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SOFTWARE ACQUISITION PROCESS (SWAP) MODEL FY81 FINAL REPORT

By
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REVIEW AND APPROVAL

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

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The SWAP Model is a software cost and schedule estimating tool that operates by simulating the acquisition process. Currently, SWAP simulates only the acquisition of embedded software in Full Scale Development. It can support more diverse usage. This ~~FY81~~ report describes the Model's concepts, developmental approach, current status, and future plans, as of the completion of the second full year of its development.

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SECTION 1

INTRODUCTION

This project began in 1979 in response to a perceived need for a method of producing more reliable software cost and schedule estimates for embedded software, and an idea that better estimates could be derived from the developmental process rather than mainly on the characteristics of the software product being developed. In this approach, the scope of the process was taken to include both the software development (usually by a contractor) and the acquisition procedures normally followed by the Government. These two distinct activities were joined together because of their intimate interaction, particularly when the software procured is embedded in a military system.

To limit the scope of the initial implementation, the acquisition process was modeled to conform to the AFR 800-series regulations, and to only include the Full Scale Development Phase of the process. The modeling approach and associated simulator, however, are not inherently subject to these limitations, and the possibility of wider application is contemplated.

The development of the Software Acquisition Process (SWAP) Model has proceeded continuously for several years under different sponsors, names and project numbers. This report documents the results achieved during FY81 on Project 6820, under the sponsorship of ESD/ACCE. In order to obtain independent readability in this year's end report, a "background" section is included. This provides descriptions of the concepts employed by the Model, as necessary to understand the work accomplished during FY81.

1.1 POTENTIAL USES

A number of advantageous uses are seen for the Simulation Model. These include:

a. Improved accuracy. This should result, in part, from the explicit contractual situation on which the Model bases its estimates.

b. Measures of uncertainty. The Simulation Model will produce measures of an estimate disper‐ ‐, and corresponding estimate ranges, as well as point ‐ ‐es

c. More flexibility. The Model's process can include the effects of changes in development technique which will occur as the practice of software engineering matures.

d. More versatility. The Simulation Model can support many uses in addition to the generation of cost and time estimates. In concept, the simulation program (i.e., the Simulator) can be applied to equipment procurement, total system acquisition, acquisitions conducted per different regulations, and many other processes.

While the main driving force behind the Simulation Model is the need for better software-related cost and schedule estimates, the Model could be effectively employed for other purposes, such as the following:

a. The diagrams of the acquisition process can be useful for training military and support personnel for work on software acquisitions. The simulation program (i.e., the Simulator) can help the training by presenting a dynamic picture that illustrates the effects and consequences of alternative actions and decisions.

b. The diagrams should be helpful in project planning. They c provide a checklist that insures that important activities and products are not overlooked, and that contractual events and products are scheduled realistically. Past experience on many projects indicates that this need has often been overlooked, with negative consequences. The Simulator can also improve system planning trade-off analyses that are performed to establish the capability and capacity mix for a particular procurement.

c. The Simulator will be useful for evaluating contractor proposals by helping to determine the extent to which the proposed schedule, allocated costs, development plans, etc. are consistent with Simulator forecasts and previous ESD experience.

d. During contract monitoring, the Simulator can help evaluate the consequences of milestone slippage, delays induced by Engineering Change Propsals (ECPs), ongoing costs vs. developmental progress, etc.

After the Model is put into routine use and data associated with contracts is accumulated, the Model accuracy will improve. Its processes and parameter values will more closely reflect those found on ESD projects. As this happens, the Model will evolve in concert with improvements in the software development art. The resultant parameter changes will provide an objective measure of a "trend line" and enable more accurate future forecasts. At the same time, the data obtained on ongoing projects will enable performance on different contracts to be objectively and numerically compared.

The graphic description of the acquisition process provided by the Model presents a compact view of how the Air Force obtains embedded software. This view will improve understanding of the process and help to determine ways by which it can be improved. The objectives sought, for example, may be ways to reduce the overall time or costs, to obtain a more reliable product, or to establish the cumulative impact of various system constituents (including operating functions, support functions, and data items) for use in tradeoff studies that consider each constituent's utility value. Use of the Simulator allows the dynamics of the process to be assessed and makes it practical to obtain quantitative answers to complex questions for both general acquisition policy and specific procurements.

Finally, the Model can also be used as a research tool for investigating development alternatives and managerial strategies. It can forecast, for example, the impact of different manning assignments, more or fewer development support facilities, longer or shorter schedules, etc.

1.2 ORGANIZATION OF THIS REPORT

This report has been organized into a report body that is supported by a number of appendices. The appendices generally serve to retain the documentation developed during the ongoing definition and design activities, as well as detailed information that would be of interest to a small subset of users. While these appendices are too detailed for inclusion in the report body, they do provide important reference and backup materials. For example, Appendix A, Process Flow Diagrams and Amplification Notes, expecially Figure A-2, Software Acquisition Process Flow Diagram - LoSim Level, depicts the entire FSD Process, at the level planned for initial simulation. This figure, which was revised during FY81, may be inspected to obtain considerable insight into this acquisition life cycle phase. While many readers are probably familiar with (or have participated in) the FSD process, the overall complexity and degree of interaction of the process are not so apparent when experienced during the two or three years during which the process unfolds. The diagram can impart an integrated view of the whole procedure.

Similarly, Appendix B, Model Definition Data, contains estimates of the manpower and elapsed times necessary to complete each of the activities depicted in Figure A-2, and the probabilities of the decisions shown there. Appendix B, which was thoroughly revised during FY81, may also be of interest because it represents the Figure A-2 flow diagram network in tabular form for use by the Simulator.

Appendix I provides design documentation for the four computer programs that implement the Simulator, and Appendix J provides example copies of output reports produced by the Simulator. Note that the appendix designators are not in consecutive order. The appendix designators were initially established in the FY79 Final Report and have been retained for consistency. Those appendices that are not applicable to the FY81 work have been omitted. Finally, Appendix K was added to this year's report to preserve the functional analysis by which the Generic Adaptation Process (GAP) was formulated.

The body of this report is organized into 6 sections. Section 2 provides background information that "sets the stage" for this year's work. Section 3 describes this year's accomplishments and achieved status. Section 4 covers program operation and a planned demonstration that was deferred to early FY82. Section 5 develops a plan for further growth of the Model, and Section 6 provides recommendations based on the year's results.

SECTION 2

BACKGROUND

This section is intended to provide information about this project to persons who have not been following its progress and have not read prior years' reports. It presents the ideas and concepts underlying the development and indicates the status of the project at the end of FY81.

2.1 BASIC PREMISES

During preparation of the Software Acquisition Process Model, it was found necessary to delineate the Model and to limit the scope of the effort to fit within a limited budget and schedule. The set of basic premises discussed below was established, therefore, as guidance for the initial phases of this work. Some of these apply to the acquisition process itself, others to simplifications introduced for application to early versions of the Simulator. These premises, whenever applicable, are referenced by Table A-2, Process Flow Diagram Amplification Notes, which supports the Process Flow Diagrams.

2.1.1 Conformance to Military Standards

The acquisition process modeled is intended to conform to all military standards and regulations that are normally applied to software acquired during Electronic System procurements. These include MIL-STD-483, Configuration Management Practices for Equipment, Munitions, and Computer Programs[1]; MIL-STD-1521A, Technical Reviews and Audits for Systems, Equipment, and Computer Programs[2]; AFR 800-2, Acquisition Program Management[3]; and AFR 800-14, Vol. II, Acquisition and Support Procedures for Computer Resources in Systems[4]. If deviation from these practices is found to be necessary, it will be explicitly described (and explained) at each point in the process where it occurs; a summary list of all such deviations, if any, will be provided.

2.1.2 System, Segment, and CPCI Relationships

The relationships among activities associated principally with a system, its segments, and its Computer Program Configuration Items (CPCIs) will be considerably simplified in the early implementations. In particular, system segments can be used in different ways on different contracts and are therefore not fully amenable to generic implementation. For this reason, the Model addresses the CPCI (level 3) and one level higher. While this higher level is referred to as "system" (level 1) it could as readily represent "system segment" (level 2). The choice is dependent on the nature of the system and the specific contract(s) being simulated.

In addition, while the Model is designed to accommodate a number of CPCIs, it will treat these initially in a somewhat simplified manner. As thus modeled, all CPCIs will initiate and terminate together (e.g., in the System Test), and proceed independently in between. In actual practice, the various CPCIs often have dependency relationships which can be of critical importance to the success of a project. Later versions of the Model will be designed to accommodate these relationships.

2.1.3 Validation Phase Activities

The Process Model of the Full-Scale Development Phase presumes that a full Validation Phase has already been completed. However, since many projects omit this phase but incorporate some of its activities in the Full-Scale Development Phase, provision should be made for such activities' incorporation (e.g., the preparation of development specifications) in the FSD Phase Model. Extension of the Model to the Validation Phase is planned for later implementation. The process flow developed for that phase will be designed so that selected activities can be readily moved into the Full-Scale Development Phase.

2.1.4 Support Facilities

The Model presumes that the Test and Programming Support functions are each provided by separate facilities. On some projects, such facilities may be shared (in whole or in part) to support both functions. The Model can reflect any combined use of these facilities.

While the current Model provides for accumulating the costs of operating and maintaining support facilities and for the impact resulting from their late availability, it does not include the effect of contention between facility users or the results of unscheduled down time. These latter capabilities will be added in later versions.

2.1.5 Staged Implementation Provisions

Procurement regulations allow design reviews to be conducted on a single or on an incremental basis. The Model is being designed to represent the incremental approach. While this decision adds to the complexity of the Model, it was taken because the single design review approach would not support the trend toward staged development, particularly for larger systems. The Model will also accommodate the single design review approach, simply by setting the number of design increments to one.

The initial Model is being designed to accommodate the following incremental or staged approach:

a. Each CPCI is defined by a specification which states the functional requirements to be met at the completion of the current procurement contract. While certain follow-on requirements may also be explicitly or implicitly defined, these are treated as beyond the scope of that contract.

b. The contractor would divide the total contractual requirements into several developmental stages (hereafter called Developmental Integration Groups (DIGs)). This division would be defined in a phased implementation plan that is included within the Computer Program Development Plan (CPDP).

c. As shown in Figure 1, Staged Group Development Example, the contractor would then proceed with the design of the first DIG (DIG-I). The work on this DIG would then pass successively through the various phases of the design process (including Preliminary Design Review (PDR) and Critical Design Review (CDR)), and through coding, debugging, integration, and contractor internal testing. The work might also be subject to Preliminary Qualification Testing (PQT), but not to Formal Qualification Testing (FQT).

d. The design and implementation of the other DIGs would proceed in order behind DIG-I. Work on the second DIG (DIG-II) would begin after completion of high level design on DIG-I; DIG-III would similarly start after DIG-II, etc. The CDRs and other development activities for each DIG would proceed in the same order.

e. During each stage of development, each successive DIG would add to and build onto the aggregated preceding DIGs. In other words, a single CPCI would be built in successive stages; it would not be built as separate DIGs to be joined together at the end.

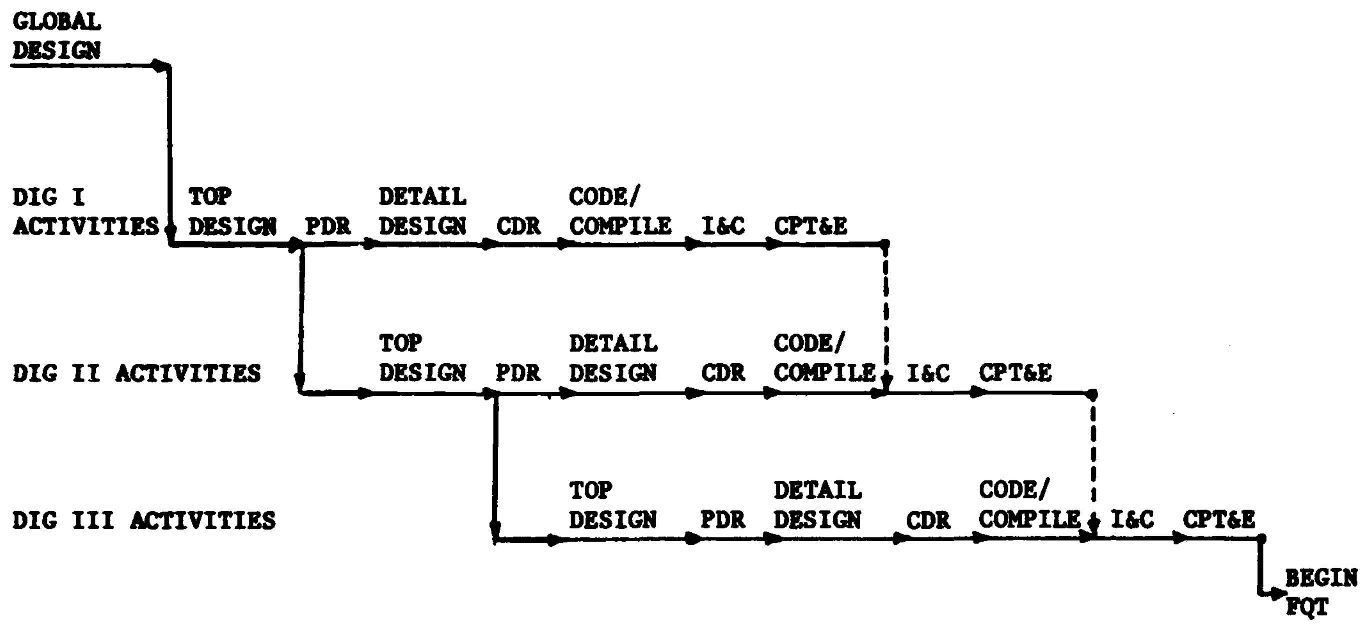


Figure 1. Staged Group Development Example

f. When the last DIG passed through each development stage, the total implementation to that stage would be complete. Therefore, each last DIG design review would be extended to survey the totality of the design, in addition to that of the last functional increment.

g. The Model documentation includes notation to accommodate the incremental development concept. The notation will indicate (with a "D"; see Figure A-1) those processes which are presumed developed in this phased manner. In addition, when a development phase is complete for one DIG, the process must return to that phase to begin work on the next DIG. This type of return is shown as type "D" on the Process Flow Diagram (Figure A-2) and in the Network Definition Table (Table B-1) (in its General Data Grp column).

h. The formal test activities may also be conducted on a similarly staged basis. The Model supports this approach by allowing Test Integration Groups (TIGs) to be sequentially processed in a manner analogous to the handling of DIGs. Note that the TIG division involves the test related activities and applies to a totally implemented CPCI; therefore, TIGs are not related to DIGs in terms of usage or quantities.

2.1.6 Incidental Activities

While the Model is planned to include all significant mainstream acquisition activities, it will not include a number of incidental tasks that are essential to a project but that would add needless complexity to the Model. Instead, the cost and loading impact of such activities are aggregated into larger mainstream activities. Similarly, certain events and activities judged too infrequent or too inconsequential to the Model (though not to the acquisition process) will not be included. Should experience or collected data indicate that some of these incidental activities be added to the Model, this can be done in a later version.

2.1.7 Resource Utilization

Each process activity uses project resources such as:

a. contractor manpower in various job categories;

b. government manpower in various job categories;

c. development support facilities;

d. test support facilities;

e. miscellaneous other resources.

In the current implementation, only manpower resources are being assigned to specific process activities.

2.1.8 Manpower Categorization

The manpower categories listed below were selected for implementation based on our acquisition program experience. In addition, the manpower accounting techniques and the effects of resource limitation are described below.

a. Contractor Personnel. Five job categories were selected for individual assignment to each activity:

(1) systems engineer or analyst;

(2) designer;

(3) programmer;

(4) test engineer;

(5) support (e.g., equipment operator, librarian, technical writer).

A sixth category, management, was not included because the need to subdivide a manager's time among many ongoing tasks made its estimation impracticable. Aside from the difficulty in estimation, results would be inaccurate because management styles differ widely and would generally be unknown. Instead, management is treated as a continuous activity with a utilization profile that conforms to the estimated (or given) needs for the project being modeled.

b. Government Personnel. Three job classifications were selected for personnel assignment to specific activities; these reflect the three principal commands involved in system acquisition: The Developing Command (e.g., Electronic Systems Division (ESD)), the Using Command (e.g., Tactical Air Command (TAC)), and the Supporting Command (e.g., Air Force Logistics Command (AFLC)). Further specification of assignments (e.g., to Engineering, Test, Configuration Management, etc.) can be provided later, if needed.

c. Initial Implementation Technique. Because personnel categories are likely to differ for different contractors and projects, the design permits any number of categories to be selected.

d. Resource Limitations. The rate of progress on any project can be strongly influenced by the quantity and quality of the available resources. When the demand for a resource exceeds its supply, the process will slow accordingly. This process behavior, while inherently simple, requires that different management strategies be devised to resolve automatically the problem of allocating scarce resources among competing activities. The Model 0 Simulator did not reflect the effects of resource limitation. Model 1 does include resource limitation, but with an elemental management strategy, as described in paragraph 3.3.1.

2.2 DESIGN APPROACH

The overall developmental effort on the project is channeled into three principal areas. These work areas, which are briefly introduced below, are detailed in Paragraphs 2.2.1 through 2.2.3 respectively.

a. Process Definition. This work involves the creation of Process Flow Diagrams and Explanatory Notes which represent the process whereby computer software is acquired by ESD under the AFR 800-series regulations. In particular, the project is focused on software that is embedded within a large command, control, and communications system (see DoDD 5000.29, Management of Computer Resources in Major Defense Systems)[5]. For maximum realism these Process Flow Diagrams represent both sequential and concurrent activities. Otherwise, to facilitate communication, they resemble conventional Von Neumann flowcharts.

b. Process Quantification. This work involves establishing parameters which describe each element within the Model, and obtaining appropriate values for these parameters.

c. Process Simulation. This task requires that the Model be mechanized so that it can be used to carry on synthetically the processes defined, using the assigned parameters. It can thereby forecast and report the statistical consequences in terms of probable schedule and cost distributions. A discrete event simulation program (i.e., the Simulator) is the mechanism of choice.

2.2.1 Process Model Definition

Process Flow Diagrams have been used as the principal means for describing the process of acquiring embedded software. They were developed at several levels of detail, as follows:

a. a global view of the whole process;

b. a high simulation level (HiSim);

c. a low simulation level (LoSim); and

d. expanded views of LoSim boxes to show more elemental relationships as needed.

During FY81, work on these diagrams has been confined to the LoSim level; only these in their revised form are contained in Appendix A.

The conventions followed by these Process Flow Diagrams are described in Appendix A, Figure A-1, Flow Diagram Notation. Briefly, they define three types of basic elements: (1) function boxes; (2) auxiliary elements (e.g., connectors); and (3) lines of flow. These conventions should be understood before the Process Flow Diagrams are reviewed.

The LoSim Process Flow Diagram (Figure A-2) uses approximately two hundred boxes on eleven pages to represent the overall process. The function represented by each box is described in abbreviated English, but box size limitations make it desirable to code some of the information via box shapes as well as in special fields. The key to connector and box number locations in Table A-1 will aid in following the flow and in finding boxes referenced in the tables of Appendix B. This diagram was prepared during FY79, and revised during FY80 and FY81.

The main flow of the process is represented using three principal box types. The purpose of each type is briefly described below:

a. The Activity Box, rectangular in shape, represents all developmental activities that use manpower and occupy time.

b. The Decision Box, diamond shaped, is used to represent all decision points in the process. Each of these show two alternative exits ("yes" or "no") that the process can take as a result of a probability function.

c. The Personnel Box, small and pointed, is used to establish and adjust the personnel level assigned to the project. This box controls the size of the pool of personnel (by type) from which each activity box will draw its manpower when it is activated.

Each box contains symbolic fields to indicate who is the doer (i.e., the contractor, government, or both), the level of the activity (e.g., system, CPCI, CPC, etc.), and whether the activity is multistaged (see 2.1.5). These are fully described in Table A-1.

The direction of flow from box to box is indicated by arrows while the logic of the flow is indicated by letters associated with the flow lines. These indicate AND/OR relationships, iterative or forward progression, and conditions for advancing to the next developmental stage. These also are defined in Table A-1.

2.2.2 Process Quantification

The Process Flow Diagrams discussed in Paragraph 2.2.1 describe the sequences of activities and decisions involved in the acquisition (including development) of embedded software. Since this description is qualitative, it can yield no quantitative predictive output. In this section, means are described for adding quantity and probability to the Process Model.

During FY80, a set of quantitative descriptors and appropriate values for each box were established for a "typical" acquisition program. This year the data for a typical project, now referred to as the "base project", was used to create a pattern for resource utilization that can be scaled to obtain appropriate values for any given (target) project. This technique, which is termed the "Generic Adaptation Process" (GAP), is defined in Appendix K and is briefly described in Paragraph 3.3.1.e.

The base project parameters and the values assigned to each box are defined and given in Appendix B. The values shown are those in effect at the end of FY81. The main parameters are briefly described below.

a. The Activity Box is given a duration (in days) and a manning level for each of five personnel types. Manning levels may be specified in fractions (i.e., to the nearest tenth of a man) to allow for personnel time sharing. The data also includes scaling factors to be applied for up to three iterations.

b. The Decision Box parameter used is the probability (in percent) of a Yes exit. The probability values for up to three iterative entries are also given.

2.2.3 Process Simulation

The Simulator computer programs by which the SWAP Model is mechanized are written in the SIMSCRIPT II.5 language for operation on the MITRE Bedford IBM-370 facility. The FY80 design consisted of four components as follows:

(1) The Data Input Processor, (2) the Simulation Conduct Processor, (3) the Output Report Generator, and (4) a Read/Write Interface package that serves to interface the three processors. The three processors execute sequentially. The Data Input Processor operates on the input data sets defined in Appendix B to produce a data base usable by the next processor. The second (the Simulation Conduct Processor) is driven by these data and develops simulation results which it stores. The Output Report Generator statistically analyzes, formats, and prints the results. The designs of the Data Input Processor and the Output Report Generator are straightforward. The design of the Simulation Conduct Processor is rather unusual (for a simulation program), and thus worth brief discussion here.

The Simulation Conduct Processor is table-driven. Thus, the complete Model is defined by a set of table data such as those given in Appendix B. Each of the two-hundred plus boxes included in the LoSim Process Flow Diagram of the Full-Scale Development Phase, discussed in previous sections of this report, is descibed by an entry in Table B-1 and another entry in Table B-2, Table B-3, or Table B-4. After the Data Input Processor has reformatted these tables, the Simulation Conduct Processor reads the data for the first box, takes actions which depend on the box type (e.g., Activity Box, Decision Box) using the assigned parameter values (e.g., activity duration or decision probability), and saves any data needed to describe the results. It then proceeds to each of that box's immediate successor boxes; these are processed in appropriate sequence until all boxes involved in the pass through the network have been accessed. Since the Simulation Conduct Processor's path through the network is determined by Monte Carlo selection of alternative Decision Box exits, a different sequence of box activation and results is likely on each path. Thus, the program must repeat many times (per another input parameter) to obtain statistically significant results.

A new program component, the Generic Adaptation Processor (GAP) was added during FY81. The GAP is described in Paragraph 3.3.1.e.

SECTION 3

ACCOMPLISHMENTS AND STATUS

During FY81 the project budget provided for less than two man years of staff effort. This effort was primarily directed at the Simulator development activity. These developmental activities did impact the process definition and quantification activities so that supplemental progress was made in these areas.

3.1 PROCESS DEFINITION

The LoSim Level Process Flow Diagram, as shown in Appendix A, defines the software acquisition process as carried out by the SWAP Model. During FY81, the following modifications were incorporated:

a. Personnel Boxes (P-Boxes) were added to establish and adjust the level of personnel available to man the project during the developmental period.

b. Remote Action Boxes (R-Boxes) were added to allow recurring and ongoing activities to be terminated at appropriate times.

c. A number of changes in the activity sequences were introduced to obtain a more uniform rate of personnel usage; these sequences are considered to be a better reflection of industrial practices.

d. The diagrams were selectively simplified by the aggregation of a number of boxes representing elemental activities into fewer boxes with combined functions. Most of these changes were introduced into the concluding FCA and PCA representations.

3.2 PROCESS QUANTIFICATION

The Box attribute quantities for the base project, as shown in the tables contained in Appendix B, were modified as follows:

a. A new table (B-5) was added to control the personnel level assigned to the project via P-Boxes.

b. Table B-4 was modified to allow remote control parameters (via R-Boxes) to be specified.

c. The levels of personnel and time durations were extensively modified as part of the project calibration activity made necessary by the other changes introduced into the Model.

d. A technique for scaling the base project tabular data into data that represents any target project was defined and developed. This capability is described in Paragraph 3.3.1.e.

3.3 PROCESS SIMULATION

The Simulator capabilities were extensively enlarged and revised as discussed below.

3.3.1 Simulation Process Changes

a. Personnel Box (P-Box) and Personnel Assignment Strategy

The prior design imposed no limits on the personnel quantities available on the project being modeled so that any box could begin as soon as all of its logical precedents have been accomplished. The P-Box was introduced to establish and regulate the level of personnel available during the project. At the same time, the box start logic was modified to require the availability of adequate personnel before a box can begin. These changes caused major manpower bookkeeping and queueing functions to be developed and the introduction of a management strategy that mediates conflicting demands on limited manpower.

b. Remote Action Boxes (R-Box)

Certain activities such as the Program Management Review (PMR), recur periodically, but eventually cease at some point near the end of the project. Other activities, such as the operation and maintenance of the developmental support facilities are ongoing, but are shut down at a point where they are no longer needed. The R-box was introduced to allow these activities to be turned off whenever the process reaches the established point.

c. Box Burst

Model 0 treats a number of multiple parallel activities as if each were a single aggregate operation. For example, module coding is represented by a single box; it is actually a collection of many individual activities being separately conducted. This treatment produces two unrealistic consequences:

(1) Individual activities can begin and end at different times, while the aggregate activity begins and ends together. Thus, any successor box which must normally wait till all individual activities have completed, will begin too soon in the simulation.

(2) Individual activities can normally begin or not in response to the level of manning available; in contrast, the aggregate box needs the full manning allocated to that box. When project manning is limited, the aggregate box approach can produce an artificial delay in starting the box; this would result from the wait until full manning becomes available.

If this problem were to be solved by individually modeling all modules, the Simulator could be swamped by excess detail, and such detail would be project specific rather than generic. The Box burst solution was implemented to allow the aggregate boxes to be given "burst" attributes. Thus, each such box is designated as a "start", "end", or "continue" burster. Burst boxes automatically subdivide into "n" equal parallel sub-boxes with each taking 1/n of the manpower, and each starting independently. The arrangement reduced the consequences described above by the factor "n", and retains the generic aspect of the process. In the current implementation, "n" was set to five.

d. Data Input Checking

Model 0 accepted table input data with only a minimum of validity checks. Because the volume of data is large and manual data entry is error prone and the consequences of data error can be serious, the validity function was expanded. In particular, those attributes that could be verified for consistency, range of value, etc., and which could seriously impact the simulation were checked by the data input processor. In addition, the input table format was simplified by the removal of data no longer needed by the program; this made table modification (e.g., adding or deleting boxes) much easier to accomplish.

e. Generic Adaptation Process

Simulator Model 0 developed quantitative output data for a single mid-range project. If some other project were to be simulated using that model, it would be necessary to update all the data in over 150 boxes to reflect the new project. This would require a very large effort:

(1) to determine correct data values for each box,

(2) to physically enter the data, and

(3) to detect and correct all errors in the process.

Of these actions, step (1) is most difficult and most uncertain in outcome.

Model 0 was never intended to be adapted to other projects by the above method; it was a stepping stone toward the more easily adaptable Simulator, Model 1. In this year's Model, the adaptation to any other (target) project has been accomplished by an automated technique known as the Generic Adaptation Process or GAP, which is documented in Appendix K.

GAP is basically a scaling technique. It produces a set of seven scaling factors that are derived by comparing the attributes of a "target" project with those for the "base" project, where "base" refers to the mid-range reference project used for Model 0.

The scaling factors developed are each oriented to a specific type of developmental activity. Between them, they account for all types of activities in the acquisition process, as modeled. Each box in the Model belongs to just one of these factors and is scaled by the value obtained for that factor. The following are the seven activity scaling factors used by GAP:

(1) Program Design
(2) Program Coding through Integration
(3) Program Test
(4) Composite (or mixed) Developmental Activities
(5) Formal Design and Program Documentation
(6) Formal Test Documentation
(7) Formal User Documentation

The scaling process itself converts the data values associated with each box in the acquisition network from the box data values established for the "base" project into data that reflects the "target" project. The scaling relationships are not strictly linear or just multiplicative. They end up altering: Activity Box manning levels and duration; Decision Box probability; and project staffing levels. They take into account the overall size of the project and the managerial policy that determines whether manning levels will be lean or heavy (e.g., to compress schedule). It also accounts differently for highly integrated activities as compared to those activities that can proceed relatively independently.

The values obtained for the seven factors are derived from a comparison of the attributes of the target project against those for the base project. A total of about 50 attributes are considered, each of which can affect the value of one or more of the seven scaling factors. The attributes for the base project are used to compute the seven effort levels for the base project. Corresponding values are computed for any target project being simulated. The ratios of these two groups of effort levels produce the seven effort factors.

All projects on which this Model is used will be compared in terms of about 50 attributes, each of which can influence the cost or schedule of the acquisition. These attributes are organized into four groups as follows:

(1) PRODUCT - These encompass requirements and characteristics associated with the products to be developed and delivered. These can be defined at the CPCI level; some can be further subdivided to the functional component (CPC) level. Product attributes include the size and complexity of the computer program, formal documentation requirements for both product maintenance and test, and any special test requirements.

(2) METHODS - These characterize the methods and tools to be used by the contractor for the design, programming, and test of the computer programs.

(3) STAFF - These characterize the productivity to be expected from each of the different types of personnel (i.e., Designer, Programmers, and Testers) that will be assigned by the contractor.

(4) CONTRACTUAL - They further subdivide into three categories involving (a) the contract itself, (b) the contracting agency, and (c) the contractor. Contractual factors tend to apply to the acquisition as a whole, while the other factors tend to apply to specific major activities.

It should be noted that the user may not know all the attributes of his project at a time when he needs to obtain an estimate. Simulator Model 1 provides default values (that reflect current common practices) for any values not supplied by the user, so that the Model can be used with minimal input. Future versions of the simulator will respond to unknown entries by treating them as instances of uncertainty. This will operate so that the range of variation in the output forecast will be selectively increased for each default value used.

f. Miscellaneous Improvements

Many of the routines that constitute the Model 0 Simulator were extensively reworked to improve the program structure. These changes will facilitate the installation of new program capabilities and allow maintenance to be performed without extensive dislocation and consequential trauma. Although this work on the "bottom side of the iceberg" is not visible from the outside, it was most important to the successful completion of the above described new capabilities and to others yet to be installed.

3.3.2 Output Improvements

a. Cost Data Reporting

The Model 0 reports provided no dollar cost data; all effort was expressed in terms of man-days. Model 1 provides the following cost data reporting;

(1) The user can enter the following financial data

(a) Base Year wage rates for each personnel type.

(b) Overhead rate, G & A, and Fee.

(c) Annual inflation rate with starting month.

(2) The "Manpower Expenditure Summary" report was expanded to include Base Year cost data and renamed "Contractual Expenditure Summary;" see Figure J-4.

(3) A new "Monthly Expenditure Profile" report was created that provides per month cost data in a four column format that provides per month and cumulative costs for both base year and then year (i.e., including inflation) labor rates; see Figure J-7.

b. Output Data Variability Format

Model 0 reports indicated the range of variation in output data by providing mean values and standard deviations. For Model 1 reports, the range of variation is provided by three entries for each data item reported, i.e., mean, optimistic, and pessimistic values. The latter two are based on run data that was segregated into groups that fall into the best and worst quintiles. The optimistic/pessimistic thresholds can be set by the user, to meet his own needs.

Examples of this format appear in the following reports:

(1) Milestone Schedule; see J-1
(2) Contractual Expenditure Summary; see J-4
(3) Monthly Expenditure Profile; see J-9

c. Activity Box Reports

In Model 0, individual reports could be obtained for any individual activity or decision box. Model 1 provides an Activity Box Summary Report instead, which uses a one line per box format in which the most significant data can be shown. The change greatly increases the utility of the data because the compact format allows box data to be easily found and readily compared; both from box to box and run to run.

d. Subnetwork Reports

In Model 0, any report could be obtained for any individual subnetwork. In Model 1, reports can be had for combinations of subnetworks, as selected by the user.

e. General Improvements

The report formats and detail content of the reports were modified to improve their readability and utility. For example, milestone dates are given now in months and days, rather than working days; overall manpower utilization is now in man-months rather than man-days; subnetwork reports include the subnetwork name as well as its number, etc.

f. Calibration Aids

The calibration activity requires that base project activity durations, box manning levels, project manning, and decision probabilities be such that reasonable schedule, cost, and personnel utilizations are achieved. Special reports that document the timing and sequence of individual activities are needed along with other reports that show how manpower pool levels fluctuate during the simulation. Program additions that create such reports were implemented during FY81.

3.4 PROGRAM DESIGN

The program consists of four packages, each of which is individually run. These packages, are listed here and described briefly below. A more detailed description of each of these programs is provided in Appendix I.

1. Data Tables Input Processor (DIP) Program
2. Generic Adaptation Process (GAP) Program
3. Simulation Conduct Processor (SCP) Program
4. Output Report Generator (ORG) Program

3.4.1 Generic Adaptation Processor (GAP)

This program reads in up to the approximately fifty project descriptors for the target project and uses these to assess the magnitude of the various activities involved in the software acquisition/development for that project. It then transforms the base project box data values into a set that reflects the magnitude of the target project. The GAP output data can then be read by DIP which checks its validity and converts the format into one that is compatible with SCP.

3.4.2 Data Table Input Processor (DIP)

This program reads in the voluminous data tables that define the target project. It runs syntax, format, and consistency checks on the data, and produces warning messages when errors are found. Finally, DIP produces a data base that can be used by SCP.

3.4.3 Simulation Conduct Processor (SCP)

This program conducts the simulation of the acquisition process. It enacts the process by following the box to box sequence defined by the network linkage table while using the box parameter data base established by DIP. It makes multiple passes through the network (quantity of passes is user specified) and retains the data produced during each pass.

3.4.4 Output Report Generator (ORG)

This program reads in the results of the SCP Simulation, statistically reduces the data, and organizes it to produce the output reports requested by the user.

SECTION 4

PROGRAM OPERATION AND DEMONSTRATION

4.1 PROGRAM OPERATION

The program is currently designed to be operated from a CRT Terminal that is tied into the MITRE System 370 facility, using TSO. This user interface, while adequate for use by programmers (the current need) is not appropriate for use by cost analysts. A "friendly" interface is planned for implementation, see 5.1.1a.

The four programs that constitute the Simulator are described in paragraph 3.5. While each is designed for independent operation, data dependencies impose an order of operation as follows:

(1) If any of the Base input tables (per Appendix B) have been altered, the DIP program is used to validate their format and consistency.

(2) The Generic Adaptation Processor (GAP) is used after step 1, or as the first step, to read in the Target project Descriptors and to accordingly convert the Base project box data values to reflect the target project.

(3) The DIP is then run to obtain an SCP-compatible data base.

(4) The Simulation Conduct Processor (SCP) is then used to conduct the simulation.

(5) Finally, the Output Report Generator (ORG) is operated to create the reports wanted.

Each of the programs has options and overrides that allow various alternative situations to be explored, without the necessity of going through the whole sequence each time. For example, the SCP permits data in certain boxes to be altered, or certain paths in the process to be cut-off, etc. before it is run.

4.2 PROGRAM DEMONSTRATION

With all the new capabilities described in Paragraph 3.3 installed, the program operation was demonstrated to the ESD/ACCE Project Sponsor.

4.2.1 Demonstration Projects

The program was operated three times as follows:

a. The Base Program was operated. This illustrates operation without the use of the GAP program and provides a baseline representation against which GAP operation could be compared.

b. A hypothetical program was formulated that was twice the size of the base program. This project (labeled "X2") illustrated how the GAP program could transform the base data to simulate a larger project.

c. This case is the same as b. above, but with a half size program (labeled "/2").

The hypothetical program characteristics are described in Appendix K.

4.2.2 Reports Produced

A set of reports were produced to illustrate the results achieved in the demonstration. These reports, as listed in the following table, are provided in Appendix J.

