Research Study 70-2

SIMPO-I DYNAMIC ARMY MODEL (DYNAMOD)

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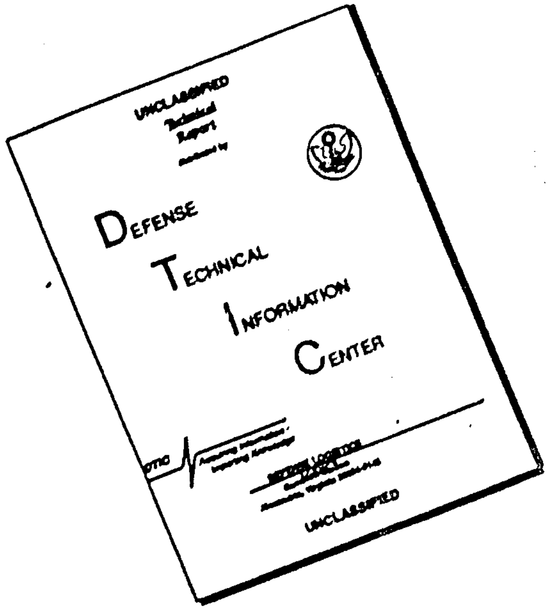

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Army Project Number
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Research Study-70-2

SIMPO-I DYNAMIC ARMY MODEL (DYNAMOD)

Joanne M. Witt, [redacted] Adele P. Narva

Pauline T. Olson, Task Leader

Submitted by:
Cecil D. Johnson, Chief
Statistical Research
Analysis Division

Approved by:
J. E. Uhlaner, Director
Behavior and Systems
Research Laboratory

May [redacted]70

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FOREWORD

The Work Unit "Computerized Models for the Simulation of Policies and Operations of the Personnel Subsystem--SIMPO-I," is conducted within the Statistical Research and Analysis Division of the Behavior and Systems Research Laboratory. The task constitutes the initial undertaking of an operations research requirement described in the Army Master Study Program under the title "A Simulation Model of Personnel Operations (SIMPO)" and is Project 2Q065101M711, "Army Operations and Intelligence Analysis" under the auspices of the Army Study Advisory Committee. Sub-Work Units include: a) Operational Analysis of Personnel Subsystems; b) Cataloging and Integration of Existing Manpower Models; c) Development of Measures of System Effectiveness; d) Development of Modeling Techniques; e) Design and Programming of SIMPO-I; f) Application and Evaluation of Computerized Models; and g) Problem Oriented Language for Management.

The present Research Study reports on the development and user application phases of the first dynamic flow models developed in SIMPO-I. The models, DYNAMOD I, II, III and IV, cover specific aspects of the personnel system. The present publication describes the systems simulated and the logic of the models. Instructions for model application, charts of model logic, and sample input and output are provided.

J. E. UHLANER, Director
Behavior and Systems
Research Laboratory

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SIMPO-I DYNAMIC ARMY MODEL (DYNAMOD)

BRIEF

Requirement:

To develop dynamic models of Army personnel subsystem functions by which to estimate required training input, authorizations needed to support rotation policies, and/or deployment capabilities under alternative utilization policies.

Operational Characteristics of the Models:

Four separate computerized models represent differing aspects of the rotation-replacement system. All models represent time in assignment by arranging personnel frequencies in a vector. Four tour areas are represented in DYNAMOD I, three in each of the other three models. DYNAMOD I and II represent two separate personnel subsystems with some common functions, for example, officer and warrant officer aviators. DYNAMOD III represents only one type of personnel subsystem but provides for differing service commitments based on length of combat service; DYNAMOD IV represents two overlapping occupational subsystems. In one tour area, personnel are assigned in two different subsystems; in another tour area, all personnel are in a single subsystem. Differences also exist in the assignment priorities used in the models and in the information output.

Starting inventories are projected by the models in monthly steps. At each step, transfers are simulated, deterministic losses are taken from the flow of personnel, and replacements are added. Constraints resulting from specified tour durations and requirements for experience are simulated. Temporary nondeployability may be simulated.

Utilization of Models:

DYNAMOD models have been used in simulating the Army Aviator System for the Capabilities and Analysis Division of the Directorate of Procurement and Distribution and the Aviation Branch of the Directorate of Individual Training of the Office of the Deputy Chief of Staff for Personnel, the staff of the Deputy Undersecretary of the Army for Operations Research, the Executive for Army Aviation in the Office of Personnel Operations, and the Office of the Undersecretary of Defense for Systems Analysis.

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SIMPO-I DYNAMIC ARMY MODEL (DYNAMOD)

In evaluating alternative personnel policies, management is beginning to employ computer-aided research techniques instead of costly data collection and the operational tryout of policies that may prove inadequate. The Behavior and Systems Research Laboratory (BESRL), on behalf of several Army and Defense staff agencies, is using the modeling techniques of operational research to study the long-range effects of alternative personnel policies. The models are logical sets of rules which describe the state and functions of Army manpower subsystems.

Because the Army manpower system is a complex interaction of many variables, the models employed must represent relatively simple abstractions of the real-world situation. The models do attempt, however, to relate the major independent variables and personnel system restraints realistically to useful criteria of performance or effectiveness. In the BESRL models, patterns of independent variables manipulated by the user define alternative management policies affecting personnel. The user must determine which factors are to be varied as experimental variables and which factors are to be dependent or criterion variables. For example, management might be interested in the effects of policies regarding the magnitude and scheduling of manpower flow into the system from outside the system. This concern may necessitate evaluating the sufficiency of programmed input from the training facilities or the impact of alternative training programs. The sensitivity of the personnel system to changes in loss rates, requirements, tour durations, or priority-of-fill rules can also be studied.

Personnel system restraints are predetermined policies concerning rotation and selection, manpower requirements for specific categories of personnel at various duty stations, limited personnel resources, and the characteristics of personnel assets. These restraints may be specified in the starting state of the system.

Determining the criteria by which to evaluate overall system effectiveness is an important aspect of the problem formulation and one of the most critical responsibilities of the operations research analysts or other users of manpower models. Many variables in the BESRL models can be used as criteria or evaluation indices. Because of the complex interaction of system variables, the user must determine the relative importance of the various effectiveness criteria. Some criteria of effectiveness of personnel policies which have been used in the past are:

Extent to which high priority tour requirements are met.

Length of CONUS tours.

Number of personnel who must return to the short combat tour.

Research scientists working on the BESRL work unit, "Simulation of Personnel Operations (SIMPO)," have designed and computerized several dynamic mass flow models. The Army and Defense Staff agencies have made operational use of three of these models:

DYNAMOD, a flexible general model, which has been used to model the Army Aviator system.

DYROM II, a revised rotation model of the career portion of the MOS subsystem.

ACCMOD, a model for predicting accession needs for the noncareer subsystems.

To expand the scope and usefulness of these models for solving additional personnel management problems, BESRL provides documentation of each model, including details regarding its development, functions, and applications. The present report documents the dynamic Army model, DYNAMOD.

GENERAL CHARACTERISTICS OF DYNAMOD

The Dynamic Army Model (DYNAMOD) is a computer simulation package consisting of four mass-flow models. Mass-flow models, which represent personnel by categories of individuals having similar characteristics and assignment histories, contrast with entity models which treat personnel as individuals.

Broad personnel categories define assignments to four main tour areas: a combat zone or short tour (ST), an overseas tour other than ST (LT), a training base tour (TB), and a sustaining base tour (SB). Within each of these tour areas, specific subtours represent personnel characteristics and the number of tours served in a given area. For example, a subtour within the combat-zone tour area could consist of warrant officers on their first combat-zone assignment. This breakdown of manpower into small sub-populations within broad tour areas provides flexibility in the application of differential loss rates, promotion rates, tour lengths, and priority-of-fill rules to the separate groups. With this capability, the models are adaptable for studying highly specific personnel subsystems.

BESRL designed the DYNAMOD models to reflect characteristics of specific Army subsystems in particular problem areas. Despite this problem-oriented development, all the models have the same basic logic and format.

Figure 1 illustrates the basic logical design of DYNAMOD. Each model simulates the flow of personnel through the system in a series of events:

1. Application of separate loss rates to appropriate categories of personnel.

2. Advancement of all personnel one time period.

3. Determination of requirements for each personnel category and calculation of category shortages.

4. Filling the shortages by following certain predetermined priority-of-fill rules.

This process is repeated for each time period in the simulation.

DYNAMOD abstracts and incorporates certain characteristics of the real personnel system. One such characteristic of all manpower systems is losses of various types. If losses are immediately replaced by personnel having the same characteristics, it is not necessary to represent the losses in the models. If the losses are not immediately replaced, however, they should be represented in the models. DYNAMOD computes personnel lost from the system as a proportion of the manpower flow through the tours per year. This flow out of the system can include retirements, separations, and deaths. Loss rates affect the flow of personnel at two times during the simulation: 1) when a tour of duty has been completed and the personnel are available for reassignment, and 2) when it is necessary to remove personnel from one tour of duty prior to completion in order to fill a higher priority tour. Loss rates must be specified by the user at the beginning of the simulation and are applied at each updating of the system during the simulation. In several of the models, new loss rates may be substituted in the simulation at prescribed times during the computer run.

Another characteristic of the real system which must be modeled is the manpower flow into the system at various intervals. This new input is needed to replace those lost from the system or to build up to the authorized strength of the system. Two methods of obtaining input to the system are modeled: 1) programmed or fixed input specified by the user prior to the beginning of the simulation and 2) variable input calculated by a computer algorithm during the simulation. Detailed descriptions of these input capabilities are presented in the sections of the present report dealing with the specific models.

In a dynamic model, the priority-of-fill rules determine flow patterns in a sequential manner, defining the priority hierarchy for filling personnel requirements for the various tours and specific subtours. These rules specify high priority tours and the extent to which other tour requirements and flow policies are to be modified in order to meet higher priority tour requirements. Priority-of-fill rules may be specified either in a hierarchical form as indicated, or in terms of proportional limits, for example: "Fill up to 60% of the deficit in the ST from the SB." Although all the models have similar priority-of-fill rules, the uniqueness of the problem-oriented situations dictates a different set of priority-of-fill rules for each model.

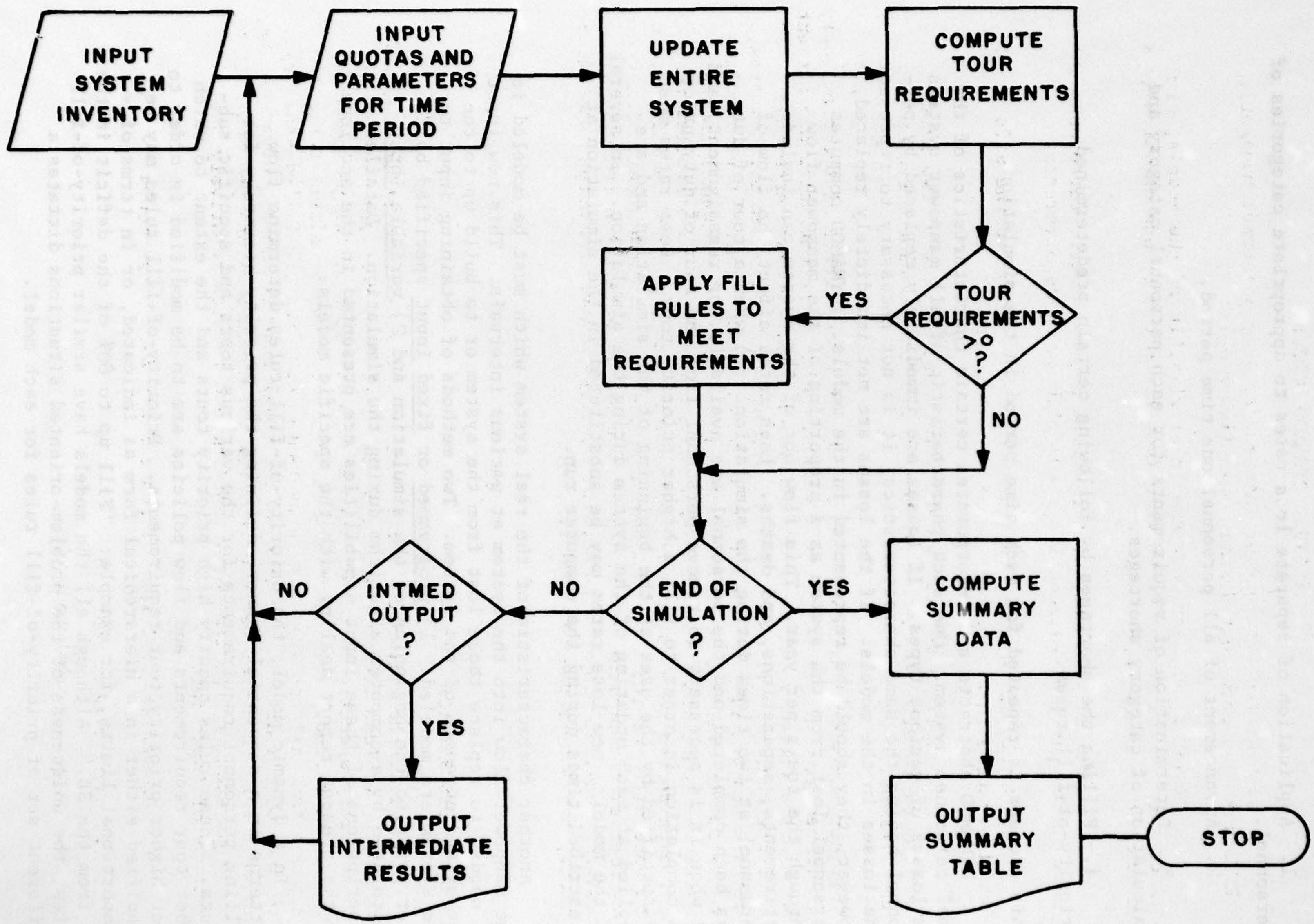


Figure 1. Basic logical design of DYNAMOD

SPECIFIC DYNAMOD MODELS

In response to problems of interest to Army personnel managers, BESRL has developed four dynamic mass flow models:

1. Model I, the earliest and least flexible of the models, simulates the flow of personnel between four broad tours, one of which is a noncombat overseas tour.

2. Model II, a widely-used flexible general model, represents the flow of two parallel personnel systems with joint requirements.

3. Model III, a modification of Model II, examines the effects of an alternative initial direction of personnel flow.

4. Model IV, a general model, simulates the flow of two intersecting or parallel personnel systems each with a separate set of requirements.

The four individual models are applications illustrative of the previously discussed general principles of DYNAMOD. Some characteristics are present within the computer programs for all models, and, because each model reflects characteristics of Army subsystems in a different problem area, certain characteristics are unique to a particular model. Data requirements for the DYNAMOD models include an inventory of personnel in the system by tour, loss rates for each tour, and quotas and scheduled renewal for each period to be simulated. The pattern of input and card format to be used with the input are described separately for each model. The remainder of the present publication describes in detail the individual models, their development and custom features, input and output specifications, and sample problem applications.

MODEL I

GENERAL DESCRIPTION

Model I, the original DYNAMOD, one of the first simulations designed by BESRL, is less flexible and less efficient than the later models; it is a highly specific computer program in which most of the parameters cannot be varied. The format and design of the model reflect the constraint that all requirements in overseas tours must be filled--the major concern of the Army at the time of the model's development. Nevertheless, Model I remains useful because its tour configurations and personnel flow patterns examine important Army problems and require relatively small amounts of input data.

The DYNAMOD Model I application defines four broad tours:

1. short combat tour (ST)
2. long noncombat tour (LT)

3. training base tour (TB)

4. CONUS or sustaining base tour (SB)

Within these tours, individual subtours represent two parallel types of personnel, A and B, and their assignments. Table 1 describes each of these tours and subtours.

Table 1

TOUR AND SUBTOUR DEFINITIONS FOR MODEL I

Tour		Subtour	
Type	Description	Type	Description
0	Short Combat Tour (ST)[a]	1	A on first O/S[a] assignment
		2	B on first O/S assignment
		3	A on second O/S assignment
		4	B on second O/S assignment
		5	A on third or subsequent O/S assignment
		6	B on third or subsequent O/S assignment
1	Long Noncombat Tour (LT)[a]	1	A on first O/S assignment
		2	B on first O/S assignment
		3	A on second O/S assignment
		4	B on second O/S assignment
		5	A on third or subsequent O/S assignment
		6	B on third or subsequent O/S assignment
2	Training Base Tour (TB)	1	A after first O/S assignment
		2	B after first O/S assignment
		3	A after second or subsequent O/S assignment
		4	B after second or subsequent O/S assignment
3	CONUS or Sustaining Base Tour (SB)	1	A after first O/S assignment
		2	B after first O/S assignment
		3	A after second or subsequent O/S assignment
		4	B after second or subsequent O/S assignment

[a] O/S = either ST or LT

Prior to the simulation, the user must specify other system characteristics, such as tour and subtour durations, loss rates, and personnel input. For each change in these system characteristics, a separate computer run is required. In contrast to the more flexible later models, Model I utilizes only fixed input; that is, an absolute number of A and B personnel enter the system during each time period. When this number exceeds ST and LT requirements, the program adds the unassigned personnel to the number input for the following time period.

In order to simulate the personnel flow among the tours and subtours, the program follows predetermined priority-of-fill rules. These fill rules, presented in Table 2, correspond to systematic policies by which management assigns personnel to the various subtours. In accordance with these assignment policies, A and B personnel flow in parallel paths among the subtours (Figure 2). Unless they are lost to the system, all A and B personnel must serve in at least one ST or LT.

Table 2

PRIORITY-OF-FILL RULES FOR MODEL I

Tour-Subtour Into	Fixed Input Tour-Subtour From	Minimum Time in Tour Prior to Removal
0,3 to 0,6	2,1 to 2,4	Completion
0,3 to 0,6	3,1 to 3,4	Completion
0,1	Outside A	0
0,2	Outside B	0
0,3 to 0,4	3,1 to 3,2	24
0,3 to 0,6	2,1 to 2,4	12
0,3 to 0,6	3,3 to 3,4	12
1,3 to 1,6	2,1 to 2,4	Completion
1,3 to 1,6	3,1 to 3,4	Completion
1,1	Outside A	0
1,2	Outside B	0
1,3 to 1,4	3,1 to 3,2	12
2,1 to 2,4	0,1 to 0,6	Completion
2,1 to 2,4	1,1 to 1,6	Completion
2,1 to 2,4	3,1 to 3,4	1
3,1 to 3,4	0,1 to 0,6	Completion
3,1 to 3,4	1,1 to 1,6	Completion
3,1 to 3,4	2,1 to 2,4	Completion

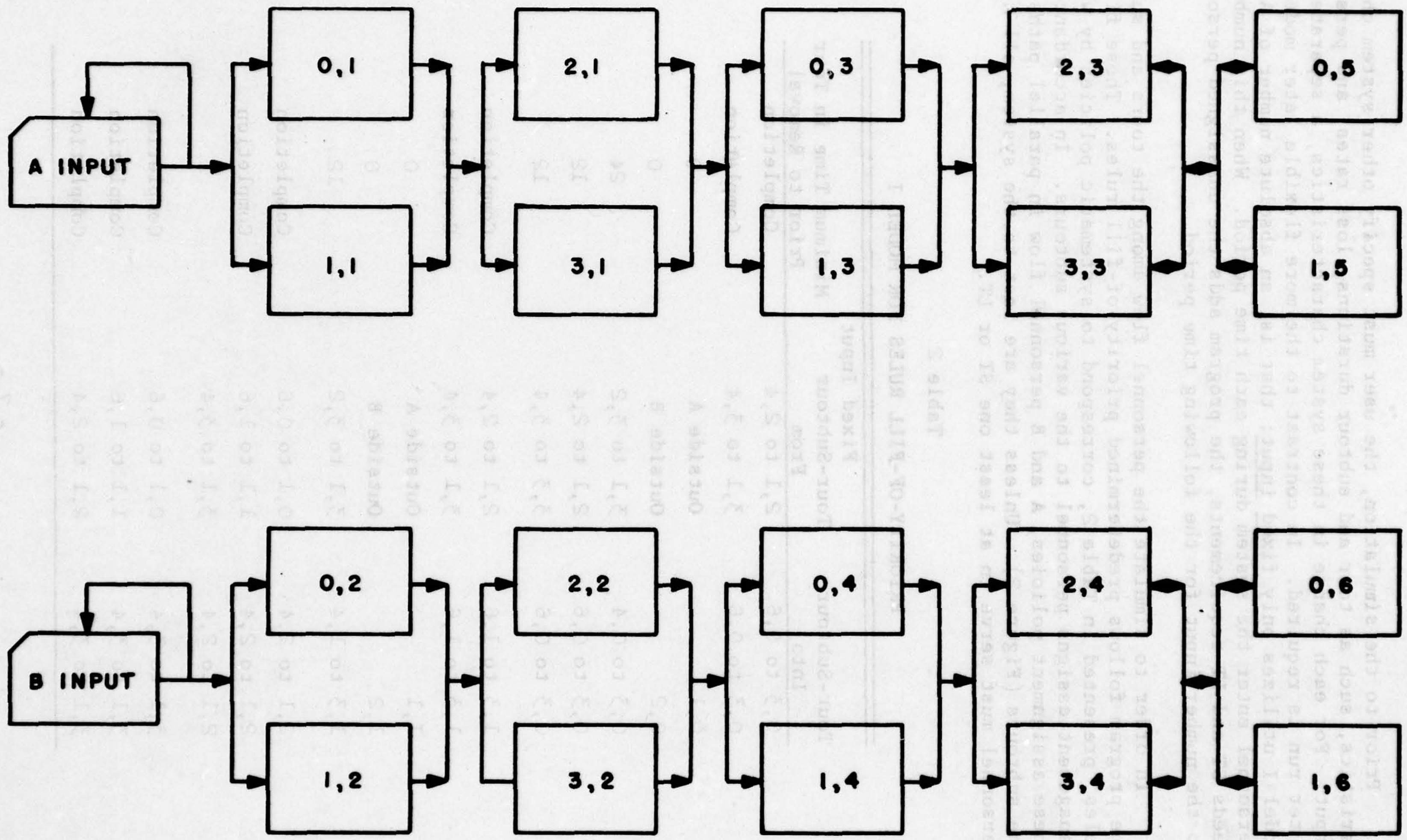


Figure 2. Flow of A and B personnel through parallel systems in Model I

Since the Model I logic is the basis for later model development, the manner in which the computer program employs these priority-of-fill rules is explained in detail. During each time period, the program systematically searches for personnel to fill requirements for tours from highest priority to lowest priority. Figure 3 illustrates how the program fills the requirements for the highest priority tour, the ST. It determines the ST requirements by subtracting from the ST quota the number of men actually serving in the ST. If there is a ST deficit, the program systematically searches for personnel until it satisfies the ST requirements or until it depletes the available personnel pool.

The program's search for personnel proceeds in the following manner: Initially, it assigns to the ST personnel who have completed TB and SB tours. If a ST deficit still exists, it removes personnel from SB subtours 1 and 2, TB subtours 1 through 4, and SB subtours 3 and 4 and assigns them to the ST. These personnel leave SB and TB subtours in an alternating sequence to insure that the average SB and TB tour durations will remain relatively equal. Similarly, the program proceeds to fill the LT, the TB, and then the SB tours (Figure 4). The flow for each subsequent time period is simulated in the same manner.

INPUT SPECIFICATIONS FOR MODEL I

To construct input for Model I is relatively simple. The general input setup consists of three distinct sections: the simulation parameter card, the tour deck, and the simulation control cards (Figure 5). Table 3 describes each of these sections.

Section one, consisting of a single parameter card, determines the time periods of the simulation and the number of tours and subtours. The two variables, TOURS and NTT, must equal 24 and 4, respectively. If the user desires to simulate less than 24 subtours, he must read blank data into the subtours that are not operative.

The tour deck setup section, which describes the initial state of the system, consists of a group of N cards for each of the 24 subtours. Within each of these 24 groups, there are cards of two types: Type A, a parameter card for the subtour, and Type B, cards which locate personnel within the subtour. The Type A card specifies tour category and subtour, tour requirements and assets at the beginning of the simulation, and number of subtours within the tour. The length of the subtour and its yearly loss rate are also specified on this parameter card. The Type B cards contain a vector in which each element represents a group of personnel in a specific time period within the subtour. For example, the third number in the vector corresponds to the number of personnel who are serving in the third time period. This tour deck inputs the inventory of all personnel within the system.

