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CONFIGURATION MANAGEMENT OF
COMPUTER PROGRAM CONTRACT END ITEMS

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M. S. Piligian
C. J. Bashaw
J. L. Pokorney, Captain, USAF

January 1968

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

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FOREWORD

The concepts presented in this technical report were developed while the authors participated in an Air Force study to improve the management of computer program acquisition.

Captain Pokorney, who was an officer in the United States Air Force during this study, is now a consultant in the firm of Peat, Marwick, Livingston and Co., Boston, Massachusetts.

This technical report has been reviewed and is approved.



PAUL L. DEIMLING
Colonel, USAF

Chief, Technical Requirements & Standards Office

ABSTRACT

Experience at ESD in the application of AFSCM 375-1, Configuration Management During Definition and Acquisition Phases, to electronic systems/projects identified a deficiency in the area of computer programs. Attempts to apply the manual to the computer segment of a computer-based system showed that techniques to handle the computer programs portion were lacking. Techniques and procedures developed for the application of configuration management to computer programs were developed and published as ESD Exhibit EST-1 to augment the basic manual. This paper presents the concepts embodied in the exhibit and describes a program for establishing, monitoring and updating a configuration management system for computer programs acquired as part of an Air Force system.

CONFIGURATION MANAGEMENT OF
COMPUTER PROGRAM
CONTRACT END ITEMS

INTRODUCTION

As set forth in Air Force Systems Command Manual 375-1¹, configuration management is a set of procedures whereby a uniform system is established and maintained to identify, control and account for all systems/equipment (and their components) which are procured by AFSC, encompassing both the general and specific operational requirements as well as their physical content and internal disposition. In practice, configuration management provides both customer and contractor a means of ascertaining, with the desired level of precision, the physical content of a system/end item and the design parameters governing it, at any time throughout the development and operational life.

The attempt to apply these techniques to the computer segment of computer-based command and control system consistently showed that the system lacked techniques to handle the computer program portion of the system. In some instances, a recognition of the importance of identification, control and accounting of the sort provided in AFSCM 375-1 led to abridgement and make-shifts which varied from program to program, thus jeopardizing the standardization aspect; in others it was foregone completely so that the configuration management and the system management as well, suffered from large voids which effectively defeated the whole management intent.

To provide the Air Force with management techniques for computer program development, the Technical Requirements and Standards Office of ESD undertook a study of the application of AFSC 375 series Systems Management to computer programs. The first product of this study effort was a set of procedures for the application of configuration management to computer programs.

The procedures described here have been published in Electronic Systems Division (ESD) Exhibit EST-1.² The purpose of this exhibit is to augment AFSCM 375-1, "Configuration Management During Definition and Acquisition Phases", dated 1 June 1964. The exhibit is intended for use in conjunction with the parent manual prior to its incorporation in the revised version of AFSCM 375-1 which is expected to be available in the near future.

In developing these procedures we found it necessary to examine all facets of systems management to determine the relationship of the computer program to a total system. Baselines and the configuration management concept for computer programs as related to system management is presented in a typical systems management flow in Attachment 1. The procedures, as documented in the exhibit, have been coordinated extensively with Systems Command, NASA and industry. The procedures are currently being used on many system programs at ESD and have been found to operate quite successfully. In addition, the Army has recently specified these procedures in the procurement of two large tactical systems.

CONFIGURATION MANAGEMENT

The computer program configuration management procedures relate to:

- a. Configuration Identification
- b. Configuration Control
- c. Configuration Accounting

<u>IDENTIFICATION</u>	<u>CONTROL</u>	<u>ACCOUNTING</u>
Identification Procedures	Processing Procedures	Spec.Maintenance & Accounting Procedures
Part I Performance/Design Requirements	Types/Classes of Changes	Spec.Change Notice Spec.Change Log
Part II Computer Program Detailed Technical Description	ECPs	End Item Configuration Chart Configuration Index Change Status Report Version Description Document

FIGURE 1
CONFIGURATION MANAGEMENT FOR COMPUTER PROGRAMS

A computer program CEI has been defined as a deck of punched cards, tapes, or other physical medium containing a sequence of instructions and data in a form suitable for insertion into a digital computer. It is the physical object which is delivered to and accepted by the procuring agency and/or user, and as such, is subject to configuration management.

