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PRODUCTION MANAGEMENT AND CONTROL SYSTEM

PROGRESS REPORT #2

(Planning Document)

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Prepared by

/CONTRACTOR PROMACS TEAM

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TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION AND SUMMARY

This first section is intended to serve as a condensed version of the total report. This is accomplished by augmenting the usual introductory material on background, purpose, and organization with a fairly comprehensive summary of the report. Thus, this section can be used to glean the key points of the total report prior to complete perusal of the report; it can also be read in lieu of the total report by individuals who have no need to delve into the details contained in subsequent sections.

A. Background

1. Original Concept of PROMACS

On 24 January 1966, a joint ACIC/Contractor group began data collection and analysis efforts to determine the requirements for a computer-assisted PROMACS for ACIC. In the earliest stages PROMACS was conceived as a management tool to be used essentially by the Production and Distribution Plant for production planning, scheduling, and controlling activities in support of chart production goals in any given year.

2. Expanded Concept of PROMACS

a. The joint ACIC/Contractor study group published its first PROMACS progress report on 14 April 1966. This report and formal briefings on their findings were reviewed by ACIC during May 1966. From the report and the briefings it became obvious that PROMACS had been expanded to include all ACIC elements which actively influenced or required production programming, scheduling, and status data from ACIC's primary mission functional area. As a result, the group recommended the development of a broadly based PROMACS to achieve four major objectives:

(1) Integrated Production Status Reporting System

(2) Production Planning Factors Data Base

(3) Computer Assisted Production Scheduling Model

(4) Production Cycle Simulation Model

b. ACIC generally concurred with these findings and the recommendation that first priority be given to the development of an Integrated Status Reporting System. However, ACIC also felt that prior to detailed PROMACS design and development there was a need for a clearer indication of the interrelationships of all PROMACS objectives, a more comprehensive description of the proposed objectives, and a time-phased development plan for achieving these objectives. Accordingly, in June 1966 ACOC directed the group to prepare a planning document which addressed these needs.

B. Purpose

This report constitutes the required planning document and has three major purposes:

1. To restate the overall PROMACS operational concept and clarify the interrelationships between the four basic objectives.

2. To propose the long-range phases of the PROMACS objectives, and the ACIC Contractor group's short-range activities in the initial development of these objectives.

3. To present preliminary design descriptions of the four PROMACS objectives.

C. Organization

This document is divided into five sections:

1. An introduction and summary which provides an overview of the document's key points.

2. A redefinition of the overall PROMACS concept predicated on the restricted scope of PROMACS within the context of a total ACIC Management Information System.

3. A description of the proposed time-phased development activities of the PROMACS concept.

4. A fairly detailed, but preliminary design description for each of the four PROMACS objectives.

5. A listing of conclusions and recommendations.

D. Summary

This document: 1) presents the scope, and thus the limitations, of PROMACS as presently conceived, 2) shows the logical phases of development to be followed in order to convert concept to reality, and 3) discusses all available design aspects considered to date for each PROMACS objective. A summarization of sections II-IV, which details each of these three areas, will follow. The conclusions and recommendations (section V) will be repeated verbatim.

1. PROMACS - Operational Concept

In reviewing reactions to the preliminary operational concept for PROMACS, it appeared to the ACIC/Contractor group that a strong possibility existed that PROMACS was being viewed as a total ACIC Management Information System. In order to place the PROMACS operational concept into proper perspective, the group decided to first describe the role of PROMACS as one of several sub-systems in a total ACIC Management Information System. Once this was accomplished, a restatement of the overall PROMACS operational concept was prepared.

a. PROMACS and a Total ACIC Management Information System

(1) PROMACS is a prime management tool for the production (primary mission function) area of ACIC. Organizationally its key users are the Directorate of Operations and the Production and Distribution Plant. It is identified with the Production sub-system in a conceptualized total ACIC Management Information System comprised of the following sub-systems:

- Production
- Personnel
- Material
- Accounting
- Administration

(2) Because of the nature of ACIC's primary mission function PROMACS will supply a large segment of ACIC's management information needs; nevertheless, PROMACS is still something less than a total management information system. For example, PROMACS can predict a certain skill level shortage which will impact production, and present the problem to Personnel for resolution. To properly address the problem, the Personnel - not PROMACS - sub-system should have detailed information available on such items as: proper recruitment actions, civil service standards, register listings, most likely source of applicants, probable GS rating needed to attract personnel, availability of in-house training courses, etc. Thus, PROMACS interacts and has data exchange with each of the other sub-systems. However, resolution of problems within a functional sub-system area must be resolved by the sub-system managers on the basis of function-oriented data available to them through their sub-system - not PROMACS. This concept does not exclude the feasibility of a master data base containing data required by each of the five sub-systems. By use of a

master data base duplication of basic data usable by all sub-systems would be minimized or eliminated.

b. Operational Concept of an Overall PROMACS

(1) The four basic objectives recommended for achieving PROMACS are essentially unchanged and designated as follows:

- PROMACS Data Base
- Integrated Status Reporting System (ISRS)
- Computer Assisted Programming/Scheduling (CAPS) Model
- Simulation Model

(2) At that point in time where all objectives of PROMACS have been achieved, the sequence of operations in a typical PROMACS cycle would generally be as follows:

- ACIC management, programming and production analysts query the Simulation Model for optimum alternatives in allocating resources to meet the year's production goals or unprogrammed assignments.
- The Simulation Model produces mathematically optimum alternatives based on total available resources and requirements information drawn from the PROMACS Data Base.
- ACIC management applies human judgment factors to the mathematically derived alternatives to account for institutional and personnel considerations. These factors establish the parameters which are input as constraints to the CAPS Model.
- The CAPS Model accepts the parameters, and draws from production and resources information in the data base to output production programs and schedules. The data base is automatically updated with the new programs and schedules in order to support the ISRS.
- In support of the ISRS the PROMACS Data Base furnishes the information for computer generation of recurring status reports. It also

furnishes accurate, timely, and complete data at various levels of summarization in order to assist the ISRS in responding to special queries.

(3) Thus, the overall PROMACS will meet ACIC's production management requirements of providing:

- Integrated, stratified production status reports.
- Computer assistance to the programming and scheduling functions.
- Computer assistance to determine alternatives for optimizing allocation of resources to programmed and unprogrammed assignments.

2. Proposed Development Plan for PROMACS

The proposed development plan for PROMACS is presented in text and PERT chart form in section III for both the long-range development (to COC) and the short-range activities (to 1 December 1966). For purposes of this summary the PERT charts have been generalized to show significant milestones in Gantt chart form (Figure I-1 and I-2). In addition there is a brief discussion on PROMACS computer equipment requirements.

a. Long Range Development of PROMACS Objectives

(1) PROMACS Data Base

The data base will be developed in three major phases as follows:

Phase I - Contains information required to support selected production status reports in support of the first phase of the ISRS.

Phase II - Expanded to support additional ISRS requirements, and the first phase of the CAPS Model which will match gross resources against requirements.

Phase III - At COC the data base will be supporting a greater variety of status reports internal and external to ACIC. It will also support the second phase of the CAPS model and the first phase of a preliminary

PROMACS MAJOR MILESTONES (LONG RANGE)

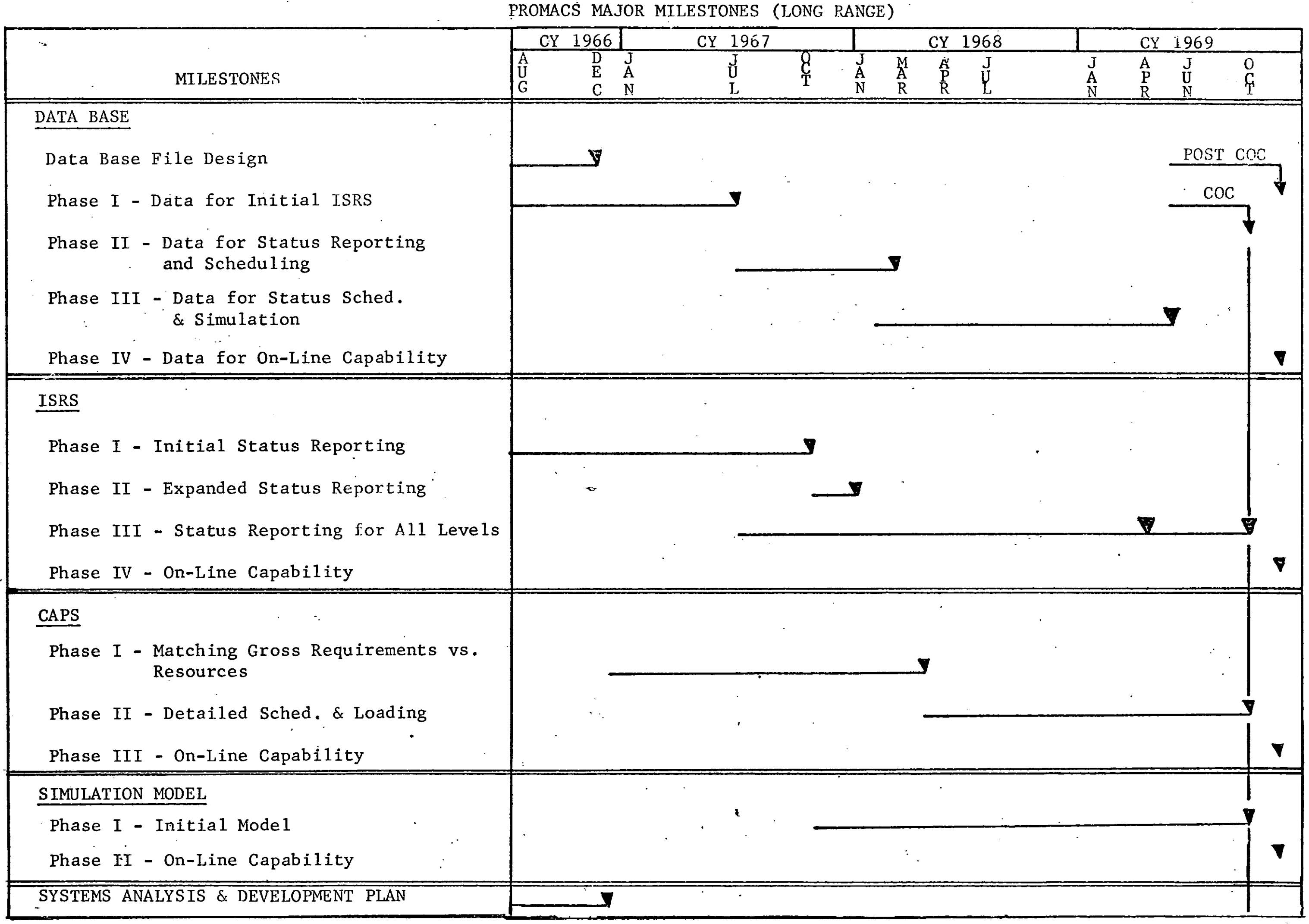


FIGURE I - 1

Simulation Model. Data will be structured along chart process lines so that programming, scheduling, and simulation activities can be investigated for end item products, using all or varying combinations of the charting processes.

(2) Integrated Status Reporting System

The ISRS will be developed in four major phases as follows:

Phase I - Maximum use will be made of the computer for production of reports on status of jobs in work and completions.

Phase II - Additional users will be serviced at this point with reports on performance of personnel, and utilization of equipment and material in addition to job status reports.

Phase III-1 - Status reporting can now be accomplished on a process as well as end item basis. This will permit automatic reporting at more definitive and meaningful points in the production cycle to a greater variety of users.

Phase III-2 - Status reporting data will be automatically updated by programming and scheduling changes incorporated into the data base by the second phase of the CAPS Model. Furthermore, all normal recurring textual status reports will be computer generated, and special query status reports can be more easily collated with computer assistance.

(3) Computer Assisted Programming and Scheduling Model

The CAPS Model will be developed in two major phases as follows:

Phase I - Primarily useful as a planning instrument. Major outputs will be gross listings of alternatives in which resources may be matched against requirements, both for the current year and the seven year period of the Consolidated Intelligence Program (CIP).

Phase II - A sophisticated representation of ACIC's programming and scheduling procedures. The model will draw from data formulated on chart processes to program and schedule the allocation of resources on the basis of human input constraints defining priorities, time, specific resources, etc.

(4) Simulation Model

The first phase of a preliminary simulation model will be able to generate optimum alternatives to resource allocation problems on the basis of total requirements and available resources. Only quantifiable constraints can be imposed, thus creating the greater flexibility to present management with more choices to which human factors judgments may be applied for determining the final course of action chosen.

b. Short Range System Design and Analysis Activities

Planned short range activities call for division of the group efforts into the two primary areas of: 1) defining the data elements in the PROMACS data base in order to begin implementation of the ISRS, and 2) refining the analysis of the overall PROMACS operational requirements and functional description. The milestones depicted in Figure I-2 or the PERT chart (Fig. III-3) in section III form adequate descriptors of the detailed activities planned.

c. Equipment Requirements

(1) Current Needs and Status - The ACIC calendar year 1966 CIP specifies remote communication stations and data collection devices for the use of PROMACS starting in FY 67. Although this equipment will be needed, it is not required as early as stated in the CIP. The data gathering devices will be required in FY 68. The remote communication stations should be available by FY 70.

(2) Anticipated Equipment Characteristics - The initial phase of PROMACS will use a RCA 501 computer, card to tape batch processing, and a

PLANNED ACTIVITY (SHORT RANGE)

ACTIVITY	CALENDAR YEAR 1966			
	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
I. INTEGRATED STATUS REPORTING SYSTEM/DATA BASE				
A. Design				
1. Review existing Systems & Requirements				
2. Define System Formats & Procedures				
3. ACIC/PRC Mgmt. Review & Concurrence				
4. Phase I ISRS Design				
B. Equipment				
1. Define Equipment Requirements				
2. ACIC Review & Concurrence				
C. Software Program				
1. Define Programming Requirements				
2. Finalize Write-Ups & Assign ACIC Programmers				
3. Assign Contractor Programming Support				
D. Data Base (Data Requirements)				
1. Define Data Elements & Storage Requirements				
2. Complete Phase I File Design				
II. SYSTEM ANALYSIS AND DEVELOPMENT PLAN				
A. Preliminary Design				
B. Draft Report				
C. ACIC Review & Concurrence				
D. Analysis Documentation (SA & DP)				

FIGURE I - 2

sequential access data base. This configuration will be used to produce the early status reports, but its utility for the total PROMACS is limited. In order to realize the full potential of PROMACS, a real time, on-line system is anticipated. Such a system will utilize a computer with time-sharing capability, a random access mass storage device, remote communication stations, and on-line input/output capability. This system will be able to interrupt a process, respond to a query, and then continue with the original processing. Random access mass storage will allow the accessibility of data that will be required for the PROMACS objectives. Man to computer communications from remote stations will allow the full use of the computer and the data base for programming and scheduling, and for determining the effect of proposed solutions to a production problem.

3. Preliminary Design Description for PROMACS Objectives

This section provides as much detail as is currently available on the design characteristics for each of the four PROMACS objectives. The information essentially furnished on each objective is a general description, an analysis of the input/output data elements, the manner in which the data is manipulated, and the relationship of a given objective to the other PROMACS objectives.

a. PROMACS Data Base

(1) The PROMACS Data Base will be a comprehensive collection of management information ultimately stored on a random access magnetic storage device and operated on by a computer. The data base will be one set of co-ordinated files in which minimum or no duplication of basic data exists. It will be a store of up-to-date, accessible, unit data comprehensive enough to serve as the base for preparation of any required primary mission function

information or report. Thus, it will serve as the nucleus of the PROMACS in direct support of the ISRS, and CAPS and Simulation Models.

(2) Historical and in-process information on individual jobs will be carried by the data base until the job is completed. At the end of a fiscal year, the entire data base will be printed out for permanent record purposes.

(3) The PROMACS data base can also serve the secondary purpose of furnishing varied format outputs of its contents to those offices not directly concerned with production but able to use aspects of the production data in support of their assigned functions. Thus the PROMACS data base could be the origin of a total management information system data base. To accomplish this, the basic units of data will be structured in a manner that is not directed towards the requirements of any particular organizational function or report.

(4) The data base will be divided into two major categories with four prime elements of data in each category as follows:

Production Category	Resources Category
. Planned Production	. Personnel
. Production Status	. Materiel
. Process Definitions	. Equipment
. Production Standards	. Contract

(5) The main function of the data base will be to provide data for status reports, computer programming and scheduling, simulation activities, and answers to special queries bearing on accomplishment of primary mission objectives. However, because of the large amount of data necessary to support PROMACS, this data base could serve as the foundation for a master data base servicing the total ACIC management information system conceptualized in section II.

b. Integrated Status Reporting System

(1) The ISRS will be a management tool utilizing an Electronic Data Processing System to provide all levels of ACIC management with pertinent data to assist them in planning, scheduling, and controlling the production effort. The reporting system will be oriented to the evaluation of production status and performance. The goal of the reporting procedures will be to provide management with quick access to reliable information for timely decision and dynamic control actions. Therefore, the reporting system will be designed to provide status information on the basis of one week's normal cycle reporting span. In addition special high priority reports on weekly activities will be available in a few hours.