Project	Report Type	Subnets	Fig. No.
Base	Milestone Schedule	Full	J-1
X2	Milestone Schedule	Full	J-2
/2	Milestone Schedule	Full	J-3
Base	Contractual Expenditure Summary	Full	J-4
X2	Contractual Expenditure Summary	Full	J-5
/2	Contractual Expenditure Summary	Full	J-6
Base	Contractor Monthly Expenditure Profile	Full	J-7
X2	Contractor Monthly Expenditure Profile	Full	J-8
/2	Contractor Monthly Expenditure Profile	Full	J-9
/2	Milestone Schedule	2,3,4	J-10
X2	Contractual Expenditure Summary	2,3,4	J-11
X2	Activity Box Summary Report	Full	J-12

4.2.3 Discussion

The demonstration was conducted to show operation of the Model 1 programs; it was not intended as an indication that the Model's output data target projects are correct or reasonable. The latter purpose was inappropriate because the base project data and GAP relationships have not yet been calibrated. Nevertheless, a number of observations can be made from these reports.

a. While the program sizes of the two hypothetical target projects were twice and half of the base project, the seven effort factors obtained for each project indicated much different scales. This is because the project descriptor sets assigned to the target projects reflected more recent technologies than those used on the base project. Thus, implementation techniques were more productive and the degree of time and storage criticality was reduced. The latter condition reflects the decreasing hardware costs for storage and computing power, which reduces the need for criticality. The seven Activity Factors obtained were as follows:

Project	Program Effort Ratios				Documentation Ratios		
Name	Design	Program	Test	Mixed	Design	Test	User
X2	1.53	1.15	0.87	1.18	1.61	1.27	1.18
/2	0.32	0.38	0.24	0.31	0.27	0.27	0.22

The model forecasts resulting from these inputs were:

Project ID	Mean Manpower Costs (loaded)	Project Duration to PCA
Base	$6.89M	30 Months 16 Days
X2	$8.76M	35 Months 12 Days
/2	$2.68M	24 Months 18 Days

The full schedule and cost breakdowns and monthly summaries can be obtained by inspection of the actual reports produced; see Appendix J. While these results reflect the operation of all the new capabilities described in 3.3.1, it should be noted that the Personnel Assignment effects (per para. 3.3.1a) were somewhat muted by the imposition of an initial manpower level override that created a larger than normal manpower pool. This was done to prevent the uncalibrated personnel box values from distorting the results of the overall operation. Some rework in the personnel assignment technique, which will facilitate manpower level calibration, is planned for FY82; see 5.1.1b.

b. New Output Report Capabilities

The new output report capabilities listed below are described in 3.3.2, and are illustrated in the Appendix J reports; see list at Para. 4.2.2:

(1) Cost Data is shown in all "Expenditure" reports.

(2) Output data variability is shown in all reports except the "Activity Box Summary" report.

(3) Examples of combined subnetwork reports are shown in Figures J-10 and J-11.

(4) An Activity Box Summary Report, which was truncated to reduce the number of pages, is shown in Figure J-12. The version shown orders the boxes by ascending Box ID. The same report, but in the order of activity start time, can also be obtained.

SECTION 5

PLANNED GROWTH

While the Model is now operable, there remains a number of capabilities that need to be implemented before it can achieve its full potential. At the anticipated project funding level, several years of continuing development are foreseen. Paragraph 5.1 describes the work planned for FY82, and indicates some extensions to this work planned for later years. Other deferred tasks are identified in Paragraph 5.2.

5.1 PLANNED FY82 WORK

5.1.1 Model 2 Simulator Development

a. User Interface

Model 1 uses a programmer oriented technique for entering project definition data and operating the Model. An interface that allows Cost Analyst personnel to operate the Model will be defined and implemented on Model 2. The interface will provide directive guidance to the user on what information is to be entered, its range of values, and any default values substituted if the data is omitted. In addition, the operation of the Model, the imposition of any desired overrides or other directive data, and the selection of the desired data base will all be simplified by a unified set of operating procedures. Directions for operating the Model will be documented.

b. Personnel Assignment Method.

In Model 1, each activity box (or a burst derived sub-box) requires a defined mix of personnel (e.g., 1 system analyst, 3 designers, 5 programmers, 0 testers, and 1 support) in order to start. If all members of this mix are not currently available, the box must wait. The wait imposed by this rigid mix technique is not representative of real world practices. Model 2 will permit a more flexible manning mix to be used to start any box, and will adjust the box duration to reflect the mix actually assigned. On future models, ongoing long running activities may include "mid stream" manning level adjustments, if the need develops.

c. Box to Box Transition Timing

In the Model 1 Simulator the starting of any box requires that all of its required predecessor boxes be fully completed. During actual developments, it is often possible for a successor activity to begin before all of its predecessor activities have fully completed. Model 2 will include provision to allow a box to start whenever each of its predecessors has reached its designated degree of completion (e.g., 75%). This technique, which permits overlap of some sequential activities will allow realistic activity durations to be compatible with a realistic overall schedule.

d. Generic Adaptation Process (GAP)

GAP program development was completed in Model 1 except for a few minor functions. Simplified versions of these functions were substituted in order to have a demonstrable model at the end of the fiscal year. These functions will be completed in Model 2.

A second stage GAP development will also be carried out on Model 2, dependent on time availability. In this second stage, the Model will respond to user input omissions (e.g., project determinants that are not known to the user at the time that an estimate is wanted) by increasing appropriately the range of variation indicated in the Output Reports. The required Model behavior will be defined in FY82, but the implementation will be dependent on the level of programming support applied to the project.

5.1.2 Model Quantification

a. Base Project Attributes and Tables.

Any Base project used to provide the "take-off" point from which other projects are extrapolated should ideally be one on which good data is available that describes:

(1) Project attributes as defined by GAP

(2) Project activities performed as defined by Table B-1

(3) Project schedule that allows Activity Box durations to be established

(4) Project manning that allows Activity Box manning levels and Personnel Box values to be established

The 407L Project used for Model 1 and Model 0, is far from this ideal. While the project was real, it was completed more than ten years ago and, therefore, reflected old technology. Also little recorded data was available so that personnel remembrances had to be used. Finally, the remembered data had been adjusted in order to reflect more current technology and the increased experience level of current developers. Because of these conditions, the Base project is more synthetic than real.

While the Synthetic 407L Project was a suitable base on which to develop the Simulator, it is not a good starting point from which to extrapolate future projects. For this reason, a search will be conducted to find other projects that more nearly meet this need. Once one is selected, the project definition table data values will be adjusted to reflect the new base project and refined by the calibration process until they produce project forecasts that conform to the results actually experienced.

b. Generic Adaptation Process (GAP) Calibration

The cost estimating relationships (CERs), i.e., the effect of the various attributes of the software project on development costs, are not well known. Most known information exists at a high, general level (macro-CERs) and are usually based on small uncontrolled (historical) data samples.

The Model requires more explicit detailed relationships (micro-CERs) than those published or otherwise available. These relationships can be obtained by examining the involved processes, developing appropriate hypotheses, testing these, and then adjusting them until their aggregated effects mirror the available higher level macro-CERs .

During FY82, the variously available macro-CERs will be studied and compared in order to establish initial concensus relationships that represent the current state of the art. These will then be used to adjust and calibrate the micro-CERs installed in the GAP program. With these CERs in place, the Model should begin to be able to produce estimates that are at least comparable to those produced by existing methods. In subsequent years, as the Model is honed on current and recent project data (fragmentary though it is), the estimates will improve. Finally, through use of the Software Acquisition Resource Expenditure (SARE) data base and actual experience in validating the Model, the capability for accurate estimation should continue to improve.

5.1.3 Process Representation

a. A comparison of the notation and data definition consistancy used on the Model vs. those used on the Software Acquisition Resource Expenditure (SARE) project, which began in FY81, will be completed. The Model terms and methods will be adjusted to facilitate the use of SARE data for Model calibration activities.

b. The process representation will be modified as necessary to reflect any findings obtained during the process calibration activities. At the same time, the representation level will be raised whenever smaller activities are found that can be appropriately aggregated.

5.1.4 Pilot Application

One or more pilot applications of the Model will be sought out to explore the mechanics of applying the Model to a project. Any such application during FY82, however, cannot provide a serious forecast; actual forecasts cannot be provided until the first level of base and generic calibration is completed.

5.2 BEYOND FY82 TASKS PLANNED

The following tasks are foreseen as necessary steps in bringing the Model up to its full potential. Each is very briefly described.

5.2.1 Simulator Development and Refinement

a. Cost Estimating Relationship (CER). The refinement of CER's is seen as an ongoing task. These will be needed in response to:

(1) Feedback from the first applications of the Model to real projects

(2) The receipt of SARE data

(3) The tracking of the ongoing improvements in developmental technology

(4) Generating CERs that apply to new applications for embedded software

(5) The tracking of new acquisition strategies

b. Facility Utilization Limitations. Facilities, as used here, refer to resources other than project manpower that are used to support software development. Mainly, these include: the computer faciliies used for activities such as program compilation and checkout, master program preparation, input data preparation, etc., and any special test facilities. In order to quantify these relationships, units of facility power need to be defined and the units used by each task assigned. The initial implementation will let the units be "available time", and each task will use an assigned amount of time. Later, multiple facilities that model those actually to be used on the project will be reflected.

c. Resource Assignment Strategy. Ultimately the program will attempt to "think" like a project manager and handle problems of manpower/resource assignments, responses to contingencies, product quality decisions, etc. The current implementation assigns resources on a FIFO basis; later, task priority will be combined with FIFO. Subsequently, manpower assignment to any task will reflect the then current supply/demand relationship. Finally, preemption will be modeled to redirect resources to any task that becomes (or may become) a bottle neck.

d. The Expanded View Diagrams and Amplification Notes that were partially developed in FY79, need to be completed. Users will need these notes in order to fully understand the process represented in the LoSim Diagrams.

e. The Acquisition Process should be compared against the applicable MIL standards, to assure compatability or to explain differences.

f. CPCI Interdependence. The basic Model is capable of reflecting CPCI interdependence by combining all the CPCIs into one run. The use of this method requires that the same basic process flow diagrams be adapted for each CPCI, with a different box number prefix being added for each CPCI so as to avoid number duplication. The long term use of this approach is not recommended because the overall network representation could be very large and the resulting simulation conduct time (and expense) costly.

Later versions of the Model would use the mixed level modeling technique, so that any desired CPCI can be run at its low (or detail) level while the other interfacing CPCIs (or CIs) are reflected at a high level. This approach implies that each of the interfacing CPCIs will itself have been run at a low level to provide the quantitative basis for the higher level manifestation.

g. Project Monitoring Support. The complimentary roles to be assigned to SARE and the Model have not yet been established. Tentatively, it is planned that SARE will evaluate actual data vs. that originally estimated (with the aid of the Model) and point out significant differences. Probably several sets of estimates will be created based on several alternative "corrective actions" that may be proposed by the contractor or government.

h. Critical Path and Slack Output. A special program will be written to examine all box start and end times while following the network progression backwards from end to start. This program will identify all boxes on the critical path. A later program version will determine the amount of slack time associated with each box.

i. Project Size via Functional Definition. Model 2 will continue to be based on program size input data; this implies that a separate sizing effort must precede the use of the SWAP estimator. A study is planned to determine the feasibility of allowing the user to substitute quantitative functional descriptions for all common components. Using this information, the SWAP Model will automatically determine size and complexity.

j. ECP Modeling. A capability to include ECP processing and rework impact is planned for inclusion in the Model.

k. Efficient and Extended Operation. The initial development activity has been focused on producing a working model with minimum implementation cost. As the Model goes into wider and more frequent use, it will become important to reduce the cost of its operation. A number of techniques will be investigated and selectively applied for accomplishing this objective.

As the Model goes into widespread use, the need may arise to operate it on some other facility than a large IBM 370 mainframe. Since SIMSCRIPT has been implemented on a number of other computers, a transfer to such other facilities can be accomplished. If the targeted facility does not support SIMSCRIPT, the transfer would require considerable effort. The amount of such effort would be determined by the language used, as well as other capabilities of that facility.

5.2.2 User Support

a. Pilot applications started in FY82 will need continuing support.

b. Once the Model goes into routine use at ESD, support will be needed to provide advice for special situations, or to design and implement changes desired by the users.

c. The Model's use as an aid in training ESD personnel in acquisition management has long been contemplated. Support for this use will be required.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

The Final Report on this project for FY79 (and repeated in FY80) summarizes the rationale for this project in the following terms:

"Effective system planning requires a reasonably accurate means for estimating the cost and schedule for developing embedded software. This need became manifest about twenty years ago when the first Air Force "L" systems were being acquired. Since then, system technology has greatly improved, enabling the feasibility of ever more complex systems. Software estimating and management, however, remain rough procedures with outputs that lead more to surprises than to sound planning.

"While the various analytic estimating techniques currently being used do yield estimates, they have not been able to forecast or account for the wide deviations in results experienced on the development of different but "similar" systems. Because of this situation, work was begun on a software estimating technique that is based on a simulation of the acquisition/development process rather than just on the product being acquired. Though more complex than the analytical methods, this approach appeared to offer the prospect of better results."

Those observations were still applicable for FY81.

During FY81, the just operable model was strengthened, extended and exercised to a point where most of the capability needed to support initial usage is in place. During this effort, the initial promise of the concept remains undiminished and the many applications for the Model retain their promise. The success of the FY81 effort, coupled with the continuing need for the product being developed, reinforces the prior year's conclusion, namely:

"The results of inaccurate software estimates and dimly illuminated management decisions are manifest in the high cost of acquiring embedded software. Considering the magnitude of annual Air Force expenditures on such software, improvement in the software acquisition process provides considerable potential for cost savings. The Process Model described in this report offers such an opportunity. The project cost is small, its cost saving potential large, and its risk modest. Continuation of this work is prudent and recommended."

REFERENCES

1. MIL-STD-483, 31 December 1970, "Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs."

2. MIL-STD-1521A, 2 January 1975, "Technical Reviews and Audits for Systems, Equipment, and Computer Programs."

3. AFR 800-2, 14 November 1977, "Acquisition Program Management."

4. AFR 800-14, Vol. II, 26 September 1975, "Acquisition and Support Procedures for Computer Resources in Systems."

5. DoDD 5000.29, 26 April 1976, "Management of Computer Resources in Major Defense Systems."

APPENDIX A

PROCESS FLOW DIAGRAMS AND AMPLIFICATION NOTES

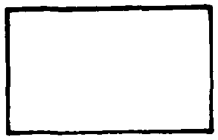
This appendix incorporates and explains the detailed diagrams of the software-related activities and decisions typical during the Full-Scale Development Phase of the Major System Acquisition Life Cycle defined in AFR 800-2. As such, it presents the results to date of the Process Definition work, discussed in Para. 2.1.1.

First, Figure A-1, Flow Diagram Notation, explains the flow diagram conventions. Table A-1, Index to Figure A-2 Connectors and Box Numbers, is provided to help locate specific information in the multi-page LoSim flow diagrams. Figure A-2, Software Acquisition Process Model LoSim Activity Flow, depicts in over 150 connected activities and decisions, the software-related functions of the entire Full-Scale Development Phase. Table A-2, Process Flow Diagram Amplification Notes, provides comments on selected activities and decisions depicted in Figure A-2. Finally, the abbreviations used in this appendix are listed and defined.

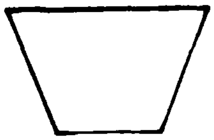
The Process Flow Diagrams contain three basic types of element; Function Boxes, Auxiliary Elements and Lines of Flow, as follows:

1. FUNCTION BOXES

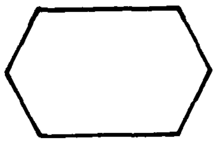
1.1 Shapes



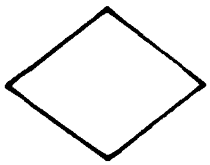
Rectangles (i.e., Rectangular Activity Boxes) are used only to represent mainstream activities (i.e., activities of principal importance).



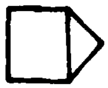
Trapezoidal Activity Boxes are used to represent support activities. Both mainstream and support activities consume time and resources.



A hexagon depicts a Special Event Box. Currently these are used for two functions. (1) The Milestone Box, marks a point and supplies a name for use in creating the Milestone schedule.
(2) A Remote Action Box alters the action of another box at a remote location.



A rhomboid depicts each Decision Box. A Decision Box is any procedure which selects between two mutually exclusive exits. By convention, these include no time or resource expenditures, which are included instead in preceding activities.



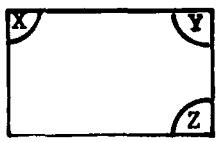
This shape represents a Personnel Box. Its purpose is to alter the manpower levels assigned to the project.

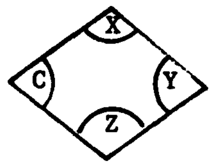
Figure A-1. Flow Diagram Notation

1.2 Labels

Each Function Box has a label, printed just above the box. Each label is a one- or two-digit number suffixed by a letter.

1.3 Features





Each box may contain several field designators, identified by corner positions within the box as shown by letters X, Y, Z and C, as follows:

X - indicates Doer; i.e., the organization responsible for the function: A = government (e.g., Air Force), C = Contractor, B = Both.

Y - indicates Integration Group: D = Developmental Integration Group (DIG), T = Test Integration Group (TIG), Blank = the function is not divided into Groups.

Z - indicates the level at which the work is conducted: 1 = System, 2 = Segment, 3 = CPCI, 4 = CPC (Computer Program Component), 5 = lower level module.

C - is present on any Decision Box used as a counter.

2. AUXILIARY ELEMENTS

2.1 Shapes

Connectors

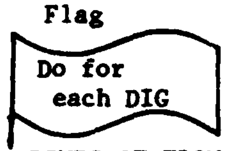
Used to indicate a specific point in the process flow. May be used to show connection between physically separated elements on flow diagrams. (A given label must apply uniquely to only one input point in the process flow). The two shapes other than the circle are used to point to a box that is to be remotely actuated.

Terminus

Used to mark a start or end point of a process. When labelled "fin" it marks the end of the specific flow path.

Figure A-1. Flow Diagram Notation (Continued)

Flag



Used to annotate flow diagrams.

3. LINES OF FLOW

The lines of flow have arrows to indicate direction, plus three alphabetic designators, as follows:

N/F/S

Start Logic

A = Logical "AND" relationships (the input is necessary to start the box).

R = Logical "OR" relationship (only one of these is necessary to start a box; inputs of other types may also be necessary, however).

S = Start immediately (this input by itself will start a box).

Progression Mode (PM)

F = Normal forward progression

I = Iterative progression

C = Continue progression mode (F or I) of predecessor.

Group Number Controller

N = No group involvement

D = Increment DIG number

T = Increment TIG number

G = Retain predecessor's Group number.

Figure A-1. Flow Diagram Notation (Concluded)

Table A-1

Index To Figure A-2 Connectors and Box Numbers

Connector	A	AA	AC	AQ	B	C	CC	CD	D	DC	DF	DX	E	E1	E2	F
Input Sheet	9	9	9	10	1	4	4	4	3	3	8	4	12	12	12	7
Output Sheet	8	7,8	9	9		3,4	1	1	2	8	3	2		12	12	6

Connector	FC	L	LC	LE	LP	P	Q	R	RQ	RT	T	TD	U	UP	V	W	WP	X	Y
Input Sheet	7	2	2	8	2	5	11	5	11	11	6	6	8	8	6	8	8	11	10
Output Sheet		1	2	2	8	2	11	1,4	5	6	5,6	11	6	6		5	5	1	11

Box Number Index

Box No.	1Y	2	4	6	6Y	8	10	10Y	12	12H	14	16	16Y	18	20	22	23	24	25	26	28
Sheet	1	1	1	2	1	2	3	2	3	8	4	4	3	4	8	4	5	8	6	8	8

Box No.	40	42	42 M&N	44	46	46Y	47Y	48	48Y	50	50Y	52	53	54	60	62	62C
Sheet	5	5	6	5	6	5	6	6	7	11	5	7	11	11	1	1	4

Box No.	66	70	72	74	80	80E	82 A-J	82 P-Z	84Y	96
Sheet	1	8	8	8	9	8	9	10	10	12

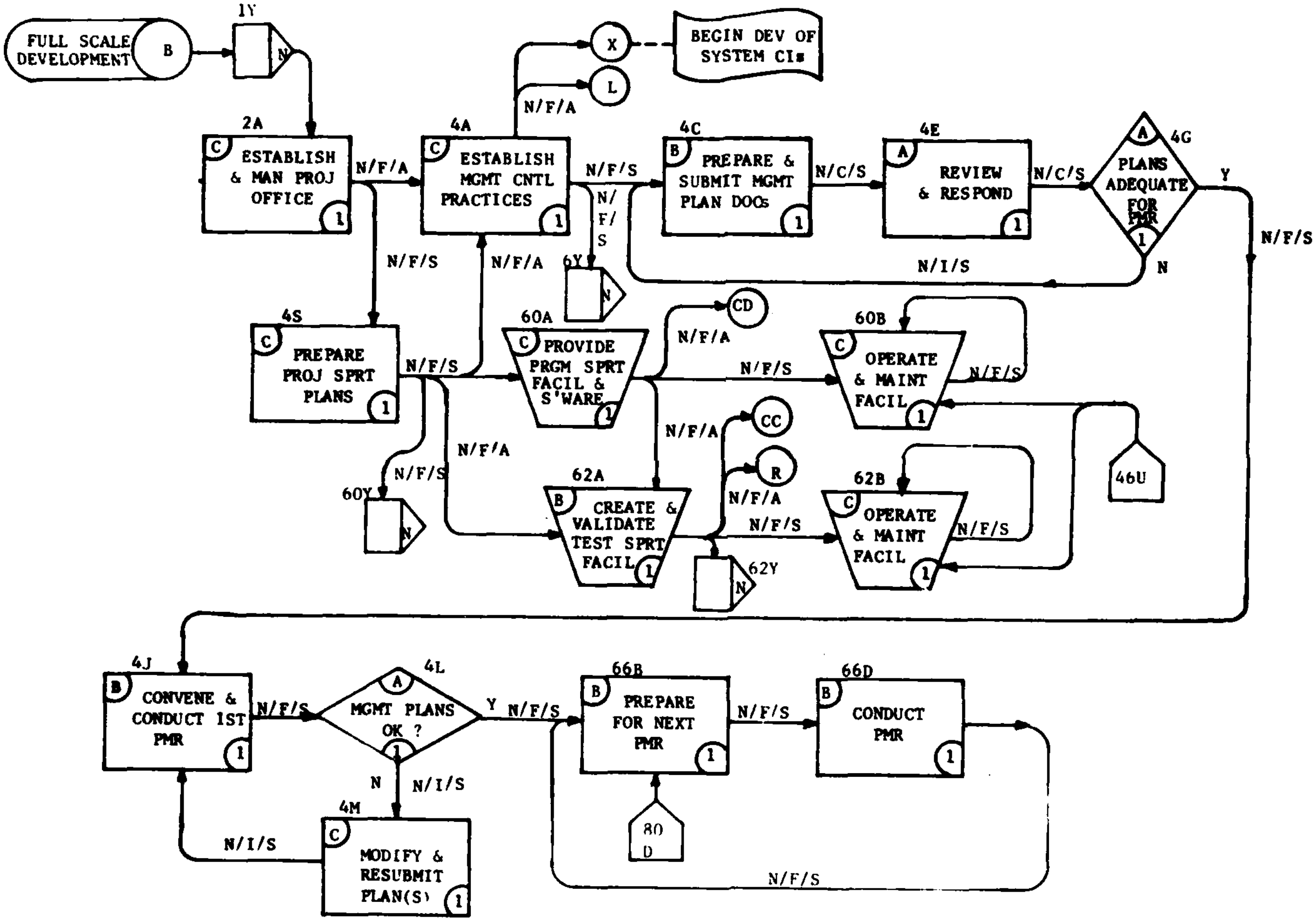


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level
Sheet 1-Organization, Management, Support

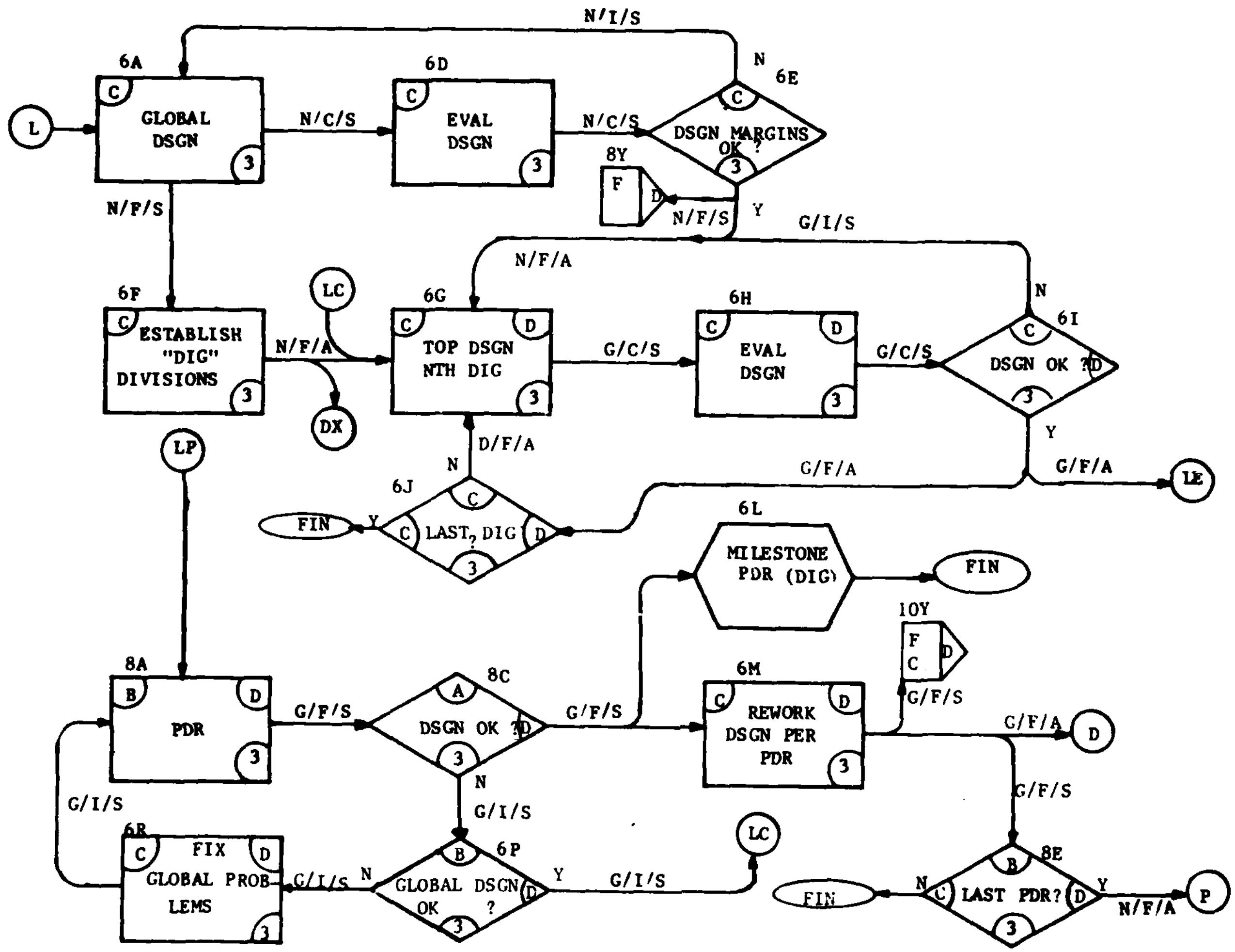


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level Sheet 2-Top Level Design Through PDR

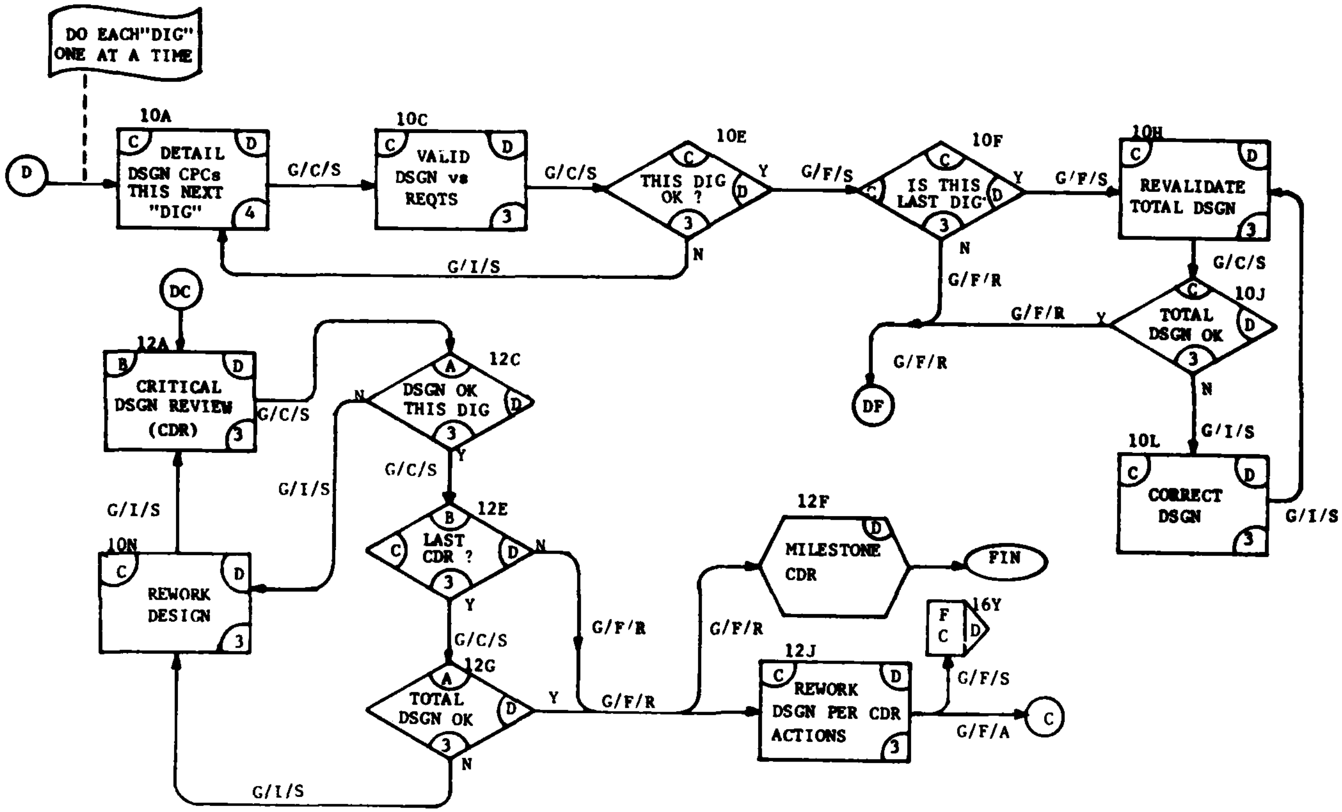


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level
Sheet 3-Detail Design Through CDR

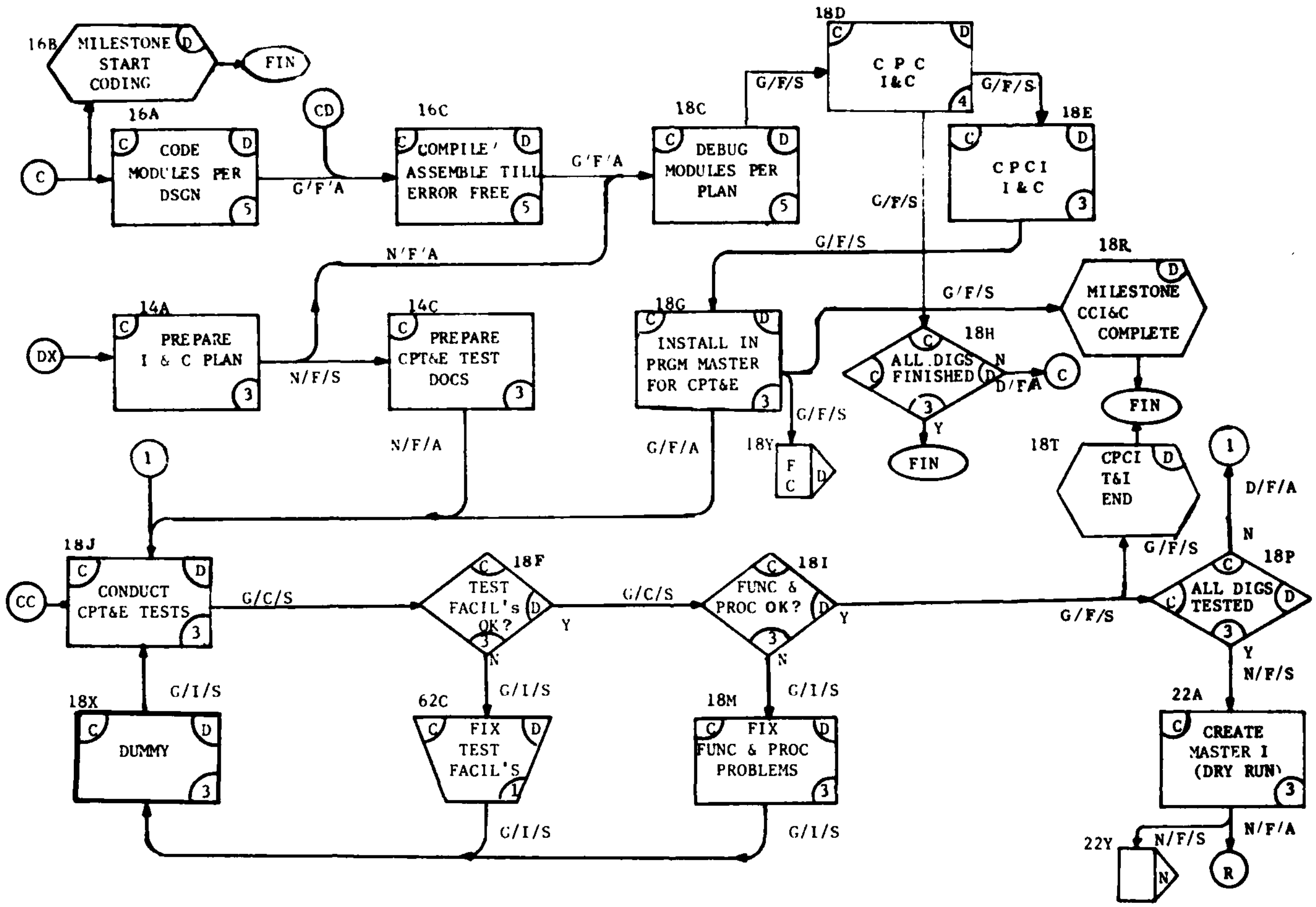


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level

Sheet 4-Code/Compile/Debug/Integrate/Checkout

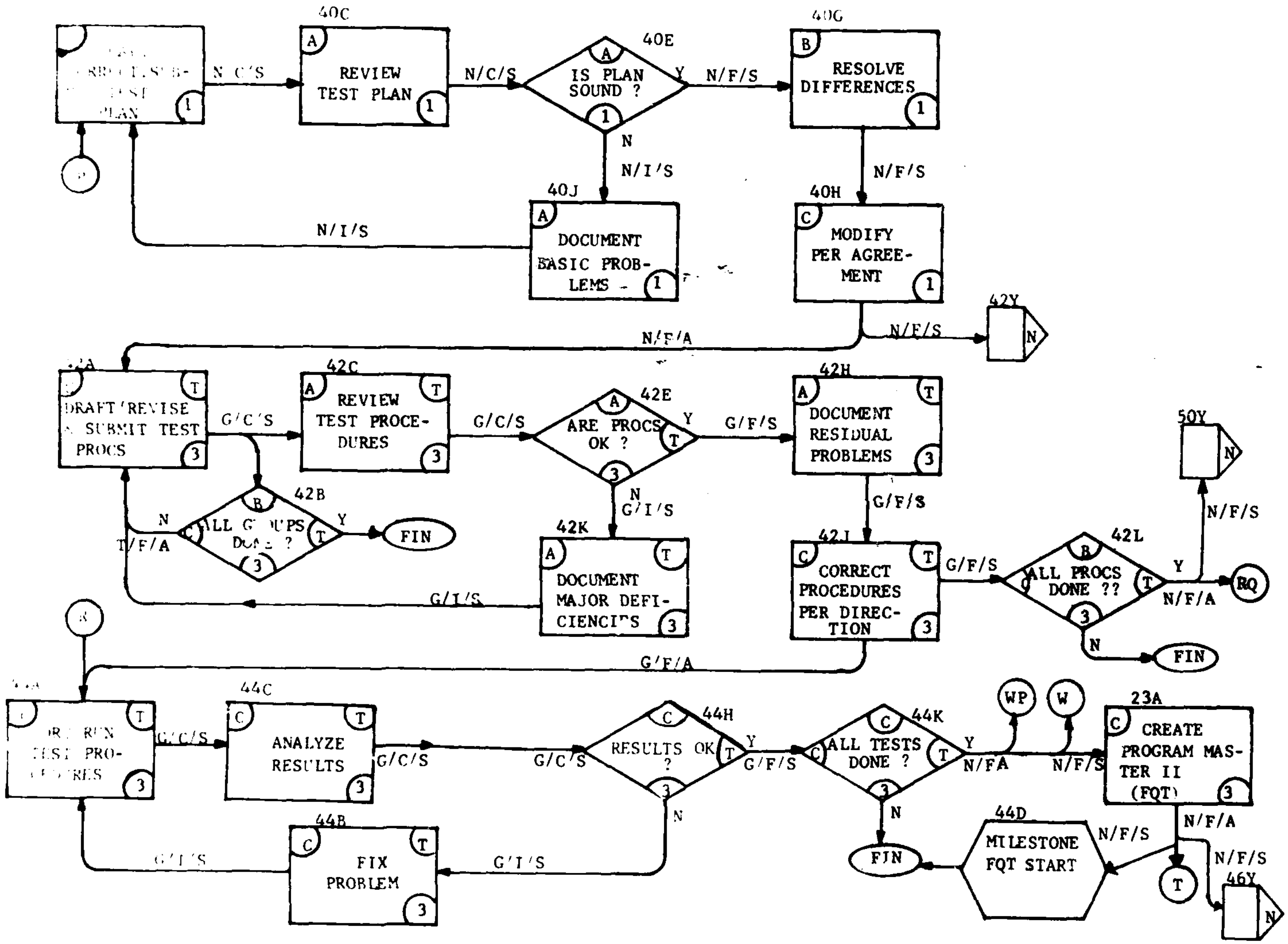


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level
Sheet 5-Test Plan/Procedures/Dry Runs