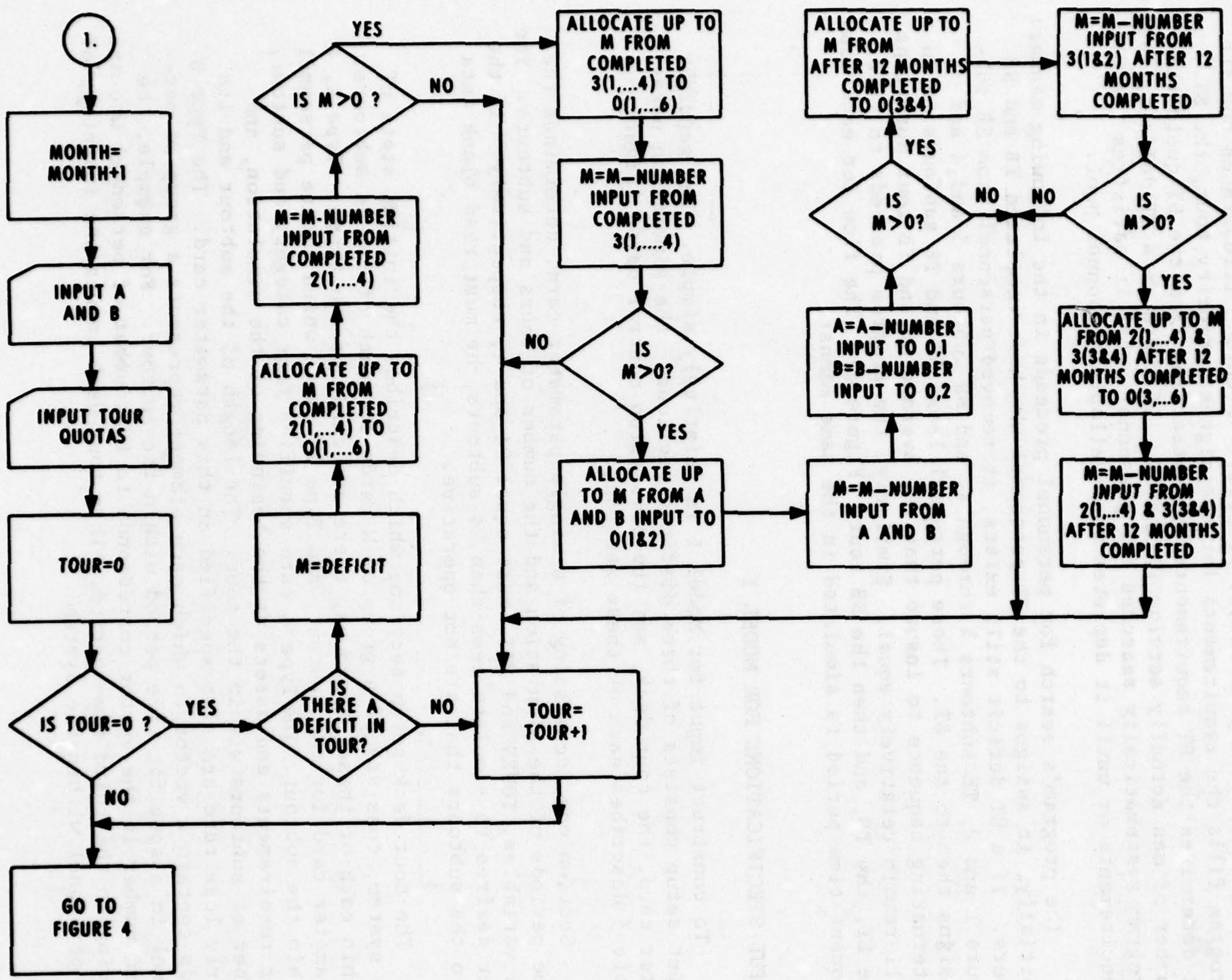


Figure 3. Implementation of priority-of-fill rules for ST in Model I

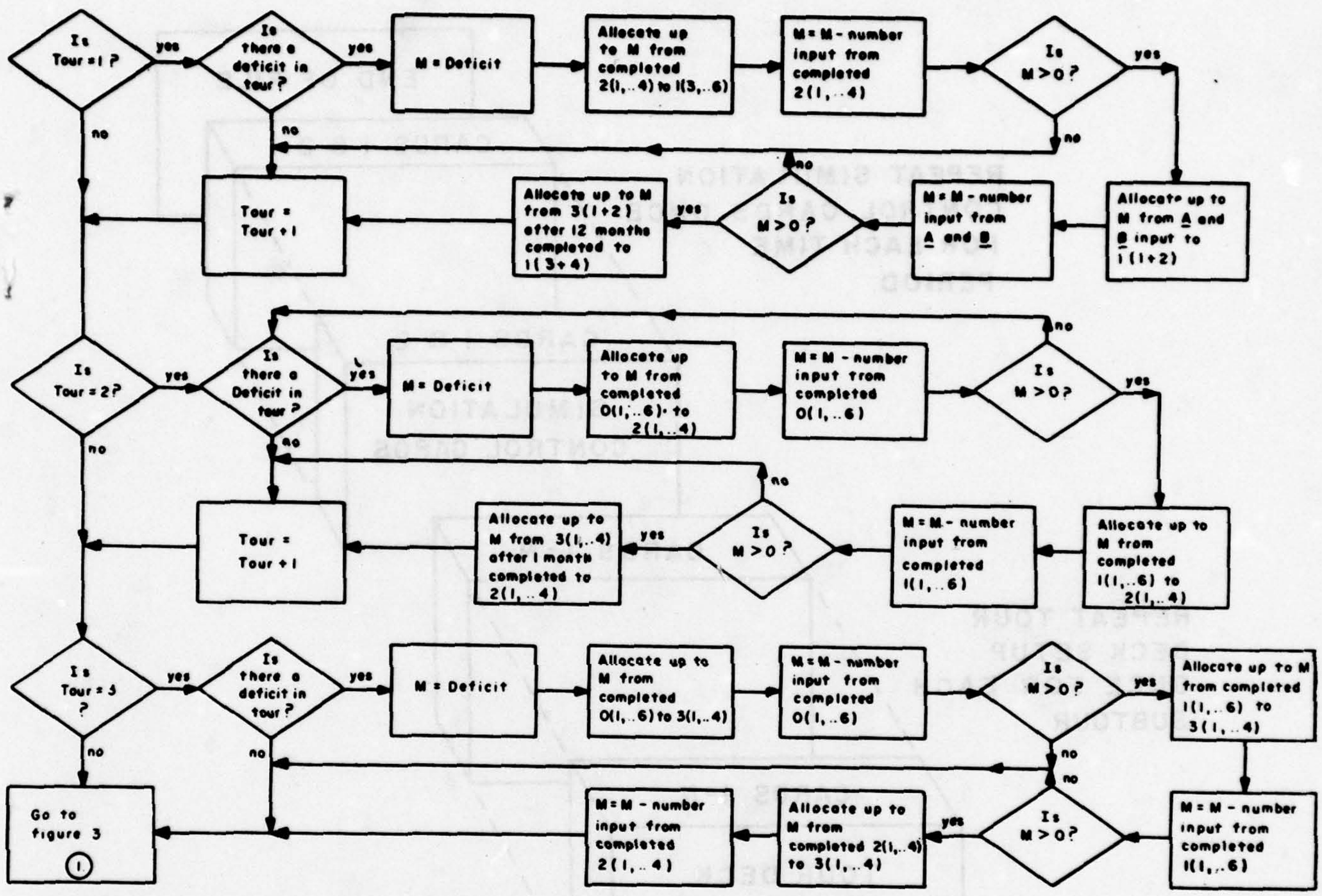


Figure 4. Priority-of-fill rules for LT, TB, and RB tours in Model I

Two simulation control cards for each time period make up the third section. The first card states the number of A and B personnel input to the system during that time period. It also contains a program control variable which determines when this simulation will end and whether or not another simulation will begin. The second card contains a vector of four elements, the requirements for each of the tours.

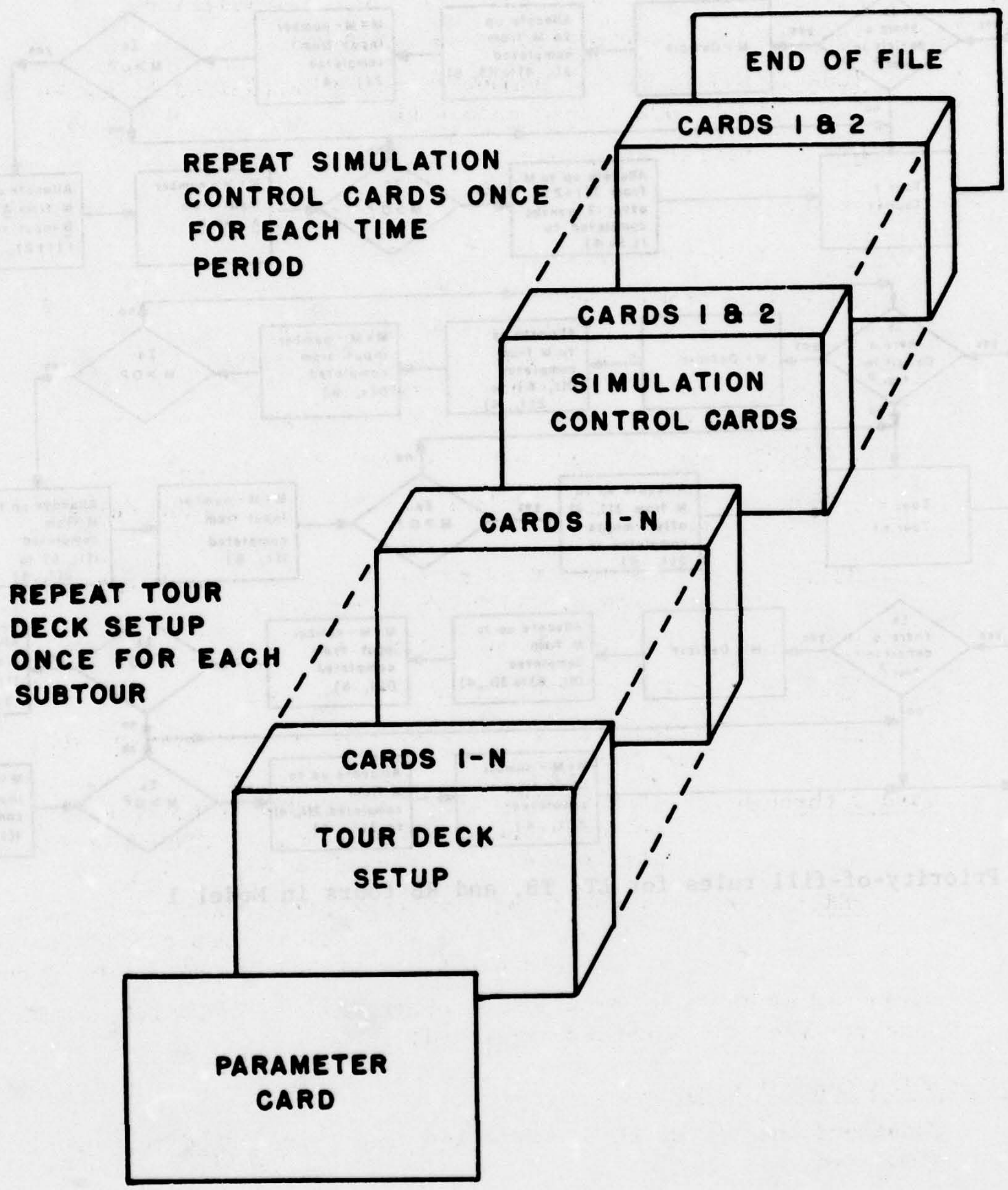


Figure 5. Input setup for Model I

Table 3

INPUT SPECIFICATIONS FOR MODEL I

Parameters Input to Similation System

Card 1: use format (8I10).

MONTH: time period at the start of the simulation.

LAST : last time period to be simulated.

TOURS: NTT*NUMSUB or number of tours multiplied by number of subtours within each tour.

NTT : number of tours.

Tour Deck Setup

Card 1: use format (6I10, F6.3).

TYPE : broad tour
type = 0 Short Combat tour (ST)
type = 1 Long Noncombat tour (LT)
type = 2 Training Base tour (TB)
type = 3 Rotation Base tour (RB)

SUBTOUR: subtour type as described in Table 1.

QUOTA : broad tour requirements for time period being simulated.

ACTUAL : actual number of personnel in this tour type for the time period being simulated.

NUM : number of subtours within this tour type.

LENGTH : length of subtour in time periods.

OUT : percentage of personnel lost to the system each year from this subtour.

Card 2 through N: (N = LENGTH/10 + 2 if LENGTH is not a multiple of 10 through LENGTH/10 + 1 if LENGTH is a multiple of 10.) Use format (10I8).

PERS: vector of number of personnel within subtour in each time period at start of simulation. Depicts state of personnel within subtour at beginning of simulation.

Cards 1-N of the Tour Deck Setup are repeated NTT*NUMSUB times, once for each tour-subtour simulated.

Simulation Control Cards

Construct one set of these cards for each time period to be simulated.

Table 3 continued

Card 1: use format (3I10).

INPUTO : number of personnel A to be input to the system at beginning of time period being simulated.

INPUTWO: number of personnel B to be input to the system at beginning of time period being simulated.

ISTOP : option to stop or continue simulation.
If ISTOP = 0, program continues.
If ISTOP = 1, program stops after time period being simulated.
If ISTOP = 2, program stops after time period being simulated and begins a new simulation.

Card 2: use format (8I10).

NEEDS: vector (1XNTT) of the requirements, or quotas, for each tour type.

OUTPUT SPECIFICATIONS FOR MODEL I

The output data for Model I is cumbersome in comparison with the more concise summarized output data of Model II. Nevertheless, similar types of information are available in the two models. Table 4 presents the basic format of the Model I output. Five sections of data are printed at the end of each time period. The first section states the number of A and B personnel input to the system at the beginning of the time period. The second section is a detailed description of the personnel input to each of the four broad tours and the subtours to which personnel are assigned. The third section accounts for the number of unassigned personnel input to the system from the outside. Representative of nondeployables, these unassigned personnel are added to the new outside input for the following time period.

The status of the subtours at the end of the time period is presented later. Tour and subtour designations, requirements and assets, length in time periods, and number of personnel in each time period are printed. The last section summarizes the manpower flow out of the tours at the end of the time period. This flow represents personnel who have completed the regular length of service in a specific subtour. These individuals are then categorized into two types: 1) those available for reassignment within the system and 2) those lost from the system. Since all five data output sections must be printed for each time period simulated, economy of computer time necessitates shorter projections than with some of the later models, which provide option to omit the massive intermediate output.

Table 4

OUTPUT SPECIFICATIONS FOR MODEL I

Number of A Input to System at Beginning of Time Period P: number of A personnel input to the system from outside the system at onset of time period P.

B Input: number of B personnel input to the system from outside the system at onset of time period P.

Total Input to Tour T: total number of personnel assigned to all subtours within tour T.

Number Input to Subtour S: total number of personnel assigned to subtour S during time period P.

From Tour T Subtour S: number of personnel input to this subtour from tour T subtour S.

From Tour T Subtour S after P time periods: number of personnel who were removed from tour T subtour S after serving there for P time periods.

Number Input from Outside: number of inexperienced personnel input to subtour S from outside the system.

Number of Unassigned A Personnel: number of personnel A input at the beginning of time period P who were not assigned to a specific tour-subtour.

Number of Unassigned B Personnel: number of personnel B input at the beginning of time period P who were not assigned to a specific tour-subtour.

Tour Type: designates the broad tour to which personnel were assigned.

Subtour: specific subtour to which personnel were assigned in time period P.

Quota: total A and B personnel requirements for tour T.

Number in Tour: total number of A and B personnel actually in tour T.

Length of Tour: length of tour T subtour S measured in time periods.

Men in this Category: total number of personnel in the subtour.

Table 4 continued

Row Vector: delineates where in tour T subtour S personnel are at the end of time period P.

Summary of Manpower Flow out of Tours at end of Time Period P: summary of personnel completing specific subtours at end of time period P.

Number Output from Tour T: total number of personnel who completed subtour within tour T.

Output from System after Tour T: number of personnel who completed subtour S and were then lost to the system.

Available for Another Tour after Tour T: number of personnel who completed subtour S and were eligible for reassignment within the system.

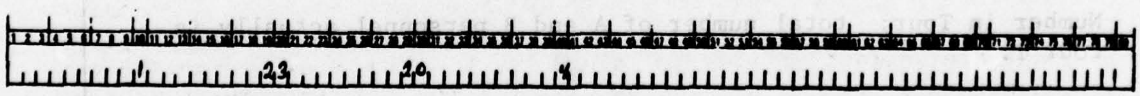
SAMPLE PROBLEM DESCRIPTION FOR MODEL I

Because the ST and the LT are considered critical tours, i.e., tours in areas vital to the U. S. defense, their requirements must be filled. It is important, therefore, to determine which policies will result in the most equitable assignments for all personnel and at the same time meet the requirements for all tours. In this example, warrant officers and commissioned officers are qualified to fill positions within the system.

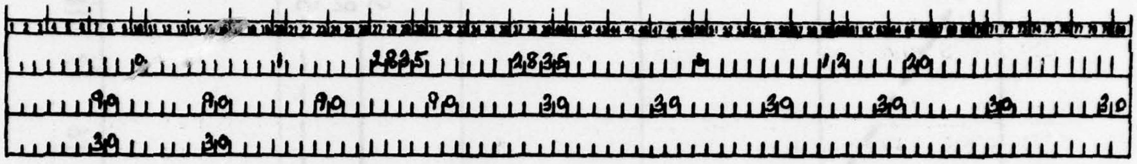
The input to Model I for this sample problem is constructed in a manner analogous to input to Model II. Therefore, only a brief description of the three data input sections is given here. (A detailed listing of the entire input for this sample problem is available from BESRL upon request.)

The parameter card determines that the simulation of four broad tours contained in 20 subtours will run for 23 time periods:

Parameter Card

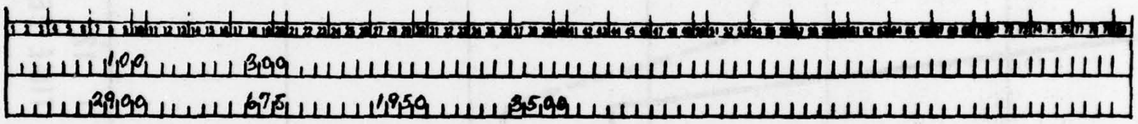


Within the tour deck setup, there are 20 sets of N cards, one for each of the 20 subtours within the system. Number of cards in a set depends on the length of the tour. Format for the three cards which make up the ST subtour 1 (warrant officers serving in a combat zone on their first overseas assignment) is shown below. At the start of the simulation, there are 2835 personnel within the six subtours. ST subtour 1, 12 time periods in duration, has a 20-percent annual loss rate. Within the subtour, 90 personnel are serving in their first time period, 30 in their fifth period, etc. Similar groups of N cards are constructed for the remaining 19 subtours within the system.



The first six simulation control card groups are identical. They input 100 warrant officers and 300 commissioned officers at the beginning of each of the six time periods and set the ST, LT, TB, and SB requirements equal to 2900, 675, 1950, and 3500, respectively:

Simulation Control Cards



The inputs and requirements increase gradually until the 23d time period, when 400 warrant officers and 400 commissioned officers are input to the system, and the ST, LT, TB, and SB requirements equal 4700, 1000, 4050, and 5250, respectively.

Five pages of output data are printed for each time period simulated. This cumbersome output must be summarized to reflect characteristics of the particular criteria that interest the user. For illustrative purposes, two different summaries of possible interest to management are presented. In these simulations, the system quotas or requirements are not always adequately filled. Figure 6 shows that during most of the time periods the requirements are higher than the number of personnel available. Consequently, the higher priority tours are filled first, and shortages occur in the lower priority tours.

Management was interested in the ratio of warrant officers to commissioned officers. Figure 7 presents the percentages of the ST and LT personnel that are warrant officers. Initially, the ratios of warrant to commissioned officers are relatively equal. As a function of input policies, loss rates, and flow priorities, the number of warrant officers gradually increases until it stabilizes at 86 percent of the ST total and 81 percent of the LT total. These comparisons and others may indicate to management a need for change in policy which should in turn be tested in additional computer runs.

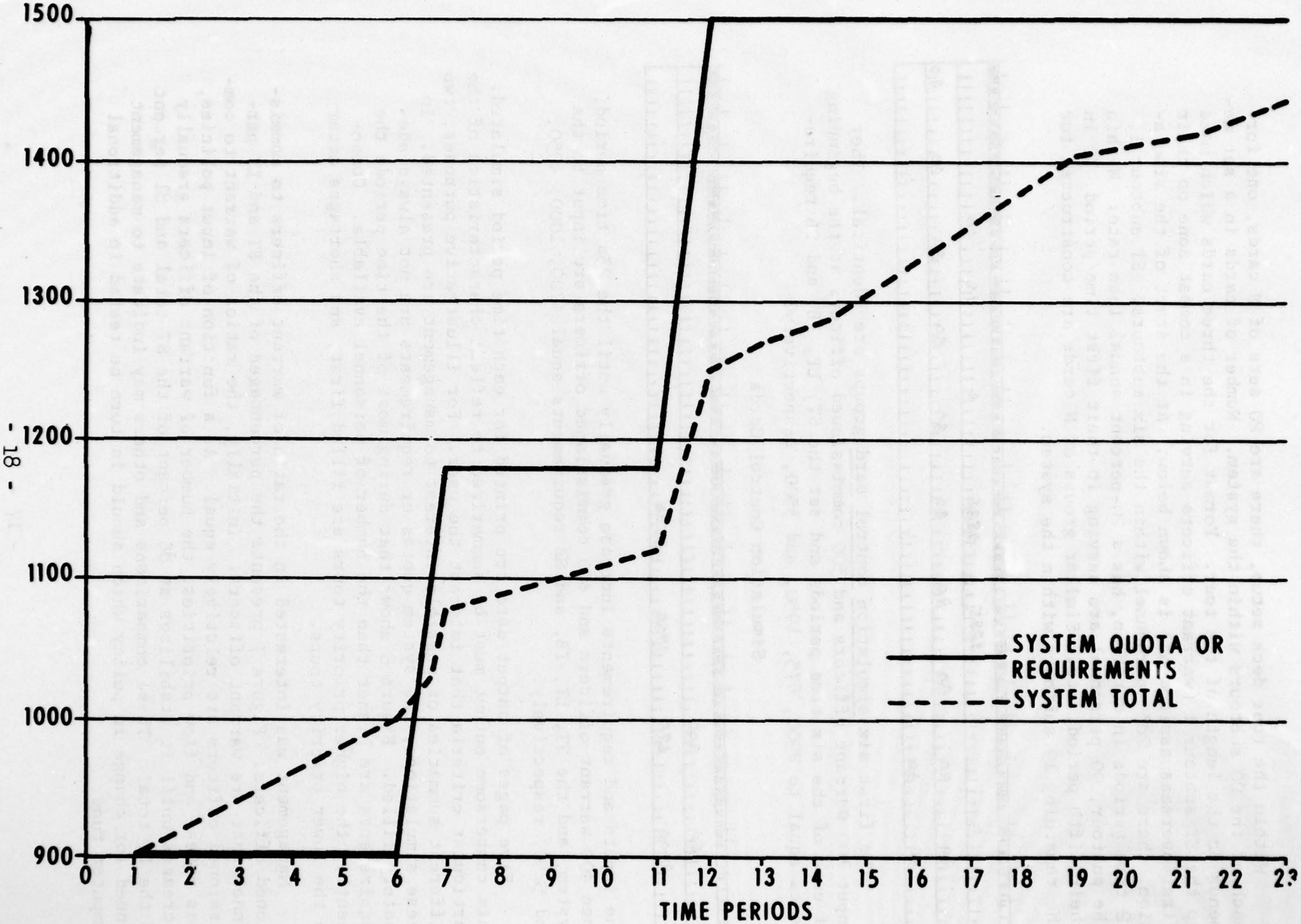


Figure 6. System quotas and totals for each time period simulated in Model I

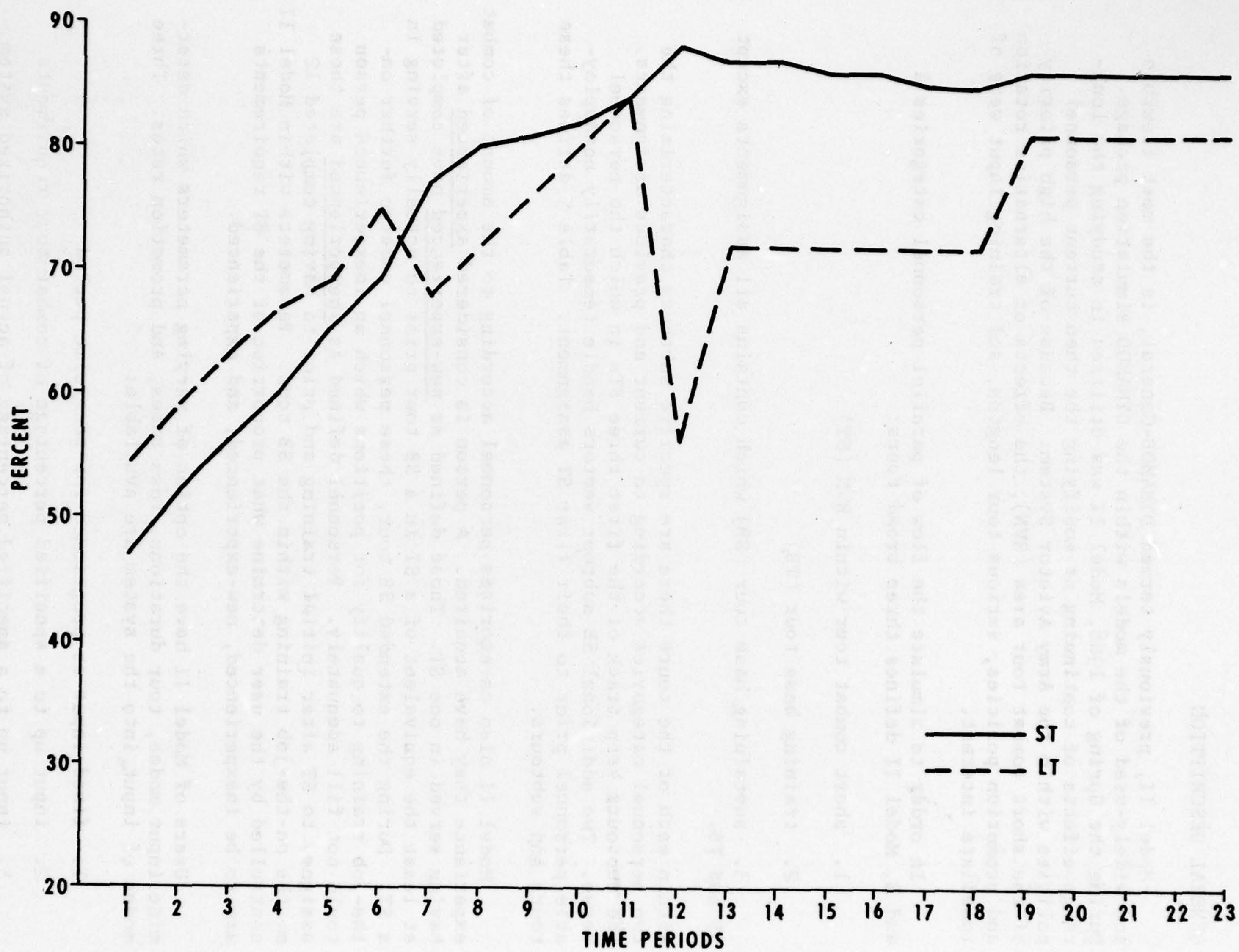


Figure 7. Percent of ST and LT who are warrant officers in Model I

MODEL II

GENERAL DESCRIPTION

Model II, previously termed DYNAMOD-General, is the most flexible and widely-used of the models within the DYNAMOD simulation package. During the Spring of 1968, Model II was utilized in studying the long-range effects of continuing or modifying the then current personnel policies within the Army Aviator System. Because of the high priority of the short combat tour area (RVN), the effects of alternative rotation and promotion policies, various tour lengths, and training input were of immediate interest.

In order to simulate the flow of parallel personnel categories A and B, Model II defines three broad tours:

1. short combat tour within RVN (ST)

2. training base tour (TB)

3. sustaining base tour (SB) which contains all assignments except ST and TB.

Within each of the tours there are specific subtours characterizing the two personnel categories according to current and previous assignments. The subtours keep track of the first three STs in which the personnel serve. Two additional SB subtour vectors handle temporarily nondeployable personnel prior to their first ST assignment. Table 5 defines these tours and subtours.