(2) The concept of integrated status reporting does not visualize a rigid reporting format for all organizational elements. Although some degree of standarization will be possible for common data, individual reports will be flexible and structured to present significant facts and useful information on which management officials can act quickly. To this end, the reports will contain, among other things, job status, manpower, equipment, material resource, contract, and performance data. Production performance and related information will be summarized against individual line item numbers as contained in Format Six of the Consolidated Intelligence Program (CIP).

(3) In general, ACIC management personnel have a requirement for timely information of three principal types for planning, scheduling and controlling production as follows:

- Long range programs and requirements - This type of information is required by upper management levels at ACIC to maintain an awareness of those factors which could affect future operations of ACIC.

. Assignments in the production process - Information in this category is of high value to the Production and Distribution Plant for scheduling and controlling items in work.

. Assignments produced - This category of information is needed to permit analysis of production accomplishment at periodic intervals to determine schedule slippages and identify potential and actual problem areas.

(4) Data input requirements in support of the ISRS center on utilization of personnel, material, equipment, and contract activities as related to a specific job. The type of information generally required will be that contained on current daily labor cards, material cost cards, equipment utilization cards, and contractor activities. With this type of minimum input data, many varied output report formats can be devised. This input/output relationship between ISRS data elements is reflected in the table forming Attachment 1.

(5) A representative listing of the types of reports which can be produced by the ISRS in its early development phases is as follows:

- Job Status
- Completion
- Program Analysis
- Resource Utilization
- Manning Status
- Quality Control

(6) A standardized coding system will be used to provide systematic integration of reports for various levels of ACIC and external management. The coding system will include, but not be limited to such items as:

- Line item codes
- Specific assignment numbers
- Job identification numbers
- Skill designators
- Function designators
- Specific operation codes
- Quality control codes
- Resource accountability codes
- Cost center codes
- Direct material cost codes
- Others

c. Computer Assisted Programming and Scheduling

(1) Computer assisted programming and scheduling is a technique whereby the large memory and the rapid, accurate computational capabilities of a computer are combined with the experience and judgement capabilities of technical personnel to perform programming and scheduling functions. The general pattern in computer-assisted programming and scheduling can be divided into the following steps.

- Problem definition
- Input to the computer
- Computer processing
- Data output from the computer
- Data analysis
- Use of simulation model (optional)
- Programming/Scheduling action
- Updating the data base
- Reiteration of previous steps (as required)

(2) Computer assisted programming and scheduling will utilize information contained in the following elements of the PROMACS data base:

- Material status
- Manpower status
- Equipment status
- Contract status
- Process definition
- Production standards
- Production
- Planned Production

(3) The computer software package will be designed to produce data useful in the preparation of Format Six to the CIP, Allocation of Resources and Production Commitments Document, Production Plans, and Production Schedules geared to various organizational and functional levels. This will require job inputs showing:

- Complete job identification number.
- Type of job and degree of difficulty.
- Time period requirements.

(4) For each job input processed, summary listing outputs will include such factors as:

- Total resources used in each selected time period.
- Totals for each of the CIP seven year time periods.
- Projection of the status of each resource pool, based on the status as of a given starting date.
- Grouping of resources projected to be used by each Division for each time period.
- Grouping of resources used for each program for selected time intervals.
- Listing of each job in order of start time grouped by branch and section.
- Exception reports which will pinpoint jobs and time periods in which there is a conflict between resources scheduled and resources available.

(5) Typically the PROMACS will support computer-assisted programming and scheduling in a four-step sequence. The first step is the analysis of the available data provided by the ISRS. The second step is the job definition manual input. The computer-assisted programming and scheduling software package, utilizing the data base, will provide a preliminary schedule and pertinent summary data on resource status versus requirements. During the third step the analyst will evaluate this data. If conflicts exist he may elect to utilize the Simulation Model to obtain additional information and alternatives. The programming and scheduling decisions are then made and the data base is updated during the fourth step. Thus, the combined utilization of the CAPS Model supported by the PROMACS Data Base, ISRS, and Simulation Model forms a powerful tool to aid in the iterative process of allocating resources to jobs and placing them in the production pipeline. This technique will liberate programming and production analysts from time-consuming details and allow them to sharpen their focus and refine their judgments. The currency, completeness, and accuracy of available information will provide considerable assistance in making more accurate programming predictions, and more timely scheduling decisions.

d. Simulation Model

(1) An ACIC Simulation Model will be a dynamic, mathematical representation of the production cycle that will be used to experimentally solve "real-life" production problems in an abstract form. The representation will be operated on by a series of mathematical techniques and procedures, such as linear programming, Monte Carlo theory, and queuing theory, in order to equate the many variables and constants that will be used in the representation. The model will be designed so that outside parameters, such as process calendar

time, can be varied and the effect of their change on the production cycle can be determined.

(2) In an effort to relate this formal description of the Simulation Model to day-to-day problems, three possible applications to the ACIC processes of programming, scheduling, and impact analysis are presented below:

- Programming - One example of a programming situation in which a simulation model would have been helpful was in determining how to handle the increased JOG program outlined for FY 65. The situation called for an increase in the number of JOG's over the number previously programmed with minimum impact on other programs, and without a significant increase in available personnel. With a fixed amount of manpower and a requirement to increase the volume of output, the obvious alternative was to increase the use of contract dollars. Since all parts of the JOG program could not be contracted, the problem became one of selecting the best combination of assignments, either in process or programmed, that could be contracted to outside companies (staying within the amount of additional contract funds that were available), thereby freeing the personnel needed for the JOG program. This type of programming involves shifting programs, matching resources with requirements, and analyzing approaches. A simulation model composed of variations of standard allocation and queuing operations research models will be a powerful tool in solving this type of problem.

- Scheduling - Use of a model in a scheduling problem would take a list of defined jobs (defined in terms of priorities and job types) and investigate the alternatives available in placing these jobs in the existing production pipeline. Constraints will also be provided to define the initial boundary conditions of the problem. Examples of constraints would be, priority of jobs which can and cannot be removed from the pipeline, degree of completion which would preclude a job from being removed, time period being considered, assigned completion date, and any other factor which would define the boundary conditions and restrict the number of possible solutions. The model would analyze the problem and its limits, and provide a list of solutions which would meet all the conditions and a listing of exceptions. Ideally, the various alternatives and their predicted impact would be shown. From this list of alternatives a solution could be selected. For example, the solution could show a list of jobs that could be worked in the given time limit with all constraints applied. There may be many combinations that would meet the boundary conditions, and the problem definition must set the limit of acceptable solutions. The problem may be to find the best order in which to work jobs with a fixed amount of manpower in the shortest amount of time. The solution, in effect, would establish an optimum schedule. The basic operations research models pertaining to the scheduling problem are the allocation, queuing, sequencing, and routing models.

- Impact analysis - Probably the most sophisticated use of a simulation model will be in analyzing the impact of unprogrammed and unscheduled changes on the existing operation. If a new job or a change to an existing job is contemplated, what effect will it have on the present schedule? Will some items be dropped? If so, which ones? Should some schedule items be extended? What is the best approach so as to minimize the disruptive effect? There are many different approaches, depending on which factors are defined as being most important. For example, the model could provide an alternative based on not bringing in personnel from other divisions. It could provide alternatives based on using contract dollars, or not using contract dollars, with all other variables remaining unchanged. The basic operations research models used in this type of problem are the allocation, queuing, sequencing and routing models.

(3) In the ACIC Simulation Model any one or combinations of the eight basic operations research (OR) models may be useful. A brief description of the primary use of these OR models follows:

- Inventory models help in deciding how much to order, when to order, how to balance inventory, carrying costs versus set-up costs, etc.
- Allocation models assist in choosing among alternatives in performing a task and the best combination of existing resources and facilities to maximize overall effectiveness. Examples include determining optimum use of facilities, scheduling, and allocation of financial and manpower resources. This model has the greatest potential use in the ACIC production process.
- Queuing models work on "bottleneck" problems. A queuing problem arises when people or units requiring service arrive at a service point at which facilities may or may not be available. The problem is to serve the maximum number of customers with the least number of facilities, and to prevent idle facilities, inventory, and manpower.
- Sequencing models deal with determing in which order units should be processed to minimize total elapsed service time.
- Routing models deal with defining the optimum sequential path that must be followed in performing a process.
- Replacement models deal with replacement schedules for equipment in order to minimize overall cost without loss in efficiency.
- Competition models deal with selecting strategies when people are in conflict.
- Search models deal with systematically filing information for maximum ease in retrieval and information flow.

(4) Characteristics and limitations - There are several characteristics that should be emphasized in the application of simulation model problem solutions:

- Models should be used on problems that are recurring in nature.
- The problem should provide an opportunity to choose between various courses of action.
- The problem should have a large number of controlled variables and a small number of relevant uncontrolled variables.
- The possibility should exist to evaluate results readily.
- The problems should be large and complex as well as current and pressing.

There are also several limitations that should be kept in mind:

- Simulation models are, at best, only an approximation of the real situation.
- Operations research is usually limited to the study of tangible and measurable factors. Many intangible and qualitative factors, such as human behavior and motivation must also be considered in a management decision. Therefore, human judgment factors must often be applied to transform the mathematically optimum solutions into the most acceptable solution from the institutional and personnel point of view.
- Good operations research studies are lengthy, complex, and expensive.

(5) The ACIC production cycle Simulation Model will be useful as an aid in determining the impact on production of a potential new assignment, and in allocating resources to meet the production program in the most efficient manner. It will provide the capability of analyzing alternative solutions to a production problem through the use of operations research techniques. These mathematically optimum alternatives can be modified on the basis of human judgment factors before inputing the parameters to a CAPS Model which will produce the programs and schedules reflecting the course of action taken. The importance

of the Simulation Model is that it affords ACIC management the opportunity to compare the degree of sub-optimization (modification) chosen against the theoretical optimum generated by the model. Thus, there will be a greater emphasis on careful determination of the human factors used, and a correspondingly stronger justification for the course of action finally taken.

4. Conclusions and Recommendations

a. Conclusions

(1) Within the context of a total ACIC Management Information System, PROMACS forms the major sub-system conceived to support the ACIC primary mission function.

(2) PROMACS, as conceived, constitutes a feasible, cohesive, and necessary management information and control system for the ACIC primary mission function.

(3) Overall PROMACS development is long-term and evolutionary in nature.

(4) The PROMACS Data Base could be eventually expanded into a master data base supporting a total ACIC Management Information System.

(5) The ISRS can be implemented in the shortest time frame, and result in improved management knowledge of job status and performance. This knowledge will result in more timely corrective action by management to alleviate identified problem areas.

(6) The CAPS Model will furnish more timely and accurate data for planning and controlling the allocation of resources to meet ACIC primary mission objectives.

(7) The Simulation Model will furnish mathematically optimum alternatives for total ACIC resource allocations to meet primary mission objectives.

ACIC management can accept these alternatives or choose the best level of sub-optimization on the basis of organization, function or personnel considerations.

b. Recommendations

(1) That ACIC accept the long range development phases presented by this report for the overall PROMACS.

(2) That ACIC concur in the short range PROMACS analysis and design activities outlined for the ACIC/Contractor team through 1 December 1966.

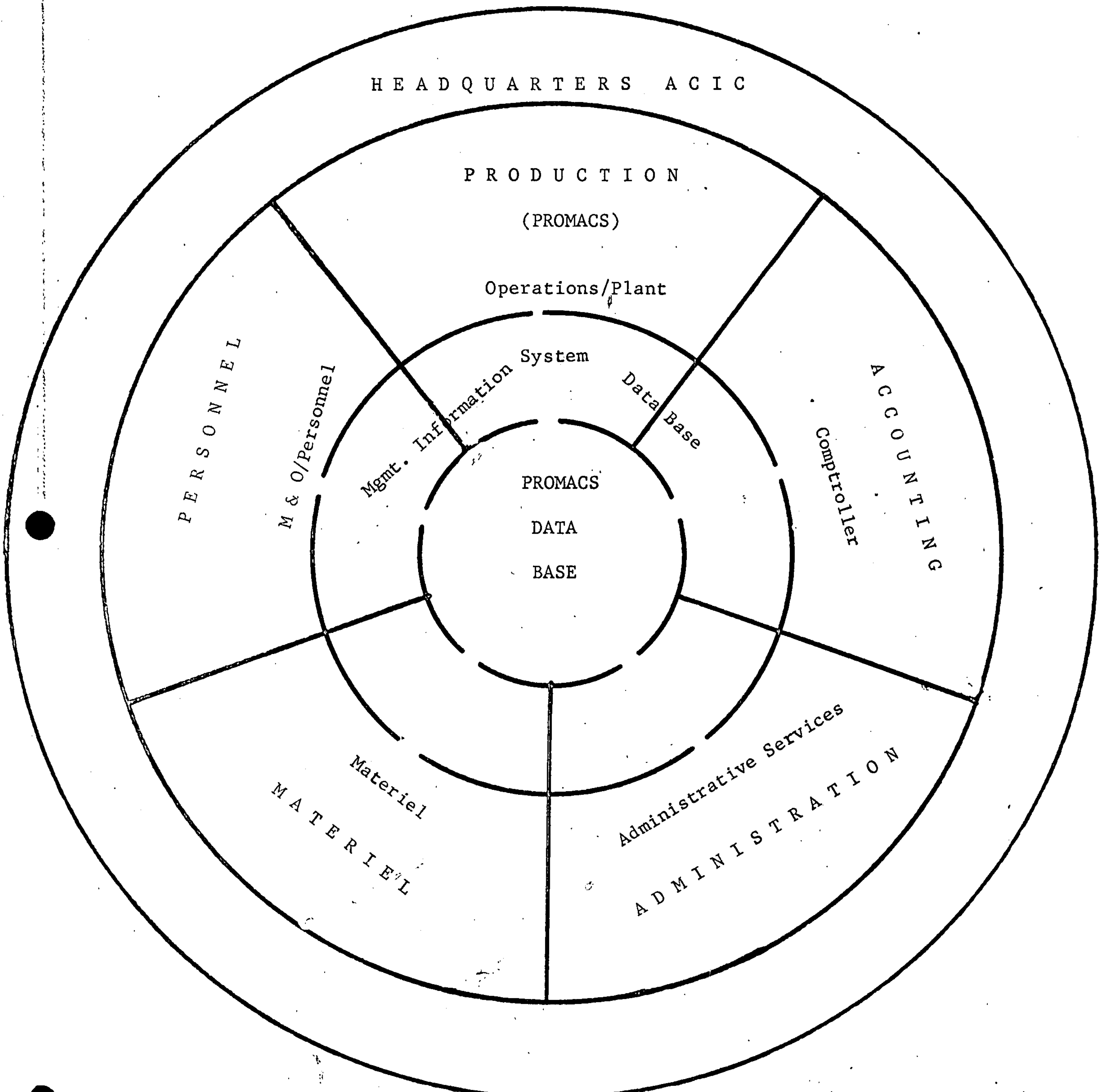
II. PROMACS - OPERATIONAL CONCEPT

The purpose of this section is to describe the scope of the PROMACS within the context of a total ACIC management information system, and to present an integrated operational concept of the preliminary PROMACS objectives described in the PROMACS progress report of 14 April 1966.

A. PROMACS and a Total Management Information System

The ultimate goal of an effective management information system is to keep each manager (supervisor) informed on those activities, developments, or problems in the total organization which affect his decision-making authority. Optimally, such a system provides accurate, timely data permitting effective action in the management functions of planning, organizing, directing, measuring, and controlling.

The Production and Management Control System (PROMACS) to be described in this report is but a segment of what is currently defined in management and data processing technology as a Management Information System. Some authors, in order to emphasize the scope of such a system, use the title, "Total Integrated Management Information System." As the words imply, such a system encompasses the total management information needs within an organization. Because of the nature of ACIC's primary mission function, PROMACS will supply a large segment of ACIC's management information needs; nevertheless, PROMACS is still something less than a total management information system. Thus, to place PROMACS into proper perspective, it is desirable to look at the relationship of PROMACS in a conceptualized total ACIC Management Information System. This relationship is portrayed graphically in Figure II-1. The significant aspects of this depiction are highlighted below:



TOTAL INTEGRATED ACIC MANAGEMENT
INFORMATION SYSTEM

Figure II - 1

1. The five functional or sub-systems comprising the total ACIC Management Information System envisioned are:

- o Production (Operations and Plant)
- o Personnel (M & O and Personnel)
- o Material
- o Accounting
- o Administration

2. Each sub-system or functional area has its own unique requirements for acquiring and maintaining operational data in the performance of its specific responsibilities. The day-to-day operational data will not be an integral part of the PROMACS data base. For example, PROMACS may identify a certain skill level shortage based on planned production schedules. The Personnel sub-system, by virtue of maintaining detailed data in recruiting activities, civil service standards, source of applicants, register listings, GS ratings, training programs, etc., can react within its functional area and inform upper management as to what actions must be taken to resolve the shortage.

3. There is an exchange of data by those activities in other sub-systems which affect management decisions in a given sub-system. For example, the Production (PROMACS) sub-system will provide information to the Materiel sub-system on the actual and projected uses of materials. The Materiel sub-system could use this information to show current inventory levels and a projection of levels. The projection could be reported weekly to show variances between actual and projected levels, to flag items exceeding pre-determined allowances, and to maintain inventory levels in accordance with economic reorder policies.

