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DATA ELEMENTS FOR A COST REPORTING SYSTEM FOR COMPUTER PROGRAM DEVELOPMENT

G. F. Weinwurm

August 1966

DIRECTORATE OF COMPUTERS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Mass

(Prepared under contract AF19(628)5166 by the System Development Corporation 2500 Colorado Ave., Santa Monica, California.)

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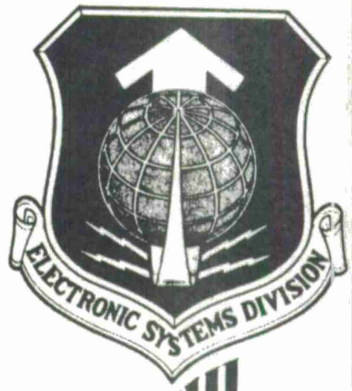

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FOREWORD

The Report is a product of the Programming Management Project at System Development Corporation (SDC), under contract with the Directorate of Computers, Deputate for Engineering and Technology, Electronic Systems Division, Air Force Systems Command. The research in the Programming Management Project is directed toward the development of guidelines, standards, and techniques that contribute to improved management of computer programming activities. The research is a continuation of the work that has been sponsored by ESD since March 1964.

Victor LaBolle has been the leader of the Programming Management Project at the System Development Corporation since its inception in late 1962. The early work to identify factors that were hypothesized to affect the cost of computer programming, and the related statistical analysis, was done by L. Farr, B. Nanus, and H. J. Zagorski. The development of earlier planning and control techniques for computer programming projects was done by L. Farr, V. LaBolle, R. Steinert, N. Wallace, and N. E. Willmorth. Some preliminary work on measuring the quality of computer programming was contributed by P. Peach.

L. Farr and C. L. Starkey contributed extensively to the review of this Report at various stages in its evolution, and special recognition is due their contributions.

Arthur Anderson & Company, Touche, Ross, Bailey & Smart, Price Waterhouse & Company, and Arthur Young & Company were engaged by the Project in mid-1965 to survey client management practices and to make recommendations for a common accounting and management information system, all with respect to computer programming. These results were included in the inputs for the analysis leading to the reporting system described in this document. The following Los Angeles partners and resident managers were responsible for the initial consultant participation:

Arthur Anderson & Company	Leland Moody
Arthur Young & Company	Leonard W. Miller
Price Waterhouse & Company	Francis Dykeman
Touche, Ross, Bailey & Smart	Thomas E. Drenton

Price Waterhouse & Company and Arthur Young & Company were retained again, during May and June 1966, to provide detailed review of a draft of this Report by their staffs and selected clients. The numerous detailed and general comments and suggestions made their by their personnel and many of their clients (whose identity is unknown to us) are gratefully acknowledged.

This technical report has been reviewed and is approved.

Stewart C. Nichols
STEWART C. NICHOLS
Captain, USAF
Project Officer

for CHARLES A. LAUSTRUP
Colonel, USAF
Directorate of Computers

ABSTRACT

This Report contains recommendations for specific items of cost and technical data to be collected from computer program development projects. Forms are provided to facilitate (1) recording of cost and technical data through the computer program development cycle, including the tracking of estimated and actual values, and (2) the creation of a skeletal history of resource expenditure patterns. Advantages are described, including the accumulation of comparable data from different types of computer programming jobs performed in different management environments, and the construction of a data bank for use in the development of standards for planning, controlling, and evaluating computer programming activities.

The reporting system is intended for use mainly by System Program Offices (SPOs) of the Air Force Systems Command. For this reason, the organization of the reporting system, the classification of costs, and the steps in the development process have been designed for compatibility with certain of the budgetary and management systems that do or are expected to affect the SPOs. Specifically, these are: (1) the Program Budget, (2) Cost Information Reports (CIR), and (3) System Program Management Procedures, as described in the AFSCM 375 series. The recommended items of cost and technical data are intended to aid both cost management and cost analysis. A subset of data items that is oriented only toward cost management is also provided.

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SECTION I

SUMMARY

This Report contains recommendations for specific items of cost and technical data to be collected from computer program development projects. For reporting purposes, computer program development is viewed as a seven-step process. Forms are provided to facilitate (1) the recording of cost and technical data at the end of each process step, (2) the tracking of estimates and actuals through the life cycle of a computer programming project, and (3) the creation of a skeletal history of resource expenditure patterns. If the planning for computer programming has been done in terms of the seven steps, application of the recommended reporting system will immediately promote improved control. In the longer view, the comparable cost and technical data from different types of jobs, performed in different management environments, will form a data bank that is intended as a basis for the development of improved management techniques for planning, controlling, and evaluating computer programming activities. As the data bank begins to reflect a true sample of the types of computer programming jobs that are done in different organizations, analyses could be conducted to develop standards for measuring relative performance, for each of the process steps and entire tasks.

The recommended system is intended to provide a basis for collecting comparable cost and technical data from computer programming development projects, whether they are done by contractors or "in-house" by the Government. In this context, the recommended cost model represents a compromise between two objectives: (1) minimization of the reporting burden imposed upon managers of computer programming in Government and industry; (2) collection of sufficient data to aid analysis of costs and the development of improved management techniques for computer program development.

This Report is a product of the Programming Management Project at System Development Corporation (SDC), under contract with the Directorate of Computers, Deputate for Engineering and Technology, Electronic Systems Division, Air Force Systems Command. The reporting system is intended for use mainly by System Program Offices (SPOs) of the Air Force Systems Command. For this reason, the organization of the reporting system, the classification of costs, and the steps in the development process have been designed for compatibility with certain of the budgetary and management systems that do or are expected to affect the SPOs. Specifically, these are: (1) the Program Budget, (2) Cost Information Reports (CIR), and (3) System Program Management Procedures, as described in the AFSCM 375 series.

The seven steps of the computer program development process defined in this Report are included within the Definition and Acquisition (including Acquisition-Operational overlap) phases of the system life-cycle. The first step begins

with identification of an information processing problem. In the system development structure of the Air Force, the statement of the problem would be found in a Specific Operational Requirement (SOR), an Advanced Development Objective (ADO), or an Operational Support Requirement (OSR). The seventh step ends with formal acceptance of the installed system at the last (if there is more than one) operational site by the user.

The proposed reporting system is also intended to reflect certain other Air Force administrative policies and procedures that may bear on computer programming; specifically: the AFR 300 series, which deals with acquisition of computer equipment; AFR 57-4, which is concerned with modification and modernization of existing systems; and AFR 100-2, which is concerned with planning for ground communications, electronics, and meteorological (CEM) systems.

The specific cost categories and reporting forms in the recommended system are based on the Department of Defense Cost Information Reports (CIR) for Aircraft, Missile, and Space Systems, with necessary modifications for computer program development. These forms are to be completed with information based upon the following classifications and data items:

(1) the seven steps in the computer program development process:

- Information Processing Analysis
- Information Processing Design
- Computer Program Design
- Computer Program Coding and Checkout
- Computer Program Functional Test
- Information Processing Integration Test
- Information Processing Installation and Implementation;

(2) a three-way classification scheme for distinguishing between different types of computer program systems;

(3) the grouping of dollar and resource costs according to standard cost accounts; and

(4) technical data items, which reflect the current results of statistical research into computer programming cost factors conducted by the Programming Management Project under ESD sponsorship since 1964.

The achievement of an operational cost-reporting system for computer program development, based on the recommendations in this Report, will require further development in several areas: (1) additional clarification and definition of cost and technical data items; (2) additional consideration of the mechanics of data collection, validation, and analysis; (3) field-testing of the reporting system on a variety of computer programming jobs; (4) exploration of compatibility problems with management reporting systems in other military services and agencies of the Government; and (5) development of procedures for feedback of cost data analysis to data suppliers.

The recommended cost-reporting system is developed in the Report as follows:

a. The objectives of the cost-reporting system are reviewed and the advantages of the proposed system are described in Section II.

b. Standard process steps, cost accounts and technical data items are defined in Section III.

c. Forms and procedures for collecting data are provided in Section IV.

d. The cost accounts and technical data items defined in Section III intended to yield information that will be useful both for cost management and cost analysis. Since, for certain applications, the primary need will be in the area of cost management, especially cost control, a subset of data items is provided for this purpose in Section V. Some estimates of the cost of applying the recommended reporting system are also given in the Section.

e. Areas for further development of the recommended cost-reporting system are discussed in Section VI.

The implication of other major existing and forseeable budgetary, planning, and administrative systems are reviewed in Appendix I.

SECTION II

PURPOSE

1. Summary of the Section. This Section defines the purpose and application of the recommended cost-reporting system for computer program development. The Section consists of five parts:

a. Nature of the Problem. Explains why a generally applicable cost-reporting system is needed for computer program development, and toward what problems the system in this Report is directed.

b. Specific Objectives of the Report. Summarizes the intent of the recommended cost-reporting system and how it helps remedy the problems described earlier.

c. Usefulness of the Report. Lists the advantages of applying the recommended cost-reporting system.

d. Audience for the Report. Explains to whom the Report is directed, and who will be able to make use of the recommended cost-reporting system.

e. Basis for the Report. Describes the types of information that were used in preparing the recommended cost-reporting system.

2. Nature of the Problem. Effective management control of computer program development is presently limited by several major factors:

a. Lack of Common Terminology. People who do computer programming usually do not describe the process, the steps in the process, or the end-products in comparable ways. While various standard definitions have been proposed, few are as yet generally applicable or accepted. This is often true within different parts of the same organization, and even more true between different organizations.

b. Lack of Meaningful Management Measures. Managers of computer programming have few proven and reliable ways of relating costs to product characteristics, e.g., to measure the cost/effectiveness or the efficiency with which resources are used. Standard measures that have been developed for hardware manufacturing are often not meaningful for computer programming.

c. Lack of Management Standards. Since there are few common terms or meaningful measures, computer programming managers have few standards by which they can plan for or control performance, or judge whether relative costs are high, average, or low.

These needs in the computer programming field (and in information processing generally) are both symptoms and causes of a more fundamental problem: There is very little comparable and reliable experience-data available from computer program developments that managers can use for immediate decision-making, or as a basis for research to improve their decision-making in the future. In effect, the lack of common terms, measures, and standards hinders the collection of comparable experience-data, which, in turn, makes it more difficult to develop common terms, measures, and standards.

It would be an exaggeration to say that no experience-data on computer program development are available: individual organizations collect various amounts of such information for their own managers. Also, several research projects, such as the Programming Management Project at System Development Corporation, have laboriously gathered and validated modest quantities of interorganizational experience-data for analysis. The fundamental problem, however, is the limited extent to which regular management reporting channels output data for both management control and management research.

3. Specific Objectives of the Report. The primary intent of this Report is to propose elements of a cost-reporting system for computer programming development, one that can be applied to different types of jobs, performed under different organizational and management environments. The immediate objective is to recommend such a system for further evaluation and testing and subsequent use by the Air Force Systems Command SPOs. As the recommended system is developed and refined at the SPO level, the longer-term objective is to look toward managers of computer programming elsewhere in the military services, in Government, and in industry, who are faced with the same fundamental lack of useful experience-data for cost management and cost analysis. That is, the evolving system can provide one means by which reliable and comparable cost data can begin to be collected on a more general basis.

To yield comparable data from different types of computer programming jobs, performed in different management environments, a cost-reporting system must include at least the following:

a. Standard process steps (or milestones) that represent a meaningful division of computer program development, e.g., computer program design.

b. Standard cost accounts that reflect resource expenditures common to computer program developments, e.g., computer hours,

c. Standard product characteristics that represent a minimal set of factors with demonstrated potential for management planning and control, e.g., number of instructions coded.

For the recommended cost-reporting system to be both feasible and practical, the standard process steps, cost accounts, and product characteristics must be meaningful not only for computer program development, but also in terms

of accepted accounting conventions, and the other cost-reporting systems that are in use.

4. Usefulness of the Report. Application of the recommended cost-reporting system should result in several advantages to managers of computer programming:

a. In the short-run, if the planning for computer programming is done in terms of the seven recommended process steps, the data collected by the proposed system will provide a basis for management control by comparison of actuals with estimates at the end of key milestones.

b. Standard recording forms and process steps will facilitate tracking of estimated and actual values for costs and technical data through the life cycle of computer programming jobs.

c. After-the-fact, the outputs of the system, i.e., the total set of cost and product-characteristic data in uniform formats, will provide a skeletal history of resource-expenditure patterns throughout computer programming developments.

d. In the longer view, as the types of jobs and management environments in the resulting data bank begin to represent a representative sample of computer programming activities, the data can be analyzed to develop improved cost measures, standards, and estimation techniques for individual process steps or entire jobs.

e. Finally, the recommended system could serve as one basis for the evolution of common cost-reporting procedures and historical data banks for computer program development, whether performed by industry or Government, on a contract basis or "in-house."

5. Audience for the Report. Since all types of computer programming have much in common[1], we expect the cost data reporting system in this Report to be of general interest to managers of such activities, especially at the project (program) level at which the development of large systems that include computer programs as components are managed. For example, Air Force Systems Command System Program Offices (SPOs) act as a primary center of authority for system development to assure that all of the ingredients--subsystems, components, contractors, users, buyers, higher level managers--are brought together at the proper and preselected time during development so that a new system exists where none existed before. (1)

---

[1] In our view, the seemingly different descriptors or labels that are commonly assigned to certain types of programming jobs can often be deceptive. For example, a so-called command-and-control system, a logistical analysis system, and a personnel data bank may all encompass largely similar functions, such as information retrieval, inventory control, etc.

