it has been discontinued for a number of years; and furnish the criteria to be used in the evaluation of a Production Plan from the standpoint of the need for a subsequent establishment of a mobilization base. Some of these criteria would include the use of strategic or short supply materials, the use of piece parts or components which required long lead time for processing or high level skills for machining, personnel skills unique to the solely military nature of the production, and dispersion of production facilities. Where hazardous materials are involved, the offeror would also be required to specify safety requirements for production, handling, and storage.

REFERENCES: AR 37–40, AR 385–16, AR 715–5, AR 700–18, AR 700–51, AR 715–50, MIL-D-1000, MIL-STD-100

BLOCK 7.6—PREPARE INITIAL MATERIEL FIELDING PLAN

RESPONSIBILITY: Materiel Developer

DESCRIPTION: A Fielding Plan is prepared to provide basic requirements for initial deployment of the system. This plan includes the functions to be performed to transport, receive, process, install, checkout and, as required, store or activate at the user location. It includes sufficient requirements and related information for incorporation into the RFP. Care is exercised to ensure compatibility with the Plan for Logistics Support. As a minimum, the Materiel Fielding Plan includes the deployment concept, identification of possible modes of transportation, and transportability characteristics that will require special transport or special precautions during movement; estimate of special procedures and processes related to receipt and processing of equipment; identification of special installation and checkout requirements; identification of critical procedures ralated to deployment activities; identification of estimated facility and storage requirements and procedures; and identification of special training requirements associated with deployment for inclusion in appropriate training plans.

REFERENCES: AR 71–5, AR 702–3, AR 750–1

BLOCK 8.0—PROVIDE TECHNICAL INPUT TO REQUEST FOR PROPOSAL

RESPONSIBILITY: Materiel Developer

DESCRIPTION: Appropriate information resulting from Blocks 7.1, 7.2, 7.3, 7.4, 7.5, and 7.6 is provided for inclusion in the Request for Proposal. The technical information furnished must satisfy the applicable requirements of AR 702–3 concerning RAM.

REFERENCES: AR 70–1, AR 70–27, AR 702–3

BLOCK 9.0—SYSTEM ENGINEERING FOR OPERATIONS ELEMENTS—PREPARATION FOR PROPOSAL

RESPONSIBILITY: Offeror

DESCRIPTION: Upon receipt of the Request for Proposal resulting from source selection approval, the offeror reviews the system specification, criteria for trade studies, operations, maintenance, test, production, and deployment plans to ensure that these elements have been properly considered and integrated for creation of the best technically and economically balanced system. The offeror applies system engineering to the operations requirements in order to expand the system specification to reflect the offeror's experience and planned approach to meeting system requirements. A proposed system design approach is selected and documented in Block 9.4. Application of the system engineering process at this point will provide the necessary base for the offeror to expand the Request for Proposal requirements for the logistics support, test, production, and deployment areas, and perform efforts essential to development of a proposal that reflects a balanced system design approach. The offeror must exercise his full knowledge and experience in considering logistics support, test, production, and deployment requirements because of their influence on the proposed design approach.

The updated system specification (Block 9.4) is used as a basis for proposal expansions of all program plans and development of the offeror's proposal.

DESCRIPTION: AR 70–1

BLOCK 9.1—EXPAND FUNCTION ANALYSIS

RESPONSIBILITY: Offeror

DESCRIPTION: Upon receipt of the Request for Proposal, the offeror reviews the system specification, criteria for trade studies, operations, logistics support, test, production, and fielding plans to ensure that these elements have been adequately considered and integrated into the functional models. The functional models and functional requirements data provided by the Government are compared with the offeror's functinal model developed in anticipation of the Request for Proposal. It may be necessary to modify the functions and their sequencing to reflect the offeror's technical experience and planned approach to meeting the system requirements. The offeror expands the preliminary functional models furnished with the Request for Proposal to lower levels to adequately portray the approach, and establishes associated function performance requirements. Alternative modes of operation are represented by alternative flows.

A time analysis is performed on time-critical functions. A function is considered time-critical when the estimated time required to perform it has a direct or contributory effort on reaction time, downtime, availability requirements, or utilization of resources.

The extent to which the functional model is expanded depends on whether or not the functions are relatively well understood, are new and unique, or at least represent an increase in capability. The modified and expanded functional model is summarized in the offeror's technical proposal.

FORMS: Functional Flow Block Diagram, Requirements Allocation Sheet, and Time Line Sheet

REFERENCES: AR 70–1, AR 702–3, AR 715–6, AR 750–1

BLOCK 9.2—SYNTHESIZE CONCEPTUAL DESIGN

RESPONSIBILITY: Offeror

DESCRIPTION: Based on the functional performance requirements developed as a result of function analysis (Block 9.1), an initial conceptual design is developed. This synthesis is not restricted to the hardware of the system, but includes all system elements. Schematic diagrams of various types are used as tools in the synthesis process to provide visibility, traceability, and means of communications. The primary objective of preparing such schematics is to graphically portray and identify interfaces between system elements and to aid in integrating performance requirements into specific element recommendations.

Requirements are identified which can be satisfied by using equipment available in the DOD inventory or which are commercially available. Facility end items are identified, particularly in the case of missile installations, fixed communications facilities, and fixed command and control centers. Facilities, training programs, equipment, and documentation are identified for which early engineering development is required. The synthesis includes gross identification of personnel tasks and an estimate of the number of personnel at various skill levels required to operate and maintain the system. An estimate is made of requirements and schedules for training programs, training equipment, facilities, procedural data, and computer programs. Trade-off studies performed and proposed trade-off studies to be accomplished along with design alternatives are identified and described in sufficient detail to enable evaluation in Block 9.3.

FORMS: Schematic Block Diagram and Concept Description Sheet

REFERENCES: AR 70–1, AR 71–5, AR 702–3, AR 715–6, AR 750–1

BLOCK 9.3—EVALUATION AND DECISION

RESPONSIBILITY: Offeror

DESCRIPTION: The alternative resulting from expansion of the function analysis and synthesis of conceptual design are evaluated from the standpoints of time, life cycle costs, and performance. The extent of analysis, synthesis, and evaluation depends on the depth of system engineering accomplished by the offeror and his/her proposed system concept to fulfill the performance/design requirements presented in the Request for Proposal. Trade-offs are performed by the offeror using the criteria furnished with the Request for Proposal. These trade-offs are both intratechnical, i.e., trade-offs of one design feature against another and extratechnical, i.e., between operational performance, logistics support, personnel skills and training, and facilities, as applicable. At this point, risks are identified. Offerors may propose additional trade-off studies and their method for accomplishment. Based on the evaluation, a conceptual design is selected for proposal.

FORM: Trade-off Study Report

REFERENCES: AR 70–1, AR 702–3, AR 715–6, AR 750–1

BLOCK 9.4—UPDATE SYSTEM SPECIFICATION

RESPONSIBILITY: Offeror

DESCRIPTION: The system specification provided with the Request for Proposal is updated by adapting the proposed system design approach to the system specification. Care must be taken to preserve the basic Army requirements which established the functional baseline. The offeror is allowed maximum flexibility within the basic system requirements to display his design approach. Initial actions include: (1) evaluation of the requirements in terms of his own background knowledge, experience, and capabilities; (2) establishment of a proposed approach to the requirements; and (3) assignment of responsibilities to engineering elements within his organization for additional preliminary design effort.

Results of engineering efforts are reflected in the updated proposed system specification and the required system engineering documentation submitted as part of the offeror's proposal.

FORM: Design Sheets

REFERENCES: AR 18–1, AR 70–1, AR 715–6, AR 750–1,

BLOCK 10.0—DEVELOP PROPOSED DESIGN AND SUPPORT APPROACHES

RESPONSIBILITY: Offeror

DESCRIPTION: The offeror will use the updated system specification (Block 9.4) as the base for developing his proposed design approach for satisfying the Request for Proposal requirements in the areas of operations, maintenance, test, production, and deployment. This includes efforts performed under Blocks 10.1, 10.2, 10.3, 10.4, and 10.5. The outputs are proposed plans reflecting the offeror's approach for satisfying all the requirements for each activity area. The proposed plans will comprise the technical inputs to the offeror's proposal (Block 11.1).

REFERENCES: AR 70–1

BLOCK 10.1—DEVELOP PROPOSED DESIGN APPROACH

RESPONSIBILITY: Offeror

DESCRIPTION: The operational requirements specified by the system specification contained in the Request for Proposal are reviewed to ensure that the trade-offs made in developing a proposed design approach have retained system compatibility and basic requirements. Trade-off studies performed in accordance with the criteria furnished with the Request for Proposal are reviewed to ensure the technical adequacy of the proposed design approach in satisfying operational requirements. The offeror's proposal will identify the trade-off studies to be accomplished and the methodology to be employed. The operational characteristics of the proposed desgin approach are evaluated against the operations requirements to ensure adequacy of design approach and to establish a sound base for making cost estimates, recommending schedules for development, and preparing performance specifications for each end item.

The offeror's design concept may be supported by functional and schematic diagrams. The updating of operations performance requirements is accomplished with respect to system readiness, survivability/vulnerability, penetrability, damage limitation, range, safety, reliability, training requirements, maintainability, transportability, number of installations required, types of facilities, and others, as applicable.

FORMS: Schematic Block Diagram, Concept Description Sheet, Design Sheets

REFERENCES: AR 70–1, AR 385–16, AR 715–6, AR 750–1

BLOCK 10.2—DEVELOP LOGISTICS SUPPORT PLAN

RESPONSIBILITY: Offeror

DESCRIPTION: The offeror reviews the Maintenance Plan requirements in the Request for Proposal for adequacy and compatibility with the system specification to identify the required maintenance capabilities. The nature and the number of any repair facilities to be provided as part of or in support of the system, and requirements to be placed on common facilities, are identified. The offeror prepares a plan which satisfies the requirements of a Contractor Logistics Support Plan required by ILS and by AR 70-1.

A plan for providing any information which is new or different from that provided by the Government is included in the proposed Contractor Logistics Support Plan. This information pertains to data to be collected, procedures for feedback of data, data analysis to be conducted, methods/techniques to be used for data analysis, and utilization of maintenance and repair data to optimize system design. A statement of any effort accomplished on maintenance evaluation not covered elsewhere in the proposed support plan is included. Proposed trade-off studies, and a plan for demonstrating the maintenance concept are identified. A plan is proposed for development and delivery of requirement maintenance technical/procedural data during various phases of the system life cycle, along with identification of parameters having an impact on maintenance and the proposed technique for resolving any incompatibilities.

FORM: Trade-off Study Reports

REFERENCES: AR 70-1, AR 385-16, AR 602-1 AR 700-127, AR 715-6, AR 750-1, AR 1000-1

BLOCK 10.3—DEVELOP TEST PROGRAM AND PLANS

RESPONSIBILITY: Offeror

DESCRIPTION: The test program and plans received as part of the Request for Proposal is realined in accordance with the proposal being prepared. The proposal identifies tests to be performed by the contractor or the Government, as well as contractor prepared support, test specifications, and test plans. In addition to revising the nature of the tests to be performed, it may be necessary to revise schedules, locations of tests, quantities of items to be tested, test support, and test personnel required. The Coordinated Test Program and all other test requirements are updated for alinement with the proposal udner preparation. Concepts, methodology, techniques, approaches, and schedules are prepared in response to the Request for Proposal. Specifically, the following are identified: Government or contractor tests to be conducted at a Government facility, period of time required, Government test equipment needed, and Government personnal and materiel support required, requirements for special test equipment, special facilities, and calibration equipment beyond those stated by the Government in the test program and plans contained in the Request for Proposal; methods and techniques to be employed to record, collect, store, retrieve, analyze, and use test data for design optimization. This includes requirements for any specific type of computer or computer language for interfacing with other programs; high technical test risk, high test cost, and long lead time items; unusual requirements for transportation of equipments to the test site, scheduling of tests, special tools, repair parts, and procedural data needed, along with a proposed approach for development of a plan for generation and delivery of required technical/procedural data; and special tests concerned with nuclear weapons effects.

FORM: Test Requirements Sheet

REFERENCES: AR 70-1, AR 70-10, AR 70-15, AR 71-3, AR 385-16, AR 700-51, AR 702-3, AR 702-9, AR 750-1, DA Pam 70-21

BLOCK 10.4—DEVELOP PROPOSED PRODUCTION PLAN

RESPONSIBILITY: Offeror

DESCRIPTION: In responding to the Request for Proposal, the offeror proposes development of a productin plan consistent with the requirements of

Block 7.5 and other specific program requirements. These include recommendations concerning production of the complete system by one source, use of prime and subcontractor structure, or use of Government depot as a check and assembly point for major system elements. The plan includes the proposed development of a product assurance program for use during production. A plan is proposed for specifying areas where production engineering will be required and the lead time needed. In addition, "make-buy" and subcontracting procurement plans are proposed. The plan includes the following: technique for feedback for production data for design optimization; development of a plan for generation and delivery of required procedural data; plan for processing ECR's under the configuration management plan; plan to minimize impact of contractor claimed rights in data; and response to any mobilization requirements of the Request for Proposal. High production risk, high production cost, and long lead time items are identified as a basis for possible trade-offs; and, as requested, production rates/scheduess are recommended.

REFERENCES: AR 37–40

BLOCK 10.5—DEVELOP PROPOSED FIELDING PLAN

RESPONSIBILITY: Offeror

DESCRIPTION: The development of a Fielding Plan is proposed to incorporate changes required by the proposed design approach and Logistics Support Plan. The Fielding Plan must ensure consistency with the system configuration being proposed and indicate any change which should be made in the Initial Fielding Plan due to anticipated increase in system effectiveness or capabilities proposed over those required in the Request for Proposal. For example, the number of helicopters needed for complete surveillance of any area may be decreased due to a proposed major increase in speed, decreased downtime, or increased speed of data interpretation and evaluation.

Initial plans are updated for transportation of the system to the field, its installations, checkout, and general concept for deployment. The updated plan reflects the differences in conceptual design between that proposed by the offeror and the Request for Proposal. As a minimum, the offeror's response must satisfy the requirements specified in Block 7.6. Applicable high-risk and high-cost areas are identified.

REFERENCES: AR 71–5, AR 750–1

BLOCK 11.0—INPUTS TO PROPOSALS

RESPONSIBILITY: Offeror

DESCRIPTION: EAch offeror prepares technical and managerial input to the RFP as described in Blocks 11.1 and 11.2

REFERENCES: AR 70–1, AR 700–51

BLOCK 11.1—TECHNICAL INPUTS TO PROPOSALS

RESPONSIBILITY: Offeror

DESCRIPTION: Each offeror will utilize the technical information developed under Blocks 10.1, 10.2, 10.3, 10.4, and 10.5 in preparation of his response to the RFP, to include a planning proposal for follow-on development.

REFERENCES: AR 18–1, AR 70–1, AR 700–51

BLOCK 11.2—SYSTEM ENGINEERING MANAGEMENT PLAN

RESPONSIBILITY: Offeror

DESCRIPTION: Each offeror prepares a System Engineering Management

Plan for incorporation in his/her proposal. The plan must state how the bidder proposes to effect system engineering management during Demonstration and Validation and subsequent phases. The System Engineering Management Plan includes proposed measures of effectiveness (MOE) models and techniques for technical performance measurement.

REFERENCES: AR 70-1, AR 700-51

BLOCK 12.0—INPUTS TO WORK STATEMENTS AND DT1

RESPONSIBILITY: Materiel Developer

DESCRIPTION: Technical inputs are provided for inclusion in the Statement of Work for the contracts to be awarded to the successful offerors. These inputs will be those provided under Block 8.0, revised to incorporate any desirable technical inputs which have been furnished by the offerors as part of their proposals. Maintenance support requirements are revised, as necessary, to include information provided by LSAR. Prior to submission of the revised inputs, coordination is effectd with the Combat Developer to ensure that the revisions are consistent with the Letter of Agreement. Inputs are also provided for Development Test I (DT I), the first iteration of development testing. The objectives of developmental tests are to demonstrate that design risks are minimal, tha engineering development is on schedule, and that progress toward achievement of system specifications is satisfactory. Evaluation of health and safety characteristics of each system or item is conducted throughout developmental testing.