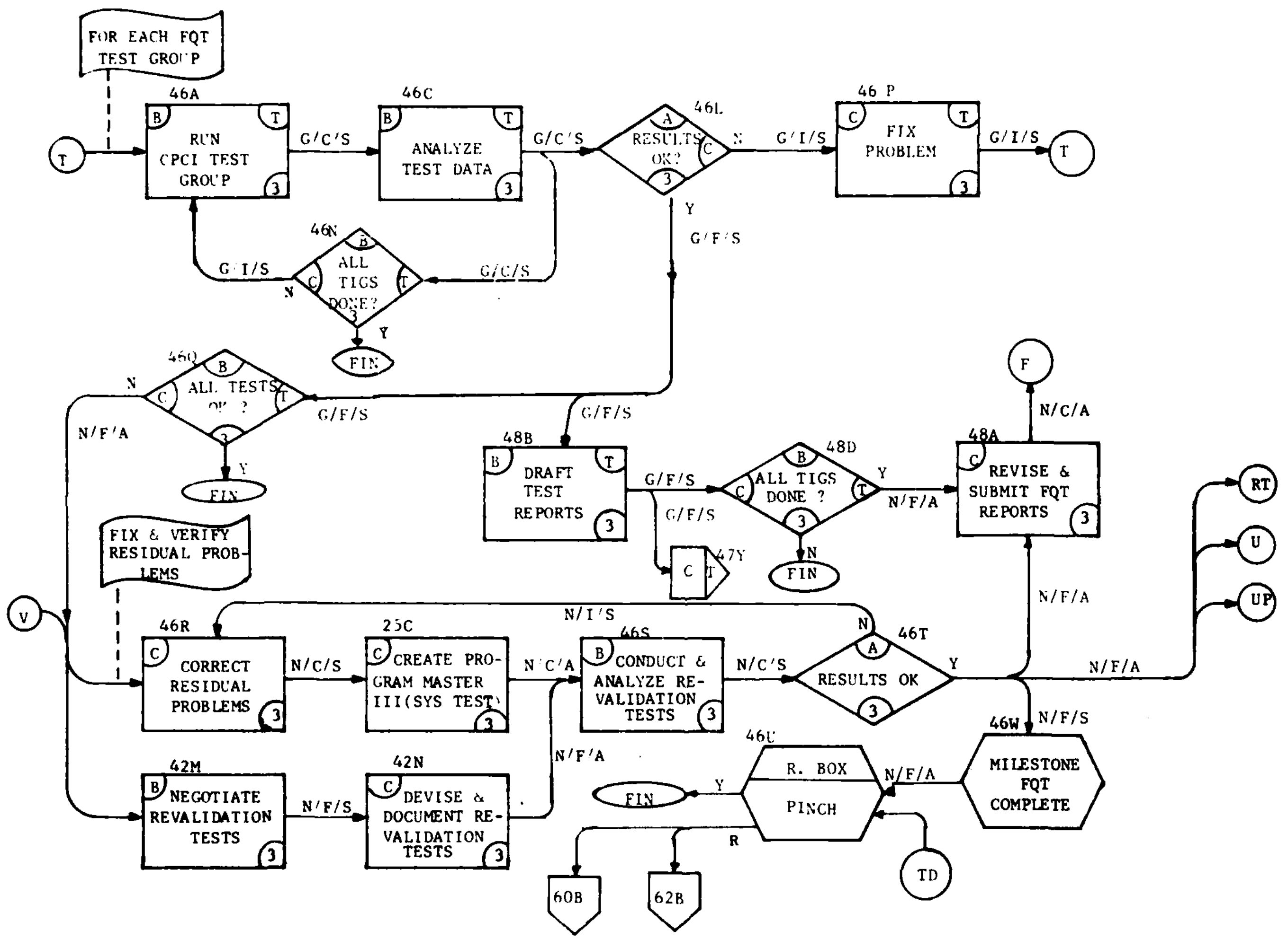


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level Sheet 6-Conduct Qualification Tests

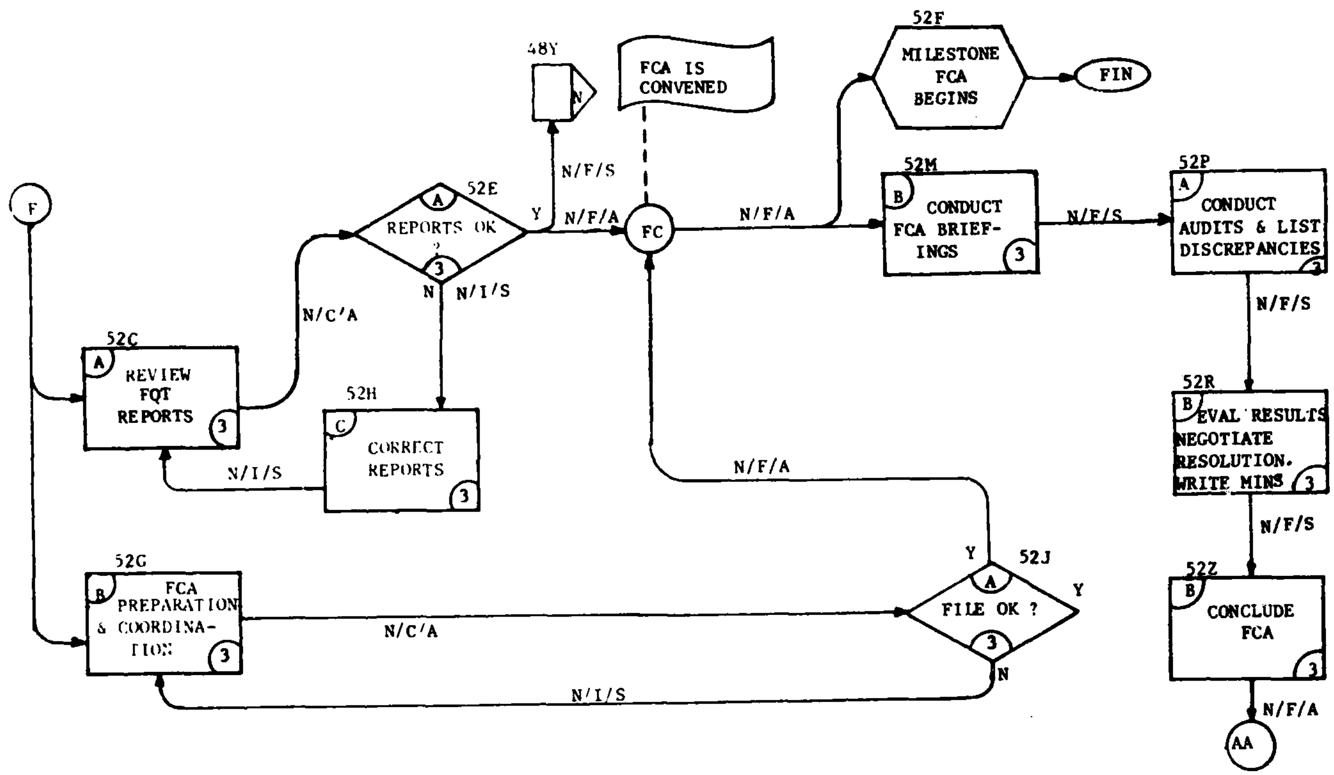


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level Sheet 7-Functional Configuration Audit - FCA

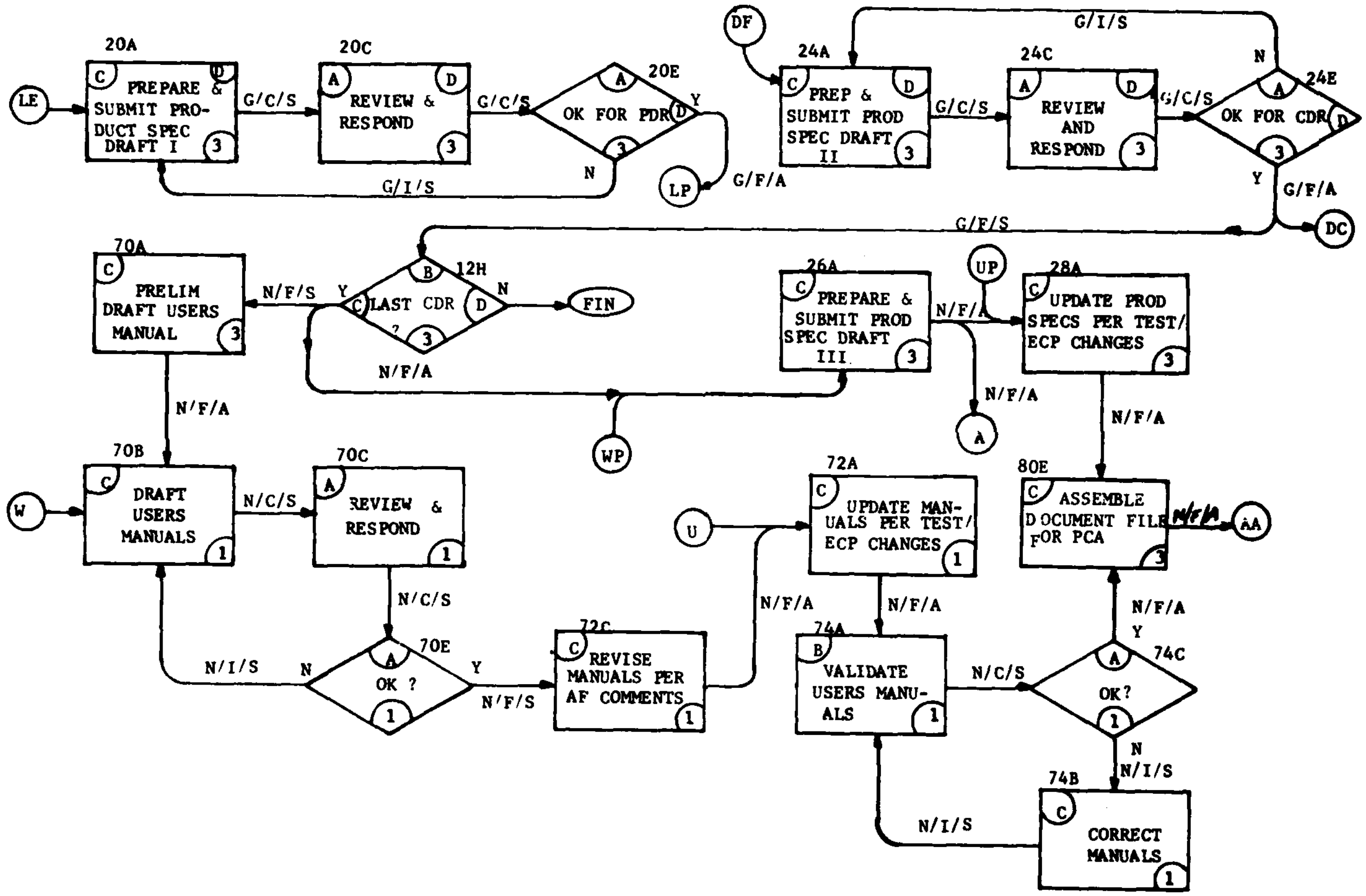


Figure A-2 (Rev. 2). Software Acquisition Processor Flow Diagram-LoSim Level Sheet 8-Product Specs/Users Manuals

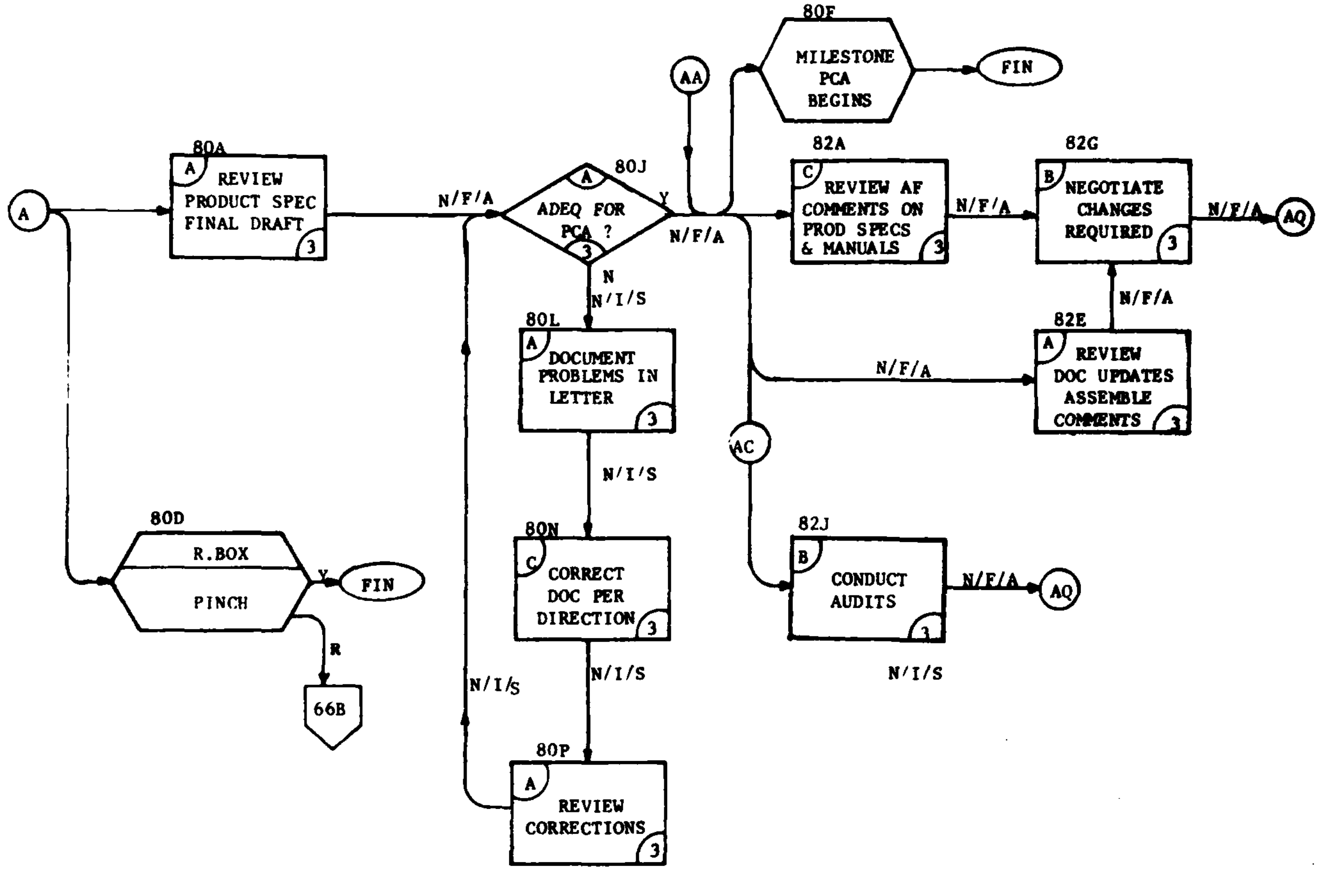


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level
Sheet 9-Physical Configuration Audit - PCA

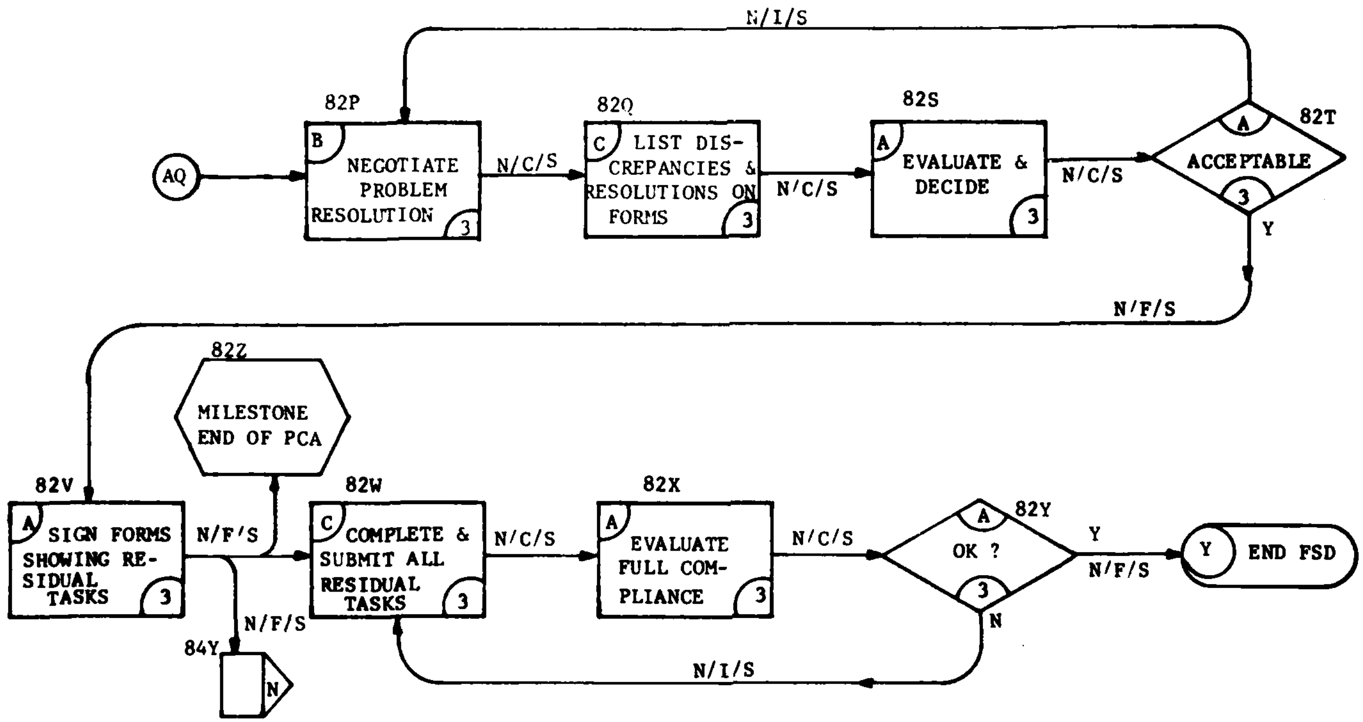


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level
Sheet 10-Physical Configuration Audit - PCA (Concluded)

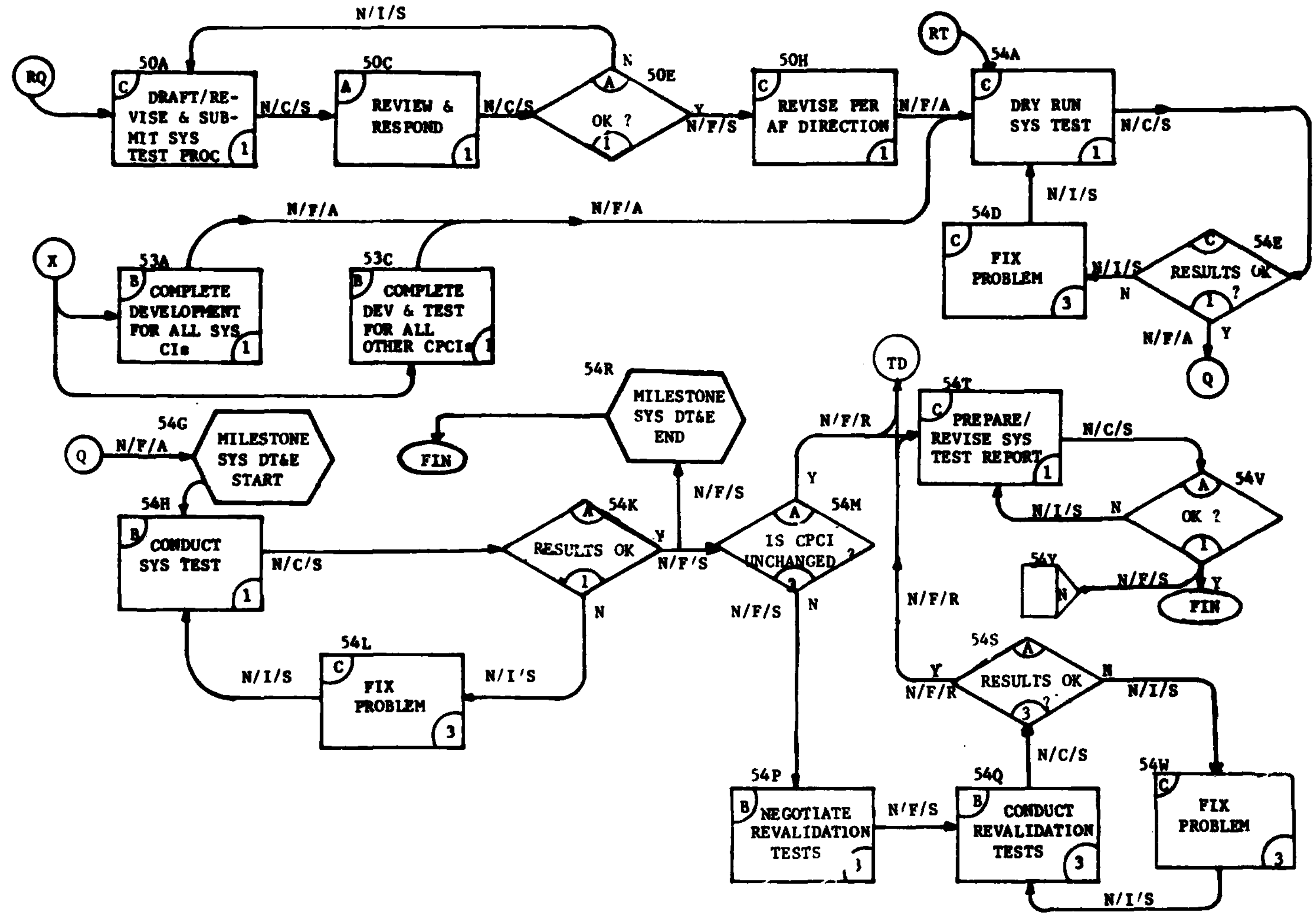


Figure A-2 (Rev. 2). Software Acquisition Process Flow Diagram-LoSim Level
Sheet 11-System Test

Table A-2

PROCESS FLOW DIAGRAM AMPLIFICATION NOTES

Note No.	Fig. Sht.	A-2 Box	Amplification Notes
1	1	2A	The assignment of key personnel at the initiation of a project is generally a slow process. Each person selected for a new project usually has an existing assignment which must be transitioned to a successor; the successor may also need to transition his job to another, etc. Advance planning by the contractor helps in the personnel selection process but the uncertainties associated with the award and timing on this contract (as well as on other contracts bid) make startup traumatic event that gets under way slowly.
2	1	4A	Just the concept and general approach to the Developmental Integration Group (DIG) (see Section 2.1.5) plan are established here to provide a basis for the status monitoring and management plans. The grouping of specific CPCs into DIGs is established in Box 6F. (See Note 11). Note that both 4A3 and 4S support activity 4C3 (CPDP preparation) even though the direct connection isn't shown on the LoSim diagram. This feedback is shown indirectly via the 4S to 4A to 4C connection; this arrangement will satisfy the precedence needs of the Simulator.
3	1	4C	The System Engineering Management Plan (SEMP), the Test and Evaluation Management Plan (TEMP), and the Computer Resources Integrated Support Plan (CRISP) are normally prepared during the system's Validation Phase. These plans usually need updating in the light of the current contract and contractor. This box covers only those portions concerned with software.

Table A-2 (Continued)

Note No.	Fig. A-2 Sht.	Box	Amplification Notes
4	1	4C	The Computer Program Development Plan (CPDP) is generally addressed in the contractor's proposal. This activity covers the rewrite and extension necessary before this plan can be put into effect contractually.
5	1	4S	Per Section 2.1.4 this activity provides for the most general case where the program and test support facilities are not identical, even though some portions of the hardware may be shared for both uses.
6	1	60A	A need to build support software will significantly increase this activity's elapsed time over that otherwise required. Parameter values for this activity must be selected to reflect the actual (or expected) contractual situation.
7	1	62A	Any non-trivial special (i.e., not specified) equipment or software which is to be used to support Qualification Testing must be evaluated to assure that it is valid for its intended use. As examples, a facility may be needed to emulate a non-available interfacing component (hardware or software) or to produce radar returns representing a flying aircraft, etc. Any deliverable test support component would not be processed in these boxes because its validity would be established in the tests associated with its acceptance by the government.
8	1	4G 4J 4L 4M	The management plans are frequently resolved the first full-scale overall Program Management Review (PMR), as shown. Instead, they can be treated at a separate meeting (if they become urgent issues), or without a meeting (by mail and phone) if not controversial; the process parameters can be adjusted to cover any expected case.

Table A-2 (Continued)

Note No.	Fig. Sht.	A-2 Box	Amplification Notes
9	1 9	66B 66D 80D	PMRs are generally conducted on a periodic basis (e.g., monthly or bimonthly) through the entire contractual period. They are shown here because the preparation and conduct activities consume considerable manpower on an intermittent basis and thereby can impact the development process. Note that a Special Event Box (80D) will cause the PMR activity to stop at the start of PCA.
10	2	6A 6D	The design and evaluation activities shown are representative of those conducted on many projects they are not intended as an all inclusive set. In general, the overall design is sampled at a moderate depth while design areas that are perceived to be risky, difficult, or innovative are given emphasis.
11	2	6F	Here the specific Developmental Integration Groups (see Section 2.1.5) comprising the CPCI are defined.
12	2	6G 6H 6I	The design activities conducted prior to these boxes are global in that they include the overall CPCI at a fairly gross level. They establish that the overall system concept is feasible and can accord with space, timing, and other restrictions. In these boxes, the capabilities to be provided in each DIG (see Section 2.1.5) are designed to a depth necessary to show that the approach for each specific function is feasible.
13	2	6I	Once the contractor establishes the adequacy of his design (in box 6I) he must document it (using Product Specification format) and submit it for government review and approval. This is shown via connectors LE and LC to Boxes 20A to 20E on Sheet 8 of Figure A-2.

Table A-2 (Concluded)

Note No.	Fig. Sht.	A-2 Box	Amplification Notes
14	2	6M 8C 12A 12J	Even when the PDR results (in Box 8C) are satisfactory, there are generally a number of specific deficiency areas noted during the extensive review. These are documented by the contractor in the design review minutes as items which he agrees to correct; Box 6M makes provision for these corrections. The references to Boxes 12A and 12J indicate that this note also applies to the CDR results.
15	2	8E 10F 12E 12H 18H 18P 42B 42L 42K 44K 46N 48D	Each of the Decision Boxes branches on a count rather than on the basis of probability. If the design at these points has not been completed for all the DIGs, this causes the design process to repeat, but on the next DIG; e.g., at Box 6G. Note that regardless of the counter, further design on the current DIG continues; e.g., by transfer to connector D.

Appendix A Abbreviations

AF	Air Force
ADEQ	Adequate
CCB	Configuration Control Board
CCI&C	Code, Compile, Integrate & Check
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CI	Configuration Item
CPC	Computer Program Component
CPCI	Computer Program Configuration Item
CPDP	Computer Program Development Plan
CPT&E	Computer Program Test & Evaluation
CRISP	Computer Resources Integrated Support Plan
CRIT	Critical
CTL	Control
DEMO	Demonstrate
DESCR	Description
DEV	Develop
DIG	Developmental Integration Group
DISCREP	Discrepancies
DIST	Distribute
DOC	Document

Appendix A Abbreviations (Continued)

DSGN	Design
ECP	Engineering Change Proposal
EVAL	Evaluate
FACIL	Facility
FCA	Functional Configuration Audit
FIN	End of this process flow diagram path
FQT	Formal Qualification Testing
FUNC	Functional
HIERARCH	Hierarchial
HWARE	Hardware
I&C	Integration and Checkout
IMPL	Implementation
INFO	Information
INTEG	Integration
LVL	Level
MAINT	Maintain
MGMT	Management
MGR	Manager
MISC	Miscellaneous
ORG	Organization
PCA	Physical Configuration Audit
PCKG	Packaging

Appendix A Abbreviations (Concluded)

PDR	Preliminary Design Review
PRGM	Program
PMR	Program Management Review
PREP	Prepare
PROB	Problem
PROC	Procedure
PROD	Product
PROG	Programming
PROJ	Project
REQT	Requirement
REVAL	Reevaluation
REVW	Review
SCHED	Schedule
SEMP	System Engineering Management Plan
S'WARE	Software
SPEC	Specification
SPRT	Support
STD	Standard
SYS	System
SZ	Size
TECH	Technical
TEMP	Test and Evaluation Master Plan
TIG	Test Integration Group

APPENDIX B

MODEL DEFINITION DATA

This appendix incorporates and describes the tables that define the software acquisition process logic and parameter values to the Simulator. These tables are input via a terminal to computer files and may easily be altered. As explained in Section 3.4.1, the Simulator reads these files, reformats the tables, and interprets the revisions to develop simulation results. Within broadly-defined limits the tables may be modified to represent more or less detail, differences in process logic, or revised parameter values. Without needing revision itself, the Simulator will interpret the modified tables and develop corresponding simulation results.

Table B-1, Software Acquisition Process Model Network Linkage, is a tabular representation of the entire LoSim Process Flow Diagram (Figure A-2). Table B-2, Software Acquisition Process Model Activity Box Parameter Data, contains the manning and duration parameter value estimates for the activities depicted in the LoSim Process Flow Diagram. Table B-3, Software Acquisition Process Model Decision Box Parameter Data, contains estimates of the decision outcome probabilities for all LoSim Flow Diagram Decision Boxes except counters. Table B-4, Software Acquisition Process Model Counter & Special Event Box Parameter Data, contains the LoSim Flow Diagram counter Decision Box limits and Special Event Box parameters so far defined. Table B-5, Software Acquisition Process Model Personnel Box Parameter Data, contains parameters that establish and adjust the levels of personnel assigned to the project. Table B-6, Software Acquisition Process Model Subnetwork Titles gives the names of the various subnetworks, for labeling of output reports.

The columns of these tables, and the values that the data in each column may legitimately contain, are explained below.

1.0 TABLE B-1

Table B-1 represents the Process Model network. It must contain an entry for each box in the Process Flow Diagram that it represents. There is currently an entry in Table B-1 for every box in the LoSim Process Flow Diagram (Figure A-2).

1.1 <u>Box Data</u>

a. Box NAME: This is the box's label (see Figure A-1).

b. Box Type:

A = a mainstream Activity Box.

B = a branching box (i.e., a normal Decision Box).

C = a counter Decision Box. This is similar to a type B box, except that the exit is determined by whether an incrementing counter has reached its limit; see Table A-2, Note 15.

H = a helping box (i.e., a support Activity Box). See Figure A-1.

M = a Milestone Box. This provides for displaying Milestones, at designated locations in the process flow.

P = a Personnel Box. This will establish and adjust manpower assigned to the project.

R = a Remote Action box. This box provides for resetting counters, changing parameter values, and providing for as yet undefined future needs.

1.2 <u>General</u> <u>Data</u>

a. Transformation Class (TRANS.CLASS)

A set of 15 transformation classes have been established to provide for combinations involving: Activity Type, Documentation, and Growth Pattern.

The classes are identified by three letters "AGD" as follows:

Basic Activity (A): D = Design; P = Programming; T = Test; G = General.

Growth Pattern (G): F = Fragmented; I = Integrated; K = Constant.

Documentation Task (D): Letter "D" identifies Documentation, if present; otherwise, it is omitted.

For example, "TFD" indicates a Test Activity, with Fragmented Growth, involving Documentation.

Fourteen of these classes are derived as combinations of the seven basic Activities (see 3.3.1e) and two of the Growth patterns (i.e., F & I). The fifteenth class includes all boxes that have type K (constant) growth. This latter class is provided to allow any project unique boxes to retain their assigned data.

b. Doer: This defines the agency or agencies assigned to perform the activity or to make the decision.

A = Government (e.g., Air Force)

C = Contractor

B = Both

N = Does not apply

c. Box Grp: This defines the box's membership (if any) within an Integration Group (see Section 4.1.5).

D = Developmental Integration Group (DIG)

T = Test Integration Group (TIG)

N = No Integration Group

d. Burst: This defines the box's status as to whether it is a burst box or not and if it is, its status within the burst group.

N = non-bursting

R = non-bursting and recurrent (see 3.3.1b)

S = start of burst

C = continue burst

E = end of burst

e. Subnet: A user may assign the box to any one of up to 15 Subnetworks by entering a number in the range 1-15 in this column. The Simulator will develop aggregate timing and cost data for each Subnetwork as well as the entire network.

1.3 Successors

a. Box: This is the Box Name (see paragraph 1.1a) of the successor box. If a box has more than one successor, the data for its second and any subsequent successors are stored in corresponding columns of successive lines.

b. Exit: This is the box's exit used to reach this successor box.

Y = "Yes" exit or single exit

N = "No" exit

R = Remote Activation Exit

c. Group: The box's Group Control parameter, used to maintain Group (i.e., DIG or TIG) number continuity and incrementation during network flow.

N = No group involvement

D = Increment DIG Number

T = Increment TIG number

G = Retain predecessor's group number

d. Progression Mode: A parameter used to indicate the direction of the box-to-box progression.

F = Normal forward progression

I = Iterative (i.e., backward) progression

C = Continue Progression Mode of predecessor

e. Start Logic: Defines the combination of predecessors that must finish before this box may start.

A = "AND" relationship. This predecessor's completion is a necessary but not a sufficient condition for starting the box.

R = "OR" relationship. Completion of only one type R predecessor is necessary to start the box. Predecessors of other types, if specified, are also required.

S = Start immediately. This predecessor's completion by itself is sufficient to start this box. All iterative progression uses immediate start.

2.0 TABLE B-2

Table B-2 contains the parameter data for each <u>Activity Box</u> (box types A & H) in Table B-1. Every Activity Box must have a Table B-2 entry. Tables B-3, B-4, B-5 contain the parameter data for the other box types.

2.1 <u>Box Data</u>

a. Box Name: This is the box's label, which must be identical to its Table B-1 Box Name (see paragraph 1.1a).

b. Box Type: This must be the same as the Table B-1 entry's Box Type (see paragraph 1.1b).

c. Box Group: Identical to the Table B-1 entry's Box Group (see paragraph 1.2c). See note d. for category F.

d. When box group is set to "F", (used only for Activity Boxes), it indicates that the box is in a group (DIG or TIG), but the activity duration on each access if fixed, i.e., not altered to reflect the quantity of DIGs/TIGs.

2.2 <u>Manpower</u>

Manpower is subdivided into five categories of work for contractor personnel, and three for government personnel, as explained below. Note that management personnel are not assigned to specific activities. Instead, manpower and dollar costs representing a given management structure are sustained for the project as a whole, or for designated parts of it. Management personnel effort is not shown for specific boxes even if the work is largely done by such persons.