Effective management at the SPOs, as described in the System Program Office Manual, presupposes that the different contractors and users involved in the system development can communicate with each other about common products in the same way. That is, the guidelines for SPOs assume that generally accepted and understood terms and definitions, management measures and standards exist for planning and control, and these are based upon reliable and comparable experience-data. These prerequisites are, of course, the very deficiencies that have been cited as major problems in the computer programming field.

Management information incompatibility and unreliability is certainly not unique to Air Force Systems Command or System Program Offices. There is increasing concern throughout Government (and industry) with the entire area of data management,(2) and numerous management information systems (mostly computer-centered) are in various stages of development and implementation. To the extent that the cost-reporting system recommended here for Air Force Systems Command management develops successfully, i.e., provides more useful data for management control and planning for computer programming, it could be adopted for broader use by both Government and industry.

6. Basis for the Report. The recommended cost-reporting system is based on two major types of information:

a. Analysis of Data from Completed Computer Programming Jobs. Since 1962, the Programming Management Project at SDC has been engaged in the development of techniques for recording experience-data from completed computer programming jobs, and analyzing the results. For the past two years, the Directorate of Computers, Deputate for Engineering and Technology, Electronic Systems Division, Air Force Systems Command, has sponsored statistical analysis of such data from nearly two hundred computer programming jobs to identify major cost factors and develop cost-estimation techniques. The technical data items recommended for collection in Section III.5 are mainly based on this Project research.

b. Analysis of Existing Management-Reporting Systems that Affect Air Force Computer Programming. Although computer programming represents a substantial ongoing investment, the cost is small as a percent of total Air Force Systems Command (or Air Force, or Department of Defense) procurement. For this reason, any proposed common cost-reporting system for computer program development must recognize other management systems in use within the Air Force and the Department of Defense. The major budgetary, reporting, and administrative procedures of this type can be grouped as follows:

(1) Program Budget System. Applies to all Department of Defense activities above certain cost-threshold levels.

(2) General Cost Reporting Systems. In particular, the Cost Information Reports (CIR), a recently developed cost-reporting system that will eventually be applied to all Department of Defense procurements above certain threshold levels.

(3) General System Development and Modification Procedures. System Program Management, as described in AFSC 375 series manuals, prescribes the process by which Air Force Systems are conceived, defined, developed, and entered into the inventory, and applies to systems above certain cost-treshold levels. Other Air Force policies and procedures considered include AFR 57-4, the procedures for approval of system modification, and AFR 100-2, the procedures for approval and management of Ground Communications, Electronics and Meteorological (CEM) system development.

(4) Particular Administrative Procedures that Affect Computer Programming. Other Air Force regulations that may initiate computer programming (although not explicitly) are prescribed by the AFR 300 series Data Automation Procedures. There are as well the AFM 171-9 procedures for reporting the use made of data processing facilities acquired through the AFR 300 channel (see Appendix I).

The recommended cost reporting system tries to combine research results on important cost factors in computer programming with the appropriate elements of the budgetary, reporting, and administrative procedures cited. (More details on these procedures are found in Appendix I.)

SECTION III

STRUCTURE AND DATA ITEMS

1. Summary of the Section. This Section defines the structure and data items that constitute the recommended cost reporting system for computer program development. The Section consists of four parts:

a. Classification of Information Processing Systems. Defines a classification scheme that is applied to distinguish between different types of information processing systems.

b. Standard Process Steps. Defines process steps (i.e., milestones) into which computer program development is divided, for reporting purposes, and how these are related to System Program Management Procedures, as defined in the AFSCM 375 series manuals.

c. Standard Cost Accounts. Defines standard cost accounts that are applied to each process step to collect resource expenditures.

d. Technical Data Items. Defines data items that are applied to each process step to reflect product characteristics, and equipment configuration and performance.

2. Classification of Information Processing Systems. One of the main objectives of a SPO historical data bank for computer programming projects is to aid the development of performance measures and standards. For this purpose, it is advantageous to be able to distinguish "populations" of computer programming jobs that tend to be more or less expensive in terms of relative costs.

Unfortunately, the classification of computer programming jobs lacks understanding at the present time. At one extreme, all computer programs have much in common, e.g., they are composed (after compilation) of storage words and machine instructions that form subprograms, logical flows, (e.g., sums, differences, choices, comparisons, etc. At the other end of the spectrum, the classification of the use of these computer programs , there are a great many intuitive labels nominally based upon the functions performed, e.g., command and control, utility, information retrieval, on-line, real-time, file-oriented and process-oriented. These classifications actually involve other dimensions in addition to functions or use, e.g., computer configurations and response time.

There is very little reliable quantitative evidence as to which (if any) of the intuitive classifications represent fundamental as opposed to apparent differences. In these circumstances, we propose a relatively simple three-level classification,[3] based on the type of feedback relationship between computer program systems and their environment:

(1) By "computer program system," we mean the computer programs that operate at an individual site or installation as a part of an information processing system, which includes the computer, operators, sensors, etc. An "information processing system" may consist of one site or many. Also, several computer program systems may operate at any one site, e.g., as in time-sharing, service bureau operations.

(2) By "feedback" we mean intercommunication under direct control of the computer program system, although the flow of information may be initiated or terminated by an operator. This perspective excludes, for example, verbal feedback between operators on the telephone.

The classification scheme consists of three hierarchical levels of information processing, i.e., all information processing systems function on the lowest level, some also function on the intermeduate level, and some that function on the first two levels also function on the highest level. The implication of these three levels is that, other things being equal, computer program developments on the highest level will tend to be more costly than those at the intermediate level, and those at the second level will tend to be more costly than those at the lowest level.

The three levels are defined as follows:

(1) Processing. Computations (i.e., logical transformations) are performed by the computer program system but direct program-controlled feedback is limited to checks within the data manipulation (i.e., computer program) sequence, apart from console start and stop commands, etc. This is the lowest level of the hierarchical classification; all information processing (and computer program) systems function at this level.

(2) Monitoring. In addition to Processing, a direct, program-controlled feedback loop exists to one or more other computer program systems and/or sensors but is used solely to initiate, terminate, and validate information flows. This is the intermediate level of the hierarchical classification; some of the information processing (and computer program) systems that do Processing also function at the Monitoring level.

(3) Control. In addition to Processing and Monitoring, the direct, program-controlled feedback loop to one or more other computer program systems and/or sensors is used by the computer program system to attempt restraint of the external environment. This is the highest level of the hierarchical classification; some of the information processing (and computer program) systems that do Processing and Monitoring also function at the control level.

Note that, as defined, the classification hierarchy assumes that a Control system, for example, will also perform Monitoring and Processing functions. No attempt is made to determine the proportion of functioning at one level as opposed to another; rather if any computer program system functions at the Control level, as defined, then the entire information processing system of

which it is a part is categorized at the Control level. The same is true for the Monitoring level. If none of the computer program systems function at the Monitoring or Control levels, as defined, then the information processing system of which they are a part is considered as Processing. The emphasis in this classification is upon the Information Processing System rather than the particular computer program development being reported on. Only when the computer program being developed is the only one, or the highest-level program in the information processing system, will that computer program determine the classification level.

Several examples of information processing applications at each level follow:

(1) Processing. Typical applications in this category would include accounting, scientific computation, information retrieval, file processing, etc. Of course, there are exceptions to the general rule: an accounting system can be part of a management information system that performs functions at the Monitoring level.

(2) Monitoring. Typical applications in this category would include "watching" systems such as surveillance, satellite tracking, communications status, inventory status, etc.

(3) Control. Typical applications in this category include command and control, process control, management control, etc.

3. Standard Process Steps. For the recommended cost-reporting system, computer program development is divided into seven process steps (or milestones). These are:

a. Information Processing Analysis
b. Information Processing Design
c. Computer Program Design
d. Computer Program Coding and Checkout
e. Computer Program Functional Test
f. Information Processing Integration Test
g. Information Processing Installation and Implementation

Before defining each of these, and relating them to the process flow of the System Program Management (AFSCM 375 series) procedures, it is essential to note the relationship between these particular steps and the whole process of computer programming.

For this Report, computer program development is considered to start with the establishment of a specific requirement for an information processing system. The first two steps, Information Processing Analysis and Information Processing Design, usually include more work than can strictly be classified as or charged to computer program development. Although no general allocation scheme is available, these two steps are included to provide the structure for collecting

costs and product-characteristic data, from which allocation schemes and cost estimation relationships can be developed for these early stages.

Many existing cost systems identify Information Processing Analysis and Information Processing Design with so-called "system" costs, and begin the allocation of charges to computer program development with the Computer Program Design step. Although all of the costs at the first two steps are not computer programming per se, many of them can be clearly associated with the computer program end-product and should be collected.

On the other hand, the work done before a specific requirement exists for an information processing system (during what System Program Management procedures term the Conceptual Phase) cannot be related to a particular computer program development in any dependable way, and is not provided for in the cost-reporting system.

The prefix "Computer Program" is used to label a step that involves work identified only with the computer program end-product. The prefix "Information Processing" labels steps that deal with other related products in the information processing system. For example, the computer program end-product that was evaluated in Computer Program Functional Test (step "e" above) is subjected to further evaluation, but as a part of the whole information processing system, i.e., including the operational computer and other parts of the operational environment in Information Processing Integration Test (step "f" above).

The work necessary to incorporate approved design changes and correct errors should be included in the seven process steps and classified according to their definitions until the computer program development ends. The process ends when the operational information processing system is turned over to the user (at the last site, if there is more than one). After this time the charges for work to make design changes and error corrections are generally allotted to maintenance or operating costs. The recommended system does not provide for reporting costs beyond information processing system turnover.

In the following paragraphs each of the seven process steps is defined and related to System Program Management procedures, as described in the AFSC 375 series manuals:

a. Information Processing Analysis. This step assumes that a requirement has been established for a certain information processing application, e.g., command and control, management information and covers the activities necessary to define and document the characteristics of the particular problem and the performance of the information processing end-product. For, example, included are analyses of the user's environment e.g., any existing interfacing information processing system, potential equipment availability and other technological constraints, economic trade-offs, and evaluation of proposed customer redirections. Information Processing Analysis results in concurred-upon and updated documents that define the design and performance

requirements the information processing end-product (such as the new or modified system) must satisfy.

In an AFSCM 375 context, Information Processing Analysis begins in the Conceptual Transition Phase, after issuance of a Specific Operational Requirement (SOR), an Advanced Development Objective (ADO), or an Operational Support Requirement (OSR), and ends during Phase A, Prepare for Contractor Definition, with the issuance of the System Specification. Modifications to the initial System Specifications that reflect approved redirections of the requirements are included in this step, even though they may occur later in the development process.

b. Information Processing Design. Based on the design and performance requirements document from Information Processing Analysis, this step includes the definition of detailed design and performance requirements for functional elements of the information processing end-product, e.g., translator, data retrieval and man-computer interaction. Included are such activities as (1) definition of major functions and their interrelationships, (2) analysis of design and performance criteria for each of these functions as well as proposals for design changes and (3) preparation of plans for production of the computer program end-product, initial and revision documentation, testing computer program elements and the entire information processing system (end-product) and training of the user. Information Processing Design results in concurred-upon and updated documents that detail the functions to be performed by the computer/computer program and interfacing operators.

In an AFSCM 375 context, Information Processing Design occurs during Phase B, Contractor Definition. The resulting document, a firm definition of detailed functions, is equivalent to the "Contract End Item Detail Specification (Computer Program)--Part I." Modifications to the Part I Specifications that reflect approved design changes are included in this step, even though they may occur later in the development process.

c. Computer Program Design. This step is based upon receipt of the detailed functional design from Information Processing Design, and covers all work necessary to design and document the computer program end-product as prescribed. For example, included are activities to design the computer program structure, data bases, tables, message formats and utility programs as well as changes to the computer program.

Computer Program Design also includes the preparation and updating of such associated products as user manuals, operator handbooks, and training materials; Computer Program Design results in a concurred-upon and updated detailed design specification for the computer program end-product (and the associated user

manuals, handbooks, etc.).[2]

In an AFSCM 375 context, computer program design occurs during the Acquisition Phase, and contributes to the "Contract End Item Detail Specification (Computer Program)--Part II" that is produced as a part of Computer Program Coding and Checkout. Computer program design modifications that reflect approved changes are included in this step, even though they may occur later in the development process.

d. Computer Program Coding and Checkout. This step is based upon receipt of the detailed computer program design specification from Computer Program Design, and covers all necessary work to produce and document the computer program in accordance with the current detailed design specification, and perform in-house tests. Included are such activities as coding, desk-checking, computing tests (or runs), integration of individual units into a computer program system, preparation of the data base, error detection and correction, compiling or assembling and listing of code. Computer Program Coding and Checkout results in a completed computer program end-product, tested in-house to assure conformity with the current detailed specifications, and ready for demonstration tests for the user and/or procuring agency.