RESPONSIBILITY: AR 18-1, AR 70-1, AR 71-9, AR 750-1

BLOCK 13.0—DEFINITION OF OPERATIONS REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: In system engineering Blocks 13.1, 13.2, 13.3, and 13.4, the contractor, through the system engineering process, further definitizes the system specified in the work statements (Block 12.0) using the approach contained in his proposal. The activities in this cycle of the system engineering process are restricted to the operation elements of the system to form a base for defining requirements for the remaining system elements. Care must be taken to observe the constraints imposed by the logistics support, test, production, and deployment requirements. The output of this cycle of the system engineering process is a description of the selected operations elements (Block 13.4) which provides a base for the System Requirements Review (Block 14). It also provides a base for the system engineering activities concerned with logistics support, test, production, and deployment.

REFERENCES: AR 70-1

BLOCK 13.1—FUNCTION ANALYSIS OF OPERATIONS REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: A detailed function analysis is performed to identify and define the operations functions which must be accomplished. This analysis will be a further iteration and expansion of the model prepared for the proposal modified to incorporate requirements of revised work statements, if any, made by the Government. And analysis of time-critical functions is performed as part of the function analysis. An identification and analysis of those functions where system life cycle costs are expected to be sensitive to incremental changes in the requirements is preformed as part of the function analysis.

It is necessary to define operations prior to defining logistics support, test, production, and deployment functions. The selection of operations functions may be influenced by previously acquired contractor experience concerning logistics support, test, production, and deployment considerations. Operations functions which cannot be logically supported from maintenance, test, production, or deployment standpoints are not to be selected. The alternative functional approaches for meeting system operation requirements within the specified performance envelope and trade-off criteria are considered. The ranges of interest around the operations requirements are established where life cycle costs, related to associated functions, are sensitive to incremental changes in the requirements. Only those alternatives which offer significant payoffs in terms of time, cost, and performance should be pursued.

Firm performance requirements are established for the operations functions which will provide an acceptable level of operational capability. Ranges in the performance requirements are maintained in those areas where significant trade-off studies in preliminary design are required due to the projected sensitivity of life cycle costs to the operations requirements. All performance requirements are stated in sufficient detail for use as criteria for equipment design and operation, and to define requirements for personnel, skills, tests, facilities, computer programs,procedural instructions, and technical data. This analysis is expanded to the point where sufficient information has been developed to define the requirements for all operations elements of the system. In conjunction with development of the detailed function model, an effectiveness model is developed to be used as guidance for the evaluation of alternatives performed in Block 13.3.

FORMS: Functional Flow Block Diagram, Reqiurements Allocations Sheet, Time Line Sheet

REFERENCES: AR 70–1, AR 71–5, AR 71–9, AR 385–16, AR 602–1, AR 702–3, AR 750–1

BLOCK 13.2—SYNTHESIS AND PRELIMINARY DESIGN OF OPERATIONS ELEMENTS

RESPONSIBLITY: Contractor

DESCRIPTION: The preliminary design approach submitted with the porposal is refined and expanded to incorporate the requirements defined by the detailed function analysis. This is accomplished by revision of schematic diagrams and development of additional schematics at lower levels of indenture. These schematics show relationships among system elements to meet established performance requirements, as well as changes in these relationships through incremental changes in the requirements within the established ranges of interest. In addition to synthesizing the operational equipment, requirements for facilities, personnel, procedural data, and computer programs are defined. In the translation of operations function requirements into design concepts, emphasis is placed on quantification of performance requirements and design constraints. Examples are: (1) input-output performance values and tolerances; (2) design constraints such as power , size, weight, volume, interface, environment, and human performance capabilities and limitations; (3) reliability, survivability, vulnerability, producibility, safety, maintainability, and transportability considerations.

Preliminary design of the operational equipment and facilities is carried to sufficient depth to define the contactor's recommended design approach. The contractor also conducts studies using human factors engineering criteria and methods to determine the training requirements, selection and design of training equipment, man-machine interfaces, and establishment of the number and type of personnel required. Logistics support, test, production, and development impacts on design of operations equipment are given appropiate consideration during this synthesis. Alternative design approaches and interfaces with other segments of the system are identified and described in sufficient detail for evaluation.

FORMS: Schematic Block Diagrams, Concept Description Sheets.

REFERENCES: AR 70-1, AR 71-5, AR 71-9, AR 385-16, AR 715-6, AR 702-3, AR 750-1

BLOCK 13.3—EVALUATION AND DESIGN

RESPONSIBILITY: Contractor

DESCRIPTION: Trade-off studies are performed to select the optimum combination of operational system elements. These studies include those directerd by the statement of work and those necessary to provide the technical subtantiation of requirements for equipment, facilities, procedural data, computer programs, manpower, and training required. Requirements of the technical specialties are identified and evaluations made on human factors engineering,safety, security, reliability, producibility, maintainability, and logistics support impact on design approaches. A thorough evaluation is made on any high technical risk techniques considered for achieving a major improvement in operational performance, maintainability, production, and the areas where the sensitivity of life cycle costs to performance has been identified as significant, The rationale for any such decisions is recorded.

Each synthesized combination of system elements and the proposed design configuration of equipment unique to a given configuration are evaluated using the system effectiveness model. The configuration of each major end item is selected in consideration of man-machine relationships with respect to operation and maintenance, safety and security, comparison of inherent reliabilities of different design approaches, and the effect of design complexity on operating reliability and maintenance. The advantages and disadvantages of designing or selecting end items which require long lead time or high cost production are considered along with their impact on deployment and maintenance. The rationale for decisions made during this iteration is recorded.

FORM: Trade-Off Study Reports

REFERENCES: AR 70-1, AR 71-5, AR 71-9, AR 385-16, AR 602-1, AR 715-6, AR 750-1

BLOCK 13.4—DESCRIPTION OF OPERATIONS ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: Detailed descriptions are prepared to enable formulation of a technical design for each operational end item. The descriptions include essential and desired operation features and specify numerical input-output values with allowable tolerances.

These descriptions include considerations pertaining to safety, man-machine interfaces, maintainability, survivability, vulnerability, reliability, producibility, transportability, and the need for and interfaces with any supporting facilities. The descriptions for all selected operations elements are supported by trade-offs studies and by decisions, with rationale which led to selection of particular elements. The descriptions define the elements in the following terms: equipment—performance constraints, design, test, and evaluation requirements; facilities—location. size, structural requirements, and equipment: personnel—numbers, types (to include MOS's where known), task performance times, and required training; procedural data—procedures to be covered and the means for imparting or communicating to the user; and computer programs—purpose, capability, input, and output requirements.

FORM: Design Sheets

REFERENCES: AR 18–1, AR 70–1, AR 71–5, AR 71–9, AR 385–16, AR 611–1, AR 702–3, AR 750–1

BLOCK 14.0—SYSTEM REQUIREMENTS REVIEW

RESPONSIBILITY: Materiel Developer

DESCRIPTION: A separate review is held with each participating prime contractor to ensure that the demonstration and validation effort is proceeding toward the objective in a logical manner. The materiel developer will ensure that the reviews are conducted so that creative or proprietary differences of the contractors are not compromised. In a competitive Demonstration and Validation Phase, the Government agencies participating must be careful to provide only negative guidance so as not to direct any one contractor toward a Government solution.

The operations elements in Block 13.4 are reviewed with each contractor to ensure that systems requirements are being met. Specific attention is directed toward a review of contractor interface documentation to ensure that compatibility is being maintained. Conceptual designs developed in Block 13.2 and selected in Block 13.4 furnish the basic information necessary for the review and evaluation of interface problems and solutions. This review ensures that adequate consideration has been given to logistics support, test, production, and deployment constraints. Compatibility of data is verified for LSAR and management purposes.

Contractor and materiel developer recommendations and actions to be taken as a result of the review are documented. The materiel develper directs specific attention to maximum use of Government-furnished equipment without compromising the capability of meeting total system requirements stated in the ROC/LR.

REFERENCE: AR 70–1

BLOCK 15.0—DEFINITION OF LOGISTICS SUPPORT REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: In Blocks 15.1, 15.2, 15.3, and 15.4, the contractor accomplishes logistics support analysis of the operations equipment and facilities described as a result of the activities of Block 13.4, to determine logistics support functions and to identify logistics support elements. This represents a portion of the logistics support analysis required by ILS. Using the system engineering process, the contractor optimizes the logistics support elements while observing the constraints imposed by operations, production, test, and deployment requirements. If the logistics support elements have an adverse effect on other system elements, the iterative process is repeated in the appropriate functional cycles using the new logistics support parameters developed. The integrity of the operations functional requirements must be preserved throughout the system engineering process while creating and maintaining an optimum economical and technical balance. This application of the system engineering process results in the Initial Description of Logistics Support Elements (Block 15.4). It also provides inputs to System Design Optimization Trade-Offs (Block 19.0).

REFERENCES: AR 70–1, AR 700–127

BLOCK 15.1—INITIAL FUNCTION ANALYSIS OF LOGISTICS SUPPORT REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The contractor identifies logistics support functions based upon the logistics support requirements of the operations equipment and facilities resulting from the activities described in Block 13.4. Each gross function is expanded in detail to the level necessary to ensure adequate definition of the logistics support requirements to satisfy demonstration and validation objectives. The logistics support function analysis completely describes the logistics support functions imposed by system requirements and constraints. The performance requirements associated with each logistics support function are developed.

An analysis of the time critical logistics support functions is conducted. The analysis depicts the concurrency, overlap, and sequential relationship of the various logistics support functions. This analysis may indicate regroupings or resequencing of logistics support functions to decrease overall maintenance time and cost, or to decrease downtime required for logistics support. The development of maintenance function requirements will be in accordance with specified system reliability and maintainability requirements.

FORMS: LSAR Forms, End Item Maintenance Sheet, Requirements Allocation Sheet, Time Line Sheet

REFERENCES: AR 70–1, AR 385–16, Ar 602–1, AR 700–127, AR 750–1

BLOCK 15.2—SYNTHESIS AND PRELIMINARY DESIGN OF LOGISTICS SUPPORT ELEMENTS

RESPONSIBILITY: CONTRACTOR

DESCRIPTION: Based on the analysis of the logistics support functions, synthesis and preliminary design is performed to define major logistics support elements. Equipment selection must be in accordance with established logistics support concepts. Peculiar equipment and facilities required by the logistics support functions are determined and selected. Quantities of equipment are related to requirements for facilities, personnel and training, procedural data, and computer programs. Items of logistics support equipment and facilities are correlated with associated system logistics support functions and functional performance requirements. Schematics are used to relate logistics support elements to their function requirements and interfaces, and to provide visibility and traceability.

As in the case of operations, the requirements specified for logistics support personnel and training will be preliminary in nature. The identification of complete personnel and training requirements will be dependent upon additional design effort and maintenance engineering analysis. Sufficient information must be developed concerning personnel and training requirements for an evaluation of the selected logistics support elements. Technical approaches for preliminary design are verified and all high risk and high cost areas identified. The operations equipment availability requirement, reliability plan, maintainability plan, product assurance plan, and proposed maintenance allocations are reviewed for their impact on the preliminary design approach. Alternatives are determined, identified, and described in sufficient detail to establish a base for trade-off studies.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 70–1, AR 71–5, AR 385–16, AR 602–1, AR 750–1

BLOCK 15.3—EVALUATION AND DECISION

RESPONSIBILITY: Contractor

DESCRIPTION: An evaluation of logistics support preliminary design is accomplished and trade-offs made with risk identified to provide a technical and economic balance between selected logistics support equipment, facilities, procedural data, personnel, training, and computer programs. The trade-off studies provide the basis for allocation of logistics support functions and design requirements.

The evaluation of logistics support preliminary design and the decision process for selection of logistics support elements include consideration of requirements for all echelons including depot maintenance; selection of logistics support elements that may be utilized for all maintenance levels; maximum utilization of selected test, production, and deployment elements, and product assurance and calibration equipment throughout all levels of logistics support; utilization of product assurance requirements and concepts throughout the spectrum of logistics support activities; an optimum balance among selected logistics support elements and specified requirements for system reliability and system equipment maintainability; and feedback of function performance requirements to ensure incorporation of necessary maintainability design features into operations equipment.

FORM: Trade-Off Study Reports

REFERENCES: AR 70–1, AR 71–5, AR 385–16, AR 602–1, AR 750–1, TM 38–703

BLOCK 15.4—INITIAL DESCRIPTION OF LOGISTICS SUPPORT ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The performance and design requirements for each selected end item of logistics support equipment and facilities provide the basis for proposed development specifications. The logistics support elements are described in the following terms: equipment—performance, constraints, design, test, and evaluation requirements; facilities—location, size, structural requirements, and equipment; personnel—number, types (to include MOS's, where known), task performance times, and required training; procedural data—procedures to be covered and the means for imparting or communicating them to the user; and computer programs—purpose, capabilities, input and output requirements.

The descriptions of logistics support elements resulting from the system engineering process as applied to maintenance will provide the basis for preparing the Logistics Support Plan and input data to LSAR. The related quality assurance requirements form an important part of these documented descriptions. The Logistics Support Plan will become more definitive as system definition and development progresses. The descriptions of logistics support elements are inputs to the System Design Optimization Trade-Offs (Block 19.0) and provide a sound basis for cost estimation.

FORM: Design sheets

REFERENCES: AR 18–1, AR 70–1, AR 71–5, AR 71–9, AR 385–16, AR 611–1, AR 750–1, TM 38–703

BLOCK 16.0—DEFINITION OF TEST REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: In Blocks 16.1, 16.2, 16.3, and 16.4, the contractor, utilizing the description of operations elements (Block 13.4) as a base, develops test functions and functional performance requirements and selects test elements for the total system. Using the system engineering process, the contractor identifies and optimizes the test elements while observing the constraints imposed by the operations, production, logistics support, and deployment elements. This optimization includes an analysis of the number of items to be tested. Test elements for utilization in all areas of life cycle testing are identified. During advanced development, engineering development, and initial production, the Single Integrated Development Test Cycle policy will be observed to ensure development and sharing of integrated data.

If the test elements selected to satisfy test functions have an adverse effect on the operations elements (Block 13.4) or other system elements, the iterative process is repeated for the appropriate functional area. The integrity of the operations function requirements must be preserved while creating and establishing an optimum economic and technical balance throughout the system life cycle. The results of the system engineering process on test elements appear in the Initial Description of Test Elements (Block 16.4). They are also inputs to System Design Optimization Trade-Offs (Block 19.0).

REFERENCES: AR 70–1, AR 70–10, AR 70–15, AR 71–3, AR 71–9, AR 702–3, AR 750–1, DA Pam 70–21

BLOCK 16.1—INITIAL FUNCTION ANALYSIS OF TEST REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The proposed test plans are reviewed to identify tests to be made on operations, logistics support, production, and deployment elements of the system. Included are those tests of the system and its elements required by the various engineering specialties. Based upon the synthesis and preliminary design resulting from the system engineering process as applied to the other functional areas, a function analysis is performed to identify all system test functions and functional performance requirements for test elements.

All test function performance requirements are identified and described in sufficient detail to permit synthesis of test equipment, facilities, personnel, procedural data, and computer programs. Test function alternatives are identified and their performance requirements are described in sufficient detail for thorough consideration in trade-off studies. Function analysis relates functional performance requirements to the test functions. Time requirements analysis is performed for time critical test functions.

FORMS: Requirements Allocation Sheet, Test Requirement Sheet

REFERENCES: AR 70-1, AR 70-10, AR 71-3, AR 71-9, AR 385-16

BLOCK 16.2—SYNTHESIS AND PRELIMINARY DESIGN OF TEST ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: This synthesis defines the test elements needed to satisfy all of the test requirements identified by the test function analysis of Block 16.1. It is performed in consideration of requirements for all test elements to include test equipment, instrumentation, and test procedures; calibration instruments and facilities; testing facilities; data collection, analysis, storage, and retrieval methods; computer programs for automated tests; personnel; and extent of data required to achieve a stated level of confidence.

Changes in the preliminary design for any of the operations, logistics support, production, or deployment elements could significantly affect test requirements. Therefore, technical personnel engaged in activities relative to definition of these operations, logistics support, production, and deployment elements must provide continuous consultation and guidance during application of the system engineering process to the test functional area. Alternative test methods and elements are identified and described in sufficient detail to provide a basis for trade-off studies. Schematics are used to postulate design concepts, define interfaces, and provide traceability. Special attention is given to selection of test elements that may be utilized in multiple test areas. This consideration includes collection of test data (beginning with feasibility test) for joint utilization throughout all life cycle phases.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 70-1, AR 70-10, AR 71-3, AR 71-9, AR 385-16, AR 602-1

BLOCK 16.3—EVALUATION AND DECISION

RESPONSIBILITY: Contractor

DESCRIPTION: This evaluation of the various test methods and elements synthesized under Block 16.2 is performed from two standpoints: the configuration of test elements which will provide the optimum test program in regard to performance, cost, and schedule; and the configuration of test elements which will provide the best technical and economic balance between the test program and the operations, logistics support, production, and deployment areas of the system. Configuration of test elements which comprise a particular test program are evaluated in terms of test set-up times, speed of data acquisition, accuracy of measurement with respect to desired accuracy limits, number of personnel, mix of personnel skills required, degree of automation, degree of calibration of instruments, commonality of test equipment for different tests, amenability of data to quick and accurate interpretation, and accessibility and applicability of data for use in later stages of development or production.

