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SYSTEM ENGINEERING GUIDE FOR INFORMATION PROCESSING ELEMENTS OF ELECTRONIC SYSTEMS

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M. S. Piligian
M. V. Ratynski

EST

January 1968

TECHNICAL REQUIREMENTS AND STANDARDS OFFICE
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

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Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Technical Requirements and Standards Office Electronic Systems Division, L G Hanscom Field Bedford, Massachusetts 01730	UNCLASSIFIED 2b. GROUP N/A

3. REPORT TITLE

SYSTEM ENGINEERING GUIDE FOR COMPUTER PROGRAMS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

None

5. AUTHOR(S) (First name, middle initial, last name)

Lloyd V. Searle
Robert L. Henderson

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO OF REFS
March 1968	157	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
AF19628-67-C-0128 b. PROJECT NO. AFSC 2801 and 6917 c. d.	System Development Corporation TM-3596, 15 Aug 1967 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale, its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Electronic Systems Division L G Hanscom Field Bedford, Mass. 01730

13. ABSTRACT

This report discusses the application of System Engineering principles to the development of computer programs and associated elements of large systems. Using the "road map" approach and basic concepts established by Air Force Manuals AFSCM 375-4 and 375-5, it describes step-by-step events during the conceptual, definition, acquisition, and operational phases of a system life cycle. Technical milestones in system computer program analysis, design and development are identified and related to associated activities and requirements in the areas of test and evaluation, configuration management, data management, and human factors. Procedures outlined in the guide are based on experience with a number of large electronic systems developed for the Air Force. Emphasis in the description is placed on aspects of the technical process which have significant implications for system program planning and management. The extent of contractual application of the material in this report should be made on a contract-by-contract basis. The selective use of the events, activities and technical processes described in this report will assure a systemized approach to the design, development and acquisition of computer-based systems.

DD FORM 1 NOV 65 1473

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
System Engineering Management						
Computer Program Management						
Computer Program Design						
Design of Computer Programs						
Engineering Management of Computer Programs						
System Life Cycle of Computer Programs						
Software Design Process						
Integration of Hardware and Software						
Total System Design						

ESD-TR-68-1

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FOREWORD

This report represents an interim product of continuing studies to develop a series of concepts and procedures for system engineering management of computer programs. Its purpose at this time is to present a description of the developmental process in a form which will provide a basis for further expansion and detailing and for interim contractual requirements. The further expansion contemplated will emphasize additional description of appropriate technical documentation, taking into account the precedents established by Air Force Systems Command Manual (AFSCM) 375-5.

It is recognized that the procedures specified in the current AFSCM 375-5 (March 1966) are derived principally from experience in weapon system and equipment engineering. While there is little question that the same general precepts and objectives apply also to information processing systems, the applicability of certain detailed procedures and requirements to computer programming, in particular, has not yet been determined. Problems stem from general characteristics of digital computer-based systems, from the variety of ways in which computer programs differ both functionally and physically from items of equipment, and from the fact that the computer programming field does not yet have the wealth of working standards which have evolved over decades in engineering.

As described herein, the technical milestones in computer program analysis, design, and development are identified and related to requirements, including documentation, in the areas of configuration management, personnel subsystem, procedural data, system exercising, and testing, which have been derived from earlier studies in this project. The project is continuing, directed towards improved clarification of system engineering for computer programs along the following lines:

1. This is a preliminary guide and, as time and manpower permit, will be revised to reflect improved integration and results of initial reviews, and to include examples of system engineering documentation.

2. Where indicated, revised or new AFLC/AFSC Forms 9 will be recommended to cover system engineering data requirements for computer programming.

3. Recommendations covering the computer program area will be formulated for future inclusion in a revised issue of AFSCM 375-5 and associated exhibits.

The process and techniques described in this report have been primarily evolved as the result of an Air Force contract (#F19628-67-C-0128, Management Procedures for Computer Programming for Electronic Systems Division) with the System Development Corporation, Santa Monica, California. The principals at the System Development Corporation were Lloyd V. Searle and Robert L. Henderson.

The Air Force technical management of this project has been provided by the Technical Requirements and Standards Office of the Electronic Systems Division, USAF, L. G. Hanscom Field, Bedford, Mass. Guidance, direction, and coordination were accomplished primarily by the authors and Joseph L. Pokorney, now with Peat, Marwick, Livingston and Co., Boston, Mass. The material in this report represents one phase of contractual support to Air Force projects 2801 and 6917, which were funded and administered by the Computer and Display Division of the Deputy for Command Systems, Electronic Systems Division.

At the System Development Corporation, essential materials for the body of this report were supplied by personnel of the Operational Systems and Training Systems Departments. Particular credit is due to Eugene H. Sydow and Stephen A. Strohman for their continuing support and coordination, as well as for their extensive personal contributions to the narratives of computer programming events during the Acquisition Phase. The writers are also indebted to Raphael J. Dubrovner and De Vere G. Arnold for their assistance in developing materials related to personnel and system exercising.

The present effort has made use of valuable precedents established by such groups as the ESD/MITRE/SDC Ad Hoc Working Group and Systems Acquisition Study Group (SAWG). The results of earlier work by those groups are documented in MITRE TM-3551, "Computer Program Acquisition Study" (February 1963); MITRE TM-69, "The Electronic Systems Acquisition Process" (October 1963); and SDC TM(L)-LX-74, "Command Control Software Subsystem Development During the Conceptual, Program Definition, and Acquisition Phases" (Draft, August 1963).

This technical report has been reviewed and is approved.

PAUL L. DEIMLING, Colonel, USAF
Chief, Technical Requirements and Standards Office

ABSTRACT

This report discusses the application of System Engineering principles to the development of computer programs and associated elements of large systems. Using the "road map" approach and basic concepts established by Air Force manuals AFSCM 375-4 and 375-5, it describes step-by-step events during the conceptual, definition, acquisition, and operational phases of a system life cycle. Technical milestones in system and computer program analysis, design, and development are identified and related to associated activities and requirements in the areas of test and evaluation, configuration management, data management, and human factors. Procedures outlined in the guide are based on experience with a number of large electronic systems developed for the Air Force. Emphasis in the description is placed on aspects of the technical process which have significant implications for system program planning and management. The extent of contractual application of the material in this report should be made on a contract-by-contract basis. The selective use of the events, activities and technical processes described in this report will assure a systemized approach to the design, development and acquisition of computer-based systems.

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Chapter 1

INTRODUCTION

A. PURPOSE

The purpose of this guide is to set forth and describe key aspects of system engineering management as applied to information processing elements of electronic systems. The scope and level of treatment are generally comparable to material contained in the AFSC Manual 375-5. However, the intent is to amplify the process for computer programs, in particular, as important system elements for which the concepts of system engineering management have not previously been clarified.

The material contained herein is derived principally from experience with L-Systems as developed at the Electronic Systems Division, and from Air Force concepts, objectives, and requirements which are set forth in the 375-series regulations and manuals. While the guide is designed to meet the specific needs of electronic systems/subsystems developed within that framework, it intentionally incorporates both system and computer programming concepts which are consistent with a wide variety of information processing applications.

B. SYSTEM ENGINEERING MANAGEMENT

1. Air Force Systems Management

Systems management is the process of planning, organizing, and controlling the activities of contractors and participating organizations to accomplish objectives of time-phased system programs which require the combined efforts of diverse functional agencies. As developed by Air Force Systems Command, it is accomplished by a centralized System Program Office (SPO), within which activities are structured into a uniform set of management sub-areas, each identified as the area of responsibility for an organizational unit of the SPO. The management areas and their general interrelationships are illustrated in Figure 1.

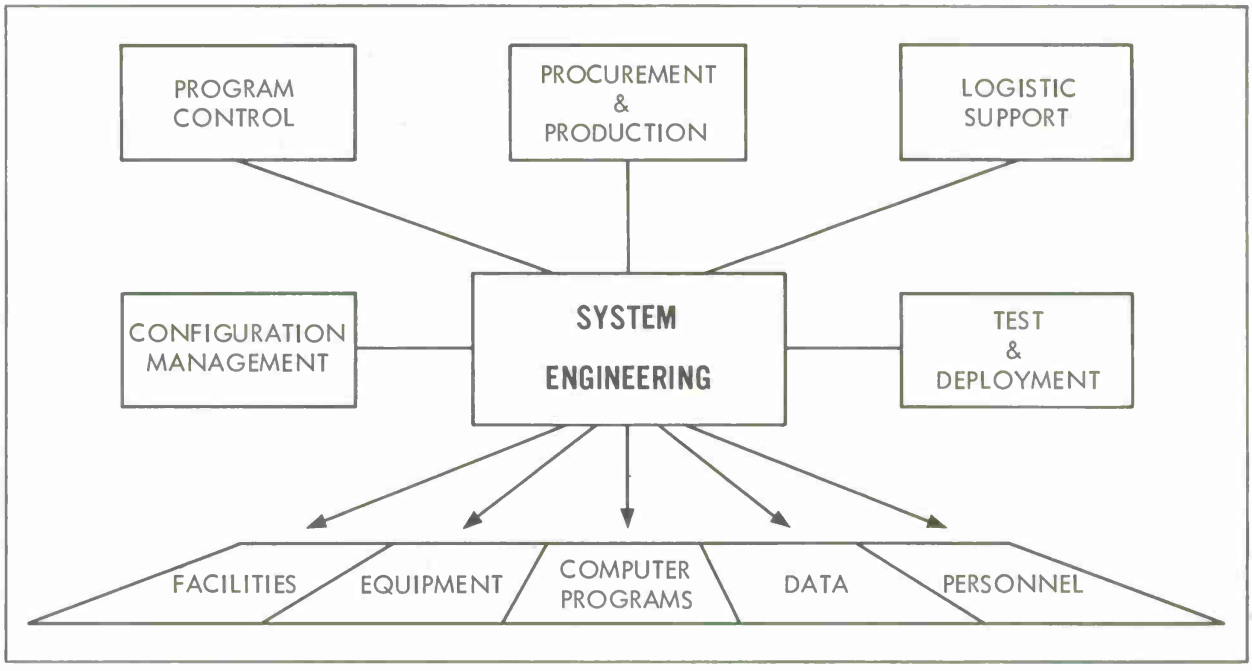

FIGURE 1. SYSTEMS MANAGEMENT.

As the figure suggests, system engineering management is the foundation of the systems management structure. It represents the direct control of technical efforts required to plan, analyze, define, design, develop, test, and supply the complex of elements that constitute a system. To achieve an integrated total program, it is supported during Definition and Acquisition Phases by the efforts of configuration management, test and deployment, procurement and production, program control, and logistics. However, the systems management process as a whole is characterized by its major dependence upon the technical processes subsumed under system engineering as the prime base for management planning and decisions. Fundamental to this emphasis is the fact that timely delivery to an operating agency of effective and self-sufficient systems embodying the latest national advances in technology is a primary objective of the total process.

2. General Precepts and Objectives

The term, system engineering, refers most directly to the analytical and integrating activities which are required to achieve a balanced design for a system as a whole, as distinct from engineering or other scientific and technical activities which are devoted to the specialized development of individual system elements. A modern complex system consists of personnel, facilities, computer programs, and data, in addition to a wide variety of equipment. The special objective of system engineering is to assure that all of these parts are properly devised and combined, in such ways that they will function efficiently as a unit in performing the system mission.

As a formally recognized concept, system engineering has had most of its growth and application during the past several years in the context of weapon systems. In that framework, items of equipment--e.g., aircraft, missiles--are typically the major elements to be designed and developed during the system program. As such, they have come to be accepted as the "pacing items" for system planning and as the reference base against which the compatibility of other elements can be estimated, evaluated, and assured during the system engineering process. Hence, many of the particular objectives and applications are most widely known and understood at present in relation to their equipment engineering origins.

It is one purpose of this guide to identify certain new interpretations and practices which are appropriate when the pacing items in a system or subsystem are computer programs and personnel, rather than special-purpose equipment. However, the modifications represent refinements and minor alterations, on the whole, rather than basic changes; in general, reference is maintained to such fundamental concepts as the following:

a. *Total System Design.* The development of an effective system is a complex process, involving such variables as facilities, equipment, personnel and training requirements, computer programs, procedural data, installation,

testing, and special elements of support equipment, services, and supply. Interaction among variables is the rule, rather than the exception. The design of a display, for example, will normally affect the requirements for knowledges and skills of operating system personnel, occasionally in a critical fashion; the location of an electronics package in an aircraft may affect not only its operation and aircraft performance, but also the requirements for ground maintenance tools, facilities, test equipment, and spares. Thus, the approach to developing a balanced system requires that design decisions for components be based not only on technical objectives for the component, but also on a proper consideration of its effects on design, operation, and support of other elements in the system as a whole.

b. *Uniform Design Process.* The analysis and design of a system and its elements occurs at a series of levels. Requirements exist initially in the form of general mission objectives to be met by the proposed system. A first step is to identify the gross functions which the system must perform to accomplish those objectives, together with performance requirements (speeds, capacities, tolerances, limits), design constraints, and associated requirements for system support and development. Functional requirements are analyzed through progressively lower levels and allocated at each stage to system elements and subelements through decisions which take into account feasible alternatives and their implications for performance and design of other elements. When carried through systematically at all levels, this functional approach serves to maintain visibility of each element's role in the system as a whole, to clarify interrelations among elements, and to reduce the possibility that essential elements will be omitted.

As applied to the life cycle of a system, the system mission, functions, and configuration are established in the Conceptual Phase; end item performance and design requirements are analyzed, defined, and selected in the Definition Phase; and the system elements are designed, assembled, and tested during Acquisition.

3. Precepts Established by AFSCM 375-5

The Air Force Systems Command Manual 375-5, System Engineering Management Procedures, defines detailed procedures and technical documentation to establish and implement a uniform design process reflecting the above general principles and logic. Since AFSCM 375-5 provides the basic references for material contained in this guide, certain of its important features are reviewed briefly below.

a. *Life-Cycle Management.* Relationships among documentation, engineering, design reviews, specifications, baselines, and major commitment points are described on a step-by-step basis for the four phases of a system life-cycle. Events and activities are identified on a "road map" and amplified by narratives for each block shown. While key points are related throughout

to system program management events established by AFSCM 375-4, emphasis is placed on amplifying the technical processes of analysis, definition, design, development, and testing.

b. *Functional Basis.* A functional approach is employed as the frame of reference for identifying initial requirements at each design level of the system. Functions to be analyzed and interrelated for each system are classified under the major categories of Operations, Maintenance, Test, and Activation.

(1) Operations functions are the repetitive actions performed by a system, following turnover to the using agency, to accomplish the using agency mission objectives. These are the primary system functions which provide the initial basis at each stage for analysis and identification of requirements in associated supporting and developmental areas. Conversely, they are affected, validated, and/or changed by subsequent effort to determine feasible and effective solutions for Maintenance, Test, and Activation.

(2) Maintenance functions are actions necessary to return a failed system element to readiness (corrective maintenance) or to assure a continued state of readiness (preventive maintenance). As in the case of Operations functions, these refer primarily to actions following turnover to a using agency.

(3) Test functions are actions necessary to verify that the system and/or its elements meet established requirements. These are primarily associated with the system development and production, rather than with user operations.

(4) Activation functions encompass production, training, and checkout actions necessary to procure, fabricate, train, assemble, handle, store, prepare for shipment, transport, and receive elements of the system. These are normally the initial and non-repetitive actions during the development program, preparatory to system, subsystem, or end item testing.

c. *Documentation.* Fundamental to the approach taken by AFSCM 375-5 is the principle that systematic documentation of each step in the technical analysis and design process is essential to both sound engineering practice and sound management of a complex system program. In following this principle, the manual defines a comprehensive set of specific technical documents, together with standard format and content requirements, around which to develop and amplify details of the system engineering process during a system life-cycle. Among the total of fourteen documents defined,the six listed and described briefly below are of particular interest in relation to information processing elements of electronic systems.

(1) Functional Flow Block Diagram (Functional Diagram). Functional Diagrams are drawings which structure and relate sequences of functional operations which will meet system requirements. They are drawn at a series

of levels, beginning with top level and progressing through first, second, third, and lower levels as required to identify and define parallel and sequential interactions of necessary functions. Their purpose is to identify functional needs of the system, independently of design solutions initially, in the areas of Operations, Maintenance, Test, and Activation.

(2) Requirements Allocation Sheet (RAS). RASs are sheets used to record design requirements and constraints for each function portrayed on the Functional Diagrams. As key records of Definition Phase analyses, the RASs are developed in a series of steps and iterations, resulting in a set of listings which identify, for each function:

(a) the design requirements, in terms of input, output, and performance values, tolerances and limits, structural/design constraints, reliability, safety, etc., and functional or technical interfaces;

(b) requirements imposed on facilities, in terms of environment, power, space, location, etc.;

(c) name, and CEI number or other designation, of the item of equipment to which the function is allocated; and

(d) for functions which involve personnel, relevant task, skill, timing, training, including training equipment, and procedural data requirements.

(3) Trade Study Report. This is a report which documents alternative design approaches and/or design solutions, together with back-up rationale for selection among alternatives based on technical capabilities, cost, time, resource limitations, or other relevant considerations and constraints. Trade-off studies to select among significant alternatives may be accomplished at all levels of system, subsystem, and end item analysis and design, backed up by time-line analyses (see below) when appropriate.

(4) Time-Line Sheet. This is a standard form used to record analyses of time-critical functions, to facilitate visibility of sequential operations or tasks and evaluate design effectiveness in relation to constraints of timing.

(5) Schematic Block Diagram. The Schematic Block Diagram portrays the solutions adopted, or proposed, for allocating functions within the system, subsystems, and end items. The diagrams are prepared, identified, and controlled as engineering drawings, for inclusion in the system and contract end item specifications. They are drawn at three levels:

(a) A first-level schematic depicts functions apportioned to subsystems, and shows inter-system relationships.

(b) A second-level schematic is a technical expansion of the first-level diagram, relating contract end items within a subsystem.

(c) A third-level diagram shows expanded logic within elements represented at the second level. These are prepared typically to reflect the detailed logic of Part I CEI Detail Specifications.

(6) Design Sheet. Design sheets are employed to integrate the design requirements identified previously by functions, in the RASs, into contract end items. They define quantitative requirements and tolerances, and organize the criteria for subsequent detail design into the format of sections three and four of the Part I Specifications.

As a set, the above six documents constitute basic elements of the processes of system-level and CEI-level analysis and design during Conceptual and Definition Phases of the system cycle. Their content, levels, and specified uses are designed to insure technical integrity of the system design, and to furnish information by which the adequacy and completeness of design can be verified. When fully executed for all items and at all levels, they should permit (a) tracing all derived requirements to their sources, and (b) correlating requirements among the diverse functional elements of equipment, facilities, procedural data, and personnel.

C. RELEVANT FACTORS IN ELECTRONIC SYSTEMS

1. General

The effort to define a uniform process for the development of systems involves certain assumptions about the degree to which systems have common characteristics. Since no two systems are ever identical, some degree of generalization is always necessary. The problem is to arrive at levels of detail which strike a proper balance between adequacy of guidance, on the one hand, and flexibility of application, on the other. While it has been conceded that electronic systems differ in significant ways from weapon systems, as a class, it is also true that electronic systems themselves are by no means alike. Currently, the Air Force recognizes important distinctions among the following three subclasses of computer-based (data) systems.

a. *Research and Development Supporting Data Systems.* These are systems for performing computational processes such as simulation, data reduction, test analyses, etc., which are supplied for direct support of approved research and development activities.

b. *Management Supporting Data Systems.* These are data processing systems which support the conduct of management or administrative functions within functional organizations or commands.

c. *Operations Supporting Data Systems.* These include systems which produce information for decision-making related to direct command, management, and/or control of forces, and those which support weather, warning, intelligence, and other operationally associated functions.

This guide is directly concerned with the Operations Supporting, including certain systems in the Command and Control class, since these are currently the types of data systems to which 375-series systems management procedures normally apply. Thus, the "model" is exemplified by such systems as BUIC, NORAD COC, 465L, 412L, and others, as well as by the information processing subsystems of more complex systems--e.g., AWAC--in which large-scale information processing capabilities are combined with the development of sensors and/or vehicles in a single system program. In general, concern is with the information processing aspects of such systems, since these are the prominent aspects to be considered in distinction to aircraft and missile systems.

In the interests of uniformity, it is desirable to avoid overemphasizing the uniqueness of any one system model, whether within the context of data systems or weapon systems. However, the system engineering process is outlined herein, largely as it has developed during the past few years, in the light of such background considerations as the following:

a. *Equipment.* The basic hardware in an information system consists

of a digital computer, or computers, and associated peripheral equipment. The technology for such equipment is well established. While it typically requires extensive contract effort during a system program to modify, adapt, and/or configure to meet military requirements of the given system, it does not normally require a totally new, special-purpose development. Reliability and maintainability are high. Since digital computers are basically general-purpose instruments, their detailed design is relatively independent of specific system functions. Consoles for system operators tend to be an exception, to the extent that the detailed nature and arrangements of display/control elements must typically meet performance/design requirements which are based upon detailed system operations. However, these are also subject to an increasing use of standard components.

b. *Communications.* Interfaces with other systems are typically of major importance in the development of a given new information system. Matters to be considered in this area include message rates, volumes, formats, and types of information to be exchanged, in relation to existing and planned communications both within and between systems.

c. *Personnel.* Skills and knowledges of importance reflect the data manipulation, decision-making, command, and resource management functions which are characteristic of information systems. A high proportion of system operators are officer personnel of the command organization. They work together as groups, with complex interpersonal as well as man-machine interactions. While equipment maintenance remains a continuing need, requirements are relatively routine as compared with the focal importance of this area in most weapon systems. In the support area, computer programming skills associated with functions and characteristics of the given system are typically significant.

d. *Computer Programs.* System engineering considerations occasioned by the prominence of computer programs as elements of information systems are a principal subject to be amplified subsequently in this guide. In general, the technical development process for computer programs involves a variety of unique features in comparison with other system elements, having implications at all phases and levels of system planning, development, and operation.

e. *System Exercising.* Requirements to establish, maintain, and evaluate operational readiness are inherent in any military system designed to perform its primary mission in a hostile environment which does not actually exist during much of the system's operational life. These requirements are most typical, in fact, of weapon systems. However, an operational exercising capability has proved to be uniquely feasible to implement in certain electronic systems, where (1) the equipment can withstand long periods of use without serious degradation, (2) exercises can be conducted without compromising system readiness while they are in progress, and (3) the nature of the system mission and operations permits realistic simulation of external inputs, including responses to system outputs. For the most part, these conditions have been typical of air defense systems, in which system exercising capabilities have had their

widest application and use. The feasibility and needs are not necessarily universal. However, in cases where requirements are established, developmental implications must be taken into account during all phases of the system program.

2. System Segments

As system elements, computer programs constitute a special class of products resulting from the system acquisition process which are distinguishable in a variety of ways from equipment, facilities, data, and personnel. Because of significant similarities in requirements for their development, however, they have become established in system programs as having roles generally similar to those of prime equipment and facilities. For example, they require performance and design specifications to be produced during the system program by a contractor; they are subject to formal design reviews, inspections, and performance testing; and they constitute products which require a variety of support items in such forms as handbooks, manuals, personnel and training, etc.*

Because of their typical prominence in electronic systems, computer programs and associated technical products are normally identified as a subsystem of the total system. With reference to the concept of system segments as set forth in AFSCM 375-1, the work associated with developing this subsystem constitutes a distinct system segment, for which responsibility is assigned to a single associate contractor or to a single prime contractor in combination with other system segments.

A system segment, in essence, is an identified area of contractor responsibility in a system program, consisting principally of research, development, and other activities associated with the development and delivery of contract end items (CEIs) and data. As discussed herein, the computer program segment encompasses the following major activities: analysis of system information processing functions; allocation of functions to operational personnel and the computer; definition of performance/design requirements for computer programs; development of operating procedures; design, development, and testing of computer programs; and development of provisions for operational training and other personnel subsystem products.

Thus, at a minimum, the typical electronic system program will normally involve the following system segments:

Computer Program
Computer and Associated Equipment
Communications
Facilities

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* A detailed discussion of similarities and differences between computer program and equipment items, with respect to implications for configuration management, is contained in ESD Exhibit EST-1, Section H.

While a given system may require other segments, e.g., sensors, vehicles, propulsion, guidance, etc., the principal areas of distinction with aircraft and missiles are actually only the first three. This guide attempts to clarify the computer program system segment primarily, but with attention to all elements during the Conceptual Phase and to essential interfaces with other elements throughout the system program.

CHAPTER II CONCEPTUAL TRANSITION

A. GENERAL

The emphasis in this guide is on those phases and parts of phases of a system life-cycle during which a system program is under formal control of a System Program Office (SPO), under Air Force Systems Command. The narrative descriptions and flow covered in Sections B and C below are confined to the last portion of the Conceptual Phase, namely, Conceptual Transition, which represents the initial stage at which a SPO undertakes to meet specific objectives which are uniformly defined for all system programs.

Prior to Conceptual Transition, exploratory and advanced development studies will have been completed, and information will have been acquired at levels needed for issuance of the Requirements Action Directive (RAD) by Hq., USAF. In addition to Advanced Development studies which may have been completed successfully to demonstrate the feasibility of hardware or computer program techniques, the prior studies should have established the firm operating needs, gross feasibility, and a proposed system configuration. There are wide variations in the specific approaches by which this point can be reached for different systems. However, the hypothetical stages which are outlined briefly below may illustrate the types and levels of information which the prior studies should have yielded, in the case of an information system.

1. Tentative System Concept

At some early stage, recognized requirements for improvement in organizational or command functioning have led to an initial concept, or set of alternative concepts, for an improved operational capability. The nature of the capability may have been identified in a preliminary way, for example, as a computerized system containing a centralized base of information required by a command organization or headquarters for controlling and managing forces and resources, with real-time execution of identified control functions, or provisions for mathematical modeling to assist in planning, policy-making, etc. At this stage, objectives are defined in general terms only, and functional needs have not been related to the organization's complex mission in sufficient scope and depth to provide a basis for initiating evaluations of the concept or its alternatives in terms of operational, technical, and economic feasibility.

A tentative system concept provides a point of departure for study and analysis at succeeding levels. As formulated initially, it may be revised, refined, or possibly even abandoned during the course of critical examination at later points in time.

2. Analysis of Operational Requirements

Objectives at this stage are to arrive at descriptions of the proposed system mission, its operational environment, and interfaces with other systems, and to formulate a doctrine of operational employment. This information is

acquired through study of the operating organization to identify and define required outputs, inputs, and processing activities at a functional level--i.e., without necessary regard to current or projected design implementation. Implementing concepts are not excluded from consideration; however, they become the principal subject of more direct inquiry, at progressively more detailed levels, during later stages. Information resulting from this stage provides the necessary basis for subsequent study of alternative implementing designs. Emphasis is on identifying specific areas in which the proposed system would be expected to improve, or make possible, the organization's performance of a specified operational mission.

There are many methods and tools which can be employed in performing an operational requirements analysis. The magnitude of the task is affected, initially, by the extent to which requirements and deficiencies in current operations have already been documented by members of the organization. It is also importantly affected by size of the organization and complexity of its mission in relation to functions contemplated for the proposed system. Early steps may indicate necessity to delimit the scope of immediate further inquiry to some subset of the mission elements which were implied by the initial system concept. In this case, substantial effort may be involved at the outset in defining, first, the general parameters of an ultimate system to be considered for long-range planning, and second, detailed parameters for the elements to be explored in depth and planned as an initial capability. Requirements for compatibility with the ultimate system must then be identified as continuing guidelines associated with the initial capability concept.* However, while these and similar considerations will influence the level and depth of activities, the general approach should encompass such points of emphasis as the following:

(a) Collect and analyze functional requirements reflected in approved missions/tasks for the organization and its subordinate units. Identify mission elements pertinent to the initial system concept; identify and select an approved subset of elements, as necessary, for detailed analysis in subsequent steps.

(b) Taking into account the boundaries implied by decisions made under (a) above, collect and organize a comprehensive listing of the relevant required outputs, identifying: nature and levels; destinations (internal and external): requirements for accuracy, sufficiency, timeliness, relevancy,

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*This does not imply the "evolutionary" development concept which has been propounded for some classes of information systems. Following the issuance of a RAD for the initial system, its development will follow a planned sequence of phases in conformance with established procedures of system program management. While design should permit flexibility for growth and incremental improvement during operations, it is assumed that major increments of expansion into the ultimate system might also occur in a series of programmed cycles.

frequency, traceability, etc. Types of outputs to be considered include decisions, recommendations, orders, or other information in the form of reports, forms, messages, etc.

(c) Collect and organize listings of inputs relevant to the outputs identified above. Identify classes, sources, accuracy, currency, availability, and all other characteristics which are related to the dual objective of (1) defining the inputs which the projected system needs, and (2) identifying the degree to which presently available inputs meet, or fail to meet, the needs.

(d) Identify and define the types and characteristics of information-handling and processing requirements associated with organizational outputs. These will encompass requirements for routine processes of retrieving, summarizing, correlating, validating, routing, etc., as well as for complex modeling, real-time computations, evaluation, prediction, and other activities leading to decisions, recommendations, control, or other information outputs.

(e) Document the system operational requirements. While most data collection occurs under steps outlined above, additional analyses and iterations occur in the process of integrating the data into a comprehensive description of system requirements. Quantitative facts and estimates are identified and included where appropriate. This step involves further evaluation, coordination, and validation of requirements for: adequacy in reflecting user needs during the projected future time period; attention to environmental, political, and organizational contingencies; functional interfaces with existing and planned other systems; major factors of reliability, flexibility, security, and state-of-the-art. Throughout, attention is needed to define specific technical objectives for feasibility studies to be conducted subsequently, including special research in areas requiring long lead-time for technical solutions.