4. All sub-systems feed summary data to ACIC Headquarters or the designated management elements who assess the effectiveness of total ACIC performance in meeting mission objectives. The nature and frequency of management information reports in such a system are tailored to the needs of the user: detailed status information for lower level management; monitoring and control information for middle management; status and performance information for upper level and top management. Reports going to upper level and top management would normally be of a summary type, based on management by exception. These reports would alert management to existing or potential problem areas requiring corrective action, and avoid burdensome statistics on areas which are performing within the tolerance of established standards.

The system diagrammed in Figure II-1 represents a long-term (5-10 years) development of a total management information system. The computer hardware for this type of system exists today. The scope and potential impact of a total management information system requires careful long-term planning to assure effective management use and organization integration. It is not the intent of this report to propose a total ACIC Management Information System. Nonetheless, the activities and scope of the ACIC production cycle is such that the development of the proposed PROMACS will constitute the foundation from which a total ACIC Management Information System could evolve. Consequently, one of the prime considerations of the PROMACS operational concept and system design will be the flexibility of the system in moving towards a total Management Information System.

B. Operational Concept of an Overall PROMACS

As a result of the preliminary analysis of the production management cycle at ACIC, three major requirements of a production management system were determined. The system should:

1. Provide integrated, stratified production status reports based on a one-week reporting cycle and a currency of three days.

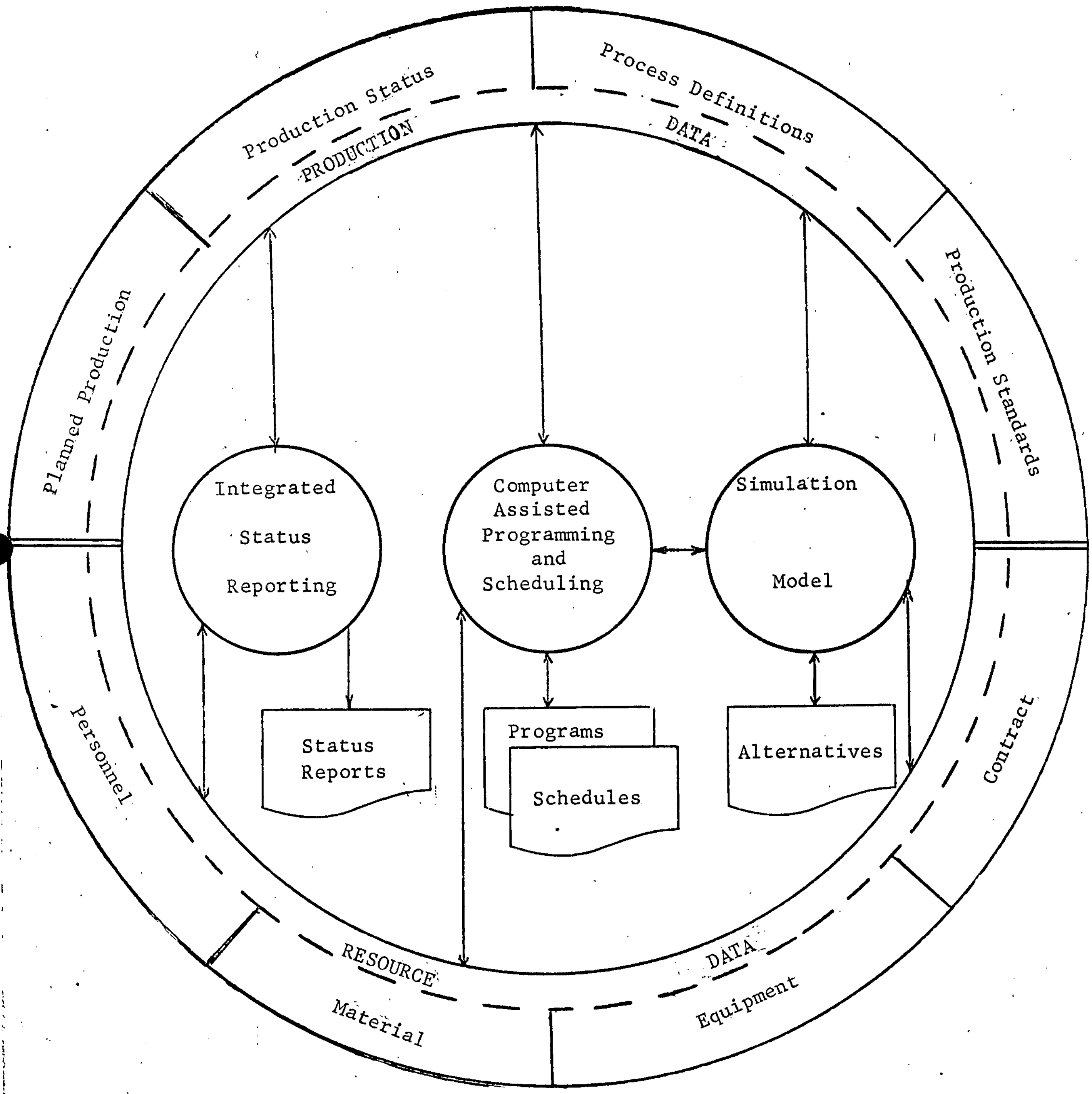
2. Provide computer assistance for the programming, scheduling, and loading of assignments.

3. Provide computer-assisted operations research techniques that will aid in selecting the best alternative for allocating resources to programmed assignments and for determining the impact of unprogrammed, unscheduled assignments on production goals.

To meet these requirements, the PROMACS will consist of a centralized Data Base, an Integrated Status Reporting System (ISRS), a Computer-Assisted Programming/Scheduling model, and a production cycle Simulation model. Figure II-2 represents a fully developed PROMACS, showing the interrelationship of the four objectives listed above. A brief discussion of the interrelationship follows:

The data base will serve as a central master file that will store and make available machinable data to the other parts of PROMACS. Basic data will be input to the data base by means of an electronic data gathering device. This basic data will include, but not be limited to the type of information presently contained on the daily labor card, material usage card, and equipment utilization card. In addition, production schedules, process definitions, personnel information, contract information, chart accountability, distribution, and inventory information will be stored in the data base. The responsible offices will update the data as required. Although the primary purpose of this master file will be to provide information for the other three PROMACS objectives, the information contained here will be available, as required, to all sub-systems in the total ACIC management information system.

PROMACS DATA BASE



INTERRELATIONSHIP OF PROMACS OBJECTIVES

FIGURE II - 2

The ISRS will be a management tool utilizing an Electronic Data Processing System to provide all levels of ACIC management with pertinent data to assist them in planning, scheduling, and controlling the production effort. The ultimate goal of this objective is computer generation of all recurring textual status reports, both within and external to ACIC. Information needed to prepare all reports will be drawn from the data base.

The Computer-Assisted Programming and Scheduling model will provide machine assistance to the functions of programming, scheduling, and loading of production assignments. Input data on job identification number, chart difficulty parameters, desired completion date, etc., and information stored in the data base on production status, resource availability, and process definitions will permit the prediction of resource requirements, production calendar times, and completion dates. In addition, the model will be able to load a new assignment into the production pipeline by determining when the needed resources will be available. New schedules generated by this model will be used to update the production status section of the data base.

The Simulation model will be a mathematical representation of the production cycle used as an aid in: (1) determining the impact of a potential new assignment, and (2) allocating resources to meet the production program in the most efficient manner. It will provide the capability of analyzing alternative solutions to a production problem through the use of operations research techniques which will mold the many variables and constants into a realistic representation of the programming and scheduling processes. Production status and resource availability information from the data base will be needed to evaluate some of the variables to be used in the model.

In an advanced form the overall PROMACS will provide status reports current enough and frequent enough to aid in controlling production, printing, and distribution. It will assist in preparing planning and programming documents, and scheduling of assignments. It will also provide a method for testing alternative solutions to production problems. Management will have the capability of directly querying the system to determine the status of a chart or the effect of a proposed solution to a production problem. Answers to a query could be available within minutes on a remote display console or in some other output form. PROMACS, as now visualized, will meet both current and future production management requirements at ACIC. The development of a PROMACS will be an evolutionary process. For example, the data base will evolve as data needs for the other objectives increase. During the initial design phases, the incremental developments will be placed into the framework of the overall concept to minimize potential redesign and computer reprogramming requirements arising from the total IDHS and ACIC electronic data processing developments.

III. PROPOSED DEVELOPMENT PLAN FOR AN OVERALL PROMACS

The proposed development plan for an overall PROMACS is presented in text and PERT chart form for both long-range, overall development of PROMACS (to COC) and short-range, design activities. In addition, a brief discussion on current and anticipated computer equipment requirements is presented in the third part of this section.

A. Long-Range Development of PROMACS Objectives

A summary PERT chart showing the long-range development of the overall PROMACS and the interrelationships and dependency of operational objectives through COC is given in Figure III-1. The development phases described below for each objective and the overall PROMACS are more easily related if the PERT chart is folded out for ready reference. The descriptions of each development phase are, of necessity, in general terms at this time. Any detail available for the basic operational objective is presented in the section on preliminary design descriptions.

1. PROMACS Data Base

Phase I - When this point of development is achieved, the PROMACS Data Base will contain only that information required to support publication of selected status reports for the first phase of the ISRS. This will constitute such production type data as job status, manpower utilization, dollar expenditure, etc.

Phase II - At this point of development it is anticipated that the data base will have been expanded to include information supporting additional status reporting requirements and data permitting achievement of the first phase of the Computer-Assisted Programming and Scheduling (CAPS) model. In support of the CAPS model, there will be a need for supplementary resource allocation information derived from the status reporting portion of the data base.

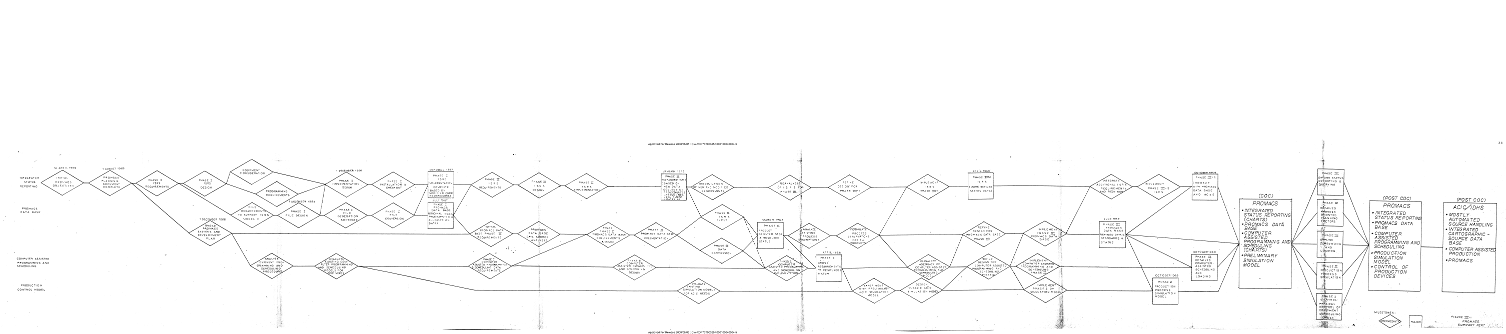


FIGURE III-1
PROMACS SUMMARY PERT

Phase III - In its final COC mode the PROMACS data base will have been broadened to support a greater variety of status reports at all required management levels within and external to ACIC. A basic change will also occur in the data required to support the second phase of the CAPS model and the first phase of a preliminary Simulation model. Data which had been product oriented will now be augmented by a process oriented data, so that programming, scheduling, and simulation activities can be used to investigate resource requirements for the production of any type of end product using all or varying combinations of the charting processes.

2. Integrated Status Reporting System (ISRS)

Phase I - In its initial development phase, the ISRS will bear much resemblance to current status reporting systems. However, collation, comparison, and summarization of status data for varying levels of management will be facilitated and broadened beyond the current system through the use of the computer. Prime emphasis will be on status of jobs in work and completions.

Phase II - Continuous analysis of user needs and utilization of status reports will permit expansion of the ISRS at this second phase. Additional users can be serviced and reports will be designed to provide wider ranging and more timely data on performance of personnel, equipment and material utilization, chart accountability, and distribution needs in addition to job status.

Phase III-1 - The ISRS at this phase of development can take advantage of the results of process definition formulations used to establish optimum sequencing of operations and resource allocations in performing the standard processes. This will permit status reporting at more definitive and meaningful points in the production process. It is anticipated that user needs for status data will shift accordingly, and that additional users may be identified.

Phase III-2 - The final COC phase of the ISRS will incorporate accurate and timely information from the second phase design of the CAPS model. Thus, "up-to-the-minute" job status and performances can be evaluated against computer generated programming and scheduling goals on a process as well as a product basis. Furthermore, at this phase of the ISRS development a complete hierarchy of level of detail and/or status reporting requirements will have been structured within the managerial pyramid of ACIC and DOD. Such a hierarchy may well take the form of the hypothesized matrices shown in Figure III-2. All normal recurring textual status reports will be computer generated, and special query status report requirements will be met more efficiently and effectively by use of computer collation of necessary status data.

3. Computer-Assisted Programming and Scheduling (CAPS)

Phase I - In its initial phase the CAPS model will be of principal use as a planning instrument. The major output will be gross listings of alternative ways in which resources may be matched against requirements. These listings will encompass the current and immediately succeeding year with a fair degree of validity. Through the use of: (1) historical statistical data drawn from the PROMACS data base supporting the ISRS, (2) input data on forecasted requirements, and (3) regression analysis techniques the computer model can also extrapolate gross matching of resources against requirements for the normal seven-year cycle of the CIP.

Phase II - In its final COC mode the CAPS model will have been developed into a much more sophisticated representation of the programming and scheduling processes used to plan and allocate resources for performance of ACIC's primary mission function. Existing computer scheduling models will have been thoroughly investigated and translated into the ACIC environment. In addition, the formulation of process definitions or descriptions for each

DATA MATRICES FOR DETERMINING MANAGEMENT INFORMATION NEED AT SUCCESSIVELY HIGHER LEVELS OF MANAGEMENT

Section (Branch)

Task \ Operation	Control Base	Manuscript Preparation	Radar Compilation	Intelligence Compilation
Prepare Projection	o			
Compute Source Maps	o			
Order Film Positives	o			
Make Panelled Base	o			
Compile Hydrography		o		
Compile Contours		o	o	
Prepare RSAC/RSPL		o	o	
Prepare Annotations and Text				o

Branch (Section)

Operation \ Function	Analysis or Data Prep	Compilation	Chart Construction
Control Base	o		
Manuscript Preparation	o	o	o
Radar Compilation		o	o
Intelligence Compilation		o	o
Aero. Info.		o	o

Division (Branch)

Function \ Job	322-12	352-8	400-1
Analysis or Data Prep	o	o	o
Compilation	o	o	o
Chart Construction	o	o	o
Reproduction	o	o	o

Plant (Division)

Job \ Sub-line Item	Compile/ Recompile	Revise/ Reprint
322-12	o	o
352-8	o	o
400-1	o	o

DIA, Operations, Plant

Sub-Line Item \ Line Item	JOG	ATC 200	PC
Compile/ Recompile	o	o	o
Revise/ Reprint		o	o

DIA, DOD

Line Item \ Major Program	Surveys & Data Procurement	Data Reduction Source Evaluation & Libraries	Production & Distribution St. Louis
JOG			o

FIGURE III-2

of the basic charting processes will contribute necessary data on optimum sequencing of tasks, resources required to accomplish these tasks, and the critical path of sequential tasks in any given process. The model will be constrained to consideration of those alternatives available on the basis of human input parameters demanding programs and schedules computed on the basis of given priorities, limitations on specified resources, time constraints, etc.

4. Simulation Model

Phase I - This first and COC phase of a primary mission function simulation model will be quite preliminary in nature. The model will be able to consider the optimum allocation of total ACIC resources and sequencing of jobs without regard to such constraints as: (1) use of skill levels within an organizational entity, (2) production on a normal shift basis, (3) scheduling impacts on personnel, and (4) political desirability of meeting certain requirements in a more expeditious manner, etc. Thus, the model can be used to produce mathematically optimum programs and schedules which management can evaluate against human judgment factors and choose to sub-optimize. The importance of the Simulation model is that it affords management the opportunity to compare the acceptability degree or sub-optimization chosen against mathematically generated optimums.

B. <u>Short-Range PROMACS System Design and Analysis Activities</u>

The short-range PROMACS system design activities are those activities which will be accomplished by the end of the current contract year, 1 December 1966. The PROMACS ACIC/Contractor team will be divided into several working groups to pursue the major objectives during this four-month period. The activities necessary to accomplish the objectives of: (1) defining the content of the PROMACS Data Base, (2) beginning the ISRS implementation, and (3) developing the overall PROMACS systems analysis and development plan are depicted on the detail PERT network (Figure III-3). The sections below briefly discuss these short-range systems design activities. These discussions and the interrelationships between activities are more easily related if the detail PERT network diagram is folded out for ready reference.

1. Define PROMACS Data Base and Begin Implementation ISRS Phase I

The milestones and supporting activities to achieve these objectives are:

a. Phase I ISRS Design - The team members assigned to this task will continue the study of both the manual status reporting system and existing automated status reporting system. This will include a review of available documentation, interviewing Division managers and key users to determine effectiveness of the present systems, and additional status information which could be of value. The information provided by the existing systems will be evaluated in context with the Phase I ISRS objectives. The result of this evaluation--the preliminary ISRS system design--will be reviewed with ACIC/PRC management to ensure that Phase I objectives are being accomplished. Upon completion of the initial management review the detail systems documentation will be developed. This documentation will include:

(1) Data Handling Procedures - procedures for the recording of input to the system, converting the recorded information to a machine processable media, and dissemination of reports.