CONFIGURATION IDENTIFICATION

A system can only be technically defined by specifications, and Configuration Identification is dependent upon this technical definition. Configuration Identification is based upon the concept of Uniform Specifications, which implies simply that in each system program there should be one general specification for the system as a whole and one specification for each contract end item. General format and content requirements of the specifications are uniform for all systems. However, requirements for the system specification and CEI specifications differ. The system specification is written at the level of performance and design requirements, while the specification for each major CEI is written in two parts-- Part I is a performance/design requirements specification to establish technical requirements and design constraints, and Part II is a technical description of the actual configuration resulting from the design/development/test process. Detailed requirements for specification format and contents are different for the major classes of CEIS, i.e., for equipment, facilities, and computer programs. Once written and approved, each specification formally defines a baseline of the system, or end item. A baseline, in general, represents an established and approved configuration, constituting an explicitly defined point of departure from which changes can be proposed, discussed or accomplished.

EST-1 contains a complete and separate exhibit (Exhibit XX) to provide contractors with instructions for the preparation of detailed specifications for computer program contract end items. This exhibit is equivalent to Exhibit II for prime equipment CEIS in the present 375-1 manual. The computer program specification is in line with the Uniform Specification Program, as described in AFSCM 375-1. For computer programs, the two-part specification is as defined below:

Part I - Delineates the Performance and Design Requirements. This part of the specification is needed to specify requirements peculiar to the design, development, test, and qualification of the computer program CEI.

Part II- Delineates a Detailed Technical Description of the CEI. This part of the specification is used to describe, in detail, the exact configuration of the computer program CEI.

Having computer program CEI specifications compatible with the uniform specification program, the concept of baseline management can be applied in the same manner as for other CEIs. The Part I of the specification technically defines the Design Requirements Baseline, and the Part II of the specification technically defines the Product Configuration Baseline. Figure 2 illustrates the major sections of the specification.

<u>PART I</u>	<u>PART II</u>
PERFORMANCE/DESIGN REQUIREMENTS	DETAILED TECHNICAL DESCRIPTION
Performance Requirements	CPCEI Characteristics
Function (1)	Flow Charts
Function (2)	Timing
Function (3)	Data Base
Interface Requirements	Computer Program Components
Design Requirements	Description
Test Requirements	Flow Charts
	Interfaces
	Listings

FIGURE 2
ORGANIZATION OF COMPUTER PROGRAM SPECIFICATIONS

PART I CEI SPECIFICATION (COMPUTER PROGRAM)

The Part I specification contains performance and design requirements. The specification defines all functions to be performed by the computer programs in concise, mathematical, logical, and operational terms with tolerances and limitations. While it must be structured to reflect considerations of computer program design, and to include design requirements and constraints, it is not technically a computer program design document, but the starting point at which the design process begins.

The contents of the Part I specification are as follows:

Performance Requirements

This section defines the performance requirements for each function within the CEI. It is written in mathematical, logical and operational terms.

Interface Requirements

This section specifies the requirements imposed on the design of the computer program in order to satisfy the requirement to interface with the other elements of the system, e.g. message formats, card formats, display formats, etc.

Design Requirements

This section specifies any design requirements for the computer program. These may include specific language to be used, requirements for expansion or design modifications, programming standards, etc.

Test Requirements

This section will specify the requirements for formal verification of the performance of the CEI in accordance with the performance requirements of the sections above.

PART II CEI SPECIFICATION (COMPUTER PROGRAM)

The Part II specification for computer program CEIs contains a complete technical description of the computer programs. Unlike the prime equipment Part II CEI specification, which is primarily a production specification, the computer program Part II specification is used for diagnosing troubles, designing and installing changes, etc., to the computer program after the program has been built.

The contents of the Part II specification are as follows:

CPCEI Characteristics

The initial section of the specification describes the overall computer program design and includes such information as storage allocation, operating sequence, data base structure, identification of the functions allocated to the individual computer program components, and a flow chart showing the relationship of the components.

Computer Program Components

This section is repeated for each individual computer program component and includes a detailed description of each component. This description material includes the documentation of logical flows, narrative description, interfaces with other programs and data base, internal table description, and finally, the complete listing of the computer program instructions.

CONFIGURATION CONTROL

Configuration Control refers to the procedures by which changes to baselines are proposed and formally processed. These procedures involve standard classes and types of change proposals, as well as formal mechanisms for review, evaluation, approval, and authorization for implementing the proposed changes.

An addendum to Exhibit IX of AFSCM 375-1 has been written specifying the ECP procedures for computer programs. While certain requirements duplicate those contained in Exhibit IX, this addendum is intended to be complete and self-sufficient in its coverage of procedures pertaining to changes to computer programs. The procedures conform with the format and intent of ANA Bulletin No. 445, and are tailored to eliminate many requirements peculiar to equipment production, retrofit, and supply and they provide additional information for processing and evaluating changes to computer program CEIs.