3. Feasibility Studies

Feasibility studies, in general, are concerned with the evaluation of proposed approaches and/or designs for implementation. They occur at different levels, and with iterations, during all phases of a system life-cycle. At this stage, they are directed towards selecting a preferred system concept--i.e., a gross system configuration--through evaluation of alternatives with respect to such major factors as organization, geography, and inter-system interfaces. The objective is to establish a definite framework of major parameters and boundaries for the selected system, as a necessary basis for delimiting the potential scope of information processing analyses to follow. Together with results of the preceding requirements analysis, results of the feasibility studies should be reflected in formal requirements documentation (viz., the RAD) issued to govern the conduct of subsequent planning and system analysis.

For the most part, the specific direction and emphasis of these feasibility studies will be determined by questions identified during the course of preceding requirements analyses. At this level, a general emphasis can be

expected on information needed to guide or reflect policy decisions in such areas as centralization vs. decentralization, organizational structure and responsibilities, deployment and operating dectrines, etc. To varying degrees, studies or summaries will be required to assess major trade-offs among relevant information processing technologies, including communications, personnel, and support factors. Additionally, state-of-the-art in relevant data processing equipment and techniques should be explored in sufficient depth to specify a general design approach for the system, considering the pertinence of such techniques as time-sharing, parallel processing, remote query, predictor displays, rapid print, and others. Where special capabilities are being considered--e.g., mathematical modeling, real-time processing with low frame times, etc.--, emphasis is needed to assess the constraints, feasible techniques, and associated concepts applicable to the performance of these functions, and to initiate further studies in depth where long lead-time for solutions can be anticipated.

B. DIAGRAM OF THE CONCEPTUAL TRANSITION PROCESS

The "Conceptual Transition Process" (Figure 2) is a diagram depicting major sequential actions of significance in system engineering which must be accomplished prior to termination of the Conceptual Phase. In this phase, actions are shown at two levels: (1) actions accomplished by higher headquarters, and (2) actions for which the SPO cadre is responsible; SPO actions may normally involve assistance by a GSE/TDC and/or necessary technical support by contractors to develop the required system engineering analyses and documentation.

The following section consists of narrative descriptions keyed to each of the numbered actions depicted on the diagram.

C. NARRATIVES

C-1. Requirements Action Directive (RAD) Issued

The RAD, prepared on AF Form 71, is the formal document issued by Hq., USAF to initiate Air Force actions necessary to begin a funded program or project leading to procurement of a new system or equipment. In conformance with AFR 57-1, 17 June 1966, it replaces and makes obsolete the former Specific Operational Requirement (SOR), Operational Support Requirement (OSR), and the Advanced Development Objective (ADO). Where the intent is to acquire a new system, the instructions from Hq., USAF to AFSC which accompany the RAD will normally specify that the Conceptual Phase will lead to a Definition Phase by the application of AFR 375 procedures.

Thus, the RAD becomes the formal authorization for all subsequent system planning, design, and testing. From this point on, the Conceptual Phase involves establishing system performance and design requirements and constraints as necessary steps in constructing the Preliminary Technical Development Plan (PTDP), and to develop prerequisites to the Definition Phase.

The RAD authorizes the AFSC division to establish the SPO cadre.

C-2. SPO Cadre Established

The SPO cadre is established as the office having full management responsibility for the program during transition from Conceptual to Definition Phase. The RAD should define future goals sufficiently for realistic planning of the effort necessary for their achievement. The SPO cadre is manned to fulfill necessary responsibilities in engineering, procurement, test, logistics, data requirements, personnel subsystem, program control, and information processing.

Under leadership of the AFSC System Program Director (SPD), the SPO cadre includes, in addition to other AFSC personnel, representatives of the using command (e.g., SAC, TAC, ADC), AFLC, ATC, and other government agencies having a responsible relationship to the system. Advanced planning support may be provided by key personnel from a GSE/TDC. People comprising the SPO cadre are the nucleus from which a formal SPO is established during Definition Phase A.

C-3. Information Processing Analysis Initiated

Initial activities will normally include compiling, reviewing, and assessing the source documentation resulting from previous Conceptual Phase events and studies. While the preceding events may not have followed a standard pattern,

they will have included the formulation of a system concept, the selection of a preferred system approach among competitive and alternative concepts, and the establishment of feasibility for a selected gross system configuration. Relevant exploratory and advanced development studies should have been completed, together with other necessary analyses to insure that the system selected will meet the operational performance capabilities specified in the RAD and will be technically attainable within the required time period, usually of 3 to 5 years.

As a critical first step, it is typically necessary to verify that the basic mission or missions to be performed have been identified and defined in sufficient scope and depth to provide a basis for the subsequent detailed analyses of information processing functions and design requirements. Additional inquiry and studies may be necessary to insure that available descriptions of mission requirements are complete and accurate with respect to such areas as: the military objectives and constraints associated with each mission element; the friendly environment, including activation requirements and integration with other systems; the concept of operation associated with each mission/environment; and operational performance requirements for each mission, including phase-overs from one mission or operating mode to another.

The Conceptual Transition Studies initiated at this time are directed towards assessing applicable data processing technologies and completing the identification of subsystems and major components by the end of the Conceptual Phase. At that time, the technical information relating to information processing functions, equipment, communications, facilities, and operational command personnel should be available in sufficient depth to provide an adequate technical base for writing the PTDP, as well as for subsequent development of the System Performance/Design Requirements General Specification which will be needed during the early part of Definition Phase A.

C-4. Develop System Functions

For the system as a whole, the system engineering process at this stage should conform generally to that outlined in AFSCM 375-5 (10 March 1966, Block 3, pp. 28 ff.). The process consists primarily in formulating a description of the system in terms of functions which must be performed in order to meet system requirements, with attention to such important considerations as: insuring that continuity is maintained with established requirements, critical decisions are documented, total system requirements are considered, means are provided for tracing gross functions down to detailed functions of elements, and interfaces among systems remain visible.

Initially, system requirements are translated into top-level Functional Flow Block Diagrams (Functional Diagrams), depicting the gross operations, maintenance, test, and activation functions. Subfunctions are then developed through first-level Functional Diagrams and to lower levels as needed to define

relevant operations, maintenance, and Category I and Category II test and activation concepts for the given system. In general, the attempt is made to limit these analyses to pure functions, avoiding the use of preconceived configurations as the basis for their development. While exceptions may normally occur, objectives at this stage are to assure completeness and accuracy of the functions, and to provide maximum latitude for their subsequent allocation to optimum combinations of equipment, facilities, computer programs, and personnel.

With regard to information processing functions, it may often be assumed that key aspects of the gross system configuration will have been determined prior to this stage, and reflected in the RAD. For example, the types and general locations of sensors, whether external or self-contained in the system, and other input sources external to the computer will be known; the decision to employ digital computing equipment will have been made; the user organization(s) interacting with the computer, and whether at fixed or movable sites, will be known; major communications constraints will have been established; etc. Hence, emphasis will typically be placed on detailing the nature, frequencies, and volumes of input data; identifying required processing functions, and defining the types, levels, and destinations of required outputs.* Additionally, for systems which involve a large data base, an important effort at this stage will be devoted to determining the data categories, volumes, and storage requirements. Where applicable, this activity will involve compiling relevant information in such areas as fixed vs. variable parameters, requirements for sites or operating mode adaptation, and special requirements for data collection and generation.

In addition to operations, attention is required to a variety of supporting functions which must be anticipated and reflected in the PTDP, System Specification, and System Test Plan. Special analyses may be required to define functions in the areas of computer programming language, other utility functions, testing, simulation, and data reduction. It should be noted that these will not include maintenance functions for the computer programs as such, although they may typically include maintenance-diagnostic functions to be performed by computer programs for equipment. "Maintenance" does not apply to computer programs in the sense that it applies to equipment, since computer programs do not wear out or otherwise degrade as a function of use, time, environment, etc. However,

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*In certain cases, other formats may be superior to the "single thread" Functional Diagrams described in AFSCM 375-5 for depicting the multiple input-output relations which are typical of real-time processing systems, in particular. At the same time, it has been demonstrated that the AFSCM 375-5 diagrams can be used, at least to the third level, as bases for material to be generated on Requirements Allocation Sheets. Further studies of examples and alternatives for these documents are currently in progress.

since requirements for frequent changes during operational use are typical, attention should be given at this time to anticipating the nature of computer programming facilities, procedures, and personnel which will be required for support of the user during the operational period.

C-5. Determine Design Requirements

Considerations set forth in AFSCM 375-5 (10 March 1966, Block 4, p. 30 ff) should be taken into account in developing the design requirements for electronic systems. The process consists, in general, of determining required characteristics of major elements of facilities, equipment, personnel, procedural data, and computer programs which will perform system functions previously identified. Emphasis is on quantified or well-qualified requirements, supported by trade study reports or time-line sheets where relevant. Requirements are keyed to functions identified on Functional Diagrams at each level, and are documented on RASs, initially, in terms of such factors as: purpose of the function; parameters of design (i.e., input and output values and allowable tolerances); constraints such as space, power, interfaces, time, and environment; system effectiveness, reliability, human performance, safety, security, etc.

In the information processing area, objectives are to (1) define performance/design/test requirements for the information processing system/subsystem as a whole, (2) identify system segments, (3) allocate requirements to system segments and to major system elements, including personnel as well as major elements of computer programs and computing equipment, and (4) define all relevant interfaces between segments and with other systems.

Together with documentation resulting from activities outlined in the two preceding Blocks, C-3 and C-4, technical information compiled prior to the end of Conceptual Transition should include coverage of the areas listed below.

(1) A verified and/or amplified description of system mission requirements, covering mission objectives and constraints, environment, integration with other systems, operational and maintenance concepts, phase-overs, operating modes, and other relevant mission conditions.

(2) Definition of system information processing functions, covering external inputs and sources, processing operations, and outputs and destinations, together with associated gross performance/design requirements in terms of volumes, rates, timing, accuracies, and special conditions.

(3) A description of the system data base, including nature, volumes, storage, adaptation, and special requirements for collection and/or generation.

(4) A description of selected techniques of computer programming to be adopted for the system--e.g., heuristic programming, adaptive control,

higher-order language, graphic analysis, time sharing, etc. A gross description of the size and operating characteristics of the computer program subsystem should be included. This description is based upon the selected computer programming techniques, together with system functional and data base analyses, and should include identified requirements in the areas of maintenance-diagnostics, utility, and support (e.g., test, simulation, data reduction).

(5) A description of the command organization, identifying: levels of command, responsibilities, and geographic locations; operator positions and responsibilities for man-machine functions; modes of display data presentation (console digital or situational, closed-circuit TV, wall display, hard copy, etc.); required operator inputs to the computer; and required communications. The description should include a preliminary estimate of personnel requirements, including computer programming and simulation/exercising, as well as operational personnel.

(6) A description of requirements for system exercising. This description is derived principally from analyses of user command requirements for system/subsystem evaluation and operational readiness training which can be met by periodically exercising the operational system. Based upon identified functional requirements (exercising configurations, conditions, missions, frequencies, functional simulation, recording, and analysis) and studies of feasibility, the description should include a preliminary identification of the major elements required to implement the exercising capability. These elements should include additional demands on the operational system (e.g., computer storage space, tape units, communications), as well as special equipments, support computer programs, and personnel required to perform the functions of planning, preparing, and conducting exercises.

(7) A description of interfaces with other systems. This description should define the requirements for inter-system data transfer for each mission, including the resulting impact on other systems from operation of the proposed system. Emphasis should be placed on identifying message types, frequencies, and volumes in relation to required automatic and voice communications links.

(8) Computer and associated equipment requirements. While this description should be at a level which permits maximum latitude for subsequent selection among design alternatives, limiting characteristics should be defined for the following components and parameters: general logical and physical equipment configuration and geographic locations; data processing speed and requirements for special instructions or characteristics; estimated storage requirements, in terms of bits, sample word structures, type of access, and access time; input/output interfaces, including rates and special interface functions; requirements for peripheral units such as magnetic tape units, card machines, etc., in terms of numbers, capacities, and speeds; operator console numbers, types, input control requirements, and display types and capacities; requirements for special synthetic signal or message generating equipment; numbers, capacities, and types of special consoles for simulation; special displays

(e.g., large wall) or hard copy printouts; and growth potential, specified in terms of the preceding items, reflecting anticipated future expansion or modification of system functions.

C-6. Provide Inputs to Preliminary Technical Development Plan (PTDP)

The PTDP is prepared in the format prescribed for the System Package Program (SPP) in AFR 375-4, which specifies sixteen sections under which system program information is to be provided for review and approval by higher headquarters. At this time, a seventeenth section, entitled " Definition Phase Plan", is also required for specific planning with reference to the ensuing Definition Phase activities.

Technical inputs supply key portions to be included in many sections of the PTDP, which becomes the governing authority for the system program during the Definition Phase and the basis for subsequent updating in the form of the Proposed System Package Plan (PSPP) and the SPP. In general, inputs will include: the diagrams of functions which will meet requirements specified in the RAD, together with their engineering descriptions; design requirements derived from the functions; the system configuration defined by Conceptual Phase Studies; significant trade-offs performed and identification of significant trade-offs remaining to be performed, with emphasis on areas of high technical risk; and activation and test concepts which will provide a basis for subsequent writing of the System Test Plan and Section 4 of the System Specification. For electronic systems, inputs should establish that hardware parameters and constraints, and other types and levels of technical information outlined in the preceding Block C-5, have been defined sufficiently to permit initiating the development of Part I Specifications for computer programs at an early point in the Definition Phase.

In addition to inputs based upon system engineering accomplished during the Conceptual Phase, Section 17.8 of the Definition Phase Plan, entitled "System Engineering Implementation Plan (SEIP)", calls for information covering the implementation of requirements cited in AFSCM 375-5. The section covers plans for application of requirements of Exhibit I, system engineering documentation, design reviews, intersystem and intrasystem trade studies, and system engineering responsibilities of in-house agencies and contractors. Normally, these requirements are to be applied to a system and its parts in a selective manner, defining specific areas in which AFSCM 375-5 procedures will be applied in full or in part to each area. In general, the emphasis on completeness of analytical documentation will be greater for those areas and elements which are new, and/or critical, than upon those which represent established previous practice and experience. Also, where the needs exist, consideration may be given to alternative documentation proposed by the contractor which may not conform to the format and content of AFSCM 375-5 documents but which can be shown to accomplish comparable end results.

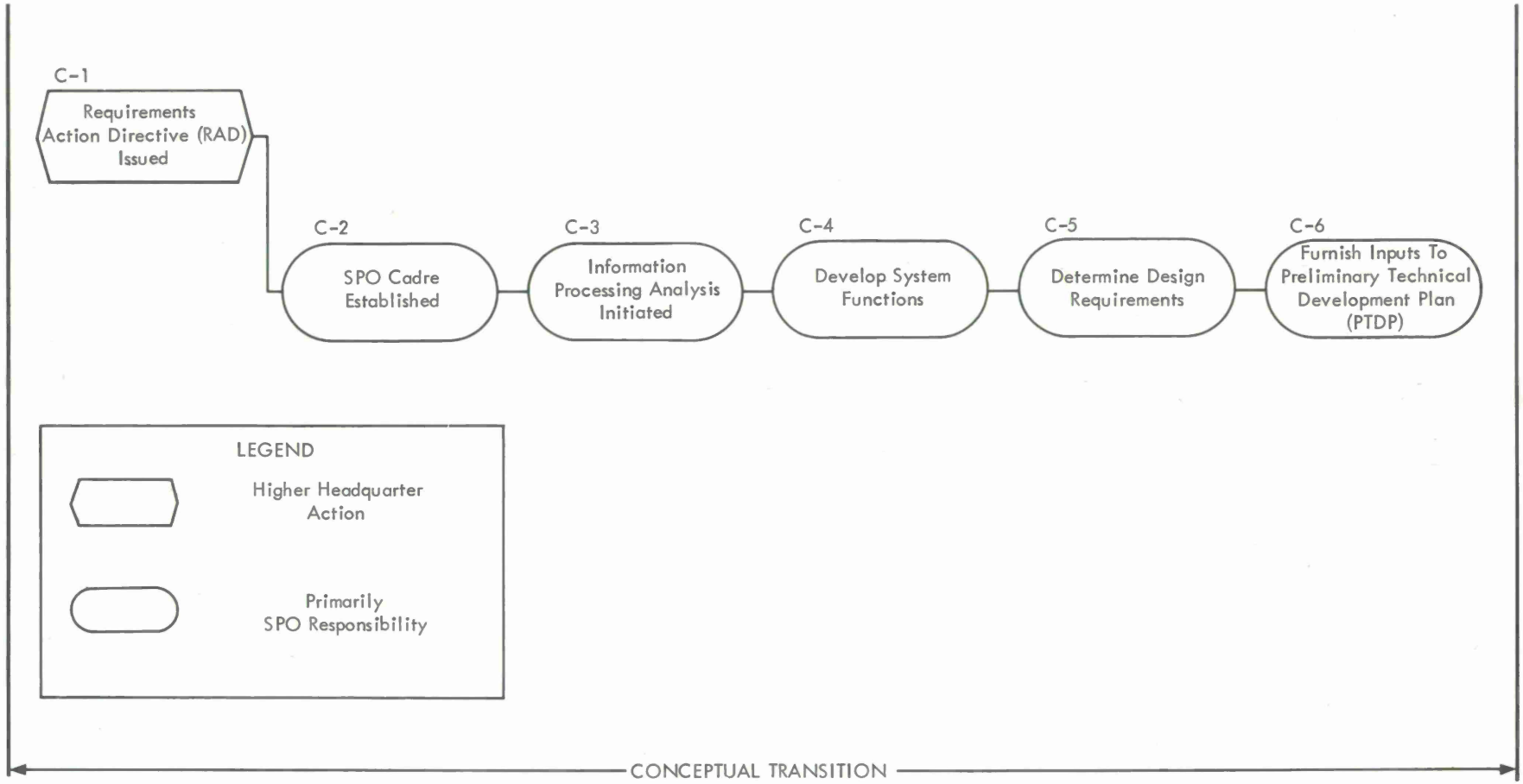

FIGURE 2. CONCEPTUAL TRANSITION PROCESS

CHAPTER III DEFINITION PHASE

A. GENERAL

1. Activities during the Definition Phase are structured into three sequential subphases which are designated, for simplicity, as Phase A, Phase B, and Phase C.

(a) Phase A begins with the issuance of an approved PTDP and associated system program documents by Hq., USAF. It consists, in turn, of three subsubphases which may extend, collectively, for a maximum duration of 8 months, as follows:

(1) In-house technical effort to prepare Work Statements, System Specification, plans, schedules, and the RFP.

(2) A period of contractor proposal preparation in response to the RFP.

(3) In-house proposal evaluation/source selection, and Phase B contract negotiations.

(b) Phase B represents the period of contractor technical definition and preparation of firm proposals for system acquisition, designated by higher headquarters for a maximum duration of 6-8 months.

(c) Phase C consists of proposal evaluation, source selection, PSPP preparation, evaluation and approval of the program by higher headquarters, and negotiation of Acquisition Phase contracts, over a 4-5 month maximum period.

2. In this guide, events depicted on the diagram (Figure 3) and discussed in the narratives below for Phases A and C represent system-level events which are performed by the SPO. In Phase B, although key interfaces with other segments are identified, description of the technical process is limited to activities and products within the computer program system segment. It is to be presumed that parallel Phase B activities for other segments of the system as a whole could be shown at a comparable level, each concerned with appropriately different specific tasks in the same general areas of analysis, design, test planning, and human factors.

3. General objectives of Phase B for the system, as set forth in AFSCM 375-4, are reflected in the nature and levels of required Phase B products which are defined for the segment. The contractor final report, as a whole, should conform to the four-part outline defined in AFSCM 375-4, in which Part II, "Technical Report", contains the major products of Phase B system engineering effort (see Block D-33). Included among these, as key products of information processing analyses accomplished up to this time, are

the Part I Detail Specifications for computer program CEIs.

4. Terms which will be found in the narratives to distinguish among subclasses of computer programs are defined as follows:

(a) Operational. These are computer programs designed to perform functions which are required to carry out the primary operational mission(s) of the system.

(b) Support. Support computer programs perform such functions as testing, recording, data reduction, and simulated data generation. The significance of distinguishing these particular programs as a subclass of "supporting" computer programs in general lies in the fact that, while they are not essential to direct performance of the operational mission, their design is closely dependent upon design of the operational computer programs.

(c) Utility. These are computer programs used to assist in the operation of the computer, for such purposes as assembling, modifying, running, or manipulating other computer programs. As a general rule, their design is relatively independent of the operational computer programs which are designed to perform specific mission applications of the computer.

(d) Maintenance-Diagnostic. These are computer programs which also assist in operation of the computer, but for the specific purposes of maintaining the computer in an operating state and aiding diagnosis of malfunctions. Their design is based on the detailed design of the computer circuitry. However, they may also involve operating and design interfaces with the operational computer programs in some real-time systems.

The above terms have been used in a limited class of systems, and are currently referred to in a number of Air Force documents. However, like many other terms and concepts to be found in the "software" field, they are by no means standard. Disagreements exist with the definitions given above; and quite different classifications are made in some systems, e.g., non-functional, applications, etc. The terms are used herein largely for convenience in distinguishing certain phasing differences and design dependencies which tend to be typical. It is not intended to suggest that they are universally applicable.

With regard to technical implications, the labels refer more directly to classes of functional elements than to computer program contract end items (CPCEIs). For example, an "operational" CPCEI often includes certain simulation or data reduction functions. In fact, the complete set of all operational and supporting functions may be combined into a single CPCEI for the system, in the event that all elements are being developed by a single contractor and are intended for common use and management during the Operational Phase (see also comments in Block D-1 footnote and in Block D-26).

It may also be noted that the distinctions correspond only partially with the AFSCM 375-5 classification of functions into operations, maintenance, test, and activation. Very briefly: operations and operational are essentially equivalent; test functions exist in both utility and support; activation is not of particular significance to computer programming; and maintenance has a variety of complex interpretations, with some (different) applicability to both utility and maintenance-diagnostic.

For simplicity of discussion, and because their definitions are not rigorous either in a technical or in a management sense, the variety of functions contained in utility, support, and maintenance-diagnostic areas are grouped together in the Definition Phase diagram (Figure 3) and referred to elsewhere, collectively, as "supporting" functions or CPCEIs.

B. DIAGRAM OF THE DEFINITION PROCESS

1. The "Definition Process", Figure 3, depicts major actions of significance which should typically be accomplished during Phases A, B, and C. Phases A and C consist principally of sequential system-level activities accomplished by the SPO, while Phase B events represent activities of a contractor responsible for the computer program system segment.

2. The different horizontal levels at which events are shown on the diagram distinguish in a gross way among subactivities associated with (a) development of Part I Specifications for operational CPCEIs, (b) human engineering and personnel requirements development, (c) system exercising capability development, (d) test analysis and planning, and (e) development of Part I Specifications for CPCEIs in supporting areas. The location of an event at one point in the sequence is not meant to imply that the event begins and ends at that discrete time, but to assist in illustrating the major dependencies which are depicted by connecting lines. It is to be assumed that most of the activities shown are in fact continuous, and that they also interact on a continuing basis, throughout the duration of Phase B.

C. NARRATIVES

PHASE A - PREPARE FOR CONTRACTOR DEFINITION

D-1. Expand System Analysis and Definition

Technical studies to be accomplished during the early part of Phase A consist primarily of reviewing, verifying, expanding, and altering the technical concepts and data resulting from Conceptual Phase studies, taking into account firm decisions and changes reflected in the approved PTDP. Necessary expansion or alteration of functions, review and verification of design requirements, and performance of trade-offs for solutions to unresolved alternatives are accomplished concurrently. At this point, immediate objectives are to establish the spectrum of operations, maintenance, test, and activation functions, together with associated design requirements and constraints, at levels required for the System Specification and other documents to be issued with the RFP.

In the information processing area, attention is needed to analyses which will assure that minimum essential interfaces between computer programs, computing equipment, communications links, facilities, and personnel are adequately defined. Parameters to be firmly established will include, for example: types and capacities of computer storage; timing, types and capacities of display and input/output equipment; types and functional characteristics of special simulation equipment; expected data links, types, formats, and rates; gross sizes and characteristics of operational, utility, support, and maintenance-diagnostic computer programs, including design requirements relating to timing, data sources, and quantities; use of higher-order language, modes of display data presentation; and simulation. Firm information in these categories is essential to the subsequent initiation and successful completion of Part I Computer Program CEI Specifications during Phase B.

This effort leads to the preparation of the initial specification tree for the system. For computer programs, the specification "tree" is essentially a list of the CPCEIs; it will not normally reflect levels of assembly, except to the extent that it may in some instances contain one indenture to depict government-furnished items tentatively designated for assembly into major CPCEIs. For all CEIs, the list will be refined and updated as a result of subsequent contractor proposals and Phase B studies.*

*It should be noted that the selection of CEIs is based only partially on technical considerations (cf. AFSCM 375-1, Exhibit XI). As a contracting concept in essence, the CEI represents a level of assembly for management control, to be defined individually in each case. Also, technical content is often secondary to anticipated configuration management following acquisition; for example, even though largely identical in initial content, two computer programs destined for separate operational users should be identified as separate CPCEIs if the users are expected to manage subsequent changes independently.

D-2. Prepare Initial System Performance/Design Requirements General Specification

The System Specification is prepared at this time on the basis of the technical information resulting from preceding system engineering studies, in conformance with content requirements set forth in Exhibit I of AFSCM 375-1. It includes system performance and design requirements, system segment allocations and interfaces, identification of major CEIs, and requirements for system testing. From the time of its subsequent issuance as part of the RFP, it becomes a controlled document which can be changed only through formal action of the Configuration Control Board (CCB) of the SPO, in accordance with the procedures specified in Exhibits VII and VIII of AFSCM 375-1. However, its use and the adequacy and accuracy of its technical content remain the responsibility of the SPO deputy director for engineering, with support by a GSE/TDC. Hence, it serves throughout the remainder of the system program as a key document for both technical and contractual management.

Parts of the System Specification as prepared by the SPO during Phase A are incomplete initially, and remain to be expanded by the results of contractor studies during Phase B. Data to be eventually incorporated in separate subsections under "System Allocations" (paragraph 3.3), are developed separately for each system segment by the responsible Phase B contractors and submitted with contractor Phase B Final Reports (see Block D-33).

In information systems, computer programming is normally identified as a separate system segment, for assignment either to a prime contractor in combination with other system segments or independently to an associate contractor. Associated technical responsibilities for the system segment will include the varieties of R&D activities and contractor data products which are outlined subsequently in this guide.

Where requirements for a system exercising capability have been established, it should be recognized that developmental responsibilities will generally parallel those for the system itself. Hence, performance/design requirements for the capability as a whole should be specified as a separate section of subparagraphs under paragraph 3.1 of the System Specification. Developmental responsibilities for the necessary additional and special equipment, computer programs, communications, facilities, and associated data are then allocated among system segments along lines corresponding to allocations for the system.

Applicable Data Item

C-1-35.1-1 System Performance/Design Requirements General Specification

D-3. Prepare Initial System Test and Activation Plans

The System Test and Activation plans prepared at this time by the SPO contain the planning information required to guide the contractors' activities related to test and activation during the Definition Phase.

System Test Plan

The System Test Plan is based upon the test concepts and requirements contained in the PTDP, the System Specification, and related system engineering documentation. It covers all aspects of the system, including hardware, facilities, computer programs, personnel, and procedural data with respect to such considerations as the following:

(1) Organizational responsibilities for testing.

(2) Basic system test concepts and objectives for Category I, Category II, Implementation, and Acceptance tests.

(3) Overall system test operations, including test control requirements and test support requirements.

(4) Test evaluation requirements.

(5) Test reporting requirements.

(6) Overall test schedules.

A primary function of the System Test Plan is to guide the contractors' planning, analysis, and system engineering activities related to the test areas. During Definition Phase B the contractors expand basic planning and guidance information contained in the System Test Plan and, in effect, replace it with the following documents:

(1) Category I Test Plan.

(2) Inputs to the Category II Test Plan.

(3) Inputs to the Implementation Test Plan (multi-site systems).

System Activation Plan

The System Activation Plan, like the System Test Plan, is based upon the contents of the PTDP, the System Specification, and related system engineering documentation. It identifies basic objectives, responsibilities, operations, controls, logistic support, and schedules for site selection, facilities construction, equipment and computer program installation and checkout, and system demonstration and turnover.

The contractors' planning, analysis, and system engineering activities during the Definition Phase are guided by the contents of the System Activation Plan. During Phase B the contractors expand upon the planning and guidance information contained in the System Activation Plan and, in effect, replace it with the following documents:

(1) Installation and Checkout Plan.

(2) Maintenance, transportation, packaging,and logistic support requirements.

Early in the Acquisition Phase, the SPO prepares a Site Activation Plan which serves as the basic management document for all activities relating to activation at the Category II test site and at each subsequent site of a multi-site system. The Site Activation Plan is based upon and responsive to the requirements contained in the Category I Test Plans, the Category II Test Plan, Installation and Checkout Plans, and the Implementation Test Plan.

Applicable Data Item

T-101 System Test Plan

D-4. Provide Inputs to the Request for Proposal (RFP)

The RFP represents a condensed and organized product of the actions of all functional elements of the SPO up to this point in the system program. Significant system engineering inputs comprise the principal content of such basic portions of the RFP as the System Specification, Statement of Work for Phase B, Specimen Work Statement for Development, System Test Plan, and Back-Up Data Package. Additionally, program planning information in the form of initial plans and schedules, the initial program breakdown structure, and program management network depend in varying degrees on system engineering for the work content on which plans are based.