Trade-off studies are performed for achieving the best technical and economic balance with risks identified among test functions, performance requirements, personnel, facilities, number of test samples, schedules, costs, programs, procedures, equipments, and technical data requirements. Evaluation must ensure that necessary design features for test of operations and logsitics support equipment are identified in order to accomplish the required test functions. These required design features are provided to the technical personnel responsible for design evaluation of the impact to test design approaches. Test elements are selected which provide optimal utilization throughout life cycle testing of the materiel. Concepts, methodology, and techniques are selected which will optimize collection and utilization of data for all tests.

FORM: Trade-Off Study Reports

REFERENCES: AR 70–1, AR 70–10, AR 71–3, AR 71–9, AR 385–16, AR 602–1

BLOCK 16.4—INITIAL DESCRIPTION OF TEST ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The performance and design requirements for each selected end item of test equipment, facilities, and computer programs are documented to provide the basis for proposed development specifications. The descriptions identify the elements in the following terms: equipment—performance constraints, design, test and evaluation requirements; facilities—location, size, structural requirements, and equipment; personnel—numbers, types (to include MOS's, where applicable and known), task performance times, and required training; procedural data—procedures to be followed and the communication media to be used; and computer programs—purpose, capabilities, input, and output requirements. Interfaces are defined and documented to provide a sound base for cost estimates and total system trade-off studies to achieve the best technical and economic balance for test of all system elements. The descriptions of test elements are an input to Block 19.0 for System Design Optimization Trade-Offs and cost estimation.

FORM: Design Sheet

REFERENCES: AR 18–1, AR 70–10, AR 71–3, AR 71–9, AR 385–16, AR 611–1, AR 702–3

BLOCK 17.0—DEFINITION OF PRODUCTION REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The results of the system engineering process on production elements appear in the Initial Description of Production Elements (Block 17.4). They are inputs to the system Design Optimization Trade-Offs (Block 19.0).

REFERENCE: AR 70–1

BLOCK 17.1—INITIAL FUNCTION ANALYSIS OF PRODUCTION REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: Based upon the description of operations, logistics support, test, and deployment equipment items, a function analysis is performed to identify functions and their performance requirements necessary to synthesize concepts for efficient and economic production of system end items in conformance with quality standards and at specified rates required to satisfy program objectives. Production alternatives are identified and described by alternate functional models in sufficient detail to provide a base for trade-off studies. A time requirements analysis is performed for each time-critical production function.

The system engineering process is applied to the production functional area to the degree necessary to establish the concepts under which the system will be produced and to determine the requirements for any special or unique production capabilities required. This is not intended to replace or duplicate the production engineering normally performed by industrial contractors. Instead, it is accomplished to interface production engineering with system engineering in the areas necessary to determine the impact of production on system design, eliminate production risks, identify and support trade-offs, and provide a basis for cost estimating.

The contractor utilizes the descriptions of operations, logistics support, test, and deployment elements (Blocks 13.4, 15.4, 16.4, and 18.4) as a base, and develops requirements for the production elements needed to produce the system. In Blocks 17.1, 17.2, 17.3, and 17.4, through the system engineering process, he identifies and optimizes the means for efficiently and economically producing the system elements while observing the constraints imposed by the operations, test, logistics support, and deployment activities.

A continuous interplay of information is maintained between the system engineering process for production elements and the system engineering process for the operations, maintenance, test, and deployment elements in order to ensure compatibility of the selected production elements with all other system elements. Function performance requirements establish a basis for special or unique production equipment, facilities, personnel, skills, computer programs, and procedural data essential to the economic and efficient production of and preparation for delivery of all system items. The function analysis includes consideration of production engineering to match the capabilities of current or achievable industrial production techniques and processes. The requirements are stated in terms of rate of production, accuracy, lead time, production flow, tolerances, and environment (e.g., air conditioning, "clean room"). Identification and definition of unusual and special requirements are established (e.g., plant facilities, machine tools, special tooling, special test equipment, jigs, fixtures, dies). Special consideration is given to unusual performance requirements for procedural data, manufacturing personnel, manufacturing techniques and processes, safety, quality control, industrial security, material flows, tolerance allocations, materials, and preservation, packaging, and packing for shipment of system items. When contractually stipulated, the analyses includes consideration of future mobilization requirements for expansion of the production equipment base, and retention, preservation, use, and ultimate disposition of production equipment and facilities. Changes in operations, logistics support, test, deployment functions, and design approaches can materially influence the production functions and performance requirements.

FORMS: Production Sheet, Requirements Allocation Sheet, Time Line Sheet

REFERENCES: AR 37–40, AR 385–16, AR 700–15

BLOCK 17.2—SYNTHESIS AND PRELIMINARY DESIGN OF PRODUCTION ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: Various production concepts are formulated which will enable performance of the production functions delineated under Block 17.1. These concepts should describe the types and quantity of production elements needed. Prime contractor "make or buy" considerations are established on a preliminary basis. Potential sources of supply (vendors) are tentatively identified relative to all major system items. High risk and high cost production areas, long lead time items, and production areas involving contractor claimed rights-in-data are identified. Production elements and processes that affect operations, logistics support, test, and deployment elements must be provided to the technical personnel responsible for definition of these elements. Critical interfaces are identified and defined. Production-critical items are identified. Production essential to deployment. Schematic diagrams are used to identify each deployment element, provide visibility and traceability, and establish interfaces. The assurance that all interfaces are properly identified, established, and maintained is accomplished through continuous liaison among technical personnel responsible for the definition of operations, logistics support, test, and production elements. It is essential during this synthesis that high risk, high cost, and long lead time deployment items, safety, and security requirements are identified and described in sufficient detail to establish a basis for trade-off studies.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 70–1, AR 385–16

BLOCK 18.3—EVALUATION AND DECISION

RESPONSIBILITY: Contractor

DESCRIPTION: The contractor evaluates deployment functions, functional performance requirements, and deployment elements in terms of validity of performance requirements and feasibility of the technical approach. This includes evaluation of deployment alternatives and trade-offs for selection of deployment elements. The rationale for decisions is documented. Information concerning decisions which affect other system elements is furnished to the technical personnel responsible for the affected elements. Trade-off studies are performed, with risks identified, to achieve the best technical and economic balance between deployment functions and all deployment elements. Considered in the trade-off studies are the functional performance requirements in relation to deployment equipment; personnel skills and training requirements; facilities, including land; procedural data; and computer programs.

FORM: Trade-Off Study Reports

REFERENCE: AR 70–1

BLOCK 18.4—INITIAL DESCRIPTION OF DEPLOYMENT ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: Descriptions are developed for all selected deployment elements. The descriptions identify the elements in the following terms: equipment—performance, constraints, design, test, and evaluation requirements: facilities—location, size, structural requirements, and facility equipment; personnel—numbers, types (to include MOS's, where known), task performance times, and required training; procedural data—procedures to be covered and the means for imparting or communicating to the user; and computer programs—purpose, capability, input, and output requirements. The documented descriptions describe types, quantities, and availability of equipment selected. These initial descriptions of deployment elements provide input to Block 19.0 and establish a base for further trade-off studies involving operations, logistics support, test, production, and deployment elements to achieve the best technical and economic balance. The description will also provide input to the updated fielding plan (Block 22.6).

FORM: Design Sheet

REFERENCE: AR 18–1, AR 611–1

BLOCK 19.0—SYSTEM DESIGN OPTIMIZATION TRADE-OFFS

RESPONSIBILITY: Contractor

DESCRIPTION: The criteria for trade-off studies which were developed in Block 7.2 are used at this time to perform trade-offs and to optimize the preliminary design of the system. The optimum preliminary design of the system is that design which represents the best combinaion of equipment, facilities, personnel, procedural data, and computer programs. These elements have been selected separately to perform the operations, logistics support, test, production, and deployment functions. The criteria for selection of "best combination" are overall performance in terms of the measures of effectiveness models (Block 11.2), fulfillment of system specification requirements, life cycle costs, and the capability of meeting deployment schedules. Trade-off decisions and rationale, with risks identified, are documented.

FORM: Trade-Off Study Report

REFERENCES: AR 70–1, AR 71–5, AR 750–1

BLOCK 20.0—SYSTEM DESIGN REVIEW

RESPONSIBILITY: Materiel Developer, Contractor

DESCRIPTION: A system design review is held by the Materiel Developer separately with each prime contractor to ensure that design approaches are responsive to the system performance objectives established in the system specification. The Combat Developer, Trainer, and other Army agencies, as needed, participate in this review.

The description of operations elements selected by contractors as representing their optimum preliminary design of the system are reviewed and evaluated. Special attention is directed toward interface documentation, high risk areas, long lead times, and trade-off studies involving all functional areas. The Material Developer will ensure that this review is conducted so that creative or proprietary differences of the contractors are not compromised. Government agencies must be careful to provide only negative guidance so as not to direct any one contractor toward a solution preferred by the Government.

At this review it will be determined whether or not the proposed combination of operations, logistics support, test, production, and deployment elements of the system has an effect on program concepts, prior estimates of quantity or types of equipment and facilities needed, or personnel requirements. The Materiel Developer reviews the description of proposed system elements to ensure that the System Design Optimization Trade-Offs, with risks identified (Block 19.0), fully integrate the operations, logistics support, test, production, and deployment requirements. In instances where a contractor has identified the requirement for Government-furnished equipment in the DOD inventory, the Materiel Developer shall validate the availability of the items.

BLOCK 21.0—PRODUCE PROPOSED DEVELOPMENT SPECIFICATIONS

RESPONSIBILITY: Contractor

DESCRIPTION: Based upon decisions from the system design review, Development Specifications are prepared for all proposed configuration items. The Specification Tree and the Work Breakdown Structure are revised to reflect any additions or deletions. It may not be possible to identify and define every configuration item in the system during the Demonstration and validation Phase. The need for some items of equipment is dependent upon the detail design of major end items, and may be established during the Full-Scale Engineering Development Phase.

REFERENCES: AR 18–1, AR 70–1, AR 71–1, MIL-STD-490 design alternatives are determined and described in sufficient detail to provide a basis for trade-off studies, cost estimates, evaluations, and decisions.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 37-40, AR 700-51

BLOCK 17.3—EVALUATION AND DECISION

RESPONSIBILITY: Contractor

DESCRIPTION: An evaluation of the various production concepts synthesized under Block 17.2 is accomplished from the standpoints of cost, effectiveness, and potential availability. Cost includes investment in new manufacturing processes and procuring of new machinery; effectiveness includes production rates, accuracy of manufacture, assembly rates, quality control methods, ratio of acceptable items produced to total items produced; and potential availability is a measure of the lead time required to acquire necessary machinery, processes, and special handling equipment, and to hire and train new personnel. Trade-off studies which consider the above parameters are conducted to arrive at an optimal concept, with risks identified, for the production of operations, logistics support, test, and deployment equipment items. An evaluation and determination is made of the impacts that are created on design of operations, logistics support, test, and deployment equipment by use of the alternative synthesized manufacturing processes and techniques.

An important consideration in the evaluation of synthesized concepts is the need for establishment of a mobilization base. A concept which will ensure quick initiation of production a number of years after multiyear procurements have been completed is more desirable from this standpoint than a concept which does not have this attribute.

FORM: Trade-Off Study Reports

REFERENCES: AR 37-40, AR 700-15, AR 700-51

BLOCK 17.4—INITIAL DESCRIPTION OF PRODUCTION ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: Initial descriptions of production elements, production alternatives, and trade-off studies will be documented with rationale used as the basis for selection. This documentation will provide a basis for overall trade-off studies which may be found necessary between the production elements and the elements comprising operations, logistics support, test, and deployment to ensure the best technical and economic balance for production of the total system.

The production elements will be described in the following terms: equipment—performance, constraints, design, test, and evaluation requirements: facilities—location, size, structural requirements, and equipment: personnel—number, skills, task performance times, required training, and rate of buildup of production force; procedural data—procedures to be followed with respect to receipt and inspection of incoming materials, manufacturing processes, degree of automation, assembly processes, and preparation for shipment; and computer programs—purpose, capabilities, input, and output requirements.

The description of selected production elements provides the basis for updating the Proposed Production Plan (Block 10.4) which now must represent an optimum of performance, cost, and schedules for production of system items. The preliminary Product Assurance Program is reviewed to ensure compatibility with the Initial Description of Production Elements. The description of selected production elements will be an input to Block 19.0 (System Design Optimization Trade-Offs) and to the Updated Production Plan (Block 22.5).

FORM: Design Sheets

REFERENCES: AR 18–1, AR 37–40, AR 611–1, AR 700–15, AR 700–51, MIL-STD-120

BLOCK 18.0—DEFINITION OF DEPLOYMENT REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The contractor develops requirements for the elements needed for deployment of the operations and logistics support elements of the system. The system engineering process is conducted to identify and optimize these deployment elements within the constraints imposed by the opertions, logistics support, test, and production functional areas. If the deployment elements selected have an adverse effect on the operations elements or other system elements, the iterative process is repeated in the appropriate functional area. The integrity of the operations function requirements must be preserved while creating and establishing an optimal economic and technical balance throughout the system.

The results of application of the system engineering process to the deployment functional area appear in the Initial Description of Deployment Elements (Block 18.4). They are inputs to the System Design Optimization Trade-Offs (Block 19.0).

REFERENCE: AR 70–1

BLOCK 18.1—INITIAL FUNCTION ANALYSIS OF DEPLOYMENT REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: A function analysis is performed on operations and logistics support equipment and facilities to derive their initial deployment requirements. This analysis identifies system deployment functions and function performance requirements necessary for initial deployment of the system under each of the different types of operations or environments in which the system may be employed. The deployment functional model is expanded to lower indenture levels as necessary to identify the functional performance requirements essential to the selection of major deployment elements. Deployment alternatives are depicted by alternate functional models. A time requirements analysis is performed to determine the optimum concurrency or sequencing of actions which will ensure timely deployment under each type of operation or environment.

FORMS: Functional Flow Block Diagram, Requirements Allocation Sheet, Time Line Sheet

REFERENCE: AR 70–1

BLOCK 18.2—SYNTHESIS AND PRELIMINARY DESIGN OF DEPLOYMENT ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: Based upon the requirements established by function analysis, synthesis is conducted to define the major and unique deployment elements of the system. All major items of equipment needed for deployment are identified, and sufficient preliminary design accomplished to clearly indicate the design approach necessary for inclusion in the development proposal. The synthesis will ensure that the elements are adequate and suitable for performing actions

BLOCK 22.0—UPDATE PROPOSED DESIGN APPROACH

RESPONSIBILITY: Contractor

DESCRIPTION: The contractor uses the results of the System Design Review (Block 20.0) as the basis for updating his/her System Specification, System Design, Logistics Support, Test, Programs and Plans, Production, and Fielding Plans. The technical outputs are provided as inputs to the allocated baseline.

BLOCK 22.1-UPDATE SYSTEM SPECIFICATION

RESPONSIBILITY: Contractor

DESCRIPTION: From technical information developed and decisions made during Demonstration and Validation, the System Specification is expanded and updated to include overall system performance requirements, design approach, personnel utilization, training, and test requirements. The updated System Specification, along with the development specification for each proposed configuration item, will describe the contrctor's recommended allocated baseline. If, as a result of the validation effort, the contractor determines that changes to the System Specification are necessary or will provide significant improvements to the system capability, he/she recommends these changes in accordance with established configuration management procedures.

REFERENCES: AR 18-1, AR 70-1, AR 71-5, AR 71-9, AR 385-16, AR 602-1, AR 750-1, MIL-STD-480, MIL-STD-481

BLOCK 22.2—UPDATE SYSTEM DESIGN

RESPONSIBILITY: Contractor

DESCRIPTION: The preliminary design of the system optimized in Block 19.0 is updated to be consistent with the Proposed Development Specification prepared under Block 22.1. The updated system design must satisfy all functional baseline requirements.