The table provides a column to indicate quantity of persons (to one decimal place) for each manpower category; i.e.:

a. Contractor

Sys = System engineers and analysts

Dsgn = Designers (junior and senior)

Prgm = Computer programmers

Test = Software test engineers

Sprt = Support personnel; e.g., writers, operators, maintenance persons

b. Government

Dev = Developing Command (e.g. ESD)

Usr = Using Command (e.g. TAC)

Sprt = Supporting Command (e.g. AFLC)

c. Iterate Factor:

Many tasks may need to be repeated because the results achieved on the first pass were not adequate to meet subsequent needs or review criteria. Since the work required on subsequent passes usually involves fewer persons, these three columns each contain a factor (from 0 to 10) representing the number of tenths by which the original number of persons in each of the manpower columns (as specified for the first pass) must be multiplied to obtain the manpower needed respectively on the second, third, and fourth or later iteration of the activity. *If* blank, the task never requires iteration, or multiplier value is equivalent to 10.

2.3 Durations

a. Days: The first duration column contains the mean duration of the activity, in work days to the nearest tenth.

b. It Fctr: The next three columns each contain a factor (from 0 to 10) representing the number of tenths of the first iteration's duration (i.e., days column) required to complete the second, third, and fourth or later iteration, respectively; a blank in these columns is the same as a "10." Some tasks have other responses to iterative entry as indicated by a negative digit as follows:

-2: This is used to signal "impossible" situations that, if encountered, will cause the whole simulation run to halt.

-1: This condition is used to indicate that certain network paths are not to be followed iteratively. Any path so entered is automatically terminated.

2.4 Wait

This field may contain a mean waiting time (in days) before the activity may begin. The action may begin only after the wait period has completed; the Wait itself starts after all predecessor conditions are satisfied. If blank, no Wait is required.

2.5 Notes

This column refers to the notes listed within Table A-2, Process Flow Diagram Amplification Notes.

3.0 TABLE B-3

Each Table B-3 entry contains the parameter data for a normal Decision Box (box type B) with an entry in Table B-1. Every normal Decision Box in Table B-1 must be represented by a Table B-3 entry.

3.1 Box Data

These fields' definitions are given in paragraphs 2.1a-c.

3.2 Yes Exit Probability

These four columns contain the probabilities (in percent) of taking the "Yes" exit on the first four iterative passes through the Decision Box; see paragraph 2.2c. The leftmost column provides first pass probability. The rightmost column probability will be used repeatedly if the box is iterated more often than four times.

3.3 Wait

See paragraph 2.4.

3.4 Notes

See paragraph 2.5.

4.0 TABLE B-4

This table contains an entry for each counter Decision Box (type C) each Special Event Box Milestone Box (type M) and each Remote Action Box (type R). Every such box must be represented by a Table B-4 entry.

4.1 Box Data

These fields' functions are given in paragraph 2.1a-c.

4.2 Type

Two types of function have thus far been allocated to Special Event Boxes:

M = Milestone. The contents of the Event Label column (a Milestone name) will be output on schedule reports for each Special Event Box entered.

R = Remote Action. This action applies to the Box override (FO) field so that a box can be caused to be skipped over, or "pinched off" or reset to normal. Only "pinch" (FO=1) is currently used.

4.3 Event Label

This contains the characters to be output as the Milestone name for a Milestone-type Special Event Box.

4.4 Parameter

This column identifies the parameter which is to be changed by a reset (type R) Special Event.

4.5 Notes

See paragraph 2.5.

5.0 TABLE B-5

This table contains an entry for each Personnel Box (type P) defined in Table B-1.

5.1 Box Data

These fields' functions are given in paragraph 2.1 a-c.

5.2 Contractor Personnel

This contains seven columns, a trigger and six manpower categories. If more than one trigger is used, additional lines are used.

a. Trigger: A parameter used to indicate the point(s) in the process at which the P-Box is activated to alter the personnel pool levels.

F = this causes the P-Box to act when the first DIG or TIG enters

C = this causes the P-Box to act when the last DIG or TIG arrives

N = this activates the P-Box on first entry for all non-DIG or TIG related boxes

b. Manpower Categories: The type of manpower used.

Syst Eng = System engineers and analysts

Dsgn Eng = Design engineers (junior & senior)

Pgrm = Computer programmers

Test = Software test engineers

Sprt = Support personnel = e.g., writers, operators, maintenance persons

Mgmt = Management persons

6.0 TABLE B-6

This table identifies the subnetworks by name and number.

6.1 Subnet#

This is the subnetwork number.

6.2 Title

This is the name given to the subnetwork.

SOFTWARE ACQUISITION PROCESS MODEL

CS

TABLE B-1F: NETWORK LINKAGE 09/08/81

GAP VERSION

MODEL 1 DATA BOX BURST

BOX		GENERAL DATA					SUCCESSORS				
NAME	TYPE	TRANS CLASS	DOER	GROUP	BURST	SUB NET	BOX	EXIT	GROUP	PROG. MODE	START LOGIC
01Y	P	GI	C	N	N	0	02A	Y	N	F	S
02A	A	GI	C	N	N	10	04A	Y	N	F	A
							04S	Y	N	F	S
04A	A	GID	C	N	N	10	04C	Y	N	F	S
							06A	Y	N	F	A
							06Y	Y	N	F	S
							53A	Y	N	F	S
							53C	Y	N	F	S
04C	A	GID	B	N	N	10	04E	Y	N	C	S
04E	A	GID	A	N	N	10	04G	Y	N	C	S
04G	B	GID	A	N	N	10	04J	Y	N	F	S
							04C	N	N	I	S
04J	A	GID	B	N	N	10	04L	Y	N	F	S
04L	B	CID	A	N	N	10	66B	Y	N	F	R
							04M	N	N	I	S
04M	A	GID	C	N	N	10	04J	Y	N	I	S
04S	A	GID	C	N	N	10	04A	Y	N	F	A
							60A	Y	N	F	S
							62A	Y	N	F	A
							60Y	Y	N	F	S
06A	A	DI	C	N	N	2	06D	Y	N	C	S
							06F	Y	N	F	S
06D	A	DI	C	N	N	2	06E	Y	N	C	S
06E	B	DI	C	N	N	2	06G	Y	N	F	A
							06A	N	N	I	S
							08Y	Y	N	F	S
06F	A	CI	C	N	N	2	06G	Y	N	F	A
							14A	Y	N	F	S
06G	A	DI	C	D	S	2	06H	Y	G	C	S
06H	A	DI	C	D	C	2	06I	Y	G	C	S
06I	B	DI	C	D	C	2	20A	Y	G	F	A
							06G	N	G	I	S
							06J	Y	G	F	S
06J	C	DI	C	D	E	2	06G	N	D	F	A
06L	M	DI	N	D	N	9					
06M	A	DI	C	D	N	2	08E	Y	G	F	S
							10A	Y	G	F	A
							10Y	Y	G	F	S
06P	3	DI	B	D	N	9	06R	N	G	I	S
							06G	Y	G	I	S
06R	A	DI	C	D	N	2	08A	Y	G	I	S
06Y	P	DI	C	N	N	0					
08A	A	DI	B	D	E	9	08C	Y	G	F	S
08C	B	DI	A	D	N	9	06L	Y	G	F	S
							06P	N	G	I	S

Table B-1 (Continued)

							06M	Y	G	F	S
08E	C	DI	B	D	N	9	40A	Y	N	F	A
08Y	P	DI	C	D	N	0					
10A	A	DF	C	D	S	2	10C	Y	G	C	S
10C	A	DF	C	D	C	2	10E	Y	G	C	S
10E	B	DF	C	D	C	2	10F	Y	G	F	S
							10A	N	G	I	S
10F	C	GK	C	D	C	2	10H	Y	G	F	S
							10A	N	D	F	A
							24A	N	G	F	R
10H	A	DI	C	D	C	2	10J	Y	G	C	S
10J	B	DI	C	D	C	2	24A	Y	G	F	R
							10L	N	G	I	S
10L	A	DF	C	D	C	2	10H	Y	G	I	S
10N	A	DF	C	D	N	2	12A	Y	G	I	S
10Y	P	DF	C	D	N	0					
12A	A	DI	B	D	E	9	12C	Y	G	C	S
12C	B	DI	A	D	N	9	12E	Y	G	C	S
							10N	N	G	I	S
12E	C	GK	B	D	N	9	12G	Y	G	C	S
							12F	N	G	F	R
							12J	N	G	F	R
12F	M	GK	N	D	N	9					
12G	B	DI	A	D	N	9	12J	Y	G	F	R
							10N	N	G	I	S
							12F	Y	G	F	R
12H	C	GK	B	D	E	0	26A	Y	N	F	A
							70A	Y	N	F	S
12J	A	DF	C	D	N	2	16A	Y	G	F	A
							16B	Y	G	F	A
							16Y	Y	G	F	S
14A	A	PI	C	N	N	3	14C	Y	N	F	S
							18C	Y	N	F	A
14C	A	PF	C	N	N	3	18J	Y	N	F	A
16A	A	PF	C	D	S	3	16C	Y	G	F	A
16B	M	GK	C	D	N	3					
16C	A	PF	C	D	C	3	18C	Y	G	F	A
16Y	P	PF	C	D	N	0					
18C	A	PF	C	D	C	3	18D	Y	G	F	S
18D	A	PF	C	D	C	3	18E	Y	G	F	S
							18H	Y	G	F	S
18E	A	PI	C	D	C	3	18G	Y	G	F	S
18F	B	PI	C	D	N	3	62C	N	G	I	S
							18I	Y	G	C	S
18G	A	PI	C	D	E	3	18J	Y	G	F	A
							18R	Y	G	F	S
							18Y	Y	G	F	S
18H	C	GK	C	D	E	3	16A	N	D	F	A
							16B	N	D	F	A
18I	B	PI	C	D	N	3	18M	N	G	I	S
							18P	Y	G	F	S
							18T	Y	G	F	S
18J	A	PI	C	D	N	3	18F	Y	G	C	S
18M	A	PI	C	D	N	3	18X	Y	G	F	S
18P	C	PI	C	D	N	3	22A	Y	N	I	S
							18J	N	D	F	A

Table B-1 (Continued)

18R	M	GK	N	D	N	3					
18T	M	GK	C	D	N	3					
18X	A	PI	C	D	N	3	18J	Y	G	I	S
18Y	P	PI	C	D	N	0					
20A	A	DI	C	D	C	7	20C	Y	G	C	S
20C	A	DI	A	D	C	7	20E	Y	G	C	S
20E	B	DI	A	D	C	7	20A	N	G	I	S
							08A	Y	G	F	A
22A	A	PI	C	N	N	0	44A	Y	N	F	A
							22Y	Y	N	F	S
22Y	P	PI	C	N	N	0					
23A	A	PI	C	N	N	0	46A	Y	N	F	A
							44D	Y	N	F	S
							46Y	Y	N	F	S
24A	A	DFD	C	D	C	7	24C	Y	G	C	S
24C	A	DFD	A	D	C	7	24E	Y	G	C	S
24E	B	DFD	A	D	C	7	12H	Y	G	F	S
							24A	N	G	I	S
							12A	Y	G	F	A
25C	A	PI	C	N	N	0	46S	Y	N	C	A
26A	A	DID	C	N	N	7	28A	Y	N	F	A
							80A	Y	N	F	S
							80D	Y	N	F	S
28A	A	DID	C	N	N	7	80E	Y	N	F	A
40A	A	TID	C	N	N	4	40C	Y	N	C	S
40C	A	TID	A	N	N	4	40E	Y	N	C	S
40E	B	TID	A	N	N	4	40G	Y	N	F	S
							40J	N	N	I	S
40G	A	TID	B	N	N	4	40H	Y	N	F	S
40H	A	TID	C	N	N	4	42A	Y	N	F	A
							42Y	Y	N	F	S
40J	A	TID	A	N	N	4	40A	Y	N	I	S
42A	A	TFD	C	T	S	4	42C	Y	G	C	S
							42B	Y	G	C	S
42B	C	GK	B	T	E	4	42A	N	T	F	A
42C	A	TFD	A	T	E	4	42E	Y	G	C	S
42E	B	TFD	A	T	N	4	42H	Y	G	F	S
							42K	N	G	I	S
42H	A	TID	A	T	N	4	42J	Y	G	F	S
42J	A	TFD	C	T	N	4	44A	Y	G	F	A
							42L	Y	G	F	S
42K	A	TFD	A	T	N	4	42A	Y	G	I	S
42L	C	GK	B	T	N	4	50A	Y	N	F	A
							50Y	Y	N	F	S
42M	A	TID	B	N	N	4	42N	Y	N	F	S
42N	A	TID	C	N	N	4	46S	Y	N	I	A
42Y	P	TFD	C	N	N	0					
44A	A	TF	C	T	S	5	44C	Y	G	C	S
44B	A	TF	C	T	N	5	44A	Y	G	I	S
44C	A	TF	C	T	C	5	44H	Y	G	C	S

Table B-1 (Continued)

44D	M	TF	B	N	N	5					
44H	B	TF	C	T	E	5	44B	N	G	I	S
							44K	Y	G	F	S
44K	C	TF	C	T	N	5	23A	Y	N	F	S
							26A	Y	N	F	A
							70B	Y	N	F	A
46A	A	TF	B	T	S	5	46C	Y	G	C	S
46C	A	TF	B	T	C	5	46L	Y	G	C	S
							46N	Y	G	C	S
46L	B	TF	A	T	C	5	46P	N	G	I	S
							46Q	Y	G	F	S
							48B	Y	G	F	S
46N	C	GK	B	T	E	5	46A	N	T	F	A
46P	A	TF	C	T	C	5	46A	Y	G	I	S
46Q	C	GK	B	T	E	5	42M	Y	N	F	S
							46R	Y	N	F	A
46R	A	TI	C	N	N	5	25C	Y	N	C	S
46S	A	TI	B	N	N	5	46T	Y	N	C	S
46T	B	TI	A	N	N	5	48A	Y	N	F	A
							46R	N	N	I	S
							46W	Y	N	F	S
							28A	Y	N	F	A
							72A	Y	N	F	A
							54A	Y	N	F	A
46U	R	GK	C	N	N	0	60B	R			
							62B	R			
46W	M	GK	N	N	N	5	46U	Y	N	F	A
46Y	P	TF	C	N	N	0					
47Y	P	TFD	C	T	E	0					
48A	A	TID	C	N	N	5	52C	Y	N	C	A
							52G	Y	N	C	A
48B	A	TFD	B	T	C	5	48D	Y	G	F	S
							47Y	Y	G	F	S
48D	C	GK	B	T	E	5	48A	Y	N	F	A
48Y	F	TID	C	N	N	0					
50A	A	TID	C	N	S	6	50C	Y	N	C	S
50C	A	TID	A	N	C	6	50E	Y	N	C	S
50E	B	TID	A	N	C	6	50A	N	N	I	S
							50H	Y	N	F	S
50H	A	TID	C	N	C	6	54A	Y	N	F	A
50Y	P	TID	C	N	N	0					
52C	A	TID	A	N	N	5	52E	Y	N	C	S
52E	B	TID	A	N	N	9	52F	Y	N	F	A
							52H	N	N	I	S
							52M	Y	N	F	A
							48Y	Y	N	F	S
52F	M	TID	N	N	N	9					
52G	A	TID	C	N	N	9	52J	Y	N	C	S
52H	A	TID	C	N	N	9	52C	Y	N	I	S
52J	B	TID	A	N	N	9	52F	Y	N	F	A
							52G	N	N	I	S
							52M	Y	N	F	A
52M	A	TID	B	N	N	9	52P	Y	N	F	S
52P	A	TID	A	N	N	9	52R	Y	N	F	S
52R	A	TID	B	N	N	9	52Z	Y	N	F	S
52Z	A	TID	A	N	N	9	80F	Y	N	F	A
							82A	Y	N	F	A

Table B-1 (Continued)

							82E	Y	N	F	A
							82J	Y	N	F	A
53A	A	GK	B	N	N	0	54A	Y	N	F	A
53C	A	GK	B	N	N	0	54A	Y	N	F	A
54A	A	TI	C	N	C	6	54E	Y	N	C	S
54D	A	TI	C	N	C	6	54A	Y	N	I	S
54E	B	TI	C	N	C	6	54D	N	N	I	S
							54G	Y	N	F	S
54G	M	GK	B	N	E	6	54H	Y	N	F	A
54H	A	TI	B	N	S	6	54K	Y	N	C	S
54K	B	TI	A	N	C	6	54L	N	N	F	S
							54M	Y	N	F	S
							54R	Y	N	F	S
54L	A	TI	C	N	C	6	54H	Y	N	I	S
54M	B	TI	A	N	E	6	54P	N	N	F	S
							54T	Y	N	F	R
							46U	Y	N	F	R
54P	A	TID	B	N	N	6	54Q	Y	N	F	S
54Q	A	TI	B	N	N	6	54S	Y	N	C	S
54R	M	GK	B	N	E	6					
54S	B	TI	A	N	N	6	54W	N	N	I	S
							54T	Y	N	F	R
							46U	Y	N	F	R
54T	A	TID	C	N	N	6	54V	Y	N	C	S
54V	B	TID	A	N	N	6	54T	N	N	I	S
							54Y	Y	N	F	S
54W	A	TI	C	N	N	6	54Q	Y	N	I	S
54Y	P	TI	C	N	N	0					
60A	H	GK	C	N	N	10	60B	Y	N	F	R
							16C	Y	N	F	A
							62A	Y	N	F	A
60B	H	GK	C	N	R	10	60B	Y	N	F	R
60Y	P	GK	C	N	N	0					
62A	H	GK	B	N	N	0	62B	Y	N	F	R
							18J	Y	N	F	A
							44A	Y	N	F	A
							62Y	Y	N	F	S
62B	H	GK	C	N	R	0	62B	Y	N	F	R
62C	H	GK	C	D	N	0	18X	Y	G	I	S
62Y	P	GK	C	N	N	0					
66B	A	GK	B	N	R	10	66D	Y	N	F	S
66D	A	GK	B	N	R	10	66B	Y	N	F	R
70A	A	GID	C	N	N	8	70B	Y	N	F	A
70B	A	GFD	C	N	N	8	70C	Y	N	C	S
70C	A	GID	A	N	N	8	70E	Y	N	C	S
70E	B	GID	A	N	N	8	72C	Y	N	F	S
							70B	N	N	I	S
72A	A	GID	C	N	N	8	74A	Y	N	F	A
72C	A	GID	C	N	N	8	72A	Y	N	F	A
74A	A	GID	B	N	N	8	74C	Y	N	C	S
74B	A	GID	C	N	N	8	74A	Y	N	I	S
74C	B	GID	A	N	N	8	80E	Y	N	F	A
							74B	N	N	I	S

Table B-1 (Concluded)

80A	A	DFD	A	N	N	7	80J	Y	N	F	A
80D	R	GK	N	N	N	0	66B	R			
80E	A	GID	C	N	N	0	80F	Y	N	F	A
							82A	Y	N	F	A
							82E	Y	N	F	A
							82J	Y	N	F	A
80F	M	GK	N	N	N	9					
80J	B	DFD	A	N	N	7	80F	Y	N	F	A
							80L	N	N	I	S
							82A	Y	N	F	A
							82E	Y	N	F	A
							82J	Y	N	F	A
80L	A	DFD	A	N	N	7	80N	Y	N	I	S
80N	A	DFD	C	N	N	7	80P	Y	N	I	S
80P	A	DFD	A	N	N	7	80J	Y	N	I	S
82A	A	DID	C	N	N	9	82G	Y	N	F	A
82E	A	DID	A	N	N	9	82G	Y	N	F	A
82G	A	DID	B	N	N	9	82P	Y	N	F	A
82J	A	DID	B	N	N	9	82P	Y	N	F	A
82P	A	DID	B	N	N	9	82Q	Y	N	C	S
82Q	A	DID	C	N	N	9	82S	Y	N	C	S
82S	A	DID	A	N	N	9	82T	Y	N	C	S
82T	B	DID	A	N	N	9	82V	Y	N	F	S
							82P	N	N	I	S
82V	A	DID	A	N	N	9	82Z	Y	N	F	S
							84Y	Y	N	F	S
82W	A	DID	C	N	N	9	82X	Y	N	C	S
82X	A	DID	A	N	N	9	82Y	Y	N	C	S
82Y	B	DID	A	N	N	9	82W	N	N	I	S
82Z	M	GK	A	N	N	9	82W	Y	N	F	S
84Y	P	GFD	C	N	N	0					

SOFTWARE ACQUISITION PROCESS MODEL

10:20 CS
9/9/81
GAP VERSION

TABLE B-2A: ACTIVITY BOX PARAMETER DATA

MODEL 1 DATA

BOX			MANPOWER: CONTRACTOR					MANPOWER: AIR FORCE						DURATIONS					
NAME	TYPE	GROUP	SYST	DSGN	PRGM	TEST	SPRT	DVLP	USE	SPRT	IT	FCTR		DAYS	IT	FCTR		WAIT	NOTES
02A	A	N					1							10	-2				1
04A	A	N	2	2		2	1							10	-2				2
04C	A	N	2	2			2	4	1	1	5	5	5	12	3	1	1		3 4
04E	A	N						6	1	1	5	5	5	10	3	1	1	5	
04J	A	N	1.5	1		1	1	10	2	1	5	3	3	4	3	2	2	10	8
04M	A	N	1	1		1	1				5	5	5	3	6	3	3		8
04S	A	N	1	1		2	1							15	-2				5
06A	A	N	2	6							10	5	3	18	3	2	2		10
06D	A	N	3	6							5	3	1	5	5	2	2		10
06F	A	N	2	2										8	-1				11 E.
06G	A	D	2	10	4						3	2	1	40	4	4	4		12 E.
06H	A	D	3	6							5	5	5	9	4	2	2		12 E.
06M	A	D	1	4				1			5	2	2	6	3	3	3		
06R	A	F	2	5							8	6	4	5	6	5	4		
08A	A	F	2	3	.6	.6	2	8	2	1	8	4	2	4	5	3	1	3	16
10A	A	D	3	20	5						6	4	2	56	3	2	1		
10C	A	D	3	4	1						5	3	2	9	6	4	2		
10H	A	F	5	6	2						6	4	2	5	6	4	2		
10L	A	F	1	8							6	4	2	10	6	4	2		
10N	A	D	1	8							9	7	5	20	6	4	2		
12A	A	F	3	4	2	1.5	2	15	4	2	8	4	2	5	3	1	1	5	16
12J	A	D	2	6	1	1	2							15	-1				
14A	A	N	1.5	1.5		2	1				5	5	5	20	4	2	2		
14C	A	N	1.5	.3		3	1				5	3	1	30	5	3	1		
16A	A	D		4	40									27	-2				
16C	A	D			40		2				3	3	3	9	5	5	5		
18C	A	D		6	40		1				3	3	3	32	6	4	2		
18D	A	D		6	20		1.5				4	4	4	28	6	4	2		
18E	A	D		6	12		2				5	5	5	36	6	4	2		
18G	A	F				1	1							3	5	5	5		
18J	A	D				4	1				10	6	4	15	6	4	2		
18M	A	F	1	2	4	2	1				9	7	5	5					
18X	A	D												0					
20A	A	D	1	6			2				5	2	1	18	5	3	1		
20C	A	D						8	2	2	6	3	2	18	5	3	1	5	
22A	A	N			1	1	1							4					
23A	A	N			1	1	1							4	1	1	1		

Table B-2 (Continued)

24A	A	D	1	12			4				5	4	2	30	5	3	1	
24C	A	D						8	2	2	8	3	2	27	5	3	1	5
25C	A	N			1	1	1							4	5	3	1	
26A	A	N	2	3			4				4	3	2	40	5	3	1	
28A	A	N	1	2.4			2				4	2	1	15	5	3	1	
40A	A	N	2			3	2				8	3	2	25	6	4	2	
40C	A	N						4	1		6	4	2	25	6	4	3	5
40G	A	N	2			3	1	4	[illegible]					6	-2			5
40H	A	N	2			4	1							10	-2			
40J	A	N						4			6	4	4	20	8	4	4	
42A	A	T	2			6	2				6	4	2	70	6	4	2	
42C	A	T						6	1		5	3	1	30	6	4	4	5
42H	A	T						4						20	-2			
42J	A	T	1			6	2							10	-2			5
42K	A	T						3			5	3	1	20	7	5	3	
42M	A	N	1			3		3						5	-1			
42N	A	N	1			3								8	-2			
44A	A	T				8	2				10	6	3	8	7	5	3	
44B	A	F	.5	1	4	2	.5							6				
44C	A	T	1	2	4	8	2				10	6	3	21	8	6	4	
46A	A	T	1			8	2	4	1		8	5	3	10	8	6	4	
46C	A	T	1			8	2	4			7	4	2	16	8	6	4	
46P	A	F	.5	1	4	2	.5							6	8	6	4	
46R	A	N	1	2	4	2	2				5	3	2	10	5	3	1	
46S	A	N	1			2	1	2			5	2	1	6	5	3	1	
48A	A	N	1			3	1				5	4	3	6	5	3	1	
48B	A	T	1	1		6	2	4	1		5	3	1	16	1	1	1	
50A	A	N	2	1		4	2				9	5	3	30	5	3	1	5
50C	A	N						4	2		6	5	4	15	5	3	2	
50H	A	N	1			3	1							7	-2			5
52C	A	N						4	1		6	4	2	20	6	4	2	5
52G	A	N	1			3	1	3	1		5	4	2	5	4	2	0	
52H	A	N	1			2	1				5	5	5	10	5	3	2	
52M	A	N	.3			1.2	1	4	2					1	-2			
52P	A	N						4	2					3	-2			
52R	A	N	1			2		2	1					2				
52Z	A	N						1						1	-2			
53A	A	N	.5					.2						300	-2			
53C	A	N	.5					.3						340	-2			
54A	A	N	2			8	2				6	4	2	20	8	6	3	
54D	A	N	.5	1	4	2	.5				6	6	5	10	8	6	5	
54H	A	N	2			8	2	6	2		6	4	2	20	5	3	2	
54L	A	N	.5	1	4	2	.5				6	4	2	8	7	6	6	
54P	A	N	1			2		2	1					3	-2			
54Q	A	N	1			3	2	3	1		8	5	2	6	7	5	2	
54T	A	N	2			4	2				6	4	2	25	6	3	1	
54W	A	N	.5	1	4	2	.5							6				

Table B-2 (Concluded)

60A	H	N	.5	1	2		4							40	-2				6
60B	H	N					2							10					
62A	H	N	.5	1	2	1	4							40	-2				7
62B	H	N					2							10					
62C	H	F			1	3	1							10	5	3	2		
66B	A	N	.4	.5			1	2	1	1				5				30	9
66D	A	N	2.1	.9		1	1	8	2	1				4					9
70A	A	N	2	2			4							40	-1				
70B	A	N	3	1.2			4				7	5	3	20	7	5	2		
70C	A	N						4	2	1	7	5	3	25	7	5	2	5	
72A	A	N	2	1		3								10	-2				
72C	A	N	2	.5										15	-2				
74A	A	N	2			1	1	2	2		8	5	2	12	3	2	1		
74B	A	N	1			.5	.5				6	4	2	6	4	2	1		
80A	A	N						6		2				20	-2			5	
80E	A	N	1	1	1	1	3	2			5	4	3	5	5	3	1		
80L	A	N						2			5	5	5	10	5	3	2		
80N	A	N	2	2	2		4				5	5	5	20	5	3	1	5	
80P	A	N						2	2	2	5	5	5	15	6	4	2	5	
82A	A	N	2	2	1		1							3	-2			3	
82E	A	N						8	2	2				3	-2				
82G	A	N	2	2				8	2	2				2	-2				
82J	A	N	1	2	1	1	1	6	2	2				3	-2			3	
82P	A	N	1	1			1	2	1	1				2	5	2	0		
82Q	A	N	1	1			1							1	5	5	5		
82S	A	N						2	1	1				1					
82V	A	N						1						1	-2				
82W	A	N	2	3	6	2	2				8	6	4	30	5	3	1		
82X	A	N						4	1	1	8	6	4	10	5	3	2		

SOFTWARE ACQUISITION PROCESS MODEL 08/27/81 CS
9/3/81
TABLE B-3C: DECISION BOX PARAMETER DATA GAP VERSION

MODEL 1 DATA

BOX			YES EXIT PROBABILITIES					
NAME	TYPE	GROUP	1ST	2ND	3RD	4TH FF.	WAIT	NOTES
04G	B	N	80	100	100	100	0	8
04L	B	N	80	90	90	90	0	8
06E	B	N	20	40	60	100	0	
06I	B	D	70	50	100	100	0	12 E.
06P	B	D	50	100	100	100	0	13
08C	B	D	90	100	100	100	0	
10E	B	D	20	50	80	95	0	
10J	B	D	20	50	80	95	0	
12C	B	D	80	90	90	95	0	
12G	B	D	90	90	90	100	0	
18F	B	D	95	100	100	100	0	
18I	B	D	00	05	15	70	0	
20E	B	D	70	90	95	100	0	
24E	B	D	70	90	95	100	0	
40E	B	N	50	80	90	100	0	
42E	B	T	40	60	75	90	0	
44H	B	T	15	35	60	80	0	
46L	B	T	15	40	60	80	0	
46T	B	N	80	90	95	100	0	
50E	B	N	0	10	30	50	0	
52E	B	N	70	80	100	100	0	
52J	B	N	75	95	100	100	0	
54E	B	N	25	50	75	90	0	
54K	B	N	10	25	60	80	0	
54M	B	N	35	100	100	100	0	
54S	B	N	30	60	90	100	0	
54V	B	N	20	50	80	100	0	
70E	B	N	50	70	90	100	0	
74C	B	N	60	80	90	100	0	
80J	B	N	80	90	100	100	0	
82T	B	N	75	80	90	100	0	
82Y	B	N	75	90	95	100	0	

TABLE B-4: EVENT BOXES PARAMETER DATA
(MILESTONE, COUNTER, AND REINITIALIZER TYPES)

MODEL 1 DATA

BOX NAME	BOX TYPE	BOX GROUP	EVENT LABEL	PARAMETER	
06J	C	D			
06L	M	D	PDR		
08E	C	D			
10F	C	D			
12E	C	D			
12F	M	D	CDR		
12H	C	D			
16B	M	D	START CODING		
18H	C	D			
18P	C	D			
18R	M	D	CCI & C END		
18T	M	D	CPCI T & I END		
42B	C	T			
42L	C	T			
44D	M	N	FQT START		
44K	C	T			
46N	C	T			
46Q	C	T			
46U	R	N		FO	1
46W	M	N	FQT - END		
48D	C	T			
52F	M	N	FCA - START		
54G	M	N	SYS DT & E START		
54R	M	N	SYS DT & E END		
80D	R	N		FO	1
80F	M	N	PCA - START		
82Z	M	N	PCA - END		

TABLE B-5: PERSONNEL BOX PARAMETER DATA

9/3/81
GAP VERSION

MODEL 1 DATA

BOX			CONTRACTOR PERSONNEL						
NAME	TYPE	GROUP	TRIGGER	SYST ENG	DSGN ENG	PGMR	TEST	SPRT	MGMT
01Y	P	N	N	2	2		2	2	3
06Y	P	N	N	2	6			1	
08Y	P	D	F	2	5	5			1
10Y	P	D	F	1	9	4		2	1
			C		-3	-4	1		
16Y	P	D	F		-6	24	1	1	
			C	-1	-9	-4			
18Y	P	D	F		2	6			
			C		-3	-20			
22Y	P	N	N	1	0	-8	3		
42Y	P	N	N				4		
46Y	P	N	N	-1	0	0	-1		
47Y	P	T	C	-1	-1	0	-4		
48Y	P	N	N	-2		0	-2	-3	-1
50Y	P	N	N	1	1	2	0	1	
54Y	P	N	N	-1	-1	-2	-3	-1	-1
60Y	P	N	N	1	2	3	1	3	1
62Y	P	N	N	-1	-2	-3	0		
84Y	P	N	N		1	3			-3

SOFTWARE ACQUISITION PROCESS MODEL

TABLE B-6: SUBNETWORK TITLES

MODEL 1 DATA

SUBNET#	TITLE
1	REQUIREMENTS DEFINITION
2	COMPUTER PROGRAM DESIGN
3	CODING THROUGH CPT&E
4	FORMAL TEST PREPARATION
5	FORMAL TEST CONDUCT/REPORT
6	SYSTEM TEST
7	PRODUCT SPECIFICATION PREP
8	USERS' MANUALS & CDRL ITEMS
9	FORMAL REVIEWS & AUDITS
10	SUPPORT & MANAGEMENT

APPENDIX I

COMPUTER PROGRAM DESIGN

The designs of and interrelations between the four packages that constitute the SWAP Simulator are described herein:

1. Overall Program Operation and Data Flow

1.1 Program Packages

The following four packages constitute the SWAP Simulator:

a. GAP - The Generic Adaptation Processor
b. DIP - The Data Table Input Processor
c. SCP - The Simulation Conduct Processor
d. ORG - The Output Report Generator

1.2 Operational Relationship

While the four packages each operate autonomously, the order of operation is established by the data dependencies shown in Figure I-1, Data Flow Diagram. The following will aid in the interpretation of this diagram:

a. The characteristics of the data contained in each box is denoted by the vertical enclosures used on the boxes, as follows:

(1) [____] indicates data entered by the user

(2) [////] indicates output data sent to the user

(3) [(())] indicates data retained in the data base

b. Horizontal arrows indicate the data flow into and out of each package (the package is denoted by its name enclosed by asterisks). These arrows, therefore, show the data transformations accomplished by the packages. Note that the direction of flow alternates from line to line.

c. Vertical arrows denote the transfer of the data base from one package to the next. These transfers account for the data dependencies that determine the order of operation.

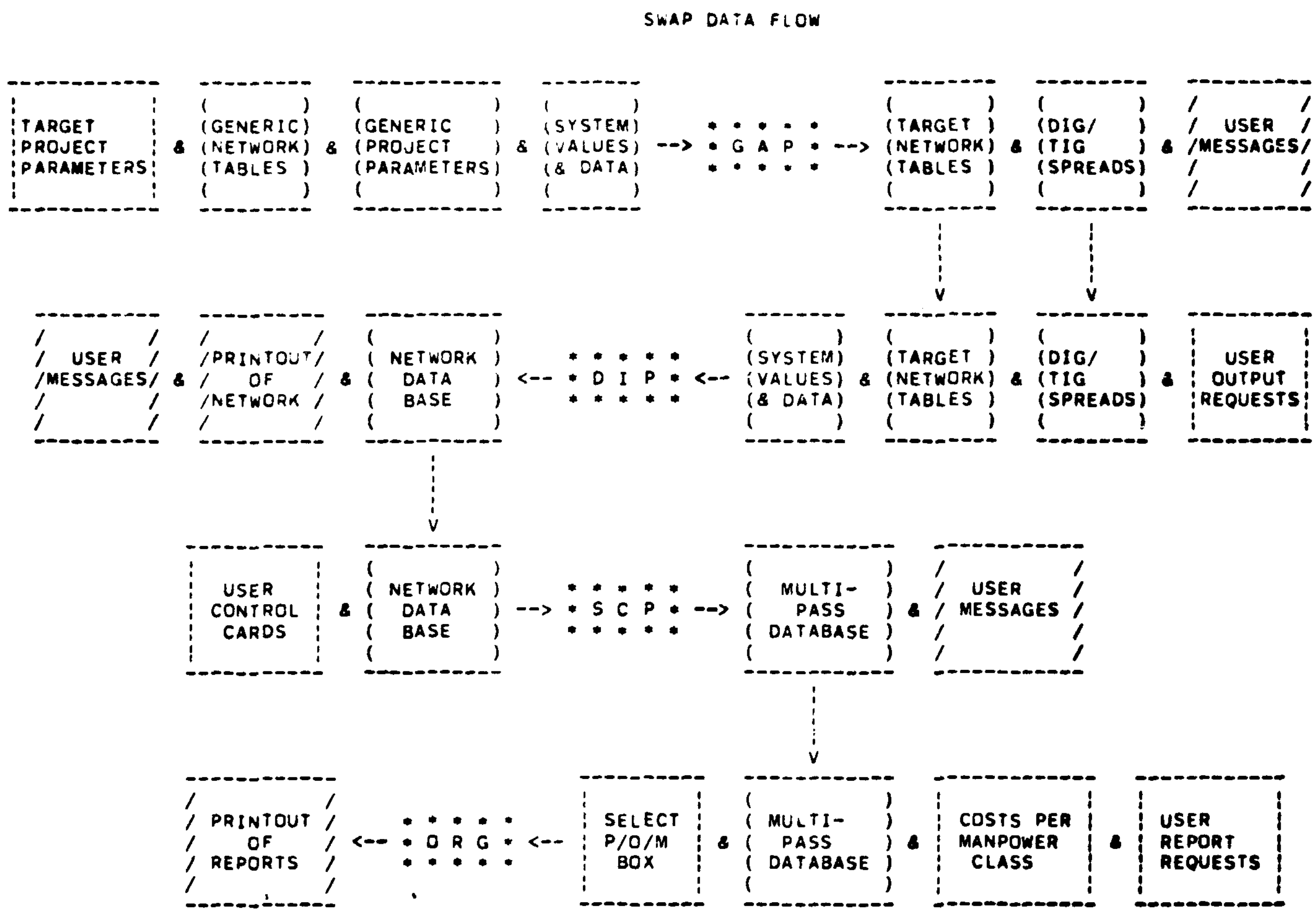


Figure I-1. Data Flow Diagram

2. The Generic Adaptation Process (GAP) Package

2.1 Overview

GAP reads in user entered data that describes a (Target) project for which an estimate is wanted and creates a set of Tables that quantify the process by which that project will be accomplished. The tables created are identical in format to a set of existing tables that defines a Base project; project attributes and results achieved (i.e., schedule and cost) for the Base project are known. GAP compares the attributes of the Target project with those of the Base and derives some critical ratios which it uses to transform the Base data tables into Target tables. This is accomplished in a five step process that is detailed below.