Model II also categorizes personnel according to the amount of combat experience they have acquired. A person is considered experienced after having served in one ST. Those defined as new-experienced have completed at least the equivalent of a ST in a SB tour prior to actually serving in a ST. During the extended SB tour, these personnel undergo further on-the-job training to qualify for positions which an inexperienced person could not fill adequately. Personnel defined as inexperienced are those assigned to ST after initial training and prior to having completed 12 months on-the-job training within the SB tour. Parameters within Model II controlled by the user determine what proportion of the ST requirements are to be inexperienced, new-experienced, and experienced.

Users of Model II have the option of varying parameters which determine input modes, tour durations, loss rates, and promotion rates. Three modes of input into the system are available:

1. fixed input as programmed for each time period

2. input up to a specified percentage of combat tour requirments

3. input up to a specified percentage of actual authorized system strength

The latter two modes allow the user either to study the effects of specific input forecast for the near future or to determine future input requirements. The user can vary these types of input within a given computer run.

Table 5

TOUR AND SUBTOUR DEFINITIONS FOR MODEL II

Tour Type	Tour Description	Subtour Type	Subtour Description
0	Short Tour (ST)	1	A on first ST assignment
		2	B on first ST assignment
		3	A on second ST assignment
		4	B on second ST assignment
		5	A on third or subsequent ST assignment
		6	B on third or subsequent ST assignment
2	Training Base Tour (TB)	1	A after first ST assignment
		2	B after first ST assignment
		3	A after second or subsequent ST assignment
		4	B after second or subsequent ST assignment
3	Sustaining Base Tour (SB)	1	A after first ST assignment
		2	B after first ST assignment
		3	A after second or subsequent ST assignment
		4	B after second or subsequent ST assignment
		5	A before first ST assignment
		6	B before first ST assignment

Tour-subtour durations, loss rates, and promotion rates are stated at the beginning of the simulation and may be changed--either increased or decreased--during the computer run. The standard loss rates apply to personnel as they transfer from one tour vector to another--either when they complete a tour or when they leave a tour early. Promotion rates, however, apply to every element within the tour-subtour vector for which they are designated. Negative promotion rates, therefore, may represent losses within the tours. All these parameters depict personnel policies of concern to management.

Unique priority-of-fill rules are defined in Table 6. These priority-of-fill rules determine the manner in which tour requirements are filled and, as a result, they control the direction and rate of personnel flow through the system. The directional flow patterns among all subtours for the two parallel systems, A and B, are illustrated in Figure 8. Personnel are rotated among TB, SB, and ST assignments with the primary objective of keeping ST requirements filled. Although many different rotational patterns are feasible, it is not possible for an individual to remain within the system without eventually serving at least two ST assignments.

Basically, the program searches for available personnel to fill deficits in ST, TB, or SB in accordance with the fill priorities. Table 6 describes in detail the fill priorities for ST under variable and fixed input conditions; Figures 9 and 10 show how the computer program represents this personnel flow. Under variable input conditions, all available men who have completed tours fill the ST deficits. The algorithm then calculates the number of inexperienced personnel needed from outside the system. After these personnel enter the system, the remaining deficit is filled by men who have been removed from tours prior to end of tour. Under fixed input conditions, however, a number of inexperienced personnel--not to exceed the programmed input or the experience factor--enter the system initially and the remaining deficit is filled by men removed from TB and SB tours. The TB and SB tours are filled in similar manner. The design of Model II insures that sufficient manpower will be present in the ST.

Table 6

PRIORITY-OF-FILL RULES FOR MODEL II

Tour-Subtour Into	Tour-Subtour From	Maximum Quota	Minimum Time in Tour Prior to Removal
		A: VARIABLE INPUT	
0,1 to 0,2	3,5 to 3,6	New Experienced	Completion
0,1 to 0,2	3,5 to 3,6	Inexperienced	Completion
0,1 to 0,2	3,5 to 3,6	New Experienced	12
0,3 to 0,6	2,1 to 2,4	Experienced	Completion
0,3 to 0,6	3,1 to 3,4	Experienced	Completion
0,1 to 0,2	Outside	Inexperienced	0
0,3 to 0,6	2,1 to 2,4	Experienced	As specified
0,3 to 0,6	3,1 to 3,4	Experienced	As specified
0,3 to 0,6	2,1 to 2,4	Experienced	18
0,3 to 0,6	3,1 to 3,4	Experienced	18
0,3 to 0,6	3,1 to 3,4	Experienced	1
2,1 to 2,4	0,1 to 0,6	Experienced	Completion
2,3 to 2,4	3,3 to 3,4	Experienced	1
3,1 to 3,4	0,1 to 0,6	Experienced	Completion
3,1 to 3,4	2,1 to 2,4	Experienced	Completion
		B: FIXED INPUT	
0,1 to 0,2	Outside	Inexperienced	0
0,1 to 0,2	3,5 to 3,6	New Experienced	Completion
0,1 to 0,2	3,5 to 3,6	Inexperienced	Completion
0,1 to 0,2	3,5 to 3,6	New Experienced	12
0,1 to 0,2	3,5 to 3,6	Inexperienced	0 to 7
0,3 to 0,6	2,1 to 2,4	Experienced	Completion
0,3 to 0,6	3,1 to 3,4	Experienced	Completion
0,3 to 0,6	2,1 to 2,4	Experienced	As specified
0,3 to 0,6	3,1 to 3,4	Experienced	As specified
2,1 to 2,4	0,1 to 0,6	Experienced	Completion
2,3 to 2,4	3,3 to 3,4	Experienced	1
3,1 to 3,4	0,1 to 0,6	Experienced	Completion
3,1 to 3,4	2,1 to 2,4	Experienced	Completion

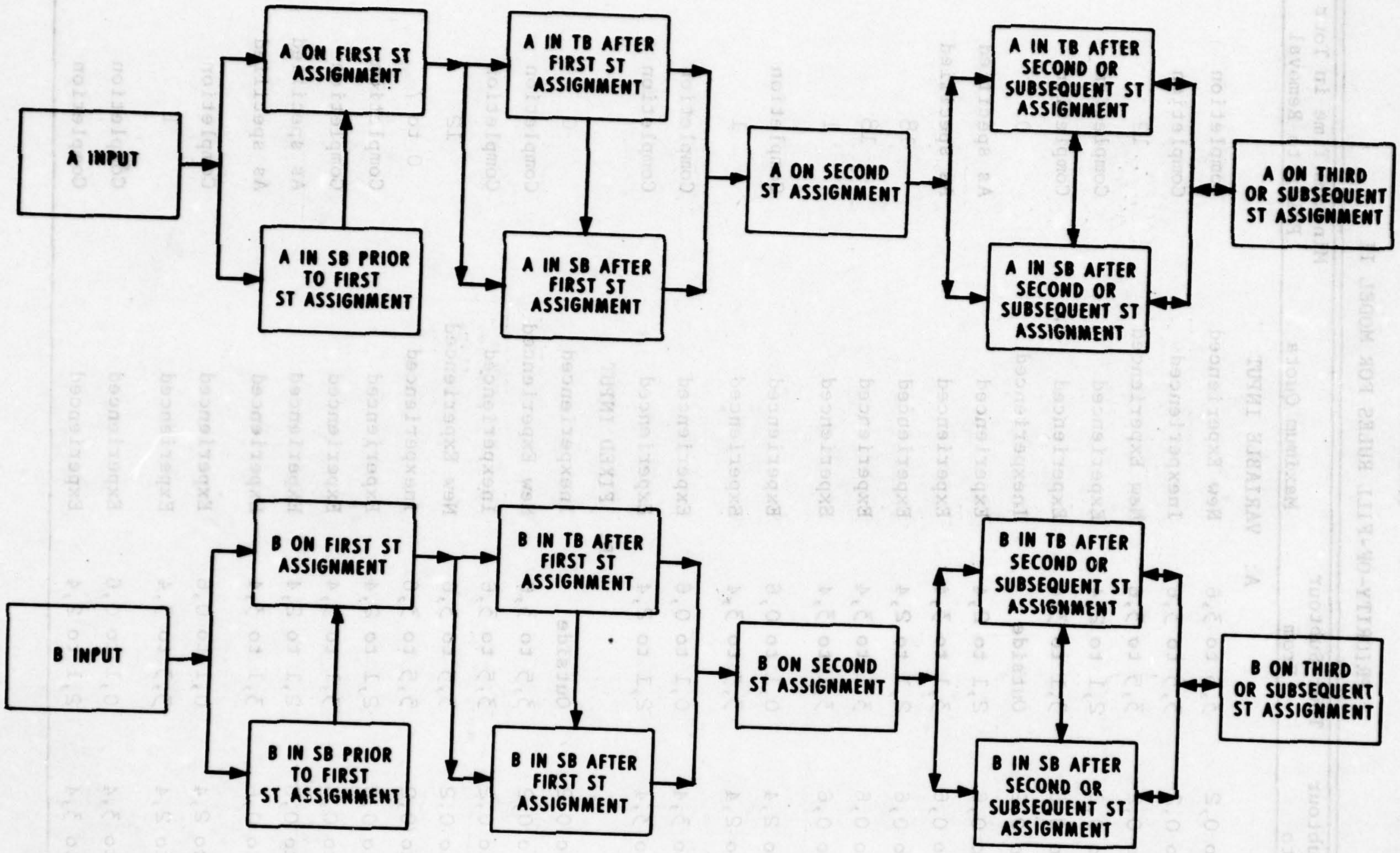


Figure 8. Flow of parallel systems, A and B, in Model II

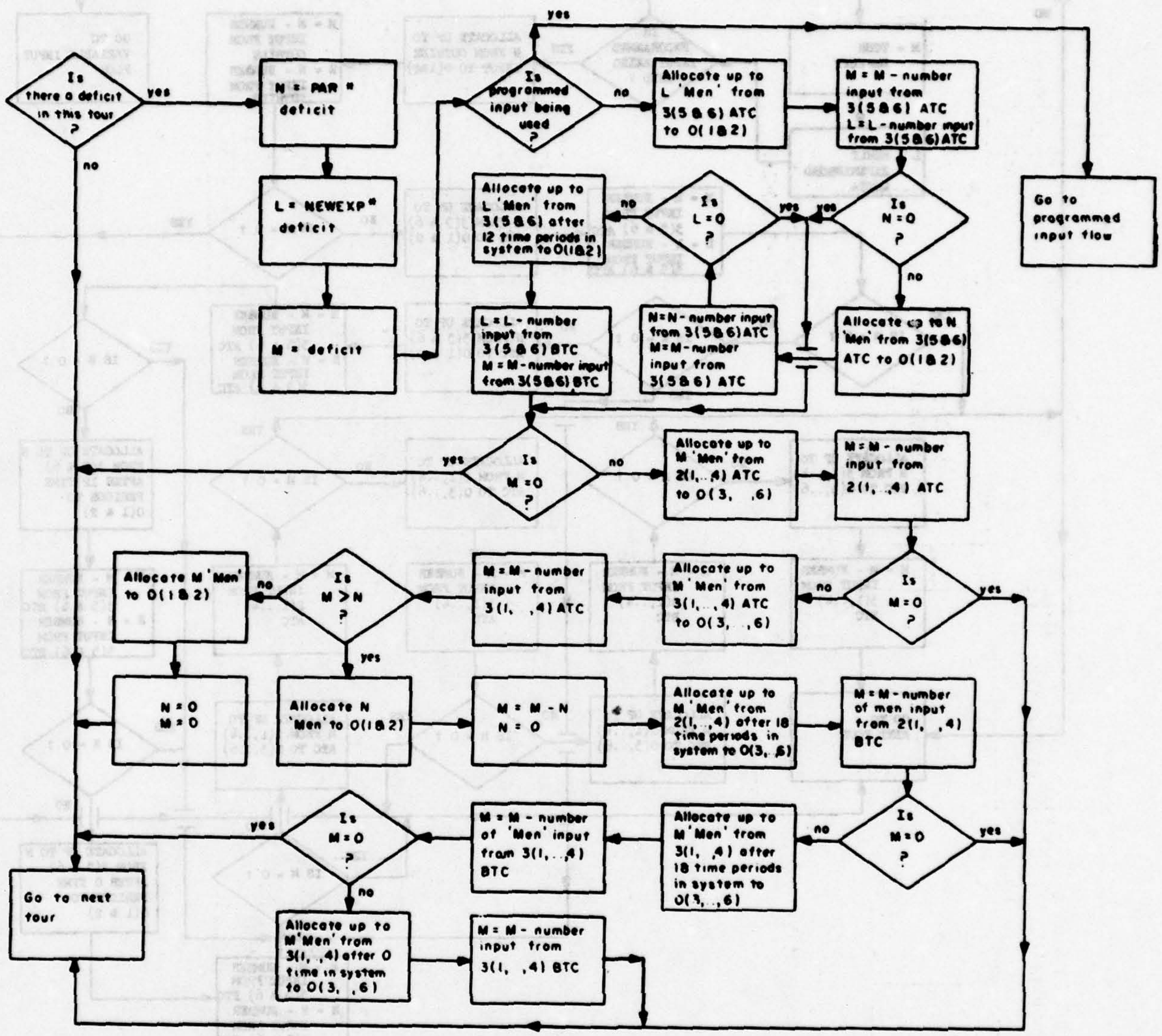


Figure 9. Flow diagram of variable input into ST in Model II

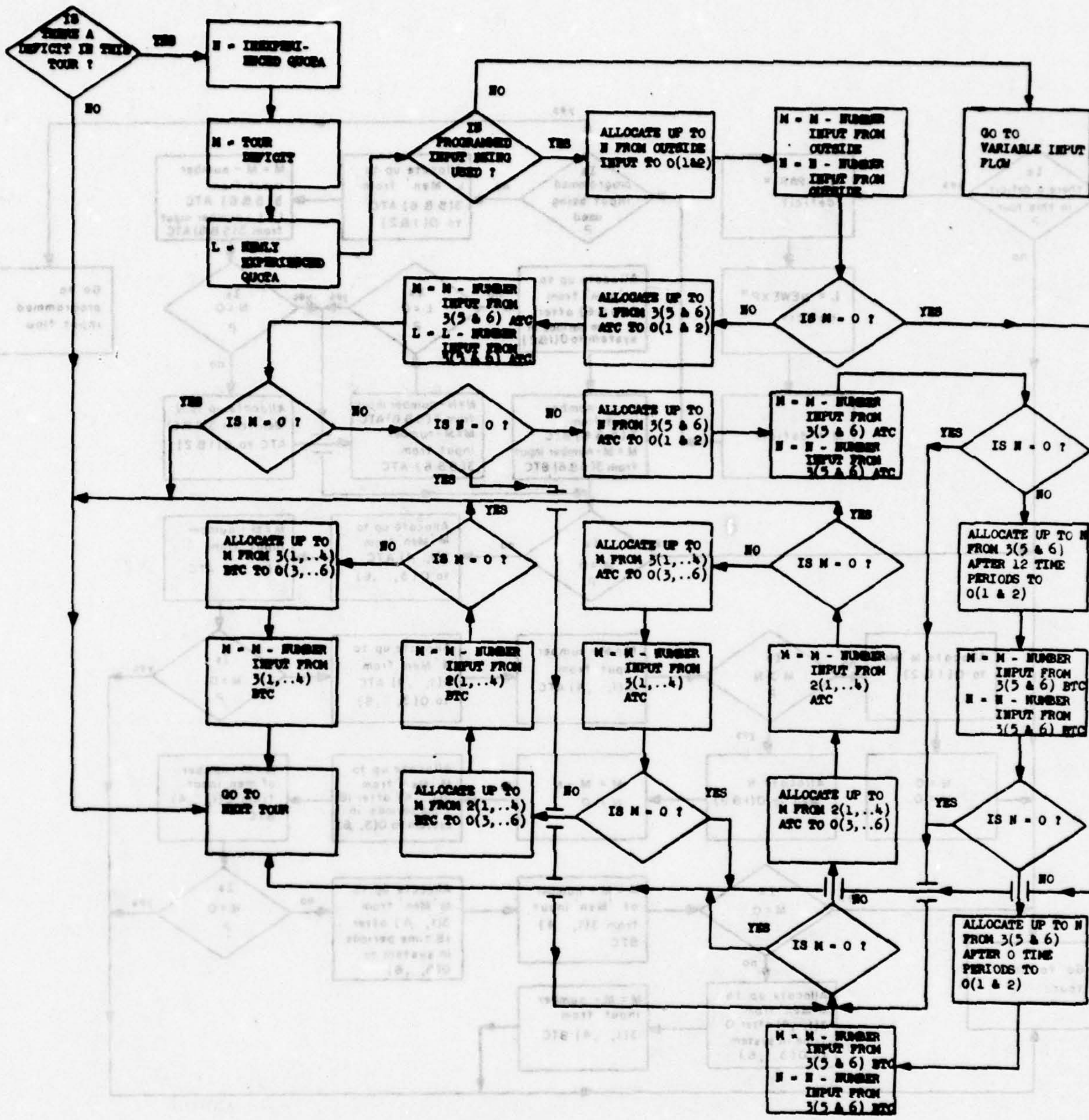


Figure 10. Flow diagram of fixed input into ST in Model II

INPUT SPECIFICATIONS FOR MODEL II

Input data to Model II consist of three sections: parameter cards, tour deck setup, and simulation control cards which are set up in the order shown in Figure 11. Table 7 describes each of these data input sections in detail. The parameter card section consists of four cards which determine the boundary conditions of the system.

The tour deck setup defines the initial state of each subtour within the system by a group of N cards. The first card in each group is a parameter card which specifies major characteristics of the subtour. The remaining two to N cards contain the personnel inventory grouped according to amount of time men have served in the subtour. This series of one to N cards is repeated once for each subtour in the system.

The last input section consists of four simulation control cards for each time period to be simulated. The cards specify values for the variables which are applied during computer run time periods. Major characteristics, such as type of input, tour requirements, and loss and promotion rates, are on these cards.

OUTPUT SPECIFICATIONS FOR MODEL II

Output specifications for Model II are presented in Table 8. For each simulation, two types of output are available: detailed intermediate output after each time period and a final summary table.

The massive intermediate output, which is useful in debugging and checking the program, consists of four major sections: 1) flows for persons shifted before the end of tour, 2) assignments, 3) tour distributions, and 4) end of tour flow for period. These four output sections are repeated for each time period simulated. Because an on-line printer is used, intermediate output is the major factor in increasing costly computer time. The user can suppress this intermediate output within any computer run in order to expedite running time.

A major improvement over the type of output used in Model I is the summary output table available in Model II. This summary table is a matrix with rows corresponding to individual time periods in which data are derived and columns corresponding to summary statistics calculated at the end of the time period. The first column designates the time periods summarized across the rows. The eleven other columns contain the following information:

1. ST requirements
2. ST assets
3. total inexperienced personnel input to the system
4. ST replacements
5. new-experienced ST input
6. inexperienced ST input
7. experienced ST input

8. average time in SB prior to ST assignment
9. inexperienced in SB
10. new-experienced in SB
11. system total

From these basic summary elements, management can determine if the policies employed in the simulation meet the objectives. Model II points up the significance of the output more clearly than does Model I.

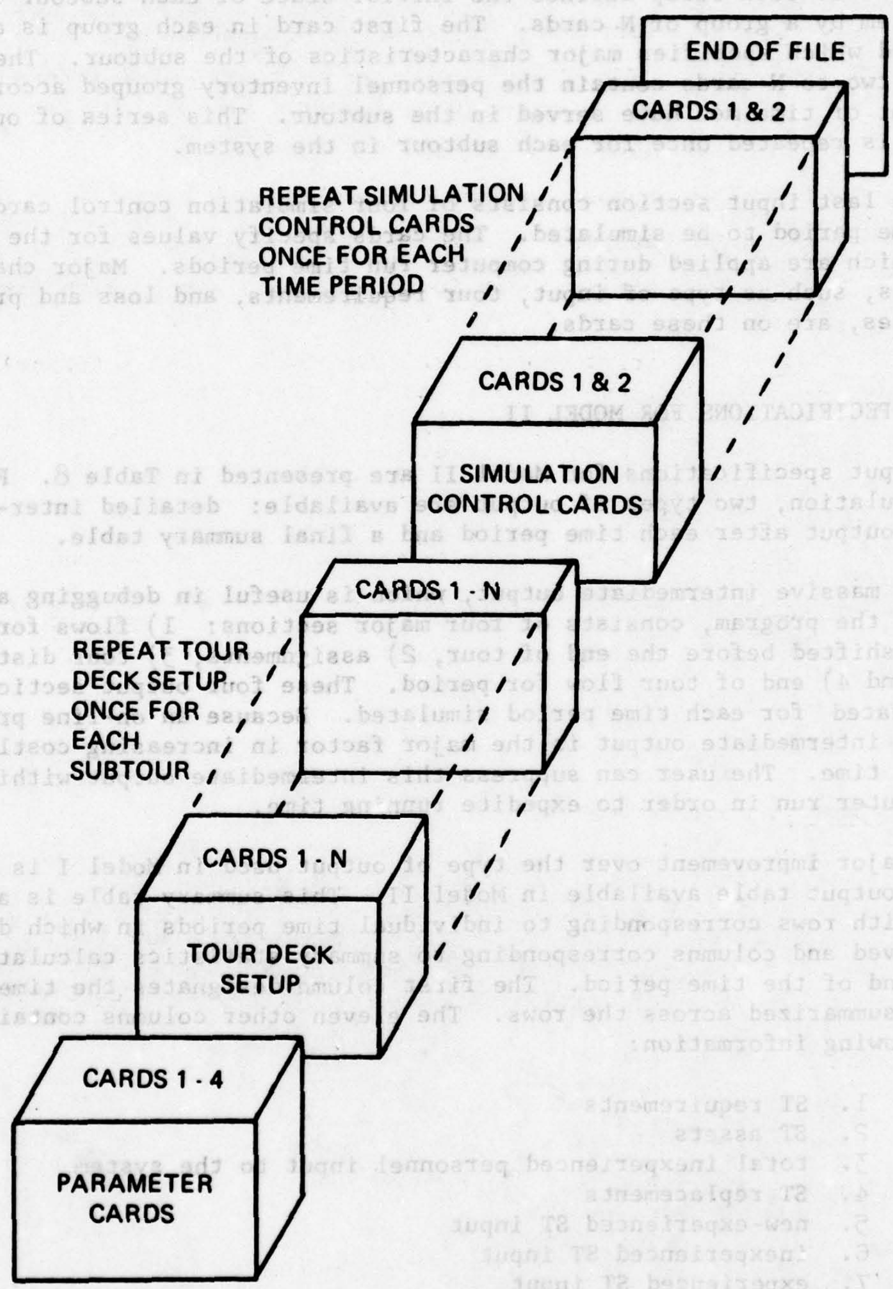


Figure 11. Input setup for Model II

Table 7

INPUT SPECIFICATIONS FOR MODEL II

Parameters Input to Simulation System
Card 1: use format (8I10)
Month : time period at start of the simulation.
Last : last time period to be simulated.
Tours : NTT*NUMSUB, or number of tours multiplied by number of subtours in each tour.
NTT : number of tours.
NUMSUB: number of subtours within each tour.
MXDUT : maximum duration of RB tours.
MNDUT : minimum duration of RB tours after which personnel may be removed before end of tour.
IPR : print controller. If IPR = 0, all intermediate output as well as the summary table will be printed. If IPR = 1, only the summary table at end of run will be printed.
Card 2: use format (2I10)
KPER : number of months within each time period.
ITE : parameter governing operation of variable input used to fill ST requirements only. If ITE = 0, program uses fixed input. If ITE = 2, it steals men as far back as 18 months within RB. If ITE = 3, it steals men from TB as far back as 18 months and from RB after zero months.
Card 3: use format (2F6.3)
CALC : percentage of ST requirements within each time period which may be inexperienced.
EXP : percentage of ST requirements within each time period which may be new-experienced. This factor is applied against the experienced requirements.
Card 4: first 72 card columns. Comment card used to label summary output.
Tour Deck Setup
Card 1: use format (6I10, 2F6.3)
Type : broad tour. type = 0 Short tour (ST)

Table 7 continued

type = 2 Training base tour (TB)
type = 3 Sustaining base tour (SB)

SUBTOUR: subtour type as described in Table 1.

QUOTA : broad tour requirements for time period being simulated.

ACTUAL : Actual number of personnel in this tour for time period being simulated.

NUM : number of subtours within this tour.

LENGTH : length of subtour in time periods.

OUT : percentage of personnel lost to the system each year from this subtour.

PRO : percentage of personnel promoted on a yearly basis within this subtour.

Cards 2 through N: (N = LENGTH/10 + 2 if LENGTH is not a multiple of 10 through LENGTH/10 + 1 if LENGTH is a multiple of 10) Use format (10I8).

PERS : vector of number of personnel within subtour in each time period at start of simulation. Depicts state of personnel within subtour at beginning of simulation.

Cards 1 to N of the tour deck setup are repeated NTT*NUMSUB times, once for each tour-subtour simulated.

Simulation Control Cards

Construct one set of these cards for each time period to be simulated.

Card 1: use format (3I10, F6.3, 2I10, 3F6.3, I2).

INPUTO : number of personnel A to be input to system at beginning of time period being simulated.

INPUTWO: number of personnel B to be input to system at beginning of time period being simulated.

ISTOP : option to stop or continue simulation.
If ISTOP = 0, program continues.
If ISTOP = 1, program stops after time period being simulated.
If ISTOP = 2, program stops after time period being simulated and begins a new simulation.

Table 7 continued

PAR : input parameter
If PAR = 0, INPUTO and INPUTWO are used as new input to system during month being simulated.
If PAR > 0 and < 3, program calculates number of new input to system during time period being simulated and uses PAR as the percentage of calculated input into the B category.
If PAR = 3, PAR1 is used as percentage of total system input into the combat tour.

MA : If > 0, it replaces MXDUT as the new maximum duration of the SB tour.

MB : If > 0, it replaces MNDUT as the new minimum SB duration.

PARI : percentage of system total to be used as input into ST during this time period.

CALCC : If > 0, it replaces CALC as the percentage used in calculating number of new trainees which may be sent to ST.

EXPP : If > 0, it replaces EXP as the percentage of ST requirements which may be newly experienced.

ITEX : If > 0, it replaces ITE as the new parameter governing variable input in same manner as ITE.

Card 2: use format (8I10).

NEEDS : the vector (1XNTT) of requirements, or quotas, for each tour type.

INTE1 : If INTE1 > 0, program reads in card 3.

INTE2 : If INTE2 > 0, program reads in card 4.

Card 3: use format (10F8.4). This card is used only if INTE1 is > 0.

POUT : a vector with NTT*NUMSUB elements which replaces OUT as percentage of personnel lost to the system each year from each subtour.