REFERENCES: AR 70-1, AR 71-5, AR 71-9, AR 750-1, MIL-STD-490, MIL-STD-100, MIL-D-100

BLOCK 22.3—UPDATE LOGISTICS SUPPORT PLAN

RESPONSIBILITY: Contractor

DESCRIPTION: The Logistics Support Plan proposed under Block 10.2 is updated to incorporate information generated by the system engineering activities of the Validation Phase. The updated plan will include quantitative reliability and maintainability goals such as maintenance man-hours and elapsed time needed to perform the major maintenance functions of periodic inspection, routine preventive maintenance, field testing and checkout, and removal and replacement of major components in each end item of equipment; a plan by which achievement of the above goals may be demonstrated; a plan for maintenance of logistics support facilities; organizational alloation of maintenance functions; nature and number of repair facilities to be provided as part of, or in support of the system; personnel numbers, types (to include MOS's, where known), task performance times, and required training; plan for collection, feedback, analysis, and utilization of maintenance and repair data during system development, production, and operation (data content and format must satisfy requirements of the Logistics Support Analysis Record); plan for development and delivery of maintenance procedural data during various phases of the system life cycle; plan for detection of design parameters having an impact on support and a description of techniques for resolving such impact; and identification of tests indigenous to support of the system (these tests will not be included in the updated test plan).

The maintenance equipment, facilities, personnel, training, computer programs, and procedural data included in the updated Logistics Support Plan must be consistent with the proposed Development Specifications prepared under Block 21.0 and the expanded System Specifications prepared under Block 22.1

FORMS: LSAR, End Item Maintenance Sheet

REFERENCES: AR 70–1. AR 700–127. AR 750–1. TM 38–703

BLOCK 22.4—UPDATE COORDINATED TEST PROGRAM

RESPONSIBILITY: Contractor

DESCRIPTION: Using information developed under Block 16.0 as a base, the test program and plans are updated to conform with actions taken under Blocks 21.0 and 22.1 and to ensure conformance with the test concept set forth in the updated system specification. The test plans identify test objectives, the number of items to be tested, numbers and types of tests required, testing objectives, testing schedules, funding requirements, and test support requirements. The plan will be of a preliminary nature since it is dependent upon detailed design of equipment items. The plan will become more definitive as the development program progressed.

Based upon the effort accomplished under Block 16.0 the following determinations are documented in the test plans: tests for validation of compliance with proposed development specification requirements; tests required to verify compliance with product assurance, and quantitative reliability and maintainability goals; tests required on logistics support facilities; identification of special test equipment, special calibration equipment, supply or maintenance facilities, special fixed and mobile test facilities that require early development; proposed plan for test data recording, collection, storage, retrieval, analysis, and feedback of design optimization, including techniques for accumulation and use of test data to preclude duplication of tests; identification of major end items to be subjected to nuclear weapons effects testing, including long lead time requirements and required access to special facilities; proposed plan for development and delivery schedule of test/procedural data, test specifications, and test plans throughout the materiel life cycle; required mode of equipment transportation and scheduling to test site; and requirements for special tools, repair parts, and technical documentation. The test plans with supporting documents must satisfy the allocated baseline test requirements.

FORM: Test Requirements Sheet

REFERENCES: AR 70–1, AR 70–10, AR 70–15, AR 71–3, AR 71–9, AR 702–3, AR 750–1, DA Pam 70–21

BLOCK 22.5—UPDATE PRODUCTION PLAN

RESPONSIBILITY: Contractor

DESCRIPTION: Using information developed under Block 17.0 as a base, the Production Plan (Block 10.4) is updated to reflect the description of production elements and ensure conformance with the production concept set forth in the Demonstration and Validation Phase contract.

Based upon the effort accomplished under Blocks 17.0, 17.1, 17.2, 17.3 and 17.4, the following determinations will be documented in the proposed production plan: general concept for production of the system; requirements and proposed plan for development of procedural data necessary to effect production (to include production equipment specifications and drawings, formulas, methods, procedures, techniques, facilities, quality controls, and the proposed method for processing ECR's approved under the configuration management plan); requirements for production engineering with required lead time; requirements for production management capability, technical capability, quality controls, potential for quantity production and possible supply sources; industrial safety and security requirements; quantitative production reliability goals; recommended production rates and schedules; high production risk and cost, long lead time items and unusual production requirements; recommendations relative to establishment of a production base for mobilization with production rates and schedules; proposed plan for identification of contractor claimed rights-in-data and their impact on production and costs; plans, methods, and techniques for feedback of production information for system design optimization; recommendation for contractor structure to produce the total system equipment (to include prime contractor structure, subcontractor structure, or Government facilities as check and assembly points for major system elements); and proposed "make or buy" plan and subcontracting procurement plan. The Production Plan must satisfy all the allocated baseline production requirements.

FORM: Production Sheet

REFERENCES: AR 70–1, AR 37–40, AR 385–16, AR 700–51, AR 702–3, MIL-STD-100, MIL-D-100

BLOCK 22.6—UPDATE FIELDING PLAN

RESPONSIBILITY: Contractor

DESCRIPTION: The Fielding Plan is updated using information developed under Block 18.0. It will include the proposed approach for accomplishment of functions such as transportation, receiving, processing, installation, checkout, and required emplacement, housing, storing, or activation at the user location. All major items of equipment and facilities needed for deployment, as well as any safety and security requirements, are identified. The plan must be consistent with the system configuration being proposed, and the collateral logistics support, test, and production plans.

REFERENCES: AR 70–1, AR 70–17, AR 71–5, AR 385–16, AR 611–1

BLOCK 23.0—TECHNICAL INPUTS TO ALLOCATED BASELINE

RESPONSIBILITY: Contractor

DESCRIPTION: The demonstration and validation contractor assembles all the technical outputs of Blocks 21.0 and 22.0 and provides them as technical inputs to the allocated baseline. These technical inputs consist of the expanded Systems Specifications, updated Development Specifications (Allocated Configuration Identifications), and updated recommended support, test, production, and deployment plans. The technical inputs to the allocated baseline will provide part of the basis for the engineering development contract negotiations.

REFERENCES: AR 18–1, AR 70–1, AR 70–37, AR 702–3, AR 715–6

BLOCK 24.0—INPUTS TO PRODUCIBILITY ENGINEERING AND PLANNING (PEP) AND DT II TEST DESIGN PLAN

RESPONSIBILITY: Contractor

DESCRIPTION: PEP should be initiated as soon as production requirements are established, but no later than DT II/OT II. Its purpose is to ensure a smooth transition from development to production, anticipating potential manufacturing problems, and seeking design and schedule trade-offs to facilitate the manufacturing process. DT II is designed to measure technical performance (e.g., RAM, compatibility, interoperability, safety, supportability) of the system and its associated support equipment, training, and logistics support packages; to demonstrate that engineering is reasonably complete; that solutions are in hand for all significant design problems; and that the system is ready for transition to production. The test is designed to require maximum exchange of test data between the contractor and materiel developer.

REFERENCES: AR 70–1, AR 70–10, AR 70–27, AR 70–37, AR 71–3, AR 700–90

B–4. The Full-Scale Engineering Development Phase (Fig. B–3)

a. The Full-Scale Engineering Development Phase begins with validation IPR/ASARC II/DSARC II approval that advanced development (brassboard) prototypes and their associated allocated configura tion identifications (allocated baselines) describe prototypes which will satisfy approved materiel needs stated in the ROC/LR. The phase ends with an engineering development prototype which very closely approximates the anticipated final product along with its documentation and test results which support a descision to enter the Production and Deployment Phase.

b. This phase of the materiel life cycle applies to all engineering development and operational system development projects. It involves detail design, development, and production of operations, logisitics support, test, deployment, and production equipment.

c. In instances when demonstration and validation is not mandatory, this phase may follow the Alternative Systems Concepts Phase, and include those functional processes and management procedures which are normally accomplished during validation. While development and production are separate functions which may be contracted on an individual basis, they may overlap as determined by production engineering programs and type-classification actions.

d. Blocks 25.0 through 43.0 describe system engineering activities in the Full-Scale Development Phase.

(Locate fig. B–3, a fold-out, at the end of this manual.)

SYSTEM ENGINEERING ACTIVITIES
FULL-SCALE ENGINEERING DEVELOPMENT PHASE

BLOCK 25.0—SYSTEM ENGINEERING INPUTS TO PLANS AND SCHEDULES

RESPONSIBILITY: Materiel Developer/Contractor

DESCRIPTION: This input is generated from the system engineering activities which were accomplished during demonstration and validation and as provided by ILS. It consists of the technical approaches selected to satisfy the requirements for which the project was established and other engineering information pertinent to the establishment of development, production, and test schedules; cost estimates; management and information systems; logistics support plans; and personnel staffing plans. This input provides a means with which to define, identify, and control various interfaces at predetermined points in time throughout the materiel life cycle, and ensures proper relationships of the design efforts to system engineering activities.

REFERENCES: AR 70–1, AR 70–17, AR 70–27, AR 70–37, AR 71–5, AR 71–9, AR 611–1, AR 750–1

BLOCK 26.0—COMPLETION OF PRELIMINARY DESIGN FOR OPERATIONS ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The completion of preliminary design for operations elements must be accomplished early in the Full-Scale Engineering Development Phase. The validation contractor(s) will normally have accomplished preliminary design for the operations elements to the indenture level necessary for formulation of firm proposals to enter the Full-Scale Engineering Development Phase. In those instances where a formal Demonstration and Validation Phase is not required, i.e., where a program proceeds directly from Alternative System Concepts to the Full-Scale Engineering Development Phase, it becomes even more essential that the system engineering process be applied early in development for completion of preliminary design of operations elements. These provide a basis for detail design and for performing preliminary design of logistics support, test, production, and deployment elements. Following award of the development contract, Blocks 26.1, 26.2, 26.3, and 26.4 describe the system engineering activities necessary for completion of preliminary design for operations elements. The documented descriptions of operational elements, Block 26.4, provide the necessary base for the preliminary design characteristics review (PDCR) of operation elements (Block 27.0). The completion of the PDCR establishes a firm base for detail design of operations elements and for definitization of requirements for logistics support, test, production, and deployment elements.

REFERENCES: AR 70–1

BLOCK 26.1—FUNCTION ANALYSIS

RESPONSIBILITY: Contractor

DESCRIPTION: The function analysis conducted during demonstration and validation is expanded to indenture levels necessary to establish all operation function performance requirements for completion of preliminary design for operations elements. The additional function performance requirements are firmly established and stated in sufficient detail for use as criteria for equipment design and operation, personnel skills and tasks, facilities, computer programs, and procedural data. A time requirements analysis is performed for any time critical functions.

FORMS: Functional Flow Block Diagram, Requirements Allocation Sheet, Time Line Sheet

REFERENCES: AR 70-1, AR 385-16, AR 602-1, AR 700-47, AR 702-3, MIL-D-1000, MIL-STD-100

BLOCK 26.2—SYNTHESIS AND COMPLETION OF PRELIMINARY DESIGN

RESPONSIBILITY: Contractor

DESCRIPTION: Synthesis and preliminary design of operations elements are completed as lower indenture level function performance requirements are established during the function analysis. Schematic diagrams are used to portray selected operations elements and their arrangement and interfaces in the system. A continuous interchange of engineering information is maintained among operations, logisitcs support, test, production, and deployment design activities. Visibility and traceability are provided by schematic diagrams. High risk, high cost, and long lead time items are identified. The preliminary designs for operations equipment and facilities are completed in order to establish a base for initiation of detail design. All required equipment, facilities, personnel, procedural data, and computer programs are identified. Alternatives are determined, identified, and described in sufficient detail to establish a basis for trade-off studies.

FORMS: Schematic Diagrams, Concept Design Sheets

REFERENCES: AR 70-1, AR 385-16, AR 700-47, AR 702-3, MIL-D-1000, MIL-STD-100

BLOCK 26.3—EVALUATION AND DECISION

RESPONSIBILITY: Contractor

DESCRIPTION: Evaluation is made of the prelimary design accomplished to satisfy functional performance requirements. Trade-off studies are conducted to establish a technical and economic balance among operations elements with minimum risk. Care is taken to ensure that this balance is retained for the total system. The evaluation and decision process ensures that the preliminary designs for operations equipment and facilities are sufficiently complete and adequate to provide a firm base for application of the system engineering process to logistics support, test, production, and deployment functional areas.

FORMS: Trade-Off Study Reports

REFERENCES: AR 70-1, AR 385-16, AR 602-1, AR 700-47, AR 702-3, MIL-D-1000, MIL-STD-100

BLOCK 26.4—DESCRIPTION OF OPERATIONS ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The performance requirements and preliminary design of selected operations equipment and facilities are documented to provide a firm base for detail design. Descriptions are produced for all selected operations elements in the following terms: equipment—performance, constraints, design, test, and evaluation requirements; facilities—location, size, structural requirements, and equipment; personnel—numbers, types (to include MOS's where known), task performance times, and required training; procedural data—procedures to be covered and the means for imparting or communicating them to the user; and computer programs—purpose, capabilities, and input and output requirements. All requirements, including interfaces, are identified, defined, and documented to achieve the best technical and economic balance for the total system.

FORMS: Design Sheet, Facilities Interface Sheet

REFERENCES: AR 70–1, AR 385–16, AR 602–1, AR 700–47, AR 702–3, MIL-STD-100A, MIL-D-1000A

BLOCK 27.0—PRELIMINARY DESIGN CHARACTERISTICS REVIEW OF OPERATIONS ELEMENTS

RESPONSIBILITY: Materiel Developer/Contractor/Combat Developer

DESCRIPTION: Preliminary design characteristics reviews (PDCR) are conducted for each operations configuration item (CI) and facility. The purpose of the review is to ensure that the preliminary design approach in terms of equipment, facilities, personnel, procedural data, and computer programs is an acceptable design solution to total system and configuration item requirements. The combat developer, trainer, and other Army agencies, as needed, participate in this review. The basic documentation reviewed includes the requirements sections of the system, and development specifications and the system engineering data generated during preliminary design of operations equipment and facilities. Considerations at the time of a preliminary design characteristics review include compliance with established design criteria, evaluation of engineering drawings, breadboards/brassboards and models, interface between configuration items, schedule compatibility, and life cycle costs. Preliminary design characteristics reviews are conducted on an incremental basis and, whenever possible, on related groups of operations equipment. They are accomplished in accordance with the schedule and attendance requirements specified in provisions of the development contract. Action items resulting from a PDCR can be made contractually binding only by appropriate action of the procuring contracting officer. During this review, information will be available for inclusion in the Logistics Support Analysis Record (LSAR) to assist in preparation of maintenance and other logistics support requirements by location.

REFERENCES: AR 70–1, AR 385–16, AR 602–1, AR 750–1, MIL–STD–100A, MIL-STD-490, MIL-D-1000A

BLOCK 28.0—DETAIL DESIGN OF OPERATIONS EQUIPMENT AND FACILITIES

RESPONSIBILITY: Contractor

DESCRIPTION: The technical data, such as function diagrams, function performance requirements, time requirements analysis, and schematic diagrams generated from preceding system engineering activities, provide the logic and constraints for detail design. Based on this data and the engineering drawings, breadboards/brassboards and models developed by preliminary design effort is directed toward accomplishing design in the detail required for manufacturing, instruction, programing, operating, and inspecting. It is an objective of system engineering to ensure that detail design efforts are coordinated and comprehensive, and that all engineering disciplines and technologies have been integrated to obtain an optimum final system design. Operations facility requirements, if any, are considered in order to ensure proper equipment and facility interfaces. Methods of ensuring design coordination and completeness include prescribing documentation approval and release procedures and establishing communication flows to obtain an adequate exchange of expertise. Although shown as a single block on the flow diagram, detail design of operations equipment and facilities is a continuous effort and is not completed until approval and release of Product Configuration Identification. The effort overlaps the detail design of logistics support, test, production, and deployment equipment and facilities, and is influenced by the requirements of those designs.