In the system engineering area, the Phase B Work Statement will typically contain a series of paragraphs which define requirements for contractor accomplishment of system engineering tasks in accordance with AFSCM 375-5, including the required adaptation of Exhibit 2 requirements for controls and documentation to fit the given Phase B program. The content of this section of the Work Statement is based on the SEIP previously submitted as part of the PTDP (see Block C-6). It will also cite specific trade studies to be conducted, together with requirements for preparing a Part I Detail Specification for each CEI, expanding the System Specification (see Block D-2), and accomplishing personnel subsystem tasks associated with each system segment. For the computer program segment, tasks and contractor data products should reflect an appropriate adaptation of elements described under Blocks D-7 through D-33 below.

D-5. Prepare Contractor Proposals

While this step will normally have been preceded by varying degrees of contractor effort associated with conceptual, advanced development, feasibility, and/or independent research and development activities for the system, issuance of the RFP initiates a series of concerted actions to review, evaluate, and expand the System Specification, establish a proposed design approach, and organize a continuing preliminary design effort.

The System Specification, together with Functional Diagrams, RASs, Schematic Block Diagrams, and associated system engineering data resulting from earlier studies (which are included with back-up data contained in the RFP) provide the initial basis for critical review, expansion, and modification to reflect the contractor's experience and planned approach to meeting system requirements. Additional trade study reports and/or time-line analyses may be generated in the proposal preparation process, as well as other appropriate system engineering documentation to support the identification of major CEI, facility, and gross personnel requirements. These activities lead to a first level of expansion of the System Specification, possibly with proposed modifications at this time, together with expanded and modified system engineering data to be included with the contractor's proposal. Expansions of the System Specification normally relate primarily to requirements allocations by system segments, including inter-segment interfaces (see Block D-2). In the case of an associate contractor structure, each associate reponds to the segment(s) for which he is responsible, as well as to the pertinent general requirements contained in other sections of the System Specification.

Applicable Data Item

S-5-14.0 Technical Proposal

Two proposals are required for each contractor, one a firm proposal for the Phase B effort and the other a planning proposal for development in response to the specimen development SOW.

For the computer program system segment, it is to be noted that the entire acquisition effort, including necessary duplication (i.e., "production") of computer programs, will be covered by the ensuing development contract to be awarded at the outset of the Acquisition Phase. In general, proposals for the computer program segment will not contain discussions in such areas as reliability, maintainability, production, environmental testing, and similar equipment-oriented concepts. These deviations should be noted on the Form 9 back-up sheets. Emphasis should be placed on activities and products which are discussed below in the Definition and Acquisition Phase chapters of this guide.

PHASE B - CONTRACTOR DEFINITION

D-6. Award Contract(s)

Following the completion and submission of contractor proposals, evaluation and source selection activities result in selection of the contractors who will accomplish Phase B. A significant SPO activity at this time is to revise and update the Definition Phase Plan to incorporate detailed integration and implementation procedures tailored to the system program and contractor structure selected (e.g., IAC, associate contractor, or teams). The plan will include a completed SEIP (see Block C-6) reflecting the Phase B and Development Specimen Work Statements which have resulted from contractor proposals and the completion of contract negotiations.

The contracts awarded at this time initiate the start of contractor technical efforts in depth to define the total requirements of the system. From this point, the system program proceeds on contractual schedules towards definition of the design requirements baseline and associated plans which will scope and pace the total technical effort for the Acquisition Phase.

D-7. Establish and Maintain System Documentation File

The purpose of this activity is to provide a common base of authoritative technical information for use by contractor personnel in carrying out the various lines of system engineering effort required during Phase B. Primary objectives are to insure that consistent and up-to-date interrelations are maintained both among the Phase B technical products within the information processing area and with other elements of the system. Normally, these objectives can best be met by establishing a central file of the system engineering data which exist at the outset of Phase B and instituting systematic procedures for validating, updating, utilizing, and expanding the file as new or revised data are developed in the course of Definition Phase activities.

Initially, the file should contain such formal documents as the System Specification and System Test Plan, as well as available system engineering analyses, functional diagrams, feasibility and trade study reports, etc. generated during the Conceptual Phase. It may also include available data relating to: training, operations, and maintenance concepts; Using Command organization; interfacing systems; and specifications or other descriptions of existing and proposed equipment, facilities, communications, and computer programs associated with the system. Expansion and revision of the data occur throughout Phase B as new information results both from the contractor's technical analyses and from external sources.

When properly organized and managed, the file constitutes both a source and a repository of technical data relating to computer programs and personnel, and to the interrelations of these with other system elements. As such, it provides a focal point for validating the available information with system requirements, for insuring that a common base of technical requirements and constraints is available for utilization in the different lines of effort within the contractor's organization, and for verifying technical integration of the contractor's Phase B products.

The concept and objectives of the file as described are related to and include those of the Personnel-Equipment Data (PED) element of the Personnel Subsystem as set forth in AFR 30-8 and AFSCM 80-3, but are extended here to encompass system functions and tasks to be performed by computer programs as well as those performed by personnel. At the same time, the PED portion represents a special subset of PED for the system as a whole, in that primary concern in this system segment is with those operational and supporting personnel for whom PS data in the areas of human engineering, QQPRI, training, technical manuals, and PSTE are dependent upon, and require close integration with, the design of computer programs. Typically, these are personnel in the operational (i.e., information system/subsystem), simulation/exercising, and computer programming support areas.

D-8. Expand Operational Functions

This activity, in conjunction with the activity described in Block D-9, is concerned with expanding system functions allocated to the information processing system segment, detailing associated performance/design requirements, and determining suitable implementation methods, in general terms. System functions were initially identified at a gross level and tentatively allocated to system segments during Conceptual Phase studies. Additional analyses were conducted by the SPO during Definition Phase A to expand system functions, identify major performance/design requirements, and verify allocations to system segments. Thus, the activity described here is another iteration of a process which began in the Conceptual Phase and which will continue throughout the Definition Phase B. Each iteration derives the additional level of detail required to proceed to the next step of the system design and development.

Functions allocated to the information processing system segment may normally be classified as either operational, or supporting. Operational functions, as discussed here, consist of those functions which are required directly and immediately to carry out the operational mission(s) of the system. Supporting functions, discussed in Block D-9, are necessary and important for development, test, and other supporting roles, but are not directly required for performance of the system operational mission.

The level of detail contained in the descriptions of the functions available at this time will vary widely from system to system, and within a given system, from function to function. The System Specification for a new system that is very similar to one already in the operational inventory may contain sufficient detail that the only activity required at this point would be to review and verify the descriptions and allocations of functions, subfunctions, etc. In the more typical case, however, the information available at this time will consist only of gross descriptions of system functions, accompanied in some instances by system-level design requirements and constraints.

The major effort required at this time is to break down the gross functions into lower levels, i.e., into subfunctions, sub-subfunctions, etc., and determine at each level the associated performance/design requirements. In this process it will be necessary to consider (1) system operational concepts, (2) design constraints imposed by the System Specification, (3) probable operational environment, (4) requirements for input data, processing, and output data, and (5) personnel capabilities and limitations.

The initial objective of this analysis is to reach the level of detail required to (1) establish the basis for allocating the implementation of design requirements among operational computer programs, manual operations, or joint man/machine operations, and (2) adequately define interrelationships of functions/subfunctions to permit subsequent man/machine task analyses (Block D-12), further definition and analysis of computer program tasks (Block D-11), and analyses of personnel requirements (Block D-12).

D-9. Expand Supporting Functions

The activity referred to in this block is comparable in some respects to that described in the preceding Block D-8, but is concerned with a variety of non-operations functions which involve requirements for computer programs. These "supporting" items are sub-classified as utility, maintenance-diagnostic, and support (see explanation of terms in paragraph A,4 at the beginning of this chapter). While they represent functions which may or may not correspond with separate CPCEIs, they are referred to herein as separate CPCEIs for convenience of discussion.

It is to be assumed that the requirements for these functions will have been established at varied levels of specificity prior to this time, and that the relative emphasis on utility, maintenance-diagnostic, and support elements may vary widely for different systems. In general, the approaches to developing Part I Specifications for items in these areas involve characteristic differences in required phasing, types of analysis, and degree of dependence upon other Phase B activities concerned with operations.

For example, major functions to be considered in the utility area may include: compiling/assembling requirements, for translating computer programmer language into machine input code; tape loading and maintenance, for generating, manipulating, cataloging, duplicating, verifying, and interpreting computer program tapes; requirements for test/debugging of tape contents; and data description requirements, e.g., for a Communication Pool (COMPOOL) and associated COMPOOL generating and analysis tools.

In large part, the performance/design requirements for these functions are typically derived from and associated with design characteristics of the computer equipment. For a given computer, most of the resulting utility tools are useful for any system or non-system data processing applications for which the computer might be employed. Many of these tools are often supplied with the computer. However, it is also often true that additional or special utility elements must be designed to take account of specific uses or general design characteristics of the operational computer program elements in a given system; the latter is typically true of the COMPOOL, for example, which is structured to satisfy data base requirements of the given system, within storage constraints of the computer.

Design requirements in the maintenance-diagnostic area are also derived basically from design characteristics of the computer. The maintenance-diagnostic computer programs may perform such functions as detection of inoperative circuits, re-routing of computer functions through redundant circuitry, and display of information to assist a monitoring operator to evaluate the status of computer functioning. These computer programs may have significant operating interfaces with the operational computer programs, either through time sharing or on a near real-time basis. Typically, they represent important elements of, or contributors to, the computer equipment reliability.

Support computer program requirements are derived from analyses of specific needs, characteristics, or intended utilization of the system personnel and operational computer programs. They are intended for Operational Phase use, primarily, but may also be required during Acquisition, for such purposes as test, evaluation, and personnel training. Major functions performed by these computer programs are typically in the areas of (a) simulation and (b) recording/data reduction. Simulation functions involve the generation of data, either off-line or on a dynamic basis, to simulate inputs to or from system equipment, personnel, or computer programs. Data recording and reduction encompass such functions as selecting, recording, storing, sorting, analyzing, reducing, and displaying data which are generated or manipulated by the operational computer programs.

Hence, activities initiated at this time will vary in depth and level as a function of the above considerations. In the utility area, analysis of functions and definition of design requirements can proceed rapidly and in depth at an early stage. Some utility tools which will be needed during early Acquisition for developing other computer programs may require not only completed Part I Specifications but also completed preliminary or detail design prior to the outset of Acquisition; others will require essential design inputs from the operational CPCEI analysis activities (e.g., Block D-20). Expansion and definition of support functions may be initiated on a limited basis at this time, but will depend closely on essential inputs generated during the course of Phase B in the system exercising, test, and operational CPCEI analysis/design activities.

D-10. Define User's Operating Organization and Allocate Personnel Functions

This activity is directed towards defining the structure of personnel for the using agency's conduct of system operations, and allocating system functions to identified types of operating personnel and/or duty stations. It is initiated on the basis of information made available to the contractor at the outset of Phase B relating to the user's operating organization, and is extended at this stage as a continuation of the functional analysis and allocation activities conducted in the preceding Block D-8.

The identified functions to be performed by operational personnel will generally fall into two broad categories, namely:

(1) Manual -- functions which do not imply direct interaction with the computer, but which are essential to the operational mission. These will include decision, planning, coordinating, communication, recording, status posting, etc. functions performed by command and/or staff personnel of the operating organization.

(2) Man-Machine -- those functions which are directly associated with computer operations, to be performed by personnel located at, or having access to, consoles, displays, or other input/output equipment.

These functions are grouped into duty positions, taking into account such factors as (1) physical locations at which the functions must be accomplished, (2) levels of skills and knowledge required, (3) frequencies and timing requirements, (4) communication demands, (5) accuracy and reliability requirements, and (6) alternate modes of system operation.

This activity represents an iteration and refinement of studies accomplished during Conceptual Transition, utilizing the more detailed definitions of functions available at this time, together with the personnel and equipment concepts, constraints, and design requirements dictated by the System Specification. Account is taken of available information relating to training, operation, and maintenance concepts established in the PTDP; and additional contractor effort is typically required to collect further detailed data relating to Using Command mission, organization, doctrine, and operating procedures.

Further refinements should occur throughout the remainder of Phase B. The result at this stage is an interim set of lists of personnel functions, grouped by types of operating position, which provide working documents for subsequent analysis, revision, and expansion in the course of (1) developing human engineering design recommmendations for equipment, communications, workspaces, and computer programs (Block D-12), and (2) providing, under the QQPRI activity, a complete forecast of operational organization and personnel composition.

Subsequent activity will also normally include the development of similar information for personnel/organizational requirements in the areas of simulation/exercising and computer programming support (Blocks D-13 and D-25).

D-11. Define Operational Computer Program Tasks

Based upon preceding identification of major functions to be performed by the operational computer program (Block D-8), this activity undertakes the further analysis and breakdown of these functions into subfunctions and tasks, and to initiate the determination of performance/design requirements at each level.

Broadly, the individual tasks to be performed will be either in the nature of logical manipulations of data, or mathematical computations. Objectives are to define the tasks, define and evaluate their interrelationships, and progress towards the formulation of comprehensive rules to govern each computation and logical manipulation.

The process should typically involve the identification of alternative sets of subfunctions and tasks for meeting the system operating requirements, as well as alternative rules or computational techniques to be employed for accomplishing the individual tasks. Since the alternatives are typically numerous, trade-off studies in depth should be accomplished only for those sets of alternatives which offer significant payoffs in relation to system objectives. Selections are based on established system requirements, design feasibility and efficiency, and impact on other system elements.

For each task, it is necessary to identify the source and form of input data, initial operations performed (e.g., quality monitoring), all logical manipulations and computations to be accomplished, and relevant output interfaces with other tasks, together with alternative modes, conditions, and rules of operation. The definition of sequencing and interactions among tasks will be initiated at this time, leading to the specification of requirements for executive control functions.

Although this activity is based upon a previously-established general framework of functional requirements allocated to the operational computer programs (Block D-8), the studies-in-depth may result in some recommended re-allocation of functions. In addition to progress towards development of Part I Specification(s) for operational CPCEI functions, it may normally also result in detailed requirements for man-machine functions (Block D-12), detailed equipment characteristics (Block D-27), and requirements pertaining to supporting computer programs (Block D-18, D-22).

D-12. Conduct Man-Machine Task Analysis

This activity consists of detailed expansion and analysis of human operator functions tentatively assigned under the preceding Block D-11. While it also initiates the development of procedural data which will have subsequent uses in such areas as personnel, training, and handbooks, its primary purpose at this stage is to develop and verify recommended performance/design requirements for interfacing computer programs and equipment.

Specific approaches, degree of detail, and emphasis should vary as a function of such factors as established constraints, novelty, and criticality of individual tasks to system performance. However, the preliminary grouping of tasks into operating personnel positions (Block D-10) is an essential prerequisite to the analysis, since the degree to which human operators will meet, or fail to meet, required levels of performance on individual tasks is typically a complex function of the total job demands and working environment. Where indicated, the initial approach may be based upon the use of preliminary drawings or a mockup of the operating station to devise detailed human action sequences for each task, identifying (1) specific initial conditions, (2) information required, (3) information available, (4) required evaluations/decisions/coordination, (5) required actions, frequencies, tolerances, and available controls, and (6) nature of feedback.

Supplementary analyses or studies may be required to verify timing, workloads, consistency or complexity of display formats, appropriate control actions and control response characteristics, and logical control-display relationships. For critical functions, or where significant cost alternatives exist, special experiments or trade-off studies may be required to identify and evaluate feasible design alternatives.

The objective of this activity is to specify performance and design characteristics of computer programs and associated equipment which will be consistent with natural capabilities and limitations of human operators, in the interests of minimizing requirements for special personnel selection or training and of promoting efficient operation of the system as a whole. The principal direct output consists of detailed definitions of content and formats of displays, varieties and sequences of switch or other manual input actions, and the nature and timing of computer response to operator interventions, including requirements for modified and/or special automatic data processing functions. Detailed performance/design requirements for these manual interfacing functions are derived in coordination with deriving other performance/design requirements for operational computer programs (Block D-11), taking into account constraints dictated by considerations of feasibility and integration of requirements for the CPCEI(s) as a whole.

The responsibility for these man-machine task analyses and development of procedural data for system operators is normally associated with this segment, because computer programs are the major determiners of specific "machine"

functions in an information processing system. At the same time, the activity also requires the development of certain associated design requirements for equipment, facilities, and communications. For example, details of available display elements, switch or pushbutton numbers and arrangements, direct or remote communication with other system personnel, etc. must be known or devised, and evaluated in the course of each task analysis. Hence, this effort should be planned as a primary source of human engineering design requirements in those areas. Normally, the recommendations should constitute expansions in detail only, within the scope of general requirements which have been anticipated and established in the System Specification. Depending on the contractor structure in a given Phase B program, some of the recommended performance/design requirements for CEIs in other system segments may be input immediately for review and coordination by the responsible contractor(s). They are normally combined with similar recommendations derived from other Phase B activities (e.g., Blocks D-21, D-24), summarized as a special section of the final report (Block D-33), and appropriately reflected in interface sections of the Part I CPCEI Specification(s). Following review, coordination, and approval, they should be subsequently incorporated into Part I Specifications of the affected equipment/facility CEIs, usually prior to PDRs for those items.

As implied above, the human engineering recommendations resulting from this activity are at the performance/design requirements level only. For equipment CEIs, for example, they might consist of specifying such items as: numbers and types of display characters available; numbers, arrangement, functions, and labels for console pushbuttons; numbers and types of available warning lights or auditory alarms. For these CEIs, additional human engineering design is normally required in the course of subsequent detail engineering design leading to the Part II specifications, both for operability and maintainability, including many of the factors treated in MIL-STD-803A in the areas of anthropometry, illumination and visibility, ambient noise levels, and control-display sizes, shapes, friction, inertia, etc.

For computer program CEIs, since they are inherently functional items, factors affecting interfaces with human performance during computer program operation must be completely specified at the performance/design requirements level, i.e., in the Part I Specification. Generally, these considerations should be summarized in Section 3.1.4, "Human Performance Requirements", to provide an explicit basis for Personnel Subsystem Test and Evaluation (PSTE) during Category I testing. However, since they are necessarily incorporated in the basic requirements contained throughout Section 3.0 of the specification, they do not normally imply additional requirements for the computer programming design and development effort during Acquisition.

Interrelationships. The analysis of man-machine tasks, as indicated above, is accomplished at this stage primarily for the purpose of identifying and evaluating performance/design characteristics of computer programs and equipment. While it continues during Phase B as a support activity to the development of Part I CPCEI Specifications, the task data are progressively

refined, organized, and expanded into sets of procedural data (Block D-29) which will provide the basis for training manuals, positional handbooks, and other job aids to be developed subsequently in the Acquisition Phase.

At this stage, the provisional task data are also input to the QQPRI activity (Blocks D-13 to D-30) for further development of personnel-oriented position descriptions, classification, and identification of individual training requirements. Additionally, the data provide the basic material for analyzing operational readiness training needs and developing functional requirements for operational system exercising (Block D-16).

D-13. Initiate Analysis of Personnel Requirements

In Block D-10 preceding, manual and man-machine tasks were identified and grouped into duty positions on the basis of preliminary estimates of the characteristics of the tasks, user organization and mission, and general guidance contained in the System Specification. Using those results as an input, this activity initiates a continuing series of analyses oriented toward identifying, by Air Force Specialty Code, the numbers and types of Air Force Personnel which will be required to operate the system. The activity is the primary source of data for the preparation of the QQPRI report, initially prepared at the end of Definition Phase B (see Block D-30), and revised and updated during the Acquisition Phase (see Block A-16).

Initially, the activity should expand the duty position descriptions identified in Block D-10 and derive preliminary estimates of operator qualifications for each position. Qualifications would include such considerations as rank, primary and secondary skills relevant to selection, additional skills and knowledge to be acquired in training, and expected duration of training status. To this end, close coordination must be maintained with the man-machine task analysis described in Block D-12 which provides the major source of information and data refining duty position descriptions and defining operator qualifications. In addition, descriptions of duty positions for computer programming support personnel are initiated at this time. This work will involve a detailed consideration of the various facets of computer programming support which will be required. Some of these relevant facets include: (1) on-site versus off-site computer program design, coding, and test support; (2) provisions for control of changes; (3) the frequency and extent of major changes; and (4) the varying levels of computer programming support to the military organization, e.g., advisory, line, staff, operations.

As a clearer picture emerges of the various duty positions and associated operator qualifications, it must be examined in relation to the user's (1) mission, doctrine, and operating procedures, and (2) personnel organization and classification structure. At this point in the analysis, sufficient detail should be available to allow comparison of each duty position and associated operator qualifications with existing Air Force Specialties (AFS) and the identification of the appropriate Air Force Specialty Code (AFSC) for each position. If new AFSs or shredouts of existing AFSs are required they should be identified at this point and analyses initiated to determine what training will be required to qualify personnel in the new AFS.

As a final step in the analyses, attention should be directed toward pertinent manning factors such as workloads, special working conditions, number of shifts, etc., to derive preliminary estimates of numbers of personnel required for each duty position. Operational and maintenance concepts for the system as documented in the PTDP and the System Specification should provide basic guidance in these analyses.

D-14. Initiate Detailed Test Planning

This activity initiates the contractor's planning for accomplishing developmental testing. The System Test Plan, prepared by the SPO and reviewed by the contractor during Definition Phase A, is the basic guidance document for the activity. It contains overall test philosophy, basic concepts and objectives for Category I and system tests, and rudimentary planning information. The planning activity initiated at this time and continued throughout the development cycle represents a progressive refinement and expansion of the material initially contained in the System Test Plan. At the end of the Definition Phase B, the System Test Plan is replaced by a preliminary Category I Test Plan and inputs to the Category II Test Plan (Block D-32). During the Acquisition Phase, these planning documents are expanded, detailed procedures prepared, tests conducted, data analyzed, and reports prepared.

At this point in time it is necessary to expand the basic test concepts and objectives with reference to the contractor's particular approach to the development process, integrate these concepts and objectives into the design process and develop preliminary plans for implementing the actual testing activity. For example, the System Test Plan should present the basic philosophy of qualification testing of computer programs and discuss the concepts and objectives of Preliminary and Formal Qualification Testing. The contractor should refine these in light of his plan and organization for accomplishing CPCEI design, and insure that design personnel are familiar with the concepts and objectives and integrate them into their design effort. Such integration of test concepts and objectives into the design process is important for two reasons:

(1) Test concepts and objectives may serve as design constraints in that they establish the basic framework for testing within which all design solutions must be testable.

(2) Detailed test requirements generated by the design process should be organized and presented in Section 4 of the Part I Detail Specification in a manner consistent with the test concepts and objectives.

As design of the operational computer programs evolves, analyses should be conducted to identify those test requirements which affect the supporting computer programs. Significant effects may occur in terms of requirements for specific capabilities which the supporting CPCEIs must provide, and/or in terms of forcing their development schedule to meet specific deadlines in testing the operational CPCEIs. These requirements will be identified initially at gross levels, but will become progressively more detailed during the Definition Phase. By the end of Phase B, they should be reflected at appropriate levels in the Part I Detail Specifications and the initial test planning documents (Blocks D-26, D-32).

The refinement of test concepts and objectives, the identification of test requirements during the design process, and the determination of requirements for supporting CPCEIs based on operational CPCEIs should be accompanied by appropriate planning for the implementation of the test activities. Basic schedules tied to system program milestones should be developed, appropriate test methods identified, controls established, responsibilities assigned, and support requirements defined. The planning effort requires continuous coordination with the technical design activity throughout Definition Phase B. It culminates in the preparation of the Category I Test Plan and Inputs to the Category II Test Plan (see Block D-32) which form part of the contractor's Phase B Final Report (see Block D-33).

D-15. Define Detailed Display/Control Requirements

As a result of analyses of functions accomplished in Block D-11 and preceding, the CPCEI will have become structured into an initial set, or sets, of functional elements, e.g., information transfer, system limits, recording, assignment, etc. Analyses to detail the subfunctions and tasks within these various elements, and to identify and select alternative functional solutions, will have been accomplished in the Block D-11 activity for tasks which are identified at an early point as fully automated (Block D-8), and in the Block D-12 activity for manual and joint man-machine functions. Important products of the man-machine task analyses will be additional definitions of detailed functional requirements to be met by the CPCEI. The purpose of this activity is to integrate these results into the direct process of developing the operational CPCEI Part I Specification.

The specific requirements resulting from Block D-12 to be incorporated are generally of the three types listed below:

(1) Requirements for display formats, contents, timing, and other relevant characteristics.

(2) Requirements for numbers, positions, labels, and functions of operator input devices, e.g., buttons, switches, knobs.

(3) Requirements for special data retrieval, computations, or other processing to support the performance of operator duties and tasks.

The integration is accomplished either by adding functional elements, or combining requirements with functional elements already identified, or both. The process typically involves the necessity to resolve conflicts between desirable and feasible solutions, and often requires iterations of earlier analyses. The refinement and updating of initial solutions will normally continue throughout the course of CPCEI Part I Specification development.

In determining the techniques to be used in displaying information, consideration is given to such items as storage and timing in regard to the computer program, display capacity, presentation rates, formatting, display selection, and symbolic repertory characteristics of the display equipment. Items to be defined in detail include:

(1) Organization of operator informational exigencies into feasible groupings.

(2) Formats to be used in presenting information.

(3) Coding conventions to be employed in presenting information details.

(4) Rules for routing displays.

(5) Rules for forcing displays.

(6) Rules for updating displays.

(7) Rules for priority handling of displays.

The determination of "use rules" for manual intervention devices requires taking into account the known or recommended characteristics of computer and console equipment (see Block D-12), as well as the sequencing, frequencies, priorities, etc. of information to be input by system operators. Specific information to be derived will include:

(1) Allocations of the types of information that can be inserted by each manual input device.

(2) Frequencies of operator insertion readout by the computer program.

(3) Informational structuring logic to be used for keyboard type devices.

(4) Actuating rules for feedback devices which inform operating personnel of the adequacy of their insertions.

D-16. Perform Training Needs/Exercise Requirements Analysis

In this context, training needs refer to the skills and knowledge which system personnel must acquire through operational readiness training in order to perform their assigned tasks. As such, they constitute the basis for identifying and defining exercise requirements. The analysis at this stage is directed towards (1) identifying the special coordinative skills and knowledges, primarily, which are required of personnel in the context of system operations, and (2) specifying, initially in functional terms, the types, frequencies, levels, and conditions of system exercising which will establish and maintain the necessary levels of personnel proficiency.

Concepts, requirements, and constraints governing the performance of this and other activities in the system exercising area are derived from the RAD, Conceptual Phase system engineering data, the PTDP, and System Specification. During Definition Phase B, the analysis of training needs should constitute an iteration, in part, of earlier Conceptual Phase studies, using the more detailed data available at this time. Significant inputs are derived from the grouping of operator functions into duty positions (Block D-10) and man-machine task analyses (Block D-12). While continuity is also required with analyses of individual training needs associated with QQPRI (Blocks D-13, D-25, D-30), this effort places major emphasis on the skills which must typically be built and maintained thorugh Operational Readiness Training (ORT). These include the pacing, load-balancing, information-filtering, and decision-making skills and knowledges which are involved in dynamic interactions among individual crew members and between crews of separate organizational units.

The nature and depth of analysis required will vary with the system, factors of novelty, and established constraints. Prerequisite information includes detailed data regarding the user's objectives and constraints pertaining to normal and emergency operations, alternate system modes, joint operation with interfacing systems and agencies, etc. Typically, additional clarification and definition of user requirements, proposed practice, and criteria must be sought in the course of this activity. A systematic approach to the analysis might include, as a first step, assessing the identified interactive skills in terms of criticality, complexity, frequency, probable loss in proficiency over time, and potential for development through practice. Initial objectives are to determine and assess exercising requirements in terms of such parameters as the following:

(1) Exercise Configuration -- the particular collection of personnel, operational equipment, and operational computer programs that are to interact in the execution of a given exercise. This may vary in magnitude from "individual" through "subsystem"--i.e., functionally distinct portion of the crew at one operation station--through successively larger organizational aggregates such as the division or command, to configurations involving other commands.

(2) Training Exercise Objectives -- the mission element or collection of mission elements to be exercised by a given configuration of the operational system for purposes of developing and maintaining proficiency of the given operational personnel, including special features and conditions of the operating environment which are to be incorporated in given exercise configurations and missions, e.g., countermeasures, degraded communications.

(3) Exercising Conditions -- conditions affecting the conduct of exercises, e.g., off-station vs. on-station considerations, time-sharing requirements, simultaneous simulated and live inputs.

(4) Exercise Frequency -- the recommended frequency with which given types of exercise should be conducted to maintain an acceptable level of crew or unit proficiency. The recommended frequency for each exercise should reflect the variety of configurations, missions, and conditions, taking into account both uniqueness and duplication among the exercises.

This activity should parallel the closely associated analysis of evaluation needs/exercise requirements performed in Block D-17. Specific implementing recommendations (Block D-21) are based upon combined functional requirements resulting from the two analyses, since it is normally anticipated that operational system exercises will be utilized for the dual purposes of personnel training and system evaluation. The evaluation area will also normally include consideration of significant evaluation requirements associated with personnel training (see Block D-17).

Applicable Data Item

Q-119 Training Needs/Exercise Requirements Analysis.

D-17. Perform Evaluation Needs/Exercise Requirements Analysis

This activity is closely related to the Training Needs/Exercise Requirements Analysis described in Block D-16, but is directed specifically towards identifying the types of exercises which are required for purposes of evaluation. At this stage, it consists of (1) defining the system functions, subfunctions, and components which require periodic test and evaluation during the operational life of the system by the user and (2) specifying the types, levels, and conditions of exercising, and of performance measurements, which are required to meet evaluation objectives.

