ESD-TR-66-256

ELECTRONIC SYSTEMS DIVISION PROGRAMS AND SYSTEMS ENGINEERING MANAGEMENT PROCEDURES, AFSCM 375-5

C. E. Gardella, ESD
C. S. Enright, MITRE

April 1966

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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FOREWORD

The System Engineering Management Manual, AFSCM 375-5, describes and specifies a system engineering process for system programs which progress from Concept Formulation through Contract Definition, Acquisition, and Operational Phases. Basically, three types of systems are acquired by the Electronic Systems Division (ESD): Command Systems, Surveillance and Control Systems, and Communications Systems. Each of these types of systems generally has its own unique features. The system engineering process described in AFSCM 375-5 must be adapted to specific program needs.

Within ESD the Staff Office specifically charged with the responsibility for implementation of Systems Analysis and AFSCM 375-5 is the Technical Requirements and Standards Office (EST). This report is not meant to represent any final word on the implementation of AFSCM 375-5 but rather to indicate possible ways of utilizing this manual on programs assigned to ESD.

The authors are indebted to Lt Colonel Donald E. Quail, Research and Development Director, Systems Management Division, Headquarters, Air Force Systems Command, Lt Colonel Albert E. Smith, Chief, Technical Integration Division, Technical Requirements and Standards Office, ESD, and R. L. Hamilton and R. C. Grandy, The MITRE Corporation, for profitable discussions during the preparation of this report and wish to express their appreciation for the invaluable assistance and guidance that was given.

REVIEW AND APPROVAL

This technical report has been reviewed and is approved.

for Albert E. Smith Lt Col
FRANK E. BRANDEBERRY, Colonel, USAF
Chief, Technical Requirements & Standards Office

ABSTRACT

This report establishes and describes a method for accomplishing the system engineering management process on programs assigned to the Electronic Systems Division (ESD). Modification to the system engineering process specified in AFSCM 375-5 for application to ESD programs is presented. Procedures for computer programs are indicated. A system engineering statement of work check list, appropriate formats, and an appendix containing implementation instructions are also included.

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APPENDICES

SECTION I

INTRODUCTION

A. General

The evolution of highly sophisticated military systems necessitates the concept of Total System Design. A military system is an entity composed of many constituent parts including:

- Hardware Items
- Facilities
- Personnel
- Training
- Computer Programs
- Procedural Data

Paramount to system operational effectiveness is the requirement for coherence between all constituent elements of the system.

The System Engineering Management Manual, AFSCM 375-5, describes and specifies a system engineering process for total system design regardless of system purpose, size, or complexity. This report attempts to adapt this process to programs assigned to ESD. Within ESD the Staff Office specifically charged with the responsibility for Systems Analysis and implementation of AFSCM 375-5 is the Technical Requirements and Standards Office (EST).

B. Observations

1. The System Engineering Process

System engineering can be considered analogous to problem solving[1]. In both instances one works from the known to the unknown by:

- Recognizing a requirement or problem.
- Analyzing and defining the requirement or problem.

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[1]David O. Ellis and Fred J. Ludwig, Systems Philosophy, Prentice-Hall, Inc. (1962).

- Gathering facts, intelligence, technology, and means.
- Establishing criteria for satisfaction or solution.
- Determining and listing practical alternative solutions.
- Analyzing the alternatives within the constraints of time, cost, and performance.
- Applying criteria, evaluating, and comparing alternatives.
- Selecting and justifying solutions.
- Applying and fostering accomplishment of the approved solution.

This basic approach underlies the philosophy of system development. Requirements are recognized and defined in the concept formulation phase; solutions are developed and selected in the contract definition phase; and the selected solutions are applied in the acquisition phase. For those programs that do not undergo a contract definition phase, equivalent system engineering activities must take place during the concept formulation and acquisition phases.

2. ESD Programs

Basically, three types of systems are acquired by ESD: Command Systems, Surveillance and Control Systems, and Communications Systems. Each of these types of systems generally has its own unique features.

a. A Command System basically deals with the automation of an existing manual or semi-automated system. Such automation is usually heavily constrained by existing organization structures and procedures. This type of system often is acquired by a mixture of Air Force 375 Series Regulations and Air Force 300 Series Regulations, Manuals, and procedures. No simple SOR-like statement of requirements is possible since there are discrete requirements in each staff area within the Using Command. The acquisition of such systems is never truly completed, since increments of capability are constantly being added. As the design of the World-Wide Military Command and Control System progresses, involvement of the Department of Defense/Research and Engineering, Joint Chiefs of Staff, Defense Communication Agency (DCA), other Services, Commanders of the Unified and Specified Commands, etc., can be expected to increase.

b. In contrast, Surveillance and Control Systems can follow a more typical acquisition route. Requirements for a system such as BMEWS or SLBM can be technically defined and a system acquired to meet such requirements. This type of system may be modified and updated but in many cases these actions are not dissimilar to Air Force Regulation (AFR) 57-4 Operational Phase Modifications.

c. Many Communications Systems present a different problem. These "systems" are acquired in direct response to DCA requirements and some, or much, of the system engineering may be performed by DCA. Thus, these "systems" are characterized by equipment design and procurement and a very involved installation, integration, and checkout task involving many widely distributed geographical sites.

C. Approach

The above considerations in no way invalidate the concepts of AFSCM 375-5, but they do preclude its implementation on a "rote" basis. Goode and Machol state in their text[2]: "...our purpose is to convey the breadth and ubiquity of the problem...." The following sections of this report represent no final word on the implementation of AFSCM 375-5, but indicate possible ways of utilizing this manual at ESD. The proposed ESD Implementing Instruction requires that each System Program Office (SPO) determine the degree of implementation by adapting the system engineering process described in AFSCM 375-5 to specific program needs. It is important that the scope of contractor(s) system engineering effort be clearly specified. This report is not intended to be a substitute for the common sense of the System Program Director and his staff. As stated in Chapter 1 of AFSCM 375-5: "Effective implementation of this manual is dependent upon the vision, degree of understanding, interest, and acceptance by the individuals to whom its application is entrusted as a prime management responsibility."

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[2]Harry H. Goode and Robert E. Machol, System Engineering, McGraw-Hill, New York (1957).

SECTION II

AFSCM 375-5 AND RELATED AIR FORCE SYSTEMS COMMAND MANUALS

A. AFSCM 375-1

This manual (Configuration Management During the Definition and Acquisition Phases) establishes the technique of baseline management. Three baselines which serve as engineering reference points, i.e., Program Requirements, Design Requirements, and Product Configuration Baselines, are defined in terms of specification formats. Application of AFSCM 375-5 procedures results in engineering data required for initial development of specifications and/or changes thereto. Some, but not all, of this data is either included or referenced in the specifications which establish the three baselines. Engineering reviews are conducted against the specifications which establish the Program Requirements and Design Requirements Baselines specified in AFSCM 375-1.

B. AFSCM 375-3

AFSCM 375-3 (System Program Office Manual) is a guide for System Program Offices to use in doing their jobs. This manual contains a general introduction to the subject of system engineering but is not regarded as definitive guidance. Therefore, in event of conflict, the engineering procedures established in AFSCM 375-5 govern.

C. AFSCM 375-4

AFSCM 375-4 (System Program Management Manual) currently in draft coordination will provide a road map of procedures to be followed for programs undergoing a Concept Formulation, Contract Definition, and Acquisition Phase. AFSCM 375-5 provides additional detail on the system engineering process. The AFSCM 375-4 manual is not addressed per se to programs which do not undergo a Contract Definition Phase or to unique problems associated with ESD programs. Therefore, we feel that comments made in this report are generally applicable to AFSCM 375-4.

D. AFSCM/AFLCM 310-1

AFSCM/AFLCM 310-1 (Data Management), Volume I, contains general Data Management Policy and a "Typical System Acquisition Flow." The flow process presented is not consistent "in toto" with AFSCM 375-5 but we understand that upon publication the flow described in AFSCM 375-4 (which is consistent with AFSCM 375-5) will prevail. Volume II of AFSCM/AFLCM 310-1 includes all the data items contained in AFSCM 375-5. This report suggests modifications to these data item formats for utilization in situations involving computer programming and Command System acquisition. If these modified formats prove to be useful, formal ESD

supplements to AFSCM 375-5 and AFSCM/AFLCM 310-1 will be considered. Data items which are discussed in succeeding sections of this report include:

AFSCM/AFLCM 310-1D Item Number	Title
S-52-6.1	Functional Flow Diagram
S-53-6.1	Requirements Allocation Sheets
S-54-6.1	System/Design Trade Study Reports
S-55-6.1	Schematic Block Diagrams
S-56-6.1	Time Line Sheets
S-57-6.1	Design Sheets
S-58-6.1	Facility Interface Sheets
S-59-6.1	End Item Maintenance Sheets
S-60-18.0	Maintenance Loading Sheets
S-61-18.0	Maintenance Ground Equipment (MGE) Utilization Sheet
S-62-18.0	Personnel Utilization Sheet
S-63-23.0	Calibration Requirements Summary

SECTION III

MODIFICATION TO AFSCM 375-5, EXHIBIT I

The following discussion attempts to indicate the wide variety of possible modifications necessary to adapt the AFSCM 375-5 system engineering management process to particular program needs. Each System Program Office (SPO) or Project Office (PO) must include their "tailored" application requirements in the System Engineering Implementation Plan (SEIP).

A. System Programs Not Undergoing Contract Definition

The system engineering management process, as shown in Figure 5 of AFSCM 375-5, Exhibit I, and duplicated in this report as Flow Chart I, represents a system program which progresses from Concept Formulation through Contract Definition, Acquisition, and Operational Phases. A definition phase is mandatory for programs which require RDT&E financing in excess of twenty-five million dollars or which are estimated to require a total production investment in excess of one hundred million dollars. Most ESD programs do not require expenditures of this magnitude. Therefore, the following paragraphs suggest modifications to the AFSCM 375-5 Figure 5 diagram for programs not undergoing Contract Definition:

1. Block 5, "Provide Inputs to Preliminary Technical Development Plan (PTDP)," must be retitled, "Provide Inputs to Proposed System Package Plan (PSPP)," to reflect the fact that the Program will move directly from the Concept Formulation Phase to the Acquisition Phase. Block 19 (Phase 1B Contract Award) becomes equivalent to Block 57 (Development Contracts Awarded). Equivalent engineering activities performed if the system program were undergoing definition must likewise be performed in the Acquisition Phase prior to the Preliminary Design Review (PDR) (Block 59) with the following exceptions:

a. Engineering reviews represented by Blocks 23, 30, 36, 43, 50, 69, and 74 generally will be omitted. Imposition of the System Requirements Reviews represented by these blocks is considered optional and dependent on the complexity of the system. However, an equivalent review of prior contractor engineering activities must occur at the PDR (Block 59) to assure system design integrity.

b. Block 55 (Prepare Inputs to Phase 1B Final Reports and the Phase II Proposals); Block 56 (Technical Evaluation and System Engineering Synthesis); and Block 57 (Development Contracts Awarded) are considered not applicable for programs that do not undergo a Contract Definition Phase.

2. Adaptation of the system engineering process in the Acquisition Phase for commercial off-the-shelf items requiring little or no modification involves:

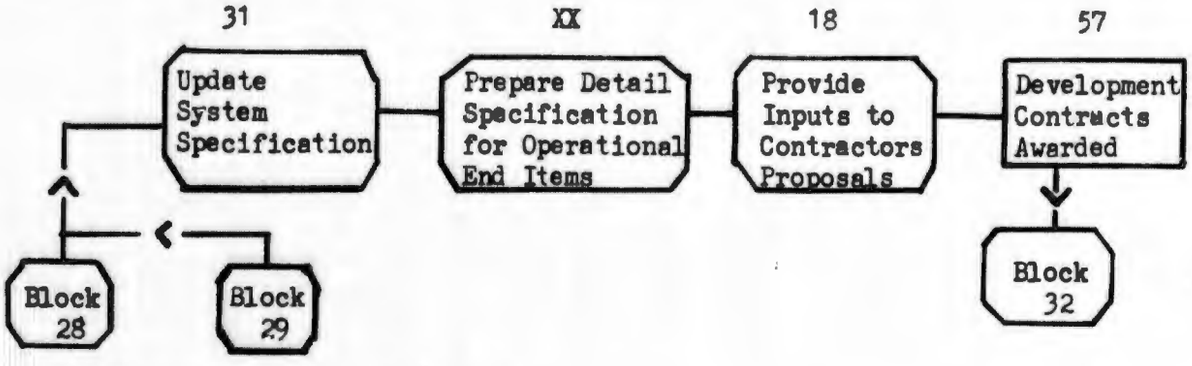
a. Shifting Block 18 (Provide Inputs to Contractors Proposals) to a point in time after Block 31 (Update System Specification).

b. Contractor accomplishing Blocks 20 (Identify Applicable Requirements and Update Source Documentation); 21 (Develop Detailed Operations Functions); 22 (Develop Design Requirements for Operations Functions); 24 (Perform Trade-Off Studies Operations Elements of the System); 25 (Develop Design Requirements for Operations End Items); 26 (Develop Operations Requirements for Facilities); 27 (Develop Requirements for Operations Personnel and Training); and 28 (Select AVE and/or OGE and Facilities) during contractor proposal preparation in response to the RFP.

c. Omitting System Requirements Review (Blocks 23 and 30) as they are not applicable.

d. Application of Block 29 (Identify High Risk Areas and Long Lead Time Items) only insofar as long lead time items are concerned.