REFERENCES: AR 70-1, AR 385-16, MIL-STD-100A, MIL-STD-480, MIL-STD-481,MIL-STD-482, MIL-D-1000A

BLOCK 29.0—DEFINITION OF ADDITIONAL LOGISTICS SUPPORT REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: As detail design of operations equipment and facilities progresses (Block 28.0), the system engineering process is directed toward the development of additional logistics support requirements for each configuration item in order to define additional logistics support elements. During this process, the logistics support requirements developed during the Demonstration and Validation Phase and documented in Logistics Support Analysis Record (LSAR) are refined and expanded. The detail design of operations equipment (Block 28.0) is a continuing and progressive activity over a long period of time in the Full-Scale Engineering Development Phase. Therefore, this process for defining detailed logistics support requirements must progress over time in concert with the detail design activity. As logistics support production and test equipment items and facilities are designed, they are also analyzed to determine their logistics support requirements. The process continues until all logistics support elements required by the system have been selected and defined. This process constitutes the maintenance engineering analysis required by ILS and the data output is provided in a format compatible with LSAR. The description data is used to update LSAR and provide the basis for the preliminary design characteristics review of logistics support elements (Block 33.1) and detail design of logistics support equipment and facilities (Block 34.2).

BLOCK 29.1—DETAIL FUNCTION ANALYSIS OF ADDITIONAL LOGISTICS SUPPORT REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: As designs evolve for operations and logistics support equipment and facilities, an analysis of each of these items is conducted to determine the logistics support functions and performance requirements for each. Qualitative and quantitative requirements are established for each logistics support function identified. The logistics support function ananlysis is carried to the lowest reparable nonstandard component for each configuration item; however, the depth of analysis necessary depends to some extent on the complexity or uniqueness of the configuration item. This function analysis is an expansion in detail of that initiated in the Demonstration and Validation Phase. The objective is to identify what has to be done to ensure that the system, subsystem, or component is maintained in an operable condition. A time requirements ananlysis is conducted for maintenance functions which are critical from the standpoint of system or equipment downtime or utilization of maintenance resources.

FORMS: Requirements Allocation Sheet, End Item Maintenance Sheet (LSAR), Time Line Sheet

REFERENCES: AR 70–1, AR 70–17, AR 700–127, AR 750–1

BLOCK 29.2—SYNTHESIS AND PRELIMINARY DESIGN OF ADDITIONAL LOGISTICS SUPPORT ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: Based upon the function analysis, a synthesis is accomplished to derive a combination of system elements that satisfy the logistics support functional requirements. Man/machine support equipment relationships are important considerations in synthesis. Product assurance and calibration requirements are considered in this synthesis. The synthesis is expressed in terms of design reqhuirements and design approaches for equipment and facilities and their interface, personnel tasks to be performed, task performance times, training and training equipment required, procedural data, and computer program requirments. The objectives are reduction in total manpower, level of technical skills and training required, and the probability and consequences of human error; use of standard parts, maintenance equipment, calibration components, modules, tools, and test equipment; interchangeability of parts, components, modules; accessibility for adjustment, calibration, and repair; reduction of repair frequency; use of throw-away and metered components; speed in malfunction diagnosis and fault isolation; reduction in repair time and downtime; and time between overhaul extensions based upon section replacement for components. Alternative logistics support elements are identified and described in sufficient detail to enable evaluation and decision.

FORMS: Schematic Block Diagram, Concept Design Sheet

REFERENCES: AR 70–1, AR 385–16, AR 602–1, AR 700–127, AR 702–3, AR 750–1, TM 38–703.

BLOCK 29.3—EVALUATION AND DECISION

RESPONSIBILITY: Contractor

DESCRIPTION: A continuous evaluation is performed to select logistics support elements from among the alternatives which have been synthesized. This evaluation includes trade-off studies to determine those methods, approaches, and techniques which can best meet the requirements. Typical subjects for study include levels of logistics support, quantity of equipment, facility utilization, degree of automation for maintenance, technical risk, and total predicted costs. The equipment, repair parts, personnel, training, and facility requirements, and requirements imposed on the rest of the system by the solution selected are identified. The most promising design approaches are selected and the rationale for their selection is documented. Decisions that affect other system elements are coordinated with the personnel responsible for the affected elements.

FORMS: Trade-Off Study Report

REFERENCES: AR 702–3, AR 750–1

BLOCK 29.4—DESCRIPTION OF ADDITIONAL LOGISTICS SUPPORT ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The description of logistics support elements documented in the Demonstration and Validation Phase is updated and expanded to incorporate

BLOCK 30.4—DESCRIPTION OF ADDITIONAL TEST ELEMENTS

RESPONSIBILITY: Materiel Developer/Contractor

DESCRIPTION: Complete descriptions of test elements are developed based upon decisions reached during the evaluation and decision process. These descriptions state the design and performance requirements for equipment and facilities needed to accomplish test functions on operations and logistics support elements of the system. They accommodate and comply with constraints imposed by operations and logistics support procedures, previously specified test facilities, and location and types of test personnel. The descriptions define performance parameters including tests and measurements to be performed, accuracies required, reliability, redundant requirements, and methods of performance. Software requirements are also described. Drawings, associated lists, and other documents oriented toward test equipment items and facilities are prepared. End items are described in terms of performance and design requirements. Personnel are described in terms of tasks, skill levels, performance capabilities, and responsibilities. Facilities are described by their purpose, capabilities, and input-output requirements. Test data requirements are described in terms of the type, method of collection, presentation dissemination, and purposes.

FORMS: Design Sheet

REFERENCES: AR 18-1, AR 70-1, AR 70-10, AR 70-37, AR 71-3, AR 611-1, AR 702-3, MIL-D-1000A, MIL-STD-480, MIL-STD-481, MIL-STD-482

BLOCK 31.0—DEFINITION OF ADDITIONAL PRODUCTION REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: As detail design of operations and logistics support equipment progresses, the system engineering process is applied to the production functional area to identify the requirements for any additional unique production elements. During this application of the process, production performance requirements developed during the Demonstration and Validation Phase are refined and expanded. The detail design operations and logistics support equipment is a continuing and progressive activity in the Full-Scale Engineering Development Phase. This process for defining production requirements must progress in concert with the detail design activity. The process continues until unique production elements required by the system have been selected and defined.

BLOCK 31.1—DETAIL FUNCTION ANALYSIS OF ADDITIONAL PRODUCTION REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: As designs for equipment and facilities are completed, a function analysis of the production requirements for each configuration item is performed. This analysis is an expansion of the analysis initiated in the Demonstration and Validation Phase. Its purpose is to determine additional unique production functions to be performed. The analysis establishes the performance requirements for production elements essential to the economical and efficient production of system items. Consideration is given to unusual requirements for procedural data, personnel skills, manufacturing techniques and processes, quality control, material flows, and packaging and packing for shipment of system items. The function analysis continues during detail design to establish unique process and tasks required for adequate and timely modifications. A time requirements analysis is performed for time-critical production functions.

FORMS: Functional Flow Block Diagram, Requirements Allocation Sheet, Production Sheet, Time LIne Sheet

REFERENCES: AR 37–40

BLOCK 31.2—SYNTHESIS AND PRELIMINARY DESIGN OF ADDITIONAL PRODUCTION ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: Additional elements required to produce operations, logistics support, test, and deployment equipment are identified. This identification includes requirements and approaches for special and unique facilities, machine tools, materials, personnel skills, manufacturing processes and techniques, computer programs, procedural data, special tooling, inspection and test equipment jigs, fixtures, quality control, and packaging and packing to ship system items. Schematic diagrams are used to identify selected production elements. Preliminary designs of unique production equipment and facilities are developed and compared to production function performance requirments in order to ensure that barrier requirements have been met. Special consideration is given to high production risks and costs, and long lead time items previously identified. Alternative production methods are identified and described in sufficient detail to provide sound bases for trade-off studies used in evaluation and decision.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 37–40, AR 611–1, AR 700–51

BLOCK 31.3—EVALUATION AND DECISION

RESPONSIBILITY: Contractor

DESCRIPTION: An evaluation of the synthesis of production methods and the preliminary design of unique production and facilities is performed by conducting effectiveness and trade-off studies to determine the best combination of production elements. Only reasonable approaches that are within the state-of-the-art minimum technical risk, or economically achievable advances in industrial technology are pursued. A continuous exchange of data is maintained between all system engineering activities to determine impact on production elements when modifications to the operations, logistics support, test, and deployment equipment items are made. Trade-offs are made, production elements selected, and preliminary design established.

FORMS: Trade-Off Study Reports

REFERENCES: AR 37–40, AR 71–9, AR 700–51, MIL-STD-100

BLOCK 31.4—DESCRIPTION OF ADDITIONAL PRODUCTION ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The description of production elements as documented during the validation phase are updated and expanded to describe in detail the additional elements required. The descriptions identify elements in terms of personnel—numbers, types, duties, task performance times, and required training; equipment—performance, design, quality control criteria. and evaluathe latest and best technical and economic balance for the system elements. Items of equipment are described in terms of performance, design, test, and evaluation requirements. Personnel are described in terms of numbers, types (to include MOS's where known), task performance times, and required training. Facilities are described in terms of location, size, structural requirements, and facility equipment. Computer programs are described by their purpose, capabilities, and their input and output requirements. Procedural data requirements are described in terms of the procedures to be covered and the types of manuals required. Logistics support elements are described in sufficient detail to provide the system engineering inputs to integrated logistics support.

FORMS: Design Sheet

REFERENCES: AR 18–1, AR 71–5, AR 602–1, AR 611–1, AR 702–3, AR 750–1, TM 38–703

BLOCK 30.0—DEFINITION OF ADDITIONAL TEST REQUIREMENTS

RESPONSIBILITY: Materiel Developer/Contractor

DESCRIPTION: As detail design of operations and logistics support equipment progresses, the system engineering process is applied to the test functional area to identify the requirements for any additional test elements. During this application of the process, the test requirements which were developed during validation are expanded and refined. The detail design of operations and logistics support equipment is a continuing and progressive activity in the full-scale development phase. This process for defining detail test requirements must progress in concert with the detail design activity. The process continues until all test elements required by the system have been selected and defined.

BLOCK 30.1—DETAIL FUNCTION ANALYSIS OF ADDITIONAL TEST REQUIREMENTS

RESPONSIBILITY: Materiel Developer, Contractor

DESCRIPTION: The detail function analysis of test requirements is accomplished as detail design of operations equipment (Block 28.0), description of additional logistics support elements (Block 29.4), and the test plans develop. This function analysis is conducted to identify critical parameters which require testing to demonstrate satisfaction of the ROC/LR, system specifications, and development specifications. Test plans concern those activities involved in testing and evaluation of the operations and logistics support elements to determine their suitability and conformance to detailed technical requirements. These tests do not include those inherent in the operations mission or in the maintenance of the operations equipment and facilities. In performing the analysis, various charts and diagrams are prepared to define the test functions to be performed on each operations logistics support configuration item. This analysis is carried to the level necessary to prescribe all system test requirements during the Full-Scale Engineering Development and Production and Deployment Phases. A time requirements analysis is performed for critical test functions. Test requirements analyses must be conducted in conjunction with the operation and logistics support cycles and the test plans in order to develop design requirements for all categories of test and checkout equipment. Each iteration of the operations and logistics support cycles introduces new requirements or constraints on the test functions. Time-phased planning of test functions is conducted at this time. The test function analysis can be completed only when operations and logistics support elements have been firmly defined.

FORMS: Functional Flow Block Diagram, Requirements Allocation Sheet, Test Requirement Sheet, Time Line Sheet

REFERENCES: AR 70–1, AR 70–10, AR 70–15, AR 71–3, AR 385–16, AR 702–3, AR 750–1

BLOCK 30.2—SYNTHESIS AND PRELIMINARY DESIGN OF ADDITIONAL TEST ELEMENTS

RESPONSIBILITY: Materiel Developer, Contractor

DESCRIPTION: Based upon the function analysis, a synthesis is accomplished to devise methods for meeting test function requirements. Various approaches which incorporate the combination of procedures, equipment, and personnel skills are synthesized. Special consideration is given to the amount of built-in test capability, and the degree of failure diagnosis and fault location required to successfully accomplish objectives of the test program; compatibility with multipurpose, automatic diagnostic equipment in the field and the test site; minimum requirements for special test equipment; requirements for test equipment access points or connections; built-in sensors or measuring devices, such as those needed for telemetry; simulation techniques, where applicable; and requirements for testing by the Government. Wherever possible, contractor testing and data will be used to satisfy Materiel Developer requirements and objectives. During synthesis, awareness of existing test equipment and facility capabilities is required to preclude unnecessary development of special test equipment, facilities, and computer programs; identification of the personnel skills, numbers, and training required to perform test functions; and procedural drafts and detailed test procedures prescribing methods for performance of test functions. Preliminary design of new test equipment and facilities is accomplished, and requirements for off-the-shelf items and existing facilities are documented. Preliminary design and detailed test procedures are compared with test function requirements in order to ensure that all requirements have been met. Operations and maintenance procedural requirements are considered as constraints on the test equipment and procedures package.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 70–1, AR 70–10, AR 71–3, AR 385–16, AR 602–1, AR 702–3

BLOCK 30.3—EVALUATION AND DECISION

RESPONSIBILITY: Materiel Developer/Contractor

DESCRIPTION: Comparison and trade-off studies are conducted on the various options developed during synthesis and preliminary design. The objective is the formulation of decisions which optimize the selection and usage of test equipment, facilities, and procedures, and minimize requirements for special test elements. The factors involved in making these decisions include mission, operations, and design characteristics of the equipment, anticipated and/or required reliability, maintenance structure, equipment and personnel available to the tester, operations environment, logistics support requirements, technical risk, and development time and costs. Special purpose, general purpose, and built-in test equipment are compared on the basis of the above factors. Trade-offs of manual vs. automatic, and built-in vs. portable test instrumentation and data collection equipment are accomplished during the evaluation. The above factors are a basis for determining sample size, replications, and data accuracy.

FORMS: Trade-off Study Report

REFERENCES: AR 70–1, AR 70–10, AR 71–3, AR 702–3, AR 750–1

BLOCK 33.0—PRELIMINARY DESIGN CHARACTERISTICS REVIEW (PDCR) OF LOGISTICS SUPPORT ELEMENTS

RESPONSIBILITY: Materiel Developer/Contractor

DESCRIPTION: The objective of this review is to ensure that design requirements approved, established, and contracted against at the end of the Demonstration and Validation Phase can be achieved; engineering design approach taken by the contractor is technically feasible and sound; and detail design can implement the design approach. Changes to development engineering documentation are made to reflect changes to design, design approach, personnel tasks, facility requirements, training and training equipment requirements, and procedural data. This review establishes that the logistics support elements are still compatible with previously accomplished design or that Engineering Change Requests have been initiated and approved to meet updated requirements. The approved data will update Logistics Support Analysis Records (LSAR).

REFERENCES: AR 602-1, AR 700-127, AR 750-1

BLOCK 34.0—PRELIMINARY DESIGN CHARACTERISTICS REVIEW (PDCR) OF TEST ELEMENTS

RESPONSIBILITY: Materiel Developer/Contractor/Combat Developer

DESCRIPTION: When test elements have been fully described, a preliminary review of their characterisitcs is undertaken and the selected approach for testing is verified. Through this review, the responsible activities ensure that the testing approach is reasonable and is within the state-of-the-art. They ensure that all test requirements can be met within the time and funding constraints of the program and that maximum utilization of test data is made to meet test requirements.

REFERENCES: AR 70-1, AR 70-10, AR 71-3, AR 71-9, AR 385-16, AR 700-51, AR 750-1

BLOCK 35.0—PRELIMINARY DESIGN CHARACTERISTIC REVIEW (PDCR) OF PRODUCTION ELEMENTS

RESPONSIBILITY: Materiel Developer, Contractor

DESCRIPTION: This review is conducted on each unique item of production equipment, facilities, and associated production elements. It is intended to evaluate the producibility of the operations and logistics support equipment items, evaluate the adequacy of procedural data, ensure compatibility with the product assurance program and technical adequacy of the selected designs, and determine compatibility with the system specification.

REFERENCES: AR 37–40

BLOCK 36.0—PRELIMINARY DESIGN CHARACTERISTICS REVIEW (PDCR) OF DEPLOYMENT ELEMENTS

RESPONSIBILITY: Materiel Developer, Contractor

DESCRIPTION: This review is conducted to evaluate the progress and technical adequacy of the selected design approach in order to determine its compatibility with the initial description as prepared during validation. Preliminary design characteristics reviews are held by the materiel developer to ensure that all deployment aspects are duly considered prior to detail design. These reviews provide for any changes updating of plans and documents to reflect these changes prior to commencing detail design.

