Configuration management of computer programs by the air force: principles and documentation*

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INTRODUCTION

This paper is addressed to Air Force concepts relating to configuration management of computer programs. For this meeting, our purpose is to summarize the nature of the concepts, and to present an introductory outline of the documentation and procedures. Although we are using the Air Force terminology and phased system program relationships, it should be recognized that the same general principles, and many of the particulars, are also in process of being adapted for use by the other military services and NASA. The basic standards lend themselves to general application in the formal management of computer programming projects.

As described earlier in this session, configuration management represents only one of several management areas which apply to a total system program. Contrary to a prevalent misconception, it is not synonymous with, nor a substitute for, the technical system engineering effort which constitutes the heart of a system design and development program. However, as an auxiliary structure which evolves in steps during the Definition and Acquisition Phases, it is closely related with the other areas of systems management, particularly with the processes of system engineering and testing. Its special concern is with procedures for controlling the performance requirements and actual configurations of the various physical parts of a system. One of the principal needs it fulfills is to provide a systematic means by which the system status and technical objectives can be formalized, for the mutual benefit of the many agencies which are typically associated with the procurement, development, logistic support, and operation of a complex system.

Contract End Items (CEIs) are the system parts to which configuration management applies. In the Defense Department and NASA, the CEI designation* does not apply to system personnel, items of data, or to contractual studies and services. It refers only to identified items of equipment, facilities, and computer programs, as the major deliverable elements of a system which is developed for use by an operational agency.

Although the emphasis in this discussion is on computer programs, it should be recognized that the procedures to be discussed are designed to fit within a common framework of configuration management for all types of CEIs in a system. In fact, they incorporate many concepts and terms which have been borrowed from established practice with items of equipment. At the same time, they are specifically tailored to reflect the many unique characteristics of computer programs as contract and items. In general, they are derived from actual experience in developing computer programs for electronic systems, and are presently in use by a number of system contractors.

General concepts

Within the scope of configuration management requirements, distinctions are made among the three major sub-processes of identification, control, and accounting:

Configuration identification refers to the technical definition of the system and its parts, primarily in

*The authors have been associated with the development of computer programming management procedures for Air Force Systems Command, through contract studies conducted in support of the Electronic Systems Division. This report summarizes selected aspects of the Air Force procedures as viewed by the authors; it is not to be construed as an official expression of policy by Air Force agencies or the System Development Corporation.

*In the Army, CEI denotes Configuration End Item, rather than Contract End Item.
the form of specifications. In general, configuration management 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 only, while the specification for each major CEI is written in two parts—Part I as a performance-level specification to establish technical objectives and design constraints, and Part II as 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, as a function of the typical differences in technical characteristics. Once written and approved, each specification formally defines a baseline configuration of the system or item. A baseline, in general, is an established and approved configuration, constituting an explicitly defined point of departure from which changes can be proposed, discussed, or accomplished.

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.

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.

Documentation and procedures

While the items of central reference 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 above, 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 also be taken of technical manuals and other data prepared for the using agency, whose contents are sensitive to changes in computer program configuration.

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 1, 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. While the tape (or alternative form, such as punched cards) is not forgotten as the eventual object of these activities, most of our concern about working procedures is with the other elements. Additionally, it should be noted that events are related in a gross way to phases of the system life-cycle. 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, an earlier baseline is not replaced by a new one; once established, all are maintained together, indefinitely.

Specifications

The system specification is typically written and issued by a procuring agency as the primary requirements document governing the developmental process for all contract end items. Its function is to describe objectives and constraints for the system as a whole. It sets forth requirements for system performance and system testing, identifies all major parts to be developed or otherwise acquired, and allocates performance requirements to the parts. As a basis for information processing efforts, one of its important roles is to define and control essential functional interfaces among computer programs, computing equipment, communications links, and personnel. When issued at the outset of the Definition Phase it is established as the program requirements baseline. While it normally undergoes subsequent expansion and refinement, all changes must be approved by a central control board, documented, and coordinated with the agencies concerned.
The *Part I specification* for a computer program contract end item (CPCEI) is primarily a detailed compendium of information processing functions to be performed by the computer program. As a product of the Definition Phase analysis activities, it is not a computer program design document, as such, although it may specify design requirements or constraints and should reflect an appreciation of feasible computer program design solutions. It contains a detailed definition of all input, output, and processing functions to be accomplished, specifies all pertinent interfaces with equipment, personnel, and other computer programs, and identifies the means by which the eventual performance of specified functions will be verified by formal testing. The standard format which has been developed for the purpose is written at a very general level to permit application to many types of computer programs, both large and small. As a specification, it does not contain planning information or procedural data pertaining to use or operation. Its functions are to govern the processes of computer program design, development, and testing, and to provide the primary instrument for management control throughout the course of a system program. Since it is written in mathematical, logical, and operational terms, rather than in technical computer programming language, it provides an essential vehicle by which the computer program functions can be communicated and managed at the level of operational performance. Part I Specifications for the collection of computer program and equipment elements for the system as a whole are verified for consistency with the System Specification and compatibility of interfaces, and are established collectively at the outset of Acquisition as the *design requirements baseline*. Because of its exceptional importance to the conduct of a system program, the Part I CPCEI Specification was chosen as a special topic to be amplified in another paper in this session.