(2) Reporting Schedules - scheduling of both input and output reporting cycles.

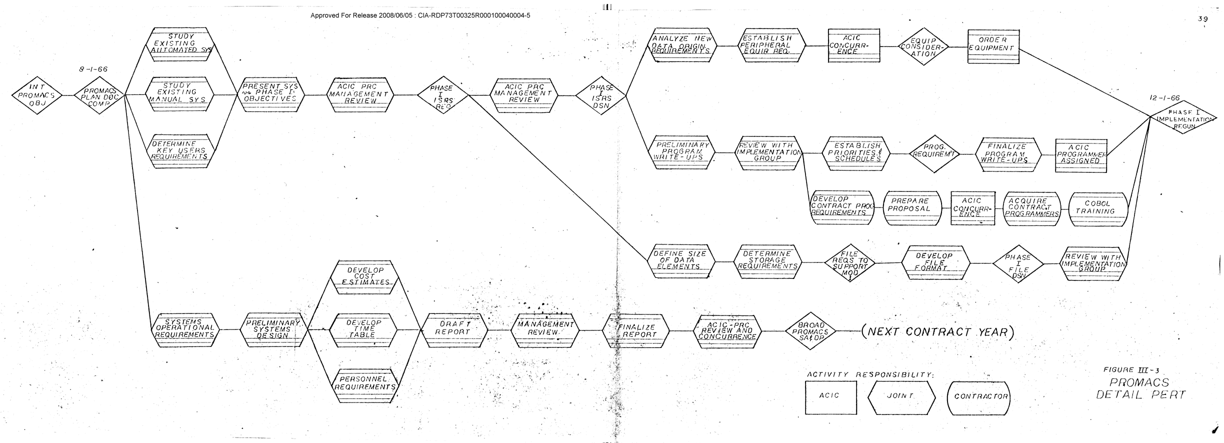


FIGURE III-3
PROMACS
DETAIL PERT

(3) Formats - design of input recording documents and layout of output reports.

The completed design will be reviewed with management for formal concurrence.

b. Equipment Consideration

This milestone will be concerned with the requirement for peripheral equipment to support the RCA 501. The increased data originating requirements brought about by need for additional information and more frequent reporting will be co-ordinated with cognizant ACIC divisions to determine effect on present workloads.

c. Programming Requirements - When management approval of the Phase I ISRS Design has been received the program write ups (detailed systems documentations) will be developed. This documentation will include data flow diagrams, description of file contents, format specifications, input/output specifications and a detailed description of the functions performed by the hardware, software, and personnel. The program writeups will be reviewed with the implementation group for content. Based on this review the implementation group will establish priorities and a schedule for software development and manpower requirements.

d. File Requirements to Support Model I - The data elements to be included in the Phase I data base will be analyzed for field size requirements, based on current and historical information. Since the initial data base will be maintained on the RCA 501, the quantified data elements must be grouped in logical subfiles to permit efficient handling.

e. Phase I File Design - Individual record formats will be developed for each of the data base subfiles.

f. Begin Implementation Phase - During this phase peripheral equipment will be ordered, documentation finalized, ACIC programmers assigned to the project, and contractor personnel assigned and trained in RCA 501-64 COBOL.

2. Systems Analysis and Development Plan

The other major effort of the PROMACS ACIC/Contractor team will be directed to the preparation of documentation on the Systems Analysis portion of the Systems Analysis and Development Plan for PROMACS. This involves a complete description of the System Operational Requirements and a refinement of the System Functional Description. Detailed design for all elements of the PROMACS and refined long-range development plans will be accomplished in the subsequent contract period.

The current contract year activities leading to documentation of the System Operational Requirements and Functional Description will include data collection and analysis on such items as:

a. Mission and organizational elements affected

b. Identification of users and service personnel

c. Current and projected functional requirements

d. Functional elements of current system(s) and work flow

e. Interface with other systems of IDHS

f. Gross resource and cost requirements

g. Anticipated benefits

h. Preliminary description of hardware and software characteristics

The documentation produced will represent a marked refinement of the preliminary design descriptions for the overall PROMACS contained in Section IV of this report. Furthermore, it will constitute a firm basis from which detailed design considerations and development phases for the overall PROMACS will evolve.

C. PROMACS Equipment Requirements

1. Current Needs and Status

The ACIC calendar year 1966 CIP specifies remote communication stations and data collection devices for the use of PROMACS starting in FY 67. Although this equipment will be needed, it is not required as early as stated in the CIP. The data gathering devices will be required in FY 68. The remote communication stations should be available by FY 70.

2. Anticipated Equipment Characteristics

The initial phase of PROMACS will use an RCA 501 computer, card to tape batch processing, and a sequential access data base. This configuration will be used to produce the early status reports, but its utility for the total PROMACS is limited.

In order to realize the full potential of PROMACS, a real time, on-line system is anticipated. Such a system will utilize a computer with time-sharing capability, a random access mass storage device, remote communication stations, and on-line input/output capability. This system will be able to interrupt a process, respond to a query, and then continue with the original processing. Random access mass storage will allow the accessibility of data that will be required for the PROMACS objectives. Man-to-computer communications from remote stations will allow the full use of the computer and the data base for programming and scheduling, and for determining the effect of proposed solutions to a production problem. Electronic data collection devices, connected on-line to the computer, will provide the means for keeping the information in the data base as current as possible.

IV. PRELIMINARY DESIGN DESCRIPTION FOR PROMACS OBJECTIVES

The purpose of this section is to provide as much detail as is currently available on the design characteristics for each of the four PROMACS objectives, namely:

- PROMACS Data Base
- Integrated Status Reporting System
- Computer Assisted Programming and Scheduling Model
- Simulation Model

Each of these objectives is described in a separate section, but each section contains frequent cross-references to the other objectives in order to provide system continuity. The information essentially furnished on each objective is a general description of the objective, an analysis or listing of the input/output data elements, the manner in which the data is manipulated, and the relationship to the other PROMACS objectives.

A. PROMACS Data Base

1. Description

The PROMACS Data Base will be a comprehensive collection of management information ultimately stored on a random access magnetic storage device and operated on by a computer.

The data base will be one set of co-ordinated files in which minimum or no duplication of basic data exists. It will be a store of up-to-date, accessible, unit data comprehensive enough to serve as the base for preparation of any required primary mission function information or report. In this manner, it will serve as the nucleus of the ACIC PROMACS in its direct support function of supplying needed information to the computer for the ISRS, the CAPS Model, and the Production Simulation Model.

A random access magnetic storage device will be required to accomodate the potential size of the PROMACS data base, and to permit expansion into a total data base if desired. Sequential storing devices, such as magnetic tape, are not large enough, within a practical number of storage units, to hold the volume of information expected to be contained in the data base. Studies of companies in private industry indicate that several billion characters of storage space are required to establish a central file for production and management information. A random access unit will allow the computer to select only that information needed at a given time without reading additional information. This results in minimum machine time processing and faster response time to queries.

The data base will be implemented in a time-phased manner. Information required for the ISRS will be developed first, since this objective will yield operational benefits in the shortest period of time. Supplemental information will be added to the data base in accordance with the phased development of the ISRS, the CAPS Model, and the Simulation Model.

Hard copy printouts of any information contained in the data base will be available whenever required by users. These printouts will give users exact knowledge of what is in the data base at any given time. Additions or changes to the data base will be possible whenever necessary, on an assigned responsibility basis. The hard copy printouts will also be useful for manual loading and scheduling during the period of time that the CAPS Model is being developed. Information such as up-to-date planning factors, and personnel available by skill level and organization is needed to schedule new assignments. The data base printouts can provide current information for this purpose.

The data base will contain historical information concerning individual jobs until the end of the fiscal year in which they were completed. At the end of the fiscal year, a printout of the entire data base will be made for a permanent record. Information concerning in-process work will be carried in the data base from one fiscal year to the next, until completed.

The PROMACS data base can also serve the secondary purpose of furnishing varied format outputs of its contents to those offices not directly concerned with production, but able to use aspects of the production data in support of their assigned functions. Thus the PROMACS data base could be the origin of a total management information system data base. To accomplish this, the basic units of data will be structured in a manner that is not directed towards the requirements of a particular organizational function or report. This file structure will allow constant coordination of functions and data as they pertain to each unit record. Data contained in this master file will be available to all offices that require it in order to carry out their missions. Updating the information will be restricted to those offices that have the responsibility for maintaining portions of the data base.

2. Categories and Elements of Data

The data base will be divided into two major categories with four prime elements of data in each category as follows:

<u>Production Category</u>	<u>Resources Category</u>
. Planned Production	. Personnel
. Production Status	. Material
. Process Definitions	. Equipment
. Production Standards	. Contract

Initially, only information relating to, and in direct support of accomplishment of the primary mission function will be contained in the data base. However, as indicated previously, information such as inventory control, personnel procedures, etc., can be added to the data base to form a central file for support areas of ACIC as well as PROMACS (See attachment I for list of basic PROMACS elements).

a. Production Category

The production category of data will make up the largest portion of the PROMACS data base. A brief description of the four elements in this category follows:

(1) Planned Production

This subdivision of the data base will contain information relevant to production assignments that have not been started in the production pipeline. A further division will be made separating assignments that have been officially assigned to ACIC for production (in backlog) from those planned for assignment. The basis and input for the latter division, which will be limited to the time period covered by the CIP, will be the approved CIP and subsequent modifications thereto, e.g., Office of the Secretary of Defense (OSD) Format B decision, current Joint Strategic Operational Planning (JSOP) and Command Operational Priority Requirement List (COPRL) requirements, and other higher headquarters directions and desires.

Information made available will include items such as the projected date when total coverage by chart series will be achieved by major geographical areas, specific charts to be completed in each fiscal year, and necessary resource requirements for accomplishing planned production.

(2) Production Status

The production status element will contain a list of all jobs in process or programmed with the scheduled completion date for each phase of the job, and the manhours by skill level and organization predicted for each phase of the job on a weekly basis. It will be designed to provide users with the status of any assignment that was placed in work, continued in process, completed, cancelled, or suspended during the fiscal year. Initially, the primary use of this data area will be to provide information for the ISRS and special queries. At a later date, this information will be utilized in the CAPS and Simulation Models. Typical information that may be required includes:

(a) Work in process - scheduled completion date, hours scheduled, and hours expended by each major production process for an individual job or a series of jobs.

(b) Completed work - date completed, actual and scheduled; hours expended, actual and estimated.

(c) Cancelled or suspended work - reason for action, labor resources expended prior to suspension or cancellation, and point or phase at which the job was halted.

Manhour expenditures will be input on a daily (direct labor) or weekly (indirect labor) basis. Information to be recorded will be employee identification, job and labor identification, hours and shift worked, organization where the work was performed, and organization where the employee is assigned. The employee's rate will be included in this input information. A job identification system will be used to permit summarization of data at any level. A study will be made on the impact of the job identification system implemented at ACIC on 1 July 1966. The manhour utilization information will be input to the data base by means of a data collection device. This device will be connected either directly to the computer, so that a real-time situation is possible, or to an off-line storage terminal. Information from the overseas elements and the

Washington office will be transmitted to ACIC via the AUTODIN network. The scheduling and loading information will be manually input to the data base until the CAPS Model is developed. Thereafter this information will be automatically stored in the data base as it is generated by the CAPS Model.

(3) Production Process Definition

The process definition element of the data base will initially contain a detailed description of the production processes of each major program. This description will contain the production steps necessary to make the product. The steps will be arranged in their proper sequence, along with the amount of men, material, and equipment needed for each step. It will also include the production steps which can be accomplished by a contractor.

The amount of manhours required for each production step will be determined by applying a set of variables to a production standard. These variables will include factors such as hydrographic, hypsometric, planimetric, and shaded relief densities. Several studies have been conducted at ACIC to determine the feasibility of using an analytical technique to estimate the manhour requirement for producing a chart using chart difficulty parameters as well as production standards. A promising technique using the regression analysis theory has been explored (Reference ACIC Technical Paper No. 13 prepared by [redacted]. This technique will be STAT investigated by the PROMACS team for applicability to the CAPS Model.

The principal use of the process definition element will be in support of the CAPS Model. When a job is placed in work, the computer-assisted scheduling program will query the data base to determine resource availability and the production flow and pertinent process definitions for the chart about to be placed in work. As chart specifications are changed or new techniques become operational, the process definition will be changed. For example, the IDHS project will alter early definitions that are established for PROMACS. After the implementation of the IDHS project a machine originated query to the index(es) of the various libraries and depositories will determine if there is sufficient source material for the assignment and in what form the material exists.

As these initial definitions are being implemented, other definitions describing the shortest possible calendar time will be in development. These accelerated definitions will include the use of additional resources, such as more personnel assigned to the job, extension of the workweek, contractor utilization, etc., to allow greater flexibility in scheduling "crash" programs.

(4) Production Standards

The production standards section of the data base will contain historically based standards for each phase of work for the major chart series. These standards will be for the process definition section of the data base and will provide the basis for estimating manhours required for a particular job phase.

b. Resource Category

A brief description of each element in this category follows:

(1) Personnel

The personnel section of the data base will contain a list of the employees, employee identification numbers, the organization to which employee is assigned, employee's primary and secondary skills, and time the employee is scheduled to be unavailable for work. The number of authorized personnel for each organization will be stored in the data base. An hourly rate for each skill category will also be contained in this section of the data base.

This area of the data base will be used by the CAPS Model to determine personnel availability by organization and skill level, and as an aid to costing the CIP line items. Reports showing personnel over/under strength for an organization could be generated from the information stored here. By adding additional data, part of the personnel reports, such as personnel registers could be obtained from this file.

(2) Material

The material element of the data base will contain information regarding direct material used in the production processes. The type of material, unit of measurement, average cost per unit, and inventory level will be maintained in the data base. Any direct material transaction will record the job identification, type of material used, quantity used, and the date. This information will be recorded on a material usage card and input to the computer via a data collection device.

The material element of the data base will be used by the CAPS Model to ensure the necessary supplies are available when a job is placed in work, and to aid in costing the CIP line items. It will also be used to keep a running inventory of material available within the plant, and to trigger requests for additional material well in advance of depletion points. The ISRS will use this element of the data base to provide material usage reports for individual jobs and programs.

(3) Equipment

This element of the data base will contain a list of all equipment directly related to the production effort, such as the APPS, plotters, and presses. The location of the equipment, scheduled maintenance, scheduled utilization, hours of utilization, operator skill level required, down-time, and capacity will be maintained in the data base. Machine usage will be charged against a specific job by the use of a machine utilization card. This card will contain the machine identification number, job identification number, hours utilized, and calendar date.

The equipment element of the data base will be used primarily to support the CAPS Model, and to monitor equipment utilization.

(4) Contracts

The contract element of the data base will contain information needed for effective utilization of the contract activity used to support the productive effort of ACIC. Typical information will include such items as type of contract, supplemental agreements, contractor identity, work description, responsible ACIC organizational element, status of the work, and data needed for planning and controlling use of commercial contracting funds such as:

(a) Funds allocated

(b) Funds obligated

(c) Actual expenditures

The contract element of the data base will be used primarily to: 1) generate reports, e.g., contract dollars available by work phase for specific charts, and 2) supply data for the CAPS and Simulation Models.

3. Summary

The main function of the data base will be to provide data for status reports, computer programming and scheduling, simulation activities, and answers to special queries pertaining to the accomplishment of primary mission objectives. However, due to the amount of data necessary to support PROMACS, the data base could serve as the foundation for a master data base servicing the total ACIC Management Information System broadly conceptualized in section II.

B. Integrated Status Reporting System (ISRS)

1. Description

The ISRS will be a management tool utilizing an Electronic Data Processing System to provide all levels of ACIC management with pertinent data to assist them in planning, scheduling, and controlling the production effort.

Methods will be designed to provide for systematic reporting of data to fulfill the needs of all echelons of management - both staff and line - in order to maximize the use of human and material resources for accomplishment of the production plan. Management will be furnished with fingertip information on production status and resource utilization needed for evaluating ACIC progress with managerial objectives.

The reporting system will be oriented to the evaluation of production status and performance. The goal of the reporting procedures is to provide management with quick access to reliable information for timely decision and dynamic control actions.