REFERENCE: AR 70–1

BLOCK 37.0—SYSTEM DESIGN OPTIMIZATION

RESPONSIBILITY: Contractor

DESCRIPTION: The optimum detail design of the system is that design which represents the best combination of system elements which have been selected to perform the operations, logistics support, test, production, and deployment functions. The criteria for selection of this "best combination" are overall performance in terms of fulfillment of system specification requirements, life cycle costs, and elapsed time needed to meet deployment schedules. The criteria developed under Block 7.2 (Develop Criteria for Trade-Off Studies) will have been included in the contract work statement and will be utilized in performing trade-offs to achieve the best combination of system elements. The trade-off studies, including risk analysis, are documented with the rationale that led to the decisions and submitted to the Government as required by the terms of the contract.

REFERENCES: AR 70–1, AR 700–51

BLOCK 38.0—DETAIL DESIGNS

RESPONSIBILITY: Contractor

DESCRIPTION: Based on the satisfactory completion of the Preliminary Design Characteristics Review of logistics support, test, production, and deployment elements, Blocks 38.1, 38.2, 38.3, and 38.4 describe the detail design of these elements. Output of the detail design activities will be in the form of detained engineering documentation which defines the configuration of each element.

tion requirements: facilities—location, size, structural requirements and equipment; procedural data—procedures to be covered and documentation for imparting the data to the user; and computer programs—purpose, capabilities, input, and output requirements.

FORM: Design Sheets

REFERENCES: AR 18–1, AR 37–40, AR 611–1, AR 700–51, MIL-STD-100A, MIL-D-1000A

BLOCK 32.0—DEFINITION OF ADDITIONAL DEPLOYMENT REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: As detail design of operations and logistics support equipment and facilities progresses, the system engineering process is applied to the deployment functional area to identify the requirements for any additional deployment elements. The detail design of operations and logistics support equipment and facilities is a continuing and progressive activity in the Full-Scale Engineering Development Phase. Therefore, this process for defining deployment requirements must progress in concert with detail design activity. The process continues until all deployment elements required by the system have been selected and defined. Data output from this iterative process will be used to update existing documentation. The process will provide sufficient data for the PDCR of deployment elements (33.4) and detail design of deployment equipment (Block 34.5).

BLOCK 32.1—DETAIL FUNCTION ANAYLSIS TO ADDITIONAL DEPLOYMENT REQUIREMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: As detail designs are completed for the operations and logistics support equipment and facilities, a function analysis of additional deployment requirements for the system and/or each end item is accomplished. This analysis is conducted in conformance with the fielding plans which were prepared and updated during the Demonstration and Validation Phase. This analysis is to determine additional and specific deployment functions to be performed to transport, receive, process, install, checkout and, as required, store or activate the system at user location. The analysis considers physical movement in the light of distribution and transportation capabilities, and to the extent practicable, identifies functional requirements associated with primary transportation modes and unusual or specialized movement and handling requirements. The function analysis continues during detail design to establish adequate and timely processes and tasks. For each function identified, the performance requirements are stated in definitive terms to provide a basis for selecting the system elements necessary to achieve the objectives of the fielding plan. A time requirements analysis is accomplished in consideration of critical and emergency situations which may affect time for activation of operations and maintenance equipment and facilities.

FORMS: Functional Flow Block Diagram, Requirements Allocation Sheet, Time Line Sheet

REFERENCES: AR 70–1, AR 70–17

BLOCK 32.2—SYNTHESIS AND PRELIMINARY DESIGN OF ADDITIONAL DEPLOYMENT ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The synthesis of additional deployment elements and preliminary design of deployment equipment are accomplished at this time. This effort may be performed concurrently with function analysis to complete the definition of deployment processes, tasks, and equipment necessary to support the deployment functions. The synthesis is pursued selectively on the basis of complexity and uniqueness of the end item and in consideration of man/machine relationships, alternative methods or combinations of resources, availability of Government-furnished equipment, and charactreristics of equipment, facilities, personnel, and procedural data required to support transportation, training, installation, checkout, storage and/or activation of the system or end item. Preliminary design of deployment equipment is completed to the extent that the design of operations and logistics support equipment has been completed so that specific transport media may be designated and evaluated, and modifications identified to provide timely availability of equipment and services in support of projected delivery schedules. During synthesis, personnel requirements are identified in terms of personnel tasks to be performed, task performance times, and changes to procedural data.

FORMS: Schematic Block Diagram, Concept Description Sheet

REFERENCES: AR 70–1, AR 71–5, AR 611–1

BLOCK 32.3—EVALUATION AND DECISION

RESPONSIBILITY: Contractor

DESCRIPTION: Continuous visibility of the operations and logistics support elements is maintained so that deployment decisions may be reviewed and revised as conditions changed and to permit evaluation of deployment alternatives which were previously synthesized. From this evaluation, the most effective means, approaches, and techniques which can be employed to accomplish deployment function requirements are determined. Only reasonably attainable low risk design approaches are pursued in consideration of technical capabilities, cost, schedules, resource limitations, or other constraints as specified in system requirement documentation. Decisions that affect other system elements must be coordinated with the personnel responsible for the affected elements.

FORM: Trade-Off Study Reports

REFERENCE: AR 70–1

BLOCK 32.4—DESCRIPTION OF ADDITIONAL DEPLOYMENT ELEMENTS

RESPONSIBILITY: Contractor

DESCRIPTION: The descriptions of deployment elements developed during the Demonstration and Validation Phase are updated and expanded at this time to describe in sufficient detail the equipment, facilities, personnel, procedural data, and computer programs required to support deployment of the system/end item. The completed descriptions of deployment elements are the basis from which to initiate detail design. The descriptions identify these elements in the following terms: equipment—performance, constraints, design, test, and evaluation requirements; facilities—location, size, structural requirements, and equipment; personnel—numbers, types (to include MOS's where applicable and known), task performance times, and required training; procedural data—procedures to be covered and the means for imparting or communicating to the user; and computer programs—purpose, capability, input, and output requirements.

FORM: Design Sheet

REFERENCES: AR 18–1, AR 70–1, AR 71–5, AR 611–1

BLOCK 38.1—DETAIL DESIGN OF LOGISTICS SUPPORT EQUIPMENT AND FACILITIES

RESPONSIBILITY: Contractor

DESCRIPTION: As designs evolve for operations and logistics support equipment, detail design specifications for logistics support equipment and its associated facilities are prepared. These specifications contain reference to an approved top level drawing for the configuration item. The detail design is constantly assessed against the performance/design requirements and the selected design approach. The "build-to" documentation must be emphasized to ensure that the product matches the requirements established for it and the criteria against which the product is to be delivered and accepted. Engineering documentation evolves in the form of detail drawings, interface drawings, detailed specifications for logistics support equipment, and facilities and engineering breadboards/brassboards and mockups.

REFERENCES: AR 18–1, AR 70–1, AR 385–16, AR 602–1, AR 611–1, AR 700–127, AR 750–1, MIL-STD-100A, MIL-STD-490, MIL-D-1000A

BLOCK 38.2—DETAIL DESIGN OF TEST EQUIPMENT AND FACILITIES

RESPONSIBILITY: Materiel Developer, Contractor

DESCRIPTION: Detail design of test equipment and its associated facilities is accomplished in accordance with the development specification, logistics support development specification, and in conjunction with the coordinated test plans. Product specifications and drawings for test equipment and facilities are prepared at this time. Test methods and procedures, including those for data analysis, computing, and recording, are developed, and the number, types, and duties of personnel needed for testing are determined.

REFERENCES: AR 18–1, AR 70–1, AR 70–10, AR 70–15, AR 71–3, AR 71–9, AR 385–16, AR 702–3, MIL-STD-1000A, MIL-STD-490, MIL-D-1000A

BLOCK 38.3—DETAIL DESIGN OF PRODUCTION EQUIPMENT AND FACILITIES

RESPONSIBILITY: Contractor

DESCRIPTION: Detail designs of unique production equipment and facilities are developed from the descriptions of these elements initially established during the Domonstration and Validation Phase and expanded during the Full-Scale Engineering Development Phase (Block 31.4). Drawings and specifications are prepared for each unique equipment item and facility.

REFERENCES: AR 18–1, AR 37–40, AR 385–16, AR 611–1, AR 700–51

BLOCK 38.4—DETAIL DESIGN OF DEPLOYMENT EQUIPMENT

RESPONSIBILITY: Contractor

DESCRIPTION: Detail design of deployment elements is generated from the descriptions which were established in the Demonstration and Validation Phase and expanded during the Full-Scale Engineering Development Phase (Block 32.4). Although some design was previously accomplished in varying degrees, the detail effort does not start until the development specifications are approved and the allocated baseline established. Product specifications and drawings for deployment equipment items are prepared at this time.

REFERENCES: AR 18–1, AR 70–1, AR 611–1, MIL-STD-100A, MIL-STD-490, MIL-D-1000A

BLOCK 39.0—DESIGN CHARACTERISTICS REVIEW (DCR) OF SYSTEM ELEMENTS

RESPONSIBILITY: Materiel Developer/Contractor

DESCRIPTION: The 39 series blocks describe the reviews which take place upon completion of detail design (Blocks 28.0 and 38.1 through 38.4) and system design optimization (Block 37.0). The DCR of logistics support, test, production, and deployment elements, while accomplished incrementally, are considered in the DCR for operations elements. Design changes resulting from these reviews are incorporated in the detail design documentation. Performance requirement changes, if any, resulting from these reviews are incorporated in applicable baseline documentation in accordance with established configuration management procedures. Design characteristics reviews are conducted prior to release of design for prototype fabrication to ensure acceptability of the detail design. The objective is to determine that detail design solutions satisfy the requirements and design constraints of the development specification. The reviews include consideration of all aspects of the design, such as performance, reliability, maintainability, producibility, transportability, human factors engineering, effectiveness factors, and safety.

FORMS:

REFERENCES: AR 70–1, AR 71–5, AR 71–9, AR 385–16, AR 602–1, AR 700–127, AR 750–1, MIL-STD-480, MIL-STD-481, MIL-STD-482, MIL-STD-490

BLOCK 40.0—PROTOTYPE DOCUMENTATION

RESPONSIBILITY: Contractor

DESCRIPTION: This documentation consists of engineering drawings, specifications, and other technical data which prescribe the initial "build-to" design of the system. It serves as the basis for producing prototypes in sufficient quantities to meet development and operational acceptance test requirements, and is prepared in a format which permits easy conversion to the requirements of quantity production and multisource use.

REFERENCES: AR 18–1, AR 70–1, AR 70–10, AR 700–51, MIL-STD-100A, MIL-STD-480, MIL-STD-481, MIL-STD-482, MIL-STD-490 MIL-D-1000A

BLOCK 41.0—FUNCTIONAL CONFIGURATION AUDIT (FCA)

RESPONSIBILITY: Materiel Developer

DESCRIPTION: This is an audit to formally examine the functional characteristics test data for a configuration item prior to acceptance of the prototype. If the item has achieved performance specified in the functional or allocated configuration identification, proceed to Block 43.0, Product Configuration Identification; otherwise, to Block 42.0 for design changes.

REFERENCES: MIL-STD-480, MIL-STD-481, MIL-STD-482, MIL-STD-490 MIL-STD-1521

BLOCK 42.0—(Blocks 42.1 through 42.5)—DESIGN CHANGES BASED ON DT II/OT II

RESPONSIBILITY: Materiel Developer/Contractor/Combat Developer

DESCRIPTION: The deficiencies which were disclosed during conduct of DT II/OT II are presented for resolution or corrective action. The system engineering process is then iterated to the depth required for each system engineering activity to identify all of the essential design changes that must be accomplished, and to ensure that any new relationships between the redesigned items or areas and those previously accepted will adequately interface.

If material revisions do not affect the operational capability of the using unit, the materiel developer implements the necessary revisions through normal engineering change action. The materiel developer performs the system engineering activities to update product configuration identification; develop research and development model prototype; develope program change request; initiate product improvement tests and required quality assurance planning; obtain required production engineering. DA publications, provisioning, and training support changes; coordinate additional required testing with appropriate agencies; initiate requests for revision of distribution, materiel, modification, and international logistics plans; and provide input to ILS for revision and updating of logistics support requirements.

If a significant change in the operational capability of the using unit is deemed necessary, the change in performance characteristics is developed by the Combat Developer assisted by the Materiel Developer. Upon Department of the Army approval of the new performance characteristics, the Materiel Developer initiates development action. The type of development necessary will determine the recycle path through the system engineering model. The Materiel Developer also accomplishes retest planning.

The system engineering process and related data are utilized in performing feasibility studies to define and justify major system modifications required as a result of product improvement changes or changes to operational requirements. Particular emphasis is placed on determining and defining the total system impact of the change, i.e., describing equipment, computer programs, facilities, personnel, and procedural data impacts. In the accomplishment of this task, the system engineering activities depicted and described in the model are iterated to the extent necessary to ensure the orderly and coherent implementation of the change.

REFERENCES: AR 18–1, AR 70–10, AR 71–3, AR 71–9, AR 385–16, AR 700–35, MIL-STD-100A, MIL-STD-480, MIL-STD-481, MIL-STD-482, MIL-STD-490, MIL-D-1000A

BLOCK 43.0—PRODUCT CONFIGURATION IDENTIFICATION (PCI)

RESPONSIBILITY: Materiel Developer/Contractor

DESCRIPTION: The product configuration identification includes program unique product specification types, C, D, E, and/or a military specification, level 3 engineering drawing and associated lists, and related data to provide a set of documents adequate for the procurement, production, test, evaluation, and acceptance of an item without requiring further development work. This set of documents provides that technical description which describes the required physical characteristics of an item, the functional characteristics designated for production acceptance testing, and required acceptance tests. PCI is followed by Development Acceptance IPR/ASARC III/DSARC III and award of contract for production.

REFERENCES: AR 70–1, AR 310–3, MIL-STD-100A, MIL-STD-480, MIL-STD-481, MIL-STD-482, MIL-STD-490 MIL-STD-961, MIL-D-1000A

B–5. The Production and Deployment Phase (Fig. B–4)

a. System engineering during the Production and Deployment Phase is concerned primarily with correction of deficiencies and with product improvements.

b. Production deficiencies may be discovered by the materiel developer during the physical configuration audit of first production items, Deficiencies in effectiveness or suitability of new systems or inadequacies in logistics support may be noted by the user.

c. Product improvements may originate from user recommendations, from requirements documents, or from directed extensive modifications to enhance materiel capabilities.

d. Blocks 44.0 through 50.0 describe system engineering activities in the Production and Deployment Phase.

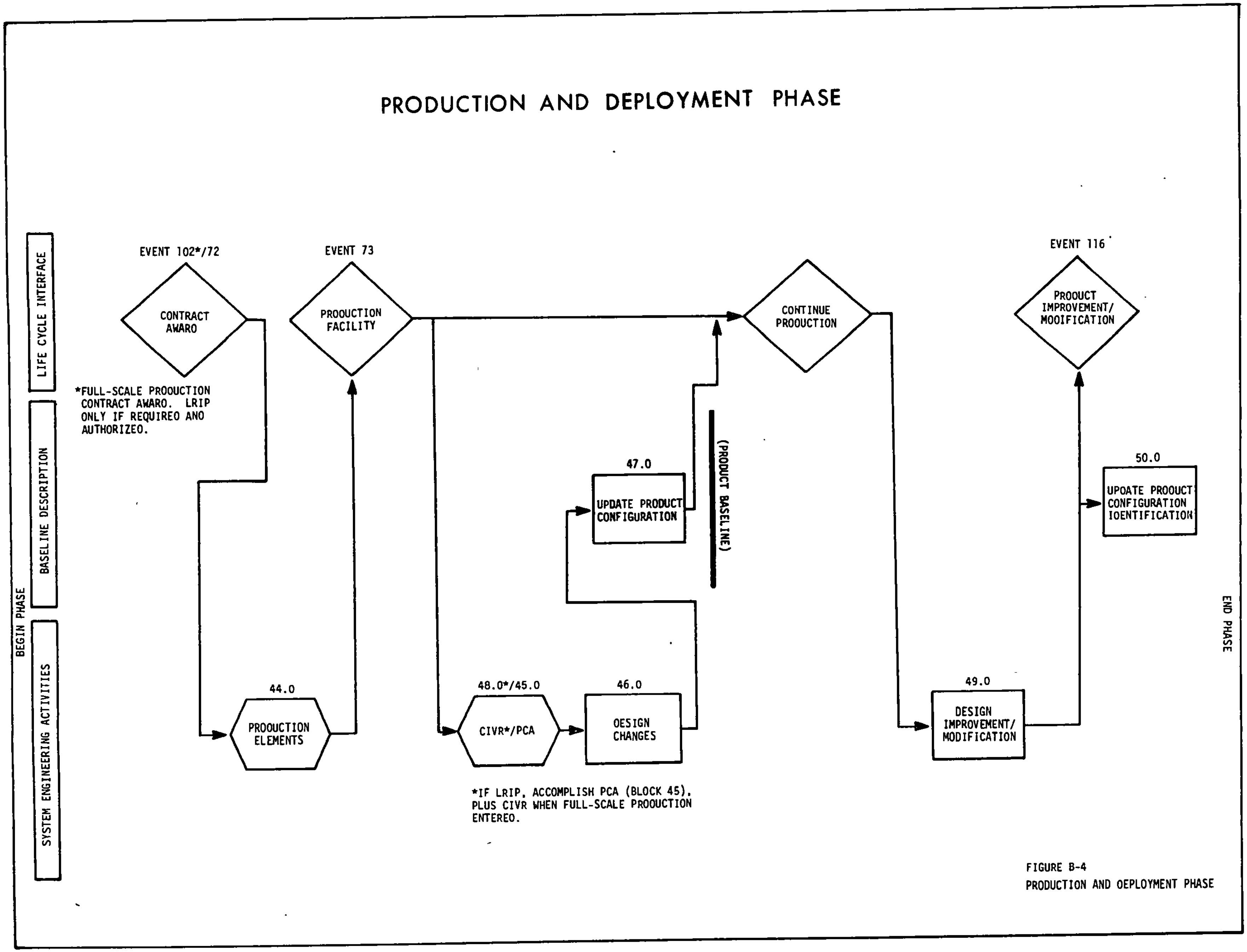


Figure B-4. Production and deployment phase.