Card 4: use format (10F8.4). This card is used only if INTE2 > 0.

PRO : a vector with NTT*NUMSUB elements which replaces PRO as percentage of personnel promoted on a yearly basis within each subtour.

Table 8

OUTPUT SPECIFICATIONS FOR MODEL II

Intermediate Output

Loss Rates to be Used during this Simulation: a vector of percentages which are applied to the subtour to determine how many personnel are lost to the system in each time period.

Summary for Period P: designates the beginning of intermediate summary output for time period P of the simulation.

Flows for Persons Shifted before End of Tour: detailed breakdown of all personnel who were removed from each subtour prior to completion of regular length of service in that subtour.

From Tour: the first and second columns designate respectively the broad tour and the specific subtour from which personnel in that row were removed.

Losses: number of personnel removed from the tour-subtour designated in this row and then lost to the system.

Reassignable: number of personnel removed from the tour-subtour designated in this row and then available for reassignment within the system.

Assignments: detailed breakdown of all personnel movement among subtours for time period P.

Tour: a column designating the broad tour to which personnel were assigned in time period P.

Subtour: a column designating the specific subtour to which personnel were assigned in time period P.

Total: total number of personnel assigned to the specific tour and subtour from all sources for time period P.

Subtotal: total number of personnel assigned to the specific subtour from a particular source during time period P.

Source: specific subtour or place in which the personnel assigned to the subtour originated.

Outside: designates inexperienced personnel input to the system from outside the system.

T, S: indicates inexperienced personnel assigned to the subtour from a previous temporarily nondeployable tour T subtour S.

Early T, S: indicates that personnel assigned to this subtour came from tour T subtour S and were removed prior to completing regular length of service in this subtour.

End T, S: indicates that personnel assigned to the subtour came from tour T subtour S after completing regular length of service in the subtour.

Table 8 continued

Tour Distributions: describes state of the system at end of time period P.

Tour T, S: designates tour T and subtour S.

Quota: total A and B personnel requirements for tour T.

Strength: total number of personnel A and B within tour T.

Duration: length of tour T subtour S measured in time periods.

Row Vector: denotes where in tour T subtour S personnel are at the end of time period P.

System Total: total number of personnel within the entire system at end of time period P.

End Tour Flow for Period P: summary of personnel completing specific subtours at end of time period P.

From Tour: the first and second columns designate respectively the tour and subtour which have been completed by the personnel.

Losses: number of personnel who completed the subtour and then were lost to the system.

Reassignable: number of personnel who completed the subtour and were eligible to be reassigned within the system.

Average Number of Months Served in CONUS: average number of months which A and B personnel served in SB tour prior to reassignment to ST.

Summary Output:

Month: the month or time period which is being summarized in this row of output data.

Gross ST Quota: total ST requirements for A and B personnel in month P.

ST Actual: total number of A and B personnel serving in ST at end of month P.

Trainee Input: total number of inexperienced A and B personnel input to the system during month P.

REP to ST: total number of A and B personnel replacements sent to ST during month P.

New Exp: total number of A and B new-experienced personnel sent to ST during month P.

Inexp: total number of inexperienced personnel sent to ST during month P.

Career: total number of experienced personnel sent to ST during month P.

Base Tour: average number of months or time periods spent in SB by A and B personnel prior to reassignment to ST.

Table 8 continued

New Trainees: total number of inexperienced personnel in the first 12 time periods of SB subtours 5 and 6 who have not served in a ST prior to month P.

Seasoned Trainees: total number of new-experienced personnel who have been in SB subtours 5 and 6 more than 12 time periods and have not served in a ST prior to month P.

System Total: total number of personnel within the system.

SAMPLE PROBLEM DESCRIPTION FOR MODEL II

Providing enough pilots to fill tour requirements, especially those in the ST area, is a major problem within the Army Aviator System. Both warrant officers and commissioned officers are qualified to fill aircraft pilot positions. Because of demands for these men in other positions within the system, however, the mix of warrant officers and commissioned officers in these positions is critical.

The problem has frequently been studied in the context of Model II, which simulates the flow of two parallel systems with joint requirements. In this example, the two parallel systems A and B represent warrant officer pilots and commissioned officer pilots.

Input to Model II for the above problem is presented as a matrix with rows and columns corresponding respectively to the input card sequence number and the card column numbers. For example, the number at the intersection of row one and column 80 corresponds to the number punched in the 80th column of the first input card.

These are the first four input parameter cards described under Input to Simulation System: Card 1 indicates that the simulation will run from month 0 to month 80 for a system of 24 subtours in four broad tours of six subtours each. Maximum and minimum SB tour durations are 25 and 18 months, and all intermediate output is suppressed. Card 2 sets one month equal to a time period and 18 months completed in TB and zero months completed in SB tours equal to minimum tour lengths. Card 3 restricts the total number of inexperienced officers and warrant officers to 80 percent and the new-experienced officers and warrant officers to 10 percent of total ST requirements. The label for the summary table is punched in Card 4.

PARAMETER CARDS

0	80	24	4	6	25	18
1	3					
100						
MODEL II	80 PER =NEW			10 PER =NEW EXP		

Table 9 presents tour deck setup cards 5-102. Each subtour within the system is described by a group of N cards consisting of one parameter card and a personnel placement vector. For example, Card 5 describes the ST which has 5502 pilots present to fill its 5502 requirements. Within the ST, there are six subtours. (Subtour 1 consists of commissioned officers on the first 12-month ST assignment.) Three percent of the total number of men within the subtour are lost to the system each year. Cards 6 and 7 place the commissioned officers into each of the 12 months in the tour. For example, there are 333 commissioned officers in their third month of the subtour. Four tours, 0, 1, 2, and 3, are input as in Model I, although the program simulates movement among only three of these tours, 0, 2, and 3. This relic of Model I was retained as a reprogramming convenience. As a result, blank data must be input for the six subtours in broad tour 1.

The <u>simulation control</u> cards 103-N are presented in Table 10. Two cards are input for each month to be simulated. The first card for month 1 (card 104) sets the ST 2d TB requirements at 6060 and 2880, respectively. The second card (card 105) sets the parameter PAR at .50; therefore, <u>variable</u> input will be calculated in the first time period, and the input will be divided equally between the A and B personnel systems. Since the input cards for months 32 to 46 are identical to those for month 31, only the data for months 1 through 31 are shown in Table 10 (page 37).

No intermediate output is available for this sample problem. The output, however, would be similar in form to that displayed for Model IV.

Summarized input data for the 46-month simulation using the previously described input data is presented in Table 11. A description of the output for the first month illustrates use of the table. The total ST requirements for commissioned and warrant officers are filled in the following manner. Besides the officers already serving in ST at the beginning of the first month, 684 personnel are sent to ST to fill additional tour requirements and to replace those who have completed their ST assignment. Of these 684, 137 are experienced career officers and 547 inexperienced officers. In order to follow the priorities as they are designated, therefore, there must be a source from which 547 persons can be input to the system. As specified by the variable input parameter PAR, 50 percent or 273 of the new input become warrant officers and 274 become commissioned officers. An average of 25 months is served in SB by career officers prior to their assignment to ST. There were 1116 inexperienced persons in the SB, no men having served long enough in the SB to be considered new-experienced. At the end of time period one, there were 12536 warrant and commissioned officer pilots in the system.

5	0	1	5502		5502	6	12	03		
6	583	352	383	176	327	218	227	157	178	198
7	61	18								
8	0	2	5502		5502	6	12	03		
9	202	116	90	47	56	94	92	75	77	98
10	76	19								
11	0	3	5502		5502	6	12	12		
12	53	47	24	27	23	24	10	22	3	14
13	18	31								
14	0	4	5502		5502	6	12	12		
15	169	133	118	84	82	107	139	126	95	112
16	142	58								
17	0	5	5502		5502	6	12	10		
18										
19										
20	0	6	5502		5502	6	12	10		
21										
22										
23	1	1				6	12			
24										
25										
26	1	2				6	12			
27										
28										
29	1	3				6	12			
30										
31										
32	1	4				6	12			
33										
34										
35	1	5				6	12			
36										
37										
38	1	6				6	12			
39										
40										
41	2	1	2647		2647	6	48	35		
42	206	87	44	53	34	21	29	21	24	20
43	18	65	27	38	21	18	29	12	10	22
44	15	13	2	2	1	3				
45										
46										
47	2	2	2647		2647	6	48	35		
48	136	79	60	27	36	17	8	8	6	6
49	12	14	12	19	5	5	3	2	9	1
50	2	9	2							
51										
52										
53	2	3	2647		2647	6	48	10		
54	39	17	4	17	18	5	8	18	16	13
55	34	39	28	11	14	21	5	8	2	5
56	6	19	8	6	2	16				
57										
58										
59	2	4	2647		2647	6	48	10		
60	138	73	41	38	57	56	47	35	31	29
61	35	87	84	51	34	26	49	11	5	9
62	13	5	6	8	2	72				
63										
64										
65	2	5	2647		2647	6	12			
97										
98										
99	3	6	3952		3952	6	24	03		
100	618	23	7		1		1	1	1	
101										
102										

Table 9. Sample tour deck setup for Model II

Card			
103			
104	6060	2880	
105			50
106	6300	3110	
107			50
108	6380	3210	
109			50
110	6660	3260	
111			50
112	6950	3320	
113			50
114	7020	3380	
115			50
116	7100	3430	
117			50
118	7280	3460	
119			50
120	7460	3460	
121			50
122	7540	3460	
123			50
124	7600	3460	
125			50
126	7720	3460	
127			50
128	7750	3460	
129			50
130	7900	3460	
131			50
132	7910	2880	
133			50
134	8150	3460	
135			50
136	8490	3460	
137			50
138	8980	3460	
139			50
140	9290	3460	
141			50
142	9940	3460	
143			50
144	10490	3460	
145			50
146	10570	3460	
147			50
148	10590	3460	
149			50
150	10610	3460	
151			50
152	10630	3460	
153			50
154	10650	3460	
155			50
156	10670	3460	
157			50
158	10680	3460	
159			50
160	10700	3460	
161			50
162	10710	3460	
163			50
164	10720	3460	

Table 10. Sample simulation control cards for Model II

Table 11

SUMMARY OUTPUT FOR DYNAMOD MODEL II-VARIABLE INPUT

BEHAVIOR AND SYSTEMS RESEARCH LABORATORY DYNAMIC ARMY MODEL

MODEL II INPUT: 80 PERCENT = NEW. 10 PERCENT = NEW EXPERIENCED.

MONTH	GROSS ST QUOTA	ST ACTUAL	TRAINEE INPUT	REP TO ST	NEW EXP	INEXP	CAREER
1	6060	6060	547	684	0	547	137
2	6300	6300	430	538	0	430	108
3	6380	6380	401	502	0	401	101
4	6660	6660	506	633	1	506	126
5	6950	6950	536	670	1	536	133
6	7020	7020	414	518	1	414	103
7	7100	7100	410	513	0	410	103
8	7280	7280	534	668	1	534	133
9	7460	7460	411	514	0	411	103
10	7540	7540	516	645	7	516	122
11	7600	7600	566	708	23	566	119
12	7720	7720	901	1127	112	901	114
13	7750	7750	571	714	71	571	72
14	7900	7900	550	688	68	550	70
15	7910	7910	409	512	51	409	52
16	8150	8150	698	873	87	698	88
17	8490	8490	808	1010	101	808	101
18	8980	8980	806	1008	100	806	102
19	9290	9290	658	823	82	658	83
20	9940	9940	1054	1318	131	1054	133
21	10400	10400	779	974	97	779	98
22	10570	10570	652	815	81	652	82
23	10590	10590	582	728	59	582	87
24	10610	10610	917	1147	0	917	230
25	10630	10630	587	734	0	587	147
26	10650	10650	566	708	0	566	142
27	10670	10670	425	532	0	425	107
28	10680	10680	706	883	0	706	177
29	10700	10700	824	1030	0	824	206
30	10710	10710	814	1018	0	814	204
31	10720	10720	666	833	0	666	167
32	10720	10720	1054	1318	0	1054	264
33	10720	10720	779	974	0	779	195
34	10720	10720	652	815	0	652	163
35	10720	10720	582	728	0	582	146
36	10720	10720	917	1147	0	917	230
37	10720	10720	587	734	0	587	147
38	10720	10720	566	708	0	566	142
39	10720	10720	425	532	0	425	107
40	10720	10720	706	883	0	706	177
41	10720	10720	824	1030	0	824	206
42	10720	10720	814	1018	0	814	204
43	10720	10720	666	833	0	666	167
44	10720	10720	1054	1318	0	1054	264
45	10720	10720	779	974	0	779	195
46	10720	10720	652	815	0	652	163

NEW TRAINEES	SEASONED TRAINEES	SYSTEM TOTAL
1116	0	12536
1116	0	12912
1116	0	13242
1115	0	13639
1114	0	14082
1113	0	14426
1113	0	14780
1112	0	15261
1112	0	15598
1105	0	16014
1082	0	16519
0	967	17287
0	894	17806
0	824	18311
0	771	18647
0	681	19290
0	577	19987
0	473	20702
0	387	21278
0	249	22224
0	147	22878
0	62	23407
0	0	23844
0	0	24512
0	0	24799
0	0	25277
0	0	25565
0	0	26067
0	0	26473
0	0	27030
0	0	27417
0	0	28142
0	0	28576
0	0	29005
0	0	29238
0	0	29725
0	0	29822
0	0	29900
0	0	29965
0	0	30275
0	0	30658
0	0	31011
0	0	31313
0	0	31950
0	0	32272
0	0	32572

Instead of variable input based on the current state of the system, a fixed programmed input can also be used so that there will be a steady increase in the number input to the system each month. Table 12 shows the summary output obtained with fixed input. Many comparisons and interpretations can be given for the different outputs obtained by altering the input policy.

Although in each month, the same number of career officers enter the ST under the two policies, the variable input condition results in longer, more predictable SB tours between ST assignments than the fixed input condition (Figure 12). This result may be one criterion of effectiveness which management considers important, since it affects officer morale and retention rate. The value of more stable SB tours, however, must be considered relative to other results. As indicated in Figure 13, more personnel are needed to maintain the system under the variable input policy. These are only a few of the factors upon which management must ultimately base its decisions. The role of the model is to present the data in a form convenient for interpretation and evaluation.

MODEL III

GENERAL DESCRIPTION

Model III, a simplified and streamlined version of Model II, provides for an additional initial direction of flow for newly acquired personnel in the Army. All newly acquired personnel, instead of being forced into the regular short combat tour (ST), have the option of serving an extended combat tour in return for a shorter total obligation. In theory, this policy could alter manpower effectiveness by increasing the number of experienced personnel within the combat zone and by alleviating shortages within other crucial areas. Incorporation of this additional policy alternative makes it necessary to redefine tours and subtours, to change the priority-of-fill rules, and to add several other variables.

The three broad tours defined in Model III are identical to those in Model II. The subtour definitions, however, are unique to Model III. In order to represent this new direction of personnel flow, two subtour vectors have been added: one for an extended ST and one for returnees from the extended ST in CONUS. In Models I and II, many categories of personnel are assigned identically. To eliminate this simultaneous tracking of several groups in parallel subtours, all personnel within Model III are combined into one category, A. Table 13 presents a detailed description of the tours and subtours.

Personnel are also classified into two experience levels: 1) experienced personnel, who have served in at least one ST, and 2) inexperienced personnel, who have never served in ST. The maximum number of inexperienced personnel assigned to ST is restricted within the computer program to 75 percent of total ST requirements for the time period being simulated.

Table 12

SUMMARY OUTPUT FOR DYNAMOD MODEL II-FIXED INPUT

BEHAVIOR AND SYSTEMS RESEARCH LABORATORY DYNAMIC ARMY MODEL

MODEL II INPUT: 80 PERCENT = NEW. 10 PERCENT = NEW EXPERIENCED.

MONTH	GROSS ST QUOTA	ST ACTUAL	TRAINEE INPUT	REP TO ST	NEW EXP	INEXP	CAREER
1	6060	6060	410	684	0	547	137
2	6300	6300	410	538	0	430	108
3	6380	6380	410	502	0	401	101
4	6660	6660	410	633	1	506	126
5	6950	6950	410	670	1	536	133
6	7020	7020	410	518	1	414	103
7	7100	7100	460	513	0	410	103
8	7280	7280	460	668	1	534	133
9	7460	7460	485	514	0	411	103
10	7540	7540	510	645	7	516	122
11	7600	7600	560	708	23	566	119
12	7720	7720	560	1127	112	622	393
13	7750	7750	610	714	71	571	72
14	7900	7900	610	688	68	550	70
15	7910	7910	610	512	51	409	52
16	8150	8150	610	873	87	698	88
17	8490	8490	610	1010	101	808	101
18	8980	8980	610	1008	100	624	284
19	9290	9290	610	823	69	610	144
20	9940	9940	613	1318	0	613	705
21	10400	10400	613	974	0	613	361
22	10570	10570	638	815	0	638	177
23	10590	10590	658	728	0	582	146
24	10610	10610	678	1147	0	754	393
25	10630	10630	689	734	0	587	147
26	10650	10650	689	708	0	566	142
27	10670	10670	689	532	0	425	107
28	10680	10680	689	883	0	706	177
29	10700	10700	689	1030	0	824	206
30	10710	10710	689	1018	0	814	204
31	10720	10720	689	833	0	666	167
32	10720	10720	689	1318	0	919	399
33	10720	10720	689	974	0	689	285
34	10720	10720	689	815	0	652	163
35	10720	10720	689	728	0	582	146
36	10720	10720	689	1147	0	833	314
37	10720	10720	689	734	0	587	147
38	10720	10720	689	708	0	566	142
39	10720	10720	689	532	0	425	107
40	10720	10720	689	883	0	706	177
41	10720	10720	689	1030	0	824	206
42	10720	10720	689	1018	0	814	204
43	10720	10720	689	833	0	666	167
44	10720	10720	689	1318	0	919	399
45	10720	10720	689	974	0	689	285
46	10720	10720	689	815	0	652	163

SE UR	NEW TRAINEES	SEASONED TRAINEES	SYSTEM TOTAL
25	979	0	12399
25	959	0	12755
24	968	0	13094
21	870	0	13394
19	742	0	13710
19	737	0	14050
19	787	0	14454
20	712	0	14861
20	786	0	15272
21	773	0	15682
22	744	0	16181
22	0	0	16504
22	39	494	17053
22	99	424	17596
23	300	371	18171
23	212	0	18694
23	14	0	19233
23	0	0	19640
22	0	0	20135
21	0	0	20113
20	0	0	20523
19	0	0	20974
19	76	0	21437
19	0	0	21735
19	102	0	22330
19	225	0	22866
19	489	0	23440
20	472	0	23936
20	336	0	24390
20	210	0	24832
20	233	0	25251
20	0	0	25393
21	0	0	25791
21	37	0	26214
21	144	0	26716
21	0	0	26937
21	102	0	27412
22	225	0	27909
22	489	0	28406
23	472	0	28840
23	336	0	29182
23	210	0	29514
23	233	0	29818
24	0	0	30140
23	0	0	30332
23	37	0	30738

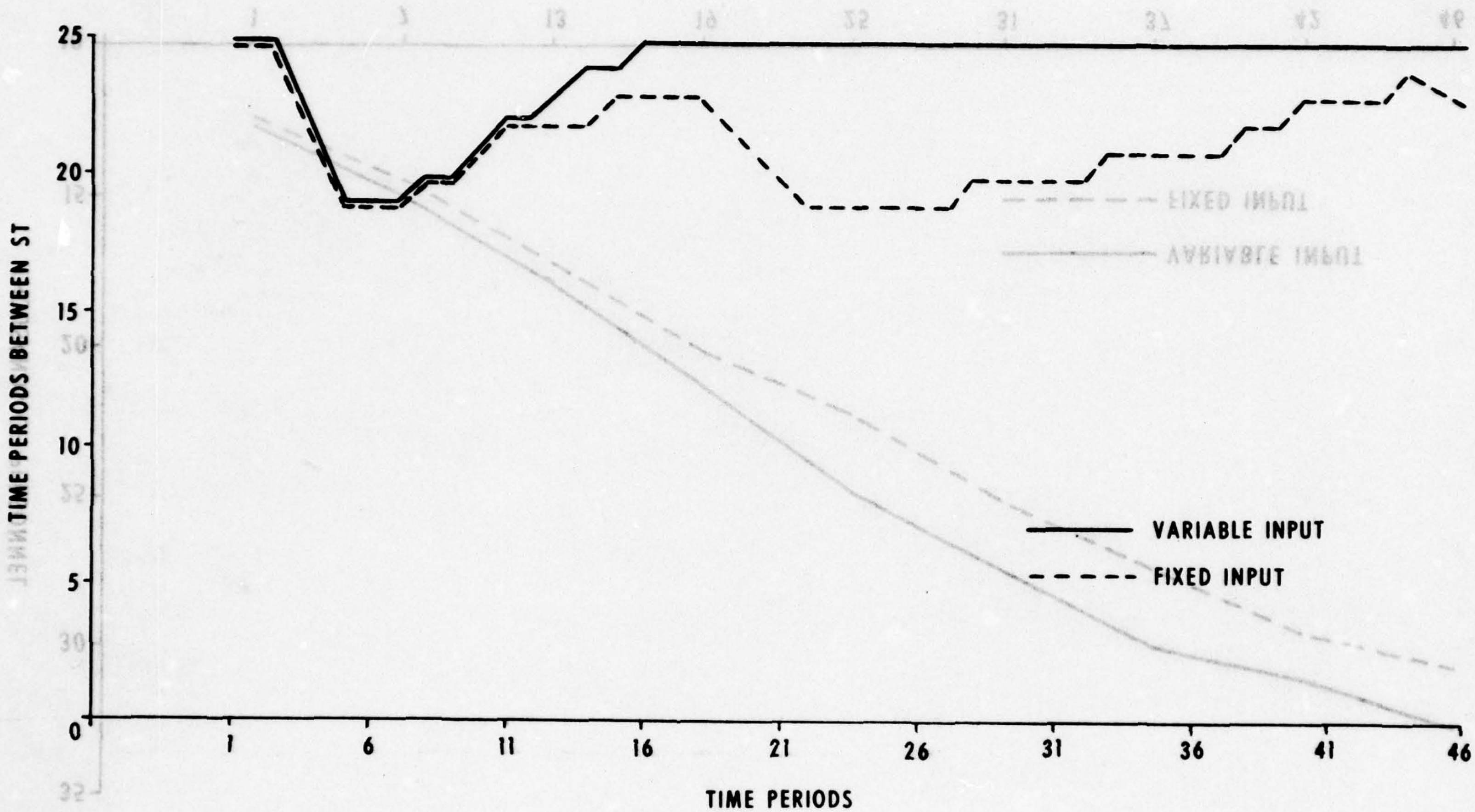


Figure 12. Average time in SB between ST assignments as a function of input

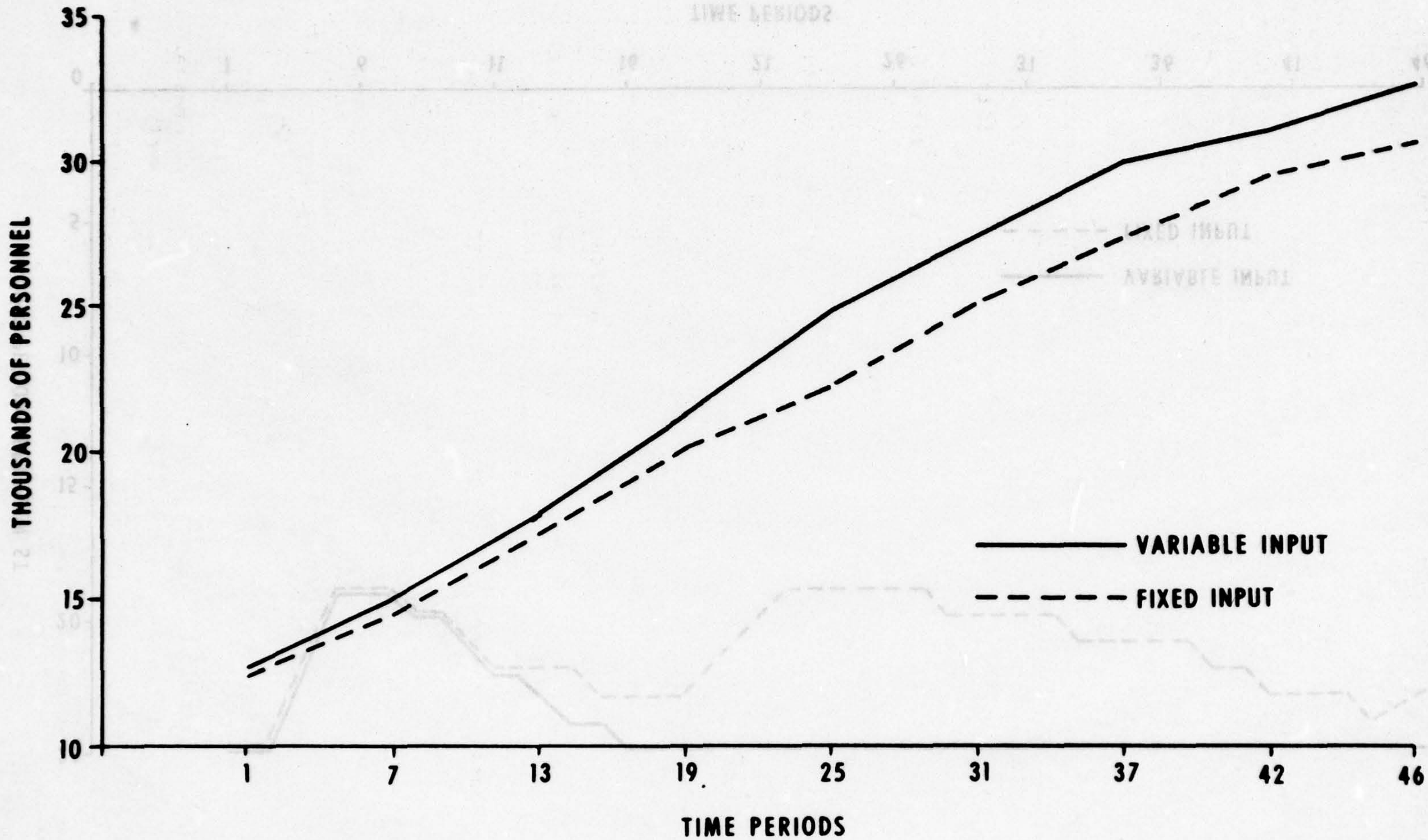


Figure 13. System total as a function of input

Prior to the simulation, the user specifies subtour durations, loss rates, and types of input. Once the tour lengths and loss rates are specified, they are constant throughout the computer run. Type of input, however, can vary from one time period to another as in Model II. As a result of the option of an extended initial ST, two additional parameters subject to change within the simulation are necessary. These parameters are PEXT, the percentage of personnel assigned to ST who elect an extended initial assignment, and RET, the percentage of those personnel who, after serving in an extended ST, elect to remain within the system as career men.