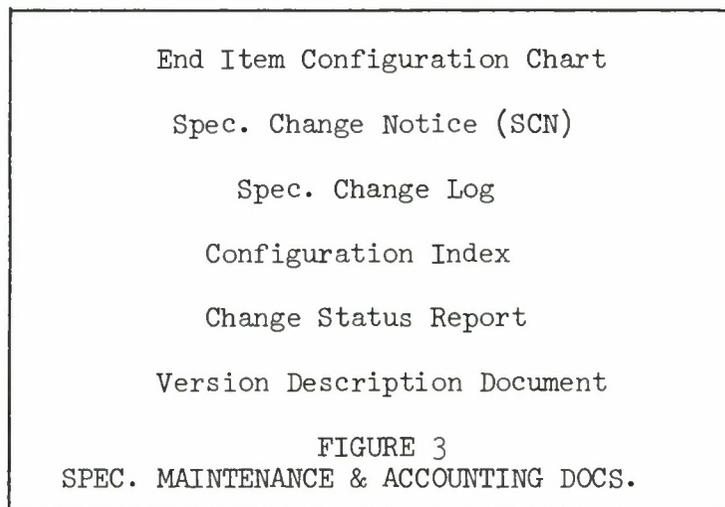
At the outset of the Acquisition Phase the contractor-prepared Part I CEI specification is approved by the procuring agency. This approval establishes the Design Requirements Baseline as a defined point of departure for configuration control. Once the Part I CEI specifications have been baselined, any changes to the Part I will be submitted, on an ECP form, as a design requirements change. The ECP will be formally approved by the Configuration Control Board (CCB) prior to effecting the change.

During the Acquisition Phase as the CEI is being developed, the Part II CEI specification is being prepared to describe the exact configuration of the CEI. Immediately prior to Category II testing a First Article Configuration Inspection (FACI) is conducted on the computer program CEI. At FACI the Part II CEI specification is accepted as an audited and approved document. After the successful completion of FACI the second computer program baseline may be established, i.e., Product Configuration Baseline. This baseline establishes a defined point of department for configuration control over the computer program detail design. In defining classes of changes to the Product Configuration Baseline, special consideration had to be given to computer program errors. It is normal to expect program errors to remain undetected in large scale programming efforts after the Product Configuration Baseline has been established. As the errors are uncovered they should be corrected as expeditiously as possible. This was taken into consideration when defining class II changes to computer programs allowing some changes to be implemented without prior approval from the CCB. However, the contractor is required to report all class II changes to the CCB.

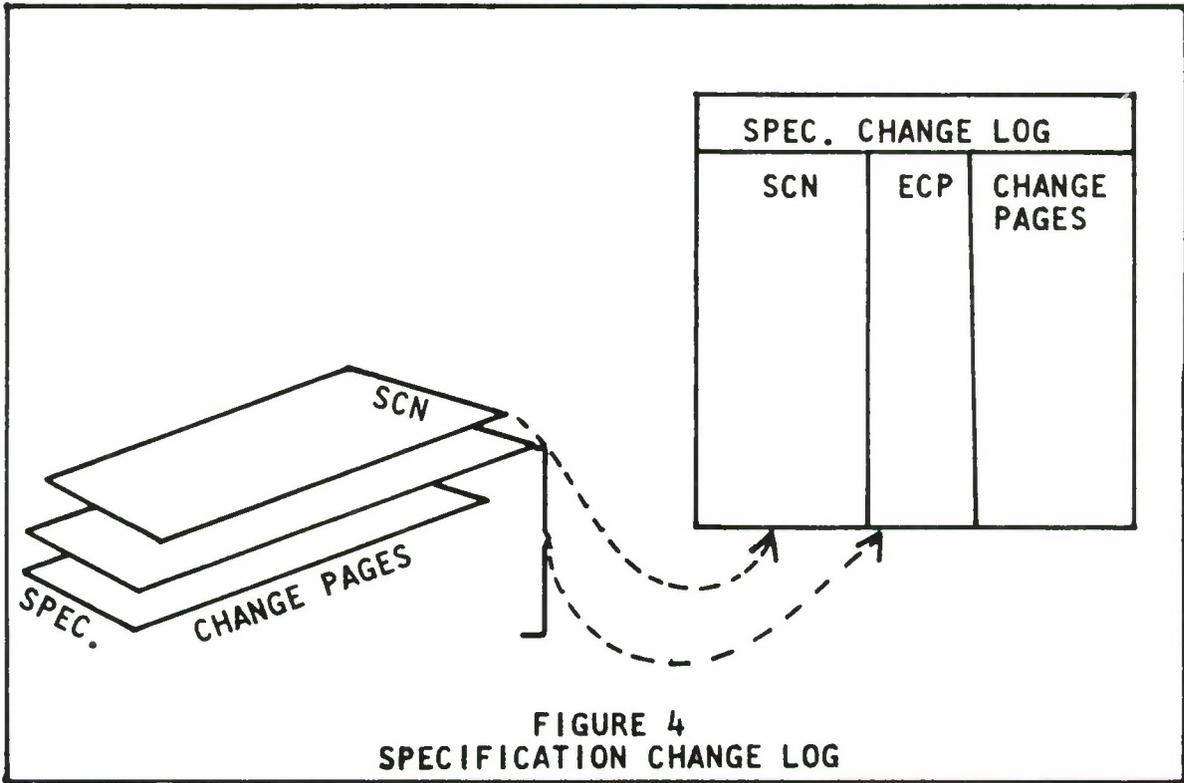
It is important that any approved change in an established computer program baseline be reflected in all derived data items (e.g., user handbooks, manuals).