Following Block 31 (Update System Specification) a Block (XX) indicating preparation of Detail Specifications for Operational End Items must be added prior to the relocated Block 18. (See a above.) Block 57 (Development Contracts Awarded) must then follow the relocated Block 18 and precede Block 32. For example:



As indicated in Paragraph 1 above:

a. Block 19 (Phase 1B Contract Award) is replaced by Block 57 (Development Contracts Awarded).

b. Blocks 55 (Prepare Inputs to Phase 1B Final Reports and the Phase II Proposals) and 56 (Technical Evaluation and System Engineering Synthesis) are deleted.

c. All Blocks indicating System Engineering Reviews are deleted since this action can be accomplished at PDR (Block 59).

3. Finally, consideration must also be given to those instances where contracting is on an associate contractor basis regardless of whether or not a Contract Definition Phase is involved. This situation necessitates that prior to Block 18 (Provide Inputs to Contractors Proposals) "in-house" system engineering has progressed to the point where:

a. System performance, general design and construction requirements, and performance allocations to system segments can be defined in the System Performance/Design Requirements General Specification[3].

It is significant to note that definition of system segment requirements may not be necessary when contracting is on a "prime" contractor basis.

B. Non-System Programs

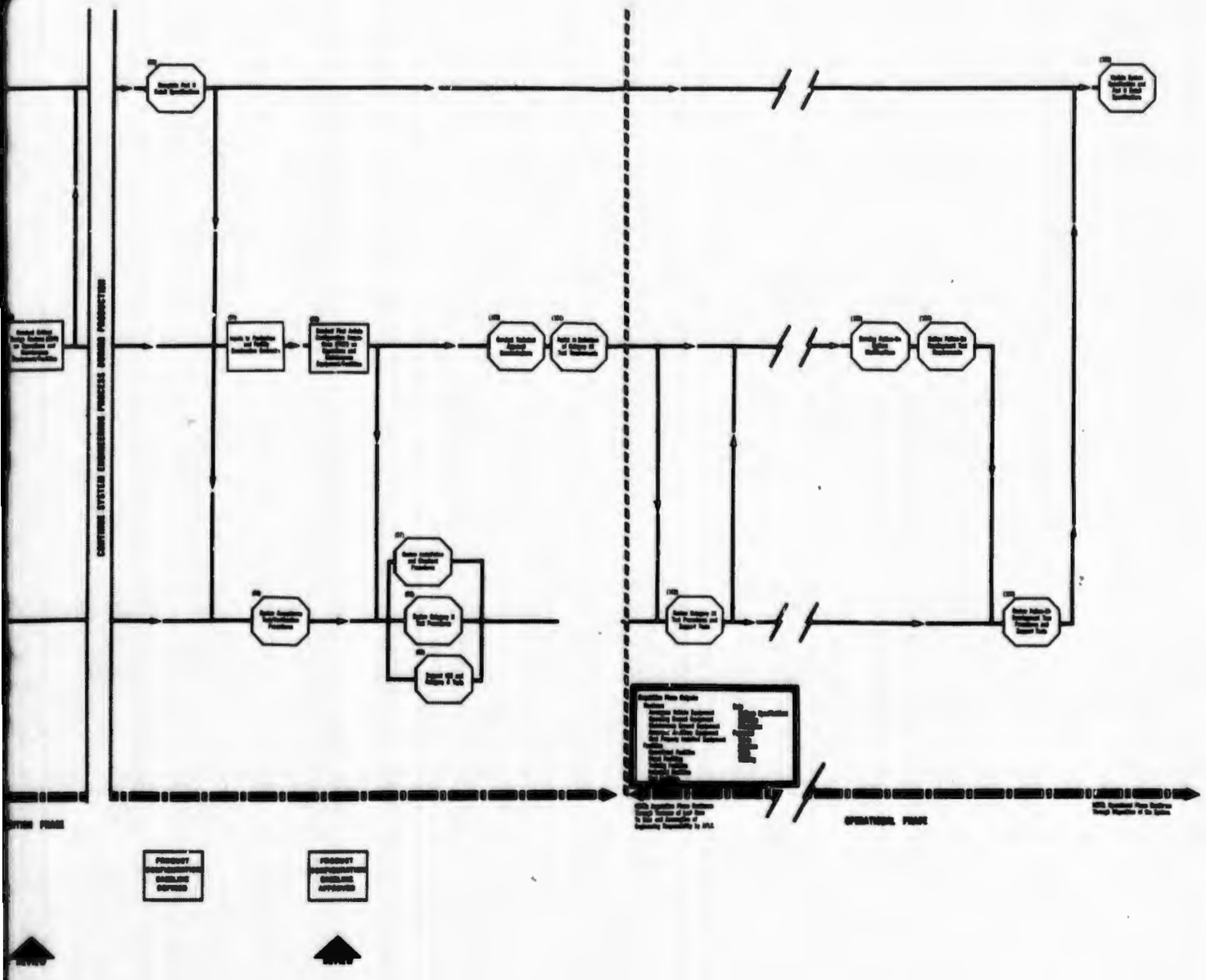
The system engineering management process described by Figure 5 of AFSCM 375-5, Exhibit I, is applicable to equipment (end item) programs as well as to System Programs. However, application of the engineering process to end item programs requires extensive revision to the Figure 5 flow process because:

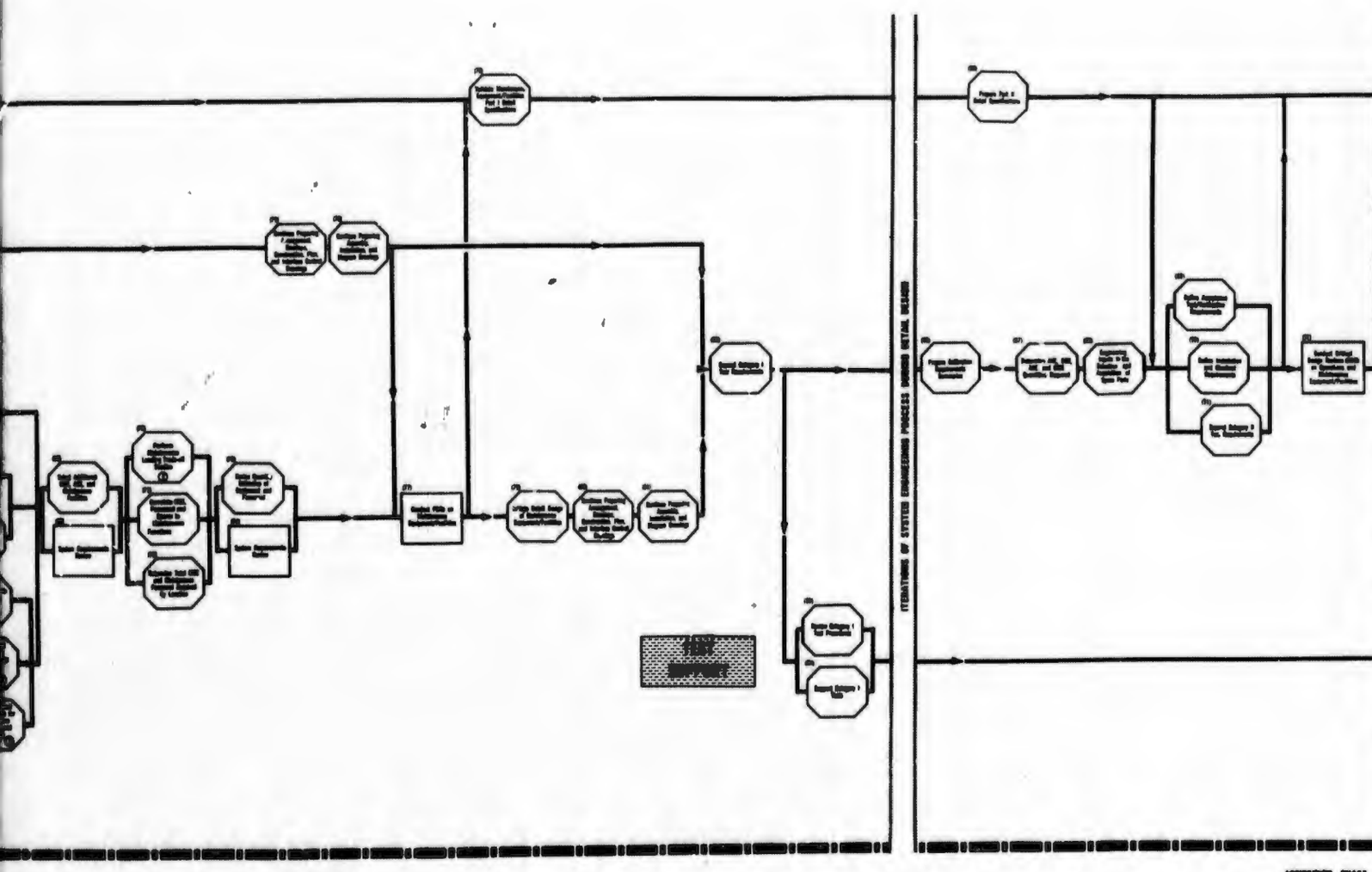
a. The end item does not go through a Contract Definition Phase. (See A above.)

b. "End Item" as opposed to "system" engineering activities are applicable.

A revised engineering process for equipment programs is shown in Flow Chart II of this report.

[3]See Exhibit I of AFSCM 375-1, Configuration Management During Definition and Acquisition Phases.





ngineering Process.