Table 13

TOUR AND SUBTOUR DEFINITIONS FOR MODEL III

Tour Type	Tour Description	Subtour Type	Subtour Description
1	Short Combat Tour (ST)	1	A on extended first ST assignment
		2	A on regular first ST assignment
		3	A on second ST assignment
		4	A on third or subsequent ST assignment
2	Training Base Tour (TB)	1	A after extended first ST assignment
		2	A after regular first ST assignment
		3	A after second ST assignment
		4	A after third or subsequent ST assignment
3	Sustaining Base Regular CONUS Tour (SB)	1	A after extended first ST assignment and prior to early release from the system
		2	A after extended first ST assignment
		3	A after regular first ST assignment
		4	A after second ST assignment
		5	A after third or subsequent ST assignment
		6	Unassigned first obligation personnel

The new parameters and additional subtours necessitate unique sets of priorities or flow rules. These priority-of-fill rules are delineated for variable and fixed input in Table 14. The flow determined by these priorities is illustrated in Figure 14.

Table 14

PRIORITY-OF-FILL RULES FOR MODEL III

Tour-Subtour Into	Tour-Subtour From	Maximum Quota	Minimum Time in Tour Prior to Removal
A: VARIABLE INPUT			
1,1 to 1,2	3,6	Inexperienced	Completion
1,1 to 1,2	3,6	Inexperienced	6
1,3 to 1,4	2,1 to 2,4	Experienced	Completion
1,3 to 1,4	3,2 to 3,5	Experienced	Completion
1,3 to 1,4	2,1 to 2,4	Experienced	As specified
1,3 to 1,4	3,2 to 3,5	Experienced	As specified
1,1 to 1,2	Outside	Inexperienced	0
2,1 to 2,4	1,1 to 1,4	Experienced	Completion
2,1 to 2,4	3,2 to 3,5	Experienced	Completion
2,1 to 2,4	3,2 to 3,5	Experienced	1
3,1 to 3,5	1,1 to 1,4	Experienced	Completion
3,2 to 3,5	2,1 to 2,4	Experienced	Completion
B: FIXED INPUT			
1,1 to 1,2	Outside	Inexperienced	0
1,1 to 1,2	3,6	Inexperienced	Completion
1,1 to 1,2	3,6	Inexperienced	6
1,3 to 1,4	2,1 to 2,4	Experienced	Completion
1,3 to 1,4	3,2 to 3,5	Experienced	Completion
1,3 to 1,4	2,1 to 2,4	Experienced	As specified
1,3 to 1,4	3,2 to 3,5	Experienced	As specified
2,1 to 2,4	1,1 to 1,4	Experienced	Completion
2,1 to 2,4	3,2 to 3,5	Experienced	Completion
2,1 to 2,4	3,2 to 3,5	Experienced	1
3,1 to 3,5	1,1 to 1,4	Experienced	Completion
3,2 to 3,5	2,1 to 2,4	Experienced	Completion

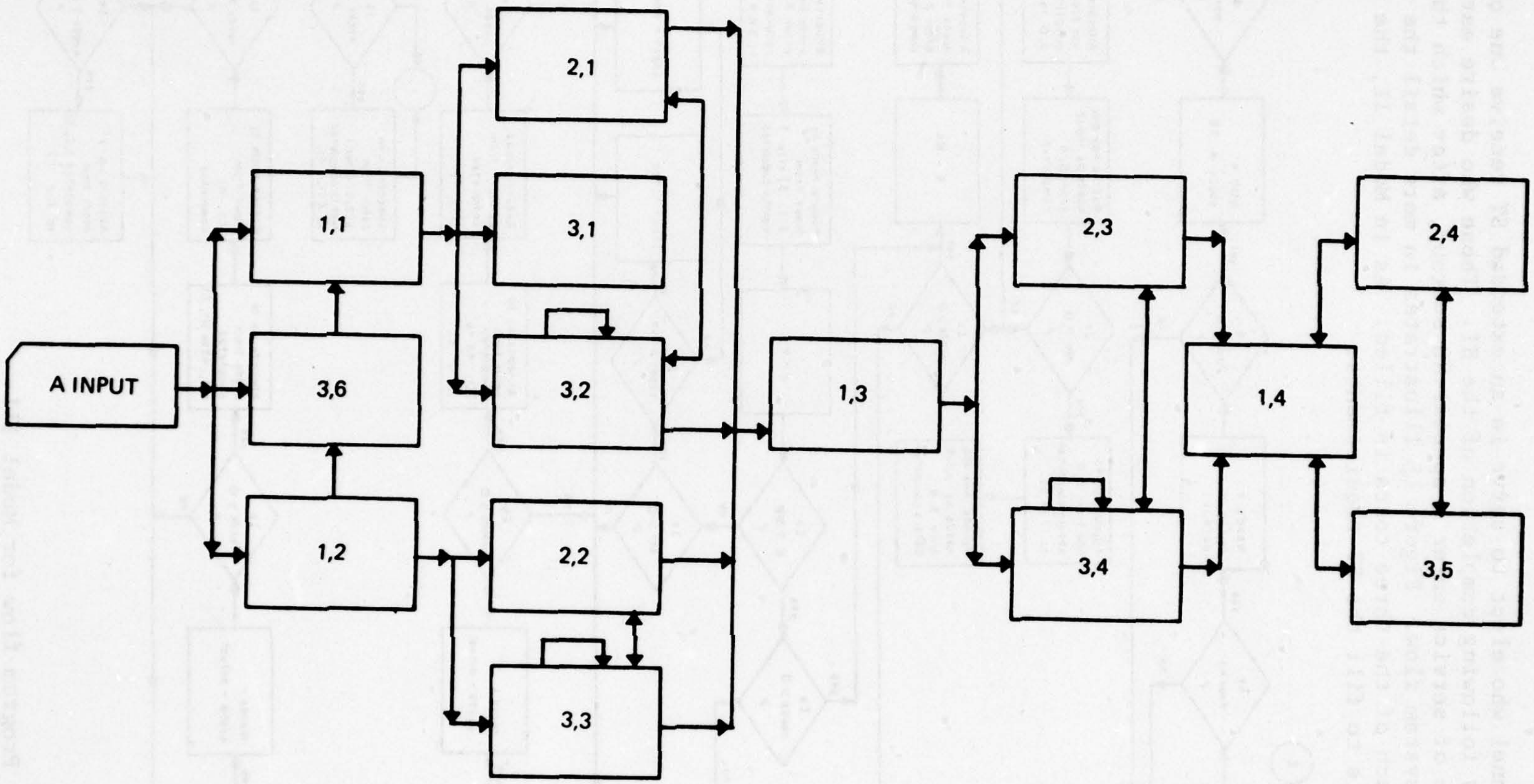


Figure 14. Flow of personnel A through the system in Model III

Personnel who elect to serve in an extended ST receive one of two assignments following completion of the ST. Those who desire early termination of service enter a special SB subtour, after which they leave the system flow. Figure 15 illustrates in more detail the manner in which each of the three tours is filled. As in Model II, the major objective is to fill the ST requirements.

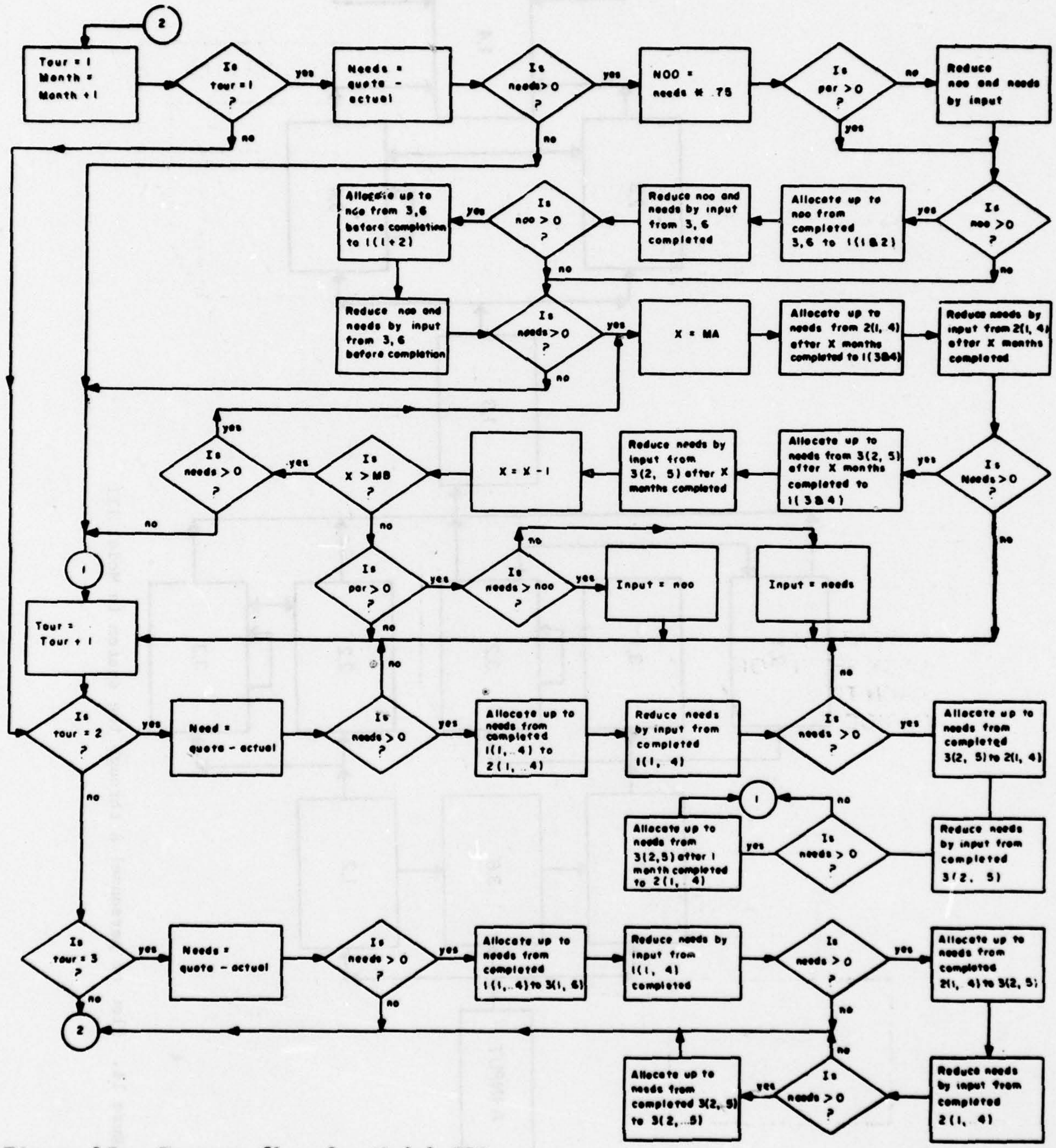


Figure 15. Program flow for Model III

INPUT SPECIFICATIONS FOR MODEL III

The basic input setup for Model III is identical to that of Model I. (Figure 16). Since Model III provides several additional options and simulates only one personnel subsystem, the details of input data construction are different. Table 15 outlines these input details for Model III.

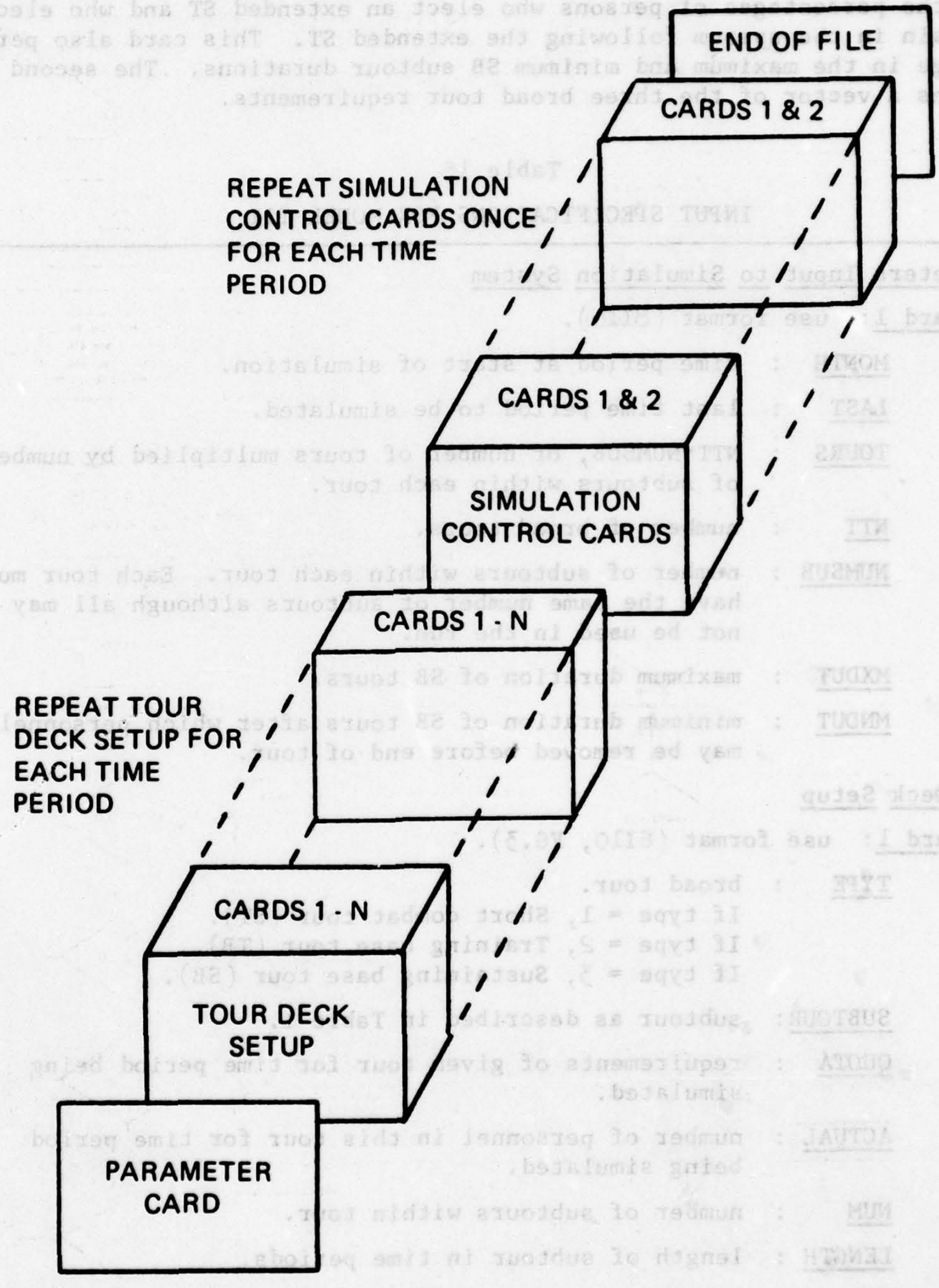


Figure 16. Input setup for Model III

As in the previous models, the first input parameter card determines the time period to be simulated and the number of tours and subtours within the system. In this model, noncombat overseas tour LT has been completely eliminated and variables NTT and TOURS must equal 3 and 18 respectively.

The tour deck setup is identical to that of Model I, with one exception--tour one, not zero, designates the ST. Because of the elimination of the dummy fourth-tour data, there are only 18 tour decks. There are two simulation control cards for each time period. The first card contains the percentages of persons who elect an extended ST and who elect to remain in the system following the extended ST. This card also permits a change in the maximum and minimum SB subtour durations. The second card contains a vector of the three broad tour requirements.

Table 15

INPUT SPECIFICATIONS FOR MODEL III

Parameters Input to Simulation System

Card 1: use format (8I10).

- MONTH : time period at start of simulation.
- LAST : last time period to be simulated.
- TOURS : NTT*NUMSUB, or number of tours multiplied by number of subtours within each tour.
- NTT : number of broad tours.
- NUMSUB : number of subtours within each tour. Each tour must have the same number of subtours although all may not be used in the run.
- MXDUT : maximum duration of SB tours.
- MNDUT : minimum duration of SB tours after which personnel may be removed before end of tour.

Tour Deck Setup

Card 1: use format (6I10, F6.3).

- TYPE : broad tour.
  If type = 1, Short combat tour (ST).
  If type = 2, Training base tour (TB).
  If type = 3, Sustaining base tour (SB).
- SUBTOUR: subtour as described in Table 1.
- QUOTA : requirements of given tour for time period being simulated.
- ACTUAL : number of personnel in this tour for time period being simulated.
- NUM : number of subtours within tour.
- LENGTH : length of subtour in time periods.
- OUT : percentage of personnel lost from the system each year from subtour.

Table 15 continued

Cards 2 through N: (N = LENGTH/10 + 2 if LENGTH is not a multiple of 10; N = LENGTH/10 + 1 if LENGTH is a multiple of 10.) Use format (10I8).

PERS : vector of number of personnel within subtour in each time period at start of simulation. Depicts state of personnel within subtour at beginning of simulation.

Tour deck setup cards 1 through N are repeated X (X = NTT*NUMSUB) times--once for each tour-subtour simulated.

Simulation Control Cards

Card 1: use format (10X, 2I10, 3F6.3, 2I10).

INPUT: number of personnel to be input to the system at beginning of time period being simulated.

ISTOP: option to stop or continue simulation.
If ISTOP = 0, program continues.
If ISTOP = 1, program stops after time period being simulated.
If ISTOP = 2, program stops after time period being simulated and begins a new simulation.

PAR : input parameter.
If PAR = 0, INPUT is used as new input to system during month being simulated.
If PAR > 0 and < 3, program calculates the number input to system during time period being simulated and uses PAR as percentage of the calculated input.

RET : percentage of A personnel who elect to remain within the system following an extended short tour.

PEXT : percentage of A personnel who elect to serve an extended short tour.

MA : if MA > 0, replaces MXDUT as new maximum duration of the SB tour.

MB : if MB > 0, replaces MNDUT as new minimum SB tour duration.

Card 2: use format (8I10).

NEEDS: vector (1 x NTT) of requirements for each tour. Repeat this tour requirements sequence for each tour (NTT times); e.g., with 3 tours, 30 columns on the card woul' be used.

60

OUTPUT SPECIFICATIONS FOR MODEL III

The output format for Model III resembles that of Model I. It is a detailed description of the state of the system at the end of each time period without the aid of a data summary. However, the format has several improvements over that used in the earlier model. The output of Model III is more concise and is easier to read. Table 16 shows the five major output sections.

The first section, an improvement in output over that of Model I, is a detailed summary of personnel transferred from subtours before completing the regular length of service in a subtour. Also described in this section are those lost to the system. The second section describes all sources of input to the subtours. As in Model I, the third section gives a complete description of each subtour at the end of the time period, including tour requirements and personnel assets, subtour length, and personnel in the subtour. The fourth section, the total number of personnel in the system, has also been added to Model III. The last section is identical to the last output section in Model I, which describes personnel who have completed specific subtours at the end of the time period. As was previously noted, the output is cumbersome and must still be summarized prior to presentation to management.

Table 16

OUTPUT SPECIFICATIONS FOR MODEL III

Losses from System During Month P: detailed breakdown of personnel who were removed before completing regular length of time in a subtour.

Lost from Tour T, S: number of personnel who were removed from broad tour T subtour S and were subsequently lost to the system.

Total Input to Tour T: total number of personnel assigned to all subtours within tour T.

Number Input to Subtour S: total number of personnel assigned to subtour S during time period P.

X from Tour T Subtour S: number of personnel input to subtour from tour T subtour S.

X from Tour T Subtour S after P months: number of personnel removed from tour T subtour S after serving there for P time periods.

Number Input from Outside: number of inexperienced personnel input to subtour from outside the system.

Table 16 continued

<u>Tour Type</u>: designates the broad tour to which personnel were assigned.

<u>Subtour</u>: designates the specific subtour to which personnel were assigned in time period P.

<u>Quota</u>: total personnel requirements for tour T.

<u>Number in Tour</u>: total number of personnel in tour T.

<u>Length of Tour</u>. length of tour T subtour S measured in time periods.

<u>Men in this Category</u>: total number of personnel in this subtour.

<u>Row Vector</u>: denotes where in tour T subtour S personnel are at the end of time period P.

<u>Total Manpower in System</u>: total number of personnel in entire system at end of time period P.

<u>Summary of Manpower Flow out of Tours at end of Month P</u>: summary of personnel completing specific subtours at end of time period P.

<u>Number Output from Tour T</u>: total number of personnel who completed subtours in tour T.

<u>Output from System after Tour T</u>: number of personnel who completed subtour S and were then lost to the system.

<u>Available for another Tour after Tour T</u>: number of personnel who completed subtour S and were eligible for reassignment within the system.

SAMPLE PROBLEM DESCRIPTION FOR MODEL III

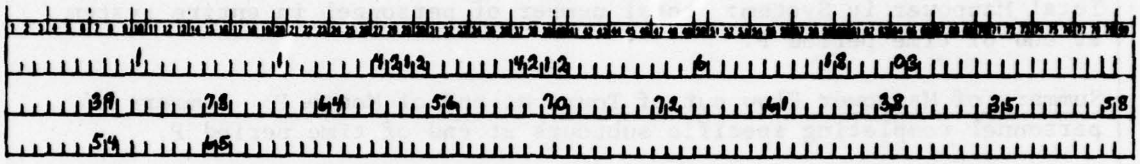
Within the Army Aviator System, warrant officers and commissioned officers both serve as aviators and are arbitrarily assigned to identical positions within the ST. This practice suggests that level of experience and <u>not</u> officer or warrant officer status is the key to aviator assignment. In the sample problem, therefore, warrant officers and commissioned officers are grouped together and level of experience of the personnel in the ST becomes the effectiveness criterion. By offering an extended first ST assignment in return for shorter total obligation, experience level of personnel within the ST area could potentially be increased.

The input for this sample problem is constructed in a manner similar to that of the sample problem for Model II. In order to eliminate unnecessary repetition of detail, only a brief sketch of the input for this sample problem will be given. (A detailed listing of the entire input is available from BESRL upon request.)

The parameter card employed determines that the simulation will run from time period zero to time period 80. The system consists of three broad tours, each containing six subtours. Maximum and minimum tour durations in the SB are 25 and 18 months.

The tour deck setup consists of 18 groups of N cards, one group for each of the 18 subtours in the system. In the tour deck are three cards which describe the ST subtour 1 (warrant and commissioned officers on extended first ST assignment).

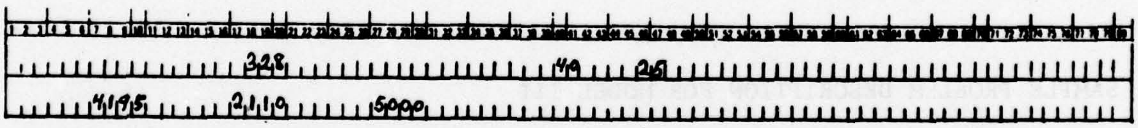
Tour Deck Setup for ST Subtour 1



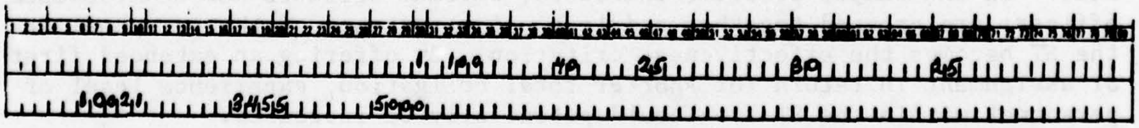
The 4212 ST requirements at the start of the simulation are filled with 4212 officers. The ST subtour 1, with a duration of 18 time periods, has a three percent loss rate. Similar groups of N cards are input for the other 17 subtours.

The simulation control cards for time periods 1 and 80 are presented below.

Simulation Control Cards for Month 1



Simulation Control Cards for Month 80



In the first time period, 328 officers are input to the system. Twenty-five percent of those input to the ST elect an extended subtour and 40 percent of those who serve an extended subtour elect to remain in the system as career officers. ST, TB, and RB requirements are 4195, 2110, and 5000, respectively. Time periods 2 through 30 have simulation control cards similar to those for month 1. The simulation control cards for time periods 31 through 80 are similar to the cards for month 80. These time periods simulate the system using variable input and maximum and minimum SB subtour durations of 30 and 25 months. Requirements for ST, TB, and SB gradually increase from month 1 to month 80, at which time they equal 10021, 3455, and 5000, respectively.

Since the output for Model III is not available in summary form, only a few characteristics of the output data are described. (Detailed output for time periods zero to 80 are available from BESRL upon request.) Figure 17 represents the input of inexperienced personnel into the system during each of the 80 time periods simulated. The fixed input during the first 30 time periods is determined by the program user and does not necessarily reflect the real system requirements. During time period 30, for example, only 9725 eligible personnel are available to fill the 9873 ST requirements. In accordance with the system restraint on the experience level of personnel, only 75 percent of the ST requirements can be filled with inexperienced personnel. The system at this point has built up an unnecessarily large reservoir of inexperienced personnel which cannot be used.

Under the variable input policy, however, only those inexperienced personnel who can be used are input to the system. As illustrated in Figure 18, the system total increases arbitrarily under the fixed input policy but fluctuates according to system requirements under a variable input policy. These are only a few of the comparisons which can aid management in its decision-making processes.