In an AFSCM 375 context, Computer Program Coding and Checkout occurs during the Acquisition Phase. This step results in a complete "Contract End Item Detail Specification (Computer Program)--Part II," which is an input to the Critical Design Review (CDR). Approved modifications to the computer program end-product, and the Part II Specification, which is subjected to First Article Configuration Inspection (FACI).

e. Computer Program Functional Test. This step covers demonstration tests of the computer program end-product conducted for the user and/or procuring organization, usually in a simulated environment at the developer's facility. For those computer program developments where the user's and the developer's facilities are the same, e.g., in case of in-house computer programming, this step should be skipped. Computer Program Functional Test includes conduct of the demonstration tests (based on test plans prepared as a part of Information Processing Design), analysis, and documentation of the results. All necessary

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[2] User manuals, operator handbooks and training materials reflect the functional design produced as a part of Information Processing Design. In time sequence, however, these associated products are usually prepared later, in parallel with Computer Program Design or Computer Program Coding and Checkout. A generally acceptable way of relating the development of associated products to the main process flow of computer program development is needed. These activities have been included with Computer Program Design as a temporary measure with the expectation that further clarifications in this area will necessitate modifications to the process steps.

work to remedy errors revealed by these tests should be charged to the appropriate previous steps, e.g., Information Processing Analysis, Information Processing Design, Computer Program Design, or Computer Programming Coding and Checkout. Computer Program Functional Test results in a computer program end-product that is ready for demonstration tests in a live operational environment.

In an AFSCM 375 context, (4) Computer Program Functional Test occurs in the Acquisition Phase, and is equivalent to Category I Preliminary and Formal Qualification testing. For systems developed according to the AFSCM 375 series, Category I Formal Qualification testing is usually conducted at the facility designated for Category II testing.

f. Information Processing Integration Test. This step covers demonstration tests conducted at an operational facility under "live" environmental conditions and includes conduct of the tests (based upon a test plan produced as a part of Information Processing Design), analysis, and documentation of the results. All necessary work to remedy errors revealed by these tests should be charged to the appropriate previous steps, e.g., Information Processing Analysis, Information Processing Design, Computer Program Design, Computer Program Coding and Checkout, or Computer Program Functional Test. Information Processing Integration Test results in a computer program that is a proven part of the information processing system (end-product), in conformance with the detailed design specifications.

In an AFSCM 375 context, Information Processing Integration Test occurs in the Acquisition Phase and is equivalent to Category II testing.

g. Information Processing Installation and Implementation. This step covers all necessary work to install and check-out the information processing end-product at operational sites (other than the one selected for the Information Processing Integration Test) and will usually apply only when there is more than one operational location. This step also includes user training as well as any phaseover activities, in the event that an information processing system (manual or automatic) exists. Information Processing Installation and Implementation results in an operational information processing end-product at all sites.

In an AFSCM 375 context, Information Processing Installation and Implementation occurs in the Acquisition-Operational Overlap Phase, beginning with the installation of the information processing contract end-item at an operational site other than the Category II site, and ending with turnover of the information processing system to the user at the last operational site.

4. Standard Cost Accounts. Cost reporting in this Report is based upon standard cost accounts, which, when applied to each of the process steps defined in Section III.3, constitute a cost model of computer program development. By collecting costs in terms of comparable accounts at each process step, the relationship of total costs and particular costs from step to step can be analyzed.

The standard cost accounts are intended to provide for:

a. Ease of Cost Accumulation. The accounts are defined for compatibility with the work order and cost distribution systems common among organizations involved in contractual reporting to the Government, and with generally accepted accounting conventions.

b. Relative Significance of Costs. The particular accounts are based on those established in the Cost Information Reports (CIR) for aircraft, missile, and space systems (5), but modifications have been made to collect costs that are of special significance to computer program development, e.g., documentation, dollars, and computer hours.

The standard cost accounts are defined as follows:

a. Standard Cost Accounts: Direct Charges. The following accounts apply to each process step:

(1) Direct Labor Hours. Hours of labor expended and charged directly against a process step.

(2) Direct Labor Dollars. For the Direct Labor Hours cited, the dollars expended at the basic rates per hour exclusive of common burden charges such as fringe benefits and insurance premiums.

(3) Direct Computer Hours. For each computer used, the hours of main-frame clock-time expended and charged directly to a process step.

(4) Direct Computer Dollars. For the Direct Computer Hours cited for each computer type, the dollars expended, including allocated overhead for the particular computer installation involved (i.e., the prorated cost of the Direct Computer Hours expended).

(5) Direct Travel Dollars. Dollars expended for travel costs (such as transportation and per diem) charged directly to a process step but not included in Direct Labor Dollars.

(6) Direct Document Duplication and Distribution Dollars. Dollars expended for final duplication and distribution of documentation outside the reporting contractor's organization, and directly charged to a process step. Work necessary to write illustrate, edit, type and rewrite, duplicate and distribute drafts of the documents is excluded.

(7) Subcontracted Dollars. Dollars expended for work subcontracted by the prime and/or associated contractor, but directly chargeable to a process step. This account is not to be used for subcontractor costs where direct reporting from the subcontractor is required by the SPO.

(8) Other Direct Dollars. Other dollars expended and charged directly to a process step, but not included in items (2), Direct Labor Dollars, (4), Direct Computer Dollars, (5), Direct Travel Dollars, (6), Direct Document Duplication and Distribution Dollars, (7), Subcontracted Dollars. For example, the cost of supplies, EDP and EAM costs not covered in item (4), Direct Computer Dollars, etc.

(9) Total Direct Dollars. The sum of items (2), Direct Labor Dollars, (4), Direct Computer Dollars, (5), Direct Travel Dollars, (6), Direct Document Duplication and Distribution Dollars, (7), Subcontracted Dollars, and (8), Other Direct Dollars.

b. Standard Cost Accounts: Indirect Charges. The following accounts summarize actual and allocated expenditures for the contract, rather than charges made against individual process steps:

(10) Indirect Document Duplication and Distribution Dollars. Dollars expended for final duplication and distribution of documentation outside the reporting contractor's organization, but not directly chargeable to a process step. Work necessary to write, edit, type, and rewrite draft material is excluded. This account supplements item (6), Direct Document Duplication and Distribution Dollars. The seven process steps defined in Section III.3 need further development to cover adequately products that are associated with the computer program end-item, e.g., user manuals and training materials. When the duplication and distribution of documents of this kind cannot properly be charged directly to a process step, the charges should be made to this indirect account.

(11) Overhead Labor Dollars. Dollars of overhead expenditure for staff and supervision, at the basic rates per hour exclusive of common burden charges such as fringe benefits and premiums, and properly allocatable to the contract. This account is intended to collect the costs associated with "people-overhead," as these are prorated to the contract.

(12) Other Overhead Dollars. Dollars of overhead expenditure other than Overhead Labor Dollars, e.g., supplies, insurance, depreciation, and taxes, and properly allocatable to the contract. This account is intended to collect the costs associated with "non-people-overhead," as these are prorated to the contract.

(13) Total Dollars Less G&A. The sum of the dollars expended in items (9), Total Direct Dollars, (10), Indirect Document Duplication and Distribution Dollars, (11), Overhead Labor Dollars, and (12), Other Overhead Dollars.

(14) G&A Dollars. Dollars expended for general and administrative expenses and properly allocatable to the contract.

(15) Profit or Fee Dollars. The total of profit or fee dollars associated with the contract.

(16) Total Price Dollars. The sum of items (13), Total Dollars Less G&A, (14), G&A Dollars, and (15), Profit or Fee Dollars.

5. Technical Data Items. The standard cost accounts in Section III.4, when applied to each process step in Section III.3, constitute a cost model of computer program development. To provide a basis for measures and standards of job performance, the cost model must be augmented with data items that reflect characteristics of the particular computer program end-product, e.g., type of computer and number of instructions.

It should be noted that "data items" as referred to in this Section are not equivalent to the contractually-required Data Items defined in AFSCM 310-1/ AFLCM 310-1 (22), as a part of the Authorized Data List. For the recommended cost-reporting system, two types of data items are defined in this part:

a. Equipment Configuration and Performance Data Items. These data items describe the equipment with which the computer program interacts, such as computers, display consoles, and intercommunication links. They are not included in the reports provided in Section IV for two reasons:

(1) Equipment configuration and performance characteristics are mainly "one-time-only" data items, i.e., they will usually remain static once defined.

(2) The design and performance documents that are produced as the result of Information Processing Analysis, Computer Program Design, and Computer Program Coding and Checkout should include the necessary equipment configuration and performance information. In an AFSCM 375 context, these data items should be provided in the "Contract End Item Detail Specification (Computer Program)--Parts I and II." For these reasons, the definitions of data items for equipment characteristics recommended here provide a suggested minimal standard.

b. Product-Characteristic Data Items. These data items apply to one or more of the process steps defined in Section III.3, and are reported at the end of each process step using the Product-Characteristic Report described in Section IV.7. The process steps to which each product-characteristic data item applies is indicated with the definitions.

The definitions for technical data items are as follows:

c. Equipment Configuration and Performance Data Items.

(1) Computer Designation. The manufacturer's designation, e.g., Philco 2000-212, IBM 7094II, Burroughs 5000, for each type and/or configuration required for the information processing system.

(2) Number of Computers Required. For each type and/or configuration cited in (1), the number of installations required for the information processing system.

(3) Complete Add Time. For each type and/or configuration cited in (1), specify the average time required in microseconds to acquire and execute one fixed-point add instruction, using all features such as overlapped memory banks, instruction look-ahead, and parallel execution. (6)

(4) High-Speed Memory Cycle Time. The high-speed memory is considered to be the primary memory from which instructions can be directly accessed and executed by the processing unit, e.g., core. For this storage and for each computer type and/or configuration cited in (1), specify the average time in microseconds required to read and restore one memory word, using overlapped memory banks when available.

(5) High-Speed Memory Capacity. For each computer type and/or configuration cited in (1), and for the high-speed memory identified in (4), specify the number of memory words of addressable storage that are accessable by the processing unit(s).

(6) Digits per Memory Word. For each computer type and/or configuration cited in (1), specify the number and type of digits comprising one memory word, i.e., alphanumeric, decimal, or binary. For alphanumeric or decimal digits, also specify the number of bits per digit.

(7) Input/Output Channels. For each computer type and/or configuration cited in (1), specify the maximum number of input and output channels that are attached to and addressable by the processing unit(s). Specify the type of channel: (1) all digits of a word are transmitted in parallel (broadside); (2) the digits of a word are transmitted as a continuous string of serial pulses; or (3) a combination of serial and parallel, where a character is transmitted in parallel, but the string of characters that constitute a full word is transmitted serially. Also specify whether input channels are: (1) input only; (2) output only; (3) input and/or output simultaneously; or (4) input or output consecutively.

(8) Input/Output Transfer Rate. For each input/output channel type cited in (7), specify the maximum number of binary digits per second that can be accommodated. For a channel that can input and/or output simultaneously, provide the transfer rate for one direction only.

(9) Time-Sharing and/or Multi-Processing. For each computer type and/or configuration designated in item (1), indicate whether the processing unit(s) provide for time-sharing and/or multi-processing operation, according to the following definitions. (7)

(a) Time-Sharing. The processing unit(s) is controlled in different periods of time, and in rapid succession, by various users (i.e., programs). The sequence in which the sharing takes place is controlled automatically, based on predetermined priority criteria and/or on a request basis.

(b) Multi-Processing. The computer system includes processing unit(s) that can interleave the execution of instructions belonging to various programs, and can execute more than one instruction at a time. Such a computer system can be considered equivalent to the concurrent operation of several processing units.

(10) Required Compilers. For each computer type and/or configuration designated in item (1), specify the compilers that are to be used in developing and/or operating the computer program end-product.

(11) Types of Operator Consoles. For each computer system type and/or configuration cited in (1), specify the manufacturer's designation for each type of operator console used by the computer program (but not part of the central computer system).

(12) Number of Operator Consoles Required. For each operator console type cited in (11), specify the number of units required.

(13) Maximum Service Rate for Operator Consoles. For each type of operator console identified in (11), specify the maximum rate that operator inputs are read by the processing unit, in bits per second.

(14) Types of Other Communications and/or EDP Equipment. For each computer and/or configuration in (1), specify the manufacturer's designation for each type of EDP and/or communications equipment (other than operator consoles or parts of the central computer system) used by the computer program.

(15) Number of Other Communications Equipment Units Required. For each type of other EDP and/or communications equipment cited in (14), specify the number of units required.

(16) Maximum Transfer Rate of Other Communications Equipment. For each type of other communications equipment cited in (14), specify the maximum data transfer rate, in bits per second.

(17) Number of Major Hardware Components Developed Concurrently. Specify the number of types of major (i.e., that can affect the critical path schedule for the computer program end-product) hardware components or equipments cited in (1), (11), and (14) that are being developed concurrently with computer program development and are not off-the-shelf.

(18) Number of Separate Operational Sites. Specify the number of separate locations at which the computer program end-product will be operated (those where different requirements must be taken into account in design, testing, etc.). We are excluding, for instance, a square-root calculation program that will be widely operated, but under identical environmental conditions.

(19) Number of Interfacing Information Processing Systems. Specify the number of separate (i.e., independent) information processing systems with which this information processing system interacts, under at least partial program control.

d. Product-Characteristic Data Items. The seven process steps defined in Section III.3 are as follows:

(1) Information Processing Analysis

(2) Information Processing Design

(3) Computer Program Design

(4) Computer Program Coding and Checkout

(5) Computer Program Functional Test

(6) Information Processing Integration Test

(7) Information Processing Installation and Implementation

The product-characteristic data items defined in this part are grouped according to the process steps to which they apply. In most cases, the intention is to track an estimate through the life-cycle of a computer program development. For example, at the end of Information System Design, the Number of Delivered Instructions (Machine) for the completed computer program cannot usually be estimated nearly as precisely as at the end of Computer Program Design. After Computer Program Coding and Checkout, an actual value for this data item is available, and the variations during the remaining process steps reflect design changes and error corrections. Some of the data item definitions are not sufficiently precise to eliminate inconsistent responses. These are included, despite their "softness," based on Project statistical analysis, or where experience supports their influence on computer programming costs. The paragraph letters, e.g., (i), refer to rows of the Product Characteristic Report, Section IV, Figure 6.