FIGURE I
Flow Chart I
9

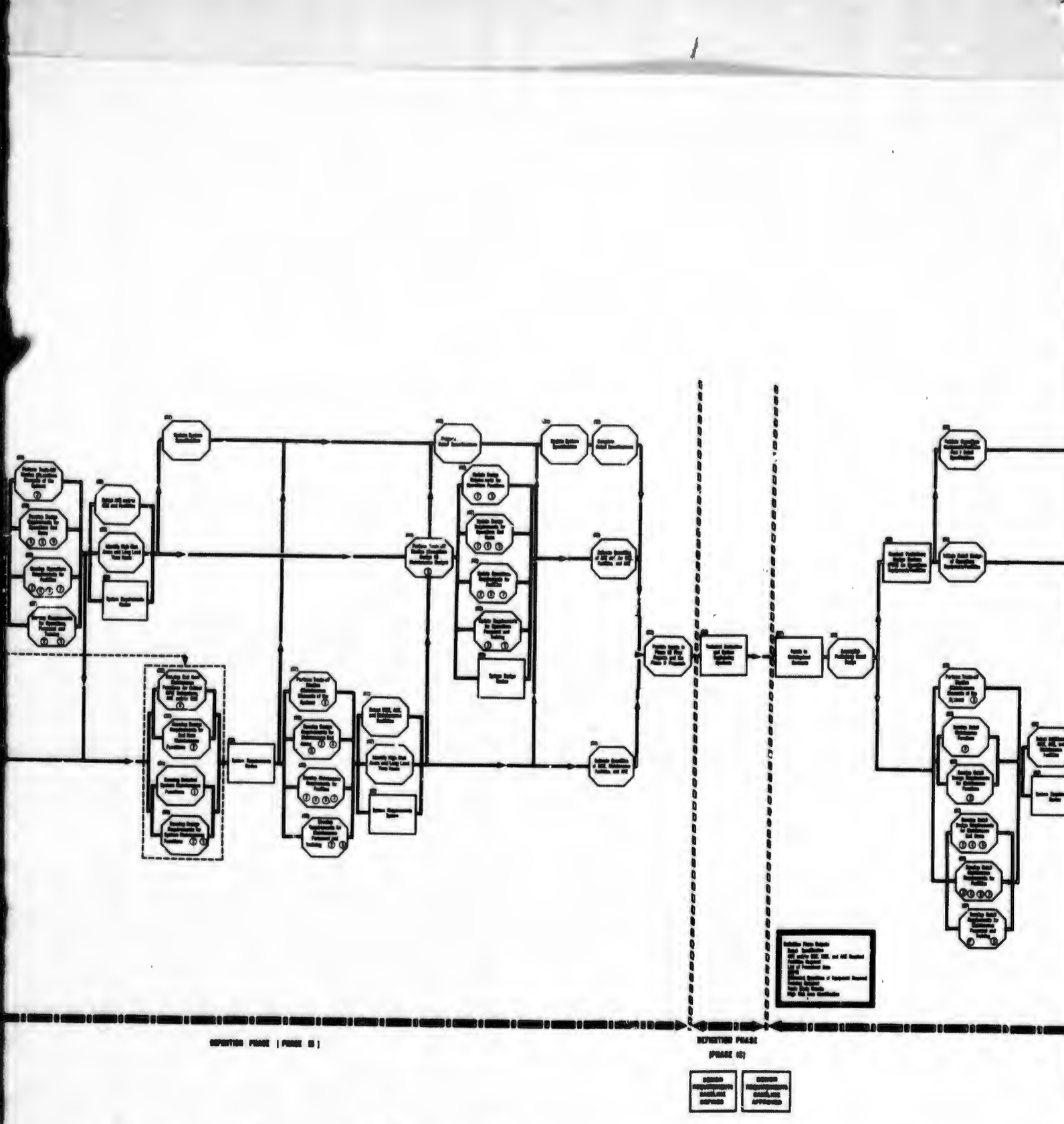


Figure 5. System Engineering Proce

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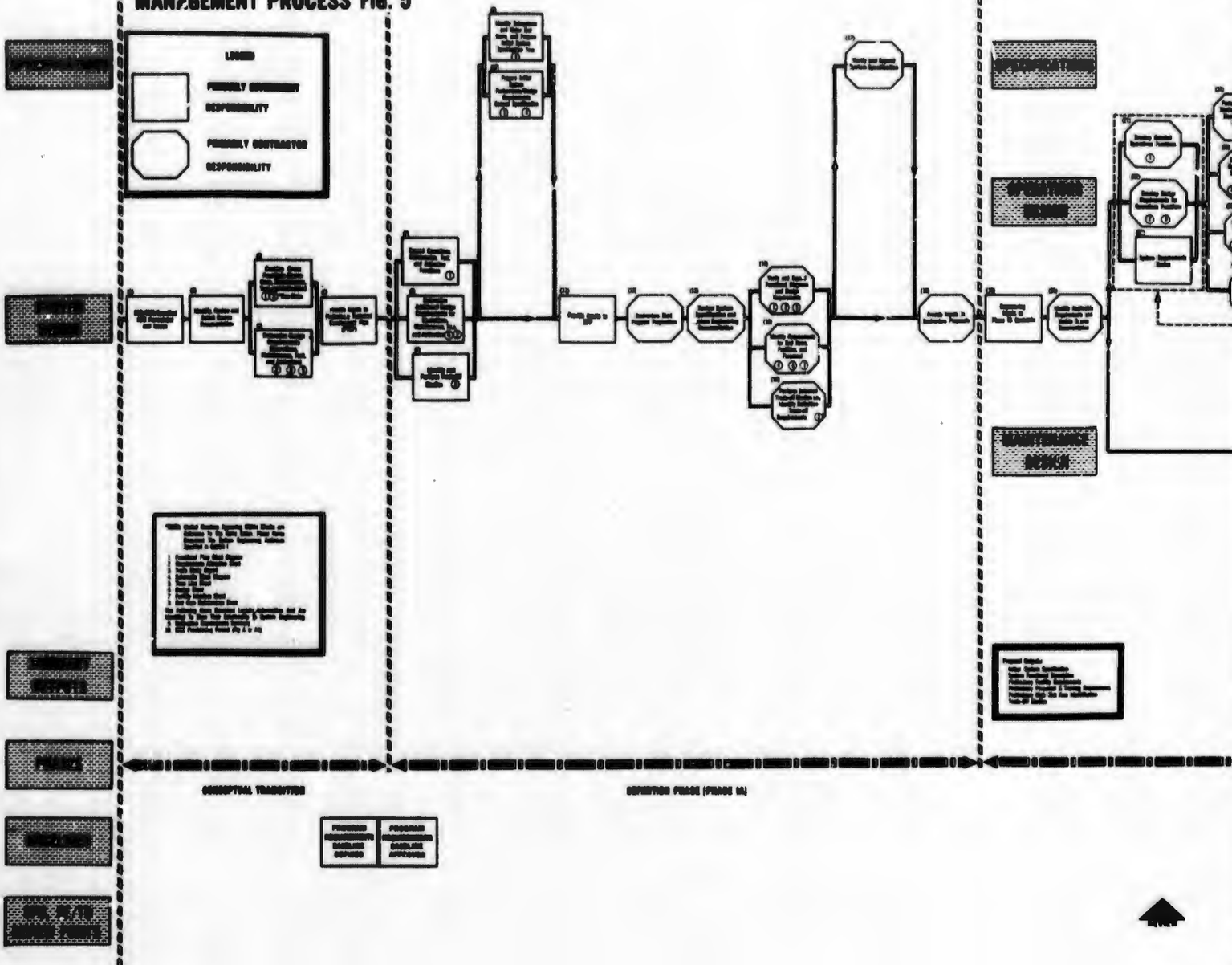
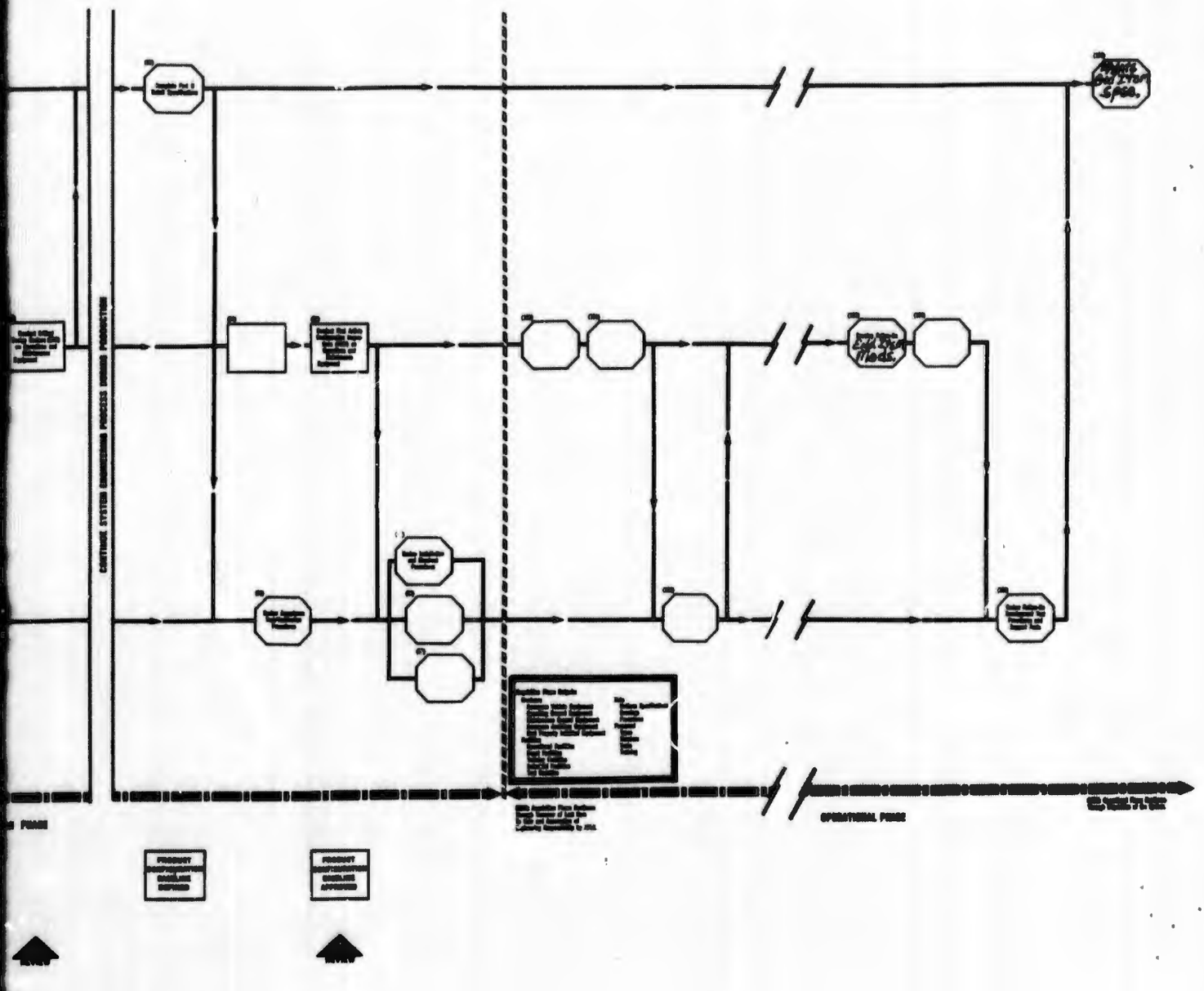
SYSTEM ENGINEERING MANAGEMENT PROCESS FIG. 5





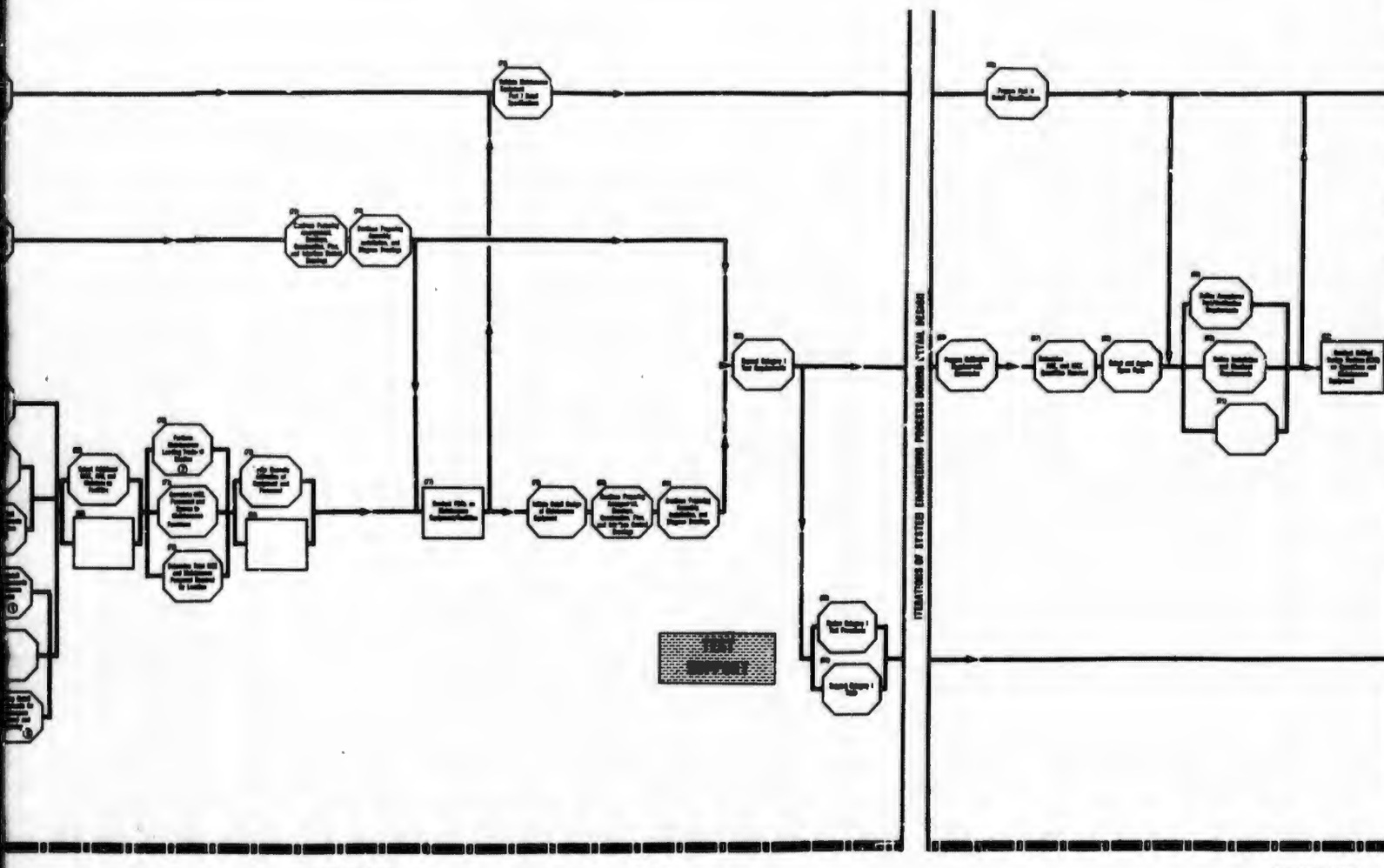
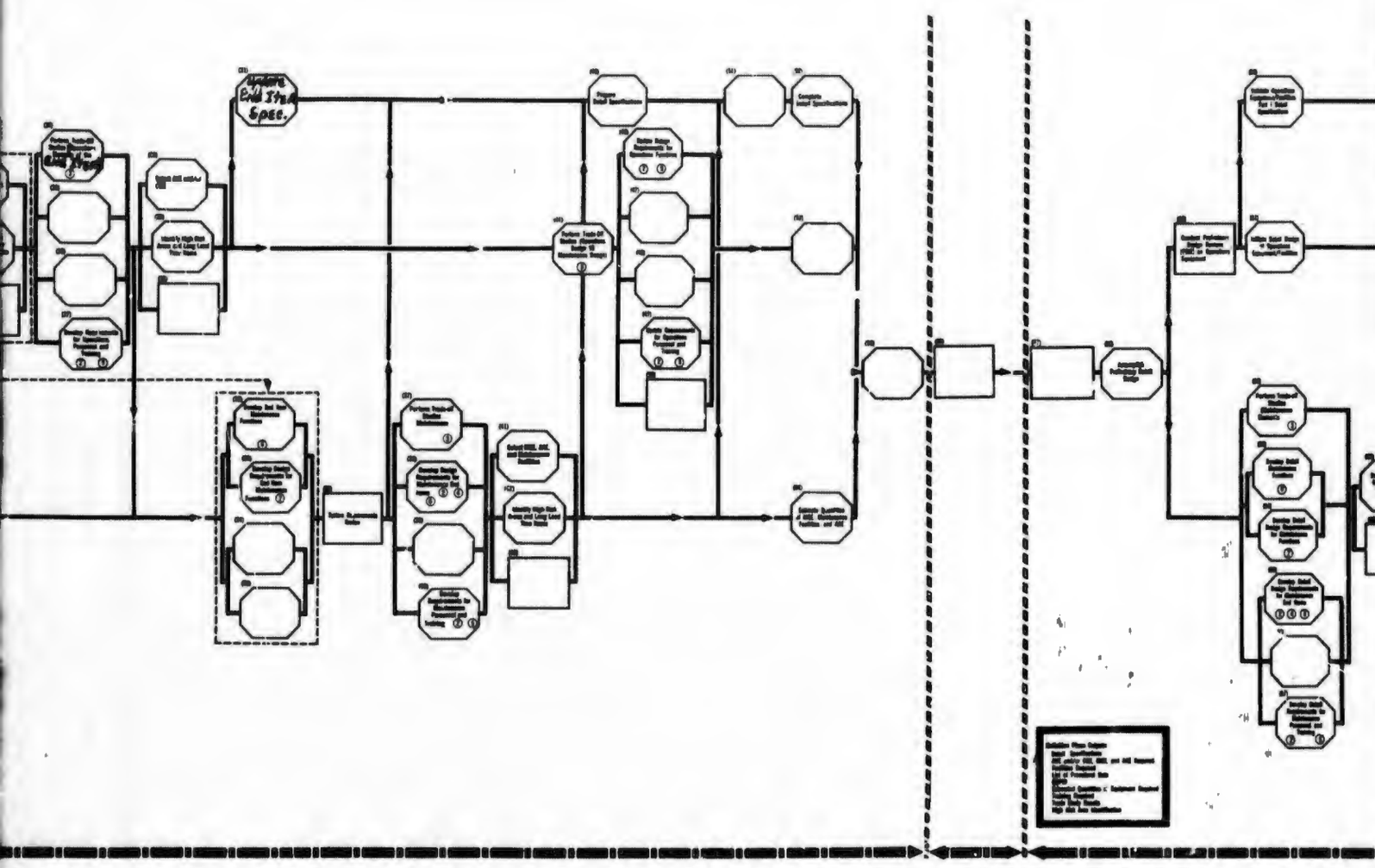