2.2 Program Details

In the first step, GAP accepts Target project descriptors from the user and creates seven Effort Factors for the Target project: Design, Programming, Test, General, Program Documentation, Test Documentation, and User Documentation. The Effort Factors are numeric representations of the difficulty and size of the "Target" project for different activity classes. Furthermore, unless the user specifically enters DIG or TIG spreads (see para. 2.1.3 of the main report), this step creates these based on CPCI size.

The second step performs a similar conversion to create the Effort Factors for the Base project.

The third step divides the Target project Effort Factors by their respective "Base" Effort Factors to produce ratios that enumerate the relative sizes of the two projects for the seven types of activities.

The fourth step expands the seven ratios to distinct ratios for manpower and duration conversion of activity boxes, yes probability conversion of decision boxes, and manpower conversion of personnel boxes. Each of the seven ratios of the third step creates two ratios--one for fragmented activities (those that easily allow more manpower to be added) and one for integrated activities (those that can less readily accept increased manpower). The manpower conversion ratio is a function of contractor manning availability, government scheduling urgency, and the ratio for the box's activity class. The duration conversion ratio is also a function of these three, assuming that the larger the project and the more people on it the less efficient the process becomes. The probability ratio is based on a similar assumption: the larger the project, the greater the chance of iteration, i.e., the smaller the yes-probability.

The fifth step creates Target project versions of Base Tables B-2, B-3, and B-5, (see Appendix B), converting the Base values by the proper ratio. This step does not produce Target project B-1, B-4, and B-6 tables, because they are not changed by GAP.

2.3 Program Structure

GAP is implemented using the group of routines shown in Figure I-2. The figure gives the name and function of each routine, and indicates by indention the hierarchial relationship between the routines.

GAP ROUTINE NAME	FUNCTION
GEN.CON	ratios for generic to target project
DEFINE	effort factors for target and generic projects
BOX.CON	ratios for specific conversion per class
BOX.VAL	change tables
B2.CONV	convert table B-2
B2.CONSTANTS.INIT	establish columns of B-2
B2.PARSE.RECORD	change values in B-2 appropriately
B3.CONV	convert table B-3
B3.PARSE.RECORD	change values in B-3 appropriately
B5.CONV	convert table B-5
B5.CONSTANTS.INIT	establish columns of B-5
B5.PARSE.RECORD	changes values in B-5 appropriately

Figure I-2. Generic Adaptation Process (GAP) Program Structure

3. The Data Table Input Process (DIP) Package

3.1 Overview

The DIP package performs two principal functions; it validates the format, syntax and data consistency of the project definition tables (per Appendix B) and it reformats the data to produce a data base that is compatible with the SCP programs. The performance of each of these functions is detailed below:

3.2 Program Details

3.2.1 Data Base Creation

DIP creates the initial data base by reading through seven input tables (per Appendix B) and arranging the data into a format that SCP can use. The data base is in four parts: the run header, the pass header, the complete box description, and the partial box description. DIP writes only the first three of these; the partial box information is used only by SCP and ORG on multi-repetition simulations.

The run header consists of system variables and default values for variables that are used by at least two of the DIP, SCP or ORG packages. Most of these values are determined in DIP. Those that are not are initialized to zero, and will have values assigned later by SCP.

The pass header contains information that is generated for each repetition, but is not related to any specific box. Because this information is not developed in DIP, the pass header arrays are not stored, and all unsubscripted data values in the pass header are written as zero.

The complete box information contains all box-related data for each box. This includes general box information (subnetwork, group, etc.), predecessors, successors, occurrence and timing data for each DIG/TIG, sub-box data (see para. 3.3.1c) for each sub-box of each DIG/TIG, activity timing and manpower data for each DIG/TIG of activity or helper boxes, yes-probabilities of decision boxes, labels for milestone boxes, and triggers and manning level changes of personnel boxes.

DIP first gathers all system data (which are shielded from the user and maintained as variables for program flexibility) from the system input file and initializes arrays that contain alphabetic codes for attributes of boxes and successors. It then reads DIG/TIG spread information from Table B-0. Next, Table B-6 is read to obtain the subnetwork titles. Subsequently, Table B-1 is read to determine the number of boxes to create. DIP then re-reads Table B-1, gathering the box level information but not the successor information. After this, data from Tables B-3, B-4, or B-5, depending on each box's type, are gathered. Subsequently, DIP again reads Table B-1, processing the successors, creating predecessors, and checking for progression, group control, and burst chain membership errors. Next, it reads Table B-2 creating the OTD's for all boxes and ATM's for activity and helper boxes. After this, the data is written to the binary file for the SCP. Finally, DIP prints all the box information it has gathered in the format specified by the user, using the user's codes, not the internal representations.

3.2.2 Input Error Checking

During DIP processing, error conditions are noted as they are found, while the program continues processing the remaining data. This reduces the number of passes needed to perform input data corrections.

a. Error Response Categories

Errors are categorized into three classes. Warning errors (signified WW) will not cause any errors when the simulation is run. They signify corrections that are needed to maintain the network within more consistent rules. Normal errors (signified XX) do not prevent the simulation from running, but the Simulator may not properly enact the logic expected by the user. Changes are made internally to try to correct these mistakes. Severe errors (signified YY) will cause the simulation to stop processing in the midst of a run.

b. Error Conditions Checked

The following conditons are checked for correctness:

(1) DIG and TIG spread percentages total 100%;

(2) Each Box is described by defined field designators: valid box types, DIG/TIG participation, organization performing the action (i.e., contractor or government), and burst membership;

(3) Tables are consistent with each other;

- boxes described in Tables B-2, B-3, B-4, or B-5 are in Table B-1;

- boxes described in Table B-1 appear in one and only one of Tables B-2, B-3, B-4, or B-5;

- group and type designators match between Table B-1 and either Table B-2, B-3, B-4, or B-5;

(4) Successor Data is complete and consistent;

- all three network progression fields are present and correctly designated;

- Box Group membership is consistent with Successor Group labels;

- Successor box ID also appears as a box entry;

- progression modes and start logic are consistent with each other;

- Box Burst memberships and successor progression modes are consistent with each other;

(5) Numeric values are within prescribed limits, e.g., many cannot be negative.

3.3 DIP Program Structure

DIP is implemented using the group of routines shown in Figure I-3. The figure gives the name and function of each routine, and indicates by indention the hierarchial relationships between the routines.

DIP ROUTINE NAME	FUNCTION
STARTUP	initialize data
SYS.INPUT	read system variables
INIT.ARRAYS	initialize conversion arrays
USER.INPUT	read dig/tig spreads
R.SUBNET	read subnetwork names
TABLES	read tables
BOX.COUNT	count boxes in B-1
INIT.TABLE.B1	position to top of B-1
BOX.INFO	read table B-1
OTHER.TABLE.DATA	read tables B-3, B-4, B-5
INIT.TALBE.B1	position to top of B-1
SUC.CREATION	read successors from B-1
PROG.CHECK	check progression mode errors
GROUP.CHECK	check group membership errors
BURST.CHECK	check burst chain membership errors
B2.PROC	process table B-2
B2.CONSTANTS.INIT	establish columns of B-2
ATM.CREATION	create the ATM entities
ERROR.CHECK	check for invalid values in B-2
MANPOWER.COMPUTATIONS	read and convert B-2 values
OTD.CREATION	create the OTD entities for all boxes
DISPLAY.TOTALS	show number of errors
W.RUN.HEADER	write run header
W.PASS.HEADER	write pass header
W1.BINARY	write box data
LIST.NET	if requested, list successors/predecessor
DUMP.BOXES	if requested, show all box data

Figure I-3. Data Table Input Processor (DIP) Program Structure

4. The Simulation Conduct Processor (SCP) Package

4.1 Overview

The SCP, which conducts the Simulation of the software acquisition process is the only package that takes advantage of the simulation features of the SIMSCRIPT language. It conducts the simulation by repeatedly calling two event routines:

One of these processes each box when its time occurs, the other moves the process from a completing box to its successor boxes. The SCP conducts many passes through the network gathering data on each pass that it saves for use by the ORG package. The operator can control SCP operation in three ways:

a. By selecting the number of passes to be conducted.

b. By entering override data that can alter box and network status; this provides a means for altering simulation conditions without the need to rerun DIP or GAP.

c. By requesting various types of output that can be used to aid in debugging the simulation.

4.2 Program Details

4.2.1 Textual Description

After initializing its variables, SCP reads user control card images, which can change data that DIP has passed to SCP. Any altered data is written to the run header, and then the box data is read. SCP then performs as many simulations as requested, writing pass information and the box data to the binary file. After the first repetition, SCP writes all box-related data to the file along with general data for the pass. After subsequent repetitions, the general pass data and only the box data that has changed since the first repetition are written. This includes each box's OTD and BOX entities, and the elements of the ATM in which timing factors and manpower expended are stored.

The actual simulation is controlled by the SIMSCRIPT internal timing facility. Two events can be scheduled, a BOX.PROC and a FLOW. BOX.PROC simulates the start of a task. Thus, for example, BOX.PROC gathers available manpower for activity boxes or decides branches for decision boxes. Activities are put on a wait queue if their requested personnel are not available. If adequate resources are available, BOX.PROC assigns them to the box, starts it, then schedules a FLOW, which corresponds to the end of a task. FLOW is scheduled at a time based on the duration of the task. The actual duration is randomized over a normal curve using the specified duration as the mean. All non-activity tasks have a duration of zero.

FLOW is a three-part process. First, it releases manpower associated with each completing activity box. Then, it schedules a BOX.PROC for each successor box that has had its predecessor and burst chain membership requirements fulfilled. Finally, FLOW determines if any activity boxes in the manpower wait queue can now be scheduled. FLOW and BOX.PROC in turn call other routines that, for example, search the manpower wait queue, or calculate the deficit manpower.

4.2.2 Diagramatic Description

A diagram showing the complete logic of the SCP is given in Figure I-4. The figure employs a Chapin Chart format, which provides an excellent portrayal of well structured code. Rules for interpreting Chapin Charts are provided in Figure I-5; these will be needed by those persons not familiar with that notation.

4.3 SCP Program Structure

SCP is implemented using the group of routines shown in Figure I-6. The figure gives the name and function of each routine, and indicates by indention the hierarchial relationships between the routines.

SIMULATION CONDUCT PROCESSOR

```
                                     |
                                     |
-------------------------------------------------------------------
|                     INITIALIZE ARRAYS AND ENTITIES              |
-------------------------------------------------------------------
|                     READ CONTROL CARDS                          |
-------------------------------------------------------------------
|                     READ DATABASE FROM DIP                      |
-------------------------------------------------------------------
|                     MODIFY BOXES AS REQUESTED                   |
-------------------------------------------------------------------
|///     FOR REQUESTED NUMBER OF REPETITIONS (OR REQUESTED REP):  |
|///|--------------------------------------------------------------
|///|               INITIALIZE STATISTIC STORES                    |
|///|--------------------------------------------------------------
|///|               MODIFY BOXES CHANGED BY REMOTE CHANGERS        |
|///|--------------------------------------------------------------
|///|               FIND THE FIRST BOX OF THE NETWORK              |
|///|--------------------------------------------------------------
|///|   &&          SCHEDULE A BOX.PROC  AND START SIMULATION      |
|///|--------------------------------------------------------------
|///|   WHEN SIMULATION ENDS, CHECK THE MANPOWER WAIT QUEUE        |
|///|           TO ENSURE EMPTY.     STOP IF NOT**                 |
|///|--------------------------------------------------------------
|///|             WRITE PASS'S STATS TO DATABASE                   |
-------------------------------------------------------------------
```

Figure I-4. Chapin Chart for Simulation Conduct Processor Sheet 1

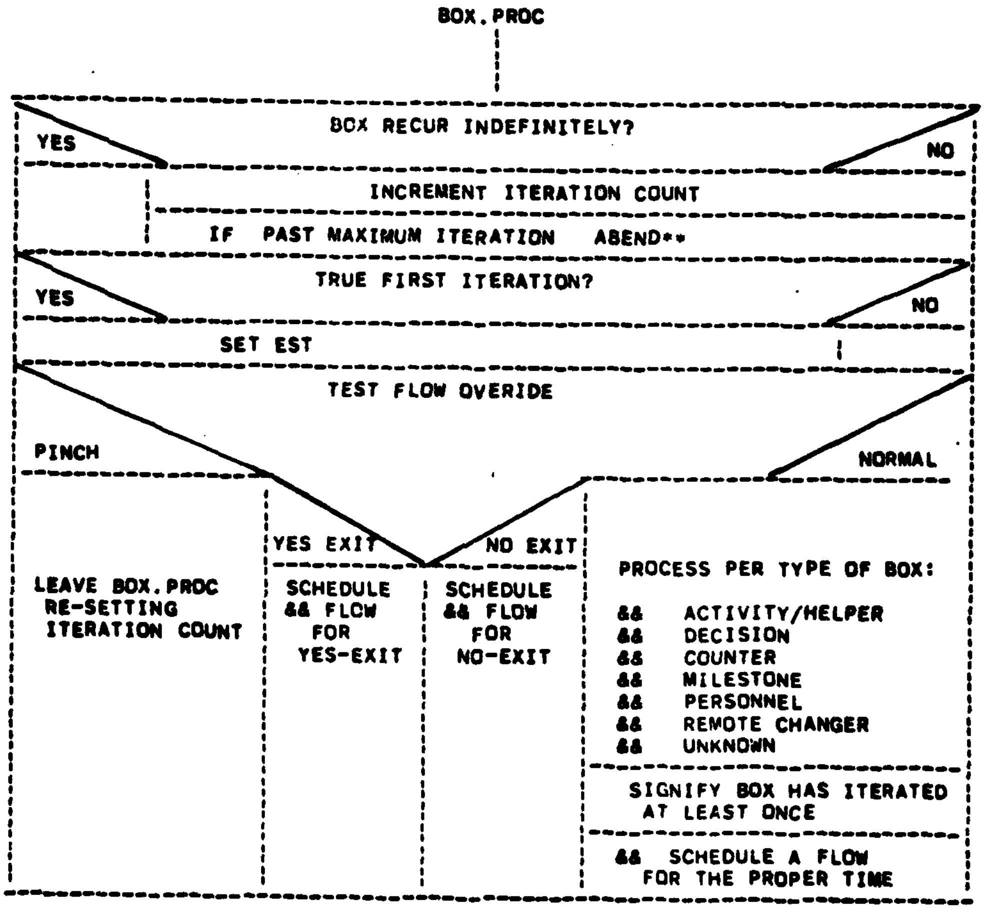


Figure I-4. Chapin Chart for Simulation Conduct Processor
Sheet 2

PROCESS BY BOX TYPE

ACTIVITY

IF DURATION IS -1, PINCH**

IF DURATION IS -2, WRITE ERROR AND STOP**

IF BOX IS ALREADY RUNNING FOR THIS ITERATION,
WRITE ERROR AND STOP**

DO ALL MANPOWER TYPES HAVE SUFFICENT MANPOWER AVAILABLE?

YES: UPDATE STATISTICS

GET A RANDOMIZED DURATION
ADD TO INITIAL WAIT
TO GET TIME FOR FLOW

NO: SEND BOX TO QUEUE

COUNTER

EACH AND EVERY ITEGRATION GROUP COMPLETE?

YES: TAKE YES EXIT

NO: TAKE NO EXIT

REMOTE CHANGER

MODIFY THE BOX REQUESTED WITH PROPER CHANGE

MILESTONE

IF NOT FIRST ITERATION , PINCH

Figure I-4. Chapin Chart for Simulation Conduct Processor
Sheet 3

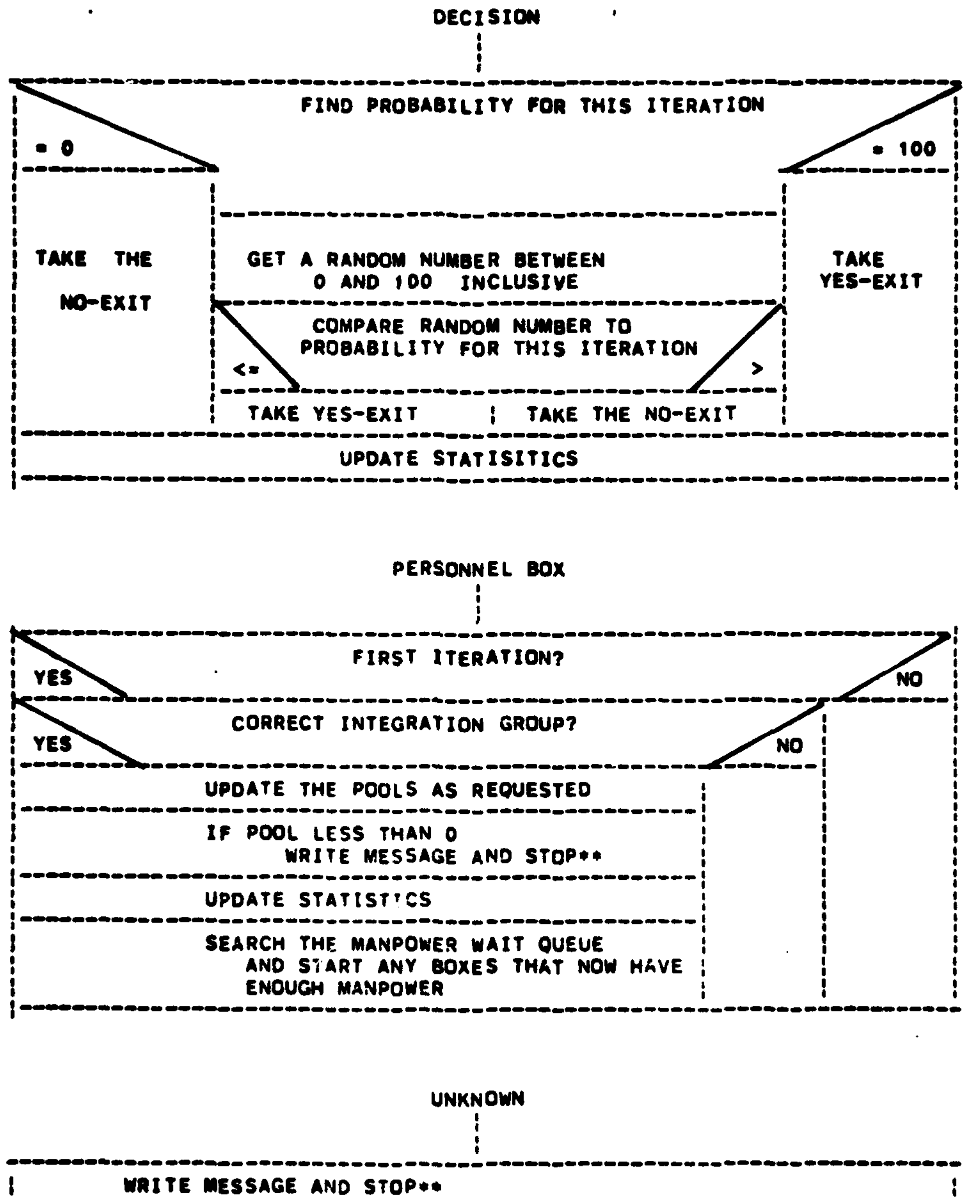


Figure I-4. Chapin Chart for Simulation Conduct Processor
Sheet 4

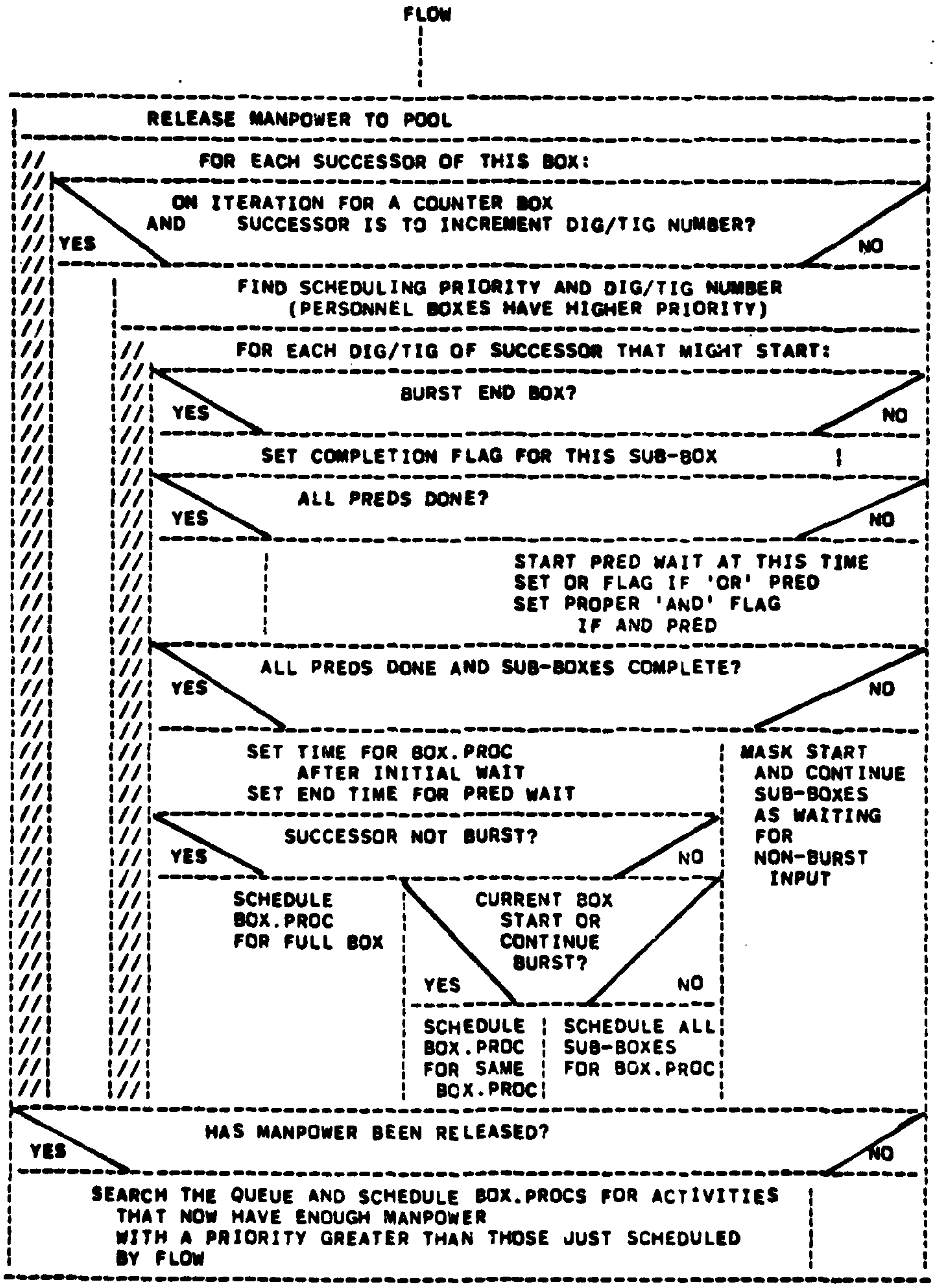


Figure I-4. Chapin Chart for Simulation Conduct Processor Sheet 5

This figure describes the notation employed on the Chapin Charts used to diagram the SCP computer program. The Chapin Chart is a structured flowchart limited to three basic elements; Sequence, Selection, and Repetition. The chart consists mainly of a series of rectangles. Control flows sequentially from top to bottom among rectangles, and from left to right within rectangles. The rectangles may be of any size and any dimension. Figures a and b show the sequential flow of control, with Figure a using Chapin notation, while Figure b uses conventional flow chart format, both indicate identical logic.

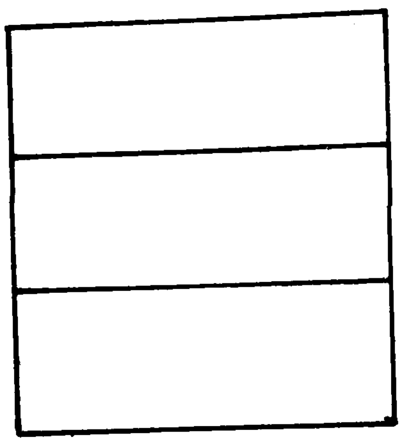


Figure a

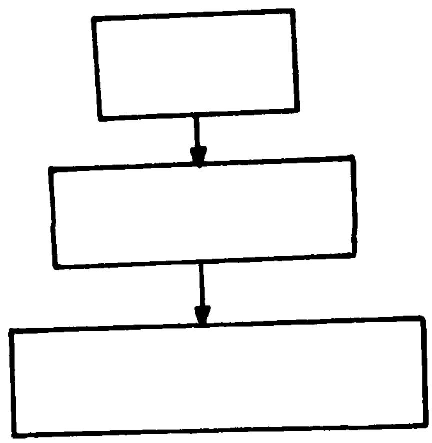


Figure b

Figure I-5. Directions for Reading Chapin Charts
Sheet 1

A loop is indicated by an inner rectangle marked off from a given rectangle as in Figure c.

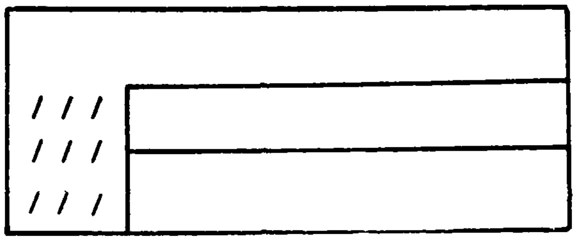


Figure c

A conditional transfer, IF-THEN-ELSE or SELECT, is denoted by a rectangle with the test condition contained within, and the lower corners capped by a triangular mark-off (see Figure d). The rectangles below the triangles contain the operations to be followed should the condition have the test result given in the triangle. The common edge acts as a convergent exit collector.

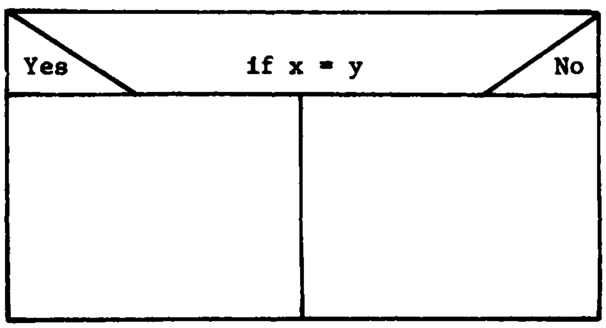


Figure d

Rectangles that are marked with an "&&" are subroutine calls that are described in another Chapin chart block. A double asterisk (**) indicates a halt to the processing in that chart; if it is accompanied by a "STOP", the simulation will cease, abnormally.

Figure I-5. Directions for Reading Chapin Charts
Sheet 2

SCP ROUTINE NAME	FUNCTION
SERVICE ROUTINES (called often by MAIN, BOX.PROC, FLOW, and MAN.Q.SEARCH)	
SHOW	display all variables when abend
PRT.MAN.STATS #	formatted print of manpower tables
PRINT.FNET.REPORT #	formatted print of manpower usage table
PRNTBOX	format print of box entities
ENDPAGE	determine if end of page for play-by-play
CURRENT.MONTH	determine which month currently in
MAIN	
ERROR.INIT	initialize error codes and messages
RUN.SIMS	do the simulations
R.RUN.HEADER	read the run header
CONTROL.CARDS	accept control cards from user
R.PASS.HEADER	read the pass header
R1.BINARY	read box data from DIP
W.RUN.HEADER	write run header for ORG
BOX.LOOKUP	find boxes of control cards to modify
MODIFY.BOX	modify boxes according to control cards
BOX.PROC	**
CALC.POOL #	calculate the final manpower pools
CALC.MGR #	calculate the final manager status
PRT.MAN.STATS	*
PRINT.FNET.REPORT	*
W.PASS.HEADER	write this pass' header for ORG
W1.BINARY	if first pass, write data for ORG
W2.BINARY	not first pass; only write changed data

Figure I-6. Simulation Conduct Processor (SCP) Program Structure
Sheet 1

SCP ROUTINE NAME	FUNCTION
BOX.PROC	simulate start of a box
MAN.Q.SEARCH	**
CALC.POOL	*
CALC.MGR	*
MODIFY.BOX	modify boxes according to remote modifier
FLOW **	
FLOW	simulate activity end and successor scheduling
CALC.POOL	*
SCHED.BOX	schedule a successor
BOX.PROC	**
MAN.Q.SEARCH	**
MAN.Q.SEARCH	search manpower wait queue and start proper boxes
CALC.DEFICIT	calculate deficit for waiting activities

\# description used below
* already described above
** described in detail below

Figure I-6. Simulation Conduct Processor (SCP) Program Structure
Sheet 2

5. Output Report Generator (ORG) Package

5.1 Overview

This package gathers and statistically analyzes the SCP simulation results (one logical record for each pass) and then produces the output reports requested by the user.

During the statistical analysis, the multiple pass results are segregated into three sets: pessimistic, optimistic, and mid-range (these are termed the p/o/m sets), which are based on the "PCA Complete" milestone time. The passes are segregated on the basis of the mean time (TIME) and Standard Deviation (SIGMA) for completing all passes, as follows:

```
Optimistic (OPT)    (TIME-M.SIGMA)>OPT>(TIME-2M.SIGMA)
Pessimistic (PES)   (TIME+M.SIGMA)<PES<(TIME+2M.SIGMA)
Mid-Range (MID)     (TIME-M.SIGMA)<MID<(TIME+M.SIGMA)
```

M is a user selectable segregation threshold that defaults to 1. Data outside the 2M.SIGMA threshold is discarded. The user can (optionally) select a different milestone for the segregation variable.

5.2 Program Details

ORG is divided into three parts. The first part determines whether a repetition is optimisitc, pessimistic, or mid-range. The second part reads each repetition's data, summing all relevant values to produce the means that are presented in the reports. The third part generates the reports requested by the user, and, if not already accomplished in the second part, transforms the gathered sums into means.

The first part of ORG reads the run header, the pass header of the first repetition, and the complete box information. Then ORG reads the box, DIG/TIG, and range percentage on which to base the p/o/m sets. Next, it passes through the entire database from SCP, saving information needed to calculate the mean and standard deviation of the earliest start time of the specified box. Once through the database, ORG determines the p/o/m set boundaries and the repetitions that fall into each set.

The second part of ORG re-reads the data base from the beginning without creating entities. It then initializes the elements in which statistical information is kept. For each pass, network and subnetwork manpower usage, completion time, milestone times, network manpower pool and deficit, activity timing data, and personnel box start times are summed in the proper p/o/m set. After the entire data base is read, each set's network manpower usage, completion time, and milestone sums are converted into means.

The third part of ORG produces the milestone report and the contractual expenditure summary report for the full network. ORG then accepts requests from the user to produce any of eight reports either for the full network, a subnetwork, or a combination of subnetworks. A report can be requested more than once if different subnetworks are wanted.

Some of the reports present the p/o/m sets on the same page, whereas others require three outputs, one each for optimistic, mid-range, and pessimistic passes. The report formats are as follows:

Report	P/O/M Reporting Format
1) Contractual Expenditure Summary	single output
2) Milestone Schedule	single output
3) Mean Monthly Manning Profile	separate outputs
4a) Personnel Box Summary Report	not segregated
4b) Mean Monthly Personnel Status	single output
5) Activity Box Summary Report--Input Order	not segregated
6) Activity Box Summary Report--EST Sort	not segregated
7) Contractor Monthly Expenditure Profile	single output
8a) Mean Monthly Personnel Pool	separate outputs
8b) Mean Monthly Personnel Deficit	separate outputs
8c) Mean Monthly Personnel Surplus	separate outputs

5.3 ORG Program Structure

ORG is implemented using the group of routines shown in Figure I-7. The figure gives the name and function of each routine, and indicates by indention the hierarchial relationship between the routines.

ORG ROUTINE NAME	FUNCTION
SERVICE ROUTINES (called by all print programs)	
MTH	convert days to months
DAY	determine days within a month
RPT.HEADER	report header for 3 separate POM reports
RPT.NET.HEADER	print project and page
LAST.RPT.HEADER	report header of one report for all POM
NEAT.PRINT	print numbers in good format
TITLES	print columnar titles
MAIN	
R.RUN.HEADER #	read the run header
START	find the p/o/m buckets
SIGMA.SEARCH	find sigma; determine pass/pom relationship
R.PASS.HEADER #	read the pass header
R1.BINARY #	read the first pass' data
R2.BINARY #	read all other pass' data
R.RUN.HEADER	*
R.PASS.HEADER	*
R1.BINARY	*
PROFILE	gather box statistics
MAN.BOX	sum manpower stats
MBOX.PROF	sum milestone box stats
ABOX.PROF	sum activity box stats
PBOX.PROF	sum personnel box stats
R2.BINARY	*
FINISH.STATS	convert network stats to means
READ.COSTS	accept costs from user

Figure I-7. Output Report Generator (ORG) Program Structure
Sheet 1

ORG ROUTINE NAME	FUNCTION
SELECT.PRTS	get report requests from user
READ.LINE	read each user request
MILER	produce milestone report
MILESTONE.SCHEDULE	milestone report for full network
M.HEAD	print full network headers
MILE.PRINT #	print milestone box data
SUB.MILE.SCHEDULE	milestone report for subnetwork
SM.HEAD	print subnetwork headers
MILE.PRINT	*
MANSUMR	produce manpower summary report
INT.MONEY.PRINT	formatted dollar print
ZERO.DIVISOR	divide by zero without abend
MTHMANR	produce monthly manpower report
MCOMBR	produce personnel status report
PSUMR	produce personnel box summary report
ASUMR	produce activity box summary report
SORT	shakersort for est sort
COSTR	produce monthly cost report
MARRAY.REPORTS	produce manpower array reports
M.POOL.REPORT	produce manpower pool report
M.DEFI.REPORT	produce manpower deficit report
M.SURP.REPORT	produce manpower surplus report

\# description used below
* already described above

Figure I-7. Output Report Generator (ORG Program Structure)
Sheet 2

APPENDIX J

SWAP MODEL OUTPUT REPORTS

This Appendix contains copies of reports produced by Model 1 of the SWAP Simulator that were selected to illustrate the improved capabilities developed during this reporting year. The creation of these reports was shown to the project sponsor during an informal demonstration of the results achieved in FY81.