Where Conceptual Phase studies (Block C-5) have resulted in establishing the feasibility and gross requirements for an exercising capability, it is normally expected that the capability will be designed to meet a variety of objectives in the Acquisition process, e.g., Category I and II testing, as well as those of Operational Readiness Training (ORT) and Operational Phase system evaluation. While it is also expected that design requirements related to the training and evaluation purposes will be basically similar in general, specific objectives should be examined at this time in sufficient detail to assure that necessary modifications or additions are not overlooked. Typically the differences between training principles and evaluation principles affect both the conduct and required technical support of system exercises in significant ways.

Major objectives and constraints are derived from the System Specification and other formal documents, as well as from Conceptual Phase system engineering data. As in the case of training needs (Block D-16), additional clarification of user requirements and criteria may also be indicated in the course of detailing evaluation needs in sufficient depth to specify implementing solutions. Purposes to be considered and amplified typically include the following:

(1) Assess operational readiness of the system to accomplish its defined missions. The focus of interest here is on valid and useful indices of total system performance, together with criteria for assessing effectiveness in relation to mission objectives.

(2) Assess alternative operating tactics, techniques, and conditions.

(3) Determine criticality of individual functions and subfunctions to system effectiveness.

(4) Assess proposed or actual changes in system and/or component configurations.

(5) Assess crew proficiency, to determine effectiveness of training, compare crews, or evaluate and develop procedures. Consideration should be given both to (a) typical needs of command staff personnel responsible for evaluation, who are not necessarily exercise participants, and (b) needs of

crew participants for feedback performance data which can be utilized for self-improvement.

Exercise requirements derived on the basis of identified needs are initially formulated in functional terms, rather than in terms of specific live or simulated inputs, outputs, or other implementing solutions. Immediate objectives at this stage are to determine and describe exercise requirements in terms of the following parameters:

(1) Exercise Configuration -- the particular collection of personnel, operational equipment, and operational computer programs that are to interact in the execution of a given exercise mission.

(2) Evaluation Exercise Objectives -- the mission element or collection of mission elements to be exercised by a given configuration of the operational system for purposes of evaluating a function or set of functions. Special features and conditions of the operating environment which are to be incorporated in given exercise configurations and missions, e.g., counter-measures or degraded communications, should be taken into account.

(3) Exercising Conditions -- conditions affecting conduct of exercises, e.g., off-station vs. on-station considerations, time-sharing requirements, simultaneous simulated and live inputs.

(4) Special Test Data Requirements -- a primary objective is to identify valid and useful measures of performance, considered in terms of (a) the total system, (b) intermediate outputs of system functions or subfunctions, and (c) special components, e.g., personnel. In general, system/subsystem output speeds (or latencies), accuracies (or errors), and volumes are the basic measures to be defined and interrelated.

In addition to operational command evaluation and training objectives as described above and in Block D-16, requirements for Acquisition Phase development testing should also be considered in association with planning for exercise capability implementation. Hence, additional inputs should be obtained from the test planning activities initiated in Block D-14. These additional requirements may include uses of the exercise capability as a whole to satisfy system test objectives during Category II and/or Implementation Tests, as well as a variety of special simulation needs associated with planned Category I testing of computer program CEIs.

Applicable Data Item

Q-117 Evaluation Needs/Exercise Requirements Analysis.

D-18. Define Supporting Computer Program Tasks

The activity referred to in this Block is analogous, technically, to that described for operational CPCEIs, under the preceding Block D-11. The development of Part I Specifications for supporting CPCEIs, or functions, is also a process of proceeding from higher to progressively lower levels of detail.

However, as indicated earlier in Block D-9, the analysis and definition of supporting elements involves a variety of technical sources and approaches, with varying degrees of dependence upon the specific system operations. The analysis and design of many utility and maintenance-diagnostic functions may proceed on the basis of relatively gross information about system operations. On the other hand, the process of detailing such functions as simulation, data recording, and data reduction must maintain a constant closed-loop relationship with other analyses being performed during Phase B. Much of the basic initial expansion of these support functions, in fact, occurs most directly in the operational CPCEI, exercise capability, and test planning flows, as described in Blocks D-11, D-14, D-15, D-19, D-20, and D-21. Hence, the types of activities described in those blocks constitute the types of technical analyses by which many support functions are defined at intermediate levels for input subsequently to the Block D-22 activity, for detailed integration into Part I CPCEI Specification form.

D-19. Expand Information Processing Requirements

The purpose of this activity is to further expand and verify the information processing functions which have been identified as logical and mathematical tasks to be performed by the operational computer program. This activity is a continuation and extension of the activities described in Blocks D-11 and D-15, and is closely coordinated with the data base studies described in Block D-20.

Each operational computer program task is further analyzed to identify the data input sources, the data received from each data input source, the information processing required, feedback responses, the data output destinations, and the data sent to each data output destination. The method of transmission, frequency of transmission, and volume of data are determined for the data received from each data input source and the data sent to each data output destination. Environmental conditions, critical load conditions, equipment limitations, and major sources of error are determined for each operational computer program function and subfunction and evaluated with respect to efficiency, completeness, design feasibility, interfaces, and conformance with the System Specification. In addition, for each task, the applicable system limits and capacities are examined and evaluated for their effect on operating efficiency of the computer program as a whole.

Alternative logical transformations are identified and evaluated and appropriate logical transformations are selected. Operational equations are determined or developed and evaluated for each mathematical computation, giving consideration to the nature and accuracy of the input data, the accuracy of data from which parameters for the equations are determined, the nature and required accuracies of output data, computer program operating time, computer program space requirements, and accuracy requirements for the operational equations.

B-20. Expand Data Base Requirements

The determination of data base requirements is a continuing activity during Phase B. It is normally based on gross requirements established initially in the Conceptual Phase and reflected in the System Specification and other prior system engineering documentation. While certain aspects of the effort must be closely coordinated with the development of other elements of the Part I CPCEI Specification, it may in some cases constitute a sizeable and relatively independent effort. Often, it may require extensive field research or active participation by other contractors or government agencies.

Depending upon the system, the size and nature of the data base may vary widely. Where the major operational function of the system centers on updating and manipulation of a very large data base, the specification of data base elements may constitute a correspondingly large portion of the effort involved in developing a Part I CPCEI Specification. In other systems, e.g., where emphasis is on real-time manipulation of continuous inputs from system sensors, the role of a fixed data base may be relatively minor. Also, although "data" constitute the basic elements which are manipulated by any information system, they may assume a variety of roles in, and in relation to, the computer program instructions. The rules for defining the data at the Part I Specification level will vary correspondingly. Differences in both the derivations and expressions of requirements will occur, for example, depending upon such distinctions as: whether the data are to be input continuously, with variable values, during the course of computer operation; whether the data are input prior to computer program operation, and cannot be changed in the course of operation; whether the data are constants or variables; whether the data exist in source input form, or result from mathematical or logical manipulation by elements of the computer program; etc.

In the uniform specifications for CPCEIs, "adaptation data" represent a special segment of the data base in multi-site systems. The distinction is made for configuration management, rather than technical, reasons. These are items which have fixed values at any one site, but which vary in value among sites. The function of this distinction is to avoid a potential requirement for the computer program at each site to be a separate CPCEI, when the copies are identical except for those selected elements of fixed data.

In preparing the Part I Specification, all types of data should be identified, and labels and definitions provided for individual data items. Eventually (see Block A-8, A-22), it will be necessary to supply coded, actual numerical values for all items which are quantitative in nature, and the coded states (e.g., wet, dry, in, out, etc.) which may be assumed by each qualitative item. At this stage, the level of definition required will vary for different classes and subclasses of items. In general, objectives are to identify the item parameters (i.e., units of measure, range of possible values, and precision or accuracy requirements), rather than actual numbers. However, the actual

numerical values are required for some items, e.g., computer program constants; these are derived in the normal course of activities described in Blocks D-11, D-15, and D-19. For some classes of data, it may be necessary to specify the source and/or methods required to convert source data values into forms suitable for use by the computer program.

D-21. Define Exercise Capability Design Requirements

Studies conducted during the Conceptual Phase identified the basic requirements for an exercising capability to be used for training and evaluation. These requirements, and gross estimates of the size and complexity of the exercising capability were contained in the System Specification, the PTDP and other Conceptual Phase documentation. The analyses described in Blocks D-16 and D-17 above expanded upon the Conceptual Phase studies and identified in detail the training and evaluation needs and associated functional requirements for an exercising capability.

The activity here is directed toward further expansion of functional requirements within established system constraints and the conduct of trade-off studies and analyses to arrive at detailed design requirements for the exercising capability. This effort involves the consolidation of all identified functional requirements, as well as identification and assessment of feasible methods, techniques, and vehicles for implementation.

Elements to be analyzed and expanded under this activity may include the following:

(1) Detailed performance/design requirements for communications, facilities, and equipment imposed by the exercising functions. These will include both impact on system operational equipment--e.g., additional computer capacity, tape units, special features of operating consoles -- and detailed characteristics of special operating stations, communications, and equipment such as special data input devices, problem generators, and other gear required for simulation, monitoring/recording, or data reduction. Recommended performance tolerances, design features, constraints, locations, etc. are input to Block D-27 and appropriately reflected in interface sections of the Part I Specifications for computer programs.

(2) Identification and definition of personnel functions associated with the exercising capability. This will include overall management of the capability and, for specific exercises, may include the functions of exercise planning and preparation of materials as well as real-time simulation functions to be performed during conduct of exercises, e.g., input messages from external agencies. This information provides inputs to the QQPRI activity (Block D-25) for further analysis and definition of personnel requirements.

(3) Detailed performance/design requirements for computer programs. These requirements typically encompass the functions of simulation, operator self-instruction, recording, and data reduction. They are input to, and coordinated on a continuing basis with, the preparation of Part I CPCEI Specifications. Depending upon the structuring of CPCEIs for a given system, the simulation, operator self-instruction, recording, and data reduction functions may be incorporated in operational computer programs or special support computer program CEIs.

(4) Problem production requirements. Requirements to be identified and defined in this area are special facilities, equipment, computer programs, and procedures for generating synthetic input "problems", e.g., simulated radar input data, synthetic messages or other inputs from specially-prepared tapes, film, scripts, etc. While some of these may be provided by deliverable support computer programs for problem-generation, others may require a centralized facility, particularly for exercises of system-wide scope, capable of producing problem inputs and associated aids and materials as required periodically by the user (see Block A-6).

(5) Procedural data. Manuals and guides to accompany delivery of the system to the user may include program users manuals, procedures manuals for planning, preparing, and conducting exercises, positional guides for simulation personnel, and exercising information for operating personnel.

The proposed implementation resulting from analyses and design trade studies conducted in the course of this activity will normally represent a combination, with some alterations, of the comprehensive requirements previously established by analyses of training and evaluation needs. A description of the actual resulting exercise configurations, missions, conditions, and test data, reflecting losses or changes in desired capabilities, is prepared as a part of this activity for inclusion in the Exercise Capability Implementation Plan (Block D-31).

Refinement of performance/design requirements and coordination with related activities in human engineering (Blocks D-12 to D-29), personnel requirements (Blocks D-13 to D-30), operational CPCEI specification (Blocks D-11 to D-26), supporting computer program specificaton (Blocks D-9 to D-26), and test planning (Blocks D-14 to D-32) are continuing activities throughout Phase B.

Applicable Data Item

S-54-6.1 System/Design Trade Study Reports.

D-22. Develop Performance/Design Requirements for Supporting CPCEIs

With respect to general methodology, this activity for supporting CPCEIs corresponds with the combined activities described in Blocks D-19, D-20, D-23, and D-24 for analysis and definition of requirements for operational CPCEIs. As indicated earlier (Blocks D-9, D-18), timing and technical sources of information used in determining performance/design requirements may vary markedly for the different classes of supporting CPCEI functions.

By this time, the allocation of supporting functions to CPCEIs will have been determined. For certain utility and maintenance-diagnostic functions, these determinations may have been established in the System Specification. In some cases, they may have been allocated to another system segment, associated with the system computing equipment. Depending primarily on administrative/management considerations (see Block D-26), the simulation, recording, and data reduction functions may be grouped in various ways as either separate CPCEIs or combined with operational functions. In any event, the allocations by CPCEI establish the existence and levels of inter-CEI functional interfaces to be defined in each CPCEI Part I Specification; the relevant interfaces to be detailed, for each CPCEI, are those with each other interfacing equipment and computer program CEI.

The definition of supporting computer program performance/design requirements may also vary in completeness and level of detail depending on the type of function. For example, a compiler and other utility tools which will be required for developing other computer programs during the early part of Acquisition should be complete, and some degree of computer program design, coding, or testing for these items may already have been accomplished by this time. For items which depend upon design of the operational data base or for simulation or data recording/reduction functions, on the other hand, completion of detailed requirements may continue to lag development of the operational CPCEI.

In addition to the development of Part I CPCEI Specifications, these activities must be associated with the formulation of detailed technical inputs to various other system engineering and planning activities. Inputs will include requirements for computer program user manuals (Block D-33), recommended equipment and facility requirements (Block D-27), expansion of the System Specification (Block D-28), and personnel requirements (Block D-25). A Section 4, "Quality Assurance Requirements", must be developed for each Part I Specification, and a Category I Test Plan prepared for each supporting CPCEI (Block D-32).

D-23. Detail Operational CPCEI Performance/Design Requirements

The purpose of this activity is to compile the detailed performance and design requirements of the operational computer program CEI. It is based upon inputs derived from the activities described in Blocks D-11, D-15, and D-19, and must be closely coordinated with the activities of Blocks D-20 and D-24; its outputs, when combined with the outputs of D-20 and D-24, will constitute Section 3, "Requirements", of the Part I CPCEI Detail Specification.

Requirements are formulated in both general, descriptive language and in precise, quantitative terms. The system limits and capacities, in terms of frequencies, volumes, time limits, etc. of data to be handled by the computer program are derived principally from the System Specification. These constitute the continuing criteria for development and evaluation of the aggregate of functional elements which constitute the CPCEI at the Part I Specification level. A part of this activity is to develop a description of the total CPCEI in terms of its functional elements, illustrating the functions and their interrelationships. Each functional element is detailed with respect to source and type of inputs, destination and types of outputs, and associated information processing subfunctions, specifying pertinent logical rules and conditions, mathematical equations and constants, required accuracies/tolerances, options, modes of operation, etc. Human performance requirements, derived from the System Specification and from the efforts described in the preceding Blocks D-12 and D-15, are specified in terms of required display/control characteristics and compatibilities, timing, and special processing to facilitate information-handling and decision-making functions of human operators; these should consist in large part of statements of human engineering design criteria which are reflected in the detailed performance requirements specified for the various CPCEI functional elements.

This activity also includes the formulation of requirements and constraints which will apply to the subsequent Acquisition Phase computer program design, derived largely from requirements contained in the System Specification. These may include requirements for the computer programming language to be employed, applicable computer programming standards, maximum storage utilization for specified functions, requirements pertaining to segmenting the CPCEI into computer program components (CPCs), testing features, and design for ease of malfunction diagnosis or ease of design modification.

D-24. Detail Functional Interfaces

The purpose of this activity is to specify in detail the functional interfaces between the operational computer program CEI and other computer program and equipment CEIs. In large part, it represents an additional detailing of gross interface information contained in the System Specification, based upon Phase B analyses performed in connection with the activities described in preceding Blocks D-8, D-11, D-12, D-15, D-19, and D-21.

Functional interfaces with each other computer program CEI in the system are identified in terms of specific input and output data, data rates, message formats, message contents, data units and accuracies, and operational limits. In the course of this process, it is important to insure that the counterparts of this information are accurately and consistently formulated for each of the other interfacing CPCEIs.

Interfaces between the computer program CEI and the computer and associated equipment are defined in terms of all such relevant characteristics as memory size, word size, access and operation times, interrupt capabilities, inputs and outputs, buffers, and special capabilities. Depending on the degree to which characteristics of the computer, consoles, and other associated equipment are known at this time, the interfaces may or may not be defined in complete detail. Some of the interface requirements may depend upon recommendations, or recommended alternatives, for subsequent selection and detailing during Phase C or early Acquisition (see Block A-3). In the case of consoles, in particular, recommended performance/design requirements for display features and manual input provisions should normally stem from the various Phase B activities which are associated with the development of Part I Specifications for CPCEIs (e.g., Blocks D-12, D-15, D-21, D-22). These recommendations are incorporated in the materials described in Block D-27, and are appropriately reflected in paragraph 3.2.1 of each Part I CPCEI affected.

Once the detailed performance/design requirements for relevant console characteristics have been derived and verified, a special set of recommendations is prepared by the operational CPCEI design activity to specify the numbers and types of display categories, numbers and types of intervention devices (e.g., buttons, switches, light pen), together with specific wiring connections to be provided between (1) the display categories and intervention devices and (2) field or bit locations in computer storage. In air defense systems, the documents containing this class of information have been known as Variable-Display Equipment (VDE) Specifications. For systems in which the consoles and computer are undergoing a parallel development, the level of detail required to complete this information may not be available prior to early Acquisition. It must normally be provided and approved, however, prior to the accomplishment of detail computer program design.

D-25. Expand Analysis of Personnel Requirements

This block is an extension and continuation of the analyses initiated in Block D-13. It is intended primarily to indicate the necessity and importance of including those personnel required by the system exercising capability and other supporting functions (see Block D-21) in the Personnel Requirements Analysis. It also emphasizes the requirement for continuing the personnel analysis to incorporate the more detailed information relative to duty positions and personnel qualifications which emerge as system definition becomes more precise.

The personnel requirements analyses for system exercising personnel will follow the same pattern as described in Block D-13 for operational personnel. Special attention should be directed to the following areas:

(1) Requirements which the system exercising capability may place on operational duty positions in terms of new tasks, changed workload, special skills, etc.

(2) The availability of operational personnel freed from their normal duty positions during system exercises which may be qualified to man duty positions required by the system exercising capability.

It should be noted that, although it is not specifically shown on the flow diagram in Figure 3, man-machine task analyses must frequently be performed with reference to the system exercising capability for the same reasons they were required for the operational system, i.e., to develop and verify performance/design requirements for interfacing computer programs and equipment, and to help establish and define duty positions and associated personnel qualifications.

D-26. Issue Part I Detail Specification(s) for CPCEI(s)

This activity consists of preparing and issuing the computer program CEI Detail Specification(s), Part I, in approved format. The contents of each specification were generated by the activities which were previously described under Blocks D-20, D-22, D-23, and D-24.

A separate specification must be prepared for each computer program CEI. At this time, all CPCEIs for the system should be firmly identified, either confirming or revising the tentative identifications which had been made at earlier points during Phase A. The grouping(s) of operational and supporting computer program functions into one or more CPCEIs is based upon a variety of both technical and administrative considerations. In general, the number of separate CPCEIs proposed by a single contractor should be held to a minimum, in the interests of reducing administrative overhead. However, functions may be separated into two or more CPCEIs on the basis of such factors as the following:

(1) When the functions are to be performed at separate locations or times, and for separate missions.

(2) When the schedules for development and qualification are significantly different.

(3) When certain computer program functions have potential use in more than one system.

(4) In all cases, when configuration management during the Operational Phase will be the responsibility of different agencies.

The computer program CEI Detail Specification, Part I, specifies the performance, design, and qualification requirements to be met by the computer program CEI. As a product of the Definition Phase, it is written in operational, logical, and mathematical language. Its primary function during Acquisition is to provide the detailed statement of formal requirements against which the computer program design, coding, checkout, test, and qualification activities proceed in the course of developing the CPCEI and its Part II Detail Specification. In addition, the Part I Specification constitutes (1) the basis for approval by the procuring and using agencies of the detailed performance and design requirements of the computer progtam CEI, (2) the instrument which defines all interfaces between the computer program CEI and other computer program and equipment CEIs, (3) the basis for the development

of the support documentation associated with the operation and use of the computer program CEI, (4) the basic vehicle for configuration control of the computer program CEI through the Acquisition and Operational Phases of the system development process, and (5) the basis for the preparation of the Category I Test Plan for the computer program CEI.

Section 3, "Requirements", constitutes the body of the specification. It contains (1) the basic specification of system limits and capacities, (2) the definition of all operating functions to be performed, including sequencing and other important relationships, (3) the sources and types of inputs, (4) types and destinations of outputs, (5) detailed requirements for logical and mathematical processing functions, (6) detailed definition of data base elements, (7) human engineering requirements incorporated, (8) definition of functional interfaces with equipment and other CPCEIs, and (9) design requirements and constraints relating to standards, organization, design for testability, growth potential, etc.

At the Part I Specification level, a complex CPCEI will normally be structured in terms of a set of major functional elements, e.g., sequencing control, data inputs, displays, etc. In this case, the specification may be issued as a series of volumes, rather than as a single bound document, to facilitate its preparation and use.

Section 4, "Quality Assurance Provisions", establishes requirements for developmental testing and qualification of the CPCEI during the course of Category I and Category II test programs. It identifies all (1) requirements associated with test support of the contractor's design and development of the CPECI, e.g., for use of government-furnished equipment, and (2) methods by which the detailed performance/design requirements contained in Section 3 will be qualified during Preliminary and Formal Qualification or Category II testing.

As issued at the end of Phase B, Part I Specifications should be complete in sufficient detail to provide a basis for evaluating performance adequacy of each proposed CPCEI, and for supporting firm estimates of Acquisition Phase schedules and costs. Often, however, a substantial amount of additional detail may be required in order to complete the specification at the level required for subsequent computer program design, coding, and qualification. In general, the necessary further refinement should be completed prior to the initiation of detail computer program design, following PDR (see Block A-3).

Applicable Data Item

ESD 236 Contract End Item Detail Specification (Computer Program), Part I

D-27. Compile Recommendations for Equipment, Facilities, and Communications

The purpose of this activity is to compile recommended design requirements for equipment, facilities, and communications based upon detailed definition of information processing functions and tasks. Inputs to this activity are derived from man-machine task analysis (Block D-12), display/control requirements (Block D-15), operational computer program performance/design requirements (Block D-23), Variable Display Equipment (VDE) specifications (Block D-24), exercise capability design requirements (Block D-21), test planning (Block D-14), and supporting computer program performance/design requirements (Block D-22).

At this stage of definition, recommended design requirements for equipment, facilities, and communications should meet one or more of the following criteria: (1) necessity for accomplishment of defined information processing tasks, (2) advantageous trade-off with computer program design and/or operation, and (3) potential cost savings or increased effectiveness in meeting predicted system flexibility requirements. If the compilation consists of recommendations for modifications or additions to a previously defined hardware system, recommendations must be referenced to the known value parameters of timing, capacity, format, reliability, configuration, transfer rates, available peripheral equipment, and structural and power requirements. If the hardware system is being defined in parallel, recommendations should reflect known or expected requirements for hardware configuration and operation, taking into account interfacing equipments set forth at gross levels in the System Specification.

The form of the compilation will vary from system to system, depending on the degree and kind of previous definition of the hardware system. In general, however, recommendations should be organized under the following headings:

(1) Equipment

(a) Central computer storage and processing

(b) Input/output--sources, destinations, processing

(c) Peripheral storage

(d) Operator display/response consoles--configuration, signal assignments

(e) Special purpose test equipment

(f) Utilization of system hardware for test purposes

(2) Facilities

(a) Space utilization

(b) Configuration

(3) Communications

(a) Automatic--inter- and intra-facility

(b) Manual-- inter- and intra-facility

Comparative analyses of the recommendations will be necessary to eliminate conflicting or redundant recommendations. Completeness of the recommendations will be verified through analysis of the functional interface requirements in the Part I Specifications (Block D-26) and review of the Category I Test Plan (Block D-32), Exercise Capability Implementation Plan (Block D-31), and Expanded System Specification (Block D-28).

D-28. Complete Expanded System Specification

The development of data to expand those portions of the System Specification which are allocated to system segments (see Block D-2) is a continuing activity throughout Phase B. At this point, inputs resulting from analysis/design efforts described under the preceding Blocks D-8 through D-25 are compiled and organized into the System Specification format for inclusion with the contractor's final report.

The expanded data will emphasize detailed definitions of functional interfaces with other segments, and will include a firm list of the contractor's proposed CPCEIs (see Exhibit 1, AFSCM 375-1).

It is a normal expectation that the expansion accomplished at this time and throughout Phase B represents additional detail to clarify and amplify basic requirements contained in the System Specification as issued and baselined at the outset of the Phase B effort. Thus, the expansion should be distinguished from changes to the basic specification. However, basic changes may also frequently be indicated by Phase B studies. In these cases, system requirements ECPs/SCNs may be prepared in accordance with Exhibits VII and VIII of AFSCM 375-1 and submitted at any point during Phase B; participating government agencies and contractors are informed of all resulting CCB actions.

Applicable Data Item

C-1-35.1-1 System Performance/Design Requirements General Specification.

D-29. Compile Operating Procedures and Task Analysis Data

This represents an activity to prepare products of Phase B human engineering studies for inclusion in the "System Engineering Documentation" portion of the final report. The scope, content, and format of information to be reported are determined selectively for each system and specified as applicable in the CDRL (DD Form 1423).

Normally, emphasis is placed on data which are required by the SPO for technical evaluation of the contractor's human engineering design solutions. This may include selected analyses and trade-off studies generated during man-machine functions allocation (Block D-8) and subsequently (e.g., Blocks D-12 and D-15), as well as procedural data organized in a form to provide the basis for subsequent Acquisition Phase development of manuals and other job or training aids.

Procedural data should normally be prepared for all types of man-machine operating stations. In general, this information should include listings of procedures for each mode of normal system operation, as well as special procedures for anticipated alternate and emergency conditions, identifying available displays, switch action sequences, and communications with other internal or external operating stations. Supplementary annexes may include summaries of all display formats, switch and other manual inputs, available inter-operator communicating links, and identification of special job aids required for efficient operation. Information in this area may also provide a necessary adjunct to the Part I CPCEI Specification as a basis for concurrence by the Using Command.

Detailed task analyses, time-line analyses, and trade-off studies are normally conducted and reported on a selective basis, emphasizing those operations which are critical to system performance or for which significant alternatives exist with reference to cost, personnel requirements, or development time.

Applicable Data Items

Q-118 Human Operator Task Analysis for Information Systems.

This item calls for data which are generated initially as aids to equipment/computer program design (Block D-12). With minor changes, it can also be used to cover the reporting of operating procedures as end products.

S-54-6.1 System/Design Trade Study Reports.

Applicable reports for this area may be associated with man-machine functions allocation accomplished at various levels during activities described under Blocks D-8, D-12, and D-15. As indicated in the Form 9, the reporting level may vary considerably as a function of each study objective.

S-56-6.1 Time-Line Sheets

This item may be used for analysis of time-critical man-machine functions, as a supplement to task analysis.

D-30. Complete QQPRI Report

The QQPRI Report is based primarily upon the data resulting from the continuing Personnel Requirements Analysis described in Blocks D-13 and D-25. At this time the report is preliminary in nature and will be updated during the Acquisition Phase (see Block A-16).

The purpose of the QQPRI Report is to provide an early estimate of personnel required to operate, maintain, and control the system. Although the report must normally conform to rules for format and content set forth in MIL-D-26239A, the principal technical content will be contained in two sections as discussed below:

(1) Position Descriptions. The position descriptions contained in Section 4 of the QQPRI Report represent the basic source of information on the types of personnel required to operate, maintain,and control the system. It should summarize the scope of responsibilities and the nature of the work performed at each position and should include, as a minimum, the following:

(a) Identification of the Air Force Specialty (AFS) required and justification of any recommendations for new or modified AFSs.

(b) A table for each position listing the job operations involved, and for each job operation the duties and tasks required. New duties and tasks should be emphasized along with any conditions likely to cause errors or which impose unique personnel or training requirements.

(c) A listing of the equipment used, with emphasis on new equipment and associated special skills.

(d) An estimate of the time required to accomplish each duty and task, the location where each is performed,and an estimate of the required frequency of performance.

(e) An evaluation of each task for probable error factors, special handling requirements, difficult control manipulations, special skills for interpreting displays, and necessary safety precautions.

(2) Preliminary Manning Estimates contained in Section 5 of the QQPRI Report provide the basis for personnel planning agencies to consider manpower sources and problems, and for the using command to develop the Unit Manning Document for the system. This section should state basic concepts and assumptions and include the following:

(a) Manning estimates showing the number of personnel required to perform the duties at each type of position per standard working shift under typical working conditions. Required personnel should be identified by AFS and AFSC and an estimate provided of the number of shifts required for each 24 hour period.

(b) Appropriate diagrams to illustrate the overall functional organization required, including the composition of major organizational units, crews, or teams.

Applicable Data Item

Q-103 Qualitative and Quantitative Personnel Requirements Information, Part I: Field and Organization Maintenance.

Since only one QQPRI Report is prepared for a system as a whole, the product for this system segment will represent only a partial input to the complete report. Information to be supplied under the computer program system segment should normally cover personnel in the categories of (1) system operators, (2) simulation/exercising, and (3) computer programming support, including contractor technical personnel support when required. Specific reporting requirements are normally determined by the procuring agency.

D-31. Prepare Exercise Capability Implementation Plan

The Exercise Capability Implementation Plan describes the total exercising capability being built for the system, defines the manner in which the various components may be used individually and collectively in various configurations to provide various levels of system exercising, and provides preliminary planning information for the implementation of the capability during system test and activation.

Description of the Exercising Capability

The design requirements for the exercise capability initially identified and described in Block D-21 above and continually updated and/or modified as a result of system engineering activities during Definition Phase B serves as the basis for describing the actual exercise capability to be provided. This description should identify the various system exercising elements (e.g., equipment, computer programs, aids, exercising personnel, etc.), indicate the manner in which the elements may interact, and relate the total exercising capability to the training/evaluation needs identified in Blocks D-16 and D-17 above. The description may be supported by block diagrams, or equivalents, which illustrate relationships among elements of the exercising capability and with elements of the operating system.