FIGURE II

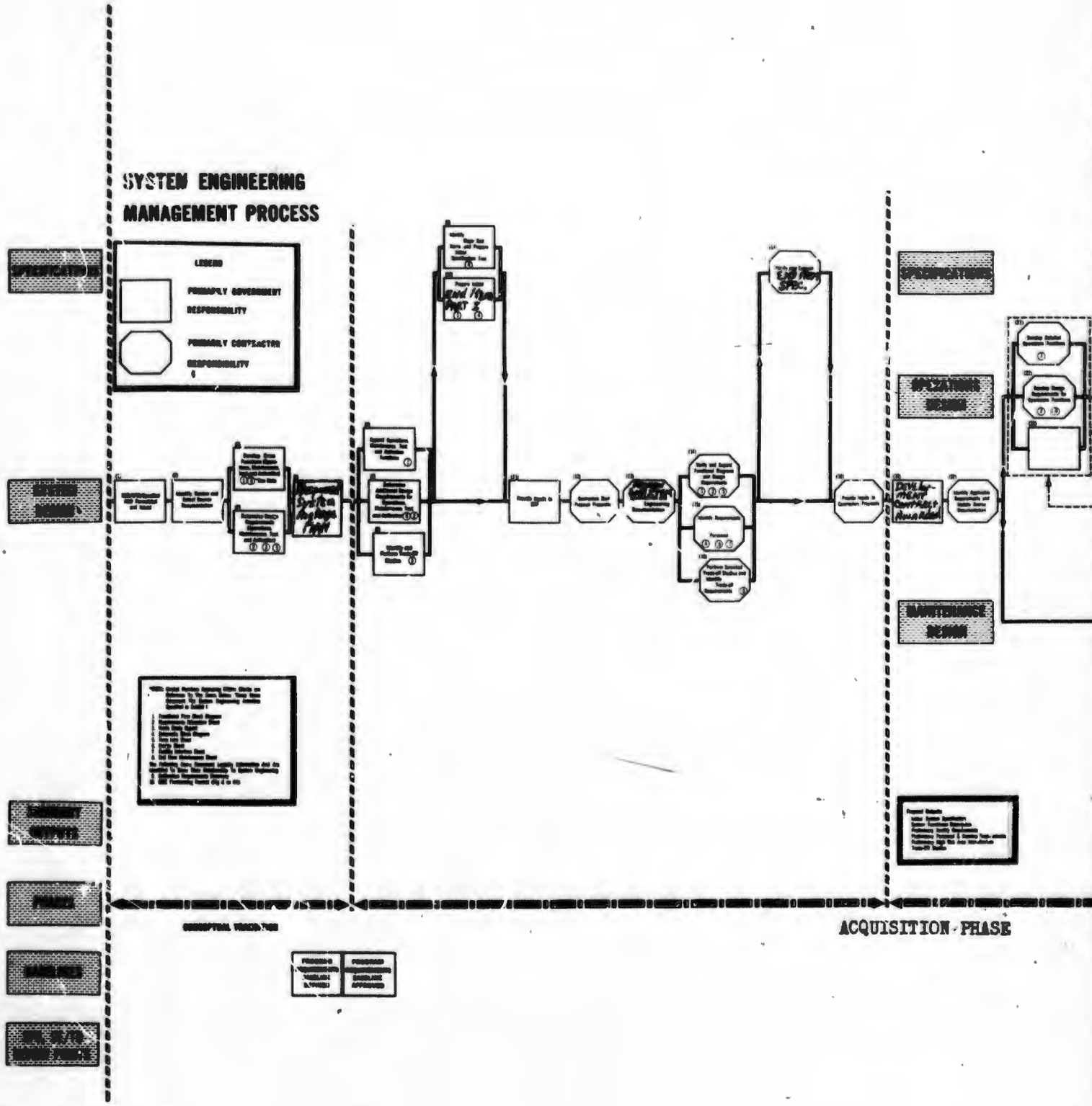
Flow Chart II:

tem Engineering Management Process

2



Modified System E


SYSTEM ENGINEERING
MANAGEMENT PROCESS
LEGEND
PRIMARILY GOVERNMENT
RESPONSIBILITY
PRIMARILY CONTRACTOR
RESPONSIBILITY
ACQUISITION PHASE

SECTION IV

USE OF AFSCM 375-5, EXHIBIT II, ATTACHMENT I, FORMATS - GENERAL CONCEPTS

Attachment I lists twelve (12) system engineering documentation formats for possible utilization on system/equipment programs. However, AFSCM 375-5 states that: "Certain systems may not require the utilization of every data item...or may require modification of the documentation." Suggested guidelines for documentation usage on ESD programs are as follows:

1. Functional Flow Block Diagrams

The use of these Diagrams is recommended to insure that all operational and maintenance functions that pertain to the system are considered. The level to which these Diagrams are prepared depends upon what is needed to accomplish the above objective. In general, one should specify the level by specifying the detail required rather than by the statement "Second Level," or "Third Level," because one contractor's "Second Level" diagram may be equivalent to another contractor's "Third Level" diagram. If the level of detail is not clearly specified, difficulty in estimating costs of contractor efforts may result. Supplemental formats and their use to further describe Functional Flow Blocks are discussed in Section VI. System level Functional Flow Block Diagrams should be incorporated into the System Specification. Functions peculiar to an end item should be incorporated into the Contract End Item (CEI) Detail Specification. Functional Flow Block Diagrams for an electronic system are shown in Figures 29-31 of Attachment 2 to AFSCM 375-5.

2. Requirements Allocations Sheet (RAS)

The use of these Sheets (or at least the philosophy thereof) is recommended. Functions should be explicitly related to:

- Design requirements (of both hardware and computer programs)
- Facility requirements
- Procedural requirements
- Personnel and training requirements, etc.

As indicated in Section V of this report, the format can be modified in the case of computer programs. If the format is not used, similar data can be contained in System Analysis Reports, with a grouping of several functions resulting in a given design requirement. If the "system" is sufficiently simple, the preparation of initial copies of System and CEI

Specifications may suffice. In such a case, paragraphs of the specification draft should reference the appropriate Functional Blocks. (See also 6 below.)

3. Trade Study Reports

Trade-off studies are an important part of any system engineering activity, and are, in many cases, required for submission to the Department of Defense (DOD) in accordance with system analysis/cost effectiveness procedures. Hitch and McKean state in their text[4]: "...it is rewarding to array the alternatives and think through their implications in terms of objectives and costs.... Judgment is always of critical importance in designing the analysis, choosing the alternatives to be compared, and selecting the criterion...." Exhibit II, Attachment I, of AFSCM 375-5 does not establish a definite over-all format for these studies since they may consist of "extracts from designer's notebook, contractor's internal memoranda, minutes of meetings, reductions of presentation charts, and formal engineering reports, etc." A comparison matrix of design approaches is also discussed in Attachment I and use of such a matrix is recommended to summarize the Trade Study Report.

4. Schematic Block Diagrams

Schematic diagrams are considered a normal part of good engineering practice and use of these diagrams on ESD programs is recommended. Such diagrams are useful not only during the initial design process (particularly to define interfaces) but also in evaluating the impact of proposed engineering change proposals. As with Functional Flow Block Diagrams, system level schematics should be incorporated into the System Specification for purposes of Configuration Management. Similarly, schematics internal to an end item should be incorporated into the CEI Detail Specification. Examples of Schematic Block Diagrams for electronic systems are shown in Figures 40 and 62 of Attachment 2 to AFSCM 375-5.

5. Time Line Sheets (TLS)

In general, determination to use or not use this item of documentation should be made by the SPO Director, based on recommendations by the Deputy Director for Engineering, the System Support Manager, and the Air Training Command representative. The latter two persons are included since data shown on the TLS may be related to maintenance and training requirements. Regardless of whether this particular format is utilized, if the system has a certain required reaction time (which is particularly the case in Surveillance and Control Systems and those

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[4]Hitch, Charles J., and McKean, Roland N., The Economics of Defense in The Nuclear Age, Harvard University Press, Cambridge, Mass. (1960).

portions of Command Systems operating in real time), studies analogous to those necessary to accomplish the preparation of TLS must be performed and the TLS can be utilized as a check list rather than a required format. The results of such studies may be included in a System Analysis Report and/or incorporated into appropriate specifications. To ascertain how a TLS is actually used, the example shown in Figure 46 of Attachment 2 to AFSCM 375-5 is most helpful.

6. Design Sheet

In general, the use of Design Sheets in addition to Part I CEI Specifications on programs of the size typical at ESD is regarded by the authors as being unnecessarily redundant. First drafts of the Part I CEI Specifications can be utilized to fulfill this need. However, as indicated in 2 above, the paragraphs of the draft specification should reference the appropriate blocks of the Functional Flow Block Diagrams. The use of a Verification Cross Reference Index (as shown in Figure 26 of Attachment 2 to AFSCM 375-5) to supplement the draft specification is also recommended to insure a coordinated approach to testing. Design Sheets for computer program end items are considered in Section V of this report.

7. Facility Interface Sheets (FIS)

Utilization of this format on a given system program should be determined by the SPO Director, based on recommendations by the SPO Deputy Director for Engineering and the ESD Deputy for Civil Engineering. If it is determined that facility design may be accomplished without the preparation of this data item, the Sheet should be used as a check list to assure no parameters have been overlooked.

8. End Item Maintenance Sheet; Maintenance Loading Analysis (Including Maintenance Loading Sheet, MGE Utilization Sheet, and Personnel Utilization Sheet); and Calibration Requirements Summary

Use of these formats on a given system program should be determined by the SPO Director, based on recommendations by the SPO Deputy Director for Engineering, the System Support Manager, and the Air Training Command representative. (See 5 above for a similar case.) In any event, maintenance and personnel subsystem analyses must be performed and these formats can be used as check lists in the conduct of these analyses.

SECTION V

MODIFICATION TO AFSCM 375-5 EXHIBITS FOR COMPUTER PROGRAMS

A. AFSCM 375-5, Exhibit I

No basic modifications to the system engineering management process described in Exhibit I are proposed for computer programs, other than the modifications already considered in Section III (A and B) of this report, i.e., (1) computer programs may be acquired by a process that does not go through a Contract Definition Phase; and (2) computer programs may be acquired by themselves and not as part of a system program. (This is particularly true of utility/higher order programming languages such as PL-1, COLINGO, JOVIAL, etc.)

While no changes to the basic system engineering process are indicated, certain additional factors should be considered relative to system engineering of a heavily computer program oriented system:

1. The general scope of the tasks to be accomplished must be known (e.g., data quantities and sources, timing, modes of data display, etc.).