(1) Data Items Applicable to All Process Steps

(i) Percent Decision-Making Function. Estimate, in terms of memory registers for the completed and delivered operative computer program, the percent that is devoted to interpretation of data, initiating or terminating information flows and sequencing of processing. The percent specified will need to take the responses to items (j), Percent Information Storage and Retrieval Function, and (k), Percent Computation Function, below, into account, i.e., items (i), (j), and (k) must sum to one hundred.

(j) Percent Information Storage and Retrieval Function. Estimate, in terms of memory registers for the completed and delivered operative computer program, the percent devoted to clerical, bookkeeping, and formatting functions, e.g., reformatting input messages, formatting output messages, maintaining or retrieving files.

(k) Percent Computation Function. Estimate, in terms of memory registers for the completed and delivered operative computer program, the percent devoted to computational functions, e.g., calculations.

(l) Number of Subprograms. Record the estimated (or actual) number of subprograms, i.e., major portions of the completed and delivered operative computer program that will be designed, coded, and tested as logical entities.

(m) Interrelation of Subprograms. For the subprograms cited in (l), specify one of the following: (1) Nearly Independent; (2) Some Interrelation; (3) Many Subprograms Interrelated; (4) Most Subprograms Interrelated.

(n) Severity of Storage and/or Timing Problems. For the completed and delivered operative computer program, estimate the timing and/or storage requirements for the computer program with one of the following: (1) None; (2) Moderate; (3) Sometimes Serious; (4) Serious.

(o) Degree of Need for a Common Data Base. For the completed and delivered operative computer program, estimate one of the following: (1) Minimal; (2) Moderate; (3) Important; (4) Essential.

(p) Familiarity of Available Programmers with Computer Equipment and Programming Languages. For the completed and delivered operative computer program, estimate one of the following: (1) Minimal; (2) Moderate; (3) Substantial; (4) Nearly Complete.

(q) Degree of Need for Programming Innovation. For the completed and delivered operative computer program, estimate one of the following: (1) Minimal; (2) Moderate; (3) Substantial; (4) Extensive.

(r) Completeness and Reliability of Information System (Including Associated Equipment) Requirements and Schedules. For the completed and delivered operative computer program, estimate one of the following: (1) No Evident Uncertainty; (2) No Major Areas of Uncertainty; (3) Some Major Areas of Uncertainty; (4) Many Major Areas of Uncertainty.

(s) Number of Deliverable Instructions (Machine). Specify the estimated (or actual) number of memory registers that will be required for operative portions of the completed and delivered computer program end-product (after compilation).

(t) Number of Deliverable Reused Instructions (Machine). Specify the estimated (or actual) number of memory registers out of (k) the Number of Deliverable Instructions that represent reused instructions, e.g., from existing computer programs, library routines, etc.

(u) Number of Non-Deliverable Instructions (Machine). Specify the estimated (or actual) number of memory registers that will be required for operative computer programs coded as a part of the development process but not delivered with the computer program end-product, e.g., utility programs, checkout and testing routines, data reduction routines, etc. Do not include instructions taken from existing computer programs, library routines, etc.

(v) Number of Classes in the Data Base: Specify the estimated (or actual) number of defined "items" or "fields" of information that will be operated on by the completed and delivered computer program (including tables, adaptation, constants, etc.).

(w) Number of Computer Words in the Data Base. Specify the estimated (or actual) number of computer storage (memory) words in the data base as defined in (v).

(x) Number of Input Message Types. Specify the estimated (or actual) number of defined types of program-processed input messages (i.e., distinct combinations of information item types that the program will recognize).

(y) Number of Output Message Types. Specify the estimated (or actual) number of defined types of program-prepared output messages (i.e., distinct combinations of items that the program can generate).

(z) Operational Computer(s) Available. Enter "Yes" or "No" to indicate whether the complete computer system (with supporting documentation) on which the program is to operate is available at the reporting date.

(aa) Operational Compiler(s) Available. Enter "Yes" or "No" to indicate whether the complete (with supporting documentation) compiler(s) is available at the reporting date.

(ab) Program Production Computer Operated by Agency other than Program Developer. Enter "Yes" or "No" to indicate whether the computer program developer is expected to have complete control over the operation and scheduling of the production facility.

(ac) Program Production Computer Operated in Open/Both/Closed Shop. Enter "Open," "Both," or "Closed," to indicate the anticipated mode of operation of the production computer facility.

(ad) Computer Program Designed and/or Coded in More than One Location. Enter "Yes" or "No" to indicate whether the computer program is expected to be designed and/or coded in more than one location.

(ae) Pages of External Documentation Written. Specify the pages of final copy (8 1/2-by-11-inch standard, single-spaced, both sides of page) written for distribution outside the reporting contractor's organization.

(af) Pages of External Documentation Distributed. Specify the number cited in (ae) multiplied by the number of copies distributed outside the reporting contractor's organization.

(ag) Number of Instructions (Machine) Discarded due to Changes Initiated by the SPO. Specify, in terms of memory registers required for the operative delivered and non-delivered program, the number of instructions discarded due to changes in the design requirements initiated by the SPO within its own authority (equivalent to a "C"-change in AFSCL 173-2).

(ah) Number of Instructions (Machine) Discarded due to Changes Imposed upon the SPO. Specify, in terms of memory registers required for the operative delivered and non-delivered computer program, the number of instructions discarded due to changes in the design requirements imposed upon the SPO by higher authority (equivalent to an "A"-change in AFSCL 173-2).

(ai) Pages of Documentation Written but Discarded due to Changes Initiated by the SPO. Specify the number of pages of final copy (8 1/2-by-11-inch standard, single-spaced, both sides of page) written for distribution outside the reporting contractor's organization, but discarded due to changes in design requirements initiated by the SPO within its own authority (equivalent to a "C"-change in AFSCL 173-2).

(aj) Pages of Documentation Distributed but Redistributed due to Changes Initiated by the SPO. Specify the number of pages cited in (ai), multiplied by the number of copies distributed outside the reporting contractor's organization but redistributed due to changes in design requirements initiated by the SPO within its own authority (equivalent to a "C"-change in AFSCL 173-2).

(ak) Pages of Documentation Written but Discarded due to Changes Imposed Upon the SPO. Specify the number of pages of final copy (8 1/2-by-11-inch standard, single-spaced, both sides of page) written for distribution outside the reporting contractor's organization but discarded due to changes in design requirements imposed upon the SPO by higher authority (equivalent to an "A"-change in AFSCL 173-2).

(al) Pages of Documentation Distributed but Redistributed due to Changes Imposed Upon the SPO. Specify the number of pages cited in (ak), multiplied by the number of copies distributed outside the contractor's

organization but redistributed due to changes in design requirements imposed upon the SPO by higher authority (equivalent to an "A"-change in AFSCL 173-2).

(2) Data Items Applicable only to Computer Program Functional Test and Information Processing Integration Test.

(am) Number of Deliverable Instructions (Machine) Discarded as a Result of Demonstration Testing. Specify, in terms of memory registers required for operative and deliverable portions of the computer program, the number of instructions discarded as a result of errors found during formal demonstration testing for the user and/or procuring agency.

(an) Pages of Documentation Written but Discarded as a Result of Demonstration Testing. Specify the number of pages of final copy (8 1/2-by-11-inch standard, single-spaced, both sides of page) written for distribution outside the reporting contractor's organization, but discarded as a result of errors found during formal demonstration testing for the user and/or procuring agency.

(ao) Pages of Documentation Distributed but Redistributed as a Result of Demonstration Testing. Specify the number of pages cited in (an), multiplied by the number of copies distributed outside the reporting contractor's organization but redistributed as a result of errors found during formal demonstration testing for the user and/or procuring agency.

SECTION IV

REPORTING FORMS AND PROCEDURES

1. Summary of the Section. This Section describes the forms and procedures to be used for collecting data in the recommended cost-reporting system. All of these forms apply to the work on a particular computer program (end item). The Section consists of seven parts:

a. Use of the Reporting Forms. Describes the application of the recommended forms to computer program development.

b. Standard Reporting Form. Describes the standard cover-sheet for all forms in the recommended cost-reporting system, and how they are to be completed.

c. Contract Cost Data Summary. Describes the forms to be used for summarizing particular data and tracking them by process step.

d. Functional Cost-Hour Report. Describes the forms to be used for reporting detailed costs for data and tracking them by process step.

e. Fiscal Year Data Summary. Describes the forms to be used for summarizing costs by process step on a fiscal year basis.

f. Fiscal Year Functional Cost-Hour Report. Describes the forms to be used for reporting detailed costs on a fiscal year basis.

g. Product-Characteristic Report. Describes the forms to be used for reporting characteristics of the product and its development for each process step.

2. Use of the Reporting Forms. The recommended cost-reporting system provides for five reports, which are defined in this Section. Three of these reports are the core of the cost and technical characteristic data, and provide a basis for cost analysis.

a. The Cost Data Summary

b. The Functional Cost-Hour Report

c. The Product-Characteristic Report

These forms are used to collect data for the seven steps in the computer programming process. The two remaining reports summarize the same data that are provided in items "a" and "b," by fiscal years:

d. Fiscal Year Cost Data Summary

e. Fiscal Year Functional Cost-Hour Report

These two reports are provided as a convenience to managers who deal with cost data on a fiscal year basis.

3. Standard Reporting Form. To promote uniformity, we have adopted the CIR reporting format but integrated the slight form-to-form variations as to headings. The proposed Standard Reporting Form (shown in Figure 1) acts as a cover sheet for all subsequent reports and contains fifteen items, which are defined as follows:

Item 1: Program. Enter the designation of the item(s) being purchased under contract, e.g., utility system for 110A System. If the contract or proposal is for or includes services (e.g., information system analysis), specify the work to be performed. In the case of associate contractors and subcontractors reporting separately, identify the end item being purchased on the contract (e.g., utility system) and the program for which it is being procured.

Item 2: Contract/RFP. Check the appropriate line for the data being reported, and enter the assigned contract and the number of the latest amendment, if any, or the RFP number.

Item 3: Multi-year Contract

(1) If a contract is funded for a single fiscal year, check the line and enter the specific fiscal year.

(2) If the report pertains to an incrementally funded contract, check the line and enter all the fiscal years covered by the contract.

(3) In some cases, contractors may be operating under a multi-year contract that provides for annual increments of the quantities, e.g., of services, to be procured under the total contract. For such a contract (which will be rare for computer program development), check the line and enter the fiscal year of funding covered by the report. Such a contract is characterized by these features:

(a) The contract is negotiated for quantities to be procured in more than one year by the government.

(b) The contractor is authorized to proceed with the annual increments either by amending the contract to increase the quantities authorized or by exercising contract options.

(c) The government does not fund the contract fully at its inception, but rather funds the quantities to be procured in each fiscal year for which the annual increment of procurement is authorized.

Normally, for this type of contract, both funds and quantities are released at fiscal-year intervals. The SPO may require on a multiyear contract that the contractor report separately for each annual increment.

Item 4: Report as of. Enter the last day, the month, and the year of the reporting period.

Item 5: Contract Type. Enter the type of contract. For example:

(1) Cost Reimbursable (CR)

(2) Cost Plus Fixed Fee (CPFF)

(3) Cost Plus Incentive Fee (CPIF)

(4) Fixed Price Incentive (FPI)

(5) Firm Fixed Price (FFP)

Also, check the appropriate line to indicate the type of appropriation, i.e., RDT&E or Procurement.

Item 6: Contract Value. If the contract is firm fixed-price, enter the total of the negotiated cost and profit for the work to be performed. For all incentive and cost contracts, enter the negotiated target cost, and profit or fee.

Item 7: Contract Ceiling. Enter the contract ceiling, when applicable.

Item 8: Prime/Associate or Subcontractor. Check the Prime/Associate line if the reporting contractor is the prime or associate contractor for the work to be performed or being proposed. Enter the name, division (if applicable), and address of the reporting contractor. Check the Subcontractor line if the report is being submitted by a subcontractor and enter the name, division (if applicable), and address of the reporting subcontractor.

Item 9: Name of Customer. If the report is being submitted by a subcontractor, enter the name of the customer for whom the work on the contract is being performed. If the report is submitted by a prime or associate contractor, leave this item blank.

Item 10: Process Step (Computer Program Development). Enter, as appropriate, one of the steps for computer program development that are defined in Section III.3. If the report pertains to more than one step, enter "N/A" and list the applicable steps in the attached report (examples are provided in this Section, parts 4, 6, and 8).

Item 11: Classification of Computer Program Development. Enter one of the nine classifications that are defined in Section III.2.

Item 12: Remarks. Enter any remarks that amplify information in the report. Separate pages may be attached if additional space is required.

Item 13: Name of Person to be Contacted. Enter the name, title, and telephone number of the person designated as primarily responsible for this report.

Item 14: Signature. The person named in Item 13 should sign in this box.

Item 15: Date. Enter the date on which the report is submitted.