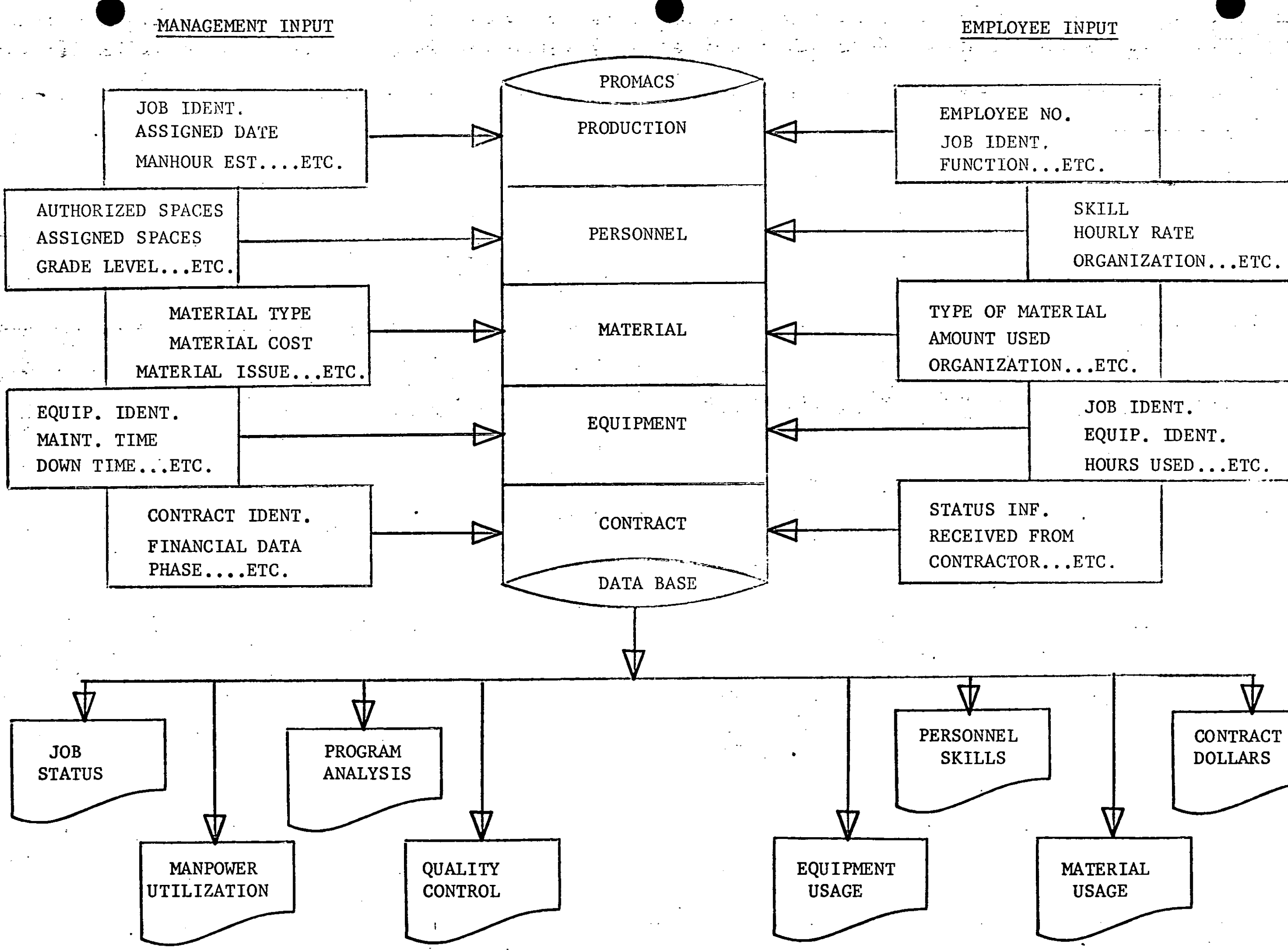
The ISRS will follow the pyramid concept for managerial reporting. This concept recognizes that management authority flows from the top of the pyramid downward, and that management reporting flows upward from the bottom of the pyramid. Therefore, the basic data will be arranged and quantified on an organizational basis with formats designed to include, combine, or consolidate detail to encompass approved needs of the user. Various types of reports, such as program status reports, production schedule reports, exception and variance reports, personnel change reports, etc., will be prepared in order to link the management system into an integral unit. The reported data will be stratified to have succeeding levels of generalization at various management levels by summarizing basic inputs at the first level of supervision. This summary will become the source of data for successive upward steps of management. Reducing the detail of process activity for higher management level reports will eliminate voluminous printout reports at those levels and provide summarized information to satisfy management by exception concepts.

The concept of integrated status reporting does not visualize a rigid reporting format for all organizational elements. Although some degree of standardization will be possible for common data, individual reports will be flexible, and will be structured to present significant facts and useful information on which management officials can act quickly. To this end, the reports will contain job status data, manpower data, equipment data, material resource data, and contract data. Figure IV-1 represents the flow of information needed to implement Phase I of the integrated status reporting model.

Production performance and related information will be summarized against individual line item numbers as contained in Format Six of the Consolidated Intelligence Program (CIP). This will provide for maximum utility and effectiveness of the system, with a wide range of application throughout the agency. It will be accomplished by reporting programs and utilization of resources against allocations defined in the production planning and program documents and related operational directives. External reporting, as with the DIA 70-15, will be made easier because of the summarization of individual jobs to a CIP line item.

2. Information Required

In general, ACIC management personnel have a requirement for timely information of three principal types for planning, scheduling and controlling production as follows:



INTEGRATED STATUS REPORTING SYSTEM INFORMATION FLOW
FIGURE IV-1

a. Long Range Programs and Requirements

This information is required by upper management levels at ACIC to maintain an awareness of those factors which could affect future operations. As a result of changes to such things as product requirement and design, relative priorities, production techniques and processes, and changing skill trends, gross plans can be formulated involving necessary organizational changes, training requirements, facilities and equipment modifications, and charting contract support requirements. The currency and availability of this data will ensure the soundness of day-to-day decisions made regarding current situations, thus minimizing any adverse effects on future operations and requirements. This information would cover the time span of the CIP and would be available generally at the level existing in that document.

b. Assignments in the Production Process

Information in this category is of high value to the Production and Distribution Plant for scheduling and controlling items in work. It involves the assignment of production elements and individual workers to particular phases of work along with estimated manhours and projected calendar dates - from the assignment date to the printing and distribution date. When necessary to divert manpower and skills from one program to another and in determining the impact of unscheduled and unprogrammed items, this information is urgently required and must be readily available. Accurate information concerning jobs to be assigned and the status of jobs in work will also be important in utilization of the CAPS and Simulation Models.

c. Assignments Produced

This category of information is needed to permit analysis of production accomplishment at periodic intervals to determine schedule slippages and to identify potential and actual problem areas. It includes production statistics which can be summarized for pertinent reports to reflect items produced versus goals and objectives at established time milestones.

3. Frequency

The reporting system will be designed to provide status information on the basis of one week's normal cycle reporting span. However, the nature and frequency of all ACIC data requirements will be considered to the maximum extent. Weekly status reports will provide the means in highlighting trouble areas in ACIC activities. The reports will also provide an up-to-date base for determining impact predictions of unscheduled and unprogrammed assignments upon all facets of ACIC operations. In addition, special high priority reports based on the current week's data must be available within a few hours for quick perusal and action. Thus, the ISRS will extend a real time complexion to the flow of management information, enabling it to overcome limitations of the present system. It will provide management a base for more timely actions leading to improved operation and accomplishment of the ACIC mission.

4. Data Requirements

The preparation of meaningful and timely reports covering a wide range and scope of management's status reporting needs requires a great deal of factual information in support of the ISRS. Recurring and special reports, useful in planning, scheduling and controlling the complexities of production, will be derived from the PROMACS Data Base. In addition, other types of management reports can be structured from the input data to assist in controlling efficient and effective use of ACIC's facilities and resources.

The principal type of computer-prepared management reports which will have broadest effect and be most widely used at ACIC will be the reports concerned with the primary mission - the production of aeronautical charts. The basic information needed for directing the production effort is concerned with: 1) personnel, 2) material, 3) equipment, and 4) contract. A brief discussion of these categories follows: .

a. Personnel Data

The information contained on the present daily labor card which accounts for employee's utilization, hourly rate, skill, organization, etc., is an example of the input data needed for the data base to support the integrated production reporting requirement. In addition to work-oriented reports, reports concerning availability and capability of skilled personnel to accomplish the work will be of value. The data which is personnel-oriented, such as authorized spaces, personnel on duty, skills, grade, levels, etc., will be contained in the PROMACS Data Base and is explained in that section of the report.

b. Material

Another class of data needed to meet forecasted ISRS requirements deals with material resource utilization. The material-oriented data must be reported accurately and in sufficient detail to ensure the necessary materials are available in proper quantities to meet production needs. Data must also be available for cost accounting and financial reporting purposes. The type of data contained on the present material cost card which accounts for the photographic paper, film, plastics, map paper, etc., that is expended on a job is an example of the data required in the central data base to support reporting of material usage, inventories, cost, etc.

c. Equipment

Equipment-oriented data is data required for overall ACIC management reporting. This type of data must be included in the system so the availability of specialized equipment needed for production purposes will be known and programmed efficiently, and that needed equipment can be justified from the information presented. Equipment-oriented data will be concerned with such items as hours used, downtime, maintenance time, etc. This type of information is collected in ACIC at the present time and will be input to the data base so the desired reports can be obtained.

d. Contract

In addition to the above groupings of data, the status report will require that data pertaining to contract activity is placed in the data base and be readily accessible in report form. The kind of data needed for contract oriented reporting will require identification of contractor, contractor work status, type of contract, etc.

5. Output Data

The ISRS is based on the concept that all data of primary interest for production management and control purposes will be contained in the PROMACS Data Base. Information for the various reports described above will be derived from this file, formatted and displayed to management in the form of hard copy or by means of available visual or audia media.

The status reports produced will contain information concerning identification of the job and producing element, CIP line item identification, status of work and resources estimated and expended for the job at a particular period of time. In addition, the report will be structured to include equipment and material utilization data and will be tied to categories of work and programs. The production data to be reported will include; but not be limited to such items as:

a. Title and definition of assignment

b. Scheduled starting and completion dates

c. Loading of manhours against schedule

d. Number of units programmed

e. Number of units completed

f. Number of units to process by phase

g. Manpower utilization

h. Comparison of utilization with loading

The reporting procedures will provide for standard terminology and unifying parameters in order to provide a common base for summarization and stratification of data to serve the needs of the various line and staff elements of ACIC. Although an objective of the ISRS will be to keep the number of reports needed to a minimum, it will still be necessary to produce a variety of reports in order to meet the requirements of the user. Examples of the type of reports needed and the requirement for each type of report is shown below:

a. Job Status Report

Format: This report will list active assignments by organizational element showing schedule, estimates, etc.

Requirement: It will be used to show the position of individual jobs in the production process and furnish information for management control.

b. Completion Report

Format: This report will include all assignments completed with related manpower, material and equipment charges.

Requirement: It will be used to evaluate operational efficiency, furnish cost data as needed, and for revision of production standards.

c. Program Analysis Report

Format: This report will organizationally reflect comparison of actual expenditures with allocations and of actual production with planned rate. It will show manpower required and predicted accomplishment.

Requirement: It will be used to identify areas and operations which need management's attention.

d. Resource Utilization Report

Format: This report will include all manpower charges by organizational element, line item, and skill. It will also include equipment, material, and contract dollars.

Requirement: It will show expenditure of resources for costing purposes.

e. Manning Status Report

Format: This report will include number of spaces authorized, on duty, on detail, and vacant. Skill and capability will be included.

Requirement: It will show resources and capabilities of production elements for planning and scheduling purposes.

f. Quality Control Report

Format: This report will reflect manhour and dollar cost of quality appraisals, and will relate number of defects to jobs completed.

Requirement: It will be used to evaluate job quality and quality costs.

The preceding examples of the type of reports and information to be derived from the ISRS is not meant to include all reports that can be obtained from the system, nor is it meant to exclude any printout that may meet a particular and valid requirement. As desired, the data indicated in the above examples can be sorted in various ways to present information for specific needs. For example, the job status report data could be sorted by line item, by organizational element, by due date, etc. This kind of sort would be useful for normal production management and control purposes. Another type of sort could be received that would print out data on jobs that were falling behind schedules, exceeding manhour estimates, were inactive, etc. This kind of information would be useful for management by exception purposes.

The ISRS can be expanded in relation to the data stored in the PROMACS Data Base. For example, additional management reports could be prepared to include information on personnel skills, cost reduction, chart inventories, material and equipment usage, employee evaluation, etc., as such data is implemented into the data base.

6. Preliminary Sample of Report Design

Periodic status and program analysis reports will be the primary method by which management will be informed of the distribution of productive manyears within production areas of the Production and Distribution Plant, production accomplishments in relation to ACIC committments, and degree of effective manpower utilization.

a. Periodic Status Report .

A representative example of the type of EDP periodic report to be derived from the ISRS is the Weekly Status Report. The purpose of this report will be to present up-to-date information concerning production status for all work in the production process and also to present information on jobs completed, suspended, or cancelled. The information presented by this type of report will be most useful for various staff and line elements of the Production and

Distribution Plant for report status on such items as Air Target Materials, Navigational Planning, Joint Operational Graphics, etc. The report will contain the following items:

(1) Organization (Division, Branch, Section, Unit or Contractor)

(2) Job Identification (Program, Line Item, Sub-Line Item, Job Number)

(3) Labor Identification (Skill, Function, Operation, Quality)

(4) Calendar Dates (Assignment Dates, Scheduled and Actual Completions, Cancellations, and Suspensions)

(5) Days Remaining

(6) Manhour Data (Estimated, Used, Daily Requirement)

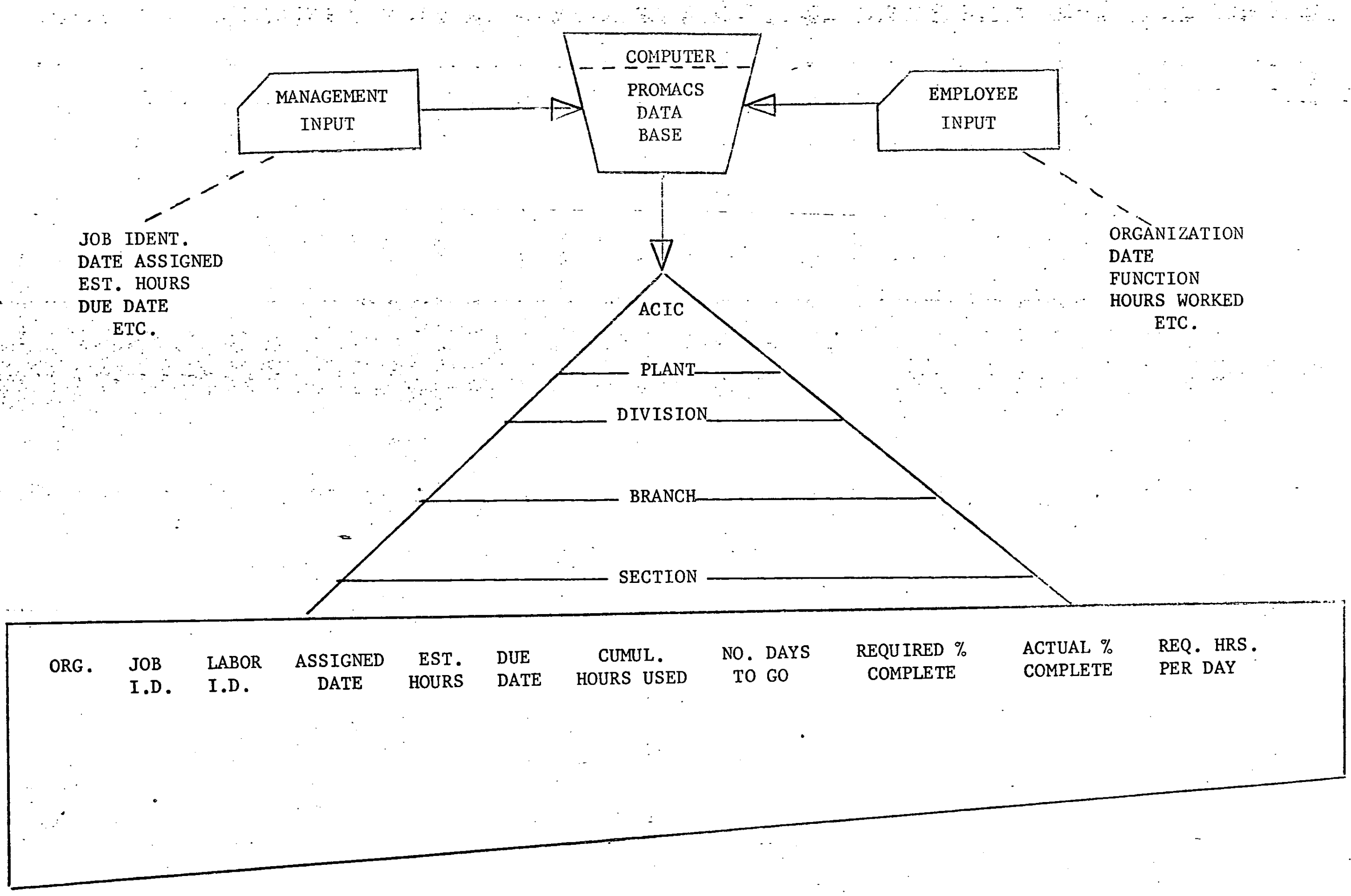
(7) Percentage of Completion (Required, Actual)

Figure IV-2 illustrates the formulation and consolidation of a Weekly Status Report. The manipulation of the job and labor identification codes by the computer will provide data at the level of detail required by the using element.

b. Program Analysis Report

Another example of the periodic reports obtainable from the ISRS is the Production Schedule and Progress Report represented by the present DIA 70-15. This report is used to reflect current information concerning the progress in expending resources toward accomplishment of the production program. It will be prepared for use primarily at the Command Staff level and to satisfy reporting requirements of higher headquarters.