2. Trade studies between hardware and computer program methods of accomplishing tasks must be prepared. Decisions must be made between character oriented and word oriented computer approaches, use of higher order programming languages, etc.

3. More detailed design of the computer programs can proceed when the class of the computer is determined (e.g., storage/file capability, transfer and access characteristics of bulk storage, number of channels available, input-output rates, etc.).

4. The computer programming process, in the case of developmental hardware, will always be dependent on, and will always lag the hardware detailed design process. Therefore, heavy expenditure of computer programming resources, in the case of developmental hardware, should be avoided until the hardware/computer program interface parameters have been established.

5. Hardware maintenance functions must be closely examined to determine if malfunction checking is to be accomplished in an automated manner. Such considerations, however, in no way modify the AFSCM 375-5 system engineering process. As stated in Block 33 of AFSCM 375-5, Exhibit I, such requirements can be "incorporated as maintenance design features into the Operations CEI's...."

6. Preliminary Design Review (PDR), Critical Design Review (CDR), and First Article Configuration Inspection (FACI) for computer

program end items serve the same functions as their hardware counterparts. Detailing of procedures for reviews and inspections of computer programs will be established in an ESD Technical Requirements and Standards Office (EST) Supplement to AFSCM 375-1, Exhibit XIV, which is currently in preparation. For any review or inspection, data must be received from the contractor in sufficient advance of the scheduled review or inspection date to allow adequate engineering review.

B. AFSCM 375-5, Exhibit II, Attachment I

The system engineering documentation formats of Exhibit II, Attachment I, are, with the exception of the Design Sheet, generally usable for computer program design and development.

1. Functional Flow Block Diagrams. Such diagrams may consider hardware functions, computer program functions, or manual/procedural functions.

2. Requirements Allocation Sheets. These Sheets either (a) require a further column to break out design requirements for hardware from requirements for computer programs; or (b) may utilize a designator such as "H" for hardware and "C" for computer programs.

3. Trade Study Reports. Such reports should indicate that appropriate hardware/computer program trade-offs have been considered (e.g., should certain display features be built into the hardware, or should they be programmed?).

4. Schematic Block Diagrams. Such diagrams will be required to indicate the interface relationships of hardware and computer program end items. In addition, within the computer program end item, diagrams similar in function to Schematic Block Diagrams must be prepared to indicate the actual design of the computer program and serve as a guide to coding.

5. Time Line Sheets. These sheets are considered in Section IV, Paragraph 5, of this report. The discussion therein is equally applicable to computer program end items as to hardware. The question of time response is vital in any real-time system. Likewise, the interrelations between the time required to process various subroutines within the computer program can also be of the utmost importance. For these reasons, as shown in Section IV of this report, time studies must be accomplished, and the Time Line Sheet utilized as a check list.

6. Design Sheets. As indicated in Exhibit II, Attachment I, of AFSCM 375-5 and in Section IV of this report, these sheets follow the format for Part I Contract End Item Specifications. Section IV of this report also indicates that, in the case of the majority of ESD programs, the preparation of a Design Sheet, in addition to the Part I Contract End Item Specification, is not necessary. A copy of a Part I

Contract End Item Specification for computer program end items is included as Appendix D to this report. This material has been taken from the proposed EST Supplement to AFSCM 375-1 previously referenced. If a Design Sheet for computer program end items is desired, its format would follow the outline of Sections 3 and 4 of the Part I Specification of Appendix D. This philosophy is in conformance with that stated in Paragraph 2, Column C, of AFSCM 375-5, Attachment I, i.e., that the Design Sheet sections "physically become Sections 3 and 4 of Part I Detail Specifications."

7. Facility Interface Sheets. Not applicable to computer programs.

8. End Item Maintenance Sheet; Maintenance Loading Analysis (Including Maintenance Loading Sheet, MGE Utilization Sheet, and Personnel Utilization Sheet); and Calibration Requirements Summary. These forms are not applicable to computer programs in the same manner as to equipment end items because computer programs do not "wear out" and they require no maintenance in the normal sense of the word. However, such forms, when prepared for equipment end items, should indicate if malfunction checking/maintenance functions are to be accomplished by computer program routines. If so determined, such requirements should be added to the applicable Computer Program End Item Specification, Part I.

SECTION VI

USE OF AFSCM 375-5, EXHIBITS I AND II

A. Command Systems

It was stated in Section I of this report that Command Systems generally are different from other ESD systems. Command Systems differ because of the following:

1. Requirements Determination

Since Command Systems generally deal with the automation of existing manual or semi-automated command capability, requirements determination may not proceed from an SOR (usually written in very general terms), but rather from a study of existing system capability. To conduct such a study the Functional Flow diagrams of Exhibit II, Attachment I, are most useful. However, their utilization is subject to certain modifications because:

a. One is dealing with the existing "system," not a "system" that will come into being.

b. The functional flows will be prepared on several levels simultaneously, in whatever detail is necessary to define the existing "system."

c. The scope of this existing "system" may be fixed by mutual agreement between ESD and the Using Command for the purposes of acquisition of certain increments of automated capability and may expand or change on the basis of later agreements (i.e., one may initially support the Command Post, or J-3, or J-5).

Additional supplemental formats to those of AFSCM 375-5 are normally used to define needed data relative to messages and data base contents. Representative samples of such formats are included as Appendices A and B. Other possible formats are contained in Air Force Manual 171-9.

2. Degree of Man/Machine/Computer Program Interaction

Such interaction may necessitate that the Using Command change their procedures as automated improvements are introduced. This generally is the case with all ESD systems, but has a far greater impact in the Command Systems area.

3. Degree to Which System is Software (Computer Program Oriented)

Modifications to AFSCM 375-5 formats for their use in computer program design and acquisition are contained in Section V of this report.

4. Need to Establish Product Configuration Baseline Control Over Existing End Items at the Beginning of an Acquisition Program

In most cases, the existing "system" contains some end items, both equipment and computer programs. If new increments of automated capability are to be added, strict control of this existing base must occur. Such control may involve Air Force Logistics Command for equipment end items and the Using Command for operationally-oriented computer programs. Therefore, the Product Baseline being controlled must include those Schematic Diagrams necessary to define precisely the relationships between existing end items.

5. Increment Acquisition Process

Once requirements for all increments have been defined, acquisition of the increment may proceed following the general philosophy and procedures of AFSCM 375-5, i.e., the design definition of the increment may proceed through the normal Baselines and Design Reviews. As noted above, the existing system will continue to be controlled at the Product Baseline level.

6. Continued Evolutional Development

Normally, a Command "System" will continue to evolve. Thus, portions of the system may be operational, and other portions may be in the Concept Formulation and/or Acquisition Phases. Therefore, specific responsibilities of AFSC, AFLC, and the Using Command relative to system/end item engineering responsibilities must be clearly defined to insure total "system" engineering integrity.

7. No Contract Definition Phase

The usual dollar cost of a given increment is such as to not require a Contract Definition Phase. Furthermore, the unique aspects previously considered would make competitive definition, particularly in the case of software (computer programs), very difficult to accomplish. Possible procedures for the acquisition of capability without a Contract Definition Phase are contained in Section III-A of this report.

8. Other

Other peculiarities of Command System acquisition which should be considered in the implementation of AFSCM 375-5 are contained in The MITRE Corporation Technical Report MTR-101[5].

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[5]Dr. Norman Waks, Implications For Acquisition of Military Information System Technology, The MITRE Corporation Technical Report MTR-101, dated 17 January 1966.

B. Surveillance and Control Systems

Subject to problems created by the utilization of computer programs and/or a non-Contract Definition Phase acquisition cycle, such systems in general follow a more typical AFSCM 375-5 system engineering process. Such a process may be extremely complex (e.g., the 407L Program) and may have evolutionary aspects. If so, the suggestions made under A above should be considered.

C. Communications Systems

Similar to the discussion in B above, Communications "Systems" may utilize computer programs (e.g., switching centers). In addition, these "Systems" may not go through a Contract Definition Phase. Furthermore, much of the "system" engineering for such programs may be done by DCA. The actual ESD tasks may be more nearly end item procurement as discussed in Section III-B of this report. In such cases, the specific engineering responsibilities of DCA and ESD, particularly concerning definition of interfaces, must be clearly defined in a memorandum of agreement.

SECTION VII

STATEMENT OF WORK CHECK LIST

This "check list" is considered general in nature and its application to statement of work preparation will vary in accordance with specific program requirements:

1. Has the application of the system engineering process described in AFSCM 375-5 been tailored to specific program needs?

a. Has the extent of contractor system engineering analysis of the system been clearly specified?

b. Does the system engineering analysis of AFSCM 375-5 as adapted produce a single analysis, definition, trade-off, and synthesis of system requirements and design solutions on a total system basis?

2. Has the system engineering effort of the integrating and participating contractors been defined in sufficient detail to assure complementary effort is achieved?

3. Has the relationship between the required system engineering analysis of AFSCM 375-5 as adapted and the AFSCM 375-1 Uniform Specification Program been established?

4. Has the requirement for conducting engineering reviews (SDR, PDR, CDR) and FACI in accordance with AFSCM 375-5/AFSCM 375-1 been provided?

5. Has the relationship of the system engineering task to work breakdown structure and cost information been identified?

6. Has a memorandum of agreement defining the responsibilities of participating Air Force agencies involved in system engineering the specific system or project been established?

SECTION VIII

SUMMARY

Methods for adaptation of the system engineering management process described in AFSCM 375-5 to Command Systems, Surveillance and Control Systems, and Communications Systems have been presented. Implementation of the manual on a "rote" basis is not recommended. Each SPO or Project Office must think out for itself the method of implementation based on specific program needs and include the "tailored" application in a System Engineering Implementation Plan. There is no substitute for the common sense of the System Program Director and his Staff. Effective implementation of AFSCM 375-5 is "dependent upon the vision, degree of understanding, interest, and acceptance" within each SPO.

APPENDIX A

CHECK LIST FOR DATA AUTOMATION[1]

Steps or Tasks to be Completed

I. Study of Objectives, Functional Area Operational Concepts, and Applicable Directives.

II. Study and Analysis of Current System:

A. Review source documents: preparation and formats.

B. Review input formats: card _____, tape _____, remote stations _____.

C. Review files: manual _____, card _____, tape _____, random access _____.

D. Review processing and output formats: card _____, tape _____, reports _____.

E. Construct Functional Flow Block Diagrams (FFBD) of existing system.

F. Document deficiencies in current system.

G. Complete documentation of current system.

H. Review above and confirm with OPR; re-estimate time and resource requirements.

III. Initial Concept and System Design (New System):

A. Study or review applicable directives.

B. Define and document over-all system requirements and degrees of response required within the data system.

C. Define and document basic structure and characteristics of the data elements to be used in the new data system:

---

[1]This Modified PACAF Data Systems Analysis Format provides a check list for system engineering personnel engaged in the process of automating user capabilities. It also indicates various data items (such as IIB, C, D) which are required in addition to AFSCM 375-5, Attachment I.

1. Input.
2. Files and records.
3. Output.

D. Design basic pattern and layout on a FFBD, portraying general methods, procedures, responsibilities, input, flow of work, machine runs, and output products.

E. Review of interface with other systems and adjust accordingly.

F. Review manpower needs and costs to develop, convert and operate the proposed new data system.

G. Complete initial documentation for management approval.

H. Other (specify).

IV. System Specifications:

A. Modify initial documentation as needed.

B. Prepare lower level FFBD's.

C. Determine and document input edits and quality control requirements.

D. Finalize programming of manpower needs and schedule development of programs. Re-estimate time needed.

E. Finalize output specifications and formats and obtain final coordination from user and OPR.

F. Finalize manual and off-line operations to provide basis for detailed procedures.

G. Prepare necessary AFSCM 375-1 specification formats.

H. Other (specify).

I. Complete final documentation for confirmation or approval by OPR.

V. Program Development:

A. Brief programmers on system logic and specifications.

B. Provide continuous technical guidance to programmers regarding specifications. Continuously evaluate progress.

C. Review test data prepared for system tests.

D. Validate system tests and output products jointly with OPR.

E. Other (specify).

VI. Conversion:

A. Convert records and files:

1. Manual.
2. Card.
3. Tape.
4. Random access.

B. Determine and document computer edits.

C. Functional Flow Block Diagrams (modified).

D. Review and validate conversion inputs.

VII. Implementation:

A. Prepare schedules.

B. Review program documentation and operating instructions.

C. Provide indoctrination and training to all organizational components affected.

D. Monitor first operational cycle.

E. Make final adjustments to data system and its documentation.

F. Other (specify).

NOTE: Another listing of detailed steps of System Design is contained in Pages 7-03 through 7-10 of Handbook of Automation Computation and Control, Volume 2, by Grabbe, Ramo, and Woolridge, John Wiley & Sons, Inc., New York (1959).