Definition of Levels of System Exercising

The description of the exercising capability provides the basis for defining how each of the elements may be used. Various levels of system exercising may be achieved by using different elements or groups of elements. Feasible levels should be identified, and for each level, the following information should be provided:

(1) System element(s) exercised.

(2) System personnel exercised.

(3) Exercising capability element(s) required.

(4) Exercising personnel required.

(5) Training/evaluation need(s) satisfied.

Any training/evaluation need identified in Blocks D-16 and D-17 which is not satisfied by one or more exercising levels should be identified.

Implementation Planning Information

Preliminary planning information should be provided which indicates the sequence with which the various levels of system exercising will be required during system test and activation. Early requirements for system exercising, such as may typically exist for Category II system tests, will have significant impact on the development and test schedule for the exercising capability itself and must be relatively well defined at this point. Requirements statements should contain the following information:

(1) Exercising level(s) required.

(2) Time and place where required.

(3) General description of supporting problem materials, procedures, and aids required.

Applicable Data Item

Q-120 Exercise Capability Implementation Plan.

D-32. Prepare Category I Test Plan(s) and Inputs to Category II Test Plan

During Definition Phase B, the rudimentary planning information contained in the System Test Plan should be expanded by the contractor into a separate Category I Test Plan, inputs to the Category II Test Plan, and for a multi-site system, inputs to the Implementation Test Plan. Where multiple contractors are involved, each contractor prepares plans only for those items contained within the system segment for which he has responsibility. In these cases, particular attention must be directed towards planning for the testing of interfaces and the identification of testing which requires the Category II test environment.

The amount of detail contained in the test plans prepared at this time must necessarily be limited to a level consistent with the state of development of the system as a whole, but should be sufficient to allow the contractor to develop realistic cost estimates for purposes of preparing a firm proposal for the acquisition effort. As system design evolves during the Acquisition Phase and more detailed design information becomes available, the initial plans will be expanded (see Block A-9).

Category I Test Plan

The Category I Test Plan for computer programs should provide the overall planning for the tests necessary to confirm, in accordance with Section 4 of the Part I CPCEI Specification, that the CPCEI fulfills the requirements of Section 3 of the Part I CPCEI Specification. Planning information should be provided for the following:

(1) The location of the tests, and schedules relative to established milestones in the overall acquisition process for the system.

(2) General methods, requirements, and responsibilities for the preparation of input data.

(3) General procedures for test conduct, including responsibilities for test direction, operation, and observation.

(4) Requirements for computer programs (other than the CPCEI under test), and equipment such as computers, input/output devices, etc.

(5) Requirements for personnel, including statements of responsibilities, authority, special skill or knowledge, etc.

(6) Data recording and reduction requirements.

(7) Test analysis and reporting requirements.

The test plan should be organized into sections corresponding to the types of Category I testing of computer programs as follows:

(1) Computer Programming Test and Evaluation. This type of testing is conducted by the contractor as an integral part of the design and development process. Information concerning this type of testing will be included in the test plan only when (a) the test is intended to be the only source of data for qualifying specified functions, or (b) the test requires the use of government facilities or other support items such as computing and peripheral equipment.

(2) Preliminary Qualification Tests (PQT). PQTs are formal tests oriented towards verifying during the process of detail design and developed prior to the availability of the complete CPCEI, that selected individual functions meet specified requirements. The test plan should indicate those functions and portions of functions which will probably not be examined during PQT, and indicate the reasons for their exclusion. PQTs serve the primary purpose of demonstrating the contractor's scheduled progress towards meeting the computer program design objectives. Although preliminary in nature, PQT test results may be utilized by the monitoring agency to verify detailed performance characteristics of individual computer program components (CPCs) which may not be feasible to examine during subsequent formal qualification of the completed CPCEI.

PQTs will normally be conducted at a contractor's development facility, typically using controlled inputs specifically prepared for test/demonstration purposes. The test plan should outline the probable sequence of individual and/or assembled CPC tests, identify special simulation, recording, equipment, or other support requirements for the PQT program. In addition to identifying all test tools which will be required, the test plan should indicate how and to what degree these test tools will have been validated for this purpose.

(3) Formal Qualification Tests (FQT). FQTs normally bear the principal burden of qualifying the CPCEI. They consist of formal tests/demonstrations using the completely assembled CPCEI, oriented towards verifying the full spectrum of functional requirements set forth in the Part I Detail Specification. In most cases, FQT will rely heavily upon simulated and controlled inputs which can be designed to cover the expected ranges of system operational modes and conditions.

Complex operational CPCEIs may be scheduled for formal qualification at the Category II test site, as the probable first location at which the system will be available in its full operational configuration. In these cases, scheduling of the FQT will normally be (a) prior to the start of Category II testing per se, in order to qualify the CPCEI for the Category II tests, but (b) following a period of contractor adaptation, installation, and checkout of the CPCEI in the previously-installed and tested operational equipment/facilities.

For less complex CPCEIs, or for those which are relatively insensitive to the system operation, formal qualification may be accomplished at the contractor's development facility. This is especially likely to be the case for a utility computer program. These items may often be qualified through use in testing and operation of other CPCEIs, rather than by special tests.

Formal qualification of a support CPCEI (e.g., simulation or data reduction) may represent a special case. In general, the qualification of functions which are sensitive to the proper performance of the operational computer program, including maintenance/diagnostic functions, may often be delayed until late in the Category II testing period.

Inputs to the Category II Test Plan

The Category II Test Plan to be prepared by the SPO during Definition Phase C or early in the Acquisition Phase will be based upon inputs provided by each contractor during Definition Phase B. The computer program contractor's inputs have special significance, since computer programs are the elements which most directly implement the operational functions of an information processing system.

The inputs prepared at this time should emphasize those aspects of system performance which involve complex interactions among computer programs, personnel, equipment, communications, and facilities during live operations of the total system and should accomplish the following:

(1) Identify all test objectives which must be fulfilled in order to satisfy the requirements of the System Specification and any CPCEI Part I Specification which may contain requirements which could not be satisfied during Category I testing.

(2) Outline in general terms the test methods and procedures for satisfying the test objectives identified above.

(3) Describe the types of data which should be collected, and how they should be reduced, analyzed, and reported. Special requirements for data recording and reduction computer programs and/or equipment should be identified.

(4) For systems which require implementation testing at follow-on sites, identify specific measures of system performance (barometers and figures of merit) to be verified during the Category II test program for the purpose of providing basic criteria for proving the acceptability of subsequent sites.

(5) Identify the numbers and types of trained personnel required. Where system level training over and above the individual training provided by ATC is a requirement, preliminary plans should be developed for its accomplishment. This should include identification of special requirements for facilities, equipment, training materials, etc.

(6) Identify simulation requirements. Although Category II testing will use live inputs to the maximum extent possible, it is frequently not technically or economically feasible to rely entirely on such inputs. For air defense systems, for example, it is not feasible to provide a sufficient number of appropriate aircraft to test the system at or near maximum load levels. In such cases it may be desirable to utilize the system exercising capability to provide exercise problems for use during Category II tests. Such a requirement should be identified at this point in time since it would have an impact on the scheduled development of the exercise capability and the production of exercise problem materials (see Blocks D-26 and D-27).

(7) Provide Personnel Subsystem planning information relative to the evaluation of:

(a) The adequacy of the man/machine interface (human engineering).

(b) The adequacy of the environmental conditions in terms of permitting effective personnel performance.

(c) The adequacy of technical data.

(d) The adequacy with which system malfunctions can be detected, isolated, analyzed and corrected by trained military personnel using only authorized equipment and technical data.

(e) The adequacy of safety precautions in all operations and maintenance activities.

(f) The adequacy of communications between and within functions.

Applicable Data Items

T-103 Category I Test Plan/Procedures (Computer Programs)

This Form 9 combines the Category I Test Plan and Category I Test Procedures into one form. Only the first part of the form dealing with planning information will be completed at this time. The portion dealing with procedures will be completed during the Acquisition Phase.

T-106 Category II Test Plan/Procedures

The appropriate paragraphs of this Form 9 will be utilized by the contractor to provide planning information relative to the system segment for which he has development responsibility. Integration of the inputs from the various contractors into the Category II Test Plan for the entire system is a SPO responsibility, which may be supported by a GSE/TDC or system contractor(s).

D-33. Provide Inputs to the Definition Phase B Final Report

The Contractor's Phase B Final Report is one of the four major products of the Definition Phase (along with the PSPP, the PCP and an updated MCP). Typically it will contain the type of information indicated below, conforming to the four-part outline set forth in AFSCM 375-4 (Part I, Ch. 3).

Part I Introduction and Brief Summary

Part II Technical Report

(1) Trade Study Conclusions

(a) Man-machine function allocations

(b) Development of mathematical equations

(c) Alternate information processing flows

(d) Display design

(e) Manual input alternatives

(2) System Engineering Documentation

(a) Functional allocations

1. Computer program functions

2. Operator functions

(b) Operator task analysis

(c) Training and Evaluation needs analyses

(d) System Exercise Capability implementation plan

(e) Inbuilt simulation and test capabilities

(f) Data reduction capabilities

(g) Computer program development tools required (Utility)

(h) Personnel requirements information for operational, computer program support, and simulation/exercising personnel.

(i) Recommended design requirements for equipment, communications, and facilities.

(3) The System Specification

(a) Definition and list of computer program CEIs.

(b) Functional allocations

(4) Part I Computer Program CEI Detail Specification(s)

(a) Operational Requirements

(b) Support requirements

(c) Utility requirements

(5) Inventory Equipment Requirement Detail Specifications (Not applicable)

(6) Contractor Data Requirements List

Part III Contractor's Acquisition Phase Program Management Plans

(1) Typical planning areas to be covered are listed below.

(a) Organization and Personnel Management

(b) Technical Management

(c) Detailed Integration During the Acquisition Phase

(d) Development

(e) Test

(f) Installation and Checkout

(g) Financial

(h) Procurement

(i) Personnel and Training

(2) Among other planning activities which may be included as parts of, or together with, the plans selected from the typical planning areas listed above are: personnel subsystem, government-furnished property (GFP), PERT/Cost,

test site responsibilities, configuration management, and exercise capability installation and orientation

Part IV Contractor's Firm Proposal for the Acquisition Phase

(1) Statement of Work for the Acquisition Phase

(2) Cost Data--PERT/Cost Report

(3) Contract Terms and Conditions

(4) Incentive Features

(5) Operating PMN

(6) Schedules

As indicated by the above outline, the major system engineering inputs to the final report will be contained in Part II, Technical Report. In practice, the Technical Report will consist of a number of separate documents corresponding to those described in Blocks D-26 through D-32 above. Additional system engineering inputs which might be expected are discussed below.

The contents of Part III, Contractor's Acquisition Phase Program Management Plans, will vary widely from system to system in terms of the number and types of program management plans required. Planning areas contained in the outline which normally require system engineering inputs and would typically be of concern to the computer program contractor include the following:

(1) Detailed Integration During the Acquisition Phase

(2) Development

(3) Test

(4) Installation and Checkout

(5) Personnel and Training

System engineering inputs to Part IV, Contractor's Firm Proposal for the Acquisition Phase, would typically be centered in the following two areas:

(1) Statement of Work (SOW). The SOW to be prepared at this time represents an expansion and refinement of the Specimen Statement of Work contained in the contractor's proposal for Definition Phase B, and consists of a detailed description of each task to be performed by the contractor during the Acquisition Phase. The basis for the detailed task descriptions will be contained in the system engineering documentation completed during Definition Phase B.

(2) Schedules. Schedule information contained in the proposal will necessarily be constrained by the overall development schedule for the system. Aspects of the system engineering effort during Phase B which would be reflected here are the verification that the system-level schedules are realistic from the standpoint of the computer program contractor, and the identification of milestones in the computer program development process which must coincide with specific system-level milestones. Where appropriate, lower level scheduling information should be provided for computer programming events which fall between identified system milestones.

Applicable Data Items

S-17-12.0-1 Technical Reports.

S-5-14.0 Proposal-Technical.

(See also Blocks D-16, D-17, D-26, D-28, D-29, D-30, D-31, and D-32.)

PHASE C - REVIEW AND DECISION

D-34. Perform Technical Evaluation and System Engineering Synthesis

The SPO technical evaluation accomplished at this time will normally emphasize the proposed Part I CPCEI Specification, the updated System Specification, together with associated system engineering documentation contained in Part II of the contractor final report, and the technical proposal for Acquisition Phase development. Objectives are to determine whether Phase B obligations have been met, through analysis of the technical adequacy and completeness of Phase B products, and to determine recommended source(s) for the ensuing Acquisition Phase.

When major deficiencies are in evidence, or when major advantages would accrue, the SPO may undertake to combine features proposed by competing contractors into an improved single approach. This activity constitutes a "system engineering synthesis"; it involves certain potential limitations with respect to proprietary rights and subsequent contracting, and may require extensive additional system engineering effort during Phase C.

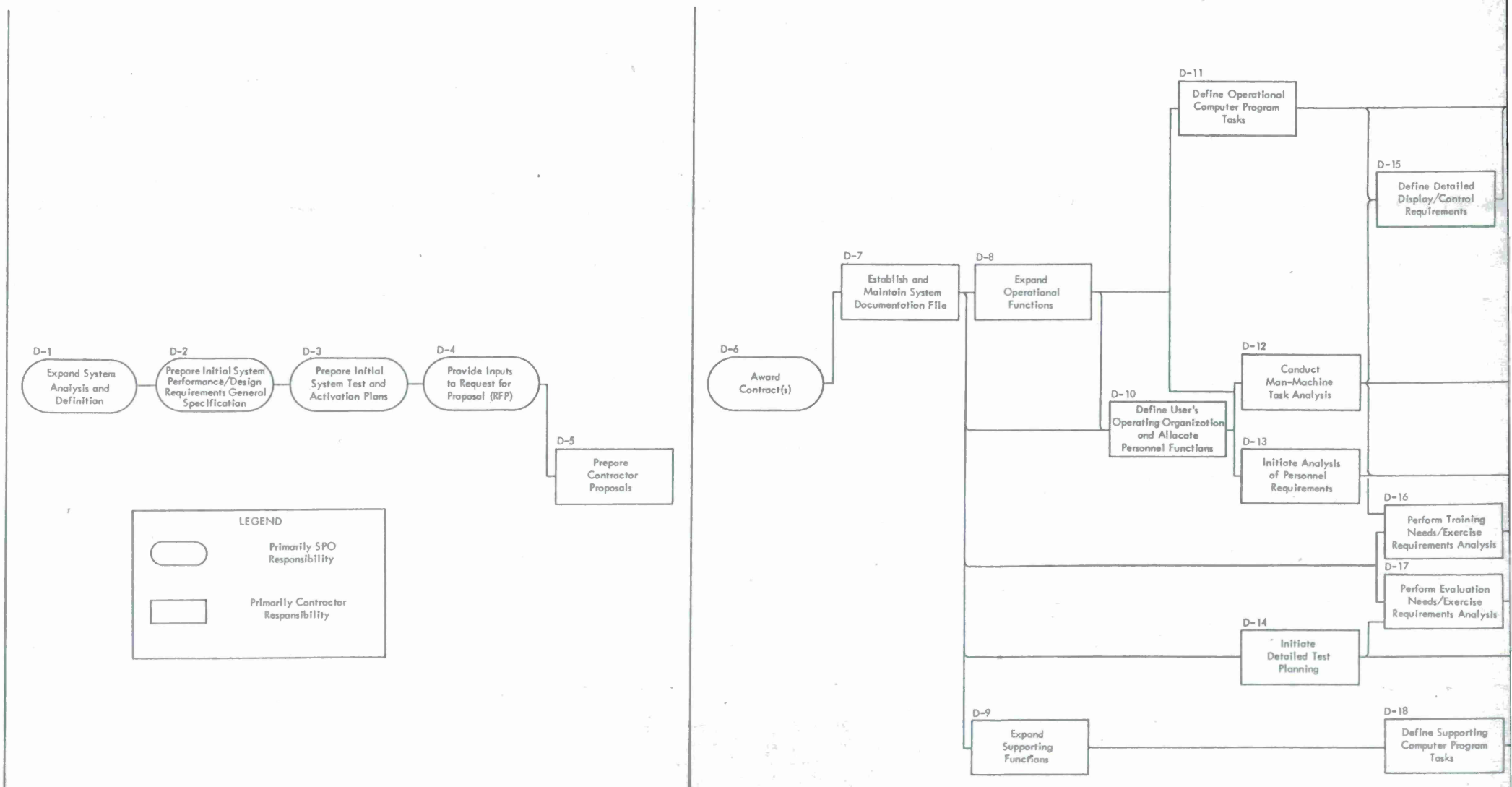

FIGURE 3. DEFINITION PROCESS

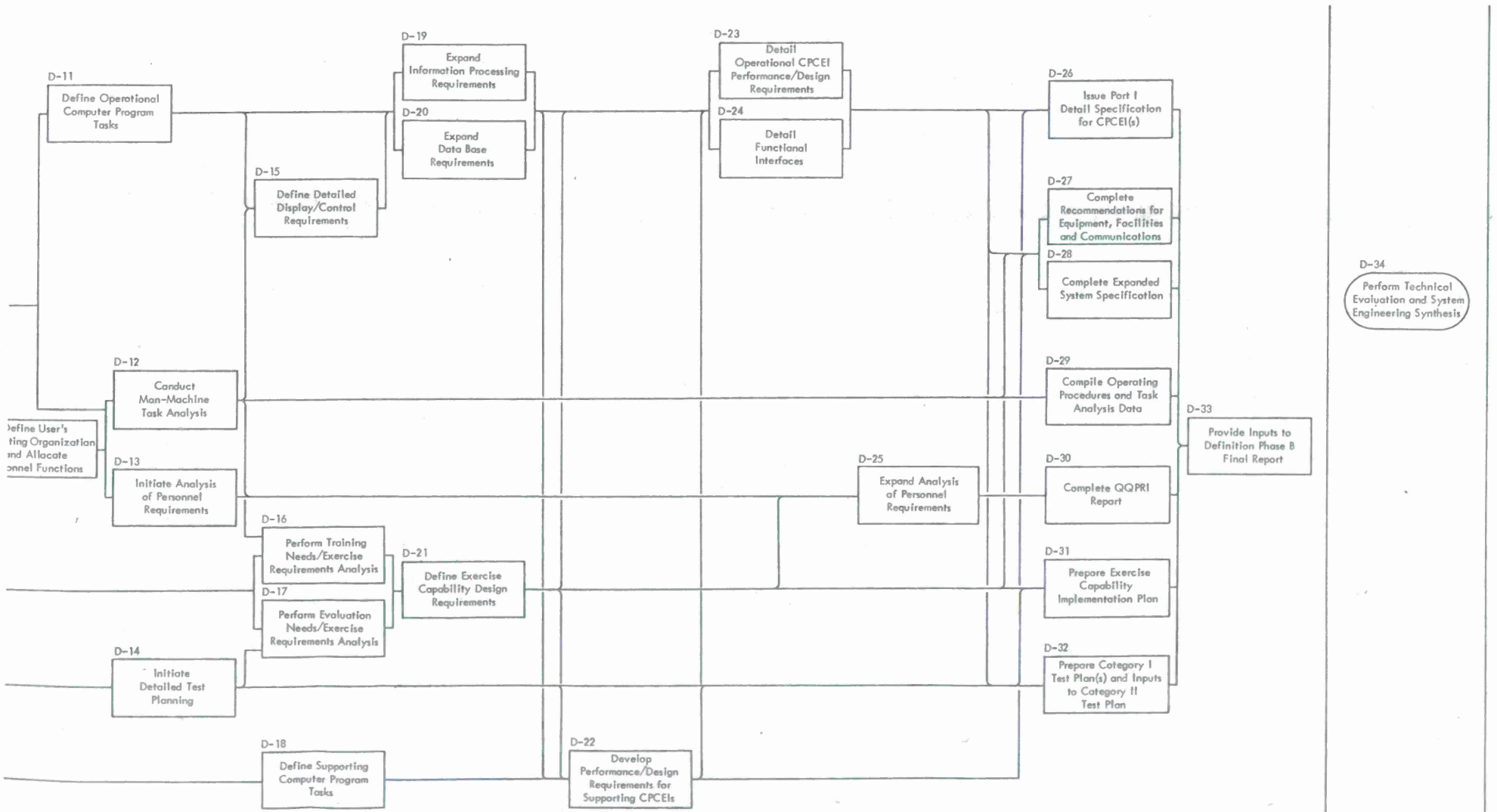

FIGURE 3. DEFINITION PROCESS

Figure 3 goes here

CHAPTER IV ACQUISITION PHASE

A. GENERAL

The Acquisition Phase is initiated by issuance of the System Management Directive, which approves the design requirements baseline, PSPP, PCP, and MCP (if applicable),and identifies the availability of funds and manpower resources required for acquisition of the system.

Based upon the typical cost and schedule requirements for system equipment and facilities, the Acquisition Phase may consist of two overlapping parts, each of which may be contracted for separately. The first is referred to as development, and encompasses the activities of design, development, and associated developmental testing. The second part is a production or construction effort, which may include the construction of one-of-a-kind hardware. It is to be noted that only the first type of contract applies to activities subsumed under the computer programming system segment, due to the relative insignificance of time and costs involved in computer program duplication (production), together with the fact that effort and costs to build the first item are integral with development of the Part II CPCEI Specification.

The Part I Specifications for computer programs, like those for equipment and facilities, constitute the baseline requirements against which design and development activities proceed during Acquisition towards the completion of computer program CEIs and their Part II Detail Specifications.

However, the Part II CPCEI Specifications may typically be completed later in the Acquisition Phase than would often be true of prime equipment items in the same system, both because of typical requirements for using system equipment to qualify the computer programs and because of the absence of required lead-time for their "production". Specific planning considerations relative to equipment and other system events are amplified in the narratives of this chapter.

B. DIAGRAM OF THE ACQUISITION PROCESS

Activities shown on the "Acquisition Process" diagram in Figure 4 are represented at four horizontal levels to correspond, in a general way, with the major subprocesses of (top to bottom): (a) computer program design and coding, including reviews and inspections, (b) test activities, (c) personnel subsystem and handbooks, and (d) development of elements required for the system exercise capability.

The development process is not shown separately on the diagram for different subclasses of operational, support, utility, and maintenance-diagnostic CPCEIs, since the design/development/test events shown apply in the same general sequence to all CPCEIs. For simplicity, the sequential phasing of events is shown which would be typical of major operational CPCEIs, and the variations in relative timing which would normally occur for certain supporting items are noted in the event narratives.

An important activity not represented on the diagram consists of a necessary continuation of the Definition Phase effort which led to the Part I CPCEI Specifications. This effort is frequently referred to as "operational design", in distinction with the Acquisition Phase computer programming design activities which lead to the Part II Specifications. Although usually at a reduced level as compared with the Definition Phase, the operational design activity must normally be maintained on a continuing basis throughout the Acquisition Phase for the primary purposes of (a) supporting the computer program design in areas related to detailed performance/design/test requirements contained in the approved Part I CPCEI Specifications, and (b) developing changes to the Part I Specifications as the needs for such changes are identified and approved during Acquisition.

In the diagram, and in the narratives, Formal Qualification Test is represented as occurring at the Category II site, following the installation and checkout of system equipment. This is the sequence which has actually been followed in recent system programs, and which may continue to be necessary in some future cases. However, it should be emphasized that it is generally desirable to accomplish formal qualification prior to this time, to the degree that available simulation, equipment, and other relevant factors justify determining that the tests are actually valid with respect to established performance requirements for a given CPCEI.

C. NARRATIVES

A-1. Award Contract(s)

Contract awards are based on the evaluations, system engineering synthesis, and negotiations conducted during Phase C, and incorporate firm constraints and requirements established through DoD/USAF approvals. Significant SPO activities preceding contract awards include preparation of the SPP, issuance of real-estate directive, activation of inter-agency agreements, updating of the design requirements baseline, and appointment of Category I and II test directors.

The contract awarded at this time for the computer program system segment will be a development contract covering the design, development, and testing of computer programs, together with the development of design requirements baseline changes, associated personnel subsystem, procedural data, and system exercising products. The contract will normally include tasks for computer program adaptation, installation, and checkout at system site locations, and necessary support of Category II and Implementation Tests.

A-2. Implement System Engineering Procedures

This activity includes expansion and revision of system engineering documentation and source data which had been established and maintained during the Definition Phase (see Block D-7), to reflect firm decisions and revisions resulting from higher headquarters review, preparation of the SPP, and contract negotiation. At this time, procedures may be augmented, using automated data handling techniques where indicated, to assure efficient maintenance of the data for continuing utilization by contractor technical personnel during Acquisition.

Where there is a large number of computer programming and other technical personnel involved in the development effort, it is also important to establish at this time a common set of standards, practices, conventions, and techniques to govern the process. Some degree of consistency is imposed by uniform computer program specifications and uniform requirements for other items of contractor data. Beyond these standard requirements for deliverable documentation, however, there exist essentially no detailed standards for computer programming which are comparable to the wealth of Federal and military specifications and standards which govern the design and construction of equipment. Nevertheless, each contractor can define and disseminate rules of standard practice to be followed internally in such areas as: terminology, with respect both to the given system and to permissible technical terms, abbreviations, characters, symbols, etc.; computer programming techniques; standard coding and flow diagram conventions; rules for identifying data and other CPCEI elements, updating, document duplication and labeling, etc.

A-3. Update Part I CPCEI Detail Specification(s)

The updating of Part I Specifications which occurs at this time should reflect both expansions of information and changes necessitated by events following the completion of Phase B. Changes may be dictated by the System Management Directive. In some cases, both changes and expansions may be based upon firm selection and approval of specific hardware, computer programs, or communications CEIs from among alternatives which had been proposed by competing Phase B contractors.

Specifications submitted at the end of Phase B must be sufficiently complete in both scope and detail to provide an adequate basis for costs, schedules, and evaluation of performance. However, the level of detail required for those purposes may often be more gross than the level which the Part I Specification for a computer program CEI must contain in order to provide an adequate basis for subsequent computer program development and qualification. Most of the necessary additional detail should have been generated by this time, through continued contractor effort during the Phase C holding period and/or at the outset of Acquisition. The specification should be fully complete in all sections prior to PDR.

The updated specifications are submitted to the SPO. Following approval, they are turned over to the configuration management division for formal control. All subsequent changes or expansions are initiated and formally processed as changes to the design requirements baseline (see Exhibits IX and XXI, ESD Exhibit EST-1).

A-4. Accomplish Preliminary CPCEI Design

The purpose of this activity is to translate the Part I Specification into a design approach to the overall CPCEI preparatory to Preliminary Design Review (Block A-7). Based upon performance requirements and design constraints established in the Part I Specification, the CPCEI preliminary design phase is concerned with establishing the design framework within which subsequent design, coding, and testing of computer program components can be accomplished, in the process of developing a Part II Detail Specification for the CPCEI.

Determine Computer Program Functional Areas

Integral with preparation for preliminary program design is the analysis which must be made of the functions to be performed by the CPCEI in order to determine the computer program structure which would permit the required functions to be performed most efficiently. This activity entails a determination of computer program functional areas which are comprised of one or more subprograms, each of which performs a particular task related to the given function. Functional areas of a computer program have a close correspondence to the functions described in the Part I Specifications. For example, the computer program functional area of tracking executes the tracking function as described in the Part I Specification. However, this correspondence may not exist in every instance. Bookkeeping tasks may be treated in the Part I Specification as tasks implicit in the performance of other functions; efficient program design may demand that bookkeeping be performed by a group of subprograms comprising a functional area. In performing this analysis, the following should be taken into consideration:

(1) Inputs from and outputs to other CPCEIs according to types, quantities, frequency, variations in sources, and destinations.

(2) Information processing functions explicit in the CPCEI Part I Specifications and the implicit information processing functions which are necessary to facilitate the performance of the explicit functions.

(3) Operating characteristics of the computer in which the CPCEI is to operate.

(4) The language(s) in which the CPCEI is to be coded.

(5) The test environment available for accomplishing Test and Evaluation and other test environments.

(6) Explicit and implicit requirements for ease of malfunction diagnosis and simplicity of modifying the CPCEI.

Determine Computer Program Component Structure

Computer programs are designed so that sets of code are grouped in such a manner that each grouping serves a specific purpose. These groupings, termed computer program components (CPCs), may consist of such elements as subprograms which serve the purpose of a task within a functional area, or a data dictionary (COMPOOL) which serves the purpose of defining storage locations, or control tables which contain data used by more than one subprogram in the execution of its specific task. Structuring the computer program into CPCs facilitates testing in that each subprogram can be tested as an isolable entity through the use of controlled inputs and analysis of the outputs; CPCs also permit optimum utilization of data storage and operating time, to the degree that the transfer of CPCs in and out of various storage elements can be performed in such a way as to achieve the desired balance between operating time and computer program size.

Storage requirements and hardware limitations may also influence the determination of CPCs. Space-sharing of functions and commonality of subfunctions will also be influencing factors.

Many of the inputs to and outputs from CPCs are obtained from other CPCs or destined for other CPCs within the CPCEI. These are intra-CPCEI communication requirements, or CPC interfaces. Accomplishing the CPCEI preliminary design requires choosing a method or methods which will be employed among the CPCs to achieve a definition of these interfaces.

Determine Operating Sequence and Timing

Once functional areas have been defined, it is possible to establish a sequence of their operation. Requirements such as several iterations of operation during a cycle in order to minimize timing of internal transfers and to most fully utilize the existing hardware capabilities must be considered. Additional factors influencing the sequence include the order of data inputs, minimization of internal transfers of data for each CPC's operating environment, and allocation for common usage of data.

Timing of the operation of the entire CPCEI must also be defined. The timing information may be of two types: (1) definition of conditions which will affect the overall operating time of the CPCEI, (2) estimations of these lengths of time for some CPCEIs. For certain functions, this definition is critical to obtain an adequate design; however, this may not be necessary for all areas. In the design of an assembler, for example, estimations for the length of operating time need not be gathered. However, the conditions which affect the operating time of the assembler should be defined.