Project	Report Type	Subnets	Fig. No.
Base	Milestone Schedule	Full	J-1
X2	Milestone Schedule	Full	J-2
/2	Milestone Schedule	Full	J-3
Base	Contractual Expenditure Summary	Full	J-4
X2	Contractual Expenditure Summary	Full	J-5
/2	Contractual Expenditure Summary	Full	J-6
Base	Contractor Monthly Expenditure Profile	Full	J-7
X2	Contractor Monthly Expenditure Profile	Full	J-8
/2	Contractor Monthly Expenditure Profile	Full	J-9
/2	Milestone Schedule	2,3,4	J-10
X2	Contractual Expenditure Summary	2,3,4	J-11
X2	Activity Box Summary Report	Full	J-12

SOFTWARE ACQUISITION PROCESS MODEL REPORT

MILESTONE SCHEDULE
FULL NETWORK

PROJECT: FY81 DEMO-BASE

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 3
MID-RANGE REPETITIONS: 21
PESSIMISTIC REPETITIONS: 5

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/28/81 08.44.25
SIMULATION CONDUCT TIME/DATE: 10/28/81 14.52.58
REPORTS PRODUCED TIME/DATE: 10/29/81 08.44.30

MILESTONE		DTN	TIME OF OCCURRENCE OPTIMISTIC	MID-RANGE	PESSIMISTIC
START NETWORK		---	0M 0D	0M 0D	0M 0D
06L	PDR	1	6M 8D	6M 15D	7M 2D
		2	7M 6D	7M 10D	7M 17D
		3	6M 15D	8M 13D	9M 5D
12F	CDR	1	11M 4D	11M 16D	12M 4D
		2	12M 1D	13M 1D	13M 5D
		3	14M 14D	15M 3D	15M 13D
16B	START CODING	1	11M 10D	12M 3D	12M 9D
		2	14M 3D	14M 15D	15M 1D
		3	15M 19D	16M 15D	17M 0D
18R	CCI & C END	1	15M 3D	15M 13D	16M 0D
		2	16M 13D	17M 3D	17M 12D
		3	16M 8D	19M 6D	19M 13D
18T	CPCI T & I END	1	16M 1[illegible]D	17M 6D	17M 13D
		2	16M [illegible]	18M 18D	19M 6D
		3	19M 1[illegible]	20M 13D	20M 19D
44D	FQT START	1	22M 1[illegible]	23M 1[illegible]D	24M 19D
46M	FQT - END	1	26M 5D	27M 9D	29M 0D
52F	FCA - START	1	27M 13D	29M 9D	31M 1D
54G	SYS DT & E START	1	30M 17D	31M 12D	32M 9D
54R	SYS DT & E END	1	33M 17D	34M 12D	35M 14D
80F	PCA - START	1	23M 8D	30M 2D	32M 6D
822	PCA - END	1	29M 1D	30M 16D	33M 1D
END NETWORK		---	37M 3D	37M 5D	38M 18D

Figure J-1. Milestone Schedule - Base

SOFTWARE ACQUISITION PROCESS MODEL REPORT

MILESTONE SCHEDULE
FULL NETWORK

PROJECT: FY81 DEMO-X2

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 8
MID-RANGE REPETITIONS: 18
PESSIMISTIC REPETITIONS: 5

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/29/81 11.00.31
SIMULATION CONDUCT TIME/DATE: 10/29/81 11.56.33
REPORTS PRODUCED TIME/DATE: 10/29/81 15.49.07

MILESTONE		DTN	TIME OF OCCURRENCE OPTIMISTIC	MID-RANGE	PESSIMISTIC
	START NETWORK	---	0M 0D	0M 0D	0M 0D
06L	PDR	1	7M 17D	7M 17D	7M 18D
		2	8M 15D	9M 5D	9M 5D
		3	10M 9D	10M 3D	11M 3D
		4	11M 2D	11M 4D	11M 13D
12F	CDR	1	12M 3D	12M 11D	12M 11D
		2	13M 10D	14M 0D	13M 18D
		3	15M 0D	15M 5D	15M 12D
		4	17M 6D	17M 14D	17M 13D
18B	START CODING	1	12M 9D	12M 18D	12M 18D
		2	14M 13D	15M 2D	15M 2D
		3	16M 8D	16M 17D	16M 15D
		4	18M 4D	18M 11D	18M 8D
18R	CCI & C END	1	15M 10D	15M 17D	15M 15D
		2	17M 0D	17M 11D	17M 9D
		3	18M 15D	19M 3D	19M 0D
		4	20M 2D	20M 11D	20M 8D
18T	CPCI T & I END	1	16M 16D	17M 8D	17M 3D
		2	18M 11D	19M 4D	18M 18D
		3	20M 2D	20M 16D	20M 10D
		4	21M 17D	22M 7D	21M 17D
44D	FQT START	1	24M 15D	27M 2D	28M 17D
46W	FQT - END	1	28M 15D	31M 0D	32M 15D
52F	FCA - START	1	30M 15D	33M 10D	35M 0D
54G	SYS DT & E START	1	34M 1D	36M 4D	38M 15D
54R	SYS DT & E END	1	36M 15D	39M 4D	41M 12D
80F	PCA - START	1	31M 11D	34M 15D	36M 16D
82Z	PCA - END	1	32M 6D	35M 12D	37M 16D
	END NETWORK	---	40M 2D	42M 11D	44M 15D

Figure J-2. Milestone Schedule - X2

SOFTWARE ACQUISITION PROCESS MODEL REPORT

MILESTONE SCHEDULE
FULL NETWORK

PROJECT: FY81 DEMO-SLASH2

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 5
MID-RANGE REPETITIONS: 20
PESSIMISTIC REPETITIONS: 6

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/30/81 09.57.08
SIMULATION CONDUCT TIME/DATE: 10/30/81 09.59.02
REPORTS PRODUCED TIME/DATE: 10/30/81 13.22.54

MILESTONE		DTN	TIME OF OCCURRENCE OPTIMISTIC	MID-RANGE	PESSIMISTIC
START NETWORK		---	0M 0D	0M 0D	0M 0D
08L	PDR	1	4M 1D	4M 8D	4M 6D
		2	4M 11D	4M 13D	4M 15D
12F	CDR	1	9M 10D	10M 11D	10M 11D
		2	11M 15D	12M 5D	11M 16D
16B	START CODING	1	9M 17D	10M 19D	11M 1D
		2	12M 17D	14M 0D	14M 3D
18R	CCI & C END	1	13M 12D	14M 13D	14M 19D
		2	15M 9D	16M 12D	16M 18D
18T	C CI T & I END	1	14M 12D	15M 11D	15M 16D
		2	16M 2D	17M 7D	17M 19D
44D	FQT START	1	18M 9D	19M 18D	21M 9D
46W	FQT - END	1	21M 12D	23M 3D	24M 18D
52F	FCA - START	1	22M 10D	24M 6D	25M 19D
54G	SYS DT & E START	1	23M 11D	24M 14D	26M 9D
54R	SYS DT & E END	1	24M 17D	25M 18D	27M 15D
80F	PCA - START	1	22M 15D	24M 10D	26M 10D
82Z	PCA - END	1	23M 3D	24M 18D	26M 18D
END NETWORK		---	26M 0D	27M 0D	29M 0D

Figure J-3. Milestone Schedule - /2

SOFTWARE ACQUISITION PROCESS MODEL REPORT

CONTRACTUAL EXPENDITURE SUMMARY
FULL NETWORK

PROJECT: FY81 DEMO-BASE

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 3
MID-RANGE REPETITIONS: 21
PESSIMISTIC REPETITIONS: 5

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/28/81 08.44.25
SIMULATION CONDUCT TIME/DATE: 10/28/81 14.52.58
REPORTS PRODUCED TIME/DATE: 10/29/81 08.44.30

LOADING FACTORS: OVERHEAD = 98.50% G&A = 14.12% FEE = 12.53%
LABOR RATES: LEVEL AT BASE YEAR RATES SHOWN

	- CONTRACTOR -							- GOVERNMENT -				- ALL -
	MANA-GERS	SYSTEMS ENGI-NEERS	DESI-GNERS	PROG-RAM-MERS	TEST ENGI-NEERS	SUP-PORT	CONT-RACT TOTAL	DEVEL CMD (ESD)	USING CMD (TAC)	SPRT CMD (AFLC)	GOV'T TOTAL	GRAND TOTAL
LABOR RATES ($)	3510	2770	2760	1870	2450	2085						
OPTIMISTIC												
MEAN MAN-MONTHS	178.5	123.7	226.2	268.1	171.6	246.6	1214.7	150.5	35.6	18.5	204.6	1419.3
% IT	----	12	10	8	27	6		8	9	3		
LOADED COSTS (X $1000)	1410	771	1406	1129	947	1158	$6821					
MID-RANGE												
MEAN MAN-MONTHS	184.6	122.7	230.4	271.0	169.0	248.2	1225.8	154.0	36.6	18.7	209.3	1435.2
% IT	----	13	11	7	26	6		10	11	5		
LOADED COSTS (X $1000)	1459	765	1432	1141	932	1165	$6894					
PESSIMISTIC												
MEAN MAN-MONTHS	195.9	124.6	232.8	271.4	175.9	255.3	1255.9	158.3	37.6	19.2	215.0	1470.9
% IT	----	14	11	8	28	7		11	13	7		
LOADED COSTS (X $1000)	1548	777	1447	1143	970	1198	$7083					

Figure J-4. Contractural Expenditure Summary - Base

SOFTWARE ACQUISITION PROCESS MODEL REPORT

CONTRACTUAL EXPENDITURE SUMMARY
FULL NETWORK

PROJECT: FY81 DEMO-X2

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 8
MID-RANGE REPETITIONS: 18
PESSIMISTIC REPETITIONS: 5

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/29/81 11.00.31
SIMULATION CONDUCT TIME/DATE: 10/29/81 11.56.33
REPORTS PRODUCED TIME/DATE: 10/29/81 15.40.07

LOADING FACTORS: OVERHEAD = 98.50% G&A = 14.12% FEE = 12.53%
LABOR RATES: LEVEL AT BASE YEAR RATES SHOWN

	- CONTRACTOR -							- GOVERNMENT -				- ALL -
	MANA-GERS	SYSTEMS ENGI-NEERS	DESI-GNERS	PROG-RAM-MERS	TEST ENGI-NEERS	SUP-PORT	CONT-RACT TOTAL	DEVEL CMD (ESD)	USING CMD (TAC)	SPRT CMD (AFLC)	GOV'T TOTAL	GRAND TOTAL
LABOR RATES ($)	3510	2770	2760	1870	2450	2085						
OPTIMISTIC												
MEAN MAN-MONTHS	215.8	157.5	329.9	317.7	183.5	285.3	1489.7	204.4	48.9	27.3	280.7	1770.4
% IT	----	12	10	8	23	6		9	10	5		
LOADED COSTS (X $1000)	1706	983	2050	1338	1012	1339	$8427					
MID-RANGE												
MEAN MAN-MONTHS	235.0	161.2	336.6	324.1	187.0	299.4	1543.4	211.5	51.1	28.5	291.1	1834.5
% IT	----	12	11	8	24	6		9	10	5		
LOADED COSTS (X $1000)	1857	1005	2092	1365	1032	1406	$8756					
PESSIMISTIC												
MEAN MAN-MONTHS	248.7	164.0	338.8	317.3	188.1	312.6	1569.5	218.5	52.0	29.5	299.9	1869.4
% IT	----	13	11	7	25	6		10	12	6		
LOADED COSTS (X $1000)	1965	1023	2106	1336	1037	1467	$8935					

Figure J-5. Contractural Expenditure Summary - X2

SOFTWARE ACQUISITION PROCESS MODEL REPORT

CONTRACTUAL EXPENDITURE SUMMARY
FULL NETWORK

PROJECT: FY81 DEMO-SLASH2

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 5
MID-RANGE REPETITIONS: 20
PESSIMISTIC REPETITIONS: 6

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/30/81 09.57.08
SIMULATION CONDUCT TIME/DATE: 10/30/81 09.59.02
REPORTS PRODUCED TIME/DATE: 10/30/81 13.22.54

LOADING FACTORS: OVERHEAD = 98.50% G&A = 14.12% FEE = 12.53%
LABOR RATES: LEVEL AT BASE YEAR RATES SHOWN

	- CONTRACTOR -							- GOVERNMENT -				- ALL -
	MANA-GERS	SYSTEMS ENGI-NEERS	DESI-GNERS	PROG-RAM-MERS	TEST ENGI-NEERS	SUP-PORT	CONT-RACT TOTAL	DEVEL CMD (ESD)	USING CMD (TAC)	SPRT CMD (AFLC)	GOV'T TOTAL	GRAND TOTAL
LABOR RATES ($)	3510	2770	2760	1870	2450	2085						
OPTIMISTIC												
MEAN MAN-MONTHS	87.5	46.1	68.4	90.4	41.0	132.0	465.4	55.4	12.4	7.1	74.9	540.3
% IT	----	7	7	3	21	2		6	6	2		
LOADED COSTS (X $1000)	691	288	425	381	226	620	$2630					
MID-RANGE												
MEAN MAN-MONTHS	91.7	45.3	69.4	90.2	40.8	135.6	473.0	55.0	12.5	7.2	74.7	547.7
% IT	----	7	8	4	22	2		6	7	3		
LOADED COSTS (X $1000)	724	282	431	380	225	637	$2680					
PESSIMISTIC												
MEAN MAN-MONTHS	98.6	47.0	70.8	95.1	43.6	144.4	499.5	57.1	12.9	7.5	77.5	577.0
% IT	----	8	8	5	24	3		7	7	3		
LOADED COSTS (X $1000)	779	293	440	400	240	678	$2831					

Figure J-6. Contractural Expenditure Summary - /2

SOFTWARE ACQUISITION PROCESS MCL.. REPORT

CONTRACTOR MONTHLY EXPENDITURE PROFILE
FULL NETWORK

PROJECT: FY81 DEMO-BASE

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 3
MID-RANGE REPETITIONS: 21
PESSIMISTIC REPETITIONS: 5

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/28/81 08.44.25
SIMULATION CONDUCT TIME/DATE: 10/28/81 14.52.58
REPORTS PRODUCED TIME/DATE: 10/29/81 08.44.30

LOADING FACTORS: OVERHEAD = 98.50 %; G&A = 14.12%; FEE = 12.53%
INFLATION RATE: 10.00%, STARTING IN MONTH 3
COSTS ARE IN $1000 INCREMENTS

CON-	OPTIMISTIC				MID-RANGE				PESSIMISTIC			
	THIS MONTH		CUMULATIVE		THIS MONTH		CUMULATIVE		THIS MONTH		CUMULATIVE	
TRACT MONTH	BASE YEAR	THEN YEAR	BASE YEAR	THEN YEAR	BASE YEAR	THEN YEAR	BASE YEAR	THEN YEAR	BASE YEAR	THEN YEAR	BASE YEAR	THEN YEAR
1	41.5	41.5	41.5	41.5	39.8	39.8	39.8	39.8	37.6	37.6	37.6	37.6
2	117.9	117.9	159.4	159.4	100.9	100.9	140.7	140.7	94.2	94.2	131.8	131.8
3	143.0	157.3	302.4	316.7	143.1	157.5	283.8	298.2	149.4	164.3	281.2	296.1
4	206.4	227.1	508.8	543.7	180.0	198.0	463.9	496.2	183.4	201.7	464.6	497.8
5	191.5	210.7	700.3	754.4	195.6	215.1	659.4	711.3	209.1	230.1	673.7	727.9
6	175.4	192.9	875.7	947.3	182.8	201.1	842.2	912.4	172.0	189.2	845.7	917.1
7	217.8	239.6	1093.5	1186.9	193.6	213.0	1035.8	1125.3	177.9	195.7	1023.6	1112.7
8	246.8	271.5	1340.4	1458.4	235.6	259.2	1271.4	1384.5	219.3	241.2	1242.9	1354.0
9	256.6	282.2	1596.9	1740.7	247.8	272.6	1519.2	1657.1	221.6	243.7	1464.4	1597.7
10	256.3	281.9	1853.2	2022.6	270.6	297.7	1789.9	1954.8	266.6	293.3	1731.0	1891.0
11	218.8	240.6	2072.0	2263.2	232.6	255.9	2022.5	2210.7	254.4	279.8	1985.4	2170.8
12	262.9	289.2	2334.9	2552.4	237.4	261.1	2259.9	2471.8	253.3	278.6	2238.7	2449.4
13	314.9	346.4	2649.8	2898.8	290.8	319.9	2550.7	2791.7	239.6	263.5	2478.3	2712.9
14	271.3	298.5	2921.1	3197.3	291.6	320.8	2842.4	3112.5	274.2	301.6	2752.4	3014.5
15	342.0	413.8	3263.2	3611.2	309.3	374.3	3151.7	3486.8	307.1	371.6	3059.5	3386.1
16	348.3	421.5	3611.5	4032.6	335.8	406.3	3487.5	3893.1	325.8	394.2	3385.3	3780.3
17	358.1	433.3	3969.6	4466.0	327.6	396.4	3815.1	4289.5	308.3	373.1	3693.6	4153.3
18	249.8	302.3	4219.4	4768.2	296.1	356.3	4111.2	4647.8	315.6	381.9	4009.2	4535.2
19	138.9	168.1	4358.3	4936.3	234.1	283.3	4345.3	4931.1	249.9	302.3	4259.1	4837.5
20	173.9	210.5	4532.3	5146.8	172.3	208.4	4517.6	5139.6	217.9	263.6	4476.9	5101.1
21	226.0	273.4	4758.2	5420.2	162.9	197.1	4680.5	5336.7	137.0	165.7	4613.9	5266.9
22	213.7	258.6	4972.0	5678.8	198.4	240.0	4878.9	5576.7	169.8	205.5	4783.7	5472.4
23	215.0	260.1	5186.9	5938.9	209.4	253.4	5088.3	5830.1	192.1	232.4	4975.8	5704.8
24	249.6	302.0	5436.5	6240.9	218.7	264.7	5307.0	6094.8	202.4	244.9	5178.2	5949.7

Figure J-7. Contractor Monthly Expenditure Profile - Base
Sheet 1

SOFTWARE ACQUISITION PROCESS MODEL REPORT

CONTRACTOR MONTHLY EXPENDITURE PROFILE
FULL NETWORK

PROJECT: FY81 DEMO-BASE

PAGE: 2
FULL SCALE DEVELOPMENT PHASE

LOADING FACTORS: OVERHEAD = 98.50 %; G&A = 14.12%; FEE = 12.53%
INFLATION RATE: 10.00%, STARTING IN MONTH 3
COSTS ARE IN $1000 INCREMENTS

CON-TRACT MONTH	OPTIMISTIC THIS MONTH BASE YEAR	OPTIMISTIC THIS MONTH THEN YEAR	OPTIMISTIC CUMULATIVE BASE YEAR	OPTIMISTIC CUMULATIVE THEN YEAR	MID-RANGE THIS MONTH BASE YEAR	MID-RANGE THIS MONTH THEN YEAR	MID-RANGE CUMULATIVE BASE YEAR	MID-RANGE CUMULATIVE THEN YEAR	PESSIMISTIC THIS MONTH BASE YEAR	PESSIMISTIC THIS MONTH THEN YEAR	PESSIMISTIC CUMULATIVE BASE YEAR	PESSIMISTIC CUMULATIVE THEN YEAR
25	208.6	252.4	5645.1	6493.3	227.1	274.8	5534.1	6369.6	175.1	211.8	5353.3	6161.5
26	158.7	192.0	5803.7	6685.3	195.8	236.9	5729.9	6606.5	246.6	298.4	5599.9	6459.9
27	152.2	202.6	5956.0	6887.9	157.4	209.4	5887.3	6815.9	222.2	295.7	5822.1	6755.6
28	128.3	170.7	6084.2	7058.6	149.7	199.2	6036.9	7015.1	152.5	203.0	5974.6	6958.6
29	118.5	157.7	6202.7	7216.3	139.1	185.1	6176.0	7200.2	133.0	177.0	6107.6	7135.7
30	135.8	180.8	6338.5	7397.1	118.2	157.3	6294.2	7357.5	151.2	201.2	6258.8	7336.9
31	111.6	148.6	6450.2	7545.6	117.6	156.6	6411.8	7514.1	131.8	175.4	6390.6	7512.3
32	79.6	105.9	6529.7	7651.6	125.0	166.4	6536.8	7680.5	112.9	150.3	6503.5	7662.6
33	73.4	97.8	6603.2	7749.3	103.6	137.9	6640.5	7818.4	110.2	146.7	6613.7	7809.3
34	56.1	74.7	6659.3	7824.0	73.0	97.1	6713.4	7915.5	143.2	190.6	6756.9	7999.9
35	49.4	65.8	6708.7	7889.8	57.4	76.4	6770.9	7992.0	102.8	136.9	6859.7	8136.7
36	53.3	71.0	6762.1	7960.9	51.5	68.5	6822.3	8060.5	67.1	89.3	6926.8	8226.0
37	36.3	48.3	6798.4	8009.1	41.2	54.8	6863.5	8115.3	48.0	63.9	6974.8	8289.9
38	22.3	29.6	6820.7	8038.8	22.8	30.4	6886.4	8145.7	43.2	57.5	7018.0	8347.4
39	0.0	0.0	6820.7	8038.8	6.8	9.9	6893.1	8155.6	33.2	48.8	7051.2	8396.0
40	0.0	0.0	6820.7	8038.8	.6	.9	6893.8	8156.5	24.8	36.1	7075.8	8432.0
41	0.0	0.0	6820.7	8038.8	0.0	0.0	6893.8	8156.5	7.4	10.8	7083.2	8442.9

Figure J-7. Contractor Monthly Expenditure Profile - Base
Sheet 2

SOFTWARE ACQUISITION PROCESS MODEL REPORT

CONTRACTOR MONTHLY EXPENDITURE PROFILE
FULL NETWORK

PROJECT: FY81 DEMO-X2

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 8
MID-RANGE REPETITIONS: 18
PESSIMISTIC REPETITIONS: 5

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/29/81 11.00.31
SIMULATION CONDUCT TIME/DATE: 10/29/81 11.56.33
REPORTS PRODUCED TIME/DATE: 10/29/81 15.49.07

LOADING FACTORS: OVERHEAD = 98.50 %; G&A = 14.12%; FEE = 12.53%
INFLATION RATE: 10.00%, STARTING IN MONTH 3
COSTS ARE IN $1000 INCREMENTS

	OPTIMISTIC				MID-RANGE				PESSIMISTIC			
CON-TRACT MONTH	THIS MONTH BASE YEAR	THIS MONTH THEN YEAR	CUMULATIVE BASE YEAR	CUMULATIVE THEN YEAR	THIS MONTH BASE YEAR	THIS MONTH THEN YEAR	CUMULATIVE BASE YEAR	CUMULATIVE THEN YEAR	THIS MONTH BASE YEAR	THIS MONTH THEN YEAR	CUMULATIVE BASE YEAR	CUMULATIVE THEN YEAR
1	37.0	37.0	37.0	37.0	38.5	38.5	38.5	38.5	37.3	37.3	37.3	37.3
2	75.4	75.4	112.3	112.3	88.9	88.9	127.4	127.4	81.0	81.0	118.3	118.3
3	150.0	165.0	262.3	277.3	150.1	165.1	277.5	292.5	153.6	169.0	271.9	287.3
4	158.2	174.0	420.5	451.4	161.6	177.8	439.2	470.3	163.6	179.9	435.5	467.2
5	207.8	228.5	628.3	679.9	200.5	220.6	639.7	690.9	196.7	216.4	632.2	683.6
6	209.0	229.9	837.3	909.8	193.1	212.4	832.8	903.3	193.5	212.8	825.7	896.4
7	185.4	203.9	1022.7	1113.7	194.9	214.3	1027.7	1117.7	188.3	207.2	1014.0	1103.6
8	224.8	247.3	1247.5	1361.0	243.3	267.6	1270.9	1385.3	215.3	236.9	1229.4	1340.5
9	328.2	361.1	1575.7	1722.1	310.1	341.2	1581.1	1726.4	309.5	340.5	1538.9	1681.0
10	342.3	376.5	1918.0	2098.6	316.2	347.8	1897.2	2074.2	357.7	393.5	1896.6	2074.5
11	326.5	359.2	2244.6	2457.8	316.4	348.0	2213.6	2422.[illegible]	305.4	335.9	2202.0	2410.4
12	342.5	376.7	2587.1	2834.5	334.6	368.0	2548.2	2790.3	307.4	338.1	2509.4	2748.5
13	403.9	444.3	2991.0	3278.9	379.5	417.4	2927.7	3207.7	347.0	381.7	2856.4	3130.2
14	390.1	429.1	3381.1	3708.0	387.7	426.5	3315.4	3634.2	394.4	433.9	3250.8	3564.0
15	340.4	411.9	3721.5	4119.9	345.0	417.4	3660.4	4051.6	387.9	469.4	3638.7	4033.4
16	362.5	438.6	4084.0	4558.5	321.3	388.8	3981.7	4440.4	306.8	371.2	3945.5	4404.6
17	361.3	437.1	4445.3	4995.6	363.6	440.0	4345.3	4880.4	369.2	446.7	4314.6	4851.3
18	363.1	439.3	4808.4	5435.0	354.9	429.4	4700.2	5309.8	330.0	399.3	4644.6	5250.6
19	340.2	411.6	5148.6	5846.6	343.7	415.9	5043.8	5725.6	332.6	402.4	4977.2	5653.0
20	287.8	348.3	5436.4	6194.9	293.1	354.6	5336.9	6080.2	275.0	332.8	5252.3	5985.8
21	176.7	213.8	5613.1	6408.7	215.1	260.2	5552.0	6340.5	185.5	224.5	5437.8	6210.3
22	177.1	214.3	5790.2	6623.0	169.0	204.5	5721.0	6545.0	159.5	192.9	5597.2	6403.2
23	193.1	233.6	5983.3	6856.6	175.5	212.3	5896.5	6757.3	158.4	191.7	5755.6	6594.9
24	222.0	268.6	6205.3	7125.3	195.2	236.2	6091.7	6993.5	146.7	177.5	5902.3	6772.4

Figure J-8. Contractor Monthly Expenditure Profile - X2
Sheet 1

SOFTWARE ACQUISITION PROCESS MODEL REPORT

CONTRACTOR MONTHLY EXPENDITURE PROFILE
FULL NETWORK

PROJECT: FY81 DEMO-X2 PAGE: 2
FULL SCALE DEVELOPMENT PHASE

LOADING FACTORS: OVERHEAD = 98.50 %; G&A = 14.12%; FEE = 12.53%
INFLATION RATE: 10.00%, STARTING IN MONTH 3
COSTS ARE IN $1000 INCREMENTS

	OPTIMISTIC				MID-RANGE				PESSIMISTIC			
CON-TRACT MONTH	THIS MONTH BASE YEAR	THIS MONTH THEN YEAR	CUMULATIVE BASE YEAR	CUMULATIVE THEN YEAR	THIS MONTH BASE YEAR	THIS MONTH THEN YEAR	CUMULATIVE BASE YEAR	CUMULATIVE THEN YEAR	THIS MONTH BASE YEAR	THIS MONTH THEN YEAR	CUMULATIVE BASE YEAR	CUMULATIVE THEN YEAR
25	240.6	291.2	6445.9	7416.4	188.0	227.5	6279.7	7221.0	175.1	211.9	6077.4	6984.3
26	237.4	287.3	6683.4	7703.7	161.1	194.9	6440.8	7416.0	180.5	218.4	6257.9	7202.6
27	250.4	333.3	6933.8	8037.0	197.8	263.2	6638.6	7679.2	134.1	178.5	6392.0	7381.2
28	202.3	269.2	7136.0	8306.2	243.2	323.6	6881.7	8002.8	164.0	218.3	6556.0	7599.5
29	158.7	211.3	7294.8	8517.5	242.0	322.0	7123.7	8324.9	229.9	306.1	6786.0	7905.5
30	155.8	207.4	7450.6	8724.9	203.3	270.6	7327.0	8595.4	274.4	365.2	7060.4	8270.7
31	128.8	171.5	7579.4	8896.4	171.7	228.5	7498.8	8823.9	262.0	348.7	7322.4	8619.4
32	126.8	168.8	7706.3	9065.2	158.4	210.8	7657.0	9034.7	209.0	278.2	7531.4	8897.7
33	138.9	184.9	7845.2	9250.1	143.6	191.1	7800.6	9225.9	157.6	209.8	7689.0	9107.4
34	139.7	186.0	7984.9	9436.1	125.6	167.2	7926.2	9393.0	140.3	186.7	7829.3	9294.2
35	94.5	125.7	8079.4	9561.8	125.7	167.3	8051.9	9560.4	153.0	203.6	7982.3	9497.8
36	82.3	109.5	8161.6	9671.3	125.6	167.2	8177.5	9727.5	129.2	171.9	8111.5	9669.7
37	67.7	90.2	8229.4	9761.4	128.5	171.0	8306.0	9898.5	113.9	151.6	8225.4	9821.3
38	50.1	66.6	8279.4	9828.1	127.2	169.3	8433.2	10067.8	128.0	170.4	8353.4	9991.7
39	42.7	62.5	8322.1	9890.5	99.0	145.0	8532.2	10212.8	150.6	220.5	8504.0	10212.2
40	42.2	61.7	8364.3	9952.3	70.9	103.7	8603.1	10316.5	131.7	192.7	8635.6	10404.9
41	31.6	46.3	8395.9	9998.5	52.6	77.0	8655.7	10393.5	77.0	112.7	8712.6	10517.7
42	20.7	30.3	8416.5	10028.8	45.2	66.2	8700.9	10459.8	69.8	102.2	8782.4	10619.9
43	10.4	15.2	8426.9	10044.0	33.0	48.4	8734.0	10508.2	62.1	91.0	8844.6	10710.9
44	.3	.5	8427.2	10044.4	15.2	22.2	8749.2	10530.4	48.0	70.3	8892.6	10781.1
45	0.0	0.0	8427.2	10044.4	4.9	7.2	8754.1	10537.6	23.1	33.9	8915.7	10815.0
46	0.0	0.0	8427.2	10044.4	2.1	3.1	8756.2	10540.8	12.0	17.6	8927.7	10832.6
47	0.0	0.0	8427.2	10044.4	0.0	0.0	8756.2	10540.8	6.9	10.0	8934.6	10842.6

Figure J-8. Contractor Monthly Expenditure Profile - X2
Sheet 2

SOFTWARE ACQUISITION PROCESS MODEL REPORT

CONTRACTOR MONTHLY EXPENDITURE PROFILE
FULL NETWORK

PROJECT: FY81 DEMO-SLASH2

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 5
MID-RANGE REPETITIONS: 20
PESSIMISTIC REPETITIONS: 6

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/30/81 09.57.08
SIMULATION CONDUCT TIME/DATE: 10/30/81 09.59.02
REPORTS PRODUCED TIME/DATE: 10/30/81 13.22.54

LOADING FACTORS: OVERHEAD = 98.50 %; G&A = 14.12%; FEE = 12.53%
INFLATION RATE: 10.00%, STARTING IN MONTH 3
COSTS ARE IN $1000 INCREMENTS

CON-TRACT MONTH	OPTIMISTIC THIS MONTH BASE YEAR	OPTIMISTIC THIS MONTH THEN YEAR	OPTIMISTIC CUMULATIVE BASE YEAR	OPTIMISTIC CUMULATIVE THEN YEAR	MID-RANGE THIS MONTH BASE YEAR	MID-RANGE THIS MONTH THEN YEAR	MID-RANGE CUMULATIVE BASE YEAR	MID-RANGE CUMULATIVE THEN YEAR	PESSIMISTIC THIS MONTH BASE YEAR	PESSIMISTIC THIS MONTH THEN YEAR	PESSIMISTIC CUMULATIVE BASE YEAR	PESSIMISTIC CUMULATIVE THEN YEAR
1	53.6	53.6	53.6	53.6	49.4	49.4	49.4	49.4	49.0	49.0	49.0	49.0
2	119.8	119.8	173.5	173.5	112.6	112.6	162.0	162.0	113.6	113.6	162.6	162.6
3	131.6	144.7	305.0	318.2	130.7	143.8	292.7	305.8	130.2	143.2	292.8	305.8
4	113.1	124.4	418.1	442.5	113.5	124.9	406.2	430.7	111.4	122.6	404.2	428.4
5	132.7	145.9	550.7	588.5	116.0	127.6	522.2	558.2	125.1	137.6	529.3	566.0
6	119.0	130.8	669.7	719.3	111.1	122.2	633.3	680.5	118.6	130.5	648.0	696.5
7	108.8	119.7	778.5	839.0	107.2	117.9	740.6	798.4	113.5	124.8	761.5	821.3
8	115.0	126.5	893.6	965.6	117.2	128.9	857.7	927.3	110.4	121.4	871.8	942.7
9	90.8	99.9	984.4	1065.5	101.9	112.1	959.6	1039.4	94.4	103.8	966.2	1046.6
10	107.0	117.7	1091.4	1183.2	91.4	100.5	1051.0	1139.9	92.5	101.8	1058.7	1148.3
11	142.7	157.0	1234.1	1340.2	97.9	107.7	1148.9	1247.6	109.9	120.9	1168.7	1269.3
12	156.5	172.2	1390.6	1512.3	138.7	152.5	1287.6	1400.1	122.0	134.2	1290.7	1403.5
13	134.4	147.8	1525.0	1660.1	144.5	159.0	1432.1	1559.1	144.9	159.4	1435.5	1582.8
14	159.9	175.8	1684.8	1836.0	130.9	144.0	1563.0	1703.1	136.6	150.3	1572.1	1713.1
15	125.3	152.8	1811.1	1988.8	147.4	178.3	1710.4	1881.4	141.0	170.6	1713.2	1883.7
16	82.6	99.9	1893.7	2088.7	126.9	153.6	1837.3	2035.0	131.1	158.6	1844.2	2042.3
17	81.8	98.9	1975.5	2187.6	92.0	111.4	1929.3	2146.4	106.0	128.3	1950.3	2170.6
18	76.5	92.5	2051.9	2280.2	87.2	105.5	2016.5	2251.9	82.6	99.9	2032.9	2270.6
19	91.3	110.5	2143.3	2390.7	76.5	92.5	2093.0	2344.4	76.0	92.0	2108.9	2362.6
20	87.6	106.0	2230.8	2496.6	80.2	97.1	2173.2	2441.5	82.3	99.6	2191.2	2462.2
21	64.6	78.2	2295.4	2574.8	88.1	106.5	2261.3	2548.0	73.4	88.8	2264.6	2551.0
22	84.7	102.5	2380.2	2677.3	70.7	85.6	2332.0	2633.6	77.1	93.3	2341.7	2644.3
23	68.0	82.3	2448.2	2759.6	72.1	87.2	2404.1	2720.8	87.4	105.7	2429.1	2750.0
24	81.7	98.9	2529.9	2858.5	78.7	95.2	2482.8	2816.0	70.1	84.9	2499.2	2834.9
25	55.9	67.6	2585.7	2926.0	74.0	89.5	2559.7	2905.5	67.0	81.1	2566.3	2916.0
26	25.2	30.5	2610.9	2956.6	76.4	85.1	2627.1	2990.7	75.5	91.4	2641.8	3007.3
27	9.4	12.5	2620.4	2969.1	41.0	54.5	2668.1	3045.2	69.6	92.6	2711.3	3099.9
28	8.2	10.9	2628.5	2980.0	10.7	14.3	2678.8	3059.5	69.1	92.0	2780.5	3192.0
29	1.6	2.2	2630.2	2982.1	.8	1.1	2679.6	3060.5	35.2	46.8	2815.6	3238.8
30	0.0	0.0	2630.2	2982.1	0.0	0.0	2679.8	3060.5	15.5	20.6	2831.1	3259.4

Figure J-9. Contractor Monthly Expenditure Profile - /2

SOFTWARE ACQUISITION PROCESS MODEL REPORT

MILESTONE SCHEDULE
SUBNETWORK 2: COMPUTER PROGRAM DESIGN
SUBNETWORK 3: CODING THROUGH CPT&E
SUBNETWORK 4: FORMAL TEST PREPARATION

PAGE: 1

PROJECT: FY81 DEMO-SLASH2

FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 5
MID-RANGE REPETITIONS: 20
PESSIMISTIC REPETITIONS: 6

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/30/81 09.57.08
SIMULATION CONDUCT TIME/DATE: 10/30/81 09.59.02
REPORTS PRODUCED TIME/DATE: 10/30/81 13.22.54

MILESTONE		DTN	TIME OF OCCURRENCE OPTIMISTIC	MID-RANGE	PESSIMISTIC
START NETWORK		---	0M 0D	0M 0D	0M 0D
16B	START CODING	1	9M 17D	10M 19D	11M 1D
		2	12M 17D	14M 0D	14M 3D
16R	CCI & C END	1	13M 12D	14M 13D	14M 19D
		2	15M 9D	16M 12D	16M 18D
16T	CPCI T & I END	1	14M 12D	15M 11D	15M 16D
		2	16M 2D	17M 7D	17M 19D
END NETWORK		---	26M 0D	27M 0D	29M 0D

Figure J-10. Milestone Schedule - /2 Subnets 2, 3, 4

SOFTWARE ACQUISITION PROCESS MODEL REPORT

CONTRACTUAL EXPENDITURE SUMMARY
SUBNETWORK 2: COMPUTER PROGRAM DESIGN
SUBNETWORK 3: CODING THROUGH CPT&E
SUBNETWORK 4: FORMAL TEST PREPARATION

PROJECT : FY81 DEMO-X2

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 8
MID-RANGE REPETITIONS: 18
PESSIMISTIC REPETITIONS: 5

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/29/81 11.00.31
SIMULATION CONDUCT TIME/DATE: 10/29/81 11.56.33
REPORTS PRODUCED TIME/DATE: 10/30/81 09.36.44