Information for this report will also come from the PROMACS Data Base. The report will be a summary of job data, such as that used to prepare



WEEKLY STATUS REPORT FORMULATION
FIGURE IV-2

the Weekly Status Report, and of resource data, such as manyears and dollars programmed. Figure IV-3 illustrates the formulation of this report. The report will contain the following items:

(1) Work Identification (Program, Line Items)

(2) Production Units (In Work, Scheduled, Completed)

(3) Manyear Data (Allocated, Used)

(4) Financial Data (Dollars Allocated, Dollars Used)

7. Coding Considerations

A standardized coding system applicable to electronic data processing will be used to provide for systematic integration of reports for various levels of management. The coding system will include, but not be limited to such items as:

a. Line item codes

b. Specific assignment numbers

c. Job identification numbers

d. Skill designators

e. Function designators

f. Specific operation codes

g. Quality control codes

h. Resource accountability codes

i. Cost center codes

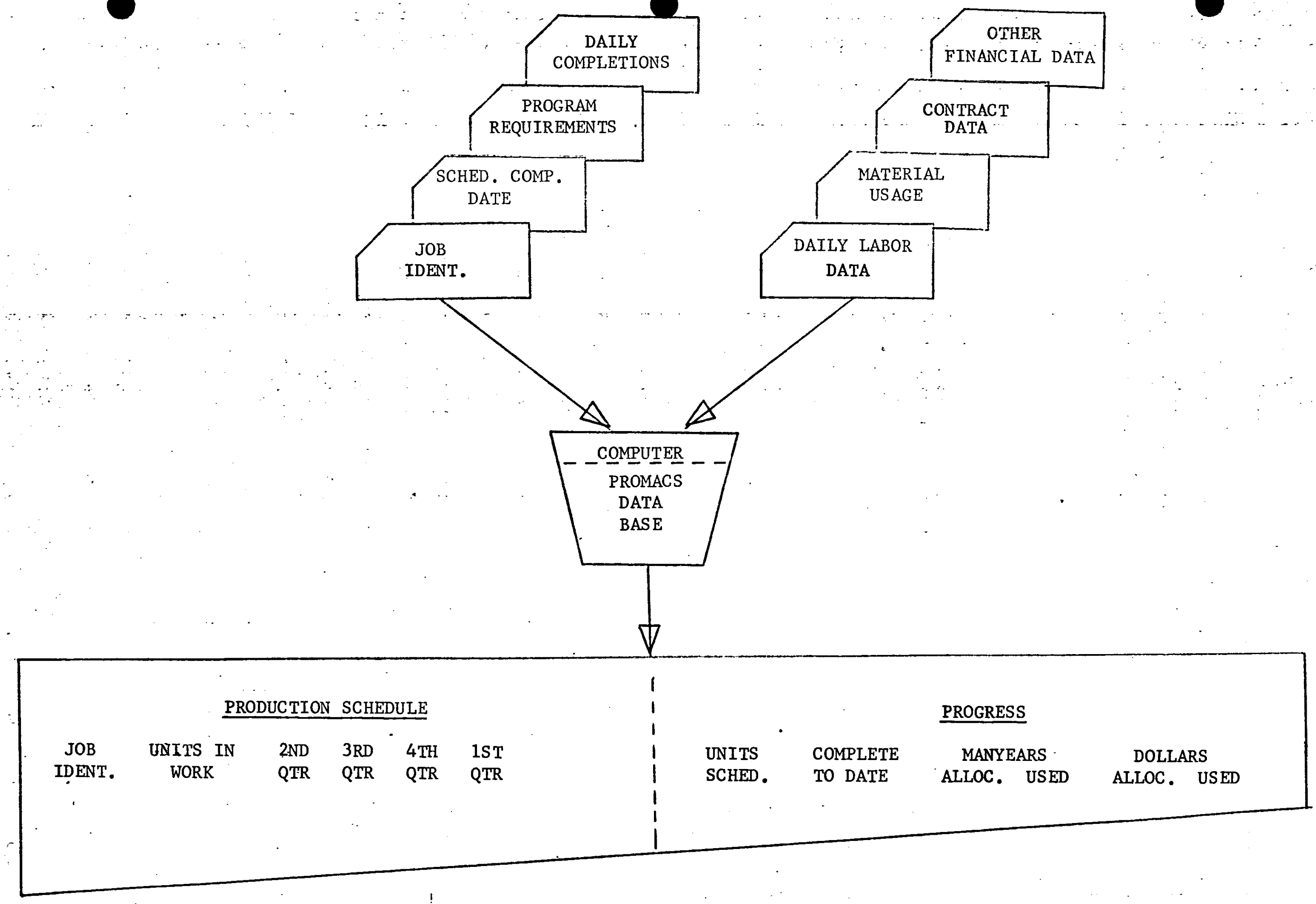
j. Direct material cost codes

k. Others

C. Computer Assisted Programming and Scheduling

1. Description

Computer-assisted programming and scheduling is a technique whereby the large memory and the rapid, accurate computational capabilities of a



PROGRAM ANALYSIS REPORT FORMULATION

DIA 70-15 REPORTING

FIGURE IV-3

computer are combined with the experience and judgment capabilities of technical personnel to perform programming and scheduling functions.

In programming, requirements are determined and resources allocated on a time-phased basis to support programs.

In scheduling, the entire production sequence and subordinate operations are established in a beginning-to-end relationship with regard to the availability of men, machines, materials and completion dates.

The general overall patterns followed in programming and scheduling are identical. However, there are differences in: 1) the degree of detail, 2) the time period being considered, and 3) nature of the data being handled. The general pattern in computer-assisted programming and scheduling can be divided into the following steps:

a. Problem definition

b. Input to the computer

c. Computer processing

d. Data output from the computer

e. Data analysis

f. Use of simulation model (optional)

g. Programming/scheduling action

h. Updating the data base

i. Reiteration of previous steps (as required)

The CAPS Model, when combined with the PROMACS Data Base, the ISRS, and the Simulation Model, is a powerful tool to aid in the iterative process of allocating resources to jobs and placing them in the production pipeline. This technique will liberate programming and production analysts from time-consuming details and allow them to sharpen their focus and refine their judgments. The currency, completeness, and accuracy of available information will provide considerable assistance in making more accurate programming predictions, and more timely scheduling decisions.

2. Input Data

Computer-assisted programming and scheduling will utilize information contained in the following sections of the PROMACS Data Base:

Resource Status	Production Status
. Material status	. Process definition
. Manpower status	. Production standards
. Equipment status	. Production
. Contract status	. Planned Production

The process definition will identify a series of critical path job definitions and the resources required for each phase of the job. All jobs will fit into one of these pre-defined structures. However, these structures will be made flexible by use of "degree of difficulty" factors to be applied to each job phase. This would allow the use of manpower and time for each phase to be varied at the discretion of the production analyst.

Production standards will provide the software package with essential factors used in calculating items such as length of job, manpower required, etc.

Job status will contain up-to-date information of all jobs in the production pipeline picture. Thus, the status of any job will be immediately available, and comparisons can be made between all jobs at any point in time.

Resource status will provide a timely status of all resources needed for programming and scheduling functions.

A more detailed discussion of the data base elements can be found in sub-section A of this section.

Manual inputs required for the programming section will be assignment of the job identification code (which includes the Major Program), the number of jobs to be accomplished within each job identification, the time period in which these jobs will be placed in the production pipeline, and contractual and specification data, if pertinent.

Manual inputs required for the scheduling section will be the assignment of the job identification number, the type of job, the applicable critical path, and the degree of difficulty for each job phase. Other input factors will be assignment of the necessary resource accountability codes, priority codes, in-house or contract production by major work phase, and completion dates. These factors cannot be pre-defined and will therefore have to be supplied manually.

3. Output Data

a. The computer software package will be designed to accept the specific input data previously described and combine it with the data elements contained in the PROMACS Data Base to produce data useful in the preparation of Format Six to the CIP, Allocation of Resources and Production Committments Document, Production Plans, and Production Schedules geared to various organizational and functional levels.

Each job will be detailed, showing:

(1) The complete CIP identification number.

(2) Calculated length of each job phase and total time for the complete job.

(3) Resources required for each phase of every job. These resources will be manpower (classified by skill levels within each Division),

equipment (type and amount of hours required), material (type, amount, and cost), contract dollars, and in-house dollars.

b. Summary listings will be an important system output. These listings will be tailored to the specific needs of the users, but for each group of job inputs processed, they will also include the following:

(1) Total resources used in each selected time period. Time periods will be projected to the end date of the job with the latest calendar end date.

(2) Grand totals for each of the seven year time periods.

(3) Projection of the status of each resource pool based on existing status on a given starting date and placing each job in the input grouping in sequence.

The projection will be segmented at selected time periods to provide overall resource status at these projected times, and will flag critical time periods where resources are not available.

(1) A grouping of resources projected to be used by each Division for each time period.

(2) A grouping of resources used for each program for selected time intervals.

(3) A listing of each job in order of start time, grouped by branch and section. This will be a preliminary schedule. This listing will also contain projected loading information.

(4) Exception reports that will pinpoint jobs and time periods where a conflict exists between resources scheduled and resources available.

c. Summary and exception reports will be tailored to the needs of each user and both individually and collectively will provide an overview of the programming and scheduling process and its problem areas. A significant feature about these reports is that they will be derived from the same basic data. Therefore, all areas will be working with compatible information in making programming and scheduling decisions.

4. A Typical Computer-Assisted Programming and Scheduling Cycle

The key to the effectiveness of the computer-assisted programming and scheduling system is efficient use of the PROMACS Data Base and judgment factors applied by Operations and P&D Plant personnel. These individuals will communicate with the data base to obtain timely and accurate information on which to base decisions and to eliminate much of the manual effort currently expended in computing and copying data.

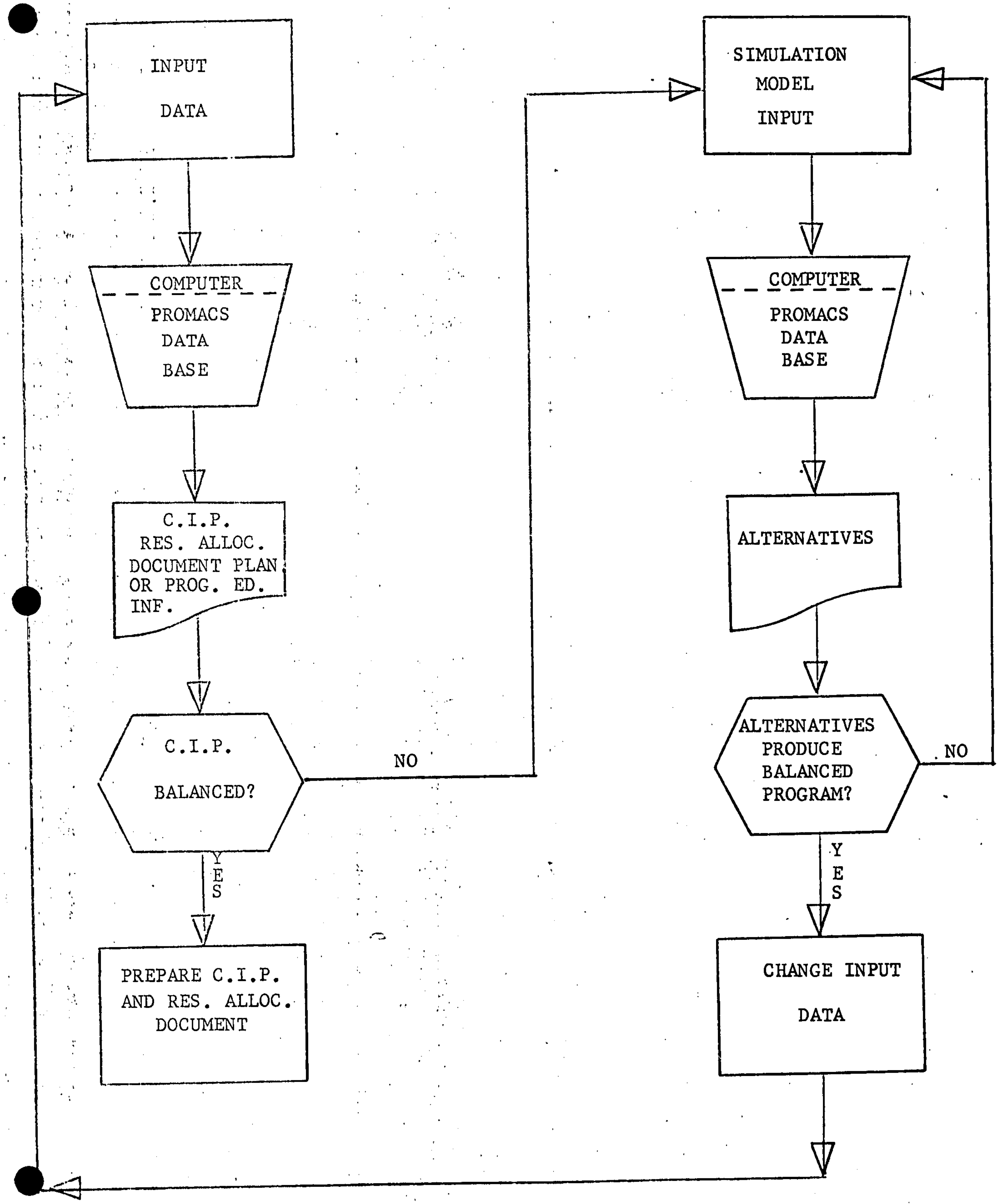
Figures IV-4, IV-5, and IV-6 are simplified flow diagrams depicting an operational concept of the CAPS Model. As shown, it reflects usage by ACODA and ACDB, but it should be emphasized that the principles outlined are applicable to all operating Divisions.

Figure IV-4 depicts a simplified programming cycle for ACODA. The time period considered during this cycle is seven years, and the data is generally gross; that is, it initially deals with total manpower and total requirements. These total figures are gradually divided and sub-divided for allocation during the iteration process.

The programming technique will be used by ACODA in the preparation of data elements required for the CIP, Allocation of Resources and Production Committments Document, and various other broad production plans prepared by them.

Input to the system, previously described in greater detail, will consist of problem definition parameters. The output data will provide the

GENERAL SYSTEMS FLOW CHART
#1

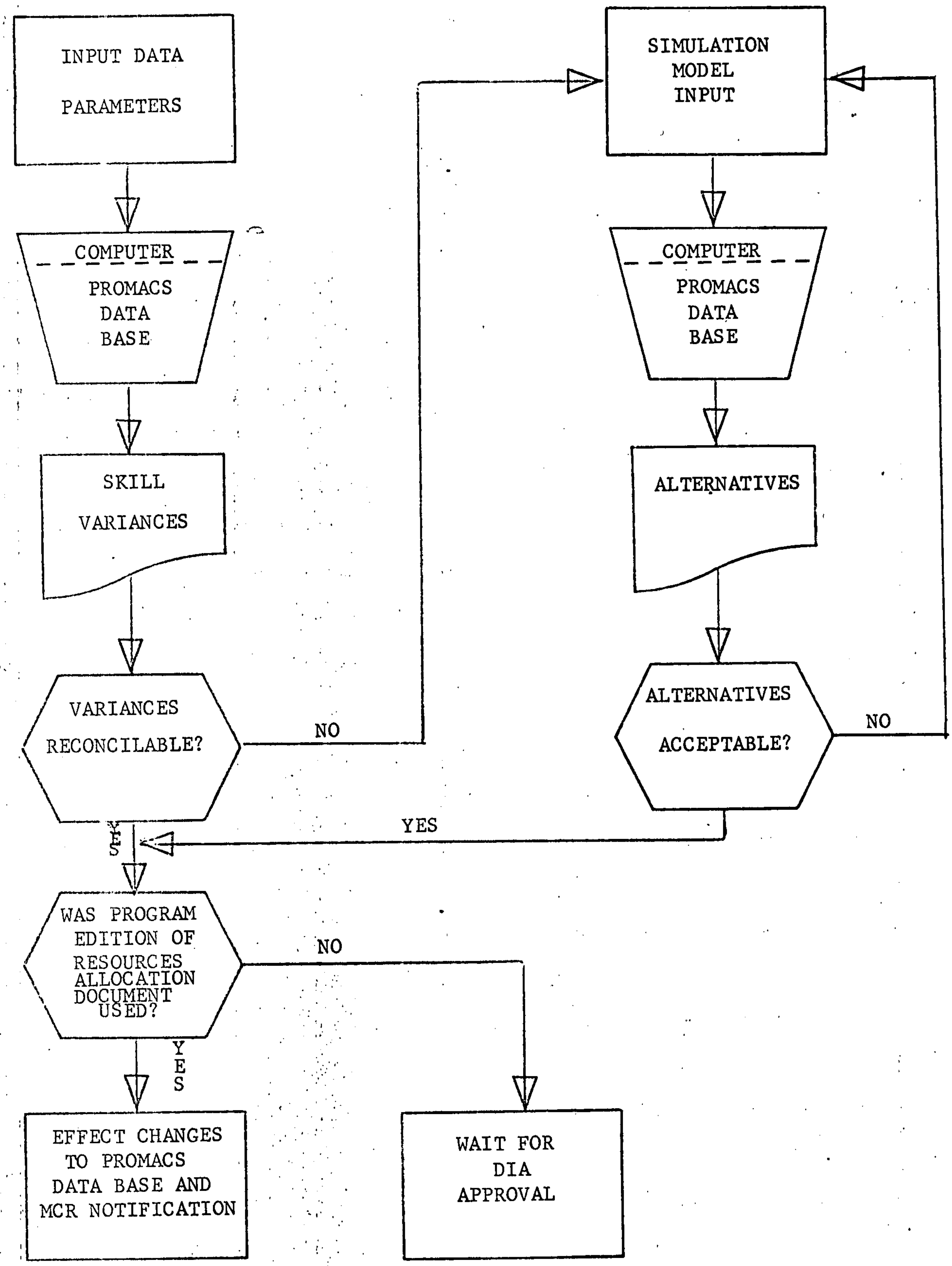


COMPUTER ASSISTED PROGRAMMING CYCLE (ACODA)
FIGURE IV-4

first programming iteration of requirements and resources. By reviewing these output reports, overloaded and underloaded periods can be identified, and the overall balance of the CIP can be determined. If necessary, jobs can be shifted from one time period to another, priorities changed, and additional resources made available for critical time periods. After these and any other required changes are made, the procedure can be repeated as many times as desired, or the Simulation Model can be brought into the cycle to provide alternate solutions. The strength of the model will be in its ability to: 1) provide many iterations in a short time, and 2) a list of possible solutions that meet the initial problem boundary conditions. The input to the Simulation Model must define the variable and non-variable factors and the limits of operation. For example, the model may be asked to assign start and stop dates for each job in order to provide the minimum average deviation from the defined available manpower. A more complete discussion of the Simulation Model will be found in sub-section D of this section.