The main difference between the Standard Reporting Form and the CIR version (apart from the "integration" mentioned) is the addition of Item 11. Classification of Information Processing System.

_____

Classification

	1. Program _____	2. _RFP No. _____ _Contractor Program Estimate Contract No. _____	3. _Multiyear Contract FY Funded _____	4. Report as of _____
5. Contract Type _____ _RDT&E _Procurement	6. Contract Value $ _____	7. Contract Ceiling $ _____	8. _Prime/Associate _Subcontractor	9. Name of Customer (Subcontractor use only) _____
10. Process Step (Computer Program Development) _____			11. Classification of Information Processing System _____	
12. Remarks				
13. Name of Person to be Contacted	14. Signature		15. Date	

Page ___ of ___

_____

Classification

Figure 1. Standard Reporting Form

4. Cost Data Summary. This report is used for tracking computer program development costs by process step. It is to be completed at the beginning of each applicable process step, and at the completion of the last applicable process step. The standard process steps are defined in Section III.3. The data items to be completed are defined as follows:

a. Item b: Total Costs Last Estimated for Step. For each process step in Column "a," enter the total costs estimated in the last report. If this is the first report, omit this column.

b. Item c: Total Costs to Date for Step. Enter the total costs (less G&A) from the inception of the contract, including payments to subcontractors. The resultant figure reported by the prime contractor will be the prime contract costs, plus the payments to all subcontractors. Cost should be reported without regard to ceilings established for incentive contracts.

c. Item d: Total Estimated Costs to Completion of Step. Enter the best current estimate of the cost less G&A to completion of the step. The resultant figure reported by the prime contractor will be an estimate of the total cost, plus the estimated payments to be made for work to all subcontractors. Cost should be estimated without regard to ceilings established for incentive contracts. The reported data should be the prime contractor's best estimate for performing currently authorized work, whether or not formally included in the existing contract--that is, all work included in the most recently executed contract amendments, plus additional directed work for which execution or negotiation of amendments is pending. The estimated amounts will be used for planning purposes only and will not be binding on either the contractor or the Department of Defense.

The last Cost Data Summary for a computer program development project will contain, in Column "d," the actual costs for each applicable step.

The main differences between the proposed Cost Data Summary and the CIR version for aircraft, missile, and space systems, are:

(1) The addition of column "d," Total Costs Last Estimated.

(2) Elimination of references to "units" produced.

(3) Elimination of references to "recurring" and "non-recurring" costs.

A blank Cost Data Summary form is shown as Figure 2.

Classification

COST DATA SUMMARY	1. Program _____	2. _RFP No. _____ _Contractor Program Estimate Contract No. _____	3. _Multiyear Contract FY Funded _____	4. Report as of _____
5. Contract Type _____ _RDT&E _Procurement	6. Contract Value $ _____	7. Contract Ceiling $ _____	8. _Prime/Associate _Subcontractor	9. Name of Customer (Subcontractor use only) _____
10. Process Step (Computer Program Development) N/A			11. Classification of Information Processing System _____	
(See Attached Pages)				
12. Remarks				
13. Name of Person to be Contacted	14. Signature		15. Date	

Page 1 of 2

Classification

Figure 2

Cost Data Summary

Classification

a. Process Step (Computer Program Development)	b. Total Costs Last Estimated	c. Total Costs to Date	d. Total Costs Estimated to Completion
e. Information Processing Analysis			
f. Information Processing Design			
g. Computer Program Design			
h. Computer Program Coding and Checkout			
i. Computer Program Functional Test			
j. Information Processing Integration Test			
k. Information Processing Installation and Implementation			
l. Total Cost Dollars			
m. G&A Dollars			
n. Profit or Fee Dollars			
o. Total Price Dollars			

Figure 2 (Sheet 2)

5. Functional Cost-Hour Report. This report is the same as the Cost Data Summary, except that costs are broken out by the Standard Cost Accounts defined in Section III,5. It is to be completed at the beginning of each applicable process step, and at the completion of the last applicable process step. The standard process steps are defined in Section III.3.

The last Functional Cost-Hour Report for a computer program development project will contain, in column "d," the actual costs for each applicable process step.

Row "u", Schedule for Completion of Next Step, is used to track completion dates on a process step-by-process step basis. The current estimate for date of completion of the next process step (than the one for which this form is being submitted) should be entered.

The Functional Cost-Hour report is the same as the CIR version for aircraft, missile, and space systems, except for the following:

(1) The addition of a column for "Total Costs Last Estimated" (as in Cost Data Summary).

A blank Functional Cost-Hour Report form is shown as Figure 3.

Classification

FUNCTIONAL COST- HOUR REPORT	1. Program _____	2. _RFP No. _____ _Contractor Program Estimate Contract No. _____	3. _Multiyear Contract FY Funded _____	4. Report as of _____

5. Contract Type _____ _RDT&E _Procurement	6. Contract Value $ _____	7. Contract Ceiling $ _____	8. _Prime/Associate _Subcontractor	9. Name of Customer (Subcontractor use only) _____

10. Process Step (Computer Program Development) _____	11. Classification of Information Processing System _____

(See Attached Pages)

12. Remarks

13. Name of Person to be Contacted	14. Signature	15. Date

Classification

Figure 3

Functional Cost-Hour Report

Classification

a. Standard Cost Accounts	b. Total Costs Last Estimated	c. Total Costs to Date	d. Total Costs to Completion
e. Direct Labor Hours			
f. Direct Labor Dollars			
g. Direct Computer Hours			
h. Direct Computer Dollars			
i. Direct Travel Dollars			
j. Direct Document Duplication and Distribution Dollars			
k. Subcontracted Dollars			
l. Other Direct Dollars			
m. Total Direct Dollars			
n. Indirect Document Duplication and Distribution Dollars			
o. Overhead Labor Dollars			
p. Other Overhead Dollars			
q. Total Dollars			
r. G&A Dollars			
s. Profit or Fee Dollars			
t. Total Price Dollars			
u. Schedule for Completion of Next Step			

Classification _____ Page 2 of 2

Figure 3 (Sheet 2)

6. Fiscal Year Cost Data Summary. This report is completed annually, and used for tracking the costs for each process step by fiscal year. The process steps for computer program development are defined in Section III.3.

The entries for each process step and fiscal year are separated according to whether they are under contract as of the report date (or have been contracted for and completed), or have been authorized but are not yet under formal contract.

The proposed Fiscal Year Cost Data Summary for computer program development is the same as the CIR version for aircraft, missile, and space systems, except for the following:

(1) Elimination of references to "quantity" produced.

(2) Elimination of the distinction between "recurring" and "non-recurring" costs.

A blank Fiscal Year Cost Data Summary is shown as Figure 4.

Classification

FISCAL YEAR COST DATA SUMMARY	1. Program _____	2. _RFP No. _____ _Contractor Program Estimate Contract No. _____	3. _Multiyear Contract FY Funded _____	4. Report as of _____
5. Contract Type _____ _RDT&E _Procurement	6. Contract Value $ _____	7. Contract Ceiling $ _____	8. _Prime/Associate _Subcontractor	9. Name of Customer (Subcontractor use only) _____
10. Process Step (Computer Program Development) N/A			11. Classification of Information Processing System _____	
(See Attached Pages)				
12. Remarks				
13. Name of Person to be Contacted	14. Signature		15. Date	

Page 1 of 2

Classification

Figure 5

Fiscal Year Functional Cost-Hour Report

Classification

a. Process Step (Computer Program Development)	b. Fiscal Year -1 Contract No.	c. Fiscal Year 0 Contract No.	d. Fiscal Year +1 Contract No.	e. Fiscal Year +2 Contract No.	f. Fiscal Year +3 Contract No.
g. Information Processing Analysis					
Now on Contract					
Not on Contract					
h. Information Processing Design					
Now on Contract					
Not on Contract					
i. Computer Program Design					
Now on Contract					
Not on Contract					
j. Computer Program Coding and Checkout					
Now on Contract					
Not on Contract					
k. Computer Program Functional Test					
Now on Contract					
Not on Contract					
l. Information Processing Integration Test					
Now on Contract					
Not on Contract					
m. Information Processing Installation and Implementation					
Now on Contract					
Not on Contract					
n. Total Dollars on Contract					
o. Total Dollars not on Contract					
p. G&A					
q. Profit or Fee					
r. Total Dollars					

Classification _____ Page 2 of 2

Figure 4 (Sheet 2)

7. Fiscal Year Functional Cost-Hour Report. This report is completed annually and facilitates tracking of detailed costs by fiscal year. Instead of a breakout by process step, however, as in the Fiscal Year Cost Data Summary, costs in this report are broken out according to the Standard Cost Accounts defined in Section III.4.

The proposed Fiscal Year Functional Cost-Hour Report is the same as the CIR version for aircraft, missile, and space systems, except for the following:

(1) Elimination of references to "quantity" produced.

A blank Fiscal Year Functional Cost-Hour Report form is shown as Figure 5.

Classification

FISCAL YEAR FUNCTIONAL COST-HOUR REPORT	1. Program _____	2. _RFP No. _____ _Contractor Program Estimate Contract No. _____	3. _Multiyear Contract FY Funded _____	4. Report as of _____
5. Contract Type _____ _RDT&E _Procurement	6. Contract Value $ _____	7. Contract Ceiling $ _____	8. _Prime/Associate _Subcontractor	9. Name of Customer (Subcontractor use only) _____
10. Process Step (Computer Program Development) _____		11. Classification of Information Processing System _____		
(See Attached Pages)				
12. Remarks				
13. Name of Person to be Contacted	14. Signature	15. Date		

Page 1 of 2

Classification

Figure 4

Fiscal Year Cost Data Summary

Classification

a. Standard Cost Accounts	b. Fiscal Year -3	c. Fiscal Year -2	d. Fiscal Year -1	e. Fiscal Year 0	f. Fiscal Year +1	g. Fiscal Year +2	h. Fiscal Year +3	i. Balance to Completion
j. Direct Labor Hours								
k. Direct Labor Dollars								
l. Direct Computer Hours								
m. Direct Computer Dollars								
n. Direct Travel Dollars								
o. Direct Document Duplication and Distribution Dollars								
p. Subcontracted Dollars								
q. Other Direct Dollars								
r. Total Direct Dollars								
s. Indirect Document Duplication and Distribution Dollars								
t. Overhead Labor Dollars								
u. Other Overhead Dollars								
v. Total Dollars								
w. G&A Dollars								
x. Profit or Fee Dollars								
y. Total Price Dollars								

Classification _____ Page 2 of 2

Figure 5 (Sheet 2)

8. Product Characteristic Report. This report is used for collecting product and development characteristics at each process step. It is to be completed at the end of each applicable process step, both for the step involved and to update data reported for previous steps. The specific data items are defined in Section III.5. Note that the data items in this report only pertain to certain of the process steps: this is indicated on the form by shading.

A blank Product Characteristic Report form is shown as Figure 6.

Classification

PRODUCT CHARACTERISTIC REPORT	1. Program _____	2. _RFP No. _____ _Contractor Program Estimate Contract No. _____	3. _Multiyear Contract FY Funded _____	4. Report as of _____
5. Contract Type _____ _RDT&E _Procurement	6. Contract Value $ _____	7. Contract Ceiling $ _____	8. _Prime/Associate _Subcontractor	9. Name of Customer (Subcontractor use only) _____
10. Process Step (Computer Program Development) N/A			11. Classification of Information Processing System _____	
(See Attached Pages)				
12. Remarks				
13. Name of Person to be Contacted	14. Signature		15. Date	

Page 1 of 5

Classification

Figure 6

Product Characteristic Report

Classification

a. Product Characteristic Data Items	b. Info.Proc. Analysis	c. Info.Proc. Design	d. Comp.Prog. Design	e. Comp.Prog. Cod.&Chkt.	f. Comp.Prog. Func.Test	g. Info.Proc. Integ.Test	h. Info.Proc. Instal. & Implem.
i. Percent Decision-Making Function							
j. Percent Storage and Retreival Function							
k. Percent Computation Function							
l. Number of Subprograms							
m. Interrelation of Sub-programs							
n. Severity of Storage and/ or Timing Problems							
o. Degree of Need for a Common Data Base							
p. Familiarity of Available Programmers with Computer Equipment and Programming Languages							
q. Degree of Need for Programming Innovation							
r. Completeness and Reliability of Information System (Including Associated Equipment) Requirements and Schedules							
s. Number of Deliverable Instructions (Machine)							

Figure 6 (Sheet 2)

Classification

	b. Info.Proc. Analysis	c. Info.Proc. Design	d. Comp.Prog. Design	e. Comp.Prog. Cod.&Chkt.	f. Comp.Prog. Func.Test	g. Info.Proc. Integ.Test	h. Info.Proc. Instal. & Implem.
t. Number of Deliverable Reused Instructions (Machine)							
u. Number of Non-Deliverable Instructions (Machine)							
v. Number of Classes in the Data Base							
w. Number of Words in the Data Base							
x. Number of Input Message Types							
y. Number of Output Message Types							
z. Operational Computer(s) Available							
aa. Operational Compiler(s) Available							
ab. Program Production Computer Operated by Agency Other than Program Developer							
ac. Program Production Computer Operated in Open/Closed/Both Shop							
ad. Computer Program Designed and/or Coded in More than One Location							

Figure 6 (Sheet 3)

Classification

	b. Info.Proc. Analysis	c. Info.Proc. Design	d. Comp.Prog. Design	e. Comp.Prog. Cod.&Chkt.	f. Comp.Prog. Func.Test	g. Info.Proc. Integ.Test	h. Info.Proc. Instal. & Implem.
ae. Pages of External Documentation Written							
af. Pages of External Documentation Distributed							
ag. Number of Instructions (Machine) Discarded due to Changes Initiated by the SPO							
ah. Number of Instructions (Machine) Discarded due to Changes Imposed upon the SPO							
ai. Pages of Documentation Written but Discarded due to Changes Initiated by the SPO							
aj. Pages of Documentation Distributed but Redistributed due to Changes Initiated by the SPO							
ak. Pages of Documentation Written but Discarded due to Changes Imposed upon the SPO							

Figure 6 (Sheet 4)

Classification

	b. Info.Proc. Analysis	c. Info.Proc. Design	d. Comp.Prog. Design	e. Comp.Prog. Cod.&Chkt.	f. Comp.Prog. Func.Test	g. Info.Proc. Integ.Test	h. Info.Proc. Instal. & Implem.
al. Pages of Documentation Distributed but Redistributed due to Changes Imposed upon the SPO							
am. Number of Deliverable Instructions (Machine) Discarded as a Result of Demonstration Testing							
an. Pages of Documentation Written but Discarded as a Result of Demonstration Testing							
ao. Pages of Documentation Distributed but Redistributed as a Result of Demonstration Testing							

Classification_____ Page 5 of 5

Figure 6 (Sheet 5)

SECTION V

APPLICATION

1. Summary of the Section. This Section discusses the application of the recommended cost-reporting system to computer program developments. The Section consists of three parts:

a. Cost of Application. Provides two estimates of the incremental initial and operating costs involved in using the recommended cost-reporting system.

b. Application for Cost Management. Discusses the product-characteristic data items that are especially suited to cost management, and the use of the recommended cost-reporting system for this purpose.

c. Application for Cost Analysis. Discusses the analytic procedures that can be applied to the data bank for developing management measures, standards, and estimation techniques.