APPENDIX B

DATA CHARACTERISTICS CHECK LIST[1]

A. Input

1. Structure
   a. Alpha
   b. Numeric
2. Frequency
   a. Normal
   b. Peak
3. Volume
4. Organization(s) Transmitting
5. Data Elements
6. Accuracy
7. Transmission Method
8. Other, as required

B. Output

1. Structure
   a. Alpha
   b. Numeric
2. Frequency
   a. Normal
   b. Peak
3. Volume
4. Organization(s) Receiving
5. Data Elements
6. Accuracy
7. Demand Time
8. Transmission Method
9. Other, as required

C. Storage (Files, Tapes, Discs, etc.)

1. Structure
   a. Alpha
   b. Numeric
2. Organization of Origin or Destination
3. Data Elements
4. Update Requirements

---

[1]Actual data from current operations must be distinguished from data on projected system capabilities after automation.

5. Accuracy
6. Volume
   a. Bulk Information
   b. Bulk Files to Generate
7. Other, as required

APPENDIX C

PROPOSED IMPLEMENTATION INSTRUCTIONS FOR AFSCM 375-5 TO ESD PROGRAMS

1. The system engineering process described in AFSCM 375-5 shall be tailored to specific program needs. Specific tasks describing the extent of contractor(s) system engineering effort shall be established by the Deputy Director for Engineering within the SPO and included in the work statements.

2. The SPO will prepare a System Engineering Implementation Plan (SEIP). This plan will be used to implement the system engineering process described in AFSCM 375-5 as adapted by the SPO to a particular program. The SEIP will be included in Section 17, Definition Plan, of the Preliminary Technical Development Plan (PTDP) for programs undergoing a Contract Definition Phase and as Section 17 of the Proposed System Package Plan (PSPP) for those programs undergoing an Acquisition Phase.

3. The SEIP will be prepared in accordance with the instructions given in AFSCM 375-5, Exhibit II, and will include SPO "program peculiar" adaptation of the system engineering process specified in AFSCM 375-5, Exhibit I. Rationale used in determining the degree of adaptation will also be stated.

4. The following additional information shall be contained in the SEIP:

a. Applicable documentation formats.

b. Organizational responsibility for system engineering performance.

c. Proposed procedures/means of implementing the Technical Direction and Technical Review functions.

d. Size and composition of the System Engineering Group.

e. Any need for special facilities (e.g., ESD Systems Design Laboratory) to validate requirements or verify design.

f. Any memorandum of agreement defining specific responsibilities of Air Force Agencies involved in the system engineering effort on the given program or project. (AFSCM 375-5, Exhibit II, Paragraph 2.0.)

g. Other text as necessary to explain the "tailored" application of AFSCM 375-5 system engineering process.

5. Preparation of the system engineering documentation discussed above for current ESD programs will be the subject of mutual agreement between

the SPO and the Technical Requirements and Standards Office (EST). In general, application of AFSCM 375-5 to programs already "downstream" is not recommended.

6. The focal point for review of engineering documentation determined applicable to a particular program by the SPO is the Technical Requirements and Standards Office. A Technical Report, ESD-TR-66-256, entitled, "Electronic Systems Division Programs and System Engineering Management Procedures, AFSCM 375-5," suggests methods of applying AFSCM 375-5 to the different types of ESD programs.

APPENDIX D

PROPOSED CONTRACT END ITEM DETAIL SPECIFICATION (COMPUTER PROGRAM) PART I AND PART II

The following AFLC/AFSC Form 9's are taken from a proposed ESD Technical Requirements and Standards Office (EST) Supplement to AFSCM 375-1.

TITLE	NUMBER (Appropriate TSAF block number)
Contract End Item Detail Specification (Computer) Program) Part I ESD 236	

USE

The computer program contract end item (CPCEI) specification is the detailed specification of computer programs which have been designated as CPCEIs for a planned operational Air Force system. Part I is usually a product of a definition phase, but not limited to a definition phase, and is used to contract for the design and development of the CPCEI.

INTERRELATIONSHIP

The computer program CEI specification is a part of the integrated approach to Configuration Managament (also see Data Items C-1 through C-17) as required by AFSCM 375-1.

DATE

2 March 1966

OFFICE OF PRIMARY RESPONSIBILITY

AFSC

DDC REQUIRED

REFERENCES (Authority - Regulation, etc.)

AFSCM 375-1

PREPARATION INFORMATION

The contractor shall prepare Part I of the CEI Detail Specification for each computer program contract end item. Contents of this specification shall be arranged in accordance with the format and paragraph headings described below. The following instructional pages are numbered or otherwise identified to define the contents of the Part I Specification.

Preparation of the Computer Program Specification, Part I. The Part I specification describes in mathematical, logical, and operational language all of the detail necessary to initiate and carry out the design of a required computer program contract end item. In addition to providing the primary design to guide for the computer programming design and development effort during the acquisition phase, this document provides (a) the basis for approval by the procuring and using agencies of the fine detail of the performance of the computer programs to be developed, (b) the instrument which defines all essential interfaces with other computer programs, equipment, and communications links, (c) the direct basis for the development of support documentation associated with operation and use of the computer program, and (d) the basic vehicle for configuration control of the computer program CEI through acquisition and operational phases of the system cycle.

For convenience in describing the minimum essential content, the paragraphs outlined below are arranged in a format which might apply if the specification were to be issued as a single document. However, the specification material required for a large information system is typically too complex and bulky to be published and distributed physically in one bound volume. In this case, the material shall be arranged into separate volumes corresponding to individual functional elements, or as determined by mutual agreement between the contractor and procuring agency to meet the requirements of a particular system. At least one volume of the series shall utilize the complete format and content to define the performance, design, and qualification requirements for the CEI as a whole, as specified below.

Title Page (Contract End Item Detail Specification). The title page shall conform to the format of Sample Format "A," and include the following information referenced to Sample Format "A":

Specification Number. An identifier unique, within system, to this CPCEI. (See Exhibit X of AFSCM 375-1.) The first two (2) characters shall be a prefix code. The code shall consist of two (2) upper case (capital) letters. The prefix code for computer program CEIs shall be the letters "CG."

Revision Identification. Sequentially assigned character(s) to uniquely identify each revision of the specification.

NOTE: The specification number and revision identification may be composed of either, or both, alpha and/or numeric characters. Under no circumstances shall the combination of specification number and revision identification exceed 15 characters. (See Exhibit X of AFSCM 375-1.)

CEI, Contract End Item Number. (See Exhibit X of AFSCM 375-1.)

Approved Nomenclature. In accordance with Exhibit X and standard practice.

System Identification. List the system or systems which the CPCEI is designed to support. For CPCEIs which cannot be identified with specific systems, enter the phrase "Not System Computer Programs."

The title page shall be followed by introductory material as appropriate, including the End Item Configuration Chart and the Specification Change Log. Such introductory material shall be followed immediately by Part I of the specification. The introductory material between the title page for the CEI specification and the introductory page to Part I shall be numbered per standard practice for introductory material, e.g., i, ii, iii, etc.; or I, II, III, IV, etc. Part I and Part II shall each be numbered within themselves as required by the sample format, e.g., for Part I, I-1 of _____ (enter the last page number of Part I), I-2 of _____ (enter last page number of Part I), etc.; for Part II, II-1 of _____ (enter last page number of Part II), II-2 of _____ (enter last page number of Part II), etc.

Introductory Page (Part I of CEI Specification). The introductory page shall conform to the format of Sample Format "B." The identifying information appearing on this page shall be identical to the respective element of information appearing on the CEI specification title page. The preparing activity and the procuring activity responsible for the CPCEI shall validate the basic Part I in the approval blocks.

Section 1 SCOPE

This section of the CEI specification shall begin with the following opening phrase - "This part of this specification establishes the requirements for performance, design, test, and qualification of a computer program identified as (insert nomenclature and contract end item number). This CPCEI is used to (provide) (accomplish).... This CPCEI requires...." Subsequent sentence-paragraph(s) shall contain a summary of the purpose of the specification, a brief description of the functions to be performed and a brief summary of the content and composition of the specification.

Section 2 APPLICABLE DOCUMENTS

This section of the CEI specification shall begin with the following lead phrase - "The following documents, of exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and the detail content of Sections 3, 4, and 10, the detailed requirements in Sections 3, 4, and 10 shall be considered superseding requirements." Those documents (specifications, standards, drawings, bulletins, manuals, etc.) which are applicable to paragraphs within other sections of the specifications shall be listed. Within the body of the specification, reference to those documents shall be by reference to their basic document number and to the title, method number, specifically identified requirements, or other definitive designation. The format in listing the applicable documents shall comply with Defense Standard Manual M200A, Chapter V.

Section 3 REQUIREMENTS

This section shall contain performance and design requirements for the CPCEI. This section shall include the functional requirements for the CPCEI and establish those requirements which will be used for verification during test. This section shall define the CPCEI and specify design contraints and standards necessary to assure compatibility of the CPCEI with other computer programs and equipments. Performance and design requirements included herein are allocated from, identical with, or in recognition of, requirements established by the system specification. Requirements included in the system specification, which are directly related to requirements specified herein, may be incorporated by reference. Requirements shall be specified to the level of detail necessary to establish limits for design. Quantitative requirements shall be specified within the three principal subparagraphs included herein. General and descriptive material may be included in the basic Section 3.

Paragraph 3.1 Performance

This paragraph shall specify the functional requirements of the CPCEI. Quantitative requirements shall be specified within the principal subparagraphs included herein. General and descriptive material may be included in basic paragraph 3.1.

Paragraph 3.1.1 System Requirements

This paragraph shall specify the limits and/or capacities of the CPCEI performance. Requirements specified herein are the product of analysis, as well as those contained in the system specification. These characteristics are the performance parameters which must be specified to constrain design within requirements established by primary mission/use of the CPCEI, e.g., for an air defense system; this could include track capacity, number and type of inputs processed, etc. Requirements included herein shall be stated in quantitative terms, with tolerances where applicable.

Paragraph 3.1.2 Operational Requirements

This paragraph shall specify, in subparagraphs defined below, the operational requirements of the CPCEI. Requirements shall be stated in quantitative terms, with tolerances where applicable. General and descriptive material may be included in basic paragraph 3.1.2, which shall incorporate, either directly or by reference, a functional block diagram or equivalent representation of the CPCEI. The graphic portrayal shall be accomplished to the level of detail necessary to illustrate the functional operation of the CPCEI, the relationships between these functions, and the relationships between the functions and other identified system functions. This diagram is not intended to be restrictive on computer program detail design.

Requirements for separately identified CPCEI functions shall be described in subsequent paragraphs as appropriate. A subparagraph shall be included for each operational function, plus special functions such as sequencing control, displays, error detection and recovery, input and output control, real-time diagnostics, operational data recording, etc. The descriptions of these CPCEI functional requirements shall include the relative sequencing, periodicies, options, and other important relationships of each as appropriate. Paragraph 3.1.2.1 and subparagraphs will be repeated for each function above.

Paragraph 3.1.2.1 Function 1

The basic paragraph shall begin with descriptive and introductory material which defines the function and its relationship to other functions. Then, the following three subparagraphs shall specify the quantitative requirements concerning the function:

Paragraph 3.1.2.1.1 Source and Type of Inputs

This paragraph shall specify the source(s) and type(s) of input information associated with a function of the CPCEI. This shall include a description of the information, its source(s), and, in quantitative terms, units of measure, limits and/or ranges of units of measures, accuracy/precision requirements, and frequency of arrival information, etc., where applicable.

Paragraph 3.1.2.1.2 Destination and Types of Outputs

This paragraph shall specify the destination(s) and type(s) of output information associated with a function of the CPCEI as a result of the processing described in paragraph 3.1.2.1.3. This shall include a description of the information, its destination(s) and, in quantitative terms, units of measure, accuracy/precision requirements, frequency of output information, etc., where applicable.

Paragraph 3.1.2.1.3 Information Processing

This paragraph shall specify the information processing associated with this function. The paragraph shall incorporate a detailed prose and mathematical description, including necessary logical concepts, timing requirements, mathematical techniques, required accuracies with tolerances, data manipulation considerations, and options. A graphic portrayal of this function shall be included for clarity as appropriate.

Paragraph 3.1.3 Data Base Requirements

This paragraph shall specify, in descriptive and quantitative terms, the requirements for all parameters which affect the design of the CPCEI. The detailed definition of parameters shall include a description of the data and quantitative definitions of units of measure, ranges of units of measure, and accuracy/precision requirements where applicable. In the case of a multi-site system in which the actual data values of certain parameters will vary among site installations, the complete set of such site adaptation parameters shall be identified either directly in a separate subparagraph or by reference. In addition, where applicable, this paragraph shall specify the methods necessary to convert these parameters into a form suitable for use by the computer program.

Paragraph 3.1.4 Human Performance

Human performance/human engineering requirements for the CPCEI shall be specified in this paragraph; for example: minimum times for human decision making, maximum time for program responses, maximum display densities of information, clarity requirements for displays, etc. For CPCEIs which directly support a system(s), this paragraph

shall cite the appropriate paragraph(s) of the system specification which establish the human performance/human engineering requirements for all system equipment, and incorporate requirements peculiar to this CPCEI on an add and/or delete basis.

Paragraph 3.2 CEI Definition

This paragraph shall, in subparagraphs included herein, specify the functional relationship of the CPCEI to other equipment/computer programs and identify government furnished computer programs incorporated in the CPCEI. General and/or descriptive material may be included in basic Paragraph 3.2.