CONFIGURATION ACCOUNTING

Configuration Accounting refers to the reporting and documenting activities involved in keeping track of the status of configurations at all times during the life of a system. For production items of equipment, it includes the intricate process of maintaining the status of production changes, retrofits, and spare parts for all production items in the current inventory. In the case of a computer program item, it is principally a matter of maintaining and reporting the status of the specification, associated documents, and proposed changes.

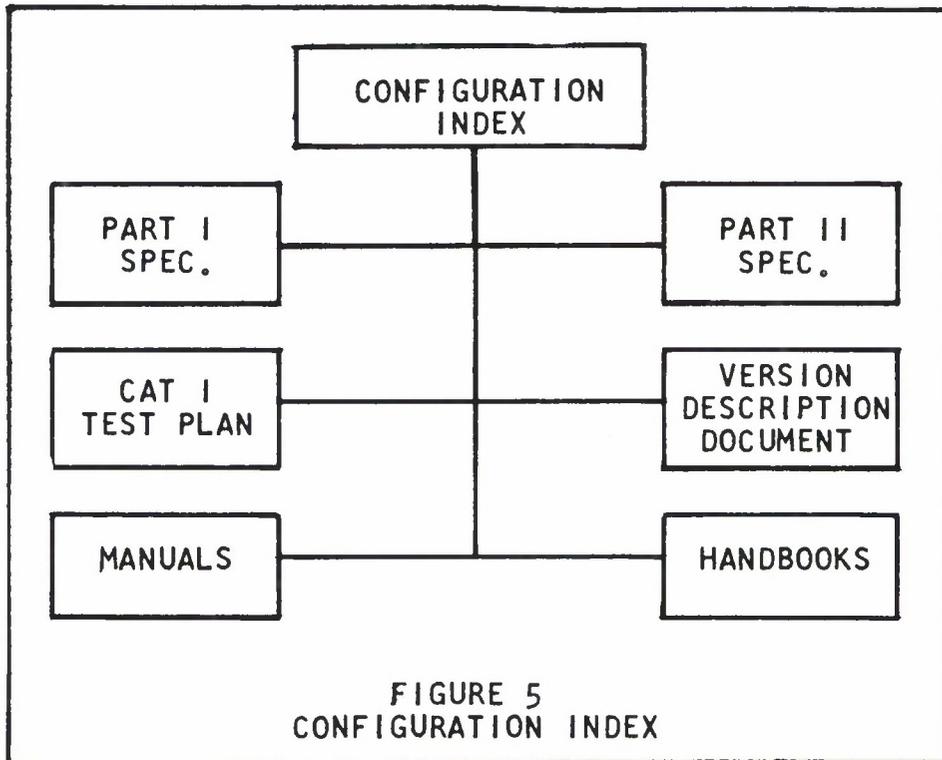


The End Item Configuration Chart is a summary record which identifies approved changes (ECPs) to the end item specification.