2. Cost of Application. The recommended cost-reporting system is intended to be compatible with other budgetary, planning, and administrative procedures that affect management reporting and control in the Air Force. At the same time, although the recommended cost system is based on these procedures, it clearly represents an additional data collection and reporting burden on the computer program developer. A question of some concern, then, is the incremental cost of this reporting burden relative to the volume of computer programming being done by a contractor.

Estimates of the incremental cost to adopt and use the recommended cost-reporting system have been obtained from two organizations:

a. The first organization, a division of a major aerospace firm, has a $300-million-a-year business. An initial cost of $40-60,000 is estimated for making necessary modifications to the internal (computerized) management information system so that the necessary data can be recorded and summarized. For approximately $1 million a year of contractual computer programming, the ongoing cost of using the recommended reporting system (once the initial modifications have been made) is considered negligible.

b. The second organization is a $30-million-a-year division of a major Government software supplier. An initial cost of $10,000 is estimated for making the necessary modifications to the internal (computerized) management information system so that the necessary data can be collected and summarized. For between $5 and $15 million of contractual computer programming a year, the ongoing cost of the using the recommended reporting system (once the initial modifications have been made) is estimated as $30-50,000 a year.

The organizations involved in both of these examples have cost distribution, and work order systems that have already been adapted for Government contract reporting requirements. The estimate therefore represents the incremental costs for adapting to the particular recommendations in this Report. For organizations whose cost distribution and work order system are not now compatible with Government contract reporting, the initial costs for conversion (apart from the particular requirements of the recommended system in this Report) would be much higher.

3. Application for Cost Management. The recommended cost-reporting system in this Report is intended to provide a bank of experience-data for both cost management and cost analysis. In situations in which a cost management is the only concern, the structure and data items defined in Section III should be applied as follows:

a. The use of the classification of information processing systems should be treated as optional, if the resulting data are not to be combined with other data from a variety of other types of information processing systems.

b. The standard process steps defined in Section III.3 should be applied, as appropriate, to the particular computer program developments.

c. The standard cost accounts should be applied, as they are defined in Section III.4.

d. Some of the product-characteristic data items could be omitted; the majority of these as defined in Section III.5 are oriented toward eventual cost analysis. The following subset of relatively "hard" data items is considered particularly appropriate for cost management purposes:

(1) Number of Deliverable Instructions (Machine)
(2) Number of Deliverable Reused Instructions (Machine)
(3) Number of Non-Deliverable Instructions (Machine)
(4) Pages of External Documentation Written
(5) Pages of External Documentation Distributed
(6) Number of Instructions (Machine) Discarded due to Changes Initiated by the SPO
(7) Number of Instructions (Machine) Discarded due to Changes Imposed upon the SPO
(8) Pages of Documentation Written but Discarded due to Changes Initiated by the SPO
(9) Pages of Documentation Distributed but Redistributed due to Changes Initiated by the SPO
(10) Pages of Documentation Written but Discarded due to Changes Imposed upon the SPO
(11) Pages of Documentation Distributed but Redistributed due to Changes Imposed upon the SPO

(12) Number of Deliverable Instructions (Machine) Discarded as a Result of Demonstration Testing
(13) Pages of Documentation Written but Discarded as a Result of Demonstration Testing.
(14) Pages of Documentation Distributed but Redistributed as a Result of Demonstration Testing.

Each of these data items should be applied as they are defined in Section III.5.d.

4. Application for Cost Analysis. Whether or not the reporting system is used in the abbreviated form just described, the resulting information can be analyzed to develop relationships between the data items and process steps, e.g., for cost estimation and performance measurement. The statistical techniques that are appropriate for this type of analysis have been discussed in detail in an earlier Project report (8), and are as follows:

- Analysis and mitigation of data outliers
- Scatterplot analysis
- Correlation analysis
- Factor analysis
- Multivariate regression analysis

It is well to note that these techniques are generally based on the notion of a sample of data, so that the usefulness of the analytical results is heavily dependent on the quantity (and reliability) of the experience-data that are available.

VI

FUTURE DEVELOPMENT

1. Summary of the Section. This Section describes the additional work necessary to develop the recommended cost-reporting system from a prototype to an operational level of capability. The Section consists of three parts:

a. Development in the SPO Context. Discusses the steps that should be taken to further the development of the recommended cost-reporting system for operational use by Air Force Systems Command SPOs.

b. Development beyond the SPO Context. Discusses the steps that should be taken to further the development of the recommended cost-reporting system for more general operational application, e.g., in the Air Force, or the Department of Defense.

c. Provision for Feedback to Data Suppliers. Discusses the need to provide constructive feedback from the data bank to data suppliers as a management guide and a motivational device.

2. Development in the SPO Context. The cost-reporting system recommended in this report needs further development, evaluation and testing before a reliable operational capability can exist. The following improvements are recommended for the use of the cost-reporting system by SPOs.

a. Provision for Computer Program Maintenance. The present version of the recommended cost-reporting system does not recognize the computer programming work needed after turnover of the information processing system to the user. Design changes and error corrections that are made to the computer programs after this time are usually called "maintenance." This is not the same as maintenance for "wear-and-tear" on equipment. The costs for computer program maintenance may be substantial, especially in that they continue year after year. Design changes to existing computer programs have in some cases cost as much or even more than the work to develop the original computer program. To accurately account for all costs, computer program maintenance should be added as an eighth step to the seven-step process proposed in this Report, and appropriate data items and costs should be defined for recording purposes.

b. More Explicit Provision for Associated Products and Activities. As noted earlier, the contents of user manuals, operator handbooks, and training materials reflect the functional design developed during the Information Processing Design step. But these documents are usually prepared later, in parallel with Computer Program Design, or Computer Program Coding and Checkout. In the Report the costs to develop these documents are included in Computer Program Design.

There are other anomalies of this type that need to be resolved for computer program development generally, and with respect to the System Program Management life-cycle specifically. For example:

(1) Training the user to operate the information processing system is often a major cost, and is included in Information Processing Installation and Implementation. In practice, it often begins earlier in computer program development, e.g., in parallel with Computer Program Functional Test, or Information Processing Integration Test.

(2) Quality assurance is becoming more important in major computer program developments. Formal demonstration (qualification and acceptance) testing is provided for in Computer Program Functional Test, Information Processing Integration Test, and Information Processing Installation and Implementation. Similar activities with respect to documentation occur earlier in the development process: e.g., formal concurrence with the user and/or procuring agency on the design and performance requirements produced during Information Processing Analysis; the detailed design of the computer program end-product, during Computer Program Design.

It may be desirable to provide for user training and concurrence activities in a more explicit way in future versions of the cost-reporting system.

c. Additional Development of Product-Characteristic Data Items.
The product-characteristic data items defined earlier mainly reflect the statistical research into computer programming cost factors done by the Programming Management Project at System Development Corporation during the past two years. These data items should be strengthened in several areas.

(1) The data items should be modified to account for any new results from another cycle of statistical cost factor analysis now underway in the Programming Management Project.

(2) The data items should be supplemented since these statistical analyses concentrate on only four of the seven process steps: Information Processing Design, Computer Program Design, Computer Program Coding and Checkout, and Computer Program Functional Test. The remaining process steps, Information Processing Analysis, Information Processing Integration Test, and Information Processing Installation and Implementation, need further study to develop product-characteristic data items (i.e., cost factors) that are appropriate in each case.

(3) The data items should be refined to deal with specific steps. The statistical analyses aggregate the costs for the four steps beginning with Information Processing Design and ending with Computer Program Functional Test. With few exceptions, the product-characteristic data items defined in Section III based upon these analyses are applied to all seven of the process steps. Further analysis is needed to identify the important product-characteristic data items for each step rather than the aggregate of several steps.

d. Compatibility with Interfacing Administrative Budgetary and Planning Systems. As noted in Section II (and in more detail in Appendix I) cost-reporting system for computer program development relates to several other administrative, budgetary, and planning systems within the Air Force Systems Command, the Air Force, and the Department of Defense. When these other systems are changed the recommended cost-reporting system should be reviewed for any consequent changes needed to provide any compatibility required. We are aware of two areas of potential change at this time:

(1) Significant changes to the Program Budget are under consideration for implementation in late 1966.

(2) To respond to the development of efforts such as the Program Budget and CIR, at the Department of Defense level. The Air Force Systems Command has been improving its management capability with several major efforts. For example, the Cost Management Improvement Program (9) has initiated the development of prototype-standard cost management systems and procedures for the Command such as the following:

(a) Cost estimating procedures (10)
(b) A CIR-compatible cost information system (11)
(c) A cost-estimate tracking system (12)
(d) PERT/cost accomplishment procedures (13)
(e) Change-cost management procedures (14)
(f) Overhead-cost management procedures (15)

The results of this work are now being, or are scheduled to be, field tested on such major programs as C5-A, Advanced Ballistic Missile, F-111, 418L, Manned Orbiting Laboratory, and 441A. At the moment, the cost estimating, cost tracking, and cost information studies (items "a," "b," and "c") are further along than the remaining projects. However, the overall Air Force Systems Command schedules call for Command-wide implementation of the remaining products by the end of Fiscal Year 1966.

As these parts of the Cost Management Improvement Program evolve, their relation to computer program development will need further definition in terms of the recommended cost-reporting system.

e. Definition of the Mechanics of Data Collection and Processing. The problems of contractor rights-to-data, and the mechanics of data validation and processing have not been addressed in this report. With respect to contractor rights-to-data, if new data reporting requirements are imposed by the Air Force, questions arise as to how the costs of collection are charged, how the data should appear when transmitted and whether or not the data are proprietary. Further, the cost of obtaining the data should be compared to the value gained from them, from the SPO point of view. This assessment will vary as the reporting mechanics change. For instance, the recommended cost-

reporting system could be used to assure the existence of comparable contractor "data banks," from which the SPO could request information, or the SPO could require actual reporting of all the data proposed in the Recommended system; or a combination of both approaches could be used. Who performs validation and analysis of these data and how, will also need to be defined clearly.

f. Field-Test of the Recommended Cost Reporting System. The most important step needed to achieve some operational cost-reporting capability is to field-test the recommended cost-reporting system on a variety of ongoing computer programming efforts. To provide thorough, comprehensive evaluation, the problems of a variety of computer programming jobs will need to be considered and the reporting difficulties analyzed in detail. (Analysis of the data per se may also prove fruitful.) On the order of twenty or thirty computer programming projects should be considered initially, to cover the diversity of management environments and job types such as Processing, Monitoring, and Control applications, and different sizes of jobs. While any degree of field-testing will be helpful, the more ambitious the plans for operational implementation, the more extensive should be the field-testing phase to assure acceptable operational reliability.

3. Development Beyond the SPO Context. These suggested improvements of the recommended cost-reporting system for use by the SPOs apply equally well if its use outside the SPO is contemplated. Specifically the improvements recommended above are:

a. Provision for computer program maintenance.
b. More explicit provision for associated products and activities.
c. Additional development of product-characteristic data items.
d. Modifications to take account of changes to interfacing administrative, budgetary, and planning systems.
e. Development of the mechanics of data collection and processing.
f. Field-test of the recommended cost-reporting system.