LOADING FACTORS: OVERHEAD = 98.50% G&A = 14.12% FEE = 12.53%
LABOR RATES: LEVEL AT BASE YEAR RATES SHOWN

	- CONTRACTOR -							- GOVERNMENT -				- ALL -
	MANA-GERS	SYSTEMS ENGI-NEERS	DESI-GNERS	PROG-RAM-MERS	TEST ENGI-NEERS	SUP-PORT	CONT-RACT TOTAL	DEVEL CMD (ESD)	USING CMD (TAC)	SPRT CMD (AFLC)	GOV'T TOTAL	GRAND TOTAL
LABOR RATES ($)	----	2770	2760	1870	2450	2085						
OPTIMISTIC												
MEAN MAN-MONTHS	----	64.5	223.4	259.8	68.7	36.2	652.6	32.9	4.5	0.0	37.4	690.0
% IT	----	14	11	5	19	14		10	13	0		
LOADED COSTS (X $1000)	----	402	1388	1094	379	170	$3433					
MID-RANGE												
MEAN MAN-MONTHS	----	65.5	227.1	262.4	69.1	36.6	660.7	35.4	4.7	0.0	40.1	700.9
% IT	----	15	12	5	20	15		11	16	0		
LOADED COSTS (X $1000)	----	409	1411	1105	381	172	$3478					
PESSIMISTIC												
MEAN MAN-MONTHS	----	66.9	226.1	259.8	72.1	37.5	662.4	40.1	5.0	0.0	45.1	707.5
% IT	----	17	12	5	22	17		18	21	0		
LOADED COSTS (X $1000)	----	417	1405	1094	398	178	$3490					

Figure J-11. Contractural Expenditure Summary - X2 - Subnets 2, 3, 4

SOFTWARE ACQUISITION PROCESS MODEL REPORT
ACTIVITY BOX SUMMARY REPORT

FULL NETWORK
INPUT ORDER

PROJECT: FY81 DEMO-X2

PAGE: 1
FULL SCALE DEVELOPMENT PHASE

OPTIMISTIC REPETITIONS: 8
MID-RANGE REPETITIONS: 18
PESSIMISTIC REPETITIONS: 5

SIMULATOR IDENTIFICATION: FY81 VERSION
SIMULATOR VERSION: MODEL ONE
DATA BASE TIME/DATE: 10/29/81 11.00.31
SIMULATION CONDUCT TIME/DATE: 10/29/81 11.56.33
REPORTS PRODUCED TIME/DATE: 10/29/81 15.49.07

										-CONTRACTOR MAN-MONTHS-					-GOVERNMENT MAN-MONTHS-		
BOX	DIG/ TIG	ITER	REPS	EST	LFT	DURA TION	PRED WAIT	INIT. WAIT	PERS WAIT	SYST ENG	DSGN	PRGM	TEST ENG	SUP- PORT	DVL CMD	USE CMD	SPRT CMD
02A	1	1.0	31	0M 0D	0M 13D	13D	0D	0D	0D	0.0	0.0	0.0	0.0	.6	0.0	0.0	0.0
04A	1	1.0	31	1M 11D	2M 3D	12D	18D	0D	0D	1.3	1.3	0.0	1.3	.6	0.0	0.0	0.0
04C	1	1.2	31	2M 3D	2M 19D	14D	0D	0D	0D	1.5	1.5	0.0	0.0	1.5	2.8	.7	.7
04E	1	1.2	31	3M 1D	3M 15D	13D	0D	6D	0D	0.0	0.0	0.0	0.0	0.0	3.8	.6	.6
04J	1	1.1	31	4M 5D	4M 11D	5D	0D	11D	0D	.3	.2	0.0	.2	.2	2.4	.5	.2
04M	1	1.0	3	4M 17D	5M 1D	4D	0D	0D	0D	.2	.2	0.0	.2	.2	0.0	0.0	0.0
04S	1	1.0	31	0M 13D	1M 11D	18D	0D	0D	0D	.9	.9	0.0	1.9	.9	0.0	0.0	0.0
06A	1	2.5	31	2M 3D	4M 5D	36D	0D	0D	0D	3.9	11.8	0.0	0.0	0.0	0.0	0.0	0.0
06D	1	2.5	31	3M 9D	4M 9D	11D	0D	0D	0D	1.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0
06F	1	1.0	31	3M 9D	4M 0D	11D	0D	0D	0D	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0
*06G	1	1.3	31	4M 10D	5M 17D	18D	10D	0D	0D	1.9	9.8	3.9	0.0	0.0	0.0	0.0	0.0
	2	1.4	31	5M 19D	7M 5D	16D	40D	0D	0D	1.7	8.4	3.4	0.0	0.0	0.0	0.0	0.0
	3	1.5	31	7M 4D	8M 10D	17D	65D	0D	0D	1.7	8.7	3.5	0.0	0.0	0.0	0.0	0.0
	4	1.4	31	8M 9D	9M 11D	13D	89D	0D	10D	1.3	8.7	2.7	0.0	0.0	0.0	0.0	0.0
*06H	1	1.3	31	5M 2D	5M 19D	4D	0D	0D	0D	.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0
	2	1.4	31	6M 9D	7M 8D	4D	0D	0D	0D	.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0
	3	1.5	31	7M 16D	8M 12D	4D	0D	0D	1D	.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0
	4	1.4	31	8M 19D	9M 14D	3D	0D	0D	1D	.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0
06M	1	1.0	31	7M 17D	7M 19D	2D	0D	0D	0D	.1	.6	0.0	0.0	0.0	.1	0.0	0.0
	2	1.0	31	9M 3D	9M 5D	2D	0D	0D	1D	.1	.5	0.0	0.0	0.0	.1	0.0	0.0
	3	1.0	31	10M 8D	10M 10D	2D	0D	0D	0D	.1	.4	0.0	0.0	0.0	.1	0.0	0.0
	4	1.0	31	11M 5D	11M 7D	2D	0D	0D	0D	.1	.4	0.0	0.0	0.0	.1	0.0	0.0

Figure J-12. Activity Box Summary Report - X2
Sheet 1

SOFTWARE ACQUISITION PROCESS MODEL REPORT
ACTIVITY BOX SUMMARY REPORT

FULL NETWORK
INPUT ORDER

PROJECT: FY81 DEMO-X2

FULL SCALE DEVELOPMENT PHASE

BOX	DIG/TIG	ITER	REPS	EST	LFT	DURATION	PRED WAIT	INIT. WAIT	PERS WAIT	-CONTRACTOR MAN-MONTHS- SYST ENG	DSGN	PRGM	TEST ENG	SUP-PORT	-GOVERNMENT MAN-MONTHS- DVL CMD	USE CMD	SPRT CMD
08R	1	1.0	1	7M 10D	7M 14D	5D	0D	0D	0D	.5	1.4	0.0	0.0	0.0	0.0	0.0	0.0
	2	1.0	1	8M 19D	9M 8D	8D	0D	0D	0D	.9	2.4	0.0	0.0	0.0	0.0	0.0	0.0
	3	1.0	3	10M 5D	10M 12D	7D	0D	0D	2D	.8	2.1	0.0	0.0	0.0	0.0	0.0	0.0
	4	1.0	1	12M 12D	12M 17D	5D	0D	0D	0D	.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0
08A	1	1.0	31	7M 11D	7M 17D	6D	22D	3D	0D	.7	1.0	.2	.2	.7	2.7	.7	.3
	2	1.1	31	8M 14D	9M 2D	6D	18D	3D	2D	.6	1.0	.2	.2	.6	2.6	.6	.3
	3	1.2	31	9M 19D	10M 8D	6D	19D	3D	0D	.7	1.0	.2	.2	.7	2.8	.7	.4
	4	1.1	31	10M 18D	11M 5D	6D	18D	3D	0D	.7	1.0	.2	.2	.7	2.7	.7	.3
*10A	1	2.2	31	7M 19D	9M 15D	24D	0D	0D	4D	4.4	29.7	7.4	0.0	0.0	0.0	0.0	0.0
	2	2.4	31	9M 9D	11M 6D	21D	12D	0D	5D	3.8	25.3	6.3	0.0	0.0	0.0	0.0	0.0
	3	2.3	31	10M 16D	12M 18D	20D	12D	0D	7D	3.7	24.9	6.2	0.0	0.0	0.0	0.0	0.0
	4	2.3	31	11M 19D	14M 2D	16D	13D	0D	13D	2.9	19.7	4.9	0.0	0.0	0.0	0.0	0.0
*10C	1	2.2	31	8M 14D	9M 17D	5D	0D	0D	0D	.8	1.0	.3	0.0	0.0	0.0	0.0	0.0
	2	2.4	31	10M 3D	11M 8D	4D	0D	0D	0D	.7	.9	.2	0.0	0.0	0.0	0.0	0.0
	3	2.3	31	11M 10D	12M 19D	4D	0D	0D	1D	.7	.9	.2	0.0	0.0	0.0	0.0	0.0
	4	2.3	31	12M 11D	14M 4D	3D	0D	0D	1D	.5	.7	.2	0.0	0.0	0.0	0.0	0.0
*10M	1	NEVER EXECUTED															
	2	NEVER EXECUTED															
	3	NEVER EXECUTED															
	4	2.4	31	12M 19D	15M 12D	11D	0D	0D	1D	2.7	3.2	1.1	0.0	0.0	0.0	0.0	0.0
*10L	1	NEVER EXECUTED															
	2	NEVER EXECUTED															
	3	NEVER EXECUTED															
	4	1.4	31	13M 6D	15M 8D	12D	0D	0D	0D	.7	5.9	0.0	0.0	0.0	0.0	0.0	0.0
10N	1	1.1	7	12M 6D	12M 15D	7D	0D	0D	4D	.5	3.8	0.0	0.0	0.0	0.0	0.0	0.0
	2	1.0	11	13M 8D	13M 14D	6D	0D	0D	2D	.4	3.1	0.0	0.0	0.0	0.0	0.0	0.0
	3	1.0	8	15M 1D	15M 7D	5D	0D	0D	0D	.4	2.9	0.0	0.0	0.0	0.0	0.0	0.0
	4	1.6	10	16M 13D	17M 3D	6D	0D	0D	0D	.4	3.3	0.0	0.0	0.0	0.0	0.0	0.0
12A	1	1.3	31	11M 18D	12M 9D	7D	25D	7D	1D	1.2	1.7	.8	.6	.8	6.2	1.7	.8
	2	1.4	31	13M 4D	13M 17D	8D	25D	7D	1D	1.4	1.9	.9	.7	.9	7.0	1.9	.9
	3	1.3	31	14M 15D	15M 5D	7D	31D	6D	0D	1.2	1.6	.8	.6	.8	6.1	1.6	.8
	4	1.5	31	17M 0D	17M 11D	8D	36D	7D	0D	1.3	1.7	.8	.7	.8	6.5	1.7	.8
12J	1	1.0	31	12M 10D	12M 15D	5D	0D	0D	1D	.7	2.1	.3	.3	.7	0.0	0.0	0.0
	2	1.0	31	13M 19D	14M 3D	4D	0D	0D	2D	.6	1.7	.3	.3	.6	0.0	0.0	0.0

Figure J-12. Activity Box Summary Report - X2
Sheet 2

SOFTWARE ACQUISITION PROCESS MODEL REPORT
ACTIVITY BOX SUMMARY REPORT

FULL NETWORK
INPUT ORDER

PROJECT: FY81 DEMO-X2

PAGE: 5
FULL SCALE DEVELOPMENT PHASE

BOX	DIG/ TIG	ITER	REPS	EST	LFT	DURA TION	PRED WAIT	INIT. WAIT	PERS WAIT	-CONTRACTOR MAN-MONTHS- SYST ENG	DSGN	PRGM	TEST ENG	SUP-PORT	-GOVERNMENT MAN-MONTHS- DVL CMD	USE CMD	SPRT CMD
40C	1	1.8	31	13M 3D	17M 3D	45D	0D	9D	0D	0.0	0.0	0.0	0.0	0.0	8.4	2.2	0.0
40G	1	1.0	31	17M 9D	17M 17D	8D	0D	5D	0D	.8	0.0	0.0	1.3	.4	1.7	.4	0.0
40H	1	1.0	31	17M 17D	18M 9D	12D	0D	0D	0D	1.3	0.0	0.0	2.6	.7	0.0	0.0	0.0
40J	1	1.1	21	14M 13D	16M 2D	25D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
*42A	1	1.6	31	18M 9D	19M 18D	19D	0D	0D	0D	2.0	0.0	0.0	5.8	2.0	0.0	0.0	0.0
	2	1.7	31	19M 7D	21M 2D	21D	18D	0D	0D	2.2	0.0	0.0	6.3	2.2	0.0	0.0	0.0
	3	1.8	31	20M 5D	21M 15D	16D	37D	0D	0D	1.6	0.0	0.0	4.7	1.6	0.0	0.0	0.0
	4	1.9	31	21M 0D	22M 9D	16D	51D	0D	0D	1.6	0.0	0.0	4.8	1.6	0.0	0.0	0.0
	5	1.8	31	21M 13D	23M 0D	16D	65D	0D	0D	1.6	0.0	0.0	4.6	1.6	0.0	0.0	0.0
	6	1.9	31	22M 7D	23M 15D	17D	78D	0D	0D	1.6	0.0	0.0	4.8	1.6	0.0	0.0	0.0
42C	1	1.6	31	19M 12D	20M 11D	8D	0D	8D	0D	0.0	0.0	0.0	0.0	0.0	2.5	.4	0.0
	2	1.7	31	20M 10D	21M 16D	10D	0D	9D	0D	0.0	0.0	0.0	0.0	0.0	2.8	.4	0.0
	3	1.8	31	21M 5D	22M 5D	7D	0D	9D	0D	0.0	0.0	0.0	0.0	0.0	2.0	.3	0.0
	4	1.9	31	21M 19D	23M 0D	7D	0D	9D	0D	0.0	0.0	0.0	0.0	0.0	2.0	.3	0.0
	5	1.8	31	22M 12D	23M 11D	7D	0D	9D	0D	0.0	0.0	0.0	0.0	0.0	2.0	.3	0.0
	6	1.9	31	23M 6D	24M 6D	7D	0D	9D	0D	0.0	0.0	0.0	0.0	0.0	1.8	.3	0.0
42H	1	1.0	31	20M 11D	20M 16D	5D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
	2	1.0	31	21M 16D	22M 0D	5D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
	3	1.0	31	22M 5D	22M 9D	4D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.8	0.0	0.0
	4	1.0	31	23M 0D	23M 4D	4D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.8	0.0	0.0
	5	1.0	31	23M 11D	23M 15D	4D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.8	0.0	0.0
	6	1.0	31	24M 6D	24M 10D	4D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.8	0.0	0.0
42J	1	1.0	31	21M 1D	21M 3D	2D	0D	5D	0D	.1	0.0	0.0	.7	.3	0.0	0.0	0.0
	2	1.0	31	22M 6D	22M 8D	2D	0D	5D	0D	.1	0.0	0.0	.7	.3	0.0	0.0	0.0
	3	1.0	31	22M 13D	22M 15D	2D	0D	5D	0D	.1	0.0	0.0	.6	.2	0.0	0.0	0.0
	4	1.0	31	23M 9D	23M 10D	2D	0D	5D	0D	.1	0.0	0.0	.5	.2	0.0	0.0	0.0
	5	1.0	31	24M 0D	24M 2D	2D	0D	5D	0D	.1	0.0	0.0	.5	.2	0.0	0.0	0.0
	6	1.0	31	24M 15D	24M 17D	2D	0D	5D	0D	.1	0.0	0.0	.6	.2	0.0	0.0	0.0
42K	1	1.8	10	19M 14D	20M 17D	7D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
	2	1.3	18	20M 13D	21M 4D	5D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.8	0.0	0.0
	3	1.5	17	21M 9D	22M 2D	5D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.7	0.0	0.0
	4	1.6	18	22M 8D	22M 19D	5D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.7	0.0	0.0
	5	1.8	14	23M 0D	23M 18D	5D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.7	0.0	0.0
	6	1.7	16	23M 7D	24M 4D	5D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.7	0.0	0.0

Figure J-12. Activity Box Summary Report - X2
Sheet 3

SOFTWARE ACQUISITION PROCESS MODEL REPORT
ACTIVITY BOX SUMMARY REPORT

FULL NETWORK
INPUT ORDER

PROJECT: FY81 DEMO-X2

PAGE: 8
FULL SCALE DEVELOPMENT PHASE

BOX	DIG/ TIG	ITER	REPS	EST	LFT	DURA TION	PRED WAIT	INIT. WAIT	PERS WAIT	-CONTRACTOR MAN-MONTHS- SYST ENG	DSGN	PRGM	TEST ENG	SUP-PORT	-GOVERNMENT MAN-MONTHS- OVL CMD	USE CMD	SPRT CMD
*54A	1	2.3	31	31M 7D	36M 0D	37D	325D	0D	0D	2.6	0.0	0.0	10.2	2.6	0.0	0.0	0.0
*54D	1	1.3	31	32M 7D	35M 10D	11D	0D	0D	0D	.2	.4	1.7	.9	.2	0.0	0.0	0.0
*54H	1	2.7	31	36M 1D	38M 19D	33D	0D	0D	0D	2.4	0.0	0.0	9.6	2.4	7.1	2.4	0.0
*54L	1	1.7	31	36M 17D	38M 14D	11D	0D	0D	0D	.2	.4	1.6	.8	.2	0.0	0.0	0.0
54P	1	1.0	23	38M 19D	39M 3D	4D	0D	0D	0D	.2	0.0	0.0	.4	0.0	.4	.2	0.0
54Q	1	2.3	23	39M 3D	40M 1D	10D	0D	0D	0D	.4	0.0	0.0	1.2	.8	1.2	.4	0.0
54T	1	2.4	31	39M 16D	42M 5D	50D	0D	0D	0D	4.3	0.0	0.0	8.6	4.3	0.0	0.0	0.0
54M	1	1.4	20	39M 2D	39M 13D	9D	0D	0D	0D	.2	.4	1.6	.8	.2	0.0	0.0	0.0
60A	1	1.0	31	1M 11D	3M 11D	41D	0D	0D	0D	1.0	2.0	4.1	0.0	8.2	0.0	0.0	0.0
60B	1	RECUR	31	3M 11D	40M 1D	730D	0D	0D	0D	0.0	0.0	0.0	0.0	73.0	0.0	0.0	0.0
62A	1	1.0	31	3M 11D	5M 11D	40D	41D	0D	0D	1.0	2.0	4.0	2.0	7.9	0.0	0.0	0.0
62B	1	RECUR	31	5M 11D	40M 1D	689D	0D	0D	0D	0.0	0.0	0.0	0.0	68.9	0.0	0.0	0.0
62C	1	1.0	1	16M 9D	17M 3D	14D	0D	0D	0D	0.0	0.0	.7	2.1	.7	0.0	0.0	0.0
	2	1.0	2	17M 19D	18M 9D	9D	0D	0D	0D	0.0	0.0	.5	1.4	.5	0.0	0.0	0.0
	3	1.0	2	19M 19D	20M 10D	12D	0D	0D	0D	0.0	0.0	.6	1.7	.6	0.0	0.0	0.0
	4	1.0	3	20M 17D	21M 9D	12D	0D	0D	0D	0.0	0.0	.6	1.7	.6	0.0	0.0	0.0
66B	1	RECUR	31	6M 1D	28M 7D	61D	0D	399D	0D	1.2	1.5	0.0	0.0	3.1	6.1	3.1	3.1
66D	1	RECUR	31	6M 6D	28M 11D	49D	0D	0D	0D	5.2	2.2	0.0	2.5	2.5	10.7	4.9	2.5
70A	1	1.0	31	16M 15D	19M 3D	48D	0D	0D	0D	5.0	5.0	0.0	0.0	3.8	0.0	0.0	0.0
70B	1	1.6	31	26M 11D	29M 1D	31D	148D	0D	0D	4.5	1.8	0.0	0.0	6.0	0.0	0.0	0.0
70C	1	1.6	31	27M 17D	30M 9D	40D	0D	8D	0D	0.0	0.0	0.0	0.0	0.0	7.4	3.8	1.8
72A	1	1.0	31	31M 14D	32M 5D	12D	26D	0D	0D	1.2	.6	0.0	1.8	0.0	0.0	0.0	0.0
72C	1	1.0	31	30M 9D	31M 7D	18D	0D	0D	0D	1.9	.4	0.0	0.0	0.0	0.0	0.0	0.0

Figure J-12. Activity Box Summary Report - X2
Sheet 4

SOFTWARE ACQUISITION PROCESS MODEL REPORT
ACTIVITY BOX SUMMARY REPORT

FULL NETWORK
INPUT ORDER

PROJECT: FY81 DEMO-X2

PAGE: 9
FULL SCALE DEVELOPMENT PHASE

BOX	DIG/ TIG	ITER	REPS	EST	LFT	DURA TION	PRED WAIT	INIT. WAIT	PERS WAIT	-CONTRACTOR MAN-MONTHS- SYST ENG	DSGN	PRGM	TEST ENG	SUP- PORT	-GOVERNMENT MAN-MONTHS- DVL CMD	USE CMD	SPRT CMD
74A	1	1.6	31	32M 5D	33M 5D	16D	0D	0D	0D	1.6	0.0	0.0	.8	.8	1.6	1.6	0.0
74B	1	1.1	17	33M 0D	33M 8D	7D	0D	0D	0D	.3	0.0	0.0	.2	.2	0.0	0.0	0.0
80A	1	1.0	31	29M 11D	30M 14D	23D	0D	5D	0D	0.0	0.0	0.0	0.0	0.0	10.1	0.0	3.4
80E	1	1.0	31	33M 5D	33M 11D	6D	30D	0D	0D	.3	.3	.3	.3	1.0	.6	0.0	0.0
80L	1	1.2	11	30M 8D	31M 11D	13D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
80N	1	1.2	11	31M 4D	32M 15D	25D	0D	6D	0D	3.4	3.4	3.4	0.0	6.9	0.0	0.0	0.0
80P	1	1.2	11	32M 12D	33M 16D	20D	0D	6D	0D	0.0	0.0	0.0	0.0	0.0	2.7	2.7	2.7
82A	1	1.0	31	34M 8D	34M 12D	4D	54D	3D	0D	.5	.5	.3	0.0	.3	0.0	0.0	0.0
82E	1	1.0	31	34M 5D	34M 9D	4D	54D	0D	0D	0.0	0.0	0.0	0.0	0.0	2.0	.5	.5
82G	1	1.0	31	34M 12D	34M 15D	3D	3D	0D	0D	.4	.4	0.0	0.0	0.0	1.4	.4	.4
82J	1	1.0	31	34M 8D	34M 12D	4D	54D	3D	0D	.3	.5	.3	.3	.3	1.6	.5	.5
82P	1	1.2	31	34M 15D	34M 19D	3D	3D	0D	0D	.2	.2	0.0	0.0	.2	.4	.2	.2
82Q	1	1.2	31	34M 18D	35M 0D	2D	0D	0D	0D	.1	.1	0.0	0.0	.1	0.0	0.0	0.0
82S	1	1.2	31	34M 19D	35M 2D	2D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.2	.1	.1
82V	1	1.0	31	35M 2D	35M 3D	1D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	.1	0.0	0.0
82W	1	1.2	31	35M 3D	37M 11D	46D	0D	0D	0D	5.4	8.0	16.1	5.4	5.4	0.0	0.0	0.0
82X	1	1.2	31	37M 4D	38M 4D	16D	0D	0D	0D	0.0	0.0	0.0	0.0	0.0	3.6	.9	.9

Figure J-12. Activity Box Summary Report - X2
Sheet 5

Notes: Information that may not be self evident to all readers is elaborated below.

1. "Reps" (i.e. repetitions) Column. Although the network was traversed 31 times for this data, not every box was entered on each pass (repetition). This column is included because the mean data values shown are averaged over the number of repetitions for the particular box. The contribution of each box to the overall result must take into account the number of repetitions it experiences.

2. "Never Executed". Certain Box Digs/Tigs (e.g. IOH and IOL) are shown as having never executed. This result is normal, because these boxes are concerned with the total design and therefore are entered only on the last Dig.

3. "Asterisk". Box IDs that are marked with an asterisk (*) are Burst boxes that subdivide for execution, see 3.3.1c. The asterisk is a reminder that these boxes begin or continue Burst Chains; Burst End boxes, which do not subdivide, are not so marked.

4. "RECUR". Certain boxes (e.g. 60B) represent recurring or ongoing activities, see para 3.3.1b. On these boxes, iteration does not indicate rework and such repeats are not counted.

Figure J-12. Activity Box Summary Report - X2

Sheet 6 - Notes

APPENDIX K

SOFTWARE ACQUISITION PROCESS (SWAP) MODEL
GENERIC ADAPTATION PROCESS (GAP)

This appendix describes the technique being developed to permit the SWAP Model to be used as a management tool for the general support of any ESD system acquisition project involving embedded software.

1. Concept

Each project requires that an explicit set of contractually defined objects be prepared, validated, and delivered. Because of the commonality prescribed within the ESD System Acquisition process, most systems are developed via the normal activity sequences diagramed and tabularized in the SWAP Model. Despite this expected commonality, each project will contain an uniqueness that can be reflected as differences in kind and in degree. The treatment for each of these types of differences (i.e., qualitative and quantitative) is introduced below.

1.1 Differences in Kind (Qualitative Uniqueness)

The qualitative description of the acquisition process is defined by the Base (or Generic) Flow Diagram and also by a Network Linkage Table (Table B-1)* that is derived from it. Qualitative changes are introduced by amending the Flow Diagrams and Linkage Table to express the special requirements.

This is done by reviewing the generic diagram to identify and eliminate differences as follows:

a. Any generic boxes that do not apply to the specific project are eliminated; e.g.

   (1) a product (or an approval) is not required
   (2) a process sequence is to be replaced by a different one.

---

* "B-n" Tables are defined in Appendix B.

b. Any additional project activities are then added to the diagrams. Each new box sequence must be appropriately linked to show its dependency relationship with the other boxes on the diagram.

c. The Network Connectivity Table (Table B-1) is then updated to reflect the changes introduced in the diagram.

d. Quantitative data are then estimated for each new box and the box inserted into the appropriate "B" table. Also, if the added and deleted activities would impact project manning, the appropriate P.BOX data (Table B-5) is amended accordingly.

1.2 Quantitative Conversion

The quantitative behavior of the Model is determined by parameter values contained in Tables B-2 through B-5 for each box in the network. For example, each activity box occupies time and utilizes personnel; the amounts are given in Table B-2. Similarly, each alternative path of the process is to be selected on the basis of probability values given in Table B-3.

Values of "duration" and "manning levels" have been assigned to each activity box, and a "yes exit probability" assigned to each decision box; these values are based on a mid-range "base" project. These values, which have been exercised and refined to produce "normal" results, have been prepared only for a typical C-cubed operating program. At a future time, variations in this basic diagram will be produced to represent the acquisition of other types of programs: e.g., test support, compilers, equipment diagnostics, etc.

In order for any other (target) CPCI to be simulated, it must be described via a set of effort determinant parameter values that can be compared with those used for the "base" project. Based on these parameter values, a set of factors is derived that converts the base program box parameter values into a set that represents the target CPCI.

These conversion factors are derived from user supplied project attributes that are categorized below and then explicitly defined in Section 2.

a. The "target" program (PRODUCT) characteristics,

b. The developmental methods and tools (METHOD) to be used by the contractor,

c. The skill and experience of the contractor's project personnel (STAFF), and

d. The general contractual environment (CONTRACT).

All effort factors are normalized so that unknown situations will default to a value of 1. This method allows an estimate to be forecast on the basis of as much data is known. While greater knowledge will produce more accurate estimates, the lack of some of this knowledge will not prevent the Model from being useful; default substitutions (on later models) will result in forecasts that indicate a wider range of expected variation.

The Generic Adaptation Process (GAP) involves the five steps shown in Figure K-1, these are detailed in subsequent paragraphs.

2. Project Definition Input Data

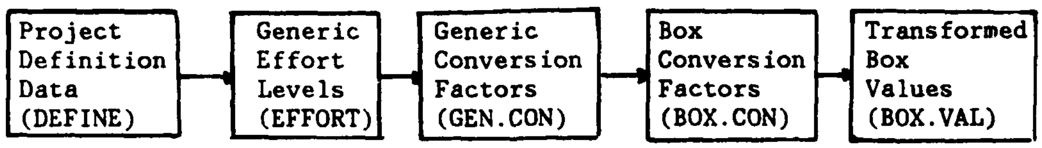
The following data shall be entered to the extent that it is known or can be determined or estimated by the user. Unless otherwise indicated, a default value of "one" will be substituted for any data not entered. For each attribute selected, the program will obtain the corresponding factor(s) shown. Two factors are sometimes used; one for the "direct", the other for "after" effects. The latter factors, which are labeled by an "AFT" suffix, are applied against subsequent activities. For example, the design technique used will not only influence the design effort, it may also exert a different effect on the programming, test, and documentation work that follows. These factors actually express inverse productivity because they directly influence the calculation of effort (man-months). Thus, a lower number indicates higher productivity. If preferred, the user may enter his own parameter value, rather than take the value that comes with his selections.

The data labeling conventions in this document are described in Figure K-2. Knowledge of these conventions will greatly simplify the task of following the data manipulations described in the later sections of this document.

2.1 Developmental Product Data

2.1.1 CPCI Level

a. Program/Design Documentation Requirement: (PDD)	(DIRECT)	(AFT)
(1) Full Product Spec per Standard DID	1.00	X
(2) Full Product Spec Content-Contractor Format	0.85	X



"DEFINE"	User prepared data that defines the "Target" Project is entered.
"EFFORT"	The "DEFINE" Data is converted into project effort levels for each of the principal activities and for the whole. The amount of uncertainty in each of the effort levels is also derived from the kinds of data obtained via default.
"GEN.CON"	The "EFFORT" values obtained above are compared with a similar set obtained for the mid-range "Base" project; the result is a set of ratios that reflect the relative magnitudes of effort required between the two projects.
"BOX.CON"	The "GEN.CON" ratios are used to obtain values that can be used to convert the "Base" project box parameters (timing, manning, range of variation, and probability) into values that apply to the "Target" project.
"BOX.VAL"	The box parameter "Base" values in Tables B-2, B-3, and B-5 are transformed into a set that applies to the "Target" project.

Figure K-1. Generic Transformation Process Overview

(3)	High Level Design plus Annotated Listing	0.70	X
(4)	Standard Contractor Content/Format	0.50	X
(5)	Annotated Listing Only	0.10	X
(6)	None Required	0.00	X

b. Test Documentation Requirement (PTD)
(.The "AFT" factor applies to Test Conduct)

(1) Approval Formality (PTD.APRVL)

a)	Formal per DID-PQT & FQT	1.20	1.30
b)	Formal per DID-FQT only	1.00	1.00
c)	Formal FQT but with Buyer Defined supplementary Tests	.85	1.00
d)	Contractor format; subject to Government approval	.90	.95
e)	Contractor format; no Government Approval	.50	.70

(2)	Detail Level for Procedures (PTD.DTAIL)	DIRECT	AFT
a)	Fully explicit. Each input explicitly defined in terms that relate directly to the entry device. All expected outputs are similarly defined.	1.00	1.00
b)	Inputs are defined in functional terms; actual outputs are evaluated for correctness.	.75	1.20

(3) Document Permanence (PTD.PERM)

a)	Document used only for formal test	1.0	1.0
b)	Document is to be used also for ongoing baseline testing during Maintenance Phase	1.1	.95

c. User Documentation Requirement (PGD)

(1)	Per Formal DID, Government Approved	1.00	X
(2)	Contractor Format, Government Approved	.70	X
(3)	Contractor format, no approval	.30	X

For convenience in reference and in programming, all data items have been labeled in accordance with the following conventions.

Each item may have up to three fields: (1) a Prefix, (2) an Elaborator that may have up to two syllables, and (3) a Suffix, as follows:

PREFIX.ELABORATOR.SUFFIX

(P) The PREFIX includes two or three letters (P1, P2, and P3) as follows:

(P1) Data Type:
P = Product Input, M = Method Input, S = Staff Input,
C = Common Input, E = Effort Factor, G = Generic Ratio,
B = Box Data Transformer

(P2) Activity or Common factor SOURCE identifier
D = Design, P = Programming, Γ = Test, G = General, C = Contract
B = Buyer, M = Maker

(P3) Documentation related if "D" is present; blank otherwise.

(E) The ELABORATOR, which includes up to 5 letters per syllable, is an abbreviation that extends the meaning of the data; e.g., MGMT = Management.

(S) The SUFFIX (AFT) is used only to identify "After-effect" factors.

Some Examples:

PTD = The Test Documentation Factor as derived from "Product" inputs.
PTD.DTAIL = As above, but denoting level of Detail.
PTD.DTAIL.AFT = As above, but applies to After-effect i.e., the affect of Test Document Detail level on Test Conduct effort.
ED = The Design Effort level.
BG.DUR = A factor that transforms the Duration parameter on an Activity Box.

Figure K-2. Data Labeling Conventions

d. Software Metrics Requirement (PG.SOFTW)

If Software METRIC requirements are imposed (e.g., Maintainability, Reliability, Quality, Portability, Reusability, Integrity, etc.), the impact should be estimated. --- X

e. Special Test Requirements (PT.SPECL)
("DIRECT" applies to test conduct; "AFT" to Documentation)

(1) Load/Capacity Test (PT.LOAD)

a. Fully specified	1.15	1.30
b. Contractor Defines	1.05	1.10
2) Flight Testing Required (PT.FLT)	1.20	1.05
3) Site Testing (PT.SITE)		
a. Military Base	1.25	1.05
b. Multiple Sites?	1.35	1.10

f. Direct Program Attributes

The parameters listed below in Par. 2.1.2 may be entered alternatively at the CPCI level, if CPC breakdown has not yet been accomplished.

2.1.2 Computer Program Component (CPC) Data

The following data, if known or can be reasonably estimated at the CPC level, should be entered. If not adequately known, all or some of the parameters may be entered at the CPCI level per par. 2.1.1.f. If any of the data is entered at the CPC level, the SIZE data must also be at that level.

If these data are entered at both the CPC and CPCI level, the former will be used by the program for all cases where it is available. The CPCI level data is then used to fill in any data gaps at the CPC level. If neither data are present, default data are used.

a. Size (PP.SIZE.IN): In Machine Oriented Language (MOL) executable instructions (X100): This data is mandatory.

b. Newness Factor

(1) Of Design: (PD.NEW) _____
(2) Of Programming: (PP.NEW) _____
(3) Of Test: (PT.NEW) _____

c. Complexity Factor

(1) Of Design: (PD.PLEX) _____
(2) Of Programming: (PP.PLEX) _____
(3) Of Test: (PT.PLEX) _____

d. Criticality Factors (PG.CRIT)

(1) Ratio of storage needed vs. available (PP.STR.RATIO) _____

(2) Ratio of Processing Time used vs. available (PP.TIM.RATIO) _____

(3) Reliability Factor: (PG.RELY)

The importance attached to functional impairment or failure can affect the effort expended for implementation and test of the function. The first four examples below provide guidance for selection of an appropriate RELR factor value on a functional basis. The last example provides a more general basis for earlier estimates.

a. Life threatening, e.g., aircraft collision avoidance	1.5
b. On-line control, e.g., aircraft tracking and guidance	1
c. Facility management, e.g., flight reservation	.8
d. Operator training	.5
e. General C-cubed operating program	1.0

2.2 Developmental Methods Data

If a method is to be used that is not listed below, the user should enter appropriate values that are estimated by comparison with the values given. If more than one method is to be used, an equivalent value should be derived based on the percentage of the work to be done with each method.