Figure IV-5 shows a typical simplified programming/pre-scheduling cycle used to match resource requirements with resource availability. The time period considered in this cycle is one year. The input to this system is basically the output from the programming system, and the problem is in matching resources against requirements. This can be done rapidly by the computer to produce a "difference listing" showing critical time periods for each Division in which significant variances exist. This information must be evaluated and decisions made on how to change the data. Again, the Simulation Model can be used or the changes made manually and reprocessed. When an acceptable solution is determined (against the data contained in the Program Edition of Allocation of Resources), manpower change requests are prepared to bring manpower and

GENERAL SYSTEMS FLOW CHART
#2



COMPUTER ASSISTED PROGRAMMING/PRE-SCHEDULING CYCLE
FIGURE IV-5

other resources into alignment with the production program requirements set forth in the Allocation of Resources and Production Commitments Document.

The scheduling technique shown in Figure IV-6 will be utilized by ACDB to establish production schedules and subordinate operations for specific assignments with regard to the availability of in-house skills, contractor resources and capabilities, equipment, relative priorities, and completion dates. This process follows the same basic procedure previously outlined, but the time period is shortened and the level of detail is greater. The basic time period will be either weekly or bi-weekly, and the detail will include each manageable phase of every job.

After processing the input job definitions, the programming software will produce the preliminary schedule and summary information. A decision is made, after analysis, to either utilize the preliminary schedule or to change it. Changes can be made and the data reprocessed or the Simulation Model can be used. In any event, the end result will be more accurate information on which to base a decision.

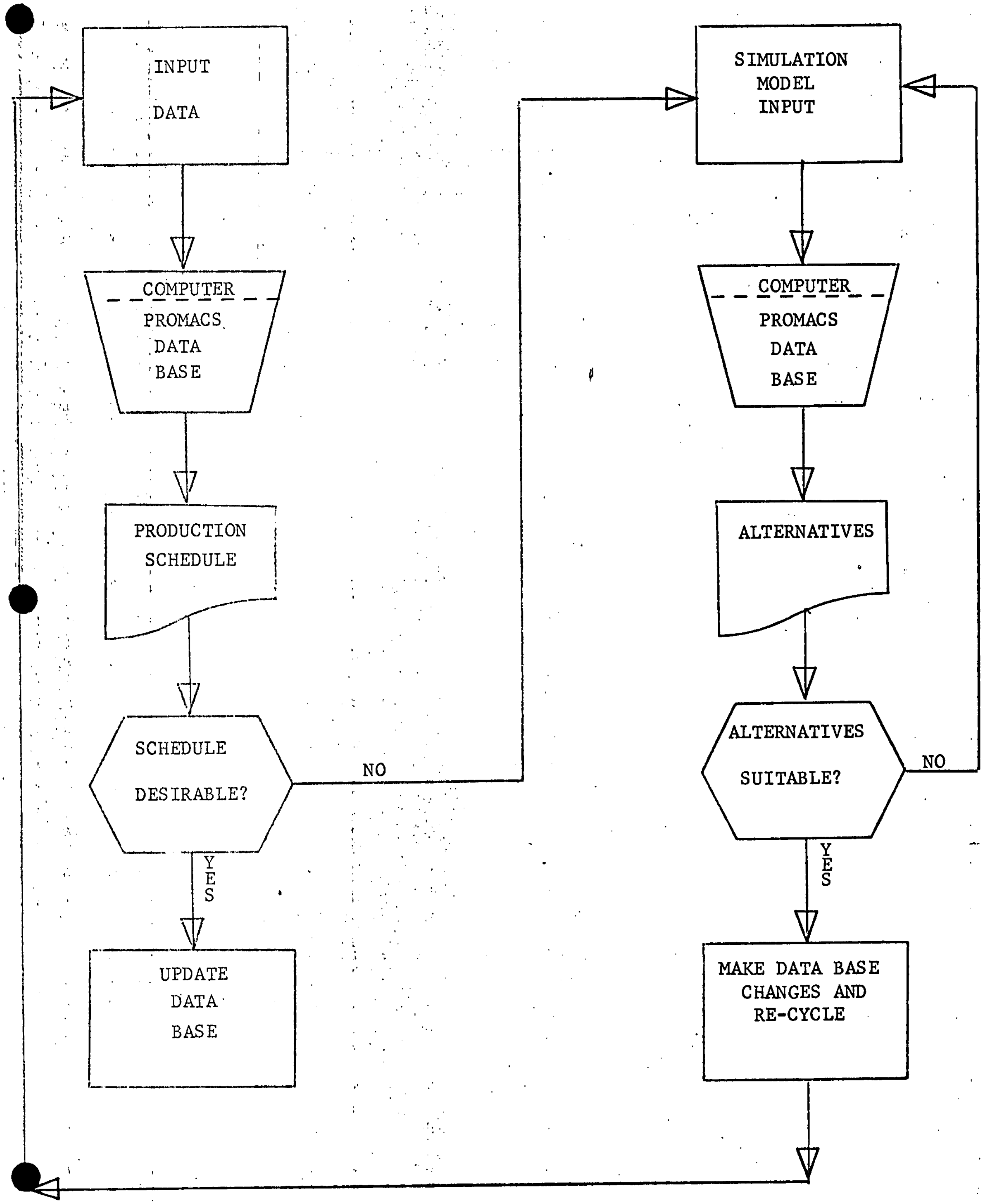
Once a finalized schedule has been determined, the PROMACS data base will be updated to reflect new jobs entered in the production schedule, and all resource bases will be updated automatically to reflect new usages.

The figures shown appear as independent systems, but will, in actual practice, be closer to a single system utilizing the same data base and software programs. Procedures followed and type of data used will be the major distinctions between the various processes.

5. Relationship to Total PROMACS

The CAPS Model will interface closely with the three other objectives of the total PROMACS, i.e., the PROMACS Data Base, the ISRS, and the Simulation Model. The ISRS will provide up-to-date summary information on which initial

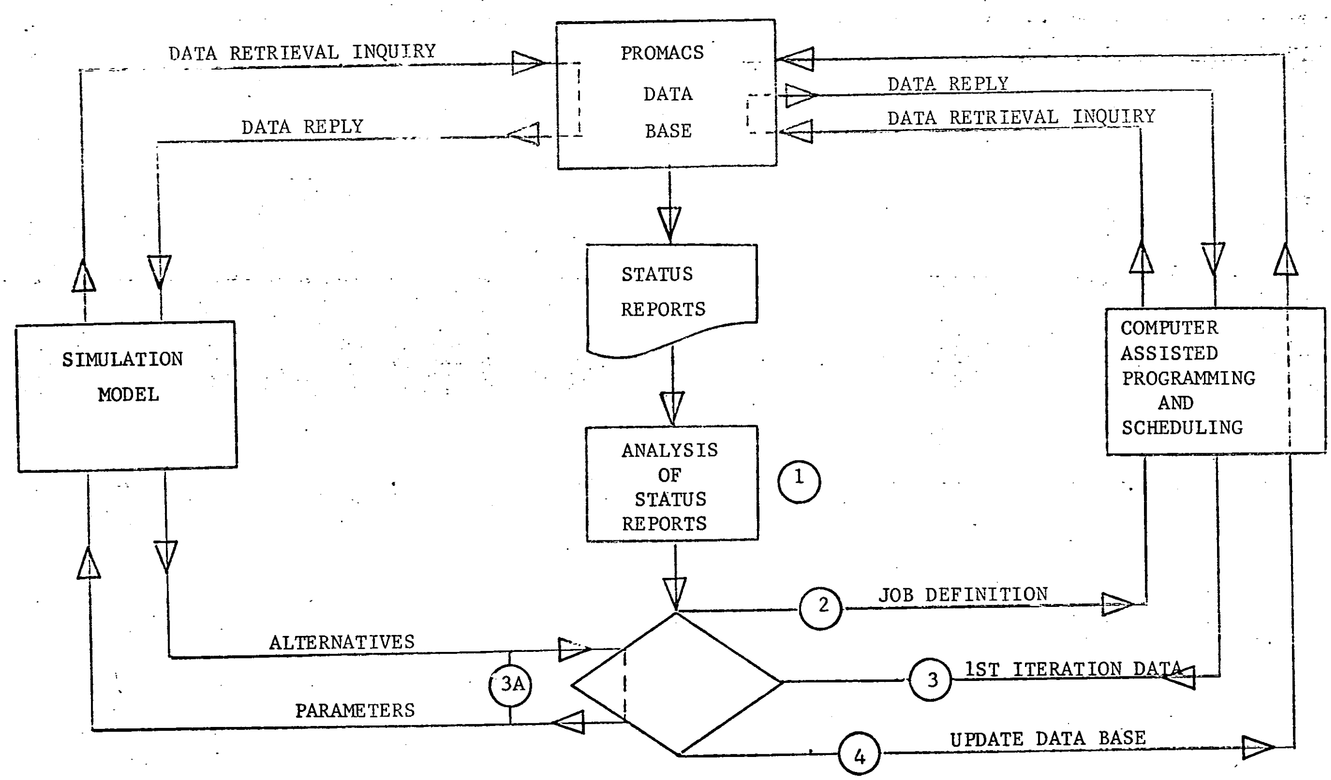
GENERAL SYSTEMS FLOW CHART
#3



COMPUTER ASSISTED SCHEDULING (ACDB)
FIGURE IV-6

decisions in preparing input data for the programming and scheduling system can be based. The PROMACS Data Base will provide the necessary information to define jobs and place them in a production pipeline using a set of rigid rules or constraints. The Simulation Model will allow ACIC management the flexibility of reviewing mathematically optimum programs and schedules based on total ACIC resource availability and requirements. Management can then choose to accept some degree of sub-optimization in order to: 1) distribute work among existing organizational entities rather than creating a temporary work force to meet a requirement, 2) consider scheduling impact on personnel reaction and morale, 3) to meet a politically important requirement in an expeditious manner, etc. These human judgment constraints will then be imposed on the CAPS Model to produce resultant programs and schedules. Thus management and program and production analysts will combine the use of all other PROMACS objectives in a highly iterative process to obtain information and alternatives leading to improved programming and scheduling decisions.

The relationship of the other three PROMACS objectives to the CAPS Model is shown in Figure IV-7 . The diagram points out: 1) the close interface required between the PROMACS objectives, 2) the iterative process followed in programming and scheduling, and 3) the critical position occupied by data analysis in the overall process. The steps in Figure IV- are numbered to assist in following the process: 1) Analysis of available data provided by the ISRS. 2) Job definition manual input. 3) The computer-assisted programming and scheduling software package, utilizing the data base, will provide a preliminary schedule and pertinent summary data on resource status versus requirements. 3) The analyst will evaluate this data. If conflicts exist he



RELATIONSHIP OF PROMACS OBJECTIVES FOR COMPUTER ASSISTED PROGRAMMING AND SCHEDULING

FIGURE IV-7

may elect to utilize the Simulation Model to obtain additional information and alternatives. 4) The programming and scheduling decisions are then made and the data base is updated.

D. Simulation Model

This sub-section will follow a slightly different format from that previously used in describing PROMACS objectives. Examples of potential uses of the Simulation Model for typical ACIC problems will follow a definition of the proposed ACIC Simulation Model. Subsequent portions of this sub-section will discuss basic operations research and simulation models, and their characteristics and limitations. This approach has been chosen because the abstract nature of the models is such that it often facilitates understanding to explain how they can be applied, rather than to mathematically develop the model itself. Also, it is not possible in a preliminary discussion of this nature to completely define how the mathematical model which will simulate ACIC operations will be derived.

1. Definition

An ACIC Simulation Model will be a dynamic, mathematical representation of the production cycle that will be used to experimentally solve "real-life" production problems in an abstract form. The representation will be operated on by a series of mathematical techniques and procedures, such as linear programming, Monte Carlo theory, and queuing theory, in order to equate the variables and constants used. The model will be designed so that outside parameters, e.g., process calendar time, can be varied and the effect of their change on the production cycle determined.

2. ACIC Applications of a Simulation Model

While it is theoretically possible to construct a simulation model for almost every phase of ACIC operations, such a task is not intended to be within the scope of the PROMACS effort. The quickest and most profitable application of a simulation model is in the areas of programming, scheduling and impact analysis; and the discussion of a simulation model in this paper concerns only these applications.

Since a simulation model is constructed to handle problem types - each with different values of <u>content</u> - the model can be used any time current values of problem <u>content</u> are entered. This allows the model to be used repeatedly over a period of time as long as the fundamental relationships of the original problem type have not changed.

a. Programming

A major type of allocation problem arises when there are more jobs to be done than available resources permit. Hence, a selection of jobs must be made, as well as a determination of how resources will be utilized to get the jobs done. This is basically the programming function. This typical ACIC problem will utilize the Simulation Model to achieve the optimum output within the defined availability of total resources.

One example of a programming situation in which a simulation model would have been helpful was in determining how to handle the increased JOG program outlined for FY 65. The situation called for an increase in the number of JOG's over the number previously programmed with minimum impact on other programs, and without a significant increase in available personnel. With a fixed amount of manpower and a requirement to increase the volume of output, the obvious alternative was to increase the use of contract dollars. Since all parts of the JOG program could not be contracted, the problem became one of selecting the best combination of assignments, either in process or programmed, that could be contracted to outside companies (staying within the amount of additional contract funds that were available), thereby freeing the personnel needed for the JOG program.

This type of programming problem involves shifting programs, matching resources with requirements, and analyzing approaches. A simulation model composed of variations of standard allocation and queuing operations research models will be a powerful tool in solving this type of problem.

b. Scheduling

Use of a model in a scheduling problem would take a list of defined jobs (defined in terms of priorities and job types) and investigate the alternatives available in placing these jobs in the existing production pipeline. Constraints will also be provided to define the initial boundary conditions of the problem. Examples of constraints would be, priority of jobs which can and cannot be removed from the pipeline, degree of completion which would preclude a job from being removed, time period being considered, assigned completion date, and any other factor which would define the boundary conditions and restrict the number of possible solutions.

The model would analyze the problem and its limits and provide a list of solutions which would meet all the conditions and a listing of exceptions. Ideally, the various alternatives and their predicted impact would be shown. From this list of alternatives a solution could be selected. For example, the solution could show a list of jobs that could be worked in the given time limit with all constraints applied. There may be many combinations that would meet the boundary conditions, and the problem definition must set the limit of acceptable solutions. The problem may be to find the best order in which to work jobs with a fixed amount of manpower in the shortest amount of time. The solution, in effect, would establish an optimum schedule.

The basic operations research models pertaining to the scheduling problem are the allocation, queuing, sequencing, and routing models.

c. Impact Analysis

Probably the most sophisticated use of a simulation model will be in analyzing the impact of unprogrammed and unscheduled changes on the existing operation. If a new job or a change to an existing job is contemplated, what effect will it have on the present schedule? Will some items be dropped? If so, which ones? Should some schedule items be extended? What is the best approach so as to minimize the disruptive effect? There are many different approaches, depending on which factors are defined as being most important. For example, the model could provide an alternative based on not bringing in personnel from other divisions. It could provide an alternative based on utilizing personnel from other divisions. It could provide alternatives based on using contract dollars, or not using contract dollars, with all other variables remaining unchanged. The basic operations research models used in this type of problem are the allocation, queuing, sequencing, and routing models.

d. Summary

The examples given have been brief, but the areas in which use of a simulation model has been defined are of prime importance in the programming and scheduling functions at ACIC. The model will not of itself provide the best answer to every problem, but it will be capable of rapidly comparing many alternatives and providing solutions within the defined boundary conditions so the selection of an approach can be made. ACIC management, applying human factors judgment, can choose to accept or implement a modified version of one of the alternatives presented. Modification will usually lead to something less optimum than the mathematical solution, but more practical because of institutional and/or personnel considerations. The important thing is that ACIC management will be able to judge the level of sub-optimization chosen by comparison against the theoretically ideal solution. Thus, the reasons for choosing sub-optimization will be emphasized and should serve as strong justification for the course of action taken.