More development effort will be required for use of such a reporting system in a larger environment beyond the SPOs for at least two reasons.

a. Interfacing with other Department of Defense Management Systems. Department of Defense Directive 5010.12, (16), specifies that all activities within the Department must develop contractor data management systems based on DD Form 1423, The Contractor Data Requirements List. We have noted the AFSC response in the form of AFSCM/AFLCM 310-1, Management of Contractor Data and Reports. (17) There is a need to explore further the compatibility of the proposed reporting system with other data management systems within the Department that have resulted from the same Directive. For example, several of the existing data management procedures are as follows:

TABLE I

OTHER DEPARTMENT OF DEFENSE DATA MANAGEMENT PROCEDURES

Organization	Authorized Data List
Army	AR 700-xx (Draft)
Navy	MIL-HDBK-22
Defense Supply Agency	DSAM 4185.1
Apollo Program (National Aeronautics and Space Administration)	Apollo DAP 500-7

A "historical data bank" for developing standards that includes as great a diversity of computer program developments as possible will be far superior to one restricted to a single Command or Service. Therefore, the problem of integrating the recommended cost-reporting system for computer program development not only with the Program Budget, System Program Management, CIR, etc., but also with management systems of other agencies will have to be attacked eventually. A major effort would be required to integrate these diverse procedures in DOD and NASA with the recommended cost-reporting system. And even more work would be needed to integrate with other management procedures in the Government, e.g., Bureau of the Budget and General Services Administration.

b. Field-Test of the Recommended Cost-Reporting System. As the scope of application broadens, the number and diversity of the computer program developments needed to field-test the recommended cost-reporting system must be increased.

4. Provision for Feedback to Data Suppliers. Given the creation of a bank of experience-data from computer program developments both for cost management and cost analysis, as one major objective of the recommended cost-reporting system, this data bank, to realize its potential, must serve two types of "customers": (1) Information Processing System users and/or procuring agency, e.g., the SPO, and (2) the computer program developers who supply the data via the recommended cost reporting system.

This report, as does the CIR, emphasizes the needs of the information processing system users and/or the procuring agencies, e.g., the SPO. The interests of the computer program developers are equally important.

Although the data provided by the recommended cost-reporting system will be subject to validation by the information processing user and/or procuring agency, the cost of validation for many of the data items will be high. In other words, for many of the more subjective data items, the quality of the response will substantially depend on the motivation of those who will complete the various reporting forms. This motivation, in turn, will depend on the obvious advantages for providing quality responses, from the computer program developer's point of view.

One potential advantage, from the computer program developer's point of view, would be in deriving aids and guidelines from the data bank that can improve the effectiveness of local management. For example, as the data bank is used to develop management measures and standards for computer program development, these could be provided to past, present, and potential suppliers of experience-data. To the extent that these proved effective, the improvement of local management practice would be an added advantage to information processing system users and/or procuring agencies.

Therefore, we recommend that in further development of the cost-reporting system, the means be developed to supply the sources of the data (the computer program developers) with feedback that can both motivate them and help them do a better job.

APPENDIX I

FOCUS

1. Summary of the Appendix. This Appendix describes the specific orientation and objectives of the Report, and the recommended cost-reporting system for computer program development. The Appendix consists of two parts:

a. Focus of the Cost Reporting System. Since the recommended system in this Report contains only elements of a complete cost-reporting scheme, this part describes the components of a reporting system that remain to be developed, and the levels of management that will find the present version most useful.

b. Major Environmental Assumptions and Constraints. This part summarizes the other budgeting, planning, and administrative procedures that the recommended cost-reporting system must take into account, and the implications of these other procedures.

2. Focus of the Cost-Reporting System. Section II, Purpose, lists three essential components of a cost-reporting system for computer program development. These are:

a. Standard process steps (or milestones) that represent a meaningful division of computer program development, e.g., computer program design.

b. Standard cost accounts that reflect resource expenditures common to computer program development, e.g., computer hours.

c. Standard product characteristics that represent a minimal set of factors with demonstrated potential for management planning and control, e.g., number of instructions coded.

Section II.6 refers to two types of information on which the recommended cost reporting system needed to be (and is) based:

d. Research results that identify major cost factors for use as product characteristics.

e. Existing budget, planning, and administrative systems that affect reporting for computer program development, e.g., CIR, AFSCM 375, general accounting practices.

While each of these aspects of cost reporting is essential, they do not together constitute a complete system that is useful at all levels of management. As indicated in the title of this Report, the specific object of this version is to recommend elements of a complete cost-reporting and analysis system, which will need to be developed in more detail. The missing components are the subject of this part.

In general, the problems of cost reporting can be considered at three levels:

a. At the first level of line management, the primary concern in cost reporting is one of properly recording cost data, e.g., on cost logs. For this purpose, detailed data item definitions and forms are necessary, as are procedures for recording, allocation, and reporting to higher management levels.

b. At the project management level (whether at Air Force Systems Command SPOs or their industrial counterparts), the primary concern is one of summarizing and relating reported cost information from different activities within the project, evaluating the data, and exercising effective and direct management control.

c. At the top-management level (whether in Government or industry), the primary concern is with summaries of cost data that reflect the activities of many different projects, and with exercising overall policy control of priorities and performance with respect to technology, resources, and schedules.

In this Report, the needs of these three levels are taken into account in the following ways:

a. First-Level Line Management. The recommended cost-reporting system includes detailed definitions of process steps, cost accounts, and product characteristics that are meaningful in terms of computer program development. The cost accounts are based on generally accepted accounting practices (especially for the Government or Government contractors), and are compatible with the methods of cost allocation and recording that are used for other types of activities, e.g., manufacturing. This Report does not include the primary forms, e.g., cost logs, that are needed to record data on a day-by-day basis. Moreover, there is no requirement that organizations adopt the particular cost accounts in this Report, so long as data can be translated into the summary form defined in the recommended cost-reporting system.

b. Project (Program) Management. The Report is focused primarily on the needs of computer programming managers at the project (program) level, especially in the context of Air Force System Command SPOs. Forms are provided, in Section IV, to summarize the day-to-day data collected at the first level of line management by process steps and by fiscal year. The structure of the forms and the cost-reporting system is intended to be compatible with other budgeting, planning, and administrative procedures that are used at the project level, especially for Government work, and will therefore facilitate further summarization of information for reporting to higher levels of management.

The process steps, cost accounts, and product characteristics provide the basis for management control of cost performance at the project (program) level. The measures and standards that are required to exercise such control will need to be developed as substantial quantities of experience-data are collected using the recommended cost-reporting system.

c. Top Management. The recommended cost-reporting system in this Report will provide information that is generally too detailed for top management needs. In the long-term, creation of reliable data banks at project management levels, and their potential for analysis, will provide for the development of improved cost-estimation and planning techniques in the area of computer program development, which will aid management planning and control at the higher levels of management in the future.

3. Major Environmental Assumptions and Constraints. Meaningful cost reporting for computer programming development, in the context of Air Force Systems Command SPOs specifically or programs undertaken within or for the Government in general, must take place within the framework of other existing or foreseeable budgetary, planning, and administrative procedures. The major applicable procedures are noted in this part.

a. General Department of Defense Budgetary Procedures. The Department of Defense Programming System (usually known as the Program Budget), as defined by DOD Directive 7045.1 and related guidance (18) is a part of the SPO manager's environment and will remain so in the foreseeable future. By Presidential order, as of August 1965, the Program Budget concept is being introduced to other areas of the Federal Government. Although some projects (programs) within the SPOs jurisdiction fall below the present thresholds (a $10 million system R&D change, a $25 million total program, or any change in obligational authority), we assume that all programs within Air Force Systems Command, Department of Defense, and eventually the Government, will be affected by the management information and control concepts inherent in the Program Budget (i.e., comparable structuring of plans and programs according to resources, uses, and implementation).

b. General Department of Defense Cost-Reporting Procedures. Within the Program Budget context, the office of the Secretary of Defense (Comptroller) has been given responsibility for designing a selected Acquisitions and Information and Management System (SAIMS)(19), one part of which consists of Cost Information Reports (CIR)(20) and the other a cost and schedule performance system. At present, CIR provides a comparable cost-reporting structure intended for aircraft, missile, and space systems. The system is being field-tested, or is scheduled to be, on such major programs as C5-A, Advanced Ballistic Missile, F-111, and Manned Orbiting Laboratory. In addition, pilot CIR reporting has been prescribed by Electronic Systems Division for the 441A and 418L command and control systems, with the intention of extending such reporting to other major information processing applications in the future. As for the Program Budget, many projects (programs) will fall below the present CIR thresholds (for new systems or where the development or production phase started after 30 June 1965, with either a fiscal year cost of $10 million or a system cost of $25 million). The cost-reporting concepts inherent in CIR (e.g., standard cost accounts, process steps, and reporting forms) are certain to exert a substantial influence on cost reporting for all military and Government procurements, regardless of size.

c. Air Force Administrative, Planning, or Control Procedures that can involve Computer Program Development. In the subsequent paragraphs, we will note four major Air Force administrative, planning, or control procedures that can involve computer program development. It is important to recognize that none of the four are specifically concerned with computer programming, especially in the sense of cost-reporting: AFR 375 deals with general system development, and has been adapted to computer program requirements; AFR 300 deals with acquisition of off-the-shelf computer equipment; AFR 100-2 deals with planning for communications, electronic, and meteorological (CEM) systems; and AFR 57-4 deals with modifications to existing systems. All four, however, can involve or trigger substantial computer programming activities. In addition, of course, considerable computer programming is performed in the Air Force on an "in-house" basis, i.e., supported by overhead and not explicitly administered through any of the four channels mentioned.

From the standpoints of the recommended cost-reporting system, no necessary difficulty is caused by the existence of four major administrative channels for approval of Air Force computer system (including software) acquisition. A serious problem results in deriving a comparable data bank of cost and product-characteristic data from the computer programming that is initiated by (implicitly) or performed under (explicitly) these various procedures and, of course, the major in-house activities that are supported out of overhead. In this context, the recommended cost-reporting system provides one basis for obtaining comparable cost and product-characteristic data from the computer programming done in various management environments.

In the following paragraphs, each of these procedures, and its relation to computer program development, is noted briefly:

(1) System Program Management. These procedures are prescribed in the AFSC 375 series manuals (21), which define the process flow for system development through the Conceptual, Definition, Acquisition, and Operational phases; the responsibilities of the SPO; and the associated functions of procurement and production, program control, configuration management, system engineering management, and test and deployment management. In addition, AFSCM/AFLCM 310-1(22) (issued jointly by Air Force Systems Command and Air Force Logistics Command) defines procedures for the management of contractor data and reports. The AFSC 375 series manuals, and AFSCM/AFLCM 310-1 deal with generalized system development and management reporting. Recently, based on further development at System Development Corporation sponsored by Electronic Systems Division, Air Force Systems Command, these general procedures have been adapted to the needs of computer program development(23). We assume that the AFSCM 375 and AFSCM/AFLCM 310-1 procedures, as modified, will be involved in most SPO activities regarding computer programming. The standard process steps, defined in Section III.3, provide for compatibility with the System Program Management life-cycle.

(2) Data Automation Procedures. The AFR 300(24) series prescribes detailed procedures for obtaining official Air Force approval for acquiring new data processing systems. The orientation of these regulations is toward off-the-shelf computer hardware and software, and explicit provision is not

made for any subsequent computer programming that may be required. Management of data processing systems acquired by the AFR 300 channel is prescribed in AFM 171-9(25), which includes procedures for reporting costs of contractor and "in-house" systems analyses and computer programming in the following categories:

- System Analysis--Man Years
- System Analysis--Dollars
- Computer Programming--Man Years
- Computer Programming--Dollars
- Cost of Computer Program and Machine Errors--Computer Hours[3]
- Cost of Computer Program Development and Maintenance--Computer Hours[3]

The AFR 300 series administrative channel recognizes three applications for computer systems:

(a) Management Supporting Data Systems. These "...maintain records and produce information or data in support of management or administrative functions. Subsystems concerned with source-data automation, information retrieval, data display, and similar techniques are included within the Management Supporting category when directly related or integral to such data systems. Systems or subsystems for training or educational purposes, including advanced mathematical or similar studies, are also considered to be Management Supporting." The procedures for acquiring Management Supporting Data Systems are defined in AFR 300-3.

(b) Operations Supporting Data Systems. These "...produce information, usually on a real-time or near-real-time basis, for decision-making related to direct command and/or control of forces, and also those weather, warning, intelligence, communications, and other operationally associated functions. For command or control, and support systems, the term applies only to the information processing portion thereof." The procedures for acquiring Operations Supporting Data Systems were defined in 1962(26), and were to become AFR 300-6 as a part of the 1964 revision of the AFR 300 series documents. AFR 300-6 has not yet been published, however.

(c) Research and Development Supporting Data Systems. These support "...systems or processes which are computational in nature (i.e., simulation, data reduction, test analysis, biometrics, etc.) and directly support approved research and development activity." In the 1962 version of AFR 300-3, such systems were termed Scientific-Computational. The procedures for acquiring Research and Development Supporting Data Systems are now defined in AFR 300-7.

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[3]This reporting requirement applies to contractor computer programming only.

(3) Air Force Regulation 100-2 Procedures. This Air Force regulation concerns the development and acquisition of ground communications, electronics and meteorological (CEM) systems, which include "...radio, wire, and other means used for electrical, optical, and visual transmission and reception of information; radar and radiating aids to aircraft, missile, and/or satellite control and navigation; meteorological equipment; radiating countermeasures; and other electronic devices installed in a fixed or mobile configuration to perform a specific function." While CEM systems as defined do not refer explicitly to computer equipment or computer programs, these are often involved in processing the information that results. AFR 100-2(27) defines the procedures for obtaining Air Force approval of CEM system developments, and provides for two management channels, one of which must be specified by Air Force Headquarters:

(a) System Program Management. As noted in Section III.3.c. (1), these are being modified to reflect the special needs of computer program development.