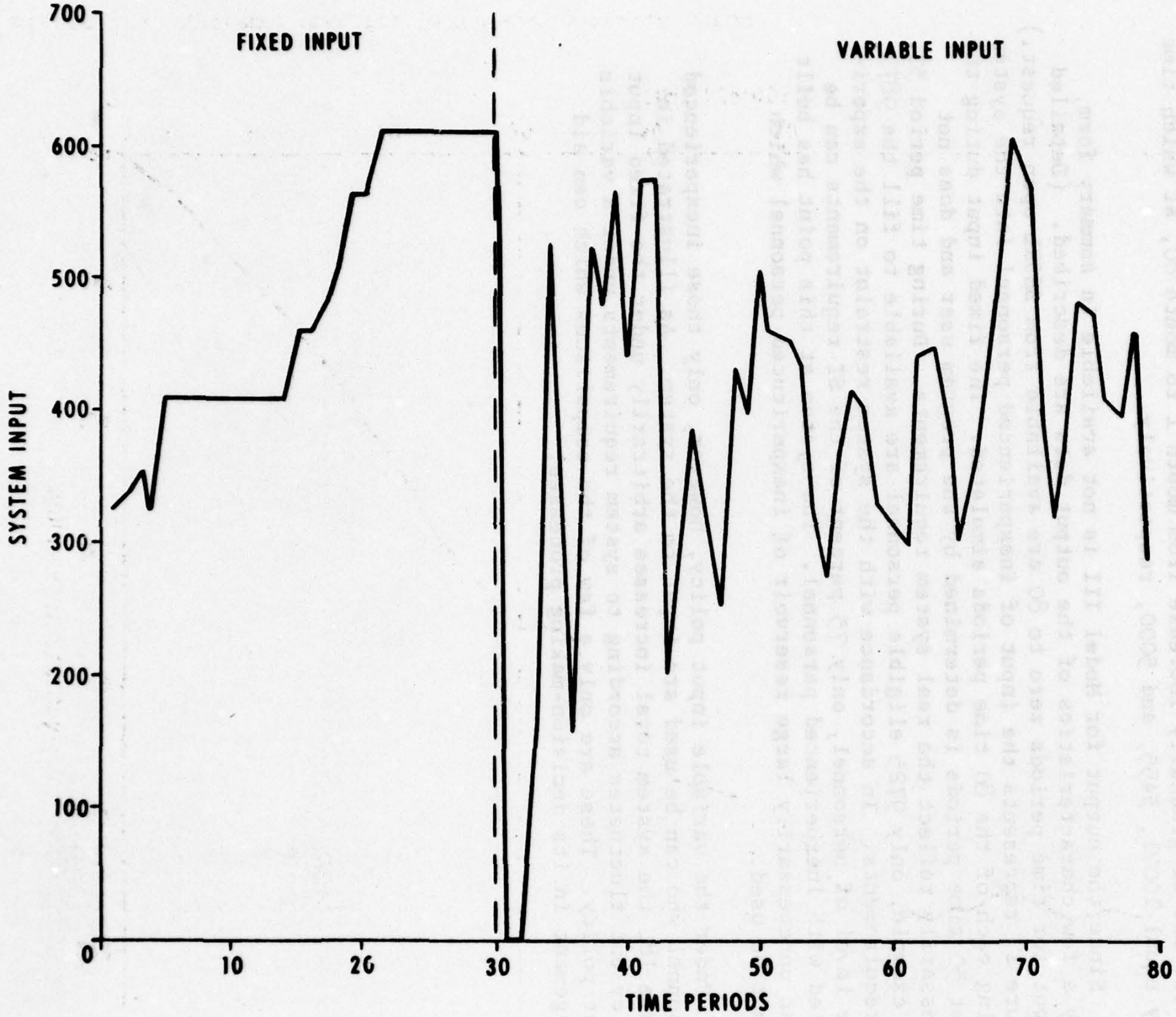


Figure 17. Input to the system from the outside for fixed and variable input

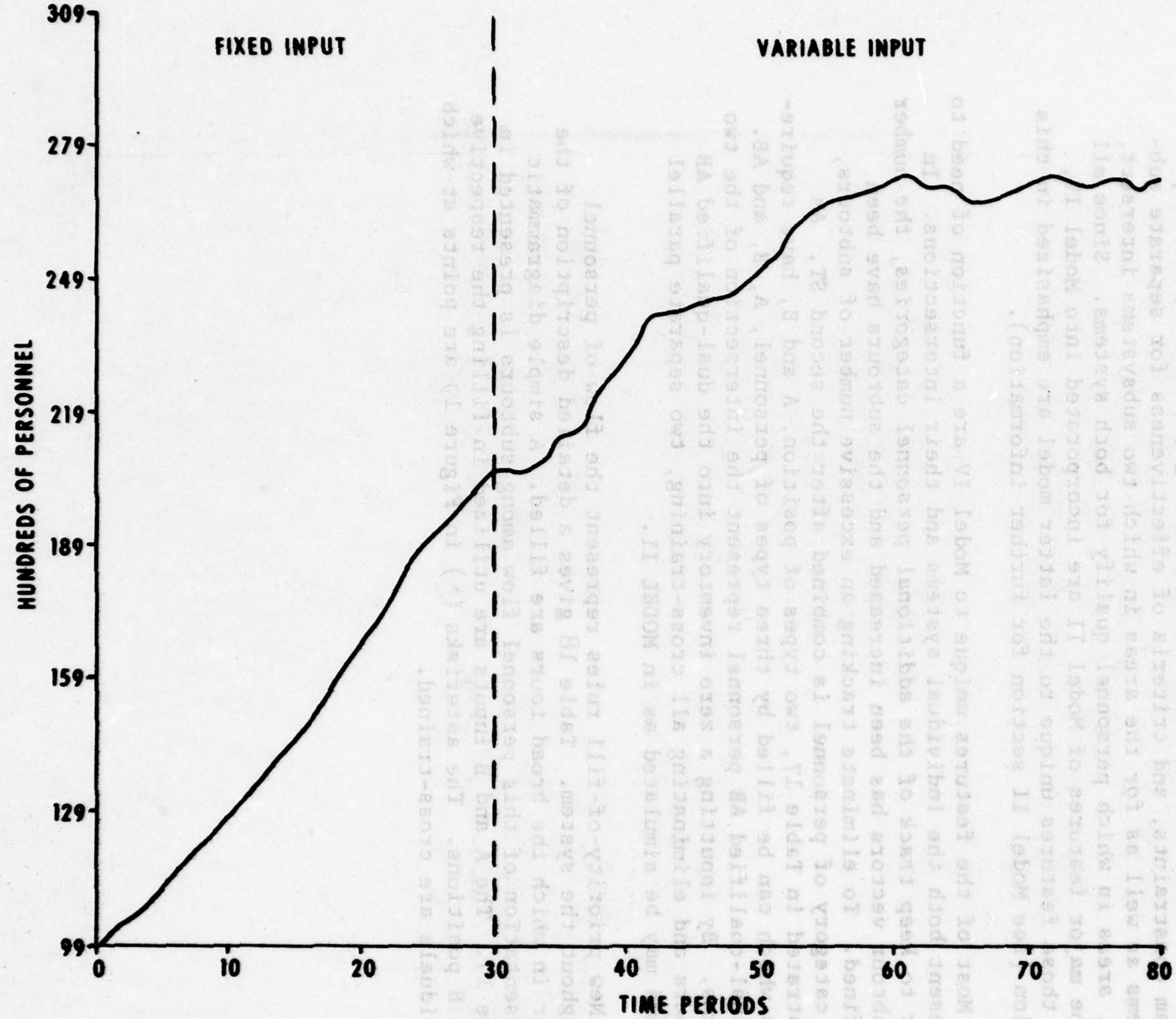


Figure 18. System total for fixed and variable input

MODEL IV

GENERAL DESCRIPTION

Model IV, a modification of Model II, evolved in response to problems associated with the personnel build-up in RVN. It simulates the flow of two intersecting or two parallel personnel subsystems, A and B, with separate requirement sets. By employing this model, management can study the relationships among personnel policies, system constraints, and criteria of effectiveness for separate subsystems as well as for the areas in which two subsystems intersect, i.e., areas in which personnel qualify for both systems. Since all of the major features of Model II are incorporated into Model IV, only those features unique to the latter model are emphasized in this section (see Model II section for further information).

Most of the features unique to Model IV are a function of need to represent both the individual systems and their intersections. In order to keep track of the additional personnel categories, the number of subtour vectors has been increased and the subtours have been redefined. To eliminate tracking an excessive number of subtours, each category of personnel is combined after the second ST. As illustrated in Table 17, two types of position, A and B, have requirements which can be filled by three types of personnel, A, B, and AB. The dual-qualified AB personnel represent the intersection of the two systems. By inputting a zero inventory into the dual-qualified AB subtours and eliminating all cross-training, two separate parallel systems may be simulated as in MODEL II.

New priority-of-fill rules represent the flow of personnel throughout the system. Table 18 gives a detailed description of the manner in which the broad tours are filled. A simple diagrammatic representation of this personnel flow among subtours is presented in Figure 19. The A and B inputs are utilized in filling the respective A and B positions. The asterisks (*) in Figure 19 are points at which individuals are cross-trained.

Table 17

TOUR AND SUBTOUR DEFINITIONS FOR MODEL IV

Tour Type	Tour Description	Subtour Type	Subtour Description
0	Short Tour (ST)	1	A on first ST assignment
		2	Dual-qualified AB serving in A positions on first ST assignment
		3	A on second or subsequent ST assignment
		4	Dual-qualified AB serving in A positions on second or subsequent ST assignment
		5	B on first ST assignment
		6	Dual-qualified AB serving in B positions on first ST assignment
		7	B on second or subsequent ST assignment
		8	Dual-qualified AB serving in B positions on second or subsequent ST assignment
2	Training Base and Stabilized Tour (TB)	1	A after first ST assignment
		2	Dual-qualified AB serving in A positions after first ST assignment
		3	A after second or subsequent ST assignment
		4	Dual-qualified AB serving in A positions after second or subsequent ST assignment
		5	B after first ST assignment
		6	Dual-qualified AB serving in B positions after first ST assignment
		7	B after second or subsequent ST assignment
		8	Dual-qualified AB serving in B positions after second or subsequent ST assignment
3	Sustaining Base Tour (SB)	1	A prior to first ST assignment
		2	B prior to first ST assignment
		3	Dual-qualified AB prior to first ST assignment
		4	A after first ST assignment
		5	B after first ST assignment
		6	Dual-qualified AB after first ST assignment
		7	A after second or subsequent ST assignment
		8	B after second or subsequent ST assignment
		9	Dual-qualified AB after second or subsequent ST assignment

Table 18

PRIORITY-OF-FILL RULES FOR MODEL IV

Tour-Subtour Into	Tour-Subtour From	Maximum Quota	Minimum Time in Tour Prior to Removal
		A: VARIABLE INPUT	
0,1	3,1	New Experienced	Completion
0,5	3,2	New Experienced	Completion
0,2	3,3	New Experienced	Completion
0,6	3,3	New Experienced	Completion
0,1	3,1	Inexperienced	Completion
0,5	3,2	Inexperienced	Completion
0,2	3,3	Inexperienced	Completion
0,6	3,3	Inexperienced	Completion
0,1	3,1	Inexperienced	Completion
0,5	3,2	Inexperienced	Completion
0,2	3,3	Inexperienced	Completion
0,6	3,3	Inexperienced	Completion
0,1	Outside	Inexperienced	0
0,5	Outside	Inexperienced	0
0,3	3,4	Experienced	Completion
0,7	3,5	Experienced	Completion
0,4	3,6	Experienced	Completion
0,8	3,6	Experienced	Completion
0,3	2,1	Experienced	Completion
0,7	2,5	Experienced	Completion
0,4	2,2	Experienced	Completion
0,8	2,6	Experienced	Completion
0,3	3,7	Experienced	Completion
0,7	3,8	Experienced	Completion
0,4	3,9	Experienced	Completion
0,8	3,9	Experienced	Completion
0,3	3,3	Experienced	Completion
0,7	3,7	Experienced	Completion
0,4	3,4	Experienced	Completion

Table 18 continued

Tour-Subtour Into	Tour-Subtour From	Maximum Quota	Minimum Time in Tour Prior to Removal
		A: VARIABLE INPUT - continued	
0,8	3,8	Experienced	Completion
0,3	3,4	Experienced	As specified
0,7	3,5	Experienced	As specified
0,4	3,6	Experienced	As specified
0,8	3,6	Experienced	As specified
0,3	3,7	Experienced	As specified
0,7	3,8	Experienced	As specified
0,4	3,9	Experienced	As specified
0,8	3,9	Experienced	As specified
0,3	2,1	Experienced	As specified
0,7	2,5	Experienced	As specified
0,4	2,2	Experienced	As specified
0,8	2,6	Experienced	As specified
0,3	2,3	Experienced	As specified
0,7	2,7	Experienced	As specified
0,4	2,4	Experienced	As specified
0,8	2,8	Experienced	As specified
2,1 to 2,8	0,1 to 0,8	Experienced	Completion
2,1 to 2,8	3,4 to 3,9	Experienced	1
3,4 to 3,9	0,1 to 0,8	Experienced	Completion
3,4 to 3,9	2,1 to 2,8	Experienced	Completion
3,1 to 3,9	3,1 to 3,9	Experienced	Completion
3,1 to 3,3	Outside	Inexperienced	0
		B: FIXED INPUT	
0,1	Outside	Inexperienced	0
0,5	Outside	Inexperienced	0
0,1	3,1	New Experienced	Completion
0,5	3,2	New Experienced	Completion

Table 18 continued

Tour-Subtour Into	Tour-Subtour From	Maximum Quota	Minimum Time in Tour Prior to Removal
		B: FIXED INPUT - continued	
0,2	3,3	New Experienced	Completion
0,6	3,3	New Experienced	Completion
0,1	3,1	Inexperienced	Completion
0,5	3,2	Inexperienced	Completion
0,2	3,3	Inexperienced	Completion
0,6	3,3	Inexperienced	Completion
0,1	3,1	Inexperienced	As specified
0,5	3,2	Inexperienced	As specified
0,2	3,3	Inexperienced	As specified
0,6	3,3	Inexperienced	As specified
0,3	3,4	Experienced	Completion
0,7	3,5	Experienced	Completion
0,4	3,6	Experienced	Completion
0,8	3,6	Experienced	Completion
0,3	2,1	Experienced	Completion
0,7	2,5	Experienced	Completion
0,4	2,2	Experienced	Completion
0,8	2,6	Experienced	Completion
0,3	3,7	Experienced	Completion
0,7	3,8	Experienced	Completion
0,4	3,9	Experienced	Completion
0,8	3,9	Experienced	Completion
0,3	2,3	Experienced	Completion
0,7	2,7	Experienced	Completion
0,4	2,4	Experienced	Completion
0,8	2,8	Experienced	Completion
0,3	3,4	Experienced	As specified
0,7	3,5	Experienced	As specified
0,4	3,6	Experienced	As specified
0,8	3,6	Experienced	As specified

Table 18 continued

Tour-Subtour Into	Tour-Subtour From	Maximum Quota	Minimum Time in Tour Prior to Removal
		B: FIXED INPUT - continued	
0,3	3,7	Experienced	As specified
0,7	3,8	Experienced	As specified
0,4	3,9	Experienced	As specified
0,8	3,9	Experienced	As specified
0,3	2,1	Experienced	As specified
0,7	2,5	Experienced	As specified
0,4	2,2	Experienced	As specified
0,8	2,6	Experienced	As specified
0,3	2,3	Experienced	Completion
0,7	2,7	Experienced	Completion
0,4	2,4	Experienced	Completion
0,8	2,8	Experienced	Completion
2,1 to 2,8	0,1 to 0,8	Experienced	Completion
2,1 to 2,8	3,4 to 3,9	Experienced	1
3,4 to 3,9	0,1 to 0,8	Experienced	Completion
3,4 to 3,9	2,1 to 2,8	Experienced	Completion
3,1 to 3,9	3,1 to 3,9	Experienced	Completion
3,1 to 3,3	Outside	Inexperienced	0

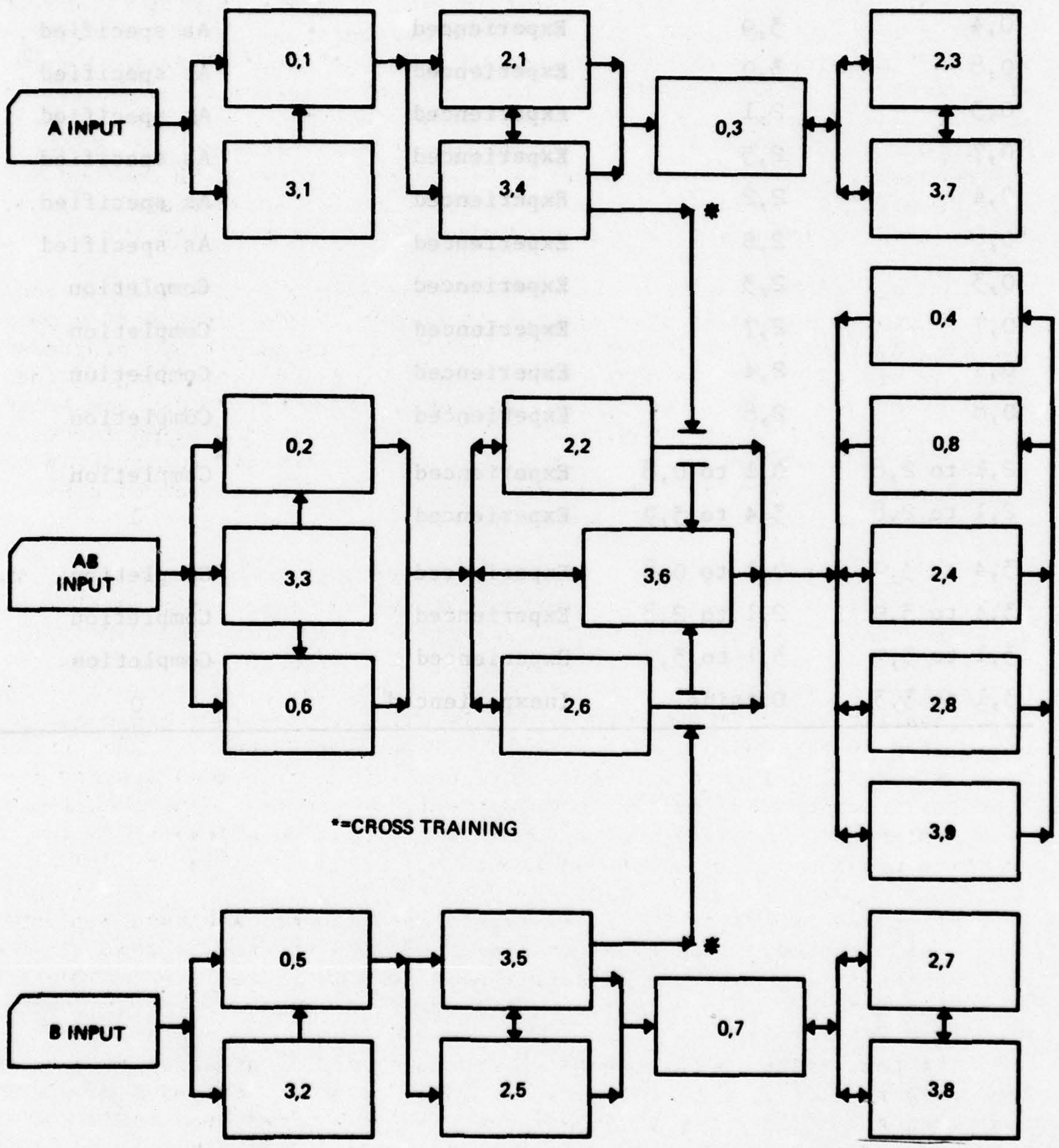


Figure 19. Flow of A, B, and AB personnel through the system in Model IV

Since Model IV incorporates all the general principles underlying the DYNAMOD series, a detailed description of Model IV is presented to illustrate general construction of all the models as well as the unique design of Model IV. Figure 20 illustrates how the computer program for Model IV represents the entire personnel flow described in Table 18. For convenience, the flow has been segmented into 11 sections, each illustrating a different process in the flow. Section A represents the updating system of the program which calculates tour and subtour losses, moves all personnel forward one time period, and determines how many personnel are in each tour at the end of the time period. Section B shows the cross-training aspect of the simulation. In order to simulate cross-training of men from A and from B subtours into dual-qualified subtours AB, Model IV transfers in each time period a variable number of personnel from SB subtour 4 (A after 1 ST) after three or two months completed and from SB subtour 5 (B after 1 ST) after four or three months completed into the first month of SB subtour 6 (AB after 1 ST). In essence, this movement, which allows for the necessary cross-training time, adds several months to SB subtour 6. This capability can easily be expanded to allow for cross-training from any subtour to another at specified times during the computer run.

The actual beginning of the monthly simulation, represented in Section C, starts by reading the simulation control cards for the time period. The program then begins a systematic search to fill each tour, progressing from the highest priority tour (ST) to the lowest (RB) according to the priority-of-fill rules. After calculating ST personnel needs, the program begins to search for personnel to fill these needs. With fixed input, inexperienced personnel are input from outside the system and the program then proceeds to find personnel within the system who have not served a ST assignment (see Program Sections C, D, and E).

As in Models I, II, and III, A and B personnel are allocated against their respective quotas. AB personnel are allocated proportionately against A and B quotas according to the specific needs (needs = requirements minus actual number of personnel already allocated against the requirements) of the system at the time of allocation. The proportion, RR, of AB available for reassignment which is allocated against A quotas is calculated by the formula RR = A needs /(A needs + B needs). The proportion, F, of AB available for reassignment which is allocated against the B quotas is calculated by the formula F = 1.0 minus RR. Consequently, in each assignment iteration, AB personnel are allocated according to the relative needs of the A and B positions.

After assignment to ST of all available personnel who have completed a subtour, Section F calculates the input of inexperienced personnel from outside the system. If the ST still needs personnel, men are removed from the SB and TB tours before completing the regular tour (see Sections G and H).

The tour index is incremented until it equals 2, at which time the TB tours are filled as illustrated in Sections I and J. Section K completes assignments by allocating to SB all those who have completed tours and have not been assigned to ST or TB. If the print controller equals zero, intermediate output for the time period is printed at this time. This cycle repeats for each time period, after which it outputs a summary table. A similar iterative procedure is a part of each of the four models.