Define Executive Control Program Requirements

Since the control functions are defined in the Part I Specifications, it is part of the design activity to assign these functions to CPCs. Some elements of the control function include system start up, operation of individual CPCs, automatic error detection and recovery, control of system timing, initiation of program interrupts caused by equipment requirements and multi-processing considerations, etc.

It is essential that the activities necessary to produce the executive control program be initiated as early as possible, as the design of this is critical to the overall interaction of the computer program system. Also, the availability of the control functions at the earliest possible date will greatly facilitate the testing of other functions.

Define the Data Base

All information contained in the computer and its auxiliary storage, which is not included in the instruction set, is considered to be the data base. This information is used for CPC inter-communication, for data manipulation, for specific environmental parameters, etc. To accomplish the definition of the data base, data items and sources must be identified and format, scaling, and expected usage detailed.

The data base is structured to allow efficient utilization of the available storage space by the CPCs. In determining the organization of the data base, considerations are given to timing requirements, frequency of use, whether the data are permanently required for the system cycle or whether only temporary storage is used. The organization of the data may be partially derived from the analysis of the flow of information, and further detailed as storage for data used by CPCs is identified. The data base will require further refining as additional work is completed and more detailed information is available at the level of individual CPCs.

Allocate Program and Data Storage Space

Plans for the CPCEI's use of program and data storage space such as core memory, drums, and discs should be described in order to accomplish the preliminary design. For some CPCEIs it may be reasonable to layout the proposed use for each register, file, channel, etc. In most instances, however, this detail is not known as early as the preliminary design stage and the proposed use is described in more general terms. Estimates for requirements of quantities of data and program storage should be obtained. This may include estimates on storage requirement lengths for each CPC in the CPCEI, or it may be estimates of lengths of groups of CPCs which are functionally or logically related in their space allocation requirements. For data storage requirements, estimates may be made for the large quantities of data divided according to logical relationships and for some smaller quantities of data where the

necessity has been determined. These quantities of data will be described according to their purpose, i.e., names of types of data which are allocated, in addition to their estimated lengths.

The description of the use of storage space can include layout charts. In some instances, it may be determined that it is more desirable for the CPCEI itself to allocate the available space. In this instance, it is useful to describe the algorithm which will be coded into the CPCEI to allocate the space.

Perform Trade-Off Studies

During prelimianry CPCEI design, trade-off studies must often be made to determine the most effective CPCEI design. In each of these studies, space, timing, and feasibility are critical factors to be considered. Additionally, for many CPCEIs, extensive and frequent changes may be expected after the initial operational implementation. The ability to implement these changes quickly and easily is also an essential consideration in these studies.

When trade-off studies are required to choose among significant alternative approaches, they should be documented to reflect the alternatives considered and the basis for the final decision, in order to facilitate review and consideration of related design decisions at subsequent levels.

A-5. Initiate Refinement of Operator Procedures

This activity is concerned with the continued analysis and refinement of the operator procedures developed during Definition Phase B as described in Block D-29.

Initially, the results of system engineering synthesis occurring in Definition Phase C (see Block D-34) should be examined for changes that might be required to the operator procedures previously prepared. Any required changes should be made at this time and any procedures not prepared earlier because of uncertainties regarding interfaces should be completed.

Analyses of manual and man-machine tasks should be initiated or continued as required to optimize procedural efficiency and allocation of functional elements and to reflect additional detailed information resulting from the acquisition process. Close coordination must be maintained with design personnel throughout the Acquisition Phase so that as problems arise requiring modification or revision to the Detail Specifications, human engineering personnel can participate in their resolution and evaluate any resultant changes for impact on operator positions or procedures.

The refined task analyses and procedures data provide the basis for the compilation of materials for handbooks and guides. A handbook is normally prepared for each type of operator position in the system, providing necessary information for the performance of that position. It should be designed as a complete reference document to supplement on-the-job-training and cross-training, and may also be required for use as a basic text for initial training of the operators. In addition to detailed procedures, the information to be compiled at this time should identify:

(1) Content and format of all displays available or forced to the position, including information concerning the frequency with which displayed data are updated, and including limits, capacities, and tolerances for each element of displayed information.

(2) Switch actions available to the position and a description of what occurs within the system as a result of each switch action.

(3) Special job aids available at the position, with detailed descriptions of how they should be used, under what circumstances, and for what purpose.

(4) Communications links available to other internal and external positions, including, when available, general operating standards or procedures to be followed in their use.

In addition to positional handbooks, operator training guides will usually be prepared for use in initial, replacement, and cross-training of operators. In contrast to the handbooks, which are reference compendiums oriented to

specific operator positions, the operator training guides are systematic expositions of the way in which system data are received, processed, and output in the performance of major system functions. Information derived from operator task and procedural analyses form a major portion of the guides.

The ongoing task analysis and refinement of operator procedures should also provide the basis for revising and updating the preliminary QQPRI Report prepared during the Definition Phase (see Block D-30). Changes required should be supported with appropriate justification from task analyses or other sources.

This activity may also be expected to provide inputs to the Category I and II PSTE planning effort (Blocks A-9, A-17, A-24, and A-29). These inputs would consist largely of detailed procedural data, and the identification of critical tasks requiring special attention during the PSTE effort.

A-6. Initiate Development of Exercise Problem Generating Capability

The activity to be discussed here is concerned with the development of a centralized capability for generating problem materials for full-scale system exercises. This centralized capability may, in some instances, represent the only source of exercise problem materials available to the system. In other instances, it may augment a problem material production capability internal to the system. In air defense systems, for example, both the SAGE and BUIC systems have computer programs at each site which are capable of producing materials on a limited basis, e.g., for exercising individual sites, or a restricted number of adjacent sites. For nation-wide air defense exercises, however, a centralized capability, in this case external to either system, produces the required exercise materials.

Although the decision that a centralized problem generating capability will be required may have been made as early as the Conceptual Phase, actual development is dependent upon having:

(1) The system exercising capability fully defined.

(2) Implementation schedules for system exercising established.

(3) Development contracts awarded.

For the purpose of this discussion it is assumed that the contractor selected for developing the system exercising capability is also responsible during system acquisition for the delivery of any exercise problems which require a centralized facility for their production. As described here, the centralized capability is not a deliverable product of the system development contract. It should be noted, however, that some or all of the problem generating capabilities and materials may be in the form of CEIs (or parts of CEIs) and associated data, handbooks, etc. which would be specified, controlled, developed, tested, and delivered with other parts of the system.

The magnitude of the effort required for developing the centralized capability may vary widely. At one extreme, only hand-prepared scripts and scenarios must be produced and no special equipments or computer programs required. At the other extreme, the capability must produce a wide variety of exercise materials and may require a complex combination of equipment, computer programs, and supporting procedures and aids. The centralized capability for producing nation-wide air defense problems represents an example of the latter case. That capability utilizes special computer programs, approaching the operational computer programs in complexity and number of instructions, and special equipments to: (1) produce maps, lists, and other exercise aids, (2) generate radar target data film which, when input to special exercising equipment, exercises the system's radars, and (3) generates problem input tapes which contain all of the inputs to the Direction Center necessary to simulate a war-time environment.

In addition to initiating the development of equipment and/or computer programs which may be required to produce exercise material, this activity should also be concerned with the development of techniques, procedures, and data necessary to effectively utilize the capability. Of particular importance is the identification and collection of the data which must be input to the capability to produce exercise material. To be effective, the exercise material should be based on detailed data concerning the anticipated operational environment in which the system to be exercised must perform. In the air defense system example, these data include such diverse items as: site location, inter-site communications, performance characteristics of enemy aircraft, enemy ECM capability, and the number, types, performance characteristics, and armament of interceptor aircraft available to the defense.

A-7. Conduct Preliminary Design Review (PDR)

The Preliminary Design Review is a formal technical review of the basic design approach for the CPCEI (or functionally related groups of CPCEIs) resulting from the preliminary design activity discussed in Block A-4. The purpose of the PDR is to establish the integrity of the design approach, verify compatibility with the Part I Detail Specification, and verify functional interfaces with other CEIs prior to the start of detail design activity (Block A-10).

The PDR for CPCEIs is accomplished by reviewing the following:

(1) *Storage Allocation Charts.* These charts describe the manner in which various elements of the computer program system have been allocated to available computer storage.

(2) *Computer Program Functional Flow.* This is a flow chart which summarizes the functions to be performed by individual computer programs and shows the sequence of operation.

(3) *Control Functions Description.* This is a description of the executive control features and start/recovery functions for the computer program system. This includes the method used to initiate system operation, together with features to enable recovery from system malfunctions.

(4) *Structure and Organization of the Data Base.* This is a description of the structural layout and allocation of storage requirements of the system data base, identifying the types and characteristics of data.

(5) *Interface Requirements.* Although these were identified in the Part I CEI Specification and approved, it is important that they be reviewed again at this time. Interface constraints identified would include such things as word length, message formats, available storage within the computer, and timing considerations.

(6) *Trade-Off Studies.* This is information developed from studying alternate methods and techniques of designing computer program CEIs.

Applicable Data Item

ESD 289 Minutes of Formal Reviews and Inspections

References

AFSCM 375-1, Exhibit XIV

ESD Exhibit EST-3, Chapter 3

A-8. Initiate Collection and Compilation of Data Base

This activity consists of the collection and subsequent compilation of those data elements of the computer program which must be obtained from sources other than the contractor responsible for the computer program development. The data base is initially identified in Conceptual Transition phase (Block C-5) and subsequently expanded in the Definition Phase (Block D-20). Data elements to be collected include those which describe the natural environment of the system, characteristics of weapons to be employed in the system, interfacing system characteristics, and other similar data. These data frequently must be acquired from several agencies, e.g., contractors and, in some instances, from other military services. Hence, much of the actual data collection may be performed by government agencies, through arrangements accomplished by the SPO. The contractor should assist by specifying schedules to assure timely availability for such dependent events as computer program testing and adaptation.

The data must be compiled, organized, and verified for consistency, completeness, and conformance with requirements of the Part I Specification(s). Some of the data, e.g., adaptation data or weapons characteristics, may require documentation in English language/decimal form for subsequent delivery to the user. Also, the contractor must normally document the processes to be employed for encoding the data in forms required for insertion into the computer program (see Block A-22) and suitable for listing in the Part II CPCEI Specification(s).

In cases where the data base elements are likely to undergo frequent or extensive change during the Operational Phase, a supporting computer program which will perform the task of encoding the data into machine language of the computer may be included in the requirements. In these cases, the design of the supporting computer program must be reviewed for compatibility with the composition of the data base elements. A user manual will normally be required for this, as well as for other supporting computer programs, for availability at AI&C (Block A-22).

A-9. Expand Category I Test Plan

The purpose of this activity is to expand and update the Category I Test Plan(s) prepared during the Definition Phase (see Block D-32). The primary objective of this expansion process is the establishment of basic Category I requirements, methods, and criteria that will (1) provide the monitoring agency with detailed information required for effective planning and management of the Category I test activity, (2) identify test requirements that are to be satisfied during Category II testing, (3) provide the basis for early review and analysis of the contractor's testing program by the monitoring agency and (4) establish the basis for preparation of Category I Test Procedures.

The Category I Test Plan developed in the Definition Phase identifies, based upon the quality assurance requirements specified in Section 4 of the Part I Specifications: the requirements for personnel, equipments, facilities, and supporting computer programs; the quantitative criteria for verification of performance; the documentation and control procedures to be employed; gross level scheduling information; and the functions and functional interactions to be tested. Expansion of this information will usually result in the preparation of a set of test plans that define in greater detail the Category I test requirements, methods, and criteria. Additional detailed information required for this activity results primarily from updating and more precise definition of:

(1) Equipment configuration, capabilities, and schedules.

(2) Facility and communication linkage capabilities and schedules.

(3) Computer program design and associated development schedules.

(4) System environmental conditions.

With the contract awards for computer, display, test, or other equipment items, Part I Specifications and other documents become available to provide firm and more detailed information relating to equipment design requirements and schedules. Pertinent technical information will include such items as addressing logic, interrupt logic, storage capacities, etc., which affect both Part I CPCEI Specifications and subsequent computer program design, and which must also be reflected in the updated Category I test planning with respect to requirements, methods, and criteria. The test schedules, locations, and personnel requirements will also require expansion, resulting from known equipment availability schedules. Factors to be taken into account will include firm availability dates for operationally configured equipment, as well as schedules and characteristics of other equipment items needed to support the computer program development and testing efforts.

Decisions made in the Definition Phase as to methods to be used in qualifying CPCEIs should be re-evaluated and assessed as a result of updating of the

Part I Specifications, preliminary CPCEI design decisions, and the equipment-related information discussed above, as well as any required modifications to the original test plan. For example, plans to use test and evaluation data for qualification may be affected if equipment other than that to be employed in an operational environment is to be used during the test and evaluation time period. Qualification requirements in this case may result in changing planned PQT and/or FQT requirements.

Testing will usually require the use of facilities and communication linkages, some of which may be newly constructed and/or installed. The expanded test plan should account for construction and installation schedules, and specify requirements and schedules for their use. In addition, existing capabilities should be examined for use in testing. Requirements for temporary capabilities should be specified and trade-offs made by assessing the costs involved and the effects on the total schedules in providing temporary capabilities, in adhering to existing facility and communication linkage schedules, and in accelerating these schedules. The assessment should consider such factors as installation schedules, verification schedules, backup capabilities, anticipated downtimes, and scheduled maintenance requirements. Expansion of test plan requirements covering these factors should be specified and provisions made for all required interfaces and time-phasing of requirements.

Information resulting from the preliminary CPCEI design activities described in Block A-4 influences the expansion of the Category I Test Plan primarily in such areas as: identification of discrete subprograms, CPCs, and functional interfaces requiring testing; test input expectations; test output requirements; test tool capabilities; and overall computer program development schedules, including the establishment of PDR and CDR schedules and requirements; manpower and computer time requirements; test procedure production schedules; and time required for test conduct and test result analysis.

All quality assurance requirements specified in Section 4.1.3 of the updated Part I Specifications, and the manner in which they are to be satisfied, are identified in the expanded test plan. Requirements that cannot be qualified during Category I testing are specified. Requirements of this nature are typically those that require interfacing equipment, personnel, facilities, and/or other systems that are unavailable until the Category II testing time period, and for which the development of sophisticated, high-cost test tools or equipment is not economically or technically feasible. Other requirements qualified during the Category I time period may be qualified by indirect means. For example, certain utility functions may be qualified in this manner since the validity of the utility functions is established through their use in developing, maintaining, and debugging other CPCEIs.

Environmental requirements, the details of which are not known sufficiently to incorporate them in the test planning during the Definition Phase, will be specified in the expanded test plan as they become available. For example, if a manned interceptor is acquired in conjunction with, or as part of the

system, characteristics requiring testing and the methods to be employed should be included in the expanded plan as the Part I Specifications for the aircraft become available.

The expanded plans are reviewed by the monitoring agency for accuracy of technical data, appropriateness of schedules and interface requirements, and completeness of coverage. The computer program test and evaluation activity (Block A-14) may be initiated in some instances prior to the completion of the updated test plans, where data resulting from the operation of a sub-program may be required for PDR. The test and evaluation effort and the production of test procedures should, however, be consistent with, and be guided by the requirements set forth in, the expanded test plan.

Applicable Data Item

T-103 Category I Test Plan/Procedures (Computer Programs)

References

(1) ESD Exhibit EST-2, Chapter 4, Block 18

(2) AFSCM 374-4, Part I, Chapter 4, Block 18

A-10. Accomplish Computer Program Component (CPC) Logical Design

The purpose of this activity is to expand and amplify the content of the CPCEI preliminary design, and to produce documentation and flow diagrams describing the detailed logic to be used in developing code for individual CPCs (see Block A-13). The input to this phase is the CPCEI preliminary design, including the results of any analysis studies which are performed during this phase that are pertinent to the implementation of the CPCEI. Examples of the latter would be studies concerned with problems of transferability from an intermediate to the operational computer, and studies concerned with problems of operating times and their relationship to the efficiency of the CPCEI.

The CPC logical design phase overlaps both the CPC preliminary design phase (Block A-4) and the CPC coding phase (Block A-13). Inputs concerning technical feasibility and cost effectiveness are provided as feedback to the preliminary design activity from the logical design activity. These may arise from detailed analysis of computer program/equipment interface limitations, refinements in estimates of the magnitudes of proposed CPCs, or limitations in capabilities for achieving certain types of computational accuracies. Similarly, inputs affecting logical design may be received from the CPC coding activity. These are normally in the nature of computer programming efficiencies, but may also include requests for design clarification or requests for corrections due to logical errors.

A large portion of the logical design for utility computer programs, and to a lesser extent for operational and support computer programs, cannot reasonably be completed until the major part of the CPC coding activity has been accomplished. In the case of utility CPCs which are used to support the development of all other CPCs that comprise a CPCEI, a need exists to start the CPC coding activity as early as possible. Because of this, and because the requirements for operating time, core storage consumption, and number and complexity of functions to be performed are less critical than those needed for operational or support CPCs, a general and flexible initial statement of logical design will suffice. The details of design for these CPCs are easily worked out during the coding phase and can be added to the logical design description later. In those cases where similarly relaxed requirements for design constraints exist for the operational and support CPCs, the final design decisions can be most expediently handled during the coding phase.

The following activities must be accomplished before this phase of development can be completed:

(1) For each CPC, provide a summary description of the functions which it is to perform.

(2) For each CPC, provide a list of input and output information descriptions, along with a description of the environment in which the CPC

is to operate. Input/output descriptions should include card formats, tape formats, item size, table size, types of data involved, and scaling information. Environmental descriptions should include names of other CPCs with which the subject CPC must interact, information concerning such things as housekeeping tasks which the subject CPC need or need not perform, and temporary and permanent storage areas with which it must deal.

(3) Provide a description of each logically isolable task to be performed within the CPC. These descriptions should include any algorithms or formulae which are to be used, along with statements of computational accuracy requirements. Descriptions should avoid dictating coding techniques, but should be of sufficient detail to describe what the resultant code is to accomplish.

(4) For each CPC, develop a logical flow diagram which shows the relationship of the tasks described in 3. above. All critical decision points should be included in the flow.

(5) For the CPCEI or each group of logically related CPCs forming a portion of the CPCEI, produce a flow diagram showing the inter-relationships and sequence of operation of individual CPCs.

(6) Develop a storage allocation chart for the CPCEI or each group of logically related CPCs which form a portion of the CPCEI. Where a data definition dictionary is to be used, its content must also be defined.

The level of detail contained in the CPC logical design should be sufficient to provide the following types of information:

(1) Detailed description of interface relationships between CPCs.

(2) Detailed descriptions of interface relationships between CPCs and equipment.

(3) Supplementary comments concerning special logic or design structures to be employed or avoided due to transferability requirements.

(4) Error checks and error message formats to be incorporated in the CPC code.

(5) Bookkeeping requirements.

(6) Timing requirements.

(7) Computational accuracy requirements.

(8) Critical decision points.

A-11. Initiate Development of Exercising Procedures and Guides

The contractor responsible for the development of the system exercising capability should initiate at this time the development of descriptive material relative to its use. This descriptive material should be organized into the appropriate manuals and guides required to train personnel at operational sites for planning, preparing, conducting, and evaluating system exercises. Since the system exercising capability will typically be utilized at the Category II test site, preparation of the manuals should be complete prior to the start of the Category II test activity. These documents are subject to revision before final issue to reflect the results of Category II tests.

Two types of system exercises are normally recognized. One type is oriented toward operational readiness training of personnel, the other toward system/subsystem/component evaluation. The distinction between the two types, though not always clearcut, is based on differences in objectives and differences in the nature and disposition of data collected. Separate manuals will normally be prepared to cover each type of exercise.

A third class of documents is required to serve as guides to identify the personnel required to conduct exercises (of both types) and to describe their duties, tasks, and responsibilities.

The required contents of the documents identified above are described below:

(1) *Exercise Conduct Manual* - This manual should present instruction for planning, preparing, and conducting simulated exercises for operational readiness training. Pertinent information of the following types should be presented:

(a) Planning - Guidance should be provided relative to

(1) determining exercise objectives
(2) selecting configuration
(3) specifying required simulated inputs and aids
(4) identifying exercise duty positions to be manned
(5) establishing implementation schedules

(b) Preparation - Methods and procedures should be identified for:

(1) preparing exercise materials, e.g., generating tapes, scripts, etc.
(2) verification of problem adequacy and accuracy

(c) Conduct - Methods and procedures for exercise conduct should be described including:

(1) Coordination with outside agencies.
(2) Briefing personnel.
(3) Assuming, operating and relinquishing control of the operational system.
(4) Collecting, analyzing, and reporting performance data.
(5) Providing feedbacks concerning the results of the exercise to the operational personnel exercised.

(2) *Evaluation Manual* - This manual is similar to the Exercise Conduct Manual in that it is concerned with defining the methods and procedures for planning, preparing, and conducting system exercises. However, the exercises to be considered are not for training operational personnel, but are for the purpose of evaluating the operational readiness of the system or some part of the system. The measures of system/subsystem operational readiness to be considered include:

(a) Organizational effectiveness against the environmental threat.

(b) Adherence of personnel to operational procedures and doctrine.

(c) Proficiency of personnel.

(d) Effectiveness of functional parts of the system.

(e) Effectiveness of alternate configurations of personnel, equipment, computer programs, doctrine, or procedures.

In general, the considerations discussed above relative to planning, preparing, and conducting training exercises also apply to evaluation exercises. In addition, special attention should be directed to:

(a) The peculiar requirements for evaluation exercises, which should be described in detail and explicitly contrasted with exercises conducted for training purposes.

(b) The nature of the data to be collected and the manner in which it will be analysed and reported. The data from evaluation exercises should be described in detail and contrasted with that obtained from incidental observation. The use of system capabilities for recording, reducing, interpreting, and reporting performance data during ordinary operations and training exercises should be described. The limitations or generalizations that can be made on the basis of such data should be made explicit and contrasted with generalizations that can be made from similar data collected during exercises designed and conducted specifically for evaluation purposes.

(3) *Exercising Personnel Guides* - These guides provide detailed information and job descriptions of the personnel required to conduct system exercises for training and evaluation. Their intended purpose is to assist in the training of personnel who will plan and conduct exercises. Each exercising personnel duty position associated with the exercising capability should be identified and described in detail. The description should include the following:

(a) The methods and procedures for overall management of the exercising capability.

(b) The methods and procedures for planning and preparing exercise material.

(c) The methods and procedures to be used in providing simulated inputs during an exercise.

(d) The type(s) of information available during the mission.

(e) The equipment/facilities to be used.

(f) The positional responsibilities and duties,including a definition of the knowledge and skills required.

(g) Structure of the exercising personnel organization.

(h) Coordination duties with other personnel/positions.

Whenever possible, the guides should contain illustrative examples to help clarify the duties and responsibilities of the position during typical exercise missions.

Applicable Data Items

Q-125	Exercise Conduct Manual
Q-124	Evaluation Manual (Information System Exercising Personnel)
Q-123	Synthetic Inputs Operator Guides

A-12. Conduct Critical Design Review (CDR)

The Critical Design Review is a formal technical reivew of the design of a CPCEI for the purpose of establishing integrity of design prior to coding and testing. Normally it is accomplished when logical design is complete at the level of flow charts (Block A-10). In the case of a complex computer program CEI which is scheduled to reach any given stage of the design/development/test process in increments of computer program components (CPCs) or assemblies of CPCs, the CDR may also be scheduled in increments. In these cases, the actual level of design at which reviews are performed may be adjusted to optimize the efficiency of the overall CDR for the entire end item. For example, when so determined by the SPO, CDRs may be scheduled in conjunction with preliminary qualification tests of components or assemblies.

Normally, CDRs are accomplished at the contractor's facility where the design activity is in progress. Design documentation available to support the review should include working drafts of design information to be incorporated subsequently in the Part II Specification, excepting portions beyond the stage of design at which the review is conducted, together with other documentation describing results of analysis, preliminary testing, etc., as mutually agreed by the procuring agency and contractor. Objectives of the CDR should include the following:

(1) Establish compatibility of the design with the Part I Detail Specification.

(2) Establish system compatibility of the design, through review of design-level interfaces among CPCs and with other computer program CEIs.

(3) Review interactions with the data base, e.g., by analysis of COMPOOL tables/listings, set-used listings, etc., when available.

(4) Establish design integrity by review of available test and analytical data in the form of logic diagrams, algorithms, storage allocation charts, detail flow charts, etc.

(5) Review functional interfaces with equipment and personnel to insure that changes have not affected compatibility.

The CDR should be conducted to encompass all technical requirements applicable to the item being reviewed--e.g., performance, operability, safety, and security. The contractor is normally responsible for providing such necessary resources and materials as: an agenda for the meeting, conference room(s), design documentation to be reviewed, results of supporting studies/analysis, and minutes of the meeting.

Applicable Data Item

ESD 289 Minutes of Formal Reviews and Inspections

References

AFSCM 375-1, Exhibit XIV, sets forth the formal requirements for design reviews and inspections as they apply to contract and items in general.

ESD Exhibit EST-3, Chapter 4, contains amplified information governing the conduct of CDRs for CEIs in electronic systems, including computer programs.

A-13. Initiate Coding of Computer Program Components (CPCs)

The purpose of this activity is to accomplish the translation of the Computer Program Components (CPCs) logical design (Block A-10) into a series of instructions which can be transformed into the machine language of the subject computer by means of an assembler or compiler. Prerequisites to accomplishing this coding activity include the following:

(1) The CPCEI preliminary design (Block A-4) and the logical design of Computer Program Components (Block A-10).

(2) A description of the computer and associated hardware which will dictate coding characteristics (e.g., scaling, byte characteristics).

(3) A specification of the programming language(s) to be used for coding the CPCs.

(4) A storage allocation scheme in the form of a data definition dictionary which includes item and table definitions for the CPCEI data base. Information contained in this scheme should include (a) the location and number of registers allotted to each CPC for each random access storage device in which it is to reside and (b) for each CPC, a description of the content, size,and location for items and tables to be used for input data, output data,and inter-CPC communication.

(5) A set of conventions to be employed in the development of code for the CPCs should be available. This insures consistency in the form of the coded CPCs and prohibits the development of unnecessarily complex code which may be difficult to interpret or modify when the need arises. Consideration should also be given to providing guidelines for organizing computer code to include logical breakpoints that can be utilized to facilitate test activities.

(6) Additionally, in the case where initial coding is to be done using an intermediate computer, a study must be conducted to provide guidelines for coding techniques which should be employed or avoided, as the case may be, to minimize the problems involved in transferring the CPCs from the intermediate to the final computer.

The CPC logical design is analyzed and interpreted by computer programming personnel and translated into the language to be used for developing the CPCEI. As a result of problems encountered in this task, or due to special considerations for coding efficiency, item and table storage requirements in addition to those described above may be defined. If storage allocation is to be controlled by a data definition dictionary,which is an input to the compiler or assembler used for the development of the CPCEI, its translation to machine language must be accomplished. In the case where the CPCEI has but one CPC, and no requirements exist for storage interface with other CPCEIs, storage definition may be included in the coding activity.

In order to facilitate the assembly of the CPCEI (Block A-18) and the task of testing the CPC (Block A-14 and following) a priority scheme for determining the order in which individual CPCs are to be coded must be developed. Such a scheme insures the orderly development of the CPCEI and avoids situations where work must be delayed until the coding of some critical CPC is completed. While contingency modifications to this scheme may be made as the coding activity progresses, its initial development should occur before the CPC coding activity is started. High coding priorities are usually assigned to CPCs having the following characteristics:

(1) CPCs which are to be utilized to support the development of other CPCs.

(2) CPCs which production estimates predict will require the longest linear time for coding.

(3) CPCs which are designed to have extensive interface with other CPCs.

The code for the CPC is transformed by an assembler or compiler into the machine language of the computer to be used with the CPCEI. Errors resulting from faulty transformation of code or errors in interpreting the logic of the CPC design may be discovered during this process. As a result, several sets of corrections must be coded and a corresponding number of attempts to produce a complete assembly or compilation may be required. The goal of this activity is to produce a machine language transformation of each CPC which is as free from error as is possible and which is acceptable for use in subsequent testing activities. As a result of feedback from testing, the code for the CPC must be amended to correct errors. If a symbolic or octal corrector capability is available, the coding of corrections can be accomplished using these capabilities and the need for intermediate compilations or assemblies is avoided. If no corrector capability is available, the correction changes must be incorporated with the code and a new compilation or assembly performed. Due to errors of omission or changes in allocation required by error correction to individual CPCs, modifications to the storage definition dictionary may also be required. In addition to errors which cause CPCs to fail to meet CPCEI Part I Specifications, various programming inefficiencies may be noted during the test activity. These should also be corrected during this phase to improve the quality of each CPC.

Changes or clarifications which are incorporated in CPCs during the CPC coding phase should be reflected in modifications made to the CPCEI preliminary design and the logical designs of CPCs. This will facilitate the completion of the CPCEI Part II Specifications as described in Block A-23.

When the number of persons assigned to work on the coding of CPCs for CPCEI development is large, means must be established to maintain communication among subgroups of personnel and to assure consistency of related efforts (see Block A-2).

Prior to the transfer of a CPC from an intermediate to the final computer, the CPC should be reassembled or compiled to incorporate all error corrections developed up to the time of transfer. Additionally, individual CPCs should be assembled or compiled to incorporate the aforementioned modifications prior to CPCEI assembly. While further error correction activity may occur during subsequent testing, the assembly of the CPCEI is greatly facilitated by having corrector patches incorporated as an integral part of the components to which they apply. Although modification of CPC code may continue to occur through the stage of Adaptation, Installation and Checkout (Block A-22), the basic coding phase may be said to be complete when all CPCs have passed through the final clean-up assembly or compilation.