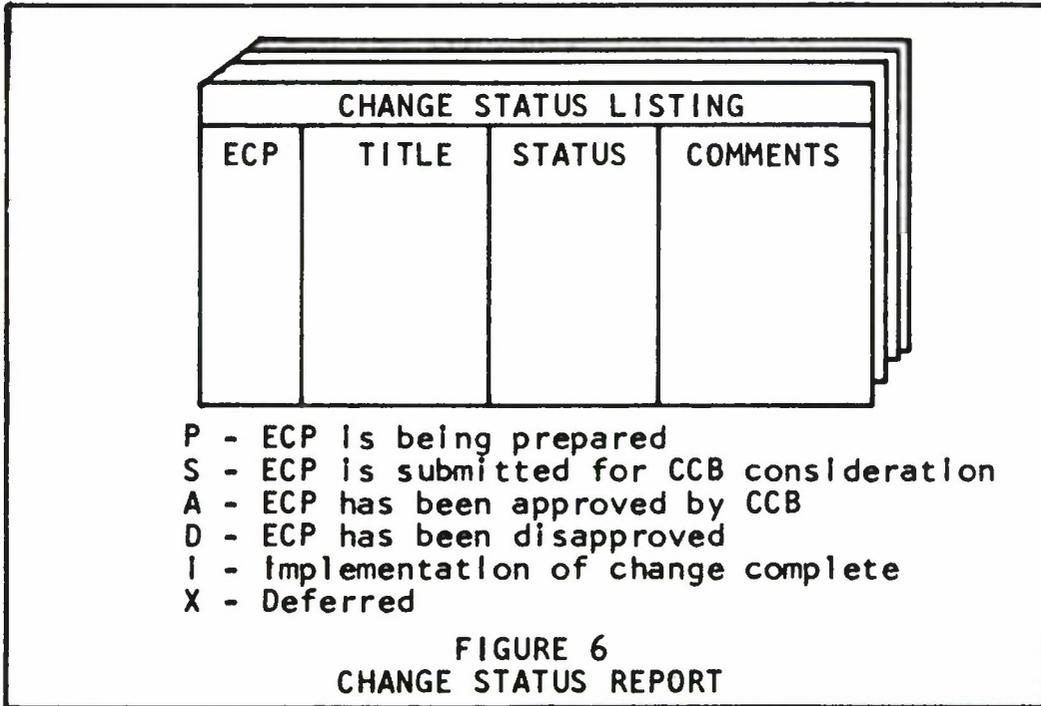


The Specification Change Notice (SCN) is used as a cover sheet for specification change pages.

The Specification Change Log provides a cross reference for SCNs, ECPs, and the associated change pages.



The Configuration Index provides an official listing of the specifications, and significant support documents. It also reflects all approved changes to these documents.



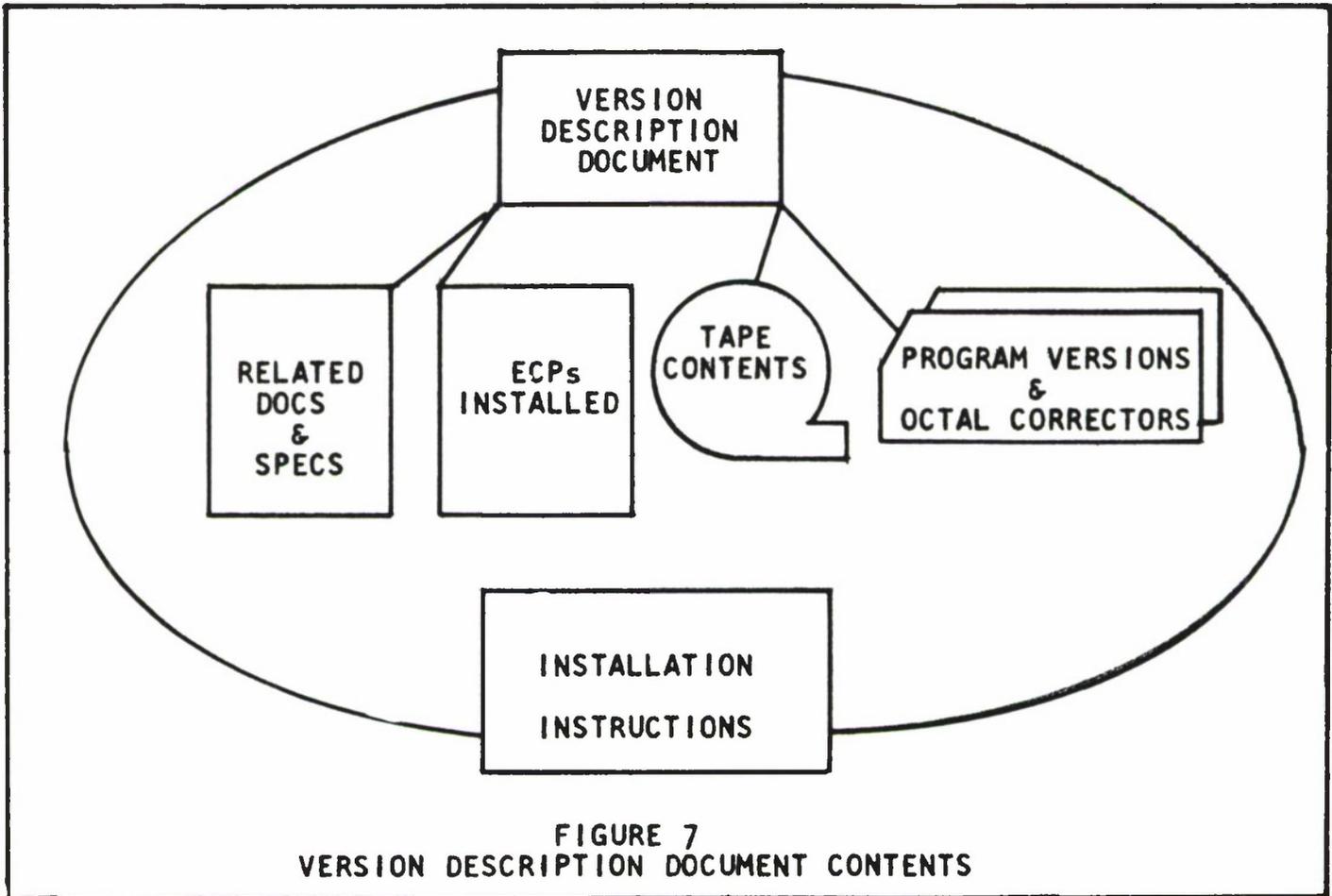
The Change Status Report details the status of all proposed changes to the computer program CEI. This report is prepared in two Parts:

Part I STATUS LISTING

This part contains a listing by number of each successive ECP prepared against the CEI with an indicator which characterizes the status of the ECP.

Part II STATUS SUMMARY

Part II of the report contains a detailed summary of the status summary of all active ECPs.



The Version Description Document accompanies the release of a computer program CEI or modification to a computer program CEI. Its purpose is to identify the elements of the computer programs delivered and to record pertinent additional data relating to status and usage.

FORMAL DESIGN REVIEWS AND INSPECTIONS

Recommended changes to Exhibit XIV of AFSCM 375-1 have been included in EST-1 defining procedures for conducting formal design reviews and inspections on computer program contract end items.

The PDR is a formal technical review of the basic design approach for contract end items. For computer program CEIs it will be conducted after the approval of the Part I specification, and at the time the computer program preliminary detail design has been accomplished and prior to the detail design of the individual computer programs. The design information, which eventually will be documented in the initial portion of the Part II, will be made available and will include such things as detailed functional interfaces, review of word lengths, message format, storage allocation, data base structure, sequence of operations, etc.

The CDR for a computer program CEI is a formal technical review of the detailed design of the CEI. The CDR is normally accomplished to establish the integrity of the computer program design prior to coding and testing. While the exhibit defines the CDR for a computer program as basically a detailed flow-chart-level review, it also provides for flexible application in the case of a complex computer program CEI which is developed in individual computer program components or blocks of programs that may reach any given stage of the design in increments. In these cases the CDR may also be scheduled in increments.

The First Article Configuration Inspection (FACI) is a formal technical reviews which establishes the adequacy of the Part II specification as an accurate and complete description of the computer program CEI. The primary product of the FACI is formal acceptance, by the procuring agency, of (1) Part II of the end item specification as an audited and approved document and (2) the first unit of the computer program CEI.

DOCUMENTATION AND PROCEDURES

While the items of interest in configuration management are contract end items, as distinct from data or services, the management process itself proves to be principally a matter of documentation and procedures. As indicated below, technical specifications are the principal substance of the Configuration Identification process. Configuration Control and Accounting are accomplished by means of other standard forms and reports. And, particularly in the case of complex computer program systems, account must be taken of technical manuals and other data prepared for the using agency, whose contents are sensitive to changes in computer program configuration.