Paragraph 3.2.1 Interface Requirements

This paragraph shall specify, either directly or by reference, requirements imposed on the design of the CPCEI because of its relationship to other equipment/computer programs. It also includes detailed interface definition resulting from contractor analysis and requirements contained in the system specification. General and/or descriptive material may be included in basic Paragraph 3.2.1. Quantitative requirements shall be included in the subparagraphs included herein.

NOTE: Interfaces defined in this section shall include, at a minimum, all relevant characteristics of the computer, such as memory size, word size, access and operation times, interrupt capabilities, and special hardware capabilities. If the compiler/assembler is another, or part of another CEI, the computer program language(s) to be employed shall be specified as one of the interfaces in subparagraph 3.2.1.2. If the compiler/assembler is a Government-furnished component to be incorporated into this CPCEI, it shall be referenced in subparagraph 3.2.2. If this compiler/assembler is to be constructed as part of the development of this CPCEI, the language characteristics are to be defined under paragraph 3.1, "Operational Requirements."

Paragraph 3.2.1.1 Interface Block Diagram

The relationship of the CPCEI to other equipment/computer programs with which it must interface, shall be graphically portrayed in this paragraph. This paragraph shall incorporate, in subparagraphs as appropriate, either directly or by reference, a functional block diagram or equivalent representation of the interface requirements of the CPCEI. The graphic portrayal of the CPCEI shall be accomplished to the level of detail necessary to identify the functional interfaces between the CPCEI and other identified equipment/computer programs.

Paragraph 3.2.1.2 Detailed Interface Definition

This paragraph shall specify, in subparagraphs as appropriate, the functional relationship of the CPCEI to interfacing equipment and computer programs. This information shall be given in quantitative terms with tolerances where applicable to the level of detail necessary to permit design of the CPCEI. Functional interfaces shall specify the input/output requirements of the CPCEI in terms of data rate, message format, etc. In addition, this paragraph shall specify design requirements imposed upon other equipment/computer programs as a result of the design of this CPCEI, e.g., operator console equipment, display characters, etc. This paragraph shall incorporate, either directly or by reference, interface drawings and/or other documentation necessary to specify the functional interfaces of the CPCEI with other equipment/computer programs.

Paragraph 3.2.2 Government Furnished Property List

This paragraph shall list the government furnished computer programs which the CPCEI must be designed to incorporate. The listing shall identify the program by nomenclature, specification number, model number, if appropriate, and associated documentation.

Paragraph 3.3 Design Requirements

This paragraph shall specify, in appropriate subparagraphs, requirements which affect the design of the CPCEI, and are distinguishable from the performance requirements of peragraph 3.1. These requirements result from general considerations of CPCEI useability. These may include but are not limited to requirements for:

a. The use of programming standards to assure compatibility among computer program components (CPCs - Subprogram or groups of subprograms).

b. Program organization, such as over-all program segmentation.

c. Program design resulting from consideration of modifications to the CPCEI during operation; for example, on-site modification requirements and the permissible amount of operational degradation allowed during installation of modifications may be specified.

d. Special features, to facilitate the testing of the CPCEI. For example, special procedures for the design of CPC interfaces, requirements for intermediate printouts, and commentary on the program listing may be required.

e. Expandability (growth potential) to facilitate modifications and additions to the CPCEI.

Section 4 QUALITY ASSURANCE PROVISIONS

Requirements for formal verification of the performance of the CPCEI in accordance with the requirements of Section 3 of this specification shall be specified in this paragraph. Formal verification of performance of the CPCEI shall determine acceptance of the CPCEI. This paragraph shall specify formal verification requirements to a level of detail which:

a. Designates verification requirements and methods in Section 4 for performance and design requirements in Section 3. The methods of verification to be specified herein may include inspection of the CPCEI, review of analytical data, demonstration tests, and review of test data.

b. Specifies requirements for verification to the level of detail necessary to clearly establish the scope and accuracy of the test method.

c. Permits ready identification of each verification requirement specified in Section 4 with the appropriate performance/design requirement paragraph in Section 3.

d. Allocates verification requirements to the subparagraphs included herein.

NOTE: This section shall not incorporate, either directly or by reference, detail test planning documentation and operating instructions. Requirements specified herein shall be the basis for preparation and validation of such documents. All test/verification requirements shall be specified within the subparagraphs included herein.

Paragraph 4.1 Category I Test

The term "Category I Test" as used herein is defined to include all testing of the CPCEI, other than that accomplished during the formal Category II and III (or equivalent) system test programs. (See paragraph 4.2 below.) Category I testing is subdivided into the following broad types of the test data.

a. Computer Programming Test and Evaluation. Tests conducted prior to and in parallel with preliminary or formal qualification tests. These tests are oriented primarily to support the design and development process.

b. Preliminary Qualification Tests. Formal tests oriented primarily towards verifying portions of the CPCEI prior to integrated testing/formal qualification tests of the complete CPCEI. These tests will typically be conducted at the contractor's design and development facilities.

c. Formal Qualification Tests. Formal tests oriented primarily towards testing of the integrated CPCEI, normally using operationally-configured equipment at the Category II site prior to the beginning of the CPCEI performance which were not verified by preliminary tests.

Paragraph 4.1.1 Computer Programming Test and Evaluation

This paragraph shall contain the following:

a. Government-furnished Equipment and/or Facilities. This paragraph shall specify all government-furnished equipment and/or facilities required by the contractor to perform design and development activities.

b. Test Requirements. Programming Test and Evaluation which satisfy one or both of the criteria listed below shall be included herein. (Routine tests accomplished in support of design and development, which do not satisfy one or both of these criteria, shall not be specified herein.)

(1) They are intended to be the only source of data to qualify specific requirements in Section 3.

(2) They must be accomplished as part of an integrated test program involving other systems/equipment/computer programs, e.g., verification of requirements in Paragraph 3.2.1.2.

NOTE: Requirements for verification included in the system specification which are directly related to requirements specified herein may be incorporated herein by reference to avoid redundant establishment of the requirement.

Paragraph 4.1.2 Preliminary Qualification Tests

This paragraph shall specify only those preliminary qualification requirements which require formal recognition by the Air Force and are oriented toward verifications of portions of the CPCEI with respect to the Part I specification prior to integrated testing of the complete CPCEI. Testing accomplished by the contractor in support of design and development which does not require recognition by the Air Force, other than that it is within the general terms and conditions of a contract, shall not be specified herein. Requirements for preliminary qualifications specified herein shall reference requirements in Section 3.

Paragraph 4.1.3 Formal Qualification Tests

This paragraph shall specify requirements for formal qualification of the integrated CPCEI to demonstrate and/or verify that the requirements

established in Section 3 have been satisfied. This paragraph shall, in subparagraphs as appropriate, specify the requirement and method of verification for the requirements specified in Section 3, with the following exceptions:

a. The requirement in Section 3 has been identified, and verification that it has been satisfied has been accomplished by one of the tests included in Paragraphs 4.1.1 and 4.1.2.

b. The requirement in Section 3 is peculiar to Category II type system testing and will be identified in Paragraph 4.2.

Verification of the requirements may be accomplished by inspection, or review of analytical data, or by demonstration, or test and review of test data, or combinations of these. This paragraph may contain a subparagraph for each of the principal methods of verification, and specify therein the requirements of Section 3 to be verified by the method.

Paragraph 4.2 Category II System Test Program

This paragraph shall identify requirements specified in Section 3 which cannot be verified until Category II testing and must be listed as a Category II test requirement.

Section 6 NOTES

This section shall include information which is stated here for administrative convenience only, and is not a part of the specification for the CPCEI in the contractual sense, i.e., it shall not include requirements which constrain design, development, and qualification of the CPCEI and require compliance by the contractor.

This section of the specification shall include information of particular importance to the procuring agency in using this particular specification as a contractual instrument for acquisition of the CPCEI either initially or for follow-on procurement.

Background information or rationale which will be of assistance in understanding the specification itself or using the CPCEI it specifies, may be included herein, e.g., technical data ordering instructions.

Section 10 APPENDIX

Requirements specified in the appendix are contractually a part of the specification, and to the extent they impose requirements on design,

development, and qualification of the CPCEI, they must be satisfied. This section may include, but not be limited to, requirements which are:

a. Bound separately for convenience, as in the case of a classified appendix or a large body of statistical data.

b. Of temporary nature, as in the case of an interim performance requirement peculiar to early test models of the CPCEI. (Requirements peculiar to early test articles of the CPCEI shall be specified in an appendix which adds to, deletes, changes, or establishes new requirements applicable to Sections 3 or 4 of Part I.)

Instrumentation requirements for test articles of the CPCEI shall be specified only to the level of detail necessary to establish the type and total capacity of the instrumentation. Requirements specified herein (with the exception of instrumentation) shall be specified to the level of detail required by the paragraphs in Sections 3 and 4 of Part I to which they relate.

SAMPLE FORMAT "A"

Specification No. _____

Volumes _____

CONTRACT END ITEM DETAIL SPECIFICATION (COMPUTER PROGRAM)

PERFORMANCE/DESIGN REQUIREMENTS AND DETAILED TECHNICAL DESCRIPTION

(CEI Number)

(Approved Nomenclature)

for

(System Name) (System)

SAMPLE FORMAT "B"

Specification No. _____

Vol._____of_____Volumes

Contract End Item Detail Specification

Part I

Performance/Design Requirements

(CEI Number)

(Approved Nomenclature)

Approved by_____
(Preparing Activity)

Date_____

Approved by_____
(SPO or Equivalent)

Date_____

TITLE	NUMBER (Appropriate TSAP block number)
Contract and Item Detail Specification (Computer Program) Part II ESD 237	

USE

The Part II specification is the detailed technical description of a computer program CEI. This description shall be identical to the actual computer program developed by the contractor. The Part II specification is a product of a program acquisition phase and is one of the instruments used for CEI acceptance. The Part II specification defines the product configuration baseline and also serves as an essential instrument for subsequent use by in service and/or contractor personnel in diagnosing trouble, making adaptation changes, and designing modifications to the computer program CEI.

INTERRELATIONSHIP

The Computer Program Specification (CPCEI) is a part of the integrated approach to Configuration Management (also see Data Items C-1 through C-17) as required by AFSCM 375-1.

DATE

22 March 1966

OFFICE OF PRIMARY RESPONSIBILITY

AFSC

DDC REQUIRED

REFERENCES (Authority - Regulation, etc.)

AFSCM 375-1

PREPARATION INFORMATION

The contractor shall prepare Part II of the CPCEI Detail Specification for each contract end item computer program in accordance with the attached format.

Part II (Computer Program Technical Description) of the specification provides a complete technical description of the computer program CEI functions, structures, operating environment, and constraints, data organization, diagrammatic/narrative flows, and source statement/machine language listings. Part II of the CPCEI specification is a product of the design and development contract. The integrity of Part II is established by First Article Configuration Inspection (FACI) prior to its acceptance by the procuring agency. Acceptance is dependent upon the accuracy and completeness with which it describes both the gross and detailed structure and functioning of the computer program.

Preparation of the Computer Program Specification, Part II. The Part II specification is a complete and detailed technical description of the computer program CEI. Part II must be identical to the actual computer program CEI which results from the contractor's developmental work during the acquisition phase, and which is qualified (or to be qualified) under the terms and conditions of the contract as meeting the detailed performance requirements initially specified in Part I of the CPCEI detail specification.

For convenience in describing the minimum essential content, the format specified below is one which might apply if the specification were to be issued as a single document. Typically, however, the Part II specification material for a large and complex computer program CEI will be too bulky to be feasibly published and distributed physically in one bound volume. Where this is the case, the material shall be arranged into separate volumes corresponding to individual computer program components; or as determined by mutual agreement between the contractor and procuring agency to meet the requirements of the given system. At least one volume of the series shall utilize the complete format and content to define the structure and functioning of the CPCEI as a whole, as specified below, and the material of paragraph 3.2 may be arranged in separate volumes.

Introductory Page (Part II of CPCEI Specification). The introductory page shall conform to the format of Sample Format "E." The identification appearing on this page shall be identical to the respective elements of information appearing on the CEI specification title page. The preparing activity and the procuring agency shall validate the basic Part II in the approval blocks.

Section 1 SCOPE

This section shall contain the following lead phrase: This specification establishes the requirements for complete identification and acceptance of (insert contract end item number and nomenclature) to be formally accepted by the procuring agency, subsequent to establishment of the product configuration baseline. The product configuration baseline shall be established by First Article Configuration Inspection (FACI) for serial number (insert CPCEI serial number). Subsequent changes to the CEI shall be processed in accordance with Exhibit (IX) Addendum, AFSCM 375-1.

Section 2 APPLICABLE DOCUMENTS

This section of the specification shall begin with the following lead phrase: "The documents, of exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and the detail content of Sections 3, 4, 5, and 10, the detail contents of Sections 3, 4, 5, and 10 shall be considered a superseding requirement." List those documents (specifications, standards, bulletins, manuals, etc.) which are applicable to paragraphs within other sections of the specification. Within the body of the specification, reference to these documents shall be by reference to their basic document number and to the title, specifically identified requirements, or other definitive designation.