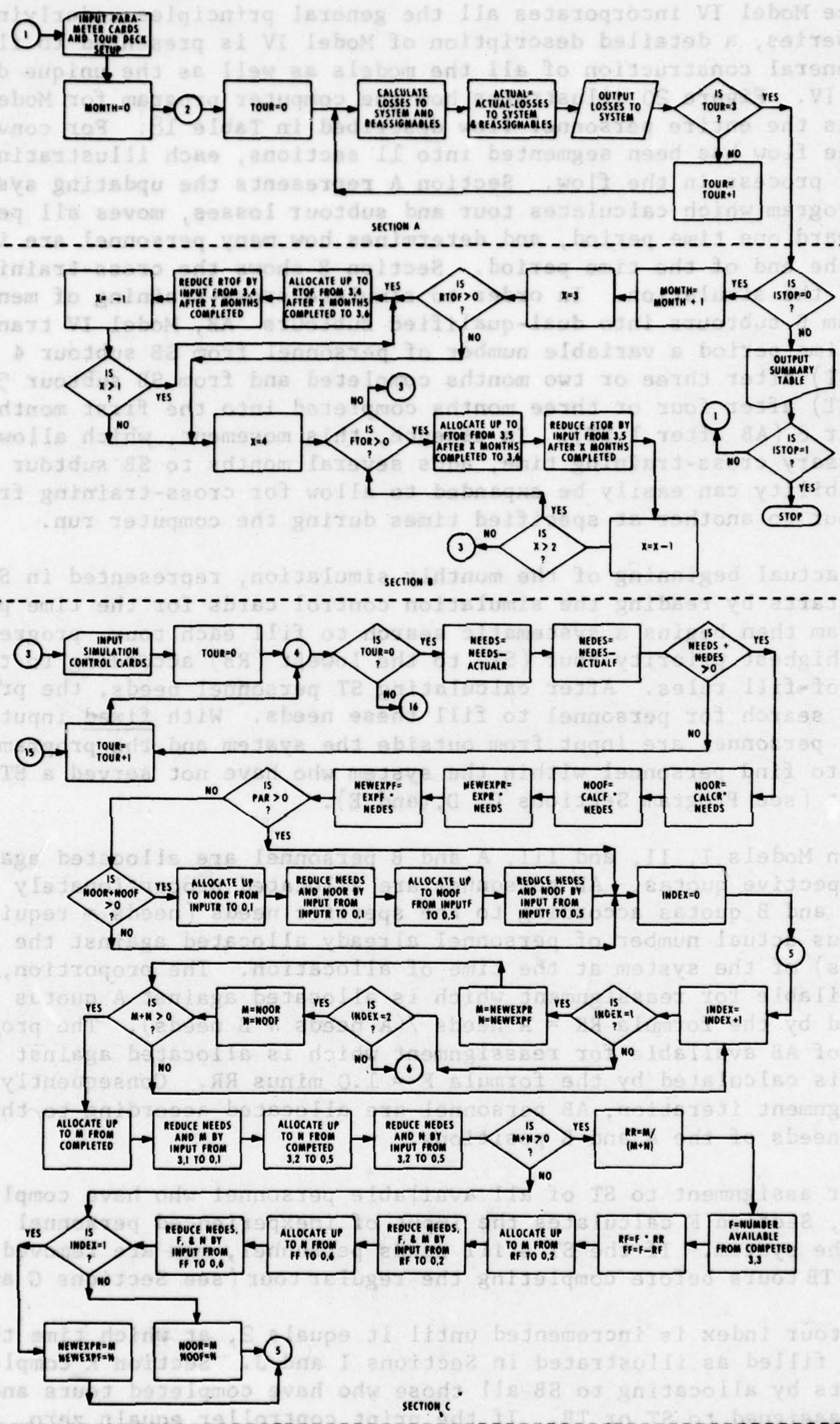


Figure 20. Problem flow for Model IV

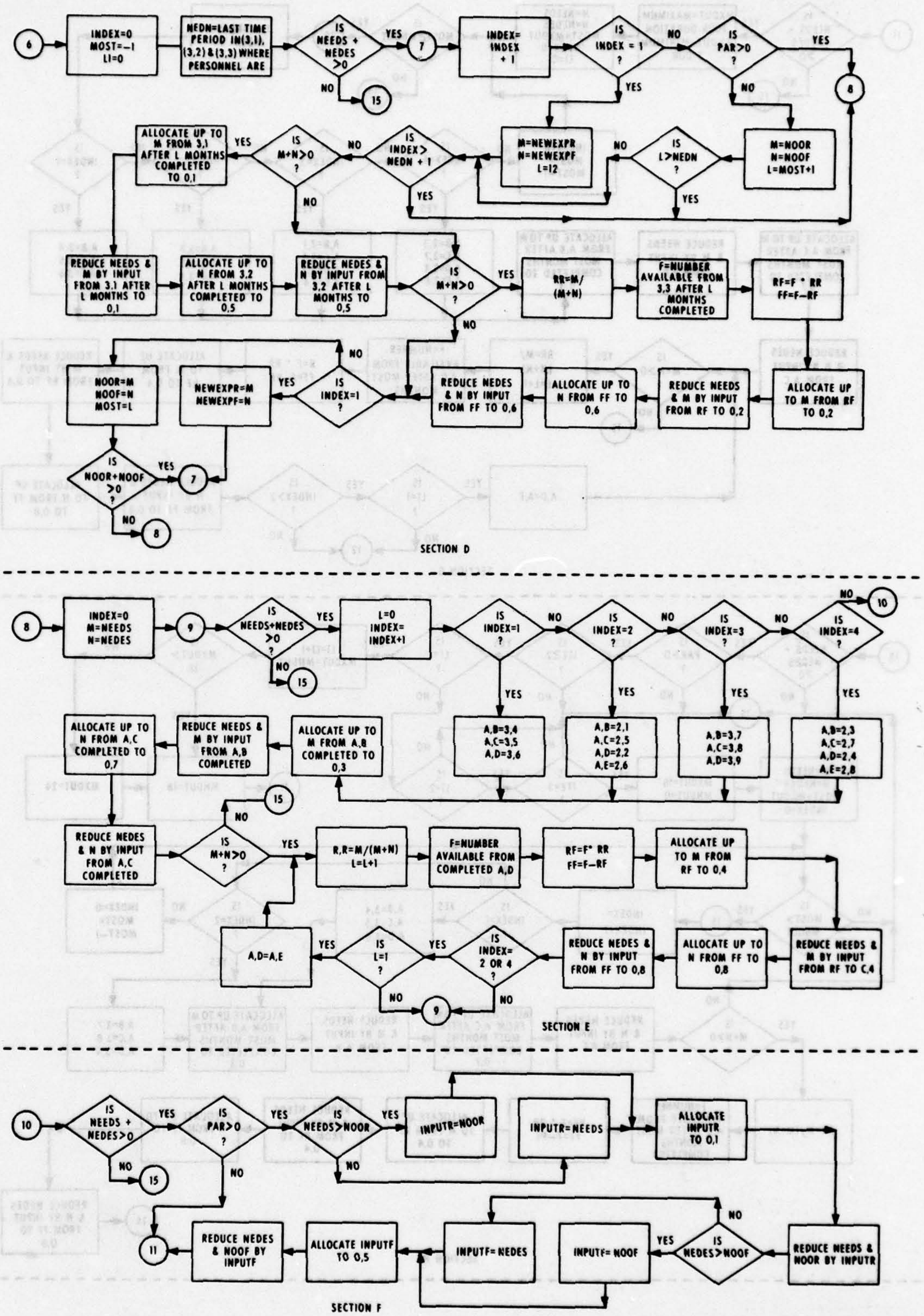


Figure 20 continued

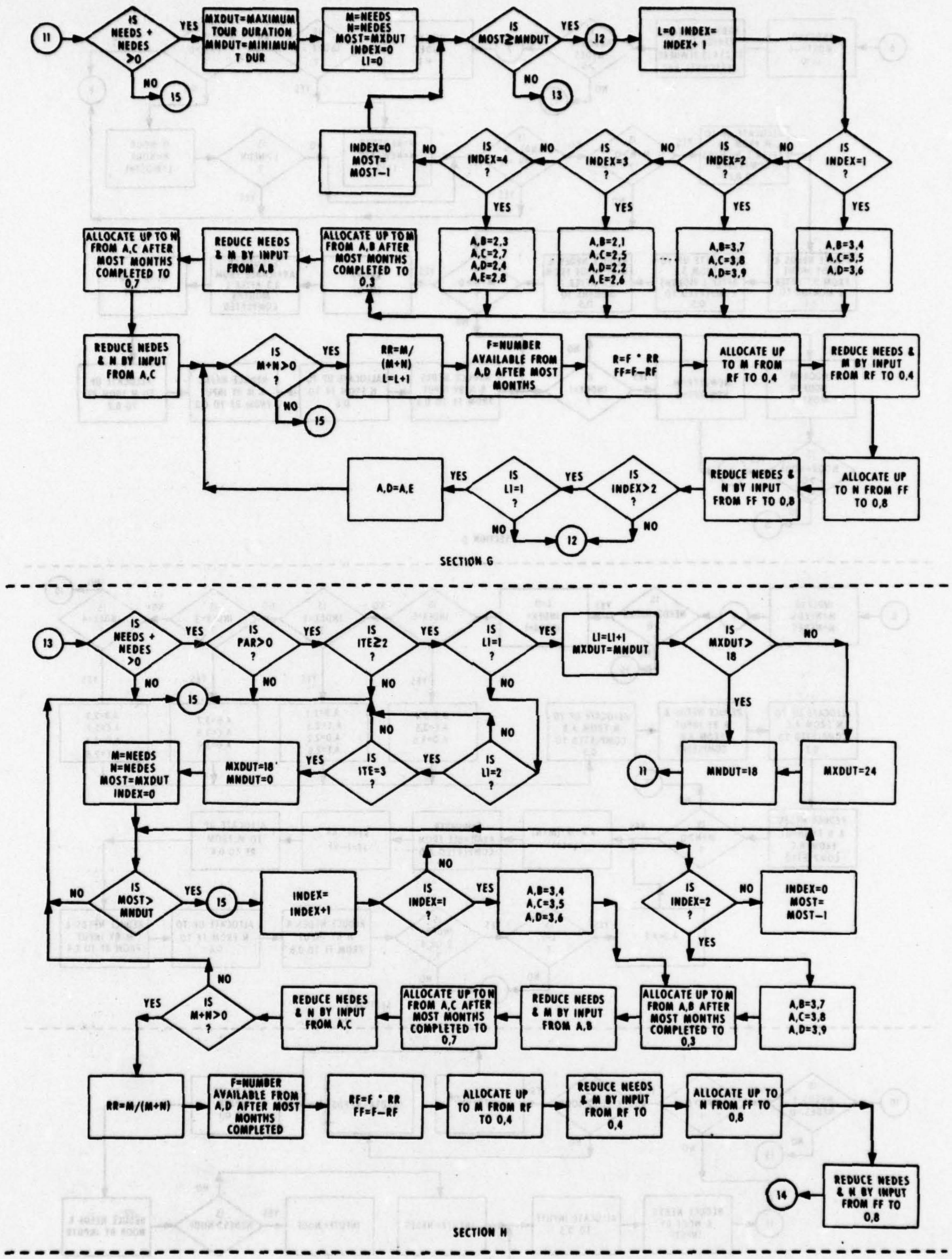


Figure 20 continued

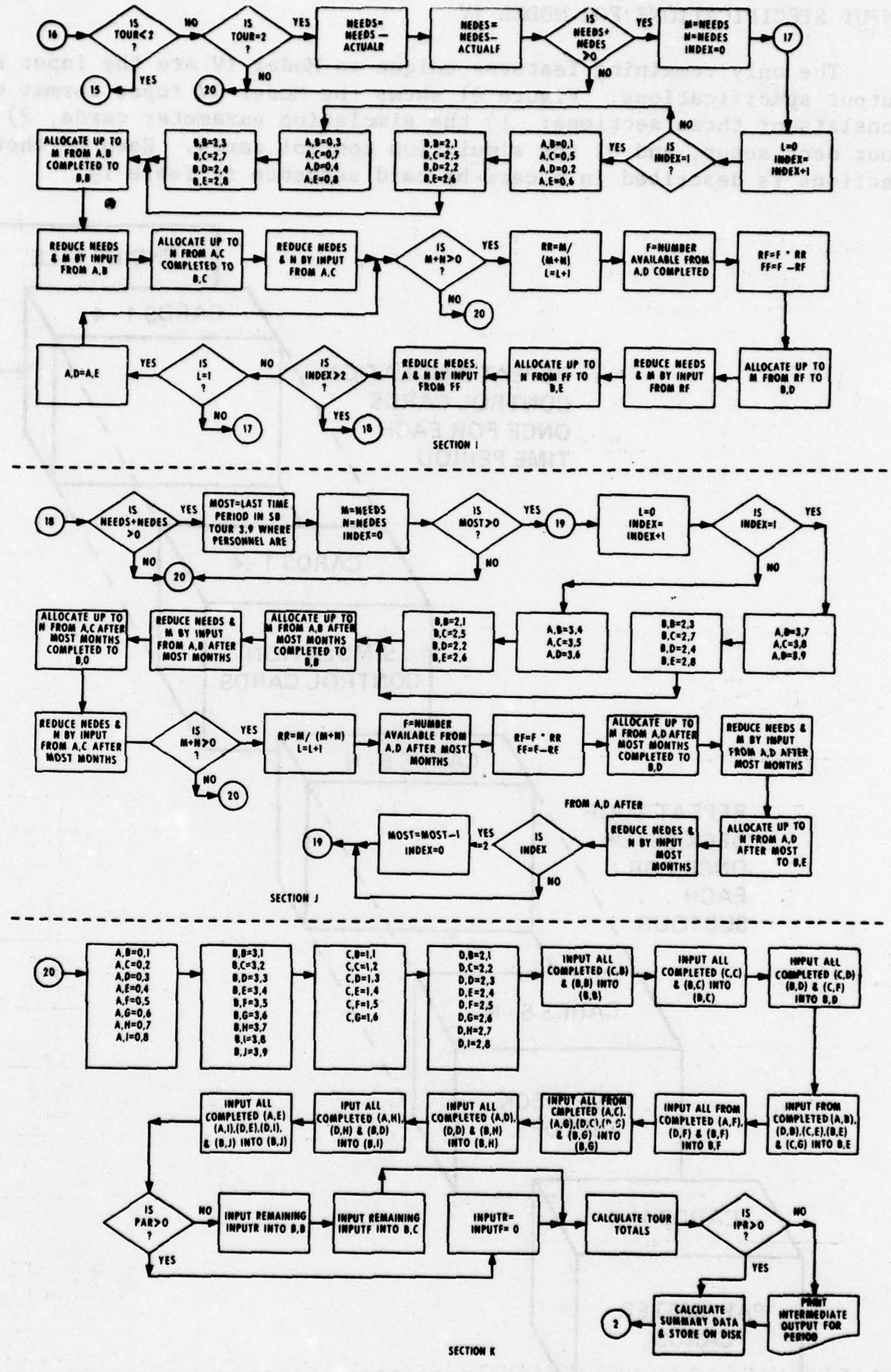


Figure 20 continued

INPUT SPECIFICATIONS FOR MODEL IV

The only remaining features unique to Model IV are the input and output specifications. Figure 21 shows the Model IV input format which consists of three sections: 1) the simulation parameter cards, 2) the tour deck setup, and 3) the simulation control cards. Each of these sections is described in a card-by-card sequence in Table 19.

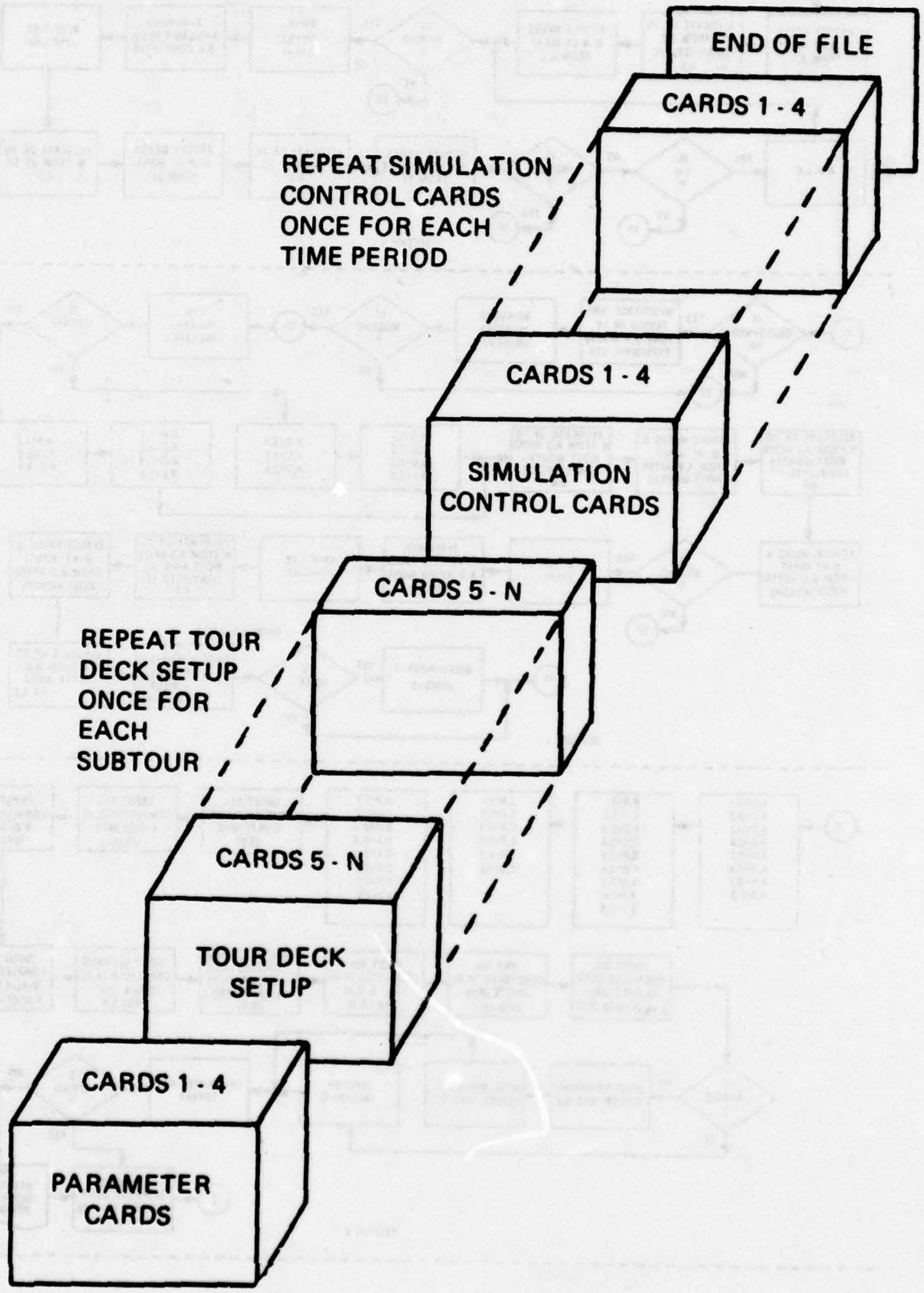


Figure 21. Input setup for Model IV

The first, second, and fourth parameter cards are identical to those employed in Model II, but the variable IPR in the first parameter card serves a different function. Instead of controlling all intermediate output as in Model II, it merely controls the intermediate output for the first time period. It is then input at the beginning of each new time period during computer run. Because Model IV represents a more complex system, the third parameter card contains variables in addition to the ones in Model II. Proportions used to calculate the number of inexperienced and new-experienced personnel allowed are input separately for the A and B personnel categories--variables CALCR, EXPR, CALCF, and EXPF. This card also contains the cross-training variables RTOF and FTOR, which specify respectively the number of men who are to be crossed-trained from A and B positions.

Except for several additional variables in the first card of Model IV, the tour deck setup is basically the same as that of Model II. Instead of one grand quota for a broad tour, separate quotas represent requirements for the A and B positions. Also, the actual number of personnel in a tour is broken down into three different variables, ACTUALR, ACTUALF, AND ACTUALT. ACTUALR and ACTUALF are respective subtotals for the number of A and B personnel in the tour. Analogous to the variable ACTUAL in Model II, ACTUALT is the total of all personnel in the tour.

Simulation control cards 1 through 4 are constructed for each time period as in Model II. Card 1 contains variables which reset the value of previously determined parameters. Unique are variables CALCCR, EXPPR, CALCCF, EXPPF, RTOFF, FTORR, and IPRR, most of which are a function of employing separate requirements sets for the A and B personnel systems. IPRR replaces IPR, allowing intermediate output for any or all time periods in the simulation. Card 2 contains separate requirements for A and B positions for each tour. Cards 3 and 4, identical to those in Model IV, reset the loss and promotion rates for the tours.

Table 19

INPUT SPECIFICATIONS FOR MODEL IV

Parameters Input to Simulation System

Card 1: use format (8I10)

- MONTH : time period at start of simulation.
- LAST : last time period to be simulated.
- TOURS : NTT*NUMSUB, or number of tours multiplied by number of subtours within each tour.
- NTT : number of tours.
- NUMSUB: number of subtours within each tour.
- MXDUT : maximum duration of SB tours.
- MNDUT : minimum duration of SB tours after which personnel may be removed before end of tour.

Table 19 continued

IPR : print controller. If IPR = 0, intermediate output for the first time period will be printed. If IPR = 1, intermediate output for the first time period will not be printed.

Card 2: use format (2I10)

KPER : number of months in each time period.

ITE : parameter governing operation of variable input used to fill ST requirements only. If ITE = 0, the program uses fixed input. If ITE = 2, it steals men as far back as 18 months within RB. If ITE = 3, it steals men from TB as far back as 18 months and from RB after zero months.

Card 3: use format (4F5.3, 2I5)

CALCR : percentage of A requirements for ST which may be filled by inexperienced personnel.

EXPR : percentage of A requirements for ST which may be new-experienced personnel. This factor is applied against the experienced requirements (experienced quota = NEEDS - CALCR*NEEDS) for A.

CALCF : percentage of B requirements for ST which may be filled by inexperienced personnel.

EXPF : percentage of B requirements for ST which may be new-experienced. This factor is applied against the experienced requirements (experienced quota = NEDES - CALCF*NEDES) for B.

RTOF : number of men to be cross-trained from A to qualify for B. These men are removed from SB subtour 4 after 3 months and entered in the first month of SB subtour 6. The three-month time lapse represents the training period from A to B.

FTOR : number of men to be cross-trained from B to qualify for A. These men are removed from SB subtour 5 after 4 months and entered in the first month of SB subtour 6. The 4-month time lapse represents the training period from B to A.

Card 4: use A format--first 72 columns
Comment card used to label summary output.

Tour Deck Setup

Card 1: use format (2I5, 5I10, 2I5, 2F5.3)

TYPE : broad tour
If type = 0, Short combat tour (ST).
If type = 2, Training base tour (TB).
If type = 3, Sustaining base tour (SB).

Table 19 continued

SUBTOUR: subtour as described in Table 1.

QUOTAR : A requirements of this tour for time period being simulated.

QUOTAF : B requirements of this tour for time period being simulated.

ACTUALR: actual number of A personnel in this tour for time period being simulated.

ACTUALF: actual number of B personnel in this tour for time period being simulated.

ACTUALT: total number of personnel in tour, including AB.

NUM : number of subtours within tour.

LENGTH : length of subtour in time periods.

OUT : percentage of personnel lost from system each year from this subtour.

PRO : percentage of personnel promoted on a yearly basis within this subtour.

Cards 2 through N: (N = LENGTH/10 + 2 if LENGTH is not a multiple of 10; N = LENGTH/10 + 1 if LENGTH is a multiple of 10.) Use format (10I8).

PERS : vector of the number of personnel within subtour in each time period at start of simulation. Depicts state of personnel within subtour at beginning of simulation.

Tour deck setup cards 1 through N are repeated X (X = NTT*NUMSUB) times--once for each tour-subtour simulated.

Simulation Control Cards

Card 1: use format (3I5, F5.3, 2I5, 3F5.3, I5, 2F5.3, 3I5)

INPUTR : number of A personnel to be input to system at beginning of time period being simulated.

INPUTF : number of B personnel to be input to system at beginning of time period being simulated.

ISTOP : option to stop or continue simulation.
If ISTOP = 0, program continues.
If ISTOP = 1, program stops after time period being simulated
If ISTOP = 2, program stops after time period being simulated and begins a new simulation.

PAR : input parameter.
If PAR = 0, INPUTR and INPUTF are used as new input to the system during month being simulated.
If PAR > 0 and < 3, program calculates number input to the system during time period being simulated and uses PAR as the percentage of the calculated input into category A.

Table 19 continued

If PAR = 3, PAR1 is used as the percentage of total system input to ST.

MA : if MA > 0, replaces MXDUT as new maximum duration of the SB tour.

MB : if MB > 0, replaces MNDUT as new minimum SB tour duration.

PAR1 : percentage of total system to be used as input into ST during this time period.

CALCCR: if CALCCR > 0, replaces CALCR as the percentage of category A requirements for ST which may be filled by inexperienced personnel. This parameter remains in effect until a new CALCCR > 0 is encountered.

EXPPR : if EXPPR > 0, replaces EXPR as the percentage of category A requirements for ST which may be new-experienced personnel. This parameter remains in effect until a new EXPRR > 0 is encountered.

ITEX : if ITEX > 0, replaces ITE as new parameter governing operation of variable input stealing priorities. See definition of ITE for details.

CALCCF: if CALCCF > 0, replaces CALCF as the percentage of category B requirements for ST which may be filled by inexperienced personnel. This parameter remains in effect until a new CALCCF > 0 is encountered.

EXPPF : if EXPPF > 0, replaces EXPF as the percentage of category B requirements for ST which may be new-experienced personnel. This parameter remains in effect until a new EXPPF > 0 is encountered.

RTOFF : if RTOFF > 0, replaces RTOF as the number of category A personnel to be cross-trained to qualify for category B until a new RTOFF > 0 is encountered.

FTORR : if FTORR > 0, replaces FTOR as the number of category B personnel to be cross-trained to qualify for category A until a new FTORR > 0 is encountered.

IPRR : replaces IPR as the print controller for the period being simulated.

Card 2: use format (8I10)

NEEDS : category A requirements for first tour.

NEDES : category B requirements for first tour.

Repeat this tour requirements sequence for each tour (NTT times), e.g., with 4 tours, 40 columns on the card would be used.

INTE1 : if INTE1 > 0, program reads in card 3.

INTE2 : if INTE2 > 0, program reads in card 4.

Table 19 continued

Card 3: use format (10F8.4). This card is used only if INTE1 is > 0.

POUT : a vector with NTT x NUMSUB elements which replaces OUT as the percentage of personnel lost to the system each year from each subtour.

Card 4: use format (10F8.4). This card is used only if INTE2 > 0.

PRO : a vector with NTT*NUMSUB elements which replaces PRO as percentages of personnel promoted on a yearly basis within each subtour.

Repeat simulation control cards once for each time period to be simulated.

OUTPUT SPECIFICATIONS FOR MODEL IV

Table 20 presents the output specifications for Model IV which are identical to those of Model II with the following exception: At the beginning of the intermediate output, the program prints the number of new A and B personnel input to the system. Separate tour requirements for A and B positions and separate averages of the number of months served in the SB by A, B, and AB personnel are also printed for each time period in which there is intermediate output.

The summary data output from Model IV varies as a function of the need to represent separately the types of personnel or positions in the system. For example, instead of one total for ST requirements under the GROSS ST QUOTA column as in Model II, Model IV presents ST QUOTAS separately for the A and B positions. The only other unique feature in the Model IV summary output is the Supplement, a rough estimate of the number of personnel over and above CONUS authorizations needed to meet rotation policies and to allow for emergency system response. This number is calculated within the program by subtracting a weighted sum of the A and B quotas from the total number in the system.

Table 20

OUTPUT SPECIFICATIONS FOR MODEL IV

Intermediate Output

Number of A Input at Beginning of Month P: number of A personnel input to the system from outside the system at onset of time period P.

B Input: number of B personnel input to the system from outside the system at onset of time period P.

Summary for Period P: designates beginning of intermediate summary output for time period P of the simulation.

Flows for Persons Shifted before End of Tour: detailed breakdown of all personnel who were removed from each subtour prior to completion of the regular length of service in that subtour.

FROM TOUR: the first and second columns designate respectively the broad tour and the subtour from which personnel in that row were removed.

LOSSES: number of personnel removed from the tour-subtour designated and then lost to the system.

REASSIGNABLE: number of personnel removed from the tour-subtour designated in this row and available for reassignment within the system.

Assignments: detailed breakdown of all personnel movement among subtours for time period P.

TOUR: column designating the broad tour category to which personnel were assigned in time period P.

SUBTOUR: column designating subtour to which personnel were assigned in time period P.

TOTAL: total number of personnel assigned to the tour and subtour from all sources for time period P.

SUBTOTAL: total number of personnel assigned to the subtour from a particular source during time period P.

SOURCE: subtour or place from which the personnel assigned to the subtour originated.

OUTSIDE: designates inexperienced personnel input to the system from outside the system.

EARLY T, S: indicates that the personnel assigned to this subtour came from tour T subtour S and were removed prior to completing the regular length of service in this subtour.

END T, S: indicates that the personnel assigned to the subtour came from tour T subtour S after completing the regular length of service in subtour.

Table 20 continued

Tour Distributions: describes state of the system at end of time period P.

TOUR T, S: designates tour T and subtour S.

QUOTAR: total position A requirements for tour T.

QUOTAF: total position B requirements for tour T.

STRENGTH: total number of personnel including A, B, and AB within tour T.

LENGTH: length of tour T subtour S measured in time periods.

ROW VECTOR: delineates where in tour T subtour S the personnel are at the end of time period P.

System Total: total number of personnel within the entire system at end of time period P.

End Tour Flow for Period P: summary of personnel completing specific subtours at end of time period P.

FROM TOUR: first and second columns designate respectively the tour and subtour which has been completed by the personnel.

LOSSES: number of personnel who completed the subtour and then were lost to the system.

REASSIGNABLE: number of personnel who completed the subtour and were eligible to be reassigned within the system.

Average Number of Months Served in CONUS: average number of months which A, B, and AB personnel served in SB tour prior to reassignment to ST.

Summary Output

MO: month or time period being summarized in this row of output data.

ST QUOTAS: respective total ST requirements for A and B positions in time period P.

ST ACTUAL: respective actual total numbers of A and B positions being filled in ST at end of time period P.

INPUT: respective total numbers of inexperienced A and B personnel input to system during time period P.

REP to ST: respective total numbers of A and B position replacements sent to ST during time period P.

NEW EXP: respective total numbers of A and B new-experienced personnel sent to ST during time period P.

INEXP: total number of inexperienced personnel sent to ST during time period P.

CAREER: total number of experienced personnel sent to ST during time period P.

Table 20 continued

BASE TOUR: average number of months or time period spent in St respectively by A, B, and AB personnel prior to reassignment to ST.

TRAINEES: total number of personnel, including A, B, and AB personnel in SB subtours 1, 2, and 3 prior to serving in a ST during time period MO.

DUAL TR: number of personnel who were cross-trained respectively from A and B positions to qualify for either position.

SUPPL: number of personnel needed within the system over and above job requirements to insure capability to comply with specific policies and to allow for flexibility within the system.

SYSTEM TOTAL: total number of personnel within the system.