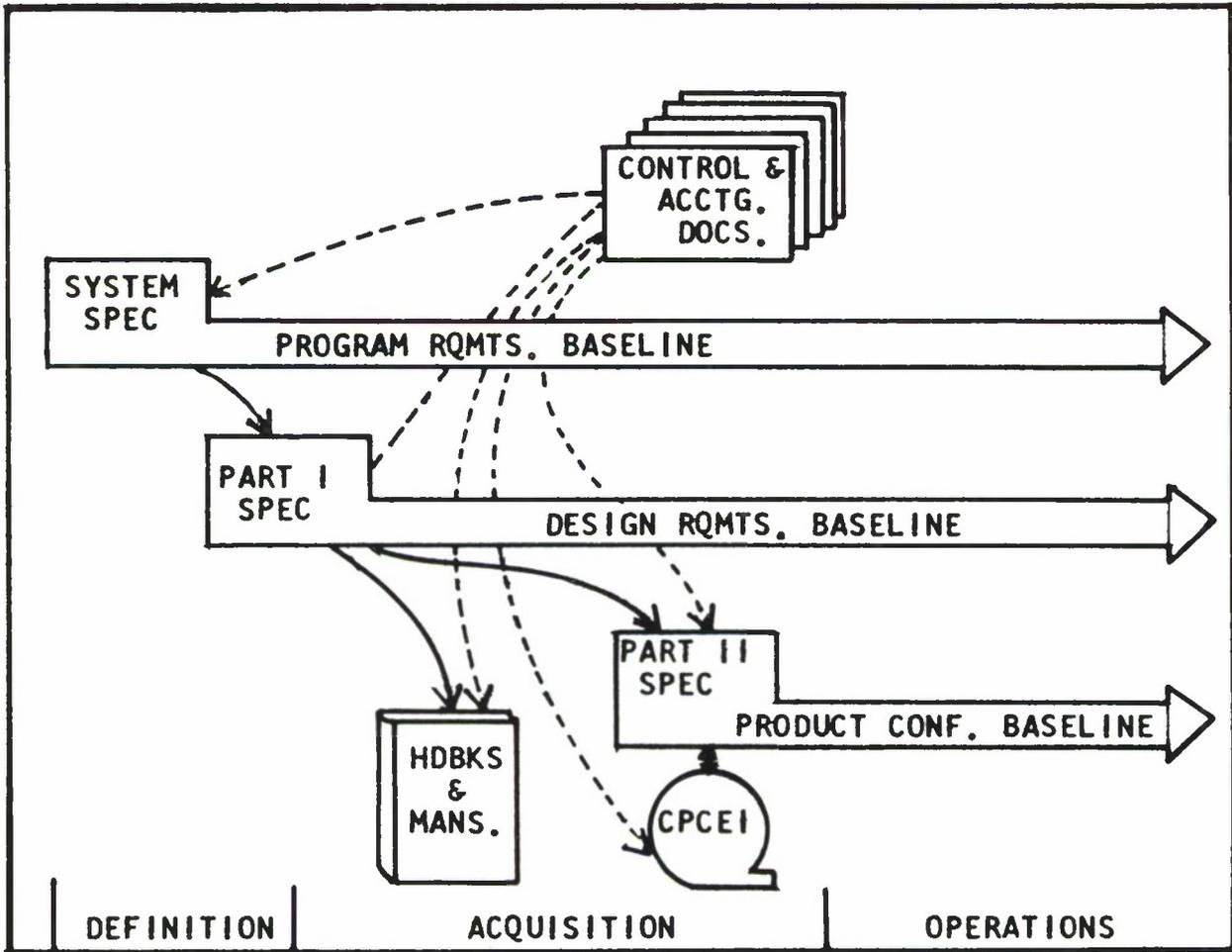


Figure 8. Sequence and Structure of Documents

Hence, the major framework of configuration management and its sub-processes can be represented as a structure of the principal documents with which standard procedures are associated. This structure is illustrated in Figure 8, which shows (a) the specifications, as the baselines which are defined and managed, (b) the dependent procedural data, in the form of handbooks or manuals, and (c) the set of forms and reports which serve as tools for control and accounting. It may be noted that the computer program contract end item (CPCEI) is also represented, in the physical form of a tape. In general, the structure begins at the outset of the Definition Phase with issuance of the System Specification, is expanded during the Acquisition Phase, and is subsequently maintained during the system's operational life. The specifications are established as the three baselines at successive times, and in dependent relations, during the developmental periods. However, no baseline is superseded by a subsequent one; each stands by itself.

RELATIONSHIP TO SYSTEM LIFE CYCLE

Configuration management is an essential part of the system management process applied throughout the life cycle of a system. The flow-chart of Attachment 1 illustrates the application of configuration management during the system life cycle. An important and often neglected concept shown by the flow-chart is that the configuration management process continues on through the operation phase. Once a baseline is established it serves as a point of departure for the life of the system. The process continues to provide the change control and accounting for computer programs which are so essential to their utilization.

The flow-chart also illustrates some of the inter-action between configuration management and systems engineering and systems testing.