The *Part II specification* is a technical description of the CPCEI structure and functions. Essentially, it consists of elements which have appeared as computer program documentation in the past in a variety of forms and combinations—e.g., functional allocations, timing and sequencing, data base characteristics and organization, flow charts, etc. The Part II
Specification organizes these into a single, comprehensive description which includes the data base and listings. It is an "as-built" description, which the procuring agency accepts only after its completeness and accuracy have been formally verified, and normally after the computer program performance has been tested against performance requirements of the Part I Specification. Like the Part I, it does not contain operating instructions, test procedures, or other non-specification materials. Its subsequent technical uses are as an aid in correcting errors and designing changes. Following completion and verification, it constitutes the product configuration baseline. As in the case of preceding baselines, it is maintained subsequently through the processes of configuration control and accounting.

Procedural data
As indicated above, operating and instructional information is not contained in the computer program specification. This class of information is the proper subject of separate handbooks or manuals, which should be written specifically to meet the needs of operating and support personnel. Configuration management does not apply directly to such documents. However, since their content is typically sensitive to CPCEI performance and/or design characteristics, they must also be maintained to reflect approved changes to the CPCEI. Hence, they appear as prominent "impact items" in the configuration control processes.

Configuration control and accounting documents
Configuration control and accounting documents are standard forms and reports which serve as the instruments by which changes to established baselines are processed and recorded.

The engineering change proposal (ECP) is the vehicle by which a change is initiated. It is a form of long-standing use for equipment which has been adopted with appropriate modifications for computer programs. A completed ECP describes the nature and magnitude of a proposed change, estimated developmental requirements, and impact of the change on all associated documents and other system elements. During most of the Acquisition Phase, "computer program changes" normally refer to changes in the Part I Specification. At later stages, a fully implemented change will also involve the preparation of change pages to the Part II Specification and other derived documents, as well as incorporation of changed instructions into the computer program. Assuming that the Part II Specification is based upon completed design and testing of the altered computer program, changes are essentially implemented with the issuance of approved change pages to the specifications.

The specification change log, end item configuration chart, and specification change notice (SCN) are also standard forms, originally developed for equipment, which have been adopted with modified uses for computer programs. They constitute, respectively, (1) a cover sheet, (2) a listing of current pages, and (3) a summary of incorporated changes to accompany each issue of change pages to a specification. As a group, they are inserted into the revised specification, to provide ready indicators of the specification's current status.

The version description document is a collection of pertinent information which accompanies each new release of a computer program tape, or cards. Its purpose is to identify the elements delivered and record additional data relating to their status and usage.

The configuration index and change status report are items issued periodically (e.g., monthly) to inform interested agencies of the current status of the CPCEI configuration and proposed changes. The Index contains up-to-date listings of basic issues and revisions of the specifications and derived documents, with dates of issue and approved changes. The Change Status Report is a supplement to the Index which records the status of all current change proposals.

CONCLUSION
The preceding description has attempted to provide only an introductory overview of configuration management for computer programs. The documentation and procedures are the result of some years of study, experience, and coordination which were accomplished principally under the direction of the Technical Requirements and Standards Office at the Electronic Systems Division of Air Force Systems Command. At the time of writing this report (January 1967), the detailed requirements are in process of being inserted into the forthcoming revision of AFSCM 375-1, which is scheduled to be issued within the next few months. A full set of requirements, in the form of a collection of the proposed changes to AFSCM 375-1, was also issued separately for interim use as ESD Exhibit EST-1 in May 1966. Although that exhibit has had limited distribution, it is presently being used in a number of Air Force contracts and significant provisions have also been coordinated for joint use by NASA in managing computer programs for the Apollo program. Experience to date has tended to confirm that the provisions are generally sound, and capable of meeting a num-
ber of long-standing needs. It is anticipated that refinements will be suggested by further use and study.

REFERENCES

1. M V RATYNSKI
   The Air Force computer program acquisition concept
   SJCC Proceedings 1967

2. ESD Exhibit EST-1:
   Configuration management exhibit for computer programs
   Electronic Systems Division Air Force Systems Command
   Laurence G Hanscom Field Massachusetts May 1966

3. B H LIEBOWITZ
   The technical specification—key to management control of computer programming
   SJCC Proceedings 1967

4. AFSCM 375-1:
   Configuration management during definition and acquisition phases
   Air Force Systems Command U S Air Force June 1 1964

5. B H LIEBOWITZ, E B PARKER III, C S SHERRERD
   Procedures for management control of computer programming in apollo
   TR-66-342-2 Bellcomm Inc September 28 1966

6. M S PILIGIAN, J L POKORNEY
   Air Force concepts for the technical control and design verification of computer programs
   SJCC Proceedings 1967