2.2.1 Design Methodology

If more than one will be used, give percentage of each

Design Representation Method (MD.REPR)	DIRECT	AFT
a. Manual Flow Charts	1.0	1.0
b. Chapin Charts	1.0	.87
c. Decision Tables	.95	.90
d. HIPO Diagrams (Hierarchial I/O)	1.05	.95
e. PDL (Program Design Language)	.90	.85
f. FSD (Functional Sequence Diagrams)	1.10	.80
g. OSD (Operational Sequence Diagrams)	1.15	.75
h. Other	--	--

2.2.2 Programming Method (MP.METH)

The direct method factor relates the effect of Programming Methods on programmer productivity, not on the resulting software qualities such as processing efficiency, storage utilization, clarity, ease of change, etc. The "AFTER" Factor (.C) relates the impact of the method on subsequent activities, e.g., test and documentation.

a. Programming Language (MP.LINGO)	DIRECT	AFT
(1) Basic Assembler	2.5	2.5
(2) Enhanced Assembler (e.g., Macros, Library, Data Definitions, etc.)	1.9	2.0
(3) FORTRAN	1.3	1.25
(4) PL-1	1.25	1.25
(5) JOVIAL (J-73)	1.0	1.0
(6) CMS-2	1.05	1.05
(7) PASCAL	1.15	1.0
(8) Ada	1.20	0.85

b. Developmental Facility Quality (MP.FCLTY) (Enter subjective estimate)	DIRECT	AFT
(1) Debug Support (MP.DBUG)	____	____
(2) Library Support (MP.LIBR)	____	____
(3) Configuration Management Support (MP.CNFIG)	____	____
(4) Exercise Support (MP.EXRSZ)	____	____
(5) Capacity (MP.CAP)	____	____

c. Machine Access Method (MP.ACCES)

(1) Punch Card open shop (3 accesses/day)	1.07	1.15
(2) Punch Card Closed Shop (3 hr. turnaround)	1.15	1.2
(3) TSO Terminals, batch	1.0	1.0
(4) UNIX Terminals, batch	0.95	0.92
(5) Interactive, Interpretive Terminal	0.8	1.1
(6) Other (enter estimate)	--	--

2.2.3 Test Methods (MT)

a. Availability of Facility (MT.AVAIL) DIRECT

(1) Physical Access (MT.ACCES)

a) Same Building (short walk)	1.0
b) Another Building (long walk)	1.04
c) Must Drive to Facility	1.10

(2) Capacity (MT.CAP)

This is a measure of the utilization of the total test facility during peak test period.

a) Can get use on day requested	1.0
b) Can get use within 2-hours of request	.95
c) Must schedule a week ahead (i.e., test priorities needed)	1.10

(3) Reliability (MT.RELY)

a) 10% unscheduled downtime	1.0
b) 5% unscheduled downtime	.98
c) 20% unscheduled downtime	1.05

b. Utility of Facility (MT.UTIL)

(1) Input Ease (MT.INPUT)

a) Manual preprocessing of inputs	1.0
b) Only manual real time entry	1.05
c) Manual preprocessing plus real time entry	.95
d) Extensive test problem generation aids	.80

(2) Output Ease (MT.OUTPT) DIRECT

a) Most outputs in numeric form (octal or hex)	1.15
b) Most outputs interpreted to meaningful unit	1.00
c) Data finding & extraction tools plus (b)	.95
d) Automatic Analysis tools plus (c)	.92

(3) Operating Ease (MT.OPER)

a) Easily operated by test conductors	1.00
b) Needs specially trained operator	1.05

2.2.4 Project Development Staging

a. Developmental Integration Groups (DIGs)

(1) Quantity (   ): % each (/ /)

(2) Default values

Size (MOL Inst)	Quant.	% Each
L.T. 20K	1	100
20K-50K	2	60/40
50K-100K	3	40/30/30
100K-200K	4	30/25/25/20
G.T. 200K	5	25/20/20/20/15

b. Test Integration Groups (TIGs)

(1) Quantity ( ): % each (/ / /)

(2) Default Values

Size	Quant.	% Each
L.T. 20K	1	100
20K-50K	2	60/40
50K-100K	4	30/25/25/20/
100K-200K	6	20/20/15/15/15/15
G.T. 200K	8	15/15/15/15/10/10/10/10

2.3 Technical Staff Experience Data

2.3.1 Designers (SD)

2.3.2 Programmers (SP)

2.3.3 Testers (ST)

2.4 Contractual Data

These data values are organized into three sets as described and decomposed below. It should be understood that while each data element does impact the development, it may be difficult to objectively quantify its effect. A default value of "one" would be used for unknowns (e.g., contractor not yet selected). Otherwise, subjective or consensus values can be initially established by the users based on the guidance provided.

2.4.1 Contract Factors

2.4.1 Contract Factors	DIRECT
a. Contract type (CC.TYPE)	1
(1) CPFF	1
(2) Cost Sharing (indicate formula)	___
(3) Fixed Price	1.10
(4) Contract Extension	.95
(5) Other	--
b. Requirements Definition Quality (CC.REQU) (estimate impact of each)	
(1) Completeness (CC.COMPL)	____
(2) Clarity (CC.CLEAR)	____
(3) Verifiability (CC.VERIF)	____
(4) Quality Assurance (CC.QA)	____
c. Schedule Urgency (CC.SCHED)	
(1) High	H
(2) Medium	M
(3) Low	L
d. Cost Realism (CC.COST)	
(1) Sole Source Negotiation	1.10
(2) Normal Competition	1.0
(3) Buy In	1.10
(4) Other	--

2.4.2 Buyer (Procurement Agency) Factors (CB)

a. Buyer Membership (CB.MEMBR)

(1) Single Using Agency	1.0
(2) Multiple Users	1.04
(3) Multi-Service	1.15

b. Monitoring Policy (CB.MONTR)

(1) Arms Length	1.08
(2) Work Sharing	.92
(3) Distance	X
a) Together (on-site)	.92
b) Frequent Visit	1.0
c) Travel Restraints	1.08

c. Personnel Experience (CB.EXPER) (TBD) ____

d. Flexibility

(1) Requirements (CB.FLEXR)	.85
(2) Quality (CB.FLEXQ)	.90

2.4.3 Maker (Contractor) Factors

a. Management/Organization (CM.MGMT) ____

b. Technical Organization (CM.TECHO)

(1) Chief Programmer Teams	.85
(2) Design/Programmer Teams	.95
(3) Design Teams/Programmer Teams	1.0
(4) Other	--

c. Developmental Practices (CM.PRACT)

(1) Design Verification (CM.VERIF)

a) Independent Interface Reviews	.94
b) Design/Program Walkthrough	.90
c) Other	--

(2) House Standard Practices (CM.STND)
(Estimate impact of each)

a) Completeness	--
b) Quality	--
c) Enforcement	--

(3) Design Approach (CM.APRCH)

a) Top Down	.92
b) Doers Choice	1.00
c) Other	--

d. Managerial/Systems Experience (CM.EXPRN)	(TBD)
e. Manning Stability/Turnover Rate (CM.STBL)	(TBD)
f. Manning Availability Level (CM.MANN)	

1) High	H
2) Medium	M
3) Low	L

3. Input Parameter Aggregation

In this section, the data obtained per para. 2 are aggregated such that items that jointly contribute to any particular Effort Level determinant (per para. 4) are joined together.

In the notation used below, the underline calls attention to aggregated data items whose constituants are defined subsequently.

3.1 Contractual Data Items

3.1.1 Common Factor (CG) Calculations

CG = (<u>CC</u>)(<u>CB</u>)(<u>CM</u>)

3.1.1.1 Contractual Factor (CC)

CC = (CC.TYPE)(CC.COST)(CC.REQU)
CC.REQU = (CC.COMPL)(CC.CLEAR)(CC.VERIF)(CC.QA)

3.1.1.2 Contracting Agency (Buyer) Factor (CB)

CB = (CB.MEMBR)(CB.MONTR)(CB.EXPER)(CB.FLEXR)(CB.FLEXQ)

3.1.1.3 Contractor (Maker) Factor (CM)

CM = (CM.MGMT)(CM.STBL)(CM.EXPRN)

3.1.2 Contractor Implementation Organization (CM.IMPL)

CM.IMPL = (CM.PRACT)(CM.TECHO)

CM.PRACT = (CM.VERIF)(CM.APRCH)(CM.STNDS)

3.1.3 Project Staffing Level (CG.STAF)

This relationship, which uses input items CC.SCHED and CM.MANN is described in para 6.2.

3.2 Product Definition Data

3.2.1 Component Criticality (PG.CRIT)

This component sums up three attributes that can influence the developmental effort. These can apply at the CPC or CPCI level.

a. Time (PP.TIM) and Storage (PP.STR) Criticality.

Each of these factors is treated as an exponential variable that is dependent on the estimated ratio between what is needed versus what is provided. If the needed is less than one-half that

provided, the factor is set to One; i.e., is not critical. If it is greater than one-half, criticality is computed as follows:

PP.TIM = e**Kt(TIM.RATIO-0.5), with Kt=2

PP.STR = e**Ks(STR.RATIO-0.5), with Ks=2

b. Calculation of Criticality

PG.CRIT = (PP.TIME)(PP.STR)(PG.RELY)

3.2.2 Special Test Requirements (PT.SPECL)

(Direct Factors apply to test effort; AFT to Test Documentation Effort)

PT.SPECL = (PT.FLT)(PT.SITE)(PT.LOAD)
PT.SPECL.AFT = (PT.FLT.AFT)(PT.SITE.AFT)(PT.LOAD.AFT)

3.2.3 Normalized Size Summaries

Three effective sizes of the program (CPCI) are obtained, one each for Design, Programming and Test activities. They are obtained by normalizing the actual size of each CPC to account for its value of newness, complexity and criticality.

a. If data is entered on a CPC basis it is summed as follows:

$$PD.SIZE = \sum_{c=1}^{n} (PP.SIZE.IN)c*(PD.NEW)c*(PD.PLEX)c*(PG.CRIT)c$$

$$PP.SIZE = \sum_{c=1}^{n} (PP.SIZE.IN)c*(PP.NEW)c*(PP.PLEX)c*(PG.CRIT)c$$

$$PT.SIZE = \sum_{c=1}^{n} (PP.SIZE.IN)c*(PT.NEW)c*(PT.PLEX)c*(PG.CRIT)c$$

b. If data is entered on a CPCI basis, the calculation is the same, but the summation is not applicable.

c. If both CPC and CPCI data is entered, method a above is used, but with equivalent CPCI data being substituted for any missing CPC level data.

3.2.4 Product Requirments

PD = (PD.SIZE)(PG.SOFTW)

PP = (PP.SIZE)(PG.SOFTW)

PT = (PT.SIZE)(PG.SOFTW)(PT.SPECL)(PTD.AFT)

3.2.5 Test Documentation Requirements (PTD)

Two products are computed for the three contributers; one for the "direct effects" the other for "after effects." The latter is applied against the test effort calculations:

(PTD) = (PTD.APRVL)(PTD.DTAIL)(PTD.PERM).

(PTD.AFT) = (PTD.APRVL.AFT)(PTD.DTAIL.AFT)(PTD.PERM.AFT).

3.3 Methods Data

3.3.1 Design Method (MD)

a. Direct Effect Factor

MD = (MD.REPR)(CM.IMPL)

b. After Effects Factor

MD.AFT = (MD.REPR.AFT)

3.3.2 Programming Method (MP)

a. Direct Effect Factor

MP = (MP.METH)(MD.AFT)(CM.IMPL).

MP.METH = (MP.FCLTY)(MP.LINGO)(MP.ACCES)

MP.FCLTY = (MP.CAP)(MP.CNFIG)(MP.DBUG)(MP.LIBR)(MP.EXRSZ)

b. After Effect Factor

MP.AFT = (MP.FCLTY.AFT)(MP.LINGO.AFT)(MP.ACCES.AFT)(MD.AFT)

MP.FCLTY.AFT =
(MP.CAP.AFT)(MP.CNFIG.AFT)(MP.DBUG.AFT)(MP.LIBR.AFT)(MP.EXRSZ.AFT).

3.3.3 Test Method (MT)

MT = (MT.AVAIL)(MT.UTIL)(MP.AFT)(CM.IMPL)
MT.AVAIL = (MT.ACCES)(MT.CAP)(MT.RELY)

MT.UTIL = (MT.INPUT)(MT.OUTPT)(MT.OPER)

3.4 Staff Experience Factors

(TBD)

4. Effort Level Computation

Effort level values are indictors of the amount of effort to be expended in the conduct of each of the seven major activities into which the total effort is divided, as follows:

a. Design (ED)
b. Programming (EP)
c. Test (ET)
d. General (a composite of the above activities) (EG)
e. Program/Design Documentation (e.g., the product specification) (EDD)
f. Test Documentation (Plans, Procedures, Reports) (ETD)
g. User (and other) Documentation (EGD)

The unit of each of these efforts is program size (i.e., the equivalent total number of executable machine instructions) that has been adjusted to account for all project parameters treated in paragraph 3, including those that affect productivity.

4.1 Main Activity Effort Level

a. Design: ED = (PD)(MD)(SD)(CG).
b. Programming: EP = (PP)(MP)(SP)(CG).
c. Test: ET = (PT)(MT)(ST)(CG).

4.2 Composite (General) Activity Effort Level (EG)

This general level is used to account for all activities that do not fall within the six explicit activities identified in paragraph 4. It consists of a weighted average of the three main activities, as follows:

EG = [Kd(ED)+Kp(EP)+Kt(ET)]/(Kd+Kp+Kt).

The initial weights are: kd = 15, kp = 10, and kt = 12

Note, that the Programming Weight Factor (Kp) is larger than is generally attributed to this activity because in this analysis, it includes all program debug, integration and checkout work.

4.3 Documentation Activity Effort Levels.

a. Program/Design: EDD = (PDD)(PD)(MD.AFT)(SD)(CG)
b. Test: ETD = (PTD)(PT.SIZE)(PG.SOFTW)(PT.SPECL.AFT)(CG)
PTD = (PTD.APRVL)(PTD.DTAIL)(PTD.PERM)
c. User: EGD = (PGD)(EG)

5. Generic Conversion Factor Computation

The Generic Conversion Factors are ratios between two sets of Effort Factors. The denominators are obtained by the application of the effort level calculations to the Base Project; i.e., the project that provided the quantitative basis for the SWAP model. The numerators are the same factors, but applied to any (Target) project.

5.1 Generic Factor Calculations

GD = (ED.TRGT)/(ED.BASE)
GP = (EP.TRGT)/(EP.BASE)
GT = (ET.TRGT)/(ET.BASE)
GG = (EG.TRGT)/(EG.BASE)
GDD = (EDD.TRGT)/(EDD.BASE)
GTD = (ETD.TRGT)/(ETD.BASE)
GGD = (EGD.TRGT)/(EGD.BASE)

5.2 Base Project Calculations

The input parameter selections and values for the Base Project are presented in four Tables of Attachment K-A as follows:

Table K-A.1 Base Project Product Input Factors - CPCI Level
Table K-A.2 Base Project Product Input Factors - CPC Level
Table K-A.3 Base Project Methods Input Factors
Table K-A.4 Base Project Common Input Factors

Based on these inputs, the resulting Effort Level values are computed in Attachment K-A. These same Effort Values are also shown in an abbreviated form in Attachment K-B, for ease of comparison with Target project values.

5.3 Target Project Calculations

A set of user input data reflective of two sample target projects are provided in Attachment K-B. The seven effort factors are calculated for each using the same relationships shown in Para. 5.2. The Generic Factor ratios shown in Para. 5.1 are then formed, as shown below:

Generic Factor		Project X2	Project/2
GD	Design Factor	1.53	0.32
GP	Programming Factor	1.15	0.38
GT	Test Factor	0.87	0.24
GG	General Composite Factor	1.18	0.31
GDD	Design/Program Documentation	1.61	0.27
GTD	Test Documentation	1.27	0.27
GGD	General/User Documentation	1.18	0.22

6. Box Conversion Factors

Three kinds of data transformers are needed for application to specific boxes. One transforms manning levels, another activity durations, and the last applies to Decision Probabilities. The specific transformations factors are derived from three contributing considerations.

a. Activity Type: The Generic Conversion Factors derived in Par. 5 account for the principal type of activity represented by the box.

b. Growth Type: Certain (highly fragmented) activities can grow just by increased manning; the other (more integrated) activities also need more time.

c. Manning Level: Personnel Availability and Contractual Schedule Urgency influence the totality of available personnel that are assigned to the project.

On later versions of the Model, another set of factors will be developed to account for user uncertainties about the project. These levels will depend initially on the kinds of input data that is selected via default. Later versions will permit the user to express his confidence level with each item of input.

6.1 Transformation Class (BG.CLASS) Assignments

A set of 15 transformation classes (BG.CLASS) have been established to provide for combinations involving: Activity Type, Documentation, and Growth Type.

The classes are identified by three letters "AGD" as follows:

A = Basic Activity: D = Design; P = Programming; T = Test; G = General.
G = Growth Pattern: F = Fragmented; I = Integrated; K = Constant.

D = Documentation Task, if present; otherwise, it is omitted.

For example, "TFD" indicates a Test Activity, with Fragmented Growth, involving Documentation.

Fourteen of these classes are derived from the seven Activity/Documentation Activities and two of the Growth Types (i.e., F&I). The fifteenth class includes all boxes that have type K (constant) growth. This latter class is provided to allow any project unique boxes to retain their assigned data.

The assignment of all system boxes among of the 15 classes is given in Table K-1.

6.2 Staff Availability Factor (CG.STAF)

Staff Availability is derived from two inputs:

Schedule Urgency (CC.SCHED) may be high, medium, or low
Manning Availability (CM.MANN) may be high, medium, or low

CG.STAF is derived per the following matrix:

Staff Availability

		H	M	L
Schedule	H	1.3	1.2	1.0
Urgency	M	1.1	1.0	0.9
	L	1.0	0.8	0.7

e.g., If Availability is "M" and Urgency is "H", then CG.STAF = 1.2.

On later SWAP Models, the staff availability derived above can be "shaded" to compensate for the coarseness of the matrix.

Table K-1. Box Activity Group (BG.GROUP) Assignments

Box ID	BG.GROUP	Box ID	BG.GROUP
1Y, 2A,	GI	48A, Y	TID
ALL 4	GID	48B	TFD
ALL 6, All 8	DI	50 All	TID
10A,C,E,L,N,Y	DF	52 All	TID
10H,J	DI		
12A,C.G	DI	53 All	GK
12J	DF	54A,D,E,H,K,L,M Q,S,W,Y	TI
		54P,T,V	TID
14A	PI	60 All	GK
14C	PF	62 All	GK
16A,C,Y	PF	66 All	GK
18C,D	PF	70A,B,C,E	GID
18E,F,G,I,J,K,L M,N,O,P,Q,Y,X	PI	72A,C	GID
		74A,B,C	GID
		80A,J,L,N,P	DFD
		80E	GID
20A,C,E	DI	82A,E,G,J,P,Q,S,T V,W,X,Y	DID
22A,Y,23A	PI	84Y	GID
24A,C,E	DFD		
25C	PI		
26A,28A	DID		
All 40	TID		
42M,N,G,H	TID		
42A,C,E,J,K,Y	TFD		
All 44	TF		
46A,C,L,P,Y	TF		
46R,S,T	TI		
47Y	TFD		

6.3 Box Transformation Factors Computation

6.3.1 Manning Levels Factor (BG.MANN)

a. For all boxes designated as fragmented the Manning Level Factor shall be the product of the Staff Availability and the Generic Conversion Factor assigned to the box. For example, if a box is in group TFD:

BG.MANN = (GTD)(CG.STAF)

b. For all boxes designated as Integrated, BG.MANN shall be the square root of the above product. For example, on boxes within Class DI:

BG.MANN = SQ.RT [(GD)(CG.STAF)]

6.3.2 Activity Duration Factor (BG.DUR)

a. The following table shows the dependency of duration (*BG.DURA*) on *Staff Availability. It reflects changes* in the relative developmental productivity induced by manning level, per the following equation:

(CG.STAF)(BG.DURA)(PRODUCTIVITY) = 1

CG.STAF	.6	.7	.8	.9	1	1.1	1.2	1.3	1.4
BG.DURA	1.51	1.31	1.17	1.07	1	.96	.93	.90	.89
Productivity	110%	109%	107%	104%	100%	95%	90%	85%	80%

b. The relative productivity of the developmental process is also affected by the magnitude of the project as reflected in each Generic Factor. This impacts the duration by the Factor BG.DURM which increases (from Base value of 1) by M% for each doubling of the "Generic Conversion Factor" and decreases by M% for each halving. This relationship (for M=5%) is shown in the following table:

Generic Factor	.25	.5	1	2	4	8
Productivity	110%	105%	100%	95%	90%	85%
BG.DURM	.91	95	1.00	1.05	1.11	1.18

c. For all boxes designated as fragmented;

BG.DUR = (BG.DURA)(BG.DURM)

d. For all boxes designated as Integrated

BG.DUR = (BG.DURA)(BG.DURM) SQ.RT (Generic Conversion Factor)

6.3.3 Probability Transformation

In general the probability of initial success diminishes as the relative magnitude of an activity increases and also as the level of manpower increases. For this reason, the product of the Generic Conversion Factor (e.g., GD) and the Staff Availability (BG.STAF) shall be used as the Decision Affecting Parameter BG.DCIDE; i.e.:

BG.DCIDE = (CG.STAF)(Generic Conversion Factor)

For each doubling of "BG.DCIDE" the yes probability (pYES) shall decrease to D% of its prior value. For each halving of "BG.DCIDE"; the pNO (= 1 - pYES) shall decrease to D% of its prior value. This relationship (for D=94%) is expressed in the following table that shows how pYES varies with "BG.DCIDE" values.

BG.DCIDE =	1/8	1/4	1/2	1	2	4	8
pYES =	34	30	25	20	19	18	16
	51	47	44	40	38	35	33
	67	65	62	60	56	53	49
	84	82	81	80	75	70	66

Any base probability values of 00 or 100 shall remain unchanged.

6.4 Uncertainty Computation

(TBD)

7. Box Value Transformations

7.1 Activity Group Assignments

Each box that is an Activity, Decision, or Personnel type is assigned to an activity group as shown in Table K-1. The duration, manning, and decisional values (as applicable) for each of these boxes shall be transformed from their base values using the factors presented in Section 6.

7.2 Uncertainty Assignments

(To be provided on later models)

K-A ATTACHMENT
TO APPENDIX K

Base Project Effort Calculations

The Base project parametric data given in Tables B-2 through B-5 was derived from a project that is defined herein. The project definition input data are contained in four tables, as follows:

Table K-A.1 Base Project Product Input Factors - CPCI Level

Table K-A.2 Base Project Product Input Factors - CPC Level

Table K-A.3 Base Project Methods Input Factors

Table K-A.4 Base Project Common Input Factors

The calculations involved in converting the input data into the seven corresponding Effort Levels are shown in this attachment. The calculations include all the relationships shown in Sections 3 and 4 of this document.

CALCULATIONS OF FACTOR VALUES

a. **Common Factor Values**

```
CG = (CC)(CB)(CM) = (1.15)(.90)(.79) = .82
     CC = (CC.TYPE)(CC.COST)(CC.REQU) = (1.0)(1.0)(1.15) = 1.15
          CC.REQU = (CC.COMPL)(CC.CLEAR)(CC.VERIF)(CC.QA) = 1.15
     CB = (CB.MEMBR)(CB.MONTR)(CB.EXPER)(CB.FLEXR)(CB.FLEXQ) = (1.0)(1.0)(.95)(1.0)(.95) = .90
     CM = (CM.MGMT)(CM.STBL)(CM.EXPER) = (.95)(.90)(.92) = .79

CM.IMPL = (CM.PRACT)(CM.TECHO) = (.81)(.95) = .77
     CM.PRACT = (CM.VERIF)(CM.APRCH)(CM.STNDS) = (.85)(1.00)(.95) = .81
```

b. **Design Effort Values**

```
ED = (PP)(MD)(SD)(CG) = (1124)(.77)(1)(.82) = 710
     PD = (PD.SIZE)(PG.SOFTW) = (1124) (1.0) = 1124
          PD.SIZE =   (PP.SIZE.IN)(PB.NEW)(PD.PLEX)(PG.CRIT) = 1124
              PG.CRIT = (PP.TIME)(PP.STR)(PG.RELY) = 1.4*
     MD = (MD.REPR)(CM.IMPL) = (1.0)(.77) = .77
```

c. **Programming Effort Values**

```
EP = (PP)(MP)(SP)(CG) = (1230)(.84)(1)(.82) = 847
     PP = (PP.SIZE)(PG.SOFTW) = (1230)(1.0) = 1230
          PP.SIZE =   (PP.SIZE.IN)(PP.NEW)(PP.PLEX)(PG.CRIT) = 1230
MP = (MP.METH)(MD.AFT)(CM.IMPL) = (1.09)(1.0)(.77) = .84
     MP.METH = (MP.FCLTY)(MP.LINGO)(MP.ACCES) = (1.02)(1.0)(1.07) = 1.09
     MD.AFT = (MD.REPR.AFT) = 1.0
```

---

* This value of criticality is the mean for the whole CPCI.

CALCULATION OF FACTOR VALUES (Cont.)

d. Test Effort Values

```
ET = (PT)(MT)(ST)(CG) = (1240)(.95)(1)(.82) = 966
     PT = (PT.SIZE)(PG.SOFTW)(PT.SPECL)(PTD.AFT) = (1078)(1.0)(1.15)(1.0) = 1240
          PT.SIZE =   (PP.SIZE.IN)(PT.NEW)(PT.PLEX)(PG.CRIT) = 1078
          PT.SPECL = (PT.LOAD)(PT.FLT)(PT.SITE) = (1.15)(1.0)(1.0) = 1.15
          PTD.AFT = (PTD.APRVL.AFT)(PTD.DTAIL.AFT)(PTD.PERM.AFT) = (1.0)(1.0)(1.0) = 1.0

     MT = (MT.AVAIL)(MT.UTIL)(MP.AFT)(CM.IMPL) = (1.04)(.97)(1.22)(.77) = .95
          MT.AVAIL = (MT.ACCES)(MT.CAP)(MT.RELY) = 1.04(1.0)(1.0) = 1.04
          MT.UTIL = (MT.INPUT)(MT.OUTPT)(MT.OPER) = (1.02)(.95)(1.0) = .97
          MP.AFT = (MP.FCLTY.AFT)(MP.LINGO.AFT)(MP.ACCES.AFT)(MD.AFT) = (1.02)(1.0)(1.2)(1.0) = 1.22
```

e. Composite (General) Effort Level

```
EG =  Kd(ED) + Kp(EP) + Kt(ET)  / (kd + Kp + Kt)
   =  15(710) + 10(847) + 12(966) / (15 + 10 + 12) = 830
```

f. Program/Design Documentation Effort

```
EDD = (PDD)(PD)(MD.AFT)(SD)(CG) = (1.0)(1124)(1.0)(1)(.82) = 922
```

g. Test Documentation Effort

```
ETD = (PTD)(PT.SIZE)(PG.SOFTW)(PT.SPECL.AFT)(ST)(CG) = (1.0)(1078)(1.0)(1.3)(1)(.82) = 1149
     PTD = (PTD.APRVL)(PTD.DTAIL)(PTD.PERM) = (1.0)(1.0)(1.0) = 1.0
     PT.SPECL.AFT = (PT.LOAD.AFT)(PT.FLT.AFT)(PT.SITE.AFT) = (1.3)(1.0)(1.0) = 1.3
```

h. User Documentation Effort

```
EGD = (PGD)(EG) = (1.0)(830) = 830
```

Table K-A.1. Base Project Product Input Factors - CPCI Level

Label	Description	Option Selected	Factor Value Direct	Factor Value AFT
PDD	Prgm. Doc.	Full MIL DID	1.0	XXX
PGD	User Doc.	Formal DID	1.0	XXX
PTD	Test Doc.	XXX	1.00	1.00
PTD.APRVL	Approval	DID/FQT only	1.00	1.00
PTD.DTAIL	Detail Lvl.	Fully Explicit	1.00	1.00
PTD.PERM	Permanence	Formal Test Only	1.00	1.00
PT.SPECL	Special Test	XXX	1.15	1.3
PT.LOAD	Load Test	Fully Specified	1.15	1.3
PT.FLT	Flight Test	None Required	1.0	1.0
PT.SITE	Site Test	None Required	1.0	1.0
PD.SIZE	Design Size	See Table A-2		
PP.SIZE	Programming Size	See Table A-2		
PT.SIZE	Test Size	See Table A-2		
PG.CRIT	Criticality	See Table A-2		
PP.STR.RATIO	Storage	60% used	0.6	X
PG.SOFTW	S'ware Metrics	None Required	1.0	X

Table K-A.2. Base Project Product Input Factors - CPC Level

CPC FUNCTION	SIZE (X100)	NEW D	NEW P	NEW T	PLEX D	PLEX P	PLEX T	CRIT. RATIO STOR	CRIT. RATIO TIME	RELR	CRIT*	ADJUSTED SIZE DSGN	ADJUSTED SIZE PRGM	ADJUSTED SIZE TEST
EXECUTIVE	40	0.4	0.8	1.0	1.0	1.1	1.0	0.6	.7	-	1.8	29	63	72
CONSOLE INPUT	120	0.8	0.9	1.0	1.3	1.4	0.7	0.6	.7	-	1.8	225	151	151
GRAPHIC DISPLAY	50	0.9	1.0	1.0	1.2	1.0	0.8	0.6	.6	-	1.5	81	75	60
TAB. DISPLAY	20	1.0	1.0	1.0	1.1	0.9	0.7	0.6	.7	-	1.8	40	32	25
RADAR-SKIN	50	1.0	1.0	1.0	1.2	1.1	1.0	0.6	-	-	1.2	72	66	60
RADAR-BEACON	70	0.9	1.0	1.0	1.5	1.6	1.1	0.6	-	-	1.2	113	134	92
TRACKING	20	0.8	0.9	1.0	0.9	0.8	0.7	0.6	-	-	1.2	17	17	17
WEAPONS	100	0.8	0.9	1.0	1.7	1.5	1.6	0.6	-	1.5	1.8	245	243	288
COMM.-IN	90	1.0	1.0	1.0	1.1	1.2	1.1	0.6	.6	-	1.5	148	162	148
COMM.-OUT	50	1.0	1.0	1.0	0.9	0.8	0.7	0.6	-	-	1.2	54	48	42
ADAPTATION	60	0.7	0.8	1.0	0.7	.6	0.7	0.6	-	-	1.2	35	35	50
I/O SUPPORT	80	0.6	0.7	0.9	0.6	.7	0.5	0.6	-	-	1.2	35	47	43
SELF TEST	50	1.0	1.0	1.0	0.5	.6	0.5	0.6	-	-	1.2	30	36	30
CPCI SIZE	800											1124	1230	1078

NOTE: UNDERLINED VALUES ARE COMPUTED AGGREGATES

* Sample Criticality Calculations: Executive Function

PP.TIM = e**Kt(TIM.RATIO-0.5) = e**2(.7-.5) = 1.5
PP.STR = e**Kt(STR.RATIO-0.5) = e**2(.6-.5) = 1.2
PG.CRIT = (PP.TIM)(PP.STR)(RELR) = (1.5)(1.2)(1) = 1.8

Table K-A.3. Base Project Methods Input Factors

Label	Description	Selected Option	Factor Value Direct	Factor Value AFT
MD.REPR	Design Rep.	Flow Chart	1.00	1.00
MP.LINGO	Language/Compiler	JOVIAL	1.0	1.0
MP.FCLTY	Facility Qual.		1.02	1.02
MP.DBUG	Debug Qual.		1.05	1.10
MP.LIBR	Library Support		1.03	1.00
MP.CNFIG	Config. Mgmt		1.05	1.15
MP.EXRSZ	Exer. Generation		.95	.90
MP.CAP	Capacity		.95	.90
MP.ACCES	Machine Access	Card/Open	1.07	1.20
MT.AVAIL	Availability		1.04	X
MT.ACCES	Access	Long Walk	1.04	
MT.CAP	Capacity	Same Day	1.00	X
MT.RELY	Reliability	10%	1.00	X
MT.UTIL	Utility		.97	X
MT.INPUT	Input Ease	Manual Pre.	1.02	X
MT.OUTPT	Output Ease	data finding	.95	X
MT.OPER	Operation	Easy	1.00	X

Note: *Underlined items are computed aggregates*

Label	Description	Selection	Factor Direct
CC Contractual	X		1.15
CC.TYPE	Contract Type	CPFF	1.00
CC.COST	Cost Realism	Competition	1.00
CC.REQU	Requirements Quality	Vague	1.15
CC.SCHED	Contract Schedule	Medium (M)	X
CB	Buying Agency	X	0.90
CB.MEMBR	Membership	Single User	1.0
CB.MONTR	Monitor.Policy	Frequent Visit	1.0
CB.EXPER	Staff Exper.	Good	0.95
CB.FLEXR	Requ. Flex.	Moderate	1.00
CB.FLEXQ	Quality	Loose	0.95
CM	Maker (Con- tractor	X	0.79
CM.MGMT	Mgmt. Org.	Responsive	0.95
CM.STBL	Staff Stab.	Excellent	0.90
CM.EXPRN	Systems Exp.	Good	0.92
CM.MANN	Manning Avail.	Medium (M)	X
CM.PRACT	Practices		0.81
CM.VERIF	Verif. Method	Design Walk-thru	0.85
CM.APRCH	Design Appr.	Doers Choice	1.00
CM.STNDS	House Stnds.	Estimate	0.95
CM.TECHO	Tech. Org.	Designer/Programmer	.95

Note: Underlined values are computed aggregates

K-B ATTACHMENT
TO APPENDIX K

Sample SWAP Target Projects Parameters vs. Base

CPCI ID	X2	/2	BASE
PRODUCT (All at CPCI level)			
SIZE (X100)	1600	400	800
NEW-D	.90	.80	.83
NEW-P	1.00	.90	.91
NEW-T	.90	.80	.99
PLEX-D	1.2	1.0	1.11
PLEX-P	1.0	1.2	1.10
PLEX-T	1.1	0.9	0.90
CRIT	1.2	1.1	1.4
PG.SOFTW	1	1	1
PT.SPECL	1.30(1.15)	1.10(1.05)	1.15(1.30)
DOCUMENTATION			
PDD	1.0	.85	1.0
PTD.APRVL	.85(1.0)	1.0(1.0)	1.0(1.0)
.DTAIL	.75(1.2)	1.0(1.0)	1.0(1.0)
.PERM	1.1(.95)	1.0(1.0)	1.0(1.0)
PGD	1.0	.70	1.0
METHOD	X2	X/2	BASE
MD.REPR	0.90(0.85)	1.05(0.95)	1.00(1.00)
MP.LINGO	1.2(.85)	1.3(1.25)	1.0(1.0)
MP.FCLTY	.95(.95)	0.9(.95)	1.02(1.02)
MP.ACCES	0.95(0.92)	1.0(1.0)	1.07(1.15)
MT.ACCES	1.04	1.00	1.04
MT.CAP	1.0	.95	1.00
MT.RELY	1.0	1.05	1.00
MT.INPUT	0.95	0.95	1.00
MT.OUTPT	0.97	1.00	.95
MT.OPER	1.00	1.00	1.00

STAGING - Default

*Parentheses indicate "AFT" factor values

COMMON FACTORS	X2	/2	BASE
CC.TYPE	1.05	1.10	1.00
CC.REQU	1.10	.95	1.15
CC.SCHED	M	L	M
CC.COST	1.0	1.05	1.00
CB.EXPER	1	1	0.95
CB.MEMBR	1.04	1.0	1
CB.MONTR	0.92	1.0	1.0
CB.FLEXR	0.85	1.0	1.C
CB.FLEXQ	1.0	0.90	0.95
CM.MGMT	1.0	0.95	0.95
CM.TECHO	0.95	0.85	0.95
CM.VERIF	0.85	0.90	0.85
CM.STND	0.93	0.95	0.95
CM.APRCH	0.92	0.95	1.00
CM.EXPRN	0.98	1.0	0.92
CM.STBL	0.92	0.95	0.90
CM.MANN	L	H	M

GLOSSARY

AFLC	Air Force Logistics Command
AFSC	Air Force Systems Command
ATM	Activity Timing and Manpower Data
Box.Proc	The label assigned to the Simulator Event Notice type which proceses each Model function box
CCI&C	Code, Compile, Integrate and Checkout
CDR	Critical Design Review
CI	Configuration Item
CPCI	Computer Program Configuration Item
CPDP	Computer Program Development Plan
CPC	Computer Program Component
CPT&E	Computer Program Test & Evaluation
CRISP	Computer Resources Integrated Support Plan
CSDCA	Center for Software Data Collection and Analysis
DELIV	Deliver
DEV	Develop
DID	Data Item Description
DIG	Developmental Integration Group
DOC	Document
DSGN	Designer
ECP	Engineering Change Proposal
ESD	Electronic Systems Division
FACIL	Facility

GLOSSARY (Continued)

FCA	Functional Configuration Audit
Flow	The label assigned to the Simulator Event Notice type which controls box-to-box transition
FQT	Formal Qualification Testing
FSD	Full-Scale Development
HiSim	High Simulation Level
I&C	Integration and Checkout
LoSim	Low Simulation Level
MGMT	Management
No.Succ	Decision Box Successor List (if "No" Exit is Taken)
ORG	Organize
OTD	Occurrence and Timing Data
PCA	Physical Configuration Audit
PDR	Preliminary Design Review
PERT	Program Evaluation and Review Technique
PM	Program Manager
PMR	Program Management Review
PO	Program Office
PQT	Preliminary Qualification Testing
Pred	Function Box Predecessor List
PROC	Procedure
PRGM	Program
PRGMRS	Programmers

GLOSSARY (Concluded)

PROD	Produce
PROJ	Project
QUAL	Qualification
RFP	Request for Proposal
SARE	Software Acquisition Resource Expenditure
SCEWG	Software Cost Estimation Working Group
SEMP	System Engineering Management Plan
SPEC	Specification
SPRT	Support
SYS	System
TAC	Tactical Air Command
TEMP	Test and Evaluation Master Plan
TIG	Test Integration Group
TOI	Computer Systems Engineering Directorate
Yes.Succ	Function Box Successor List (if "Yes" or Only Exit it Taken)