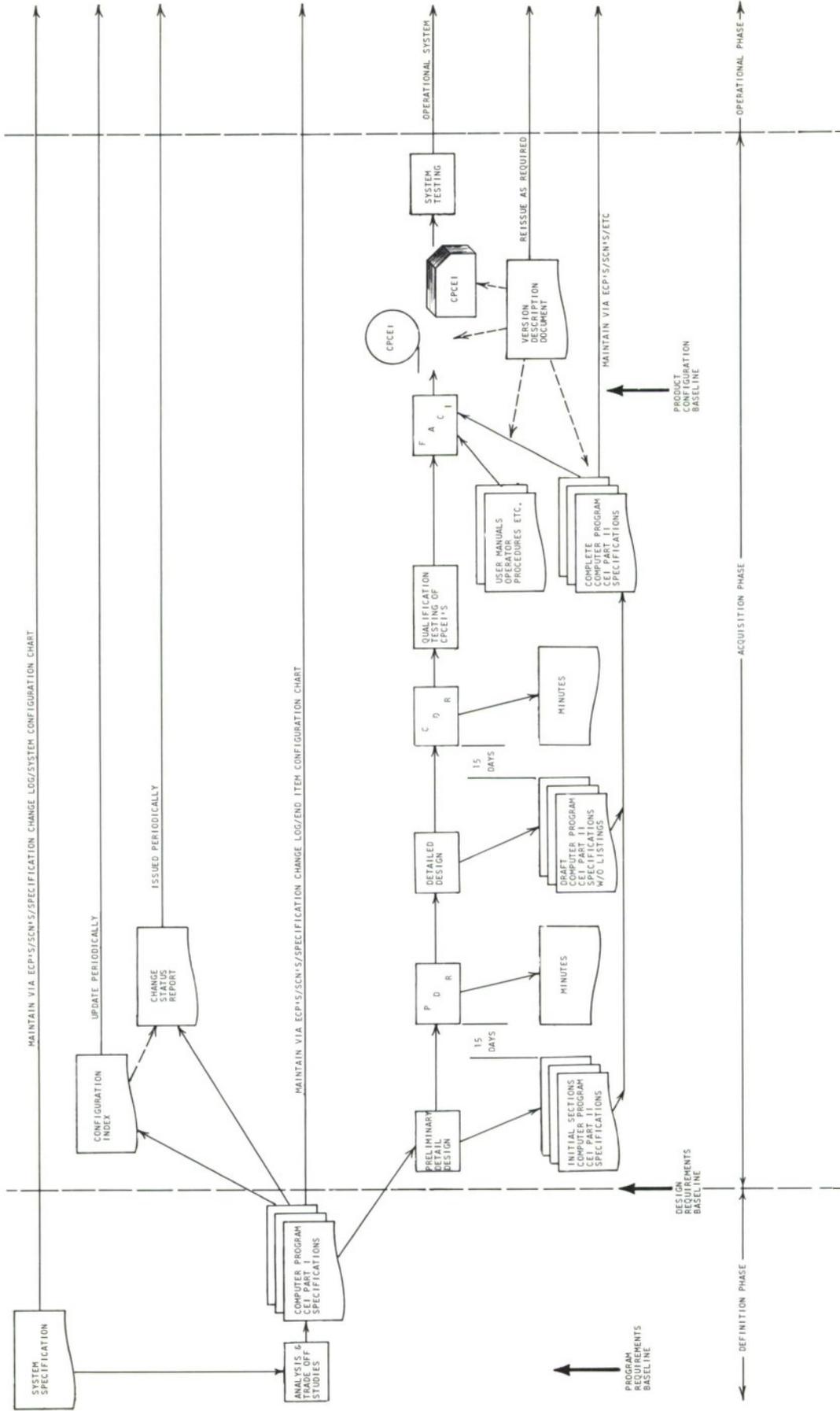
CONCLUSION

The configuration management techniques discussed represent an integrated approach to change control of computer programs. The process is a logical extension of the Air Force concepts that have been successfully applied to hardware systems over the past years. When combined with the basic techniques for configuration management of hardware, they provide change control for total information processing systems. These techniques have been applied successfully to most new Air Force contracts for command and control systems since May, 1966. The approach has been enthusiastically accepted by many contractors and other government agencies.

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CONFIGURATION MANAGEMENT PROCESS FOR COMPUTER PROGRAMS



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Computer Program Management Computer Program Specification Configuration Management of Computer Program Soft Ware Configuration Management Computer Program Identification Change Control of Computer Program Computer Program Contract End Item Computer Program Specification Maintenance						