A-14. Initiate Computer Programming Test and Evaluation

This activity starts as soon as coding for the first logically discrete computer program routine is complete and continues throughout the entire computer program coding phase. Objectives are to validate the integrity of the code with respect to decision making, computation, and non-arithmetic data processing, and to determine the ability of the various CPCs, when assembled, to communicate with each other, to operate as a unit, and to correctly process system inputs and produce system outputs.

Computer programming test and evaluation progressively encompasses three distinct levels of testing. Although, ideally, the requirements of one level of testing should be completely satisfied before proceeding to the next higher level, in practice this never occurs. As a result, activities at lower levels are iterated as the results of the tests dictate.

The lowest level of this activity is a subprogram testing. This type of testing is performed upon computer program components, or perhaps on parts of CPCs when the parts are logically independent. Its objectives are to determine that each subprogram (or part thereof): interprets its inputs correctly; performs correctly all functions assigned to it by the design specifications; and adheres to all conventions, restrictions, and limitations explicitly or implicitly defined in the design of the computer program. Subprogram testing deals with numerous details and demands punctilious validation of each detail. Each mathematical function must be tested for accuracy, using arguments not only in the middle range but also at both ends of the spectrum of values. Each major decision point and as many minor decision points as possible must be examined for logical correctness.

There exist two immediate prerequisites to subprogram testing. One of these is successful assembly or compilation of the source subprogram assuring the technical accuracy of the code. The other is visual examination of the source subprogram assuring elimination of the more obvious logical errors. The actual testing is an iterative process, for several reasons. The variety of logical paths which a subprogram may take cannot be tested in one pass. Threshold values that might be introduced are usually mutually exclusive. Each error discovered and corrected requires a test re-run.

Inputs to subprogram testing are simulated. This means that the values which are used as inputs for subprogram testing are determined by the programmer and are inserted by means of a utility tool. The values that are selected should be representative of the total range of values and conditions which the subprogram is designed to process. Utility tools must be available to: insert data; record test outputs; reduce test outputs to a form amenable to analysis; and to produce hard copy printouts. For each test that is run, the programmer must have prepared in advance a set of expected results. The actual results obtained by recording subprogram outputs are then compared with expected results. Differences that exist indicate subprogram errors. The cause of the errors must be isolated, corrections made, and the test re-run.

If no differences exist, it can be assumed that the subprogram is error free.

The second level of this activity is functional area testing. This type of testing is performed upon a set of one or more CPCs implementing a total system task. The objective of this activity is to determine that: inputs to the system task are being correctly interpreted; communications from and to the various CPCs relative to the task are being correctly generated and interpreted; and that functional area outputs are being correctly generated.

Functional area testing generally requires interaction with the computer system control program. In a sense, subprogram testing of the system control program may be considered as taking place simultaneously with functional area testing. Analysis of test results must always consider this duality, and error results must look to both areas for solution.

System tasks interface with hardware and/or other system tasks. Inputs to functional area testing are simulated,in the sense that they are programmer determined and inserted by means of a utility tool. Inputs must be varied sufficiently to exercise the system task to produce every class of output, including outputs due to equipment, operator, and program malfunction. The preparation, conduct, and anlaysis of functional area testing is generally a cooperative effort, since many computer programs (and programmers) are usually involved.

As in subprogram testing the availability of utility tools to insert data and to record, reduce, and list outputs is essential. A set of expected results must have been prepared in advance for comparison with actual results. Errors are relatively easy to discern, but determination of the error cause may be elusive. This is due to the possibility that the error may exist in either inter-program interface, control program action, or action of one or more of the computer programs constituting the functional area. A reversion to subprogram testing may be necessary in order to isolate the error before a re-run of the functional area test is possible.

The highest level of this activity is computer program system testing. This type of testing is performed upon a program system, comprised of many programs acting in concert to fulfill system goals. The objective of this level of testing is to determine that the programs operate as a unit in interpreting system inputs and producing system outputs. This level of testing lays emphasis on: communications between functional areas; computer system outputs; and the exercising of system capacities and limits.

System inputs are simulated and inserted by means of a utility tool. The availability of utility tools to perform the function and to reduce and list system outputs and functional area communications is assumed. Errors discovered in this level of testing may cause reversion to functional area testing, or even subprogram testing. This level of testing requires a high degree of planning, coordination, and direction because of the many functions to be tested and the numbers of personnel involved both in the design of the inputs and analysis of outputs.

This total activity begins after the Critical Design Review and, although always a step behind, proceeds concurrently with the coding activity. It requires the availability of a computer and associated input/output equipment (tape units, card reader, printer, and possibly operator consoles), as well as utility computer programs to perform the functions of assembly or compilation, read-in, data insertion, recording, data reduction, and listing.

A-15. Prepare Preliminary Qualification Test (PQT) Procedures

This activity results in specifying the detailed procedures to be followed in conducting a particular test or set of tests that are scheduled for the purpose of implementing selected portions of the Category I Test Plan (Block A-9). Its objectives are to produce the documentation that controls the conduct of the tests, establish schedules, and specify all requirements. It also provides the essential basis for PQT reports (Block A-21). The Category I Test Plan upon which the individual Category I PQT procedures are based typically contains plans for a series of PQTs and a Formal Qualification Test (FQT). A Category I Test Procedures document that is prepared in advance of each of these scheduled tests specifies the specific test objective, test inputs, expected outputs, test result analysis methods, manning requirements, event sequence, and other detailed procedures for conducting the test.

Prior to conducting a PQT (Block A-19), a Test Procedures document is prepared by the contractor and submitted to the procuring agency sufficiently in advance of the scheduled test for review.

The format and content of a typical Test Procedures document are specified in the applicable data item to cover such information as the following:

(1) The location and schedule for the test, including pre-test briefings and post-test debriefings and data analysis/reduction.

(2) Applicable reference documents such as Category I Test Plan, CEI Detail Specifications, and user documentation.

(3) Requirements and responsibilities for console operators, test directors, technical consultants, and other essential test personnel.

(4) Requirements for computer programs other than the CEI being tested, and for equipment necessary to support the test.

(5) Procedures for operating the computer program to be tested, including the following:

(a) Procedures required to read the program into the computer, establish the required mode, establish initial conditions, provide required inputs and outputs, and begin operation of the computer program. Listings of input material should be provided.

(b) Procedures required to maintain operation in those cases where operator intervention is required.

(c) Procedures for normal and unscheduled termination of program operation and restarting procedures.

(6) A detailed description of test inputs, events, and expected results related to specific test objectives, described in the order of occurrence.

(7) Requirements and procedures for reduction and analysis of test data, including a description of the data to be recorded, means of recording, and data reduction and analysis to be accomplished.

Scheduling of test procedure development must allow sufficient time for: selection, scripting, generation, and verification of test inputs; development of required recording forms and associated documentation (e.g., scripts); review, concurrence, and modification of the documents; scheduling and coordination of required supporting equipment, facilities, communication linkages, and personnel; and updating of materials to reflect results of prior tests, if required.

Applicable Data Item

T-103 Category I Test Plan/Procedures (Computer Programs)

Only the second part (Procedures) of the Form 9 applies to this item.

A-16. Update QQPRI

This activity is concerned with updating the preliminary QQPRI Report prepared during Definition Phase B (see Block D-33) to incorporate changes resulting from:

(1) System engineering synthesis conducted by the SPO during Definition Phase C, which may have altered equipments, computer programs, and their interfaces in such a manner as to alter the structure of duty positions and associated manual and man-machine tasks.

(2) Firm definition of the performance/design requirements for operator-associated equipments. The QQPRI Report prepared by the computer program contractor during Definition Phase would have been based in some instances on assumptions regarding system hardware rather than on firm specifications. The equipment specifications should be reviewed and analyzed as required to detail and expand all duty position descriptions and related operator tasks (see Block A-5), and the results of the analysis reflected in the updated QQPRI Report.

(3) Completion of the CPCEI Detail Specifications. Frequently it may not be possible to complete all portions of the CPCEI Detail Specification until after the Acquisition Phase contractors have been selected and firm specifications for the equipment are available. The completed CPCEI Detail Specification must be examined for possible impact on the duty positions and task descriptions as contained in the preliminary QQPRI Report.

(4) The development of the Exercise Problem Generating Capability (Block A-6) and the development of exercise procedures and guides (Block A-11). These activities will provide detailed information relative to requirements for personnel to prepare, conduct, and evaluate system exercises. Although the basic duty positions for these personnel would have been identified in the preliminary QQPRI Report, the additional information available at this time should be incorporated in the updated report.

Applicable Data Item

Q-103 Qualitative and Quantitative Personnel Requirements Information Part I: Field and Organization Maintenance

A-17. Initiate Preliminary Qualification Tests (PQTs)

Preliminary Qualification Tests (PQTs) are formal tests that are conducted by the contractor in accordance with approved Category I Test Plans (Block A-9) and Category I PQT procedures (Block A-15). PQTs are the means by which selected individual functions of a CPCEI are verified during the process of computer program design and development, prior to the availability of the complete CPCEI for formal qualification testing. Typically, PQTs consist of progressive tests of CPCs or sets of related CPCEI functions as they are developed, and again as they are integrated with other CPCs or functions. PQTs may be scheduled to be held in conjunction with CDR increments for the CPCs or CPCEI functions undergoing testing. In general, the activity should be designed to accomplish the following objectives:

(1) Provide the procuring agency with checkpoints for monitoring contractor progress in computer program development.

(2) Permit detailed verification of CPCEI functions that cannot be throughly validated during FQT due to depth of detail required.

(3) Allow detailed examination and evaluation of CPCEI interfaces with other CPCEIs.

(4) Serve as a demonstration that functions qualified with Test and Evaluation data are properly functioning.

(5) When combined with a CDR, assure design integrity of CPC or CPCEI functions as specified in Part I Detail Specifications.

(6) Permit detailed verification of adaptation parameters, system limits, and other critical values prior to utilization of live supporting equipments, and personnel, facilities, and communications.

(7) Allow an orderly transition from the testing of basic and elementary CPCEI functions to testing of the total CPCEI, to provide confidence that all requirements and quality assurance provisions specified in Sections 3 and 4 of the Part I Detail Specifications are satisfied.

PQTs are preliminary in the sense that they are not intended to serve the purpose of formal qualification of individual components. Formal qualification occurs later in the Acquisition Phase (Block A-24). CPCEI acceptance, which involves acceptance of the Part II Detail Specification as an accurate technical description of the CPCEI, occurs after FQT, at FACI (Block A-28). Since PQTs are preliminary tests, they are usually conducted at the contractor's design and development facilities and witnessed by the procuring agency. Prior to test conduct, Category I PQT Test Procedures are prepared and submitted for review by the procuring agency (Block A-15). Test Procedures documentation, in addition to specifying detailed operating instructions, event sequences,

required inputs, and other instructional material, also specify the test results that are expected or have been predicted. In order to insure that the computer programs satisfy the requirements of Part I Detail Specifications, the PQT expected/predicted results are identified in the Test Procedures and are directly related on a paragraph-by-paragraph basis to the performance/design requirements in Section 3 of the Part I Detail Specifications.

Initial PQTs are generally oriented towards verification of detailed CPC operations. Typical areas for verification include subprogram decision paths, branch points, and data dictionary usage. Also, detailed testing of timing constraints, storage space utilization as agreed to during PDRs, and subprogram interfaces is best accomplished during the conduct of initial PQTs. Test input values that are usually employed include minimums, maximums, zero conditions, points of discontinuity, system limits, selected illegals, and representative samples derived from known critical value permutations and combinations.

Simulated test inputs are required during PQT test conduct. In addition, test outputs must be recorded and reduced both during and following the tests. Therefore, test output and test input tools to be employed for these functions must be available. In most instances, if these tools are deliverable, they must be qualified prior to their employment in PQTs. In some instances, however, qualification of deliverable test tools may be inferred and demonstrated by their successful performance in testing other CPCEI functions.

It is desirable to conduct PQTs using equipment which is configured to meet requirements of the given system, to the extent feasible. However, it is normally necessary to initiate early PQTs with minimal (often, prototype) computer and peripheral equipment; or, equipment simulation may be necessary during the early part of Acquisition if a new computer, consoles, and associated items are undergoing a parallel design and development effort. In general, the scope and realism of testing may be progressively expanded as additional items of the operational equipment are made available for the purpose. Development of the required computer programs and the acquisition or provision of satisfactory substitute equipment for this task must be evaluated and trade-offs assessed within the framework of cost constraints, schedule implications, and satisfaction of PQT objectives.

It is to be expected that computer program and/or documentation errors will be encountered during the PQT activity. Agreement on the requirements to be satisfied and the procedures to be employed in correcting errors and testing corrections must be reflected in the appropriate Test Procedures documents.

A-18. Assemble CPCEI(s)

The purpose of this activity is to integrate individual CPCs into an assembled CPCEI which can then be subjected to higher levels of testing and qualification. The inputs to this phase are the coded and tested CPCs, including the data definition dictionary (A-14), along with a plan for assembly testing the CPCEI. The output is an assembled and tested CPCEI which should be ready for the Adaptation, Installation and Checkout (AI&C) activity described below (Block A-22). In order to complete this phase, the following tasks must be accomplished:

(1) Collect and assemble all CPCs which are to comprise the CPCEI. If a machine language encoded data definition dictionary is a part of the CPCEI, it is included in this assembly. The assembly consists of loading all components onto a common peripheral storage device such as a magnetic tape. It is usually performed in increments as CPCs which have passed PQT become available. An exception to this is the data definition dictionary which is normally loaded with the initial assembly but may be recompiled and reloaded as new requirements arise from the CPC code activity performed in Block A-14.

(2) Determine that all corrector patches produced in Block A-14 which have not been incorporated with individual CPCs are added to the assembly described in (1) above.

(3) Assembly test all functions related to program areas associated with interfaces between CPCs to determine that thes areas have been correctly matched.

(4) Assembly test all facility and input/output functions associated with the CPCEI to assure compatibility with available equipment and to assure that such functions are performed correctly. As these functions are critical to techniques used to assemble and modify the CPCEI, their test and correction should receive first priority.

(5) Add correctors or recompilations of CPCs which are developed to correct errors discovered in the assembly test activity as these become available for the base CPCEI developed in (1) above.

(6) Establish and maintain an up-to-date file of CPC and data base inputs used to produce the assembled CPCEI along with duplicate back-up copies of the CPCEI. This provides for recovery from situations in which the CPCEI working assembly used in the assembly test activity is lost or damaged.

(7) Record all changes made to the CPCEI logical design which are made during this phase for use in the completion of CPCEI Part II Specifications.

CPCEIs which are to be used for the support and development of other CPCEIs will be assembled earliest. These include such things as compilers, assemblers, generators of simulated inputs, and data reduction tools. However, certain

functions of these tools cannot be completely tested until the programs which they support have been assembled. A reduction in the size of such untested areas is normally accomplished by developing special test programs which simulate interfaces internal to the CPCEI. These tools are developed by the contractor as items whcih are not necessarily part of the CPCEI. Their use is not intended to obviate the need for testing with real inputs, but to reduce the probability of unnecessary delay in discovering critical errors.

A-19. Prepare Preliminary Qualification Test (PQT) Reports

Following the conduct of each Category I Preliminary Qualification Test, the contractor describes the test results in a Category I Test Report. This report should be written to satisfy the following procuring agency requirements:

(1) Identification of planned test objectives specified in the related Test Procedure for which test results were identical with the expected results, or for which variations between actual and expected results were within tolerances.

(2) Identification of planned test objectives for which actual test results differed from expected results.

(3) Identification of planned test objectives for which actual results were not obtained, including associated causative explanations.

(4) Recommendations for subsequent action based upon the identified test results.

Test result materials, including such items as computer and teletype printouts, completed switch action checklists, display verification sheets, and other materials required for test result verification are included in PQT Test Reports. Inclusion of detailed test result materials in the PQT Test Reports permits:

(1) Valid and meaningful assessments to be made by the procuring agency of both the conduct of the test and the contractor's recommendations for subsequent action based upon the results of the test.

(2) Verification that the PQT was conducted in accordance with contractor prepared and procuring agency approved Test Plans and Test Procedures.

(3) Coordination with other affected agencies and contractors, if required, to be effectively initiated, and detailed information regarding problem areas and recommended solutions to be properly disseminated.

(4) Addition of meaningful and required information to the contractor's documentation and data files.

Applicable Data Item

T-118 Category I Test Report (Computer Programs).

The approved format for a Category I Test Report is normally used for both PQTs and the FQT. Standard content to be covered includes the following:

(1) Identification of the CPCEI to which the Test Report applies.

(2) Identification of the portions of the associated Test Procedures to which the Test Report applies.

(3) The primary function(s) of the conducted test.

(4) Reference to both the applicable Test Plan and Test Procedures.

(5) A complete description of the test results specifying satisfied objectives, problem areas, and failures to obtain any results. In instances when actual test results either differed from expected results or no results were obtained, reasons for the discrepancies derived from analytical processes must be stated. In addition, the analytical methods, techniques, and tools employed should be specified.

(6) Recommendations for subsequent action based upon the reported test results. Such recommendations may include, but are not limited to:

(a) Revising the computer program code.

(b) Revising the Part I Detail Specification.

(c) Conducting additional tests.

(d) Qualifying those functions for which test objectives were fulfilled.

References

AFSCM 375-4, Part I, Chap. 4, Block 18c

AFSCM 375-4/ESD Sup 1, Part I, Chap. 4, Blocks 18d and 21

A-20. Specify Initial Exercising Problem(s)

This activity is concerned with specifying the exercise problem(s) to be used during the Category II test program and/or initial exercising of operational sites. Although the SPO has primary responsibility for the activity, the contractor responsible for the development of the system exercising capability and the production of exercise problem materials should be an active participant.

The activity should accomplish the following:

(1) Identify the primary mission of the problem and define specific objectives and overall design concept.

(2) Identify the simulated data that must be generated to satisfy problem requirements. Types of input information necessary to generate the simulated data should be defined and sources identified.

(3) Select from the alternatives available the means of inputting the simulated data. Where multiple input means are selected, the simulated data should be specifically allocated to each.

(4) Identify and describe the training aids and support items that must be generated.

(5) Prepare a schedule of significant events such as information gathering, dates of delivery, etc., and identify the organization(s) responsible for each event.

Applicable Data Items

ESD-295 System Exercising Problem Agreements Document.

This Data Item is a formal record of the agreements reached between the procuring agency and the contractor responsible for producing the exercising problem material. It provides the basis for designing the exercise problem and related material.

Q-121 System Exercising Problem Package.

This Data Item lists and describes the various types of material which could be included in any given exercise problem package. Although specifically oriented toward problem packages for air defense systems, it might also be adapted by suitable back-up sheets to define the contents of a problem exercise package for other types of systems.

A-21. Prepare Formal Qualification Test (FQT) Proceudres

This activity is initiated by the contractor following the preparation of the Category I Test Plan (Block A-9) that establishes the basis for preparation of Category I Test Procedures for both preliminary and formal qualification of the computer program design requirements specified in paragraph 3 of the Part I Detail Specifications. The content of the FQT Procedures document resulting from this activity specifies such information as the specific test objectives, test inputs, expected outputs, test result analysis methods, manning requirements, event sequences, and procedures to be followed in solving problem areas, e.g., contingency plans. Thus, FQT Proceudres, when completed, serve the primary purposes of ensuring effective control of the FQT, establishing schedules for the FQT and all related activities, and providing the basis for the Category I Test Final Report (Block A-25).

FQT Procedures are prepared and submitted initially in preliminary form, since approval by the procuring agency is normally required. Review and analysis of the preliminary documentation may result in proposed changes that must be resolved and reflected in revisions prior to formal submission of the FQT Procedures. Therefore, sufficient time must be allotted (e.g., three months prior to the scheduled FQT) for this process to be completed, including necessary time for: selection, scripting, generation, and verification of test inputs; development of required recording forms and scripts; scheduling and coordination of required supporting equipment, facilities, communication ties, and personnel; and updating of materials as a result of prior tests.

Applicable Data Item

T-103 Category I Test Plan/Procedures (Computer Programs).

Only Section 2, Test Procedures, of the Form 9 applies to this item. The documents should cover the following items:

(1) The location and schedule for the test, including pre-test briefings and post-test debriefings.

(2) Applicable reference documents, such as the Category I Test Plan, Part I Detail Specifications, and user documentation.

(3) Requirements and responsibilities of console operators, test directors, technical consultants, or other essential test personnel.

(4) Requirements for equipment necessary to support the test.

(5) Procedures for operating the computer programs to be tested.

(6) A detailed description of test inputs, events, and expected results. This description should be related to specific test objectives in the order of occurrence.

(7) Requirements and procedures for reduction and analysis of test data, including a description of the data to be recorded, means of recording, and data reduction and analysis to be accomplished.

A-22. Accomplish CPCEI Adaptation, Installation, and Checkout (AI&C)

The activities of adaptation, installation, and checkout of CPCEI(s) should occur in accordance with an approved plan. This activity is normally performed following I&C of the computer and associated equipment (Block A-24). At the Category II Test site, this activity will be accomplished by the computer programming contractor, following which Formal Qualification Test of the CPCEI(s) will occur prior to the initiation of Category II Test.

Prerequisite to the task of adaptation to be accomplished at this time is the availability of data base elements describing the natural environment of the Category II site which had been collected and compiled earlier in the Acquisition Phase (Block A-8). These data must be encoded into a form which can be recognized by the CPCEI(s) in order to permit the tasks of installation and checkout to proceed. For CPCEIs which will undergo frequent or extensive changes to this data base, a supporting computer program which accomplishes the task of encoding may be a requirement, in which case it should be available at this time. Where such a computer program is not available, encoding the data must be done in accordance with prior documented directions which explain item and table structure, scaling, and the processes to be followed. The data must then be assembled or compiled into the CPCEI to which they apply and then verified. Verification of the data is accomplished as part of the installation and checkout.

Upon completion of the adaptation task, installation and checkout are accomplished employing the CPCEI(s), the computer and peripheral equipment, and other associated equipment of the system. Checkout tests make use of simulated inputs and live inputs; the degree to which the latter can be used will be predicated upon the availability of associated equipments (e.g., radar ties).

Although AI&C is a contractor responsibility, assistance in the conduct of tests may be rendered by personnel of the using command that are available at this time. Emphasis is placed on checking out the compatibility of the CPCEI(s) with the computer and other interfacing equipments.

Functions which must be considered include the following:

(1) reading of the CPCEI(s) from the storage device (tape, disc, cards) to the computer operating element

(2) startup

(3) switchover where applicable

(4) tape maintenance functions

(5) representative switch actions

Checkout of the CPCEI(s) should exercise the supporting computer programs as well as the operational computer programs; many functions such as simulation, recording, data reduction, and others of the supporting computer programs can be checked out by their use in the checkout of the operational computer program.

During the course of this activity, problems may be revealed which cannot be readily ascribed to any particular source, that is, in many cases the determination of the origin of a problem can require extensive analysis of the computer program, the computer, and other equipments. In such instances, a means of coordinating efforts of experts in each of the component elements must be established, with the responsibilities of each participant clearly delineated under the direction of the site activation coordinator.

Implicit in this activity is the correction of errors in the CPCEI data base or computer program logic. Correction can be effected by means of a symbolic corrector where such capability exists, or by assembling or compiling the CPCEI to be corrected.

At subsequent sites, adaptation, installation, and checkout (Block A-33) will also follow the equipment I&C, and CPCEI tests emphasizing unique-to-site adapation differences will be accomplished prior to Implementation Tests.

A-23. Complete Part II CPCEI Detail Specification(s)

The purpose of the activity performed during this phase is to produce a completed set of CPCEI Part II Specifications for use in FACI. These specifications are completed in accordance with the specifications for format and content defined in ESD-237, Contract End Item Detail Specification (Computer Program), Part II. In order to complete this phase, the following tasks must be accomplished:

(1) A review and update, if necessary, of CPCEI design documentation to insure that it accurately reflects the organization and content of the computer program for the following areas:

(a) Data base storage allocation and item/table definition.

(b) Computer program flow charts.

(c) Timing and sequencing characteristics.

(d) CPC interface with other CPCs and with equipment.

(e) CPC limitations (external to those specified in the CPCEI Part I Specs).

(f) CPC relationship to functional allocations.

(g) CPCEI interface with other CPCEIs.

(2) A review and update of all CPCEI computer program listings to insure that all modifications required for error correction or approved design changes have been included.

(3) A review and update of all data base content descriptions for completeness and accuracy.

(4) Collection of a list of documents which are applicable to the CPCEI Part II Specifications and which form a part of these specifications.

(5) Preparation of descriptions of the relationship of CPCs to the CPCEI data base.

(6) Preparation, publication, and packaging of all CPCEI Part II Specification documentation specified in ESD-237.

(7) Review to insure conformance of the CPCEI Part II Specification to the CPCEI Part I Specification.

Normally, the Part II Specification must be completed and delivered sufficiently in advance of FACI, e.g., thirty days, to permit review and analysis by the procuring agency. Certain problems may be occasioned by this requirement which must be recognized and resolved through specific agreements relating to the detailed specification content at time of initial delivery, specification content at FACI, and content of the associated CPCEI at each of these times. As examples, pertinent considerations may include:

(1) Whether actual listings of instructions and data are included in the advance issue and, if so, whether or not error corrections and other interim changes (resulting, for example, from FQT) are to be incorporated in the FACI versions of both the CPCEI and its specification, etc.

(2) A cut-off date for incorporating changes resulting from previously approved ECPs to the Part I Specification. In some cases, the Part II Specification changes may not be scheduled for completion until after the product configuration baseline is to be established.

Applicable Data Item

ESD-237 Contract End Item Detail Specification (Computer Program), Part II.

A-24. Conduct Formal Qualification Test (FQT)

Formal Qualification Test (FQT) is a comprehensive performance test of the integrated CPCEI to verify compliance with requirements of the CPCEI Part I Detail Specification. FQTs are conducted by the contractor in accordance with the Category I Test Plan (Block A-9) and Category I FQT Procedures (Block A-23). The formal qualification of an operational CPCEI may normally be expected to require the use of operationally configured equipment which has successfully passed FACI. When the required capabilities are not available at an earlier time, the computer program FQT may be accomplished at the Category II test facility, following installation and checkout of system equipment.

The requirements to be qualified at FQT are identified in Section 4.1.3 of the Part I Specification. For a complex operational CPCEI, the duration and complexity of the FQT could be prohibitive unless the testing can be designed to emphasize CPCEI-level inputs, outputs, and interfaces, rather than detailed intermediate processing functions. This end can be achieved if earlier Preliminary Qualification Tests are comprehensive and successful in their coverage of the detailed intermediate functions, and if assurance exists that design integrity of the computer programs has been maintained during testing of successive CPCEI assembly levels. The utility computer programs that are used to incorporate error corrections, generate new assemblies, and, in general, modify computer programs after PQT, should, themselves, be initially qualified prior to such use.

While Preliminary Qualification Tests are primarily directed toward testing of detailed CPC or functional area intermediate functions (e.g., testing of subprogram decision paths, subprogram interfaces, processing of specific data items, and other similar levels of testing), Formal Qualification Tests are typically directed towards testing of:

(1) Points at which functional areas interchange data.

(2) Processing of CPCEI-level input messages received from external sources (both legal and illegal).

(3) Generation of CPCEI-level output messages.

(4) Integrated CPCEI system limits, capacities, and critical data item permutations and combinations.

(5) Critical timing factors and storage uses.

(6) Computer program sequencing and conditions for transferring internal data and computer programs.

(7) Interfaces with parallel operating computer programs.

A-25. Prepare Category I Test Final Report

This report serves the two purposes of (1) delineating results of the Formal Qualification Test and (2) summarizing results of the overall Category I test effort for the CPCEI.

In satisfying the requirements for reporting specific FQT results, the report should contain complete coverage of the following items:

(1) Planned test objectives which have been completely satisfied, through correspondence of actual test results with predictions contained in the FQT Test Procedures.

(2) Planned test objectives that were not satisfied due to differences between expected test results and test results actually obtained.

(3) Where discrepancies exist between planned and actual test methods or results, the report should contain analyses of causes and recommended solutions.

Since Formal Qualification Tests have as their primary objective qualification of the integrated computer program CEIs for Category II testing, an overall summary status report of the Category I testing activity should be included in the Category I Test Final Report. Typically, this information will consist of critical qualitative and quantitative test results and associated objectives that have a direct bearing on the Category II test effort, an accounting of all computer program modifications required prior to initiating Category II testing, a summary of the Category I testing effort with particular attention given to test objectives requiring detailed verification during the Category II test effort, and an up-to-date status of the computer programs, including all information relative to the ability of the subsystem to meet the operational requirements of the System Performance/Design Requirements General Specification.

As with PQT Reports (Block A-21), all pertinent FQT test result materials, including such items as computer and teletype printouts, completed switch action checklists, and display verification sheets, are included in the Category I Test Final Report. When properly prepared, the report will normally be used to serve the following functions:

(1) Permit the SPO to make valid and meaningful assessments of FQT conduct and results, in relation to approved Test Plans and Procedures.

(2) Provide an adequate basis for assessing problem areas and recommended solutions.

(3) Disseminate significant test information to participating contractors and government agencies.

(4) Provide a record of test methods and experiences for the contractor's subsequent use, as well as for general dissemination to the DoD technical and scientific community (see comment under Data Item S-17 below).

Applicable Data Items

T-118 Category I Test Report (Computer Programs)

Requirements include the following:

(1) Identification of the CPCEI to which the Test Report applies.

(2) Identification of associated Test Plan/Procedures and specific test objectives.

(3) Primary functions of the tests.

(4) Complete description of test results.

(5) Summary and status report of the Category I test effort.

(6) Recommended actions based on test results.