SYSTEM ENGINEERING ACTIVITIES
PRODUCTION AND DEPLOYMENT PHASE

BLOCK 44.0—PRODUCTION ELEMENTS

RESPONSIBILITY: Materiel Developer

DESCRIPTION: These are PCI and production plan inputs which describe capital equipment, hardware, software, personnel, and materials requirements necessary to transform design into efficient and economical production of the end item or system. Examples of production functions include such actions as materials handling, fabricating, processing, assembling, inspecting, testing, packaging, packing, storing, and shipping.

REFERENCES: AR 700-47, AR 700-90

BIOCK 45.0—PHYSICAL CONFIGURATION AUDIT (PCA)

RESPONSIBILITY: Materiel Developer

DESCRIPTION: This audit is conducted to determine the adequacy and validity of the product configuration identification. It is conducted on, or during the assembly of, the first (LRIP) article of system equipment items. The PCA consists of comparing the as-produced system equipment with the product configuration in accordance with the approved PCI (drawings and specifications).

REFERENCES: AR 18-1, AR 70-1, MIL-STD-100A, MIL-STD-480, MIL-STD-481, MIL-STD-482, MIL-STD-490, MIL-STD-961, MIL-D-1000A, MIL-STD-1521

BLOCK 46.0—DESIGN TO EQUIPMENT BASED UPON PHYSICAL CONFIGURATRION AUDIT

RESPONSIBILITY: Materiel Developer/Contractor

DESCRIPTION: Design changes indicated and approved as a result of PCA or CIVR are introduced into the system in a manner which will minimize conflicting interrelationships with accepted elements. The system engineering process is iterated to the depth required to ensure optimization of the total system after incorporation of the design changes. Changes which affect the product baseline are processed by engineering change requests in accordance with configuration management procedures. Additional tests may be run if necessary to ensure acceptability of the modified system.

REFERENCES: AR 18-1, AR 70-1, AR 70-10, AR 385-16, AR 700-127, AR 702-3, AR 750-1, MIL-STD-100A, MIL-STD-480, MIL-STD-481, MIL-STD-482, MIL-STD-490, MIL-STD-961, MIL-D-1000, MIL-STD-1521

BLOCK 47.0—UPDATE PRODUCT CONFIGURATION IDENTIFICATION (PCI)

RESPONSIBILITY: Materiel Developer

DESCRIPTION: The product configuration identification is updated as required to correct deficiencies resulting from PCA or from CIVR. These changes are incorporated into the PCI in accordance with established configuration management procedures.

REFERENCES: AR 70–37, AR 385–16, MIL-STD-100A, MIL-STD-480, MIL-STD-481, MIL-STD-490, MIL-STD-961, MIL-D-100A, MIL-STD-1521

BLOCK 48.0—CONFIGURATION ITEM VERIFICATION REVIEW (CIVR)

RESPONSIBILITY: Materiel Developer

DESCRIPTION: This review is a formal technical audit of the (full-scale) production item to verify conformance to technical data and to performance interfaces within the system. It validates continuation of production.

REFERENCE: AR 70–37

BLOCK 49.0—DESIGN IMPROVEMENT/MODIFICATION

RESPONSIBILITY: Materiel Developer/Combat Developer

DESCRIPTION: The need to repeat the system engineering process to support modifications and/or product improvements may result from equipment improvement recommendations, suggestions from the field, or be self-initiated to improve cost-effectiveness or product performance.

Extensive modification of items of materiel may require recycling or partial recycling of the system engineering process. Combat developer concurrence and participation is required in any change which affects the ability or manner of an item to perform the mission for which it was designed as reflected in the ROC/LR. Modifications of this nature are tested in the same manner as service testing of the original item. The combat developer participates in confirmatory and check tests in the same manner as for service tests. Accomplishment of the modifications may require that production be continued or reinitiated, as necessary, to meet the additional or changed requirements. Elimination of discovered deficiencies may also require review of technical assistance capability, development of logistics support or overhaul requirements, and appropiate actions outlined in system engineering Block 46.0. This process provides input to ILS so that actions may be accomplished to revise and up date previously established support data and requirements.

REFERNCES: AR 70–15, AR 700–35, MIL-STD-100A, MIL-STD-480, MIL-STD-481, MIL-STD-490, MIL-STD-961, MIL-D-1000A

BLOCK 50.0—UPDATE PRODUCT CONFIGURATION IDENTIFICATION

RESPONSIBILITY: Materiel Developer

DESCRIPTION: The product configuration identification is updated by engineering change requests to effect all modifications and/or product improvements. These changes are incorporated in accordance with configuration management procedures.

REFERENCE: AR 70–37

APPENDIX C
GLOSSARY

Definitions in this glossary conform to or are derived from official publications or generally accepted usage. Should conflict of definitions arise, the following should be used in the interpretation of this publication.

ACI. Allocated Configuration Identification.

Acquisition Plan (AP). The definitive plan for management of the program for development of materiel which will accomplish the objectives in an approved materiel requirement document.

ADP terms (all). See AR 18–1.

Allocated baseline. The initial approved configuration identification. This is the baseline to which systems and equipment are controlled.

Allocated configuration identification (ACI). Current, approved performance oriented specifications governing the development of configuration items that are part of a higher level CI, in which each specification: (1) defines the functional characteristics that are allocated from those of the higher level CI; (2) establishes the tests required to demonstrate achievements of its allocated functional characteristics; (3) delineates necessary interface requirements with other associated configuration items; and (4) establishes design constraints, if any, such as component standardization, use of inventory items, integrated logistics support requirements.

AP. Acquisition Plan.

Baseline. A configuration identification document or a set of such documents formally designated and fixed at a specific time during a CI's life cycle. Baselines, plus approved changes from baselines, constitute the current configuration identification. For configuration management there are three baselines; Functional, Allocated, and Product.

Basic (input) requirements. Those statements of fact and assumption portraying the primary universe for application of the system engineering process; these are mission/objective, environment, constraints, and measures of effectiveness.

"Build-to" specifications. Those specifications which are developed during detail design and prototype fabrication. They contain the information necessary to fabricate, assemble, test, and produce equipment and facility items. In MIL-STD-490 these are identified as Product Specifications; in MIL-STD-961, as Military Specifications.

CDS. Concept Description Sheet.

CI. Configuration Item.

Combat Developer. The agency or command responsible for concepts, doctrine, organization, and materiel objectives and requirements for the employment of Army forces. TRADOC is the principal combat developer.

Concept description sheet (CDS). A sheet for relating gross level designs to the functions, requirements, and constraints that the design is to meet.

Conceptual design. Synthesis.

Configuration. The functional and/or physical characteristics of hardware/software as set forth in technical documentation and achieved in a product.

Configuration identification. The current approved or conditionally approved technical documentation for a configuration item as set forth in specifications, drawings, and associated lists, and documents referenced therein.

Configuration item (CI). An aggregation of hardware/software, or any of its discrete portions, which satisfies an end use function and is designated by the Government for configuration management. CI's may vary widely in complexity, size, and type.

Configuration management. A discipline applying technical and administrative direction and surveillance to— (1) identify and document the functional and physical characteristics of a configuration item; (2) control changes to those characteristics; and (3) record and report change processing and implementation status.

Deployment. Fielding functions to be performed and system elements required to initially transport, receive, process, install, test, checkout, train, operate and, as required, emplace, house, store, or deploy the system into a state of full operational capability.

Description of the system elements. Engineering data that defines the configuration, arrangement, and usage of all system elements and their effectiveness in achieving functional performance.

Design reviews. Determination of the technical adequacy of the system engineering and design efforts in meeting system requirements.

Design sheet. Documentation on which is recorded performance, test, and design requirements for equipment end items, critical components, and computer programs.

"Design-to" specifications. Those specifications which contain the performance, design, and verification (test) requirements for an item of equipment or facility. They are developed prior to detail design of the item and provide the basis for design. In MIL-STD-490, these are identified as the System Specification and Development Specifications.

DS. Design Sheet.

EIMS. End Item Maintenance Sheet.

End item maintenance sheet (EIMS). Document for identifying maintenance functions on a specific end item, subassembly, and component basis.

Engineering specialty plan. Descriptive name for any plan or activity having requirements, constraints, or contributions that must be considered in developing the system elements.

Evaluation and decision. Process of determining the combination of system elements that best meet the mission objectives and support requirements.

Facility interface sheet (FIS). Documentation of environmental requirements and interface design requirements imposed upon facilities by the end items of equipment.

FFBD. Functional Flow Block Diagram.

Fielding. See Deployment.

FIS. Facility Interface Sheet.

Function. Actions required to accomplish part or all of a specific mission objective and those actions required to support the basic mission.

Function analysis. Determination of the functions and their sequence and interdependence required to accomplish a mission objective, and the relating of (basic) requirements to the functions upon which they impact.

Functional area. The activities, subfunctions, and elements of a primary function.

Functional baseline. The initial approved functional configuration identification.

Functional configuration audit. The formal examination of functional characteristics test data for a configuration item, prior to acceptance, to verify that the item has achieved the performance specified in its functional or allocated configuration identification.

Functional configuration identification (FCI). The current approved technical documentation for a configuration item which prescribes all necessary functional characteristics.

Functional cycle. The application of the system engineering process to an activity for definition or refinement of appropriate system elements.

Functional flow block diagram (FFBD). A drawing on which the system requirements are structured into functional terms.

Indenture. A method of showing relationships to indicate dependence.

Integrate. To put or bring (parts) together into a whole; unify.

Interface. A boundary or point common to two or more command and control systems, subsystems, or other entities against which or at which necessary information flow takes place.

Integrated logistics support. A composite of the elements necessary to ensure the effective and economical support of a system of equipment at all levels of maintenance for its programed life cycle.

Interface control documentation. Documents resulting from that part of the System Engineering Management Plan describing how interface requirements will be accomplished.

Iterate. To do again for the purpose of expanding, understanding, refining, improving, indenturing, or updating current knowledge.

Iterative methodology. Sequential and repetitive top-down development of a topic by— identifying those actions (functions) required to accomplish the objective; allocating the (basic input) requirements to the appropriate functions (functional allocation); translating the requirements into solutions (synthesis or conceptual design) through system/design engineering studies; portraying the interdependence among the solution elements; researching and evaluating the alternate solutions and determining the most feasible solution; analyzing the selected solutions to assess the impact on the requirements/design and other solution elements.

Letter of Agreement. An STF/SSG document outlining basic agreements between combat developer and materiel developer for further investigation of a potential materiel system.

Letter Requirement. An abbreviated procedure which may be used in lieu of the ROC for acquisition of low value items.

Life cycle test plan. A generic term which encompasses the major materiel tests conducted throughout the materiel life cycle.

LOA. Letter of Agreement.

Logistics Support Analysis Record. Record of maintenance task analysis data used to identify, define, analyze, and quantify logistics support requirements.

LSAR. Logistics Support Analysis Record.

Maintenance. The functions of sustaining materiel in an operational status, restoring it to a serviceable condition, or updating and upgrading its functional utility through modification.

Materiel Developer. The command or agency responsible for research, development, and production validation of a system which responds to HQ DA objectives and requirements.

Measures of effectiveness. A particular value or set of values of system/subsystem effectiveness pertinent to one or more mission objectives.

MENS. Mission Element Needs Statement.

Mission Element Need Statement. The justification document for initiation of a new major system acquisition (AR 71–9). Includes mission needs, threat assessment, existing capability identification, deficiency assessment, constraint consideration, impact assessment, and program planning.

Mission profile. A portrayal of operations functions, e.g., a top level FFBB.

OAP. Outline Acquisition Plan.

Operations. A military action or the carrying out of a strategic, tactical, service, training, or administrative military mission; the process of carrying on combat, including movement, supply, attack, defense, and maneuvers needed to gain the objectives of any battle or campaign.

Optimization. The process of identifying the relative operational and/or support effectiveness of system and technical program element alternatives which have been defined by system engineering, determining cost and schedule implications, and selecting a preferred alternative or set of alternatives.

Outline Acquisition Plan. The document of record which supports the advanced development effort.

PEP. Production Engineering and Planning.

Physical configuration audit (PCA). The formal examination of the "as-built" configuration of a CI against its technical documentation and functional requirements in order to establish the CI's initial product configuration identification.

PIP. Product Improvement Proposal.

Product baseline. The initially approved or conditionally approved product configuration identification.

Product configuration identification (PCI). The current approved or conditionally approved technical documentation which defines the configuration of a CI during the production, operation, maintenance, and logistics support phases of its life cycle, and which prescribes: (1) all necessary form, fit, and functional characteristics of a CI; (2) the selected functional characteristics designated for production acceptance testing; and (3) the production acceptance tests.

Product Improvement Proposal (PIP). A proposal for product improvement which does not significantly change the approved performance envelope of the system.

Production sheet. Document describing production facilities, equipment, personnel, and operations required to produce each configuration item.

Production Engineering and Planning (PEP). RDTE planning and engineering tasks of the materiel developer to ensure producibility of material prior to procurement.

PS. Production Sheet.

RAS. Requirements Allocation Sheet.
Rationalization, Standardization, Interoperability (R/S/I) (AR 34–1).

Required operational capability (ROC). Narrative description of minimum operational, technical, and cost information required for a HQ DA decision to initiate development of a new materiel system or item.

Requirements allocation sheet (RAS). A format on which the requirements and constraints are defined for each function and related to the appropriate system element(s).

Risk analysis. The application of qualitative and quantitative techniques for analyzing, quantifying, and reducing the uncertainty associated with the realization of time, cost, or performance goals. The prediction of cost growth, schedule, slippage, and performance degradation to allow for proper management of future events. Also called risk evaluation.

ROC. Required Operational Capability.

RSI. Rationalization, Standardization, Inter-Interoperability.

SBD. Schematic Block Diagram.

Schematic block diagram (SBD). A basis for assembling function performance requirements and criteria into an integrated set of design requirements for the system.

Sciences and Technology Objective (STO) (AR 71–9).

SEMP. System Engineering Management Plan.

STO. Science and Technology Objective.

Synthesis. Translation of functions and requirements into possible solutions (resources and techniques) satisfying the basic input requirements. Synthesis is performed concurrently with function analysis, whenever possible, and often yields alternative solutions for analysis during trade-off studies.

System. A composite of equipment skills and techniques capable of performing and/or supporting an operational role. A complete system includes all equipment related facilities, materiel, software, services, and personnel required for its operation and support to the degree that it can be considered a self-sufficient unit in its intended operational environment. The system is what is employed operationally and supported logistically. It is the product of the acquisition program.

System element. Any item required to produce, test, deploy, operate, maintain, and support the system, i.e., equipment, personnel, facilities, procedural data, or computer programs.