(b) Functional Management. If the proposed CEM system does not "warrant the emphasis" afforded by the AFSCM 375 series, the Air Force must apply the AFM 100-18 functional management procedures.(28) At present, AFM 100-18 does not make any explicit provision for computer program development.

(4) Air Force Regulation 57-4 Procedures. AFR 57-4(29) deals with procedures for Air Force approval and control of modifications to operational systems, excluding changes to CEM systems (see paragraph (3)). The regulation defines five classes of modifications, which are oriented mainly toward hardware systems. Three of these classes refer to conditions that could initiate modifications of existing computer programs:

(a) Class II Modifications. "Temporary modifications required to support research, development, or Operational Test and Evaluation programs."

(b) Class IV Modifications. "Modifications required to correct deficiencies that would result in unacceptable mission aborts or would seriously impede accomplishment of the system/equipment mission."

(c) Class V Modifications. "Modification of a system or equipment that will provide:

- A change in operational requirements or performance that provides an added capability not inherent in the base-line configuration.

- The capability to accomplish an assigned mission that the basic system or equipment was not originally designed to accomplish.

- A significant and measurable training or logistic improvement certified essential by the command or the agency primarily concerned."

For AFR 57-4 modifications that fall within the System Program Management (AFSCM 375 series) thresholds, or are significant enough to warrant application of AFSCM 375, the comments in Section III.3.c. (2) regarding modification of these procedures for computer program development apply. For AFR 57-4 modifications that include computer programming but do not involve AFSCM 375, management, procedures especially for computer program development, have been established on a local level only(30).

d. Summary of Major Environmental Assumptions and Constraints. In the preceding pages, we have noted several major budgetary, planning, and administrative procedures that are in effect, or are being implemented, within the Department of Defense and/or the Air Force and the Air Force Systems Command. We might summarize the relation of these procedures to the recommended cost-reporting system in this Report:

(1) Since computer program developments account for only a small proportion of total Department of Defense spending (although individual computer programming jobs may be substantial), a standard cost-reporting system in this field must be compatible with the budgeting and cost-reporting procedures that are generally in effect, i.e., the Program Budget and CIR. On the other hand, computer program development is different enough from aircraft, missile, and space hardware that modifications to the existing budgeting and reporting procedures must be made if the resulting data are to be meaningful in terms of this special field.

(2) The long-term objective of the recommended cost-reporting system is to provide one basis for collecting comparable cost and product-characteristic data from all substantial Air Force computer programming jobs, and thereby to create a representative bank of experience-data for cost management and cost analysis. To make this possible, standard data items and collection procedures must be applied to different types of computer programming jobs, performed under different management environments. The four procedures cited previously, AFSCM 375, AFR 300, AFR 100-2, and AFR 57-4, provide four formal administrative channels within the Air Force for the initiation, and sometimes the management, of computer programming activities. There is, as well, the "in-house" route, which does not fall within any of the procedures mentioned. Since this Report is focused mainly on the needs of Air Force System Command SPOs, which deal primarily with AFSCM 375 series procedures, we have only mentioned the overlap in terms of computer program development with the other three management channels. To the extent that the data bank is intended to be representative of the computer programming that is done in Air Force Systems Command or the Air Force, the AFR 300, AFR 100-2, AFR 57-4, and "in-house" procedures will have to be explored more fully as the recommended cost-reporting system is developed.

REFERENCES

(1) System Program Office Manual, AFSCM 375-3, Air Force Systems Command, 15 June 1964, p. 1, 2.

(2) Proceedings of the Air Force/Industry Data Management Symposium, co-sponsored by United States Air Force, Aerospace Industries Association, Beverly Hills, California, 28-30 September 1965.

(3) The development of this classification scheme for information processing systems can be found in: Weinwurm, G. F., "The Management of Information Processing," Economics of Automatic Data Processing, Freilink, A. B. (Ed.), North-Holland Publishing Company, Amsterdam, 1965, pp. 109-126; also in SDC SP-1992/000/01, 15 July 1965.

(4) In the area of qualification testing, AFSCM 375 follows the policies and procedures in AFR 80-14, Testing/Evaluation of Systems, Subsystems, and Equipments, Department of the Air Force, Washington, D.C., 14 August 1963.

(5) Cost Information Reports (CIR) for Aircraft, Missile, and Space Systems, Department of Defense, 1 March 1966.

(6) The definitions for items (3), (4), (6), (7), and (8) are adapted from: Charles W. Adams Associates Inc., Computer Characteristics Quarterly, Cambridge, Massachusetts, June 1965.

(7) The definitions of Time-Sharing and Multi-Processing are adapted from: IFIP/ICC Vocabulary of Information Processing, North-Holland Publishing Company, Amsterdam, 1965.

(8) TM-2712/000/00, Research into the Management of Computer Programming: A Transitional Analysis of Cost Estimation Techniques, G. F. Weinwurm and H. J. Zagorski, 12 November 1965.

(9) Strengthening Management Information and Control in the Air Force Systems Command, AFSC Report, 1 June 1964, Air Force Systems Command, Andrews AFB.

(10) AFSCL 173-1, Cost Estimating Procedures, 1 October 1965, Air Force Systems Command, Andrews AFB.

(11) AFSCL 173-2, Cost Information System, 1 October 1965, Air Force Systems Command, Andrews AFB.

(12) AFSCL 173-3, Estimate Tracking System, 1 October 1965, Air Force Systems Command, Andrews AFB.

(13) Appendix B, Financial Management System Project Plan to AFSC Operations Order 65-6, Task Organization and Responsibilities for Development and Implementation under the FY 66 AFSC Cost Management Improvement Program, November 1965, Air Force Systems Command, Andrews AFB.

(14) Appendix C, Change Cost Management Subproject Plan, to AFSC Operations Order 65-6, Task Organization and Responsibilities for Development and Implementation under the FY 66 AFSC Cost Management Improvement Program, November 1965, Air Force Systems Command, Andrews AFB.

(15) Appendix D, Overhead Cost Management Project Plan, to AFSC Operations Order 65-6, Task Organization and Responsibilities for Development and Implementation under the FY 66 AFSC Cost Management Improvement Program, November 1965, Air Force Systems Command, Andrews AFB.

(16) Directive 5010.12, Technical Data and Information, Definition of Requirement and Procurement of, Department of Defense, Washington, D.C., 27 May 1964.

(17) AFSCM/AFLCM 310-1, Management of Contractor Data and Reports, Volume I, United States Air Force, Washington, D.C., 15 March 1964.

(18) Directive 7045.1, DOD Programming System, Department of Defense, Washington, D.C.; Program Budgeting: Program Analysis and the Federal Budget, D. Novick (Ed.), U.S. Government Printing Office, Washington, D.C., 1965; Bulletin Number 66-3, Planning-Programming-Budgeting, Bureau of the Budget, Executive Office of the President, Washington, D.C., 12 October 1965.

(19) "Defense Planning New Management System for Controlling Weapons Costs," Armed Forces Management, January 1966, pp. 66, 68.

(20) Cost Information Reports (CIR) for Aircraft, Missile, and Space Systems, Department of Defense, 1 March 1966.

(21) AFSCM 375-1, Configuration Management During the Definition and Acquisition Phases, 1 June 1964; AFSCM 375-3, System Program Office Manual, 15 June 1964; AFSCM 375-4, Systems Program Management Procedures, 15 June 1965; AFSCM 375-5, System Engineering Management Practice, 10 March 1966; and AFSCM 375-6, Development Engineering, June 1964: Air Force Systems Command.

(22) AFSCM 310-1/AFLCM 310-1, Management of Contractor Data and Reports, Volume I, 15 March 1964.

(23) ESD Exhibit EST-1, Configuration Management Exhibit for Computer Programs, and ESD Exhibit EST-2, Systems Management Procedures for Computer-Based Command and Control Systems, Technical Requirements and Standards Office, Electronic Systems Division, Air Force Systems Command, Bedford, Massachusetts. Also see: SDC TM-2661/000/01, Supplementary ESD Narrative Material (for) AFSCM 375-4, L. V. Searle, G. Neil, S. G. Benson, 27 June 1966; SDC TM-3014/000/00, Systems Management Documentation for Computer Programs, L. V. Searle, G. Neil, R. L. Henderson, 17 June 1966, System Development Corporation, Santa Monica, California.

(24) AFR 300-2, Data Automation: Objectives and Policies, 1 April 1964; AFR 300-3, Data Automation: Management Supporting Data Systems, 1 September 1964; AFR 300-7, Data Automation Research & Development (R&D) Support, 20 October 1965; Department of the Air Force, Washington, D.C.

(25) AFM 171-9, Management of Data Processing Equipment, 9 May 1966, Department of the Air Force, Washington, D.C.

(26) AFR 300-2, Data Systems Automation Objectives, Policies, and Responsibilities, 12 February 1962; AFR 300-3, Data Systems Automation Procedures and Responsibilities, 28 June 1962: Department of the Air Force, Washington, D.C.

(27) AFR 100-2, Ground Communications Electronics Meteorological (CEM) Planning and Programming, 15 January 1964, Department of the Air Force, Washington, D.C.

(28) AFM 100-18, USAF Ground Communications-Electronics Planning and Program Management, 15 September 1965, Department of the Air Force, Washington, D.C.

(29) AFR 57-4, Modification/Modernization of Systems and Equipment, 10 July 1962, Department of the Air Force, Washington, D.C.

(30) As one of the best examples of Command-wide procedures see: ADCM 55-32, Processing: Adaptation Data, Changes to Computer Programs and Related Equipment, Headquarters, Air Defense Command, Colorado Springs, 1 March 1965.

BIBLIOGRAPHY

Previous Publications of the Programming Management Project

1. TM-1021/002/00, A Description of the Computer Program Implementation Process, L. Farr, 25 February 1963.

2. TM-903/000/02, Management of Computer Programming for Command and Control Systems, K. Heinze, N. Claussen and V. LaBolle, 8 May 1963.

3. TM-1021/003/00, A Description of the Computer Program Implementation Process: A Process Flow, R. E. Bleier, 9 May 1963.

4. TM-1603, Frequency Analysis of Machine Instructions in Computer Program Systems, R. Bleier, 19 November 1963.

5. TM-1447/000/02, Factors that Affect the Cost of Computer Programming, L. Farr and B. Nanus, 30 June 1964.

6. TM-1447/001/00, Factors that Affect the Cost of Computer Programming: A Quantitative Analysis, L. Farr and H. J. Zagorski, 31 August 1964.

7. SP-1747, Estimation of Computer Programming Costs, V. LaBolle, 14 September 1964.

8. SP-1768, Operations Research Opportunities in Computer Programming Management, B. Nanus, 14 September 1964.

9. SP-1934, Critical Management Points, V. LaBolle, 12 February 1965.

10. TM-2313/000/00, Quality Control for Systems and Programming: A Survey of the Literature, P. Peach, 25 March 1965.

11. TM(L)-2222, System Programming Management, N. E. Willmorth. This document has not been cleared for open publication.

12. SP-2059, Research in the Management of Computer Programming, G. F. Weinwurm, 1 May 1965.

13. TM-2314/000/00, Planning Guide for Computer Program Development, L. Farr, V. LaBolle and N. E. Willmorth, 10 May 1965.

14. SP-1992/000/01, The Management of Information Processing, G. F. Weinwurm, 15 July 1965.

15. SP-2036, Quantitative Analysis of Computer Programming Cost Factors: A Progress Report, L. Farr and H. J. Zagorski, 26 August 1965.

16. TM-2313/001/00, Quality Control for Computer Programming: A Final Report on an Initial Study, P. Peach, 9 September 1965.

17. TM-2704/000/00, Research into the Management of Computer Programming: Some Characteristics of Programming Cost Data from Government and Industry, E. A. Nelson, 15 November 1965.

18. TM-2712/000/00, Research into the Management of Computer Programming: A Transitional Analysis of Cost Estimation Techniques, G. F. Weinwurm and H. J. Zagorski, 12 November 1965.

19. TM-2918/000/00, Development of Equations for Estimating the Costs of Computer Program Production, V. LaBolle, 5 April 1966.

20. TM-3026/000/00, Current Results from the Development of Cost Data for Computer Programming, T. Fleishman, 27 June 1966.

21. SP-2418/000/00, Cost Estimation for Computer Program Development: A Progress Report and an Evaluation, G. F. Weinwurm, to be published.

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13. ABSTRACT This report contains recommendations for specific items of cost and technical data to be collected from computer program development projects. Forms are provided to facilitate (1) recording of cost and technical data through the computer program development cycle, including the tracking of estimated and actual values, and (2) the creation of a skeletal history of resource expenditure patterns. Advantages are described, including the accumulation of comparable data from different types of computer programming jobs performed in different management environments, and the construction of a data bank for use in the development of standards for planning, controlling, and evaluating computer programming activi - ties. The reporting system is intended for use mainly by System Program Offices (SPOs) of the Air Force Systems Command. For this reason, the organization of the reporting system, the classification of costs, and the steps in the development process have been designed for compatibility with certain of the budgetary and management systems that do or are expected to affect the SPOs. Specifically, these are: (1) the Program Budget, (2) Cost Information Reports (CIR), and (3) System Program Management Procedures, as described in the AFSCM 375 series.

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