S-17-12.0-1 Technical Report

This data item sets forth specific requirements associated with the preparation of all reports to be submitted to the Defense Documentation Center (DDC). Requirements typically apply to test reports.

References

AFSCM 375-4, Part I, Chapter 4, Block 18c.

AFSCM 375-4/ESD Supplement 1, Chapter 4, Block 18d.

A-26. Issue Preliminary Handbooks and Manuals

The operator procedures developed during the Definition Phase (see Block D-29) and updated and refined throughout the Acquisition Phase (see Blocks A-5, A-11, and A-16) are formally documented in the form of Position Handbooks, Users Manuals, and Exercising Capability Manuals and Guides. The preliminary copies prepared at this time will be used and verified during Category II and subsequently reissued for operational use.

Positional Handbooks

A Positional Handbook should be prepared for each type of operator position in the system, and should provide all information necessary for performance of that position. Although designed primarily as a complete reference document to supplement on-the-job training and cross-training, it is also suitable for use as a basic text for initial operator training.

In electronic systems, the handbooks must typically meet the needs of operating console stations having computer-generated displays, manual switch actions, and external communications capabilities. To be complete as a basic reference the handbook should include the following types of information:

(1) A comprehensive description of the position including positional responsibilities and duties, knowledge and capabilities required of the operator, and an indication of where the position exists in the organizational structure, i.e., personnel to whom the operator is directly responsible and personnel directly in his charge.

(2) Detailed procedures to be followed in accomplishing each task assigned to the position. Alternate procedures should be present where applicable and any special emergencies procedures detailed. Procedural steps should be ordered sequentially as they will be performed, and information presented explaining why the action is taken and expected results. Factors that should be considered prior to taking any action should be explained.

(3) Content, format, and interpretation of all displays available to the position should be presented. Limits, tolerances, and capacities of each informational element displayed should be identified, including where appropriate, the rate or frequency of updating.

(4) All switch actions available to the positon should be listed and described in terms of what the system does in response to the action and how it does it.

Operator Training Guides

An operator training guide should be prepared for each major system function. Examples of such functions in air defense are: weapons commitment and control,

air surveillance, manual inputs, real-time simulation, etc. As a manual for training of system operators, including command or supervisory personnel, the guide should present a systematic delineation of the (1) inputs to the function, (2) data processing of the information, including operator-machine interaction, and (3) outputs from the function.

The guide should be organized into chapters dealing with subfunctions and contain such information as the following:

(1) General description of the purpose, logic or objective of the subfunction and its operational significance. Describes the kinds of data being input for processing and the source from which it is derived.

(2) Description of the automatic/operator-assisted processing of the inputs by the computer program. Describes the switch actions and displays available for operators and the logic underlying their design and usage. Describes operator responsibilities under various modes of operation.

(3) Relationship of the subfunction to major functions and/or total system operation. Includes a description of data outputs, especially those involving system interfaces.

The operator training guides are oriented to functions and so may cut across positional duty assignments. As a basic text for operator training, guides should emphasize wherever possible the concepts and logic underlying design and operation with respect to each function.

Computer Program Users Manual

Users Manuals are intended to provide service and contractor personnel with the necessary instructions concerning usage of a computer program. They should contain the following types of information:

(1) A definition of required inputs including purpose, use, input media, limitations/restrictions, format and content, sequencing, and relationship to output.

(2) A description of the results to be expected after computer program operation including the form on which results will appear, the output format and content, limitations/restrictions, and relationship to inputs.

(3) Step-by-step procedures required to:

(a) Initiate the Computer Program, including reading the program into the computer, establishing mode of operation, setting initial conditions (parameters), and beginning operation.

(b) Maintain computer program operation in those cases requiring operator intervention.

(c) Terminate and restart the computer program for normal and unscheduled interrupts.

System Exercising Capability Manuals and Guides

System exercising manuals and guides are required to describe the exercising capability and manner in which it should be used. Typically the following documents will be produced:

(1) Exercise Conduct Manual--contains detailed procedures for exercise planning, preparation, conduct, and uses for operational readiness training.

(2) Evaluation Manual--describes techniques, specific objectives and criteria, data reduction and evaluation methods, and planning procedures for system/subsystem evaluation exercises.

(3) Synthetic Inputs Operator Guide--specifies duties, responsibilities, and procedures for simulation personnel during the conduct of exercise missions.

Applicable Data Items

ESD-178	Positional Handbooks--Information System Operational Personnel
ESD-290	Users Manual (Computer Program)
Q-125	Exercise Conduct Manual
Q-124	Evaluation Manual (Information System Exercising Personnel)
Q-123	Synthetic Inputs Operator Guide

A-27. Complete Initial Exercising Problem Package(s)

The initial exercising problems specified in the activity described in Block A-20 must be completed by this time for use at FACI of the computer program (Block A-28) and the Category II test program.

The contents of problem packages will vary widely depending upon the type of system involved, and within a particular type of system depending upon the purpose of a specific exercise. For systems whose primary function is to present summarized data to command personnel, for example, the exercise package might consist of a series of scripts containing summary information whose sequence of presentation would be dynamically related to the decisions and actions taken by the user during the exercise. For real time command and control systems involving multiple sensor inputs, complex data processing, and personnel intervention and control of a variety of effector mechanisms, the problem package will have more complex and diverse content. The problem package for an air defense system such as SAGE provides a good example. Typically it will contain a set of correlated material designed for a particular operational air defense situation. The material providing the simulated radar inputs to the system is of major importance; this may be provided in the form of film and/or magnetic tape. Other problem aids are correlated with the radar inputs and simulate other inputs normally received by the system such as flight plans, intelligence reports, and tell messages. Some of these inputs are routed through regular operational channels; however, where this is impractical, a script may be utilized in simulating parts of the system. Still other materials cite the objectives of the problem, provide an overall description of the problem, and provide detailed descriptions of each flight included in the problem. These materials are reference aids for use prior to the exercise for planning and briefings; they are used during the exercise for monitoring, coordinating and reporting, and after the exercise for debriefing and interpreting the results. An actual problem package for an air defense system exercise might contain any or all of the following:

(1) Films--contain radar target data generated for each radar site participating in an exercise, with the data specifically oriented to each participating site. Special equipment is required at sites to convert the data on film into a form suitable for processing by operational equipment.

(2) Magnetic Tapes--provide simulated data which, when processed by the operational computer programs, produce a simulated air picture.

(3) Maps--provide pictorial representatives of:

(a) the threat contained in the problem at succesive intervals of problem time;

(b) flight information on each flight in the problem, including flight path, special events along the flight path, when in radar coverage, etc.;

(c) position and heading of each flight in a particular geographic area at specified times in the problem;

(d) the air picture as it exists during each 15, 20, or 30 minute interval of problem time.

(4) Map Overlays--provide pictorial representation of air defense data which do not vary from problem to problem, such as division boundaries, etc.

(5) Tell Aids--provide time ordered information relating to threats/tracks which would normally be transmitted to exercising sites and received under actual operating conditions but which will be simulated for the purposes of the exercise.

(6) Flight Plan Aids--provide the basis for the generation of simulated flight plan information.

(7) Jamming Aids--provide a time and/or flight ordered listing of jammer flights defining the start and end time, intensity, and direction of the jammer with respect to each site (for use with films containing jamming targets)

(8) Flight History List--provides a time-ordered description of each flight, including a time-ordered sequence of events along the flight path.

(9) Height Input Script--provides altitude and location information for flights, and location information for chaff and noise in the surveillance area of each site.

(10) Problem Description--provides both generalized and specific information on the problem objectives and problem content.

(11) Reference Aids--provide a source of data which simulation personnel can refer to during an exercise to develop simulated inputs.

(12) Recording Forms--provide a set of pre-printed forms used to aid in the running of the exercise, recording of results, etc.

Applicable Data Item

Q-121 System Exercising Problem Package

This Data Item lists and describes the various types of material which could be included in any given exercise problem package. Although specifically oriented toward problem packages for air defense systems, it might be used with suitable back-up sheets to define the contents of a problem exercise package for other types of systems.

A-28. Conduct First Article Configuration Inspection (FACI)

First Article Configuration Inspection is a formal technical review and inspection conducted by the SPO. The primary product of the FACI is formal acceptance by the procuring agency of the Part II Detail Specification as an audited and approved document. Successful completion of FACI establishes the Part II Specification as the Product Configuration Baseline for the CEI. This action also normally results in the introduction of formal change procedures at that level.

Since no production lead time is required for Category II test or operational inventory, the completion of FACI for a computer program may not be required until late in the acquisition phase. For a complex operational computer program, in particular, FACI should occur as late in the Acquisition Phase as feasible, provided that it be completed prior to acceptance of the item for Category II testing. Thus, it will normally occur for such CPCEIs following installation and checkout, formal qualification, and completion of the Part II Specification.

Procedures for the control of computer program changes, specification maintenance, and accounting are currently described in ESD Exhibit EST-1, May 1966, Exhibit IX Addendum. Following FACI, these procedures will continue to apply to the processing of changes to both Part I and II of the CEI Specification.

Applicable Data Item

ESD-289 Minutes of Formal Reviews and Inspections

References

AFSCM 375-1, Exhibit XIV

ESD Exhibit EST-3, Chapter 5

A-29. Support Conduct of Category II Test

Category II testing is accomplished under Air Force direction, using the integrated system in as near the operational environment as feasible. In the case of an information system, it is normally accomplished following installation at the operational site or, for a multi-site system, at the first site installed. Primary objectives are to assure that the system meets requirements specified in the RAD, System Specification, and Part I Detail Specification for CEIs.

The initiation of tests at this time will have been preceded by the completion of a comprehensive Category II Test Plan and approved Category II Test Procedures documentation. Together, these documents define the objectives, environment, methods, instrumentation, locations, dates, conditions, specific operations, criteria, and requirements for subsequent reporting. Specific activities completed at the Category II site for an information system will have included the installation and checkout of equipment, the adaptation, installation, and checkout of computer programs (Block A-22), and the formal qualification testing of operational computer programs (Block A-24).

In general, system engineering support of the test activities consists of participation in the analysis and evaluation of test results and in resolving technical problems encountered. Reliance is normally placed on continued support in these areas by Acquisition Phase contractors throughout the Category II period. In the computer programming system segment, emphasis is required on completing the qualification of computer programs with respect to conditions not previously available, e.g., live inputs and trained operating personnel, as well as on continued support to the Test Force in diagnosing malfunctions, devising solutions to difficulties which jointly involve computer programs, equipment, personnel, and procedures, and formulating figures of merit for subsequent use in Implementation Testing (Block A-31).

A-30. Accomplish CPCEI Adaptation, Installation, and Checkout (AI&C) at Subsequent Sites

Multi-site systems are normally activated on a site-by-site basis, incrementally, following the initiation and conduct of Category II testing at the first site installation. While the Category II testing may not be fully complete in all cases prior to the beginning of installations at subsequent site locations, it should have progressed sufficiently to provide necessary procedures and criteria for Implementation Tests and to complete the qualification of CEIs.

In general, it is assumed that CPCEIs will have been fully qualified by this time. The Part II CPCEI Specifications will have been established as product configuration baselines, including adaptation data for all sites. Hence, the AI&C activity at this time should be relatively routine, in comparison with AI&C at the Category II site, to the extent that the earlier objectives were successfully accomplished.

However, the encoded adaptation data for each site must be properly incorporated into the computer program, and verified for conformance with the Part II Specification data listings. Following insertion into the computer, performance tests are made to accomplish a number of purposes in preparation for initiating Implementation Tests. These tests, in part, provide further verification of equipment installation and operating condition, as well as verification that the computer program operates satisfactorily with the given site adaptation data.

When difficulties are encountered, their diagnosis may often involve the same types of complex analyses required during earlier Category II testing to determine causes and problem solutions. Discrepancies associated with adaptation, for example, may be caused by errors in the coding, errors in the specified data values, or by wrong settings of equipment limits and various other factors in the installation or functioning of equipment and data links at the site. Frequently, changes to the computer program prove to be the most feasible solutions to problems encountered.

The computer program checkout activity will normally continue until the system is ready for Implementation Tests (see Block A-31).

A-31. Support Conduct of Implementation Tests

Implementation Testing is accomplished only for multi-site electronic systems, at sites other than the site selected for Category II Test. Its primary purpose is to demonstrate to the using command that the production system as installed and equipped at each site is functionally complete and ready for operational use.

At each site, Implementation Tests are preceded by equipment installation and checkout, a period of Installation Testing (by GEEIA), and computer program adaptation, installation, and checkout (Block A-30). The types of tests/ demonstrations accomplished during the Implementation Test period are comparable to those of Category II, although generally less complex to the degree that problems exposed during Category II have been previously resolved. Continued system engineering support is also comparable, although normally at a reduced level. Typically, emphasis is placed on verifying (a) satisfactory performance of production-run equipment elements, (b) operation of live communications links, and (c) the accuracy of adaptation data values incorporated in the operational computer programs.

Figure 4 - Acquisition Process

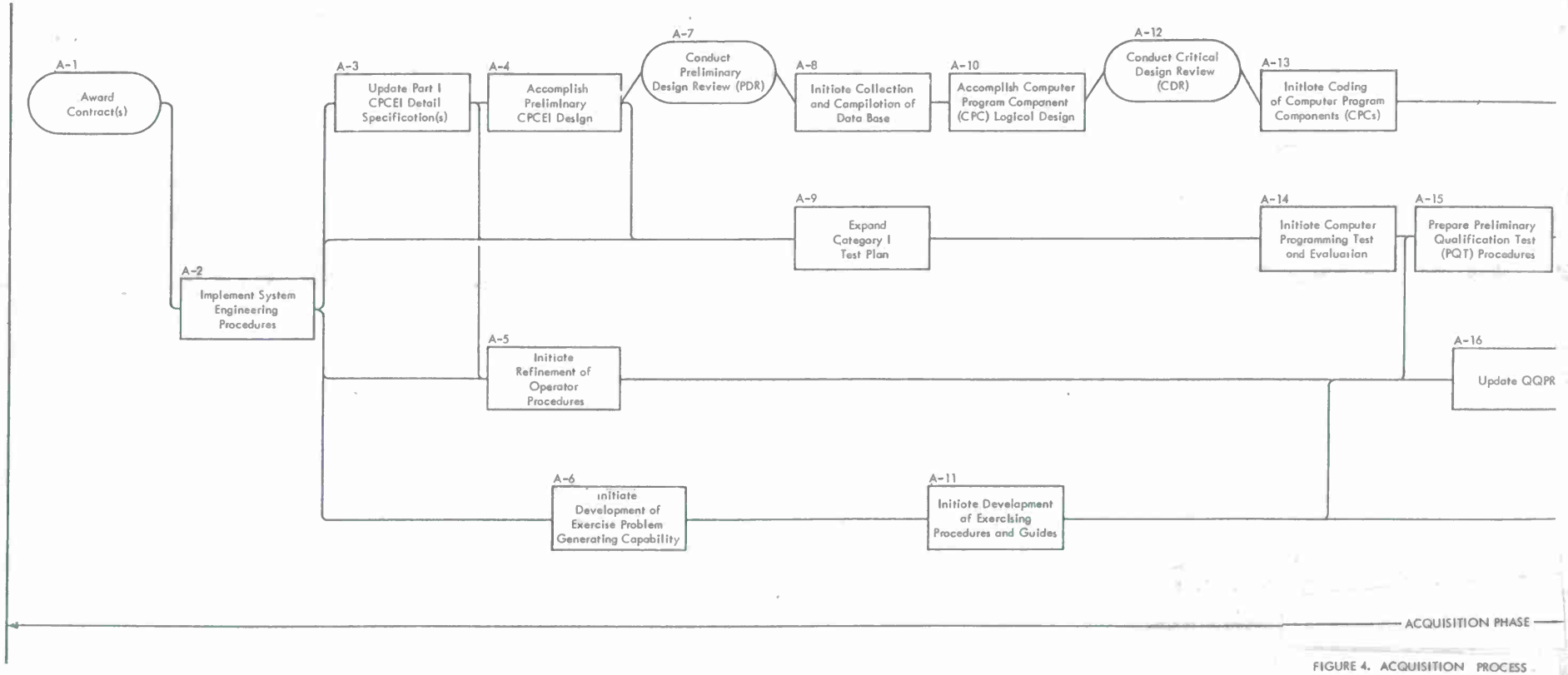

FIGURE 4. ACQUISITION PROCESS

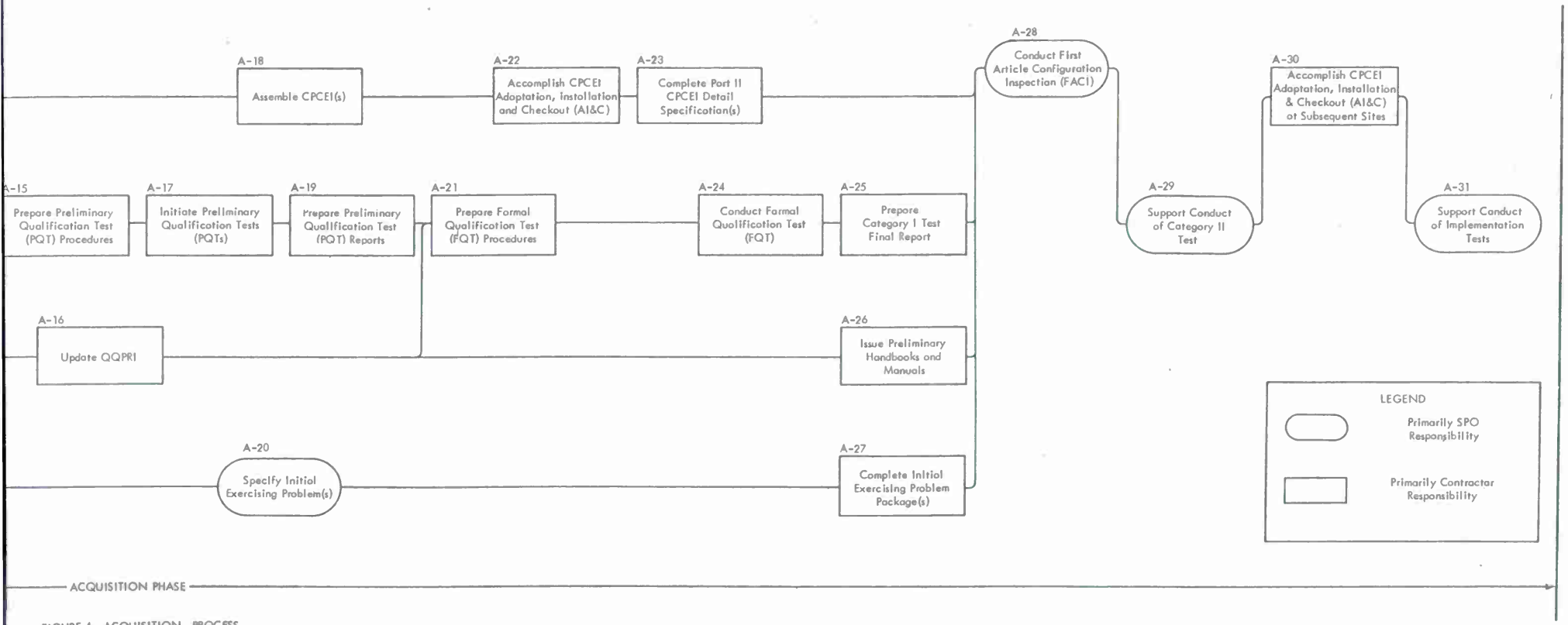

FIGURE 4. ACQUISITION PROCESS

CHAPTER V OPERATIONAL PHASE

A. GENERAL

While the Operational Phase begins when a using command accepts the first operational unit, the Acquisition Phase continues until such time as the full operational responsibility for the system has been transferred to the user and the SPO has completed the delivery of updating changes resulting from Category II testing. Thus, there is often an extended period of transition, during which engineering, logistic, and operational responsibilities are assumed on an incremental basis by AFLC and a using command. Events described under Blocks A-30 and A-31 of the preceding chapter, which occur mostly during this transition period, represent normal continuations of SPO Acquisition Phase responsibilities for the system development.

Engineering and logistic support responsibilities for system equipment are transitioned from AFSC to AFLC. Subsequent modifications are accomplished within the scope of AFLC engineering, except for major changes (Class IVB or V modifications as defined by AFR 57-4) which require support by an AFSC SPO. When so directed by Hq USAF, major changes are accomplished under the requirements of AFR 375-1. In these cases, the technical procedures and documentation requirements of AFSCM 375-5 may be applied in essentially the same way as in earlier phases of the system life-cycle. To the degree that information processing elements are involved in Class IVB or Class V modifications, they are also included among the system engineering responsibilities of the AFSC SPO.

"Engineering responsibility", as currently defined in AFR 57-4 and other regulations, does not explicitly encompass the development and/or operational support of computer programs. In many operational information processing systems, corrective actions and incremental improvements of operational capabilities are accomplished on a continuing basis by changes to the computer programs. Within the constraints of existing digital computing equipment configuration in a system, the changes which can be made range in magnitude from simple error corrections to extensive additions, deletions, and modifications in operating functions. Depending on magnitude and other factors, the changes may be accomplished on-site or centrally, by in-house ("Blue Suit") capability or contractor support, or by combinations of these. Definitions of standard classes of these changes comparable to the AFR 57-4 classes of system/equipment modifications do not currently exist. Nor are the Operational Phase responsibilities uniformly defined among AFLC, AFSC, and using commands. Hence, the minimum material contained in this chapter is essentially limited to a synopsis of the generalized system/equipment modification process which is outlined in Blocks 102 through 106 of AFSCM 375-5, Exhibit 1.

B. DIAGRAM OF THE OPERATIONAL PROCESS

The diagram for this phase depicts a highly generalized sequence of major milestones associated with significant system modifications. The sequence may occur, initially, during the period of overlap between Acquisition and Operational Phases, and may be iterated for successive major modifications throughout the operational life of the system.

C. NARRATIVES

O-1. Approved System/CEI Modification

User experience with the system during Category III testing and/or operational use may normally be expected to result in establishing requirements for system modification. Such modifications may be in the form of product improvement changes, or may be the result of new or modified operational requirements.

For information systems, three classes of modifications are often distinguished: (1) combined equipment and computer program changes, (2) equipment changes only, and (3) computer program changes only. All major modifications, which are identified in AFR 57-4 as Class IV or Class V changes, will typically be combined equipment/computer program changes and will require system engineering support by AFSC which will normally be identical to the support of previous changes to established baselines during the Acquisition Phase. These involve analyses to determine and define the total system impact, taking into account all elements of hardware, facilities, computer programs, personnel, and procedural data.

Computer program changes which do not involve hardware are typically numerous and frequent during the operational life of a system. Depending on the magnitude of the changes, they may require iteration of appropriate portions of analysis, design, and development efforts described in preceding chapters of this guide, taking account of impact on personnel and procedural data in the form of supporting handbooks and manuals.

O-2. Develop Follow-On Modifications

The development of follow-on modifications to the system requires the same sequence of events as previously outlined for the Acquisition process to the degree indicated by the nature and the magnitude of the modification. Special attention is required during the system engineering activities to develop data defining the development test requirements for the modification. Such testing may be necessary because of (1) significant changes in system capability or changes in system application not tested during Category I or II tests or (2) changes to correct system deficiencies for which test articles were not available during Category I and II tests.

O-3. Plan and Conduct Modification Testing

The system engineering activity should support planning, conduct, and analysis of testing at both CEI and system levels as appropriate to the modification. This support should include (1) review of the test plans and procedures for compatibility with the development test requirements described in Block O-2 preceeding, (2) identification and resolution of problems arising during test conduct and (3) test result evaluation to assure that performance and design requirement compliance has been demonstrated.

0-4. Update System and CEI Specifications

Configuration management data affected by engineering changes required to accomplish a Class IVB or V modification program are managed by the SPO configuration management division. AFSCM 375-1 Exhibits VII and IX apply to changes in specifications for equipment CEIs, and Exhibits VII and VIII to the System Specification.

In the case of computer program CEIs, continued maintenance of the Part I Specifications is a normal requirement throughout the life of the system. All changes managed by the SPO, for both Part I and Part II CPCEI Specifications and associated items of procedural data, are accomplished in accordance with Exhibits IX, XX, and XXI of ESD Exhibit EST-1. (In the 1967 revision of AFSCM 375-1 which is currently in preparation, the corresponding requirements will be contained in Exhibits IX, XX, and VII.)

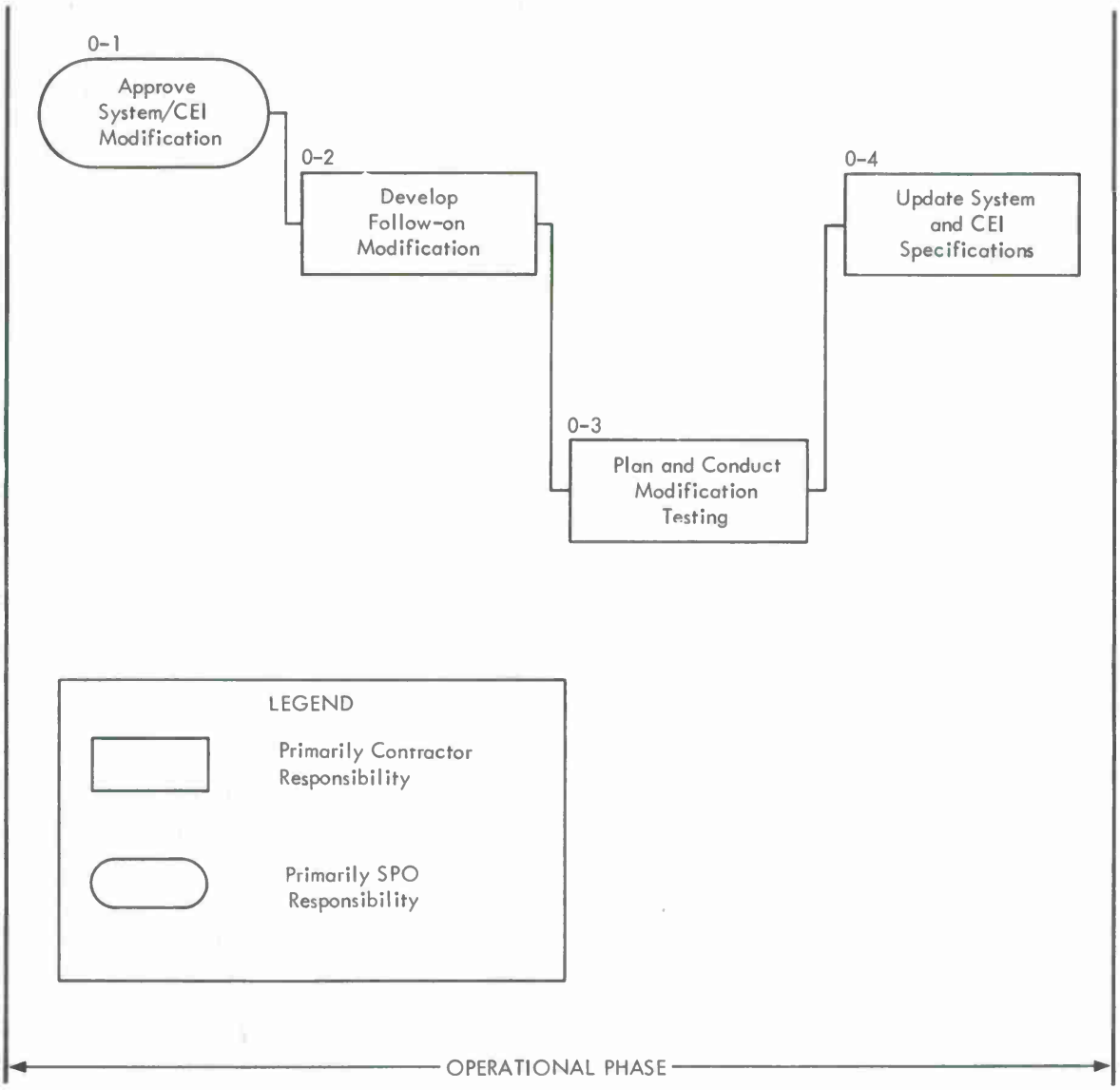

FIGURE 5. OPERATIONAL PROCESS

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Technical Requirements and Standards Office Electronic Systems Division, L G Hanscom Field Bedford, Massachusetts 01730	UNCLASSIFIED
	2b. GROUP N/A

3. REPORT TITLE

SYSTEM ENGINEERING GUIDE FOR COMPUTER PROGRAMS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

None

5. AUTHOR(S) (First name, middle initial, last name)

Lloyd V. Searle
Robert L. Henderson

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1968	157	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
AF19628-67-C-0128	
b. PROJECT NO. AFSC 2801 and 6917	System Development Corporation TM-3596, 15 Aug 1967
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale, its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Electronic Systems Division L G Hanscom Field Bedford, Mass. 01730

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DD FORM 1 NOV 65 1473

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
System Engineering Management						
Computer Program Management						
Computer Program Design						
Design of Computer Programs						
Engineering Management of Computer Programs						
System Life Cycle of Computer Programs						
Software Design Process						
Integration of Hardware and Software						
Total System Design						

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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Technical Requirements and Standards Office
Electronic Systems Division, L G Hanscom Field
Bedford, Massachusetts 01730

2a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

2b. GROUP
N/A

3. REPORT TITLE
SYSTEM ENGINEERING GUIDE FOR INFORMATION PROCESSING ELEMENTS OF ELECTRONIC SYSTEMS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
None

5. AUTHOR(S) *(First name, middle initial, last name)*
M. S. Piligian
M. V. Ratynski

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1968	157	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
IN-HOUSE	ESD-TR-68-1
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
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DD FORM 1 NOV 65 1473

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Printed by
United States Air Force
L. G. Hanscom Field
Bedford, Massachusetts