3. Types of Operations Research Models

a. Models are used to solve problems, therefore a classification of problem types can be used to classify models. There is no unique classification of the various forms of a problem. However, the following eight forms, singly or in combination, account for the majority of problems that confront managers:

1. Inventory
2. Allocation
3. Queuing
4. Sequencing
5. Routing
6. Replacement
7. Competition
8. Search

b. A brief description of the model types used for each of these problems follows:

(1) Inventory models help in deciding how much to order, when to order, how to balance inventory, carrying costs versus set-up costs, etc.

(2) Allocation models assist in choosing among alternatives in a task and the best combination of existing resources and facilities to maximize overall effectiveness. Examples include determining optimum use of facilities, scheduling, and allocation of financial and manpower resources. This model has the greatest potential use in the ACIC production process.

(3) Queuing models work on "bottleneck" problems. A queuing problem arises when people or units requiring service arrive at a service point at which facilities may or may not be available. The problem is to serve the maximum number of customers with the least number of facilities, and to prevent idle facilities, inventory, and manpower.

(4) Sequencing models deal with determining in which order units should be processed to minimize total elapsed service time.

(5) Routing models deal with defining the optimum sequential path that must be followed in performing a process.

(6) Replacement models deal with replacement schedules for equipment to minimize overall cost without loss in efficiency.

(7) Competition models deal with selecting strategies when people are in conflict.

(8) Search models deal with systematically filing information for maximum ease in retrieval and information flow.

4. Operational Concept

Simulation models are composed of a set of operations research programs. These programs take the form of equations in which a measure of the system's overall performance is equated to some relationship between a set of controlled aspects of the system, such as what organization will do the assignment, and a set of uncontrolled aspects, such as new charting assignments. The values of the controlled variables can be set by management but the value of the uncontrolled variables cannot.

Since a model measures the system's performance, the development of a suitable standard of measure is critical, and is probably the most difficult part of developing the model. The standard of measure must reflect the relative importance of, and conflict between the multiplicity of objectives involved in a management decision.

A simulation model will use one or more of the models described in paragraph 3 to test various courses of action under simulated conditions similar to the "real" situation without costly and disruptive changes to actual operations. Conclusions reached from the simulated situation can then be applied to the actual operations with fairly predictable consequences. With the aid of flexible mathematical models and electronic computers, simulation thus permits experimentation, often trial and error, with various courses of action, and evaluates the potential effects of decisions on a situation under laboratory conditions.

The basic model will have to be supplemented by a set of limits on the possible values of the controlled variables. For example, more personnel cannot be used than are available. By simulating the industrial decision-making situation, it can be determined, with varying degrees of accuracy, those values of the controlled variables which optimize the performance of the system. The word optimum does not necessarily mean the best of all possible solutions, since the time to obtain all possible solutions may be prohibitive. Optimum means the best of those solutions investigated within the defined constraints.

The values of uncontrolled variables change with time. As these variables change, so must the optimizing values of the controlled variables. The model must yield not only a solution under a specific set of feasible conditions, but it must also contain a procedure for determining when significant changes have occurred in the system, and adjusting the solution to take these changes into account. The adequacy of the solution depends on how accurately the model represents the real system, thus testing and evaluation of the model and the solutions is a necessary repetitive process. The optimizing values of the controlled variables are expressed as functions of the values of the uncontrolled variables.

Whereas the mathematical solution to a problem would be impossible to accomplish manually, use of the computer will often alleviate this problem. However, operations research computations are extensive even for a computer. For example, if we have ten jobs to sequence over two machines and all jobs must go over them in the same order, there are approximately 3,700,000 possible sequences! Hence, approximate solutions are sometimes utilized to circumvent computer time limitations. Even so, these approximations are usually better than the alternatives provided through judgment and intuition.

5. Characteristics and Limitations

a. There are several characteristics that should be emphasized in the application of simulation model problem solutions:

(1) Models should be used on problems that are recurring in nature.

(2) The problem should provide an opportunity to choose between various courses of action.

(3) The problem should have a large number of controlled variables and a small number of relevant uncontrolled variables.

(4) The possibility should exist to evaluate results readily.

(5) The problems should be large and complex as well as current and pressing.

b. There are also several limitations that should be kept in mind:

(1) Simulation models are, at best, only an approximation of the real situation.

(2) Operations research is usually limited to the study of tangible and measurable factors. Many intangible and qualitative factors, such as human behavior and motivation must also be considered in a management decision. Therefore, human judgment factors must often be applied to transform the mathematically optimum solutions into the most acceptable solution from the institutional and personnel point of view.

(3) Good operations research studies are lengthy, complex, and expensive.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

1. Within the context of a total ACIC Management Information System, PROMACS forms the major sub-system conceived to support the ACIC primary mission function.

2. PROMACS, as conceived, constitutes a feasible, cohesive, and necessary management information and control system for the ACIC primary mission function.

3. Overall PROMACS development is long-term and evolutionary in nature.

4. The PROMACS Data Base could be eventually expanded into a master data base supporting a total ACIC Management Information System.

5. The ISRS can be implemented in the shortest time frame, and result in improved management knowledge of job status and performance. This knowledge will result in more timely corrective action by management to alleviate identified problem areas.

6. The CAPS Model will furnish more timely and accurate data for planning and controlling the allocation of resources to meet ACIC primary mission objectives.

7. The Simulation Model will furnish mathematically optimum alternatives for total ACIC resource allocations to meet primary mission objectives. ACIC management can accept these alternatives or choose the best level of sub-optimization on the basis of organization, function or personnel considerations.

B. Recommendations

1. That ACIC accept the long range development phases presented by this report for the overall PROMACS.

2. That ACIC concur in the short range PROMACS analysis and design activities outlined for the ACIC/Contractor team through 1 December 1966.

PROMACS DATA ELEMENTS

This attachment contains a list of the basic data elements applicable to PROMACS.

The data elements have been tabulated into an input and output column in order to represent:

1. Those elements which principally serve as input to the system.
2. Those input elements which are also used as output items.
3. Those output elements which have been generated by the computer for presentation of information for production management and control.

Attachment 1

DATA ELEMENTS	INPUT	OUTPUT
I. PRODUCTION ACTIVITY DATA ELEMENTS		
A. Job Status		
1. Jobs in work		
a. Job Identification		
(1) Major program	x	x
(2) Line item	x	x
(3) Sub item	x	x
(4) Specific job	x	x
(5) Edition number/date	x	x
(6) Chart Name/Number	x	x
b. Direct labor/dollar expenditures		
(1) Skill	x	x
(2) Function	x	x
(3) Operation	x	x
(4) Organization	x	x
(5) Hourly rate	x	
(6) Civilian hours/dollars for reporting period		
(a) Regular hours/dollars per organization		x
1. Regular hours/dollars per job		x
a. Regular hours/dollars per skill/function/ operation		x
(b) Overtime hours/dollars per organization		x
1. Overtime hours/dollars per job		x
a. Overtime hours/dollars per skill/function/ operation		x
(7) Military hours/dollars for reporting period		
(a) Hours/dollars per organization		x
1. Hours/dollars per job		x
a. Hours/dollars per skill/function/operation		x
(8) Overseas civilian hours/dollars for reporting period		
(a) Regular hours/dollars per organization		x

DATA ELEMENTS	INPUT	OUTPUT
A. Job Status (continued)		
1. Regular hours/dollars per job		x
a. Regular hours/dollars per skill/function/ operation		x
(b) Overtime hours/dollars per organization		x
1. Overtime hours/dollars per job		x
a. Overtime hours/dollars per skill/function/ operation		x
(9) Indigenous personnel hours/dollars for reporting period		
(a) Regular hours/dollars per organization		x
1. Regular hours/dollars per job		x
a. Regular hours/dollars per skill/function/ operation		
(b) Overtime hours/dollars per organization		x
1. Overtime hours/dollars per job		x
a. Overtime hours/dollars per skill/function operation		x
(10) Overseas military hours/dollars for reporting period		
(a) Hours/dollars per organization		x
1. Hours/dollars per job		x
a. Hours/dollars per skill/function/operation		x
(11) Cumulative civilian hours/dollars		
(a) Fiscal year hours/dollars		x
1. Hours/dollars per organization		x
a. Regular hours/dollars per job		x
1) Regular hours/dollars per skill/function/ operation		x
b. Overtime hours/dollars per job		x
1) Overtime hours/dollars per skill/function/ operation		x

DATA ELEMENTS	INPUT	OUTPUT
A. Job Status (continued)		
(b) Inception hours/dollars		
1. Hours/dollars per organization		x
a. Regular hours/dollars per job		x
1) Regular hours/dollars per skill/function/ operation		x
b. Overtime hours/dollars per job		x
1) Overtime hours/dollars per skill/function/ operation		x
(12) Cumulative military hours/dollars		
(a) Fiscal year hours/dollars		x
1. Hours/dollars per organization		x
a. Hours/dollars per job		x
1) Hours/dollars per skill/function/operation		x
(b) Inception hours/dollars		
1. Hours/dollars per organization		x
a. Hours/dollars per job		x
1) Hours/dollars per skiol/function/operation		x
(13) Cumulative overseas civilian hours/dollars		
(a) Fiscal year hours/dollars		x
1. Hours/dollars per organization		x
a. Regular hours/dollars per job		x
1) Regular hours/dollars per skill/function/ operation		x
b. Overtime hours/dollars per job		x
1) Overtime hours/dollars per skill/function/ operation		x
(b) Inception hours/dollars		
1. Hours/dollars per organization		x
a. Regular hours/dollars per job		
1) Regular hours/dollars per skill/function/ operation		x

DATA ELEMENTS	INPUT	OUTPUT
A. Job Status (continued)		
b. Overtime hours/dollars per job		x
1) Overtime hours/dollars per skill/function/operation		x
(14) Cumulative indigenous personnel hours/dollars		
(a) Fiscal year hours/dollars		x
1. Hours/dollars per organization		x
a. Regular hours/dollars per job		x
1) Regular hours/dollars per skill/function/operation		x
b. Overtime hours/dollars per job		x
1) Overtime hours/dollars per skill/function/operation		x
(b) Inception hours/dollars		
1. Hours/dollars per organization		x
a. Regular hours/dollars per job		x
1) Regular hours/dollars per skill/function/operation		x
b. Overtime hours/dollars per job		x
1) Overtime hours/dollars per skill/function/operation		x
(15) Cumulative overseas military hours/dollars		
(a) Fiscal year hours/dollars		x
1. Hours/dollars per organization		x
a. Hours/dollars per job		x
1) Hours/dollars per skill/function/operation		x
(b) Inception hours/dollars		
1. Hours/dollars per organization		x
a. Hours/dollars per job		x
1) Hours/dollars per skill/function/operation		x
c. Loading/Scheduling		
(1) Assignment date	x	x
(2) Scheduled completion date	x	x
(3) Date job placed in work	x	x
(4) Number of days to completion		x
(5) Scheduled completion date by operation	x	x
(6) Scheduled completion date by organization	x	x
(7) Direct manhours available	x	x
(8) Allocated manhours by skill	x	x
(9) Manhours estimated by operation	x	x
(10) Manhours estimated by job	x	x
(11) Manhours predicted for period by skill	x	x
(12) Organization capability expressed in manhours		x
(13) Number of manhours overloaded		x
(14) Number of manhours underloaded		x
(15) Manhours remaining on job		x
(16) Manhours required per day		x
(17) Probability Factor	x	x
(18) Percent of job complete (required)		x
(19) Percent of job complete (actual)		x
(20) Jobs backlogged	x	x

DATA ELEMENTS

		INPUT	OUTPUT
A.	Job Status (continued)		
	2. Jobs completed		
	a. Job identification		
	b. Edition number	x	x
	c. Edition date	x	x
	d. Completion date	x	x
	e. Direct labor/dollar expenditures		x
	f. Number of charts printed	x	x
	3. Jobs suspended		
	a. Job identification		
	b. Edition number	x	
	c. Edition date	x	
	d. Suspension date	x	
	e. Reason for suspension	x	
	f. Direct labor/dollar expenditures		x
	4. Jobs cancelled		
	a. Job identification		
	b. Edition number	x	x
	c. Edition date	x	x
	d. Cancellation date	x	x
	e. Reason for cancellation	x	x
	f. Direct labor/dollar expenditures		x
B.	Major Program/Line Item Status		
	1. Assignments/Completions		
	a. Number of assignments programmed	x	x
	b. Number of new assignments received	x	x
	c. Number of jobs in work	x	x
	d. Number of scheduled completions	x	x
	e. Number of actual completions	x	x
	f. Number of equivalent completions		x
	2. Labor/Cost Expenditures		
	a. Direct labor hours/civilian/military/indigenous		x
	b. Direct labor dollars civilian/military/indigenous		x
	c. Indirect labor hours civilian/military/indigenous		x
	d. Indirect labor dollars civilian/military/indigenous		x

DATA ELEMENTS	INPUT	OUTPUT
II. Personnel Activity Data Elements		
A. Authorized/On Duty		
1. Civilian positions authorized by organization by direct and indirect	x	x
2. Military positions authorized by organization by direct and indirect	x	x
3. Indigenous positions authorized by organization by direct and indirect	x	x
4. Civilian on duty by organization by direct and indirect	x	x
5. Military on duty by organization by direct and indirect	x	x
6. Indigenous on duty by organization by direct and indirect	x	x
7. Temporary employees on duty by organization by direct and indirect	x	x
8. Total civilian authorized by direct and indirect		x
9. Total military authorized by direct and indirect		x
10. Total indigenous authorized by direct and indirect		x
11. Total civilian on duty by direct and indirect		x
12. Total military on duty by direct and indirect		x
13. Total indigenous on duty by direct and indirect		x
14. Total temporary employees on duty by direct and indirect		x
15. Total direct authorized		x
16. Total indirect authorized		x
17. Total authorized		x
18. Total direct on duty		x
19. Total indirect on duty		x
20. Total temporary employees on duty		x
21. Total on duty		x
22. Civilian manyears allocated by direct and indirect	x	x
23. Civilian manyears utilized by direct and indirect		x

DATA ELEMENTS (continued)	INPUT	OUTPUT
II. Personnel Activity Data Elements (continued)		
24. Military manyears allocated by direct and indirect	x	x
25. Military manyears utilized by direct and indirect		x
26. Strength ceiling authorization	x	x
B. Skill Category Data		
1. Authorized	x	x
2. On duty		x
3. Training manyears allocated	x	x
4. Training manyears utilized		x
5. Attrition	x	x
6. Vacancies	x	x
7. Trends		x
8. Equivalent trained capabilities	x	x
9. Average years of service time	x	x
C. Other		
1. Detailed in		x
2. Detailed out		x
3. Civilian grade dispersion	x	x
4. Average civilian grade		x
5. Military personnel rotation	x	x

DATA ELEMENTS	INPUT	OUTPUT
III. Material Activity Data Elements		
A. Direct Materials		
1. Type of material		
a. Identification and nomenclature	x	x
b. Unit of issue	x	x
2. Quantity Used		
a. Direct material quantity used by operation	x	x
b. Direct material quantity used by job		x
3. Cost		
a. Unit of issue cost	x	x
b. Direct material cost by operation	x	x
c. Direct material cost by job		x
4. Date		
a. Direct material issue date	x	x
b. Direct material used date	x	x
B. Indirect Material		
1. Items Issued	x	x
2. Direct labor factor	x	x
3. Cost per labor hour		x
C. Inventory level		
1. Inventory on hand	x	x
2. Reorder point		x

DATA ELEMENTS	INPUT	OUTPUT
IV. Equipment Activity Data Elements		
A. Identification		
1. Nomenclature	x	x
2. Location	x	x
B. Usage		
1. Hours used daily	x	x
2. Hours used reporting period		x
3. Hours used fiscal year		x
4. Hours used since inception		x
C. Maintenance		
1. Daily maintenance time	x	x
2. Maintenance time reporting period		x
3. Maintenance time fiscal year		x
D. Downtime		
1. Daily downtime-equipment failure	x	x
2. Downtime reporting period		x
3. Downtime fiscal year		x
E. Production Output		
1. Capabilities	x	x
2. Programmed	x	x
3. Actual		x
F. Cost		
1. Operation	x	x
2. Rental	x	x
3. Maintenance		x

DATA ELEMENTS	INPUT	OUTPUT
V. Contract Activity Data Elements		
A. Identification		
1. Purchase Request Number	x	x
2. Responsible ACIC organization	x	x
3. Invitation for bid	x	x
4. Scheduled review	x	x
5. Description of work	x	x
6. Date required	x	x
7. Facility check	x	x
8. Date of contract award	x	x
9. Level of approval	x	x
10. Identification of contractor	x	x
11. Type of contract	x	x
12. Termination date of contract	x	x
13. Supplemental agreement	x	x
B. Status of Work		
1. Call number	x	x
2. Delivery order number	x	x
3. Job status	x	x
4. Acceptance report	x	x
C. Financial		
1. Unit cost		x
2. Hourly rate	x	x
3. Estimated cost	x	x
4. Commitments		x
5. Fiscal year funded	x	x
6. Minimum guarantee	x	x
7. Not to exceed amount	x	x
8. Obligations		x
9. Object class citation	x	x
10. Payments	x	x
11. Actual cost		x