System engineering. The selective application of scientific and engineering efforts to: (1) transform an operational need into a description system configuration which best satisfies the operational need according to the measures of effectiveness; (2) integrate related technical parameters and ensure compatibility of all physical, functional, and technical program interfaces in a manner which optimizes the total system definition and design; and (3) integrate the efforts of all engineering disciplines and specialties into the total engineering effort.

System engineering management. Management of the system engineering process and the integration of all engineering activities and technical aspects of the system/project from receipt of a requirement for a new system or materiel item through the delivery of the system or item to the operational inventory.

System engineering management plan (SEMP). A plan for the application of the principles of management to ensure effective execution of the system engineering effort.

System engineering process. The sequential and iterative methodology involving top-down development of the product and technical program task elements of the Work Breakdown Structure and allocation of requirements for design and for technical program definition to all system and technical program elements including those for technical performance measurement. Repetitive steps for resolving requirements, i.e., a four-step process consisting of function analysis, synthesis, evaluation and decision, and description which is repeated for every design requirement.

System engineering process element. A specialty task/program which contributes to an integrated, comprehensive system engineering process.

Tailoring. The selective application of system engineering, technical, and managerial resources to fulfill the objectives of a project/program.

Technically critical area. System functional requirements which are critical to system operational and/or support effectiveness, program schedule or cost, and/or for which the proposed or alternate solutions involve significant technical risk.

Technical performance measurement (TPM). The design assessment function of performance measurement which estimates through engineering analyses, or measures through tests, the values of essential performance parameters of the current design of system elements and forecasts the values to be obtained through the planned technical approach.

Technical program. The total program effort for a system. It includes all design/development/test/evaluation activities and associated resources to progress from an operational requirement to the system in operational use, including interfaces with production, operation by user, logistics support, and training. The technical program includes the management functions of planning and controlling as well as the accomplishment of functions. System engineering is itself a part of the technical program.

Technical program element. Element of the Contract Work Breakdown Structure down to the Work Package level.

Test. Functions to be performed and system elements required to verify that a system meets, exceeds, or fails to meet the technical or operational properties ascribed to the system.

Test requirements sheet (TRS). A document for identifying test functions on a specific end item, subassembly, and component basis; documentation of all requirements that must be demonstrated or verified during life cycle testing.

Time critical functions. Those functions which must be accomplished within critical time constraints; otherwise system performance (e.g., reaction time) fails.

Time line sheet (TLS). Documentation for analysis of (expected) time-critical functions and functional sequences.

TLS. Time-Line Sheet.

TPM. Technical Performance Measurement.

Traceability. The capability to track system requirements from a system function to all elements of the system which, collectively or individually, perform the function; an element of the system to all functions which it performs; a specific requirement of the source analysis or contractual constraint which originated the requirement. Traceability includes tracking allocation design (and technical program) requirements through the work breakdown structure between the system level and the lowest level of assembly.

Trade-off. Selection of a preferred parameter.

Trade-off study reports (TSR). Documentation for the evaluation of all possible problem solutions and the selection of the most promising approach.

Training Developer. The agency or command responsible for concepts, doctrine, organization, materiel objectives, and requirements for the training of Army personnel. TRADOC is the principle training developer.

TRS. Test Requirements Sheet.

TSR. Trade-Off Study Report.

Visibility. Documentation to verify that data is so constructed as to determine and illustrate factors concerning technical or mission critical areas for evaluation.

WBS. Work Breakdown Structure (MIL-STD-881A).

Work Breakdown Structure (WBS). A product-oriented family tree composed of hardware, services, and data. A summary WBS is the upper three levels of a WBS; it has uniform element terminology, definition, and placement in the WBS. A project summary WBS is a summary WBS tailored to a specific defense materiel item. A contract WBS is the complete WBS for a contract. A project WBS is the complete WBS for the project.

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By Order of the Secretary of the Army:

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Chief of Staff

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Major General, United States Army
The Adjutant General

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COMPONENTS OF THE SYSTEM ENGINEERING MANAGEMENT PLAN

SYSTEM ENGINEERING MANAGEMENT PLAN (SEMP)

SEMP, PART 1 — SYSTEM ENGINEERING MANAGEMENT (SEM)

- **MISSION REQUIREMENTS/CONSTRAINTS** — Interprets, clarifies and validates basic inputs to the System Engineering Process.
- **RESPONSIBILITY/AUTHORITY** — Identifies organization(s) and key personnel for managing the system engineering effort and defines responsibilities, lines of communication and functions of personnel associated with system engineering policy.
- **RESOURCE ALLOCATION** — Allocates resources of budget, schedule and expertise necessary to achieve effective System Engineering and System Engineering Management.
- **PROCEDURES** — Establishes the formal process for implementing System Engineering and System Engineering Management through all phases of the program.
- **DOCUMENTATION/FORMAT** — Establishes procedures for the generation and management of all system engineering documentation. Specifies formats of documentation.
- **DESIGN REVIEWS** — Establishes schedules and procedures for the comprehensive examination and review of all aspects of the design. MIL-STD-1521
- **INTERDISCIPLINARY INTEGRATION** — Establishes procedures to assure design compatibility from the standpoint of all pertinent engineering and scientific disciplines.
- **ENGINEERING DECISION PROCESS** — Establishes formal internal procedures utilizing system effectiveness models, trade-off studies, risk analysis, etc.
- **PROGRAM ASSURANCE** — Identifies technical measures which can reduce the risks and unknowns associated with critical areas of the program and selects measures to be implemented.
- **CHANGE CONTROL** — Establishes formal internal procedures necessary to control all technical data that has an impact upon configuration, performance requirements, design constraints or functional/physical interfaces. MIL-STD-480, 483
- **WORK BREAKDOWN STRUCTURE** — Identifies the structure of products and services comprising the entire work effort. MIL-STD-881
- **TRAINING** — Identifies and establishes methods and procedures that will be used to train selected personnel in the system engineering process/system engineering management methodology and rationale.
- **TECHNICAL PERFORMANCE MEASUREMENT** — Identifies items which have significant impact upon system effectiveness; identifies and quantifies parameters which have significant impact upon system effectiveness; establishes analytical or test criteria for the estimation or measurement of technical performance; estimates or measures, evaluates and forecasts all significant technical performance characteristics of the system through the design activity. MIL-STD-1521
- **TAILORING** — Deletes, alters or adds requirements in order to adapt this manual to the peculiarities of specific systems or subsystems
- **MILESTONES/SCHEDULES** — Identifies and establishes cost, time and performance accomplishments that are essential at a specified point in time to meet the objectives of the system engineering effort.

SEMP PART 2 — SYSTEM ENGINEERING PROCESS (SEP)

- **FUNCTION ANALYSIS** — Defines functions and function performance requirements which must be met in order to accomplish the operations, maintenance, test, production and deployment requirements of the system.
- **SYNTHESIS OF CONCEPTUAL SYSTEMS** — Depicts a complete response to functional needs; provides alternatives for trade studies; depicts compatibility between system elements and interfacing systems; provides traceability between system elements and their functional origin in the operational usage.
- **EVALUATION AND DECISION** — Selects the best combination of system elements to meet the mission objectives and support requirements as a balance of cost, performance and schedule.
- **DESCRIPTION OF SYSTEM ELEMENTS** — Produces engineering data that identifies, describes and specifies the configuration, arrangement and usage of all system elements and their effectiveness in achieving functional performance. Controls the design, development, test, production and deployment of equipment and facilities; the selection and training of personnel; the development of procedural data and computer programs. Provides a basis for change control.

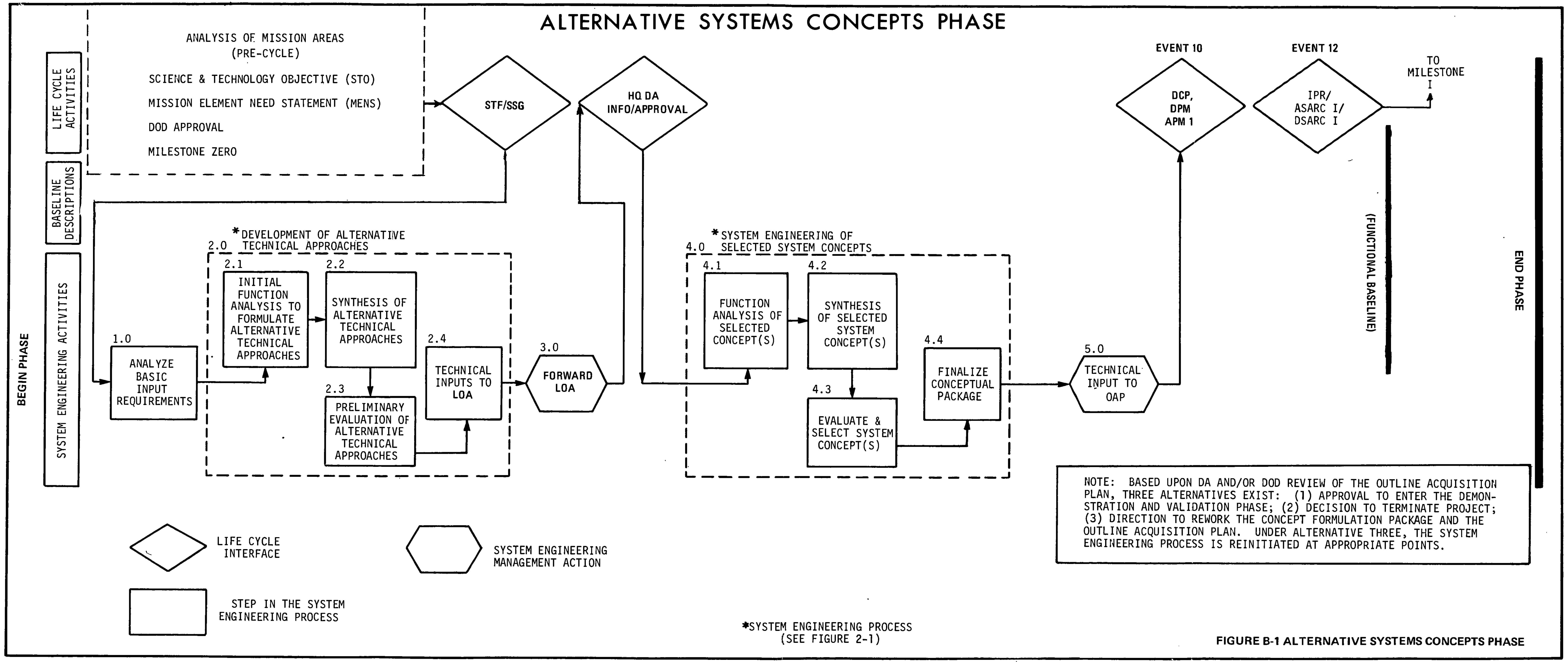
SEMP, PART 3 — ENGINEERING SPECIALTY INTEGRATION

- **RELIABILITY** — MIL-STD-785A, 756, 781, AR 702-3; MIL-HDBK-217A
- **MAINTAINABILITY** — MIL-STD-470, 471, AR 702-3
- **HUMAN ENGINEERING/HUMAN FACTORS** — MIL-STD-1472, MIL-H-46855
- **PERSONNEL REQUIREMENTS** — MIL-STD-26239A
- **ELECTRONIC WARFARE**
- **SURVIVABILITY/VULNERABILITY**
- **SECURITY ENGINEERING**
- **SAFETY** — MIL-STD-882, AR 385-16
- **STANDARDIZATION/RSI** — AR 34-1
- **ILS & LSA** — DOD Directive 4100.35, AR 700-18, AR 750-1, AR 700-127, AR 1000.1, AR 1000.2, MIL-STD-1388-1, MIL-STD 1388-2, DI-L-7017
- **ELECTROMAGNETIC COMPATIBILITY** — MIL-STD-461, 462, 463, 462; DODD 3222.2, DODD 4650.1
- **SYSTEM/COST EFFECTIVENESS** — MIL-STD-721B, 217
- **VALUE ENGINEERING**
- **TRANSPORTABILITY** — AR-70-44
- **QUALITY ASSURANCE** — MIL-Q-9858A
- **MATERIALS/PROCESSES**
- **HEALTH**
- **ASSESSMENT** — AR 70-1, AR 70-27, AR 705-50
- **POLLUTION CONTROL**
- **MIS** — DODD 5000.29, AR 18-1
- **OTHERS AS REQUIRED**

NOTE: THIS IS AN EXAMPLE OF A SEMP, NOT A REQUIREMENT. PART 3 IS ACCOMPLISHED IN CONJUNCTION WITH PARTS 1 & 2.

REFERENCES CITED FOR INITIAL REFERENCE ONLY.

FULL REFERENCES IN DOD INDEX OF SPECIFICATIONS AND STANDARDS (DODISS), PARTS I & II, AND IN DA PAM 310-1.



NOTE: BASED UPON DA AND/OR DOD REVIEW OF THE OUTLINE ACQUISITION PLAN, THREE ALTERNATIVES EXIST: (1) APPROVAL TO ENTER THE DEMONSTRATION AND VALIDATION PHASE; (2) DECISION TO TERMINATE PROJECT; (3) DIRECTION TO REWORK THE CONCEPT FORMULATION PACKAGE AND THE OUTLINE ACQUISITION PLAN. UNDER ALTERNATIVE THREE, THE SYSTEM ENGINEERING PROCESS IS REINITIATED AT APPROPRIATE POINTS.

*SYSTEM ENGINEERING PROCESS (SEE FIGURE 2-1)

FIGURE B-1 ALTERNATIVE SYSTEMS CONCEPTS PHASE

FULL-SCALE ENGINEERING DEVELOPMENT PHASE

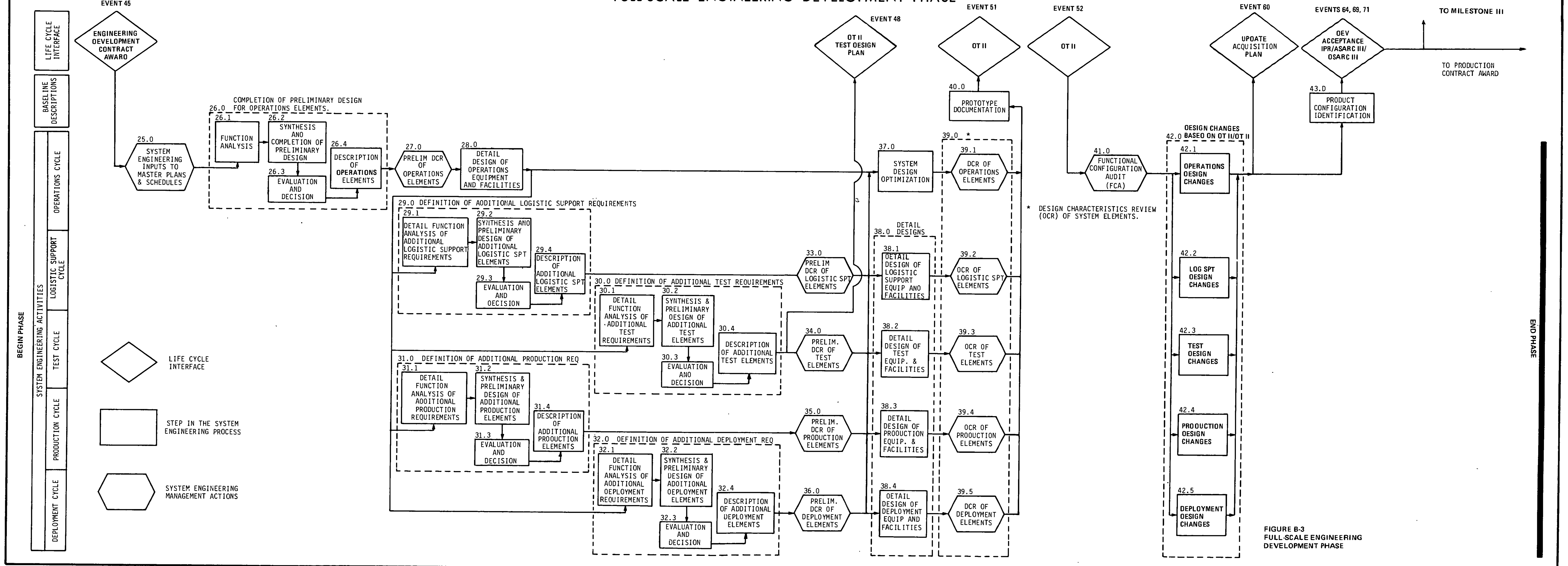


FIGURE B-3
FULL-SCALE ENGINEERING DEVELOPMENT PHASE

FIGURE B-2
DEMONSTRATION AND VALIDATION PHASE