Section 3 REQUIREMENTS

This section shall specify the detailed configuration of the CPCEI. This section shall contain a complete technical description of the CPCEI structure and functions, the data base, and the individual CPCs. General and/or descriptive material may be included in basic Section 3 lead paragraph.

Paragraph 3.1 CPCEI Characteristics

This paragraph shall contain a description of the over-all structure and functions of the CPCEI. This description shall include: the allocation of functions to the CPCs that comprise the CPCEI; flow charts; timing and sequencing characteristics of the CPCEI; and a graphic portrayal of storage allocation. This description shall be given in the following paragraphs.

Paragraph 3.1.1 Functional Allocation

The relationship of each computer program component (CPC) to the performance and design requirements of the Part I Detail Specification shall be specified in this paragraph. This relationship will be specified to the level of detail necessary to identify how the computer program components are associated with the requirements of the functions specified in the Part I specification. If the CPCs are grouped into functional entities ("packaging") for separate stages of development and checkout, this grouping shall be delineated.

Paragraph 3.1.2 CPCEI Flow Chart

This paragraph shall graphically portray the operations performed by the CPCEI. This shall be done by a (series of) flow chart(s) which depict the processing being performed, the sequence of operations, and decision points. A "top-level" flow chart shall be used to depict in a single figure the over-all information flow of the CPCEI. This diagram shall reference lower level flow charts included in this paragraph, as appropriate, to provide more detailed information. The lowest level flow charts shall be those which identify as functional entities the computer program components described in section 3.2 below. All symbology used in the flow chart shall be defined either directly in this paragraph or on the individual flow chart sheets, or by reference to a documented set of standards.

Paragraph 3.1.3 CPCEI Timing and Sequencing

This paragraph shall describe the timing and sequencing of operations of the computer program components relative to each other. If the sequencing is dynamically controlled during the CPCEI's operations, this description shall include the method for sequence control and the logic and input conditions of that method. Such factors as timing variations, plus such internal operations as data transfers in and out of core, disc, drum, or tape memory, sensing of discrete input signals, and the timing relationships between interrupt operations within the CPCEI shall be included.

Paragraph 3.1.4 Storage Allocation

The relationship of the CPCEI storage requirements to the total computer equipment storage capability shall be graphically portrayed in this paragraph. This paragraph shall incorporate, in subparagraphs as appropriate, either directly or by reference, a schematic diagram, or equivalent representation. This graphic portrayal of the CPCEI shall be accomplished to the level of detail necessary to identify such requirements as: Data base allocation, computer program allocation, computer program

operation allocation, and spare storage allocation. If allocations cannot be specified precisely or portrayed graphically in a manner meaningful for program design, the algorithms used to allocate storage will be included.

Paragraph 3.1.5 Data Base Characteristics

This paragraph shall include a detailed definition of the content and storage location of each file, table, and item within each table that is incorporated in the CPCEI data base, as well as the storage location of each computer program component contained in the CPCEI. This paragraph will contain the following:

a. "File Description." A list of files that have been incorporated in the computer program data base shall be included. This shall include a descriptive title for each file, length of file, and format, etc.

b. "Table Description." A list of tables that have been incorporated in the computer program data base shall be included. This shall include a descriptive title for each table, method of indexing the table, length of table, and block format for item and itemless tables, etc.

c. "Item Description." A list of all items contained in the computer program data base shall be included. This shall include for each item, a descriptive title, most significant bit, number of bits, coding type, scaling factor, and, if appropriate, units and item value, etc.

d. "Graphic Table Description." The relationship of the items specified in c above "Item Description" to the tables listed in b above and the relationship of tables specified in b above to the files listed in a above will be graphically portrayed. This shall incorporate, in subparagraphs as appropriate, either directly or by reference, a diagram or equivalent representation. The graphic portrayal of each table shall be accomplished to the level of detail necessary to identify words per block, untagged items, bits/items, bit allocation, number of blocks, and type of table construction.

e. "Data Organization." A definition of the relationship of the items, table, and files contained within the data base, and the computer program components described in paragraph 3.2 to locations in computer storage, shall be included. This paragraph will incorporate such information as the following:

(1) A list of files, specifying for each file the address in storage and number of tables contained in the file, etc.

(2) A list of tables, specifying for each table the location within the file and number of words contained in the table, etc.

(3) A list of items, identifying item location within the table, number of bits, item type, scaling, etc.

(4) A list of computer program components, specifying for each the storage address and number of words allocated.

f. "CPCEI Constants." A list of all constants (e.g., fixed values assigned to the parameters defined in paragraph 3.1.3, Part I CPCEI specification) contained in the CPCEI, other than those which are defined as "Adaptation Data" below shall be included. The list contained herein shall include, as a minimum, a description of each constant and its actual numerical or coded value.

g. "Adaptation Data." For multi-site computer based systems, the actual data required to adapt the CPCEI to the environment associated with each site shall be listed. For convenience, this information may be contained in Section 10, "Appendix."

h. "Relationship of Computer Program Components to Data Base." The relationship of the various computer program components to the various tables and items contained in the CPCEI data base shall be graphically portrayed. This paragraph shall incorporate, in subparagraphs as appropriate, either directly or by reference, a diagram or equivalent representation. This graphic portrayal of the relationship of CPCs to the data base shall be accomplished to the level of detail necessary to identify the tables and items within the tables required by each computer program component to the relationship of the CPC to each table/item (e.g., sets the item, uses the item, etc.). The use of such tables and items by each CPC shall be fully described in the appropriate subparagraphs under paragraph 3.2.

Paragraph 3.2 Computer Program Component Characteristics

The individual computer program components (CPCs) shall be described in separate paragraphs as required. This description shall be given at a level of detail that will define the design and configuration of the CPC sufficiently to allow for CPC modification and adaption to the operation phase. Each CPC shall be described in words, flow charts, and with a listing of the instructions used. The basic paragraph 3.2 shall contain the following lead phrase: "This paragraph contains the detailed technical descriptions of the computer program components identified in paragraph

3.1 of this specification. The instruction listings contained herein by inclusion or reference specify the exact configuration of the (name of CPCEI)...." The following subparagraphs will be repeated for each CPC.

Paragraph 3.2.1 Computer Program Component 1

The basic paragraph shall identify the CPC by including as a minimum, the title, tag (symbolic code) and component identification number. It shall also include a brief abstract of the functions of the CPC, the language(s) in which it is written and its major functional interfaces. The CPC shall then be described in detail in subparagraphs.

Subparagraph 3.2.1.1 CPC No. 1 Description

This subparagraph shall describe in words, figures, equations, and references to the flow chart(s) of subparagraph 3.2.1.2, the functions and design of the CPC. This subparagraph shall contain, as appropriate, a description of the program logic and data flow; equations to be solved; algorithms used to solve these equations; timing and accuracy characteristics; and any special conditions for operation of the CPC. The description shall be sufficiently detailed to facilitate understanding of, and modification to, the listing given in subparagraph 3.2.1. Equation derivations and numerical analysis shall not be included herein, but may be included in Section 6, "Notes."

Subparagraph 3.2.1.2 CPC No. 1 Flow Chart

This subparagraph shall graphically portray the operations performed by the CPC. This shall be done by a (series of) flow chart(s) which depict the processing described in subparagraph 3.2.1.1, including the sequence of operations and decision points, in the CPC. The "highest level" flow chart shall depict on a single sheet the over-all information flow of the CPC and shall reference the flow chart(s) in paragraph 3.1.2 that identifies the CPC. In general, the lowest level flow chart identifies all decision points in the CPC and references higher level charts as appropriate. All flow charts shall use descriptive symbology and shall reference the program listing of the CPC by use of statement labels or tags. All symbology used in the flow chart shall be defined in this subparagraph, or by reference to paragraph 3.1.2 above, or by reference to a documented set of standards, or on the individual flow chart sheets.

Subparagraph 3.2.1.3 Interfaces

This subparagraph shall describe the relationship of the CPC to other CPCs, to that part of the data base external to the CPC, and, where applicable, to other CPCEIs. Appropriate subparagraphs shall include:

a. The exact format, content and source of all input data.

b. The exact format, content and destination of all output data.

c. A list of the subroutines called by the CPC.

d. A list of other CPCs which call the CPC.

e. A list of external (to the CPC) tables, buffers, constants, control registers used by the CPC.

Subparagraph 3.2.1.4 CPC Data Organization

This subparagraph shall contain or refer to a portion of subparagraph 3.2.1.6, if appropriate, a list and description of all data items and tables which are unique to and included within the CPC, and shall describe the areas of memory available for temporary storage. This list shall include all internally defined symbols and their equivalence and meaning.

Subparagraph 3.2.1.5 Limitations

This subparagraph shall summarize any known or anticipated limitations of the CPC. A listing of all restrictions and constraints which apply to the CPC shall be provided, including timing requirements, limitations of algorithms and formulas used, limits of input and output data, associated error correction sensing, and the error checks programmed into the routines.

Subparagraph 3.2.1.6 Listing

This subparagraph shall contain a complete listing of instructions contained in the computer program component(s). The type of listing provided in this paragraph shall be established between the contractor and the procuring agency. The listing will show the relationship to the flow diagrams above by appropriate use of statement labels or tags. For convenience, the listing may be included in Section 10, "Appendix."

Section 4 QUALITY ASSURANCE

This section shall specify the tests required to satisfy quality assurance provision given in Section 4 of the Part I specifications.

Subparagraph 4.1 Test Specifications Cross Reference Index

In this subparagraph, all Test Plan and Test Specification documents shall be referenced, with cross indexing to the CPCEI functions being tested

and the CPCEI components and other computer programs required for the tests. This subparagraph shall also describe or reference special simulation capabilities required for test/verification of the CPCEI.

Subparagraph 4.2 Other Quality Assurance Provisions

This paragraph shall reference applicable standards and/or specify the test/verification requirements, methods and procedures which apply to duplication of the computer program (e.g., tapes and/or card decks) which are covered by the specification.

Section 5 PREPARATION FOR DELIVERY

This section shall specify, in subparagraphs as appropriate, the requirements for packaging, marking and otherwise preparing the CPCEI for shipment and/or storage. Where approved existing Government Specifications are adequate to satisfy current requirements for the item these shall be incorporated by reference in lieu of providing duplicate detailed requirements in this section. Where suitable specifications do not exist, requirements peculiar to the CPCEI shall be specified in appropriate subparagraphs included herein.

Subparagraph 5.1 Packaging Requirements

This paragraph shall describe the packaging requirements of the completed CPCEI. Packaging requirements include a description of the product packaging (card decks, tapes, manuals), preservation methods, packing, etc., involved in preparing the CPCEI for shipment and/or storage. Special handling requirements or other special considerations will be included in this subparagraph.

Subparagraph 5.2 Markings

This subparagraph shall specify in detail the identification markings to appear on every separable portion of the CPCEI to be delivered by the contractor and formally accepted by the procuring agency.

Section 6 NOTES

This section of the specification is not contractually binding. It shall include information of particular importance to the procuring agency in using Part II of this specification as a contractual instrument, or administrative or background information, e.g., ordering instructions for technical data pertaining to the computer program, or specific information related to the use of the program in future assembly and integration

testing. It shall not include requirements which constrain design, development, or qualification of the CPCEI. It shall reference the technical manuals which can be singularly and peculiarly identified with the CPCEI, and which are necessary to its operation and maintenance. For each CPC, this paragraph shall include any pertinent information not included in the above subparagraphs, such as rejected alternative CPC designs, the rationale behind the design, reference material in support of the algorithms used, and suggestions for future modifications to the CPC if changes in requirements should materialize. It shall also describe as appropriate the pertinent tests which were performed to verify the final implementation of the CPC, with key test results included or referenced.

Section 10 APPENDIX

This section of the pecification may contain requirements which are part of Section 3 and/or of Section 4, but are bound separately for comments. Examples are computer-produced listing, multi-site adaptation requirements, etc.

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)*
Technical Requirements and Standards Office,
Electronic Systems Division,
L. G. Hanscom Field, Bedford, Mass.

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b GROUP
N/A

3. REPORT TITLE
ELECTRONIC SYSTEMS DIVISION PROGRAMS AND SYSTEM ENGINEERING MANAGEMENT PROCEDURES, AFSCM 375-5

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

5. AUTHOR(S) *(Last name, first name, initial)*
Gardella, Charles E.
Enright, Charles S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
April 1966	51	6

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
IN-HOUSE	ESD-TR-66-256
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	None

10. AVAILABILITY/LIMITATION NOTICES
Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
None	Technical Requirements and Standards Office, Electronic Systems Division, AFSC, USAF, L. G. Hanscom Field, Bedford, Mass.

13. ABSTRACT

This report establishes and describes a method for accomplishing the system engineering management process on programs assigned to the Electronic Systems Division. Modification to the system engineering process specified in AFSCM 375-5 for application to ESD programs is presented. Procedures for computer programs are indicated. A system engineering statement of work checklist, appropriate formats, and an appendix containing implementation instructions are also included.

DD FORM 1 JAN 64 1473

Security Classification

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
System Engineering Process Command Systems Surveillance and Control Systems Communications Systems Computer Program (Software) Formats Contract End Item Detail Specifications						

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