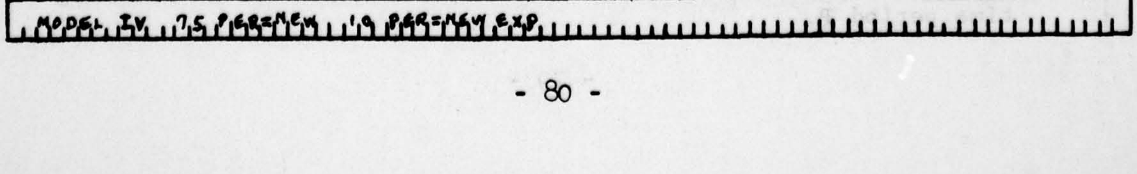
SAMPLE PROBLEM DESCRIPTION FOR MODEL IV

The Army Aviator System is increasingly faced with the difficult task of filling requisitions for aviators trained on specific types of aircraft, i.e., either fixed-wing or rotary-wing aircraft. It is essential to be able to predict which type of aviators will be most in demand and whether or not different requirements sets can be satisfied.

Model IV can aid management in this decision-making process so that the aviator training program can foresee shortages in certain types of pilots and can correct these shortages prior to the time the pilots are needed. Aviators of three types are eligible for these assignments: fixed-wing, rotary-wing, and dual-qualified. The dual-qualified aviators are qualified to fly both fixed-wing and rotary-wing aircraft. The fixed-wing and rotary-wing aviators are analogous to the two parallel systems A and B with separate requirements sets; the dual-qualified aviators AB are analogous to the intersection of the two systems, A and B.

A matrix with rows and columns corresponding respectively to input card sequence numbers and card column numbers presents the input to Model IV for this sample problem. For example, the number at the intersection of row two and column ten corresponds to the number punched in the tenth column of the second input card.

Parameter Cards



The first four input cards contained in the Input to Simulation System section are Parameter Cards. Card 1 determines that the simulation will run from month 0 to month 42 for a system of 36 subtours contained within four broad tours of nine subtours each. Maximum and minimum SB tour durations are 25 and 18 months, and intermediate output is suppressed during month 1. Card 2 designates one month as the length of the simulated time periods. Personnel can be moved to ST from SB tour at any time and from TB tour after completing 18 months. Card 3 restricts inexperienced aviators and new-experienced aviators respectively to 75 percent and 10 percent of the total ST requirements. Also, in each time period five aviators may be cross-trained from rotary- to fixed-wing aircraft, and seven aviators may be cross-trained from fixed- to rotary-wing aircraft. Card 4 designates the label for the printed output.

Table 21 presents the input data for the tour deck setup. This section of the model includes cards 5 through 148, consisting of one group of N cards for each subtour in the system. In this problem, then, there are 36 groups of N cards representing 36 subtours. Each group of N cards consists of two card types: 1) Type A, a parameter card for that subtour, and 2) Type B, cards 2 to N, which assign groups of aviators to specific time periods within that subtour.

Thirty-six Type A cards represent four broad tours, 0, 1, 2, and 3. The computer program for Model IV, however, simulates only the flow among 24 subtours from three of these broad tours, 0, 2, and 3 (ST, TB, and SB tours). Reading this dummy data for the nine subtours in tour 1 (LT) is a vestige of reprogramming shortcuts from Model II to Model IV. Card 5 in Table 21, an example of a Type A card, designates broad tour 0 (ST) with requirements for 4508 rotary-wing aviators and 994 fixed-wing aviators. Of the 5502 aviators in the ST, 2885 are rotary-wing, 625 are fixed-wing, and the remainder are dual-qualified. Nine subtours are in the ST; this is subtour 1 (rotary-wing aviators on their first ST). Loss rates equal three percent of the total number of aviators in this subtour.

Cards six and seven are Type B cards. The numbers on these cards determine the number of aviators serving in each of the 12 time periods in this subtour. In columns 15 and 16 of card number seven, for example, there are 19 aviators in their 12th time period in subtour 1. The number of Type B cards per subtour is a function of the length of the subtour.

Table 22 presents input cards 149 through N--the Simulation Control Cards. In this sample, there are three input cards for each month to be simulated. The first card in each month designates the amount of input to the system and the second gives requirements sets. For example, card 149 in Table 22 sets rotary-wing and fixed-wing inexperienced aviator inputs at 360 and 50 while card 150 sets the requirements at 5060 and 1000 for the ST. TB and SB requirements are 2530 and 3770 for rotary-wing aviators, and 350 and 0 for fixed-wing aviators. The third card is blank.

5	0	1	4508		994	2885	623	5502	9	12	93	0
6	412		246	222	117	201	158	157	122	134		156
7	12		119									
8	0	2	4598		994	2885	623	5502	9	12	93	0
9	231		138	125	66	113	89	88	68	75		87
10	49		11									
11	0	3	4508		994	2885	628	5502	9	12	12	0
12	116		95	74	58	55	68	78	77	51		66
13	84		47									
14	0	4	4598		994	2885	623	5502	9	12	12	0
15	66		53	42	33	31	39	49	44	94		37
16	48		26									
17	0	5	4598		994	2885	623	5502	9	12	93	0
18	89		53	48	25	43	35	34	26	29		33
19	16		4									
20	0	6	4508		994	2885	623	5502	9	12	93	0
21	53		31	28	15	26	20	20	16	17		21
22	9		3									
23	0	7	4508		994	2885	623	5502	9	12	12	0
24	25		29	16	13	12	15	17	17	11		14
25	18		12									
26	0	8	4508		994	2885	623	5502	9	12	12	0
27	15		12	10	7	3	9	10	10	7		9
28	11		6									
29	0	9	4508		994	2886	623	5502	9	12	10	0
30												
31												
32	1	1							9	12		
33												
34												
35	1	2							9	12		
36												
37												
38	1	3							9	12		
39												
40												
41	1	4							9	12		
42												
43												
44	1	5							9	12		
45												
46												
47	1	6							9	12		
48												
49												
50	1	7							9	12		
51												
52												
53	1	8							9	12		
54												
55												
56	1	9							9	12		
57												
58												
59	2	1	2296		351	1472	333	3647	9	36	38	0
60	199		92	58	44	39	21	15	16	17		115

Table 21. Sample tour deck setup for Model IV

61		17	38	23	31	15	13	15	8	6		13
62		10	7	2	1	1	6					
63												
64	2	2	2296		351	1472	223	2647	9	36	15	0
65		107	52	32	25	22	12	8	9	9		8
66		0	22	12	18	8	7	8	4	3		7
67		5	4	1	1	0	1					
68												
69	2	3	2296		351	1472	223	2647	9	36	12	0
70		99	53	25	31	42	34	31	29	26		23
71		38	70	62	35	21	26	8	19	4		8
72		10	8	8	8	2	49					
73												
74	3	4	2296		351	1472	223	2647	9	36	12	0
75		55	39	14	17	33	19	17	17	15		13
76		22	39	35	19	12	15	5	6	2		4
77		6	5	4	4	1	27					
78												
79	2	5	2296		351	1472	223	2647	9	36	38	0
80		28	14	9	7	6	3	3	3	3		2
81		3	0	3	5	2	2	2	1	1		2
82		1	1	1	0	0	1					
83												
84	2	6	2296		351	1472	223	2647	9	36	15	0
85		17	8	5	4	0	2	1	1	1		1
86		1	3	2	3	1	1	1	1	0		1
87		1	1	0	0	0	0					
88												
89	2	7	2296		351	1472	223	2647	9	36	12	0
90		14	8	4	4	0	5	4	4	4		4
91		0	11	9	5	3	4	1	2	1		1
92		2	1	1	1	1	8					
93												
94	2	8	2296		351	1472	223	2647	9	36	12	0
95		9	5	2	3	4	3	3	3	2		0
96		3	6	6	3	2	2	1	1	0		1
97		1	1	1	1	0	4					
98												
99	2	9	2296		351	1472	223	2647	9	36	12	0
100-103												
blank												
104	3	1				1996	524	3957	9	36	03	10
105		865	14	4		1		1	1	1		
106												
107												
108												
109	3	2				1996	524	3957	9	36	03	0
110		199	3	1								
111												
112												
113												
114	3	3				1996	524	3957	9	36	03	0
115		24	8	2								
116												
117												

Table 21 continued

118											
119	3	4			1996	524	39.57	9	36	38	10
120	45	23	17	15	21	19	14	19		26	25
121	37	43	19	12	7	11	8	6		2	5
122	3	3	2	1	4	7					
123											
124	3	5			1996	524	39.57	9	36	38	10
125	12	6	5	4	5	3	4	5		7	16
126	19	11	5	3	2	1	2	2		9	1
127	1	1	1	0	4	2					
128											
129	3	6			1996	524	39.57	9	36	15	10
130	82	17	12	11	15	7	9	13		18	18
131	26	32	14	9	4	3	6	4		1	4
132	2	2	2	1	10	5					
133											
134	3	7			1996	524	39.57	9	36	12	10
135	198	49	28	29	43	30	34	37		54	73
136	86	124	89	40	9	17	5	7		8	9
137	19	18	15	16	8	115					
138											
139	3	8			1996	524	39.57	9	36	12	10
140	28	11	7	8	11	8	9	10		14	19
141	23	33	21	11	2	4	1	2		2	2
142	3	5	4	4	2	30					
143											
144	3	9			1996	524	39.57	9	36	12	10
145	78	29	20	20	31	21	25	27		39	512
146	62	99	57	29	4	12	3	5		5	7
147	6	12	11	12	6	84					
148											

Table 21 continued

149	360	50				
150		5060	1000	2520	350	3770
151						
152	360	50				
153		5293	1007	2760	350	3790
154						
155	360	50				
156		5366	1014	2910	350	4000
157						
158	360	50				
159		5639	1021	2970	350	4100
160						
161	360	50				
162		5932	1028	3010	350	4100
163						
164	360	50				
165		5985	1035	3080	350	4230
166						
167	410	50				
168		6958	1042	3110	350	4480
169						
170	410	50				
171		6231	1049	3110	350	4660
172						
173	435	50				
174		6404	1056	3110	350	4850
175						
176	460	50				
177		6479	1063	3110	350	5290
178						
179	510	50				
180		6530	1070	3110	350	5750
181						
182	510	50				
183		6640	1080	3110	350	6150
184						
185	560	50				
186		6670	1080	3110	350	6500
187						
188	560	50				
189		6820	1080	3110	350	6920
190						
191	560	50				
192		6830	1080	3110	350	7380
193						
194	560	50				
195		7070	1080	3110	350	7620
196						
197	560	50				
198		7410	1080	3110	350	7750
199						
200	560	50				
201		7900	1080	3110	350	7750
202						
203	560	50				
204		8210	1080	3110	350	7750

Table 22. Sample simulation control cards for Model IV

205						
206	560	50				
207		8860	1080	3110	350	7750
208						
209	560	50				
210		9320	1080	3110	350	8110
211						
212	560	50				
213		9490	1080	3110	350	8610
214						
215	560	50				
216		9510	1080	3110	350	9160
217						
218	560	50				
219		9530	1080	3110	350	9660
220						
221	560	50				
222		9550	1080	3110	350	9660
223						
224	560	50				
225		9570	1080	3110	350	
226						
227	560	50				
228		9590	1080	3110	350	
229						
230	560	50				
231		9600	1080	3110	350	
232						
233	560	50				
234		9620	1080	3110	350	
235						
236	560	50				
237		9630	1080	3110	350	
238						
239	540	50				
240		9640	1080	3110	350	

Table 22 continued

For illustrative purposes, the intermediate output for one time period and the final summary output matrix are presented, followed by a description of the output for the specific-wing aviator problem. At the beginning of the simulation of month 46, 560 rotary-wing and 50 fixed-wing inexperienced aviators were input from outside the system.

NUMBER OF ROTARY WING PILOTS INPUT AT BEGINNING OF MONTH 46 = 560

FIXED WING PILOTS INPUT = 50

SUMMARY FOR PERIOD 46

FLOWS FOR PERSONS SHIFTED BEFORE END OF TOUR

FROM TOUR		LOSSES	REASSIGNABLE
2	5	17	8
3	4	171	98
3	5	77	30
3	6	3	9
3	7	7	29
3	8	4	21
3	9	10	41

Following the input is a summary of the personnel flow during month 46. First, personnel who are removed before completing the normal length of time in the subtour are summarized. For example, a total of 25 personnel are moved from tour 2 (TB) subtour 5 (fixed-wing aviators after their first ST) prior to completion of that subtour. Of those 25 who are moved, 17 are lost to the system and 8 are available for reassignment. The number of personnel lost to the system is a direct function of the high loss rate (38%) for this subtour.

The assignments section of the model summarizes the movement of all aviators during time period 46. It locates personnel prior to and after their reassignment.

	ASSIGNMENTS			
TOUR	SUBTOUR	TOTAL	SUBTOTAL	SOURCE
0		815		
	1	529		
			529	OUTSIDE
	3	127		
			98	EARLY 3,4
			29	EARLY 3,7
	4	50		
			9	EARLY 3,6
			41	EARLY 3,9
	5	50		
			50	OUTSIDE
	7	59		
			8	EARLY 2,[illegible]
			30	EARLY 3,[illegible]
			21	EARLY 3,8
2		25		
	5	25		
			25	END 0,5
3		791		
	1	31		
			31	OUTSIDE
	4	514		
			514	END 0,1
	5	24		
			24	END 0,5
	6	12		
			5	EARLY 3,4
			7	EARLY 3,5
	7	124		
			124	END 0,3
	8	45		
			45	END 0,7
	9	41		
			33	END 0,4
			8	END 0,8

For instance, in broad tour 0 (ST), 529 inexperienced personnel enter subtour 1 (rotary-wing aviators on their first ST) from outside the system and 127 experienced aviators enter subtour 3 (rotary-wing aviators on their second or subsequent ST). Of the latter 127 aviators, 98 move prior to the completion of broad tour 3 (SB) subtour 4 (rotary-wing aviators after their first ST) and 29 move prior to the completion of SB subtour 7 (rotary-wing aviators after second or subsequent ST).

The tour distribution (Table 23) gives the state of the system at the end of month 46. Every subtour is presented as a personnel vector with certain characteristics printed above the vector. Note that tour 0 subtour 2 (dual-qualified aviators on first ST serving as rotary-wing aviators) is not printed because there are no aviators present in this subtour at month 46. For tour 0 (ST), however, the requirements are for 9640 rotary-wing and 1080 fixed-wing aviators. To meet these requirements, 10720 aviators enter the ST. The duration of tour 0 subtour 1 (rotary-wing aviators on first ST) is 12 months. In each of the third and fourth months of service, there are 560 aviators. Each tour-subtour is described in similar fashion.

At the end of month 46, there were 27725 aviators in the entire system. Those aviators who have completed the regular length of service in a subtour and are eligible for reassignment or are lost to the system are indicated.

END TOUR FLOW FOR PERIOD 46

FROM	TOUR	LOSSES	REASSIGNABLE
0	1	13	440
0	3	16	125
0	4	1	10
0	5	1	49
0	7	4	34
0	8	4	31

Of the eleven aviators who complete tour 0 (ST) subtour 4 (dual-qualified aviators serving as rotary-wing pilots on second or subsequent ST), for example, one is lost to the system and 10 are available for reassignment. Of those aviators who are reassigned to the ST during month 46, the average number of time periods served in the SB by rotary-wing, fixed-wing, and dual-qualified pilots are respectively 20, 21, and 20. The previously discussed detailed output for time period 46 is summarized with the other time periods in the summary table at the end of the simulation. This detailed intermediate output is especially valuable in debugging and system checking procedures.

Table 23

SAMPLE TOUR DISTRIBUTIONS FOR MODEL IV

	TOUR	0	1								
QUOTAR	9640	QUOTAF	1080	STRENGTH		10720	LENGTH	12			
529	560	560	560	743	704	563	336	485	528	698	453
	TOUR	0	3								
QUOTAR	9640	QUOTAF	1080	STRENGTH		10720	LENGTH	12			
127	310	541	160	135	226	125	105	127	177	242	141
	TOUR	0	4								
QUOTAR	9640	QUOTAF	1080	STRENGTH		10720	LENGTH	12			
50	37	122	27	128	9	63	8	35	0	15	11
	TOUR	0	5								
QUOTAR	9640	QUOTAF	1080	STRENGTH		10720	LENGTH	12			
50	50	50	50	62	57	52	63	45	21	50	50
	TOUR	0	7								
QUOTAR	9640	QUOTAF	1080	STRENGTH		10720	LENGTH	12			
59	17	45	36	26	19	17	20	13	5	77	38
	TOUR	0	8								
QUOTAR	9640	QUOTAF	1080	STRENGTH		10720	LENGTH	12			
0	0	0	0	0	0	1	1	3	3	65	35

Table 23 continued

	TOUR	2	1								
QUOTAR	3110	QUOTAF		350	STRENGTH	3460	LENGTH	36			
0	163	544	287	211	654	188	34	92	105	122	52
17	93	52	96	73	0	161	50	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
	TOUR	2	3								
QUOTAR	3110	QUOTAF		350	STRENGTH	3460	LENGTH	36			
0	0	116	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
	TOUR	2	5								
QUOTAR	3110	QUOTAF		350	STRENGTH	3460	LENGTH	36			
25	21	49	27	54	15	6	19	2	0	25	15
18	0	4	23	16	1	16	11	0	2	0	0
0	0	0	0	0	0	0	0	0	0	0	0
	TOUR	3	1								
QUOTAR	0	QUOTAF		0	STRENGTH	13545	LENGTH	36			
31	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
	TOUR	3	4								
QUOTAR	0	QUOTAF		0	STRENGTH	13545	LENGTH	36			
514	381	0	252	505	24	354	287	374	403	551	383
492	446	597	519	743	752	445	75	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
	TOUR	3	5								
QUOTAR	0	QUOTAF		0	STRENGTH	13545	LENGTH	36			
24	28	0	22	0	34	38	36	35	14	17	27
24	42	38	19	38	48	28	44	36	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

Table 23 continued

	TOUR	3 6									
QUOTAR	0	QUOTAF	0	STRENGTH		13545	LENGTH	36			
12	12	12	12	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
	TOUR	3 7									
QUOTAR	0	QUOTAF	0	STRENGTH		13545	LENGTH	36			
124	221	131	121	97	46	124	30	49	102	133	96
67	156	266	53	74	61	59	37	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
	TOUR	3 8									
QUOTAR	0	QUOTAF	0	STRENGTH		13545	LENGTH	36			
45	15	32	28	22	13	15	15	10	6	28	18
45	15	30	15	18	12	12	15	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
	TOUR	3 9									
QUOTAR	0	QUOTAF	0	STRENGTH		13545	LENGTH	36			
41	85	346	50	137	167	45	76	100	57	193	85
97	150	229	52	65	68	46	27	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

SYSTEM TOTAL 27725

END TOUR FLOW FOR PERIOD 46

FROM	TOUR	LOSSES	REASSIGNABLE
0	1	13	440
0	3	16	125
0	4	1	10
0	5	1	49
0	7	4	34
0	8	4	31

AVERAGE NUMBER OF MONTHS SERVED IN CONUS FOR ROTARY = 20 FIXED = 21 DUAL = 20

Table 24 presents the final output summary for the simulation of the aviator problem. The summary table describes the type and number of aviators assigned to the ST.

A second computer run was made with identical data except that the percentage of inexperienced personnel was changed to 60%. Figures 22 and 23 present graphs of the average number of months spent in the SB between ST assignments under the two policy alternatives. The inexperience level noticeably affects the length of the SB tours. Under the policy of 60% inexperienced, the average number of SB months is lower than under the 75% inexperienced policy. This phenomenon is predictable, since the 75% policy alternative makes fewer demands on career personnel than does the 60% policy. Under both the 75% and 60% inexperienced policies, results reflect shorter SB tours for the dual-qualified aviators than for fixed- or rotary-wing aviators. Studies such as these are helpful in determining policies which will make these tour lengths equitable for all aviators.

CONCLUSIONS

In applying the four models, in the DYNAMOD simulation package, the amount of computer time the programs require becomes increasingly important as the number of policy alternatives to be evaluated increases. Lengthy computer runs are not only expensive but are also impractical when immediate results are desired. Table 25 shows the total running time for a 46-month simulation using the four models. The advantage of suppressing intermediate output is dramatically demonstrated by these results. Also, when summary data is not available, as in Models I and III, the output for management is further delayed by the time it takes the analyst to compile the output into a meaningful summary.

Since the length of time in the personnel system is only roughly represented by the number of ST assignments, and reenlistment rates can only be represented in certain time periods, nondeployment related to ETS is not accurately accounted for in any of the models. In addition, loss rates apply only at certain times and temporary casualties are therefore not represented directly. Losses are only crudely taken into account by inflating ST requirements.

Perhaps the greatest difficulty is in modifying flow patterns and personnel categories. Each time priorities change or additional subtours are needed, it is necessary to reprogram the models. Reprogramming becomes highly impractical when management desires to study several different priority-of-fill configurations for one problem.

Table 24

SUMMARY OUTPUT FOR DYNAMOD MODEL IV-FIXED INPUT

BEHAVIOR AND SYSTEMS RESEARCH LABORATORY DYNAMIC ARMY MODEL

MODEL IV INPUT: 75 PERCENT = NEW. 10 PERCENT = NEW EXPERIENCED.

MO	ST QUOTAS ROTARY	ST QUOTAS FIXED	ST ACTUAL ROTARY	ST ACTUAL FIXED	INPUT ROTARY	INPUT FIXED	REP TO ST ROTARY	REP TO ST FIXED	NEW ROT	EXP FIX	INEXP	CAREER	BASE R	TO F
1	5060	1000	5060	1000	360	50	655	29	0	0	512	172	25	25
2	5293	1007	5293	1007	360	50	477	61	0	0	402	136	25	25
3	5366	1014	5366	1014	360	50	419	63	0	0	376	126	23	25
4	5639	1021	5578	1021	360	50	501	70	1	0	473	97	23	25
5	5922	1028	5846	1028	360	50	579	76	1	0	548	106	22	24
6	5985	1035	5985	1035	360	50	506	88	1	0	445	148	21	23
7	6055	1042	6055	1042	410	50	427	66	0	0	384	129	21	22
8	6231	1049	6231	1049	410	50	573	95	1	0	500	167	21	22
9	6404	1056	6404	1056	435	50	447	67	0	0	385	129	21	22
10	6477	1063	6477	1063	460	50	536	109	5	2	483	155	21	22
11	6530	1070	6530	1070	510	50	545	123	18	5	530	155	21	22
12	6640	1080	6640	1080	510	50	935	192	93	19	835	180	21	22
13	6670	1080	6670	1080	560	50	685	29	68	0	534	112	21	22
14	6820	1080	6820	1080	560	50	627	61	62	0	515	111	21	22
15	6830	1080	6830	1080	560	50	429	84	42	0	384	87	21	22
16	7070	1080	7070	1080	560	50	741	70	74	0	607	130	21	22
17	7410	1080	7410	1080	560	50	919	76	91	0	740	158	21	22
18	7900	1080	7900	1080	560	50	996	88	99	0	809	176	21	22
19	8210	1080	8210	1080	560	50	737	66	87	0	602	134	21	22
20	8860	1080	8860	1080	560	50	1223	95	4	0	720	594	21	22
21	9320	1080	9320	1080	560	50	907	67	0	0	610	364	21	22
22	9490	1080	9490	1080	560	50	706	109	0	0	579	236	21	22
23	9510	1080	9510	1080	560	50	605	123	0	0	503	225	21	22
24	9530	1080	9530	1080	560	50	955	192	0	0	748	399	21	21
25	9550	1080	9550	1080	560	50	705	29	0	0	549	185	21	21
26	9570	1080	9570	1080	560	50	647	61	0	0	530	178	21	21
27	9590	1080	9590	1080	560	50	449	84	0	0	399	134	21	21
28	9600	1080	9600	1080	560	50	751	70	0	0	615	206	21	21
29	9620	1080	9620	1080	560	50	939	76	0	0	761	254	21	21
30	9630	1080	9630	1080	560	50	1006	88	0	0	805	289	21	21
31	9640	1080	9640	1080	560	50	747	66	0	0	610	223	21	21
32	9640	1080	9640	1080	560	50	1223	95	0	0	610	708	21	21
33	9640	1080	9640	1080	560	50	907	67	0	0	610	364	21	21
34	9640	1080	9640	1080	560	50	706	109	0	0	579	236	21	21
35	9640	1080	9640	1080	560	50	605	123	0	0	503	225	21	21
36	9640	1080	9640	1080	560	50	955	192	0	0	748	399	20	21
37	9640	1080	9640	1080	560	50	705	29	0	0	549	185	20	21
38	9640	1080	9640	1080	560	50	647	61	0	0	530	178	20	21
39	9640	1080	9640	1080	560	50	449	84	0	0	399	134	20	21
40	9640	1080	9640	1080	560	50	751	70	0	0	615	206	20	21
41	9640	1080	9640	1080	560	50	939	76	0	0	761	254	20	21
42	9640	1080	9640	1080	560	50	1006	88	0	0	805	289	20	21
43	9640	1080	9640	1080	560	50	747	66	0	0	610	223	20	21
44	9640	1080	9640	1080	560	50	1223	95	0	0	610	708	20	21
45	9640	1080	9640	1080	560	50	907	67	0	0	610	364	20	21
46	9640	1080	9640	1080	560	50	706	109	0	0	579	236	20	21

[a]The sudden increase in the Supplement reflects a change to zero quotas in the SB.

…OUR …D	TRAINEES	DUAL HOT	TR FIX	SUPPL	SYSTEM TOTAL
25	1014	5	7	163	12385
24	1022	5	7	-1	12681
20	1056	5	7	-106	13020
18	992	0	7	-153	13390
18	852	0	7	-131	13739
18	816	0	7	-32	14082
19	892	0	7	6	14475
19	851	5	7	32	14846
20	951	5	7	94	15264
21	971	5	7	0	15683
21	977	5	7	-42	16155
21	585	5	7	-117	16591
21	591	5	7	37	17123
22	622	5	7	4	17648
22	805	5	7	84	18197
22	731	5	7	152	18726
22	500	5	7	214	19231
22	197	5	7	256	19723
22	115	5	7	485	20237
21	0	5	7	101	20451
21	0	5	7	-287	20845
21	31	5	7	-498	21290
21	138	0	7	-599	21758
20	0	5	7	-808	22067
20	61	5	7	-419	22474
20	141	5	7	9744[a]	22997
20	352	5	7	10236	23507
21	347	5	7	10540	23820
21	195	5	7	10974	24273
20	0	5	7	11317	24625
21	0	5	7	11628	24945
20	0	5	7	11667	24984
20	0	5	7	11788	25105
20	31	5	7	12111	25428
20	138	5	7	12414	25731
19	0	5	7	12445	25762
19	61	5	7	12735	26052
20	141	5	7	13140	26457
20	352	5	7	13532	26849
21	347	5	7	13934	27251
20	195	5	7	14044	27361
21	0	5	7	14391	27708
21	0	5	7	14610	27927
20	0	5	7	14089	27406
20	0	5	7	14129	27446
20	31	5	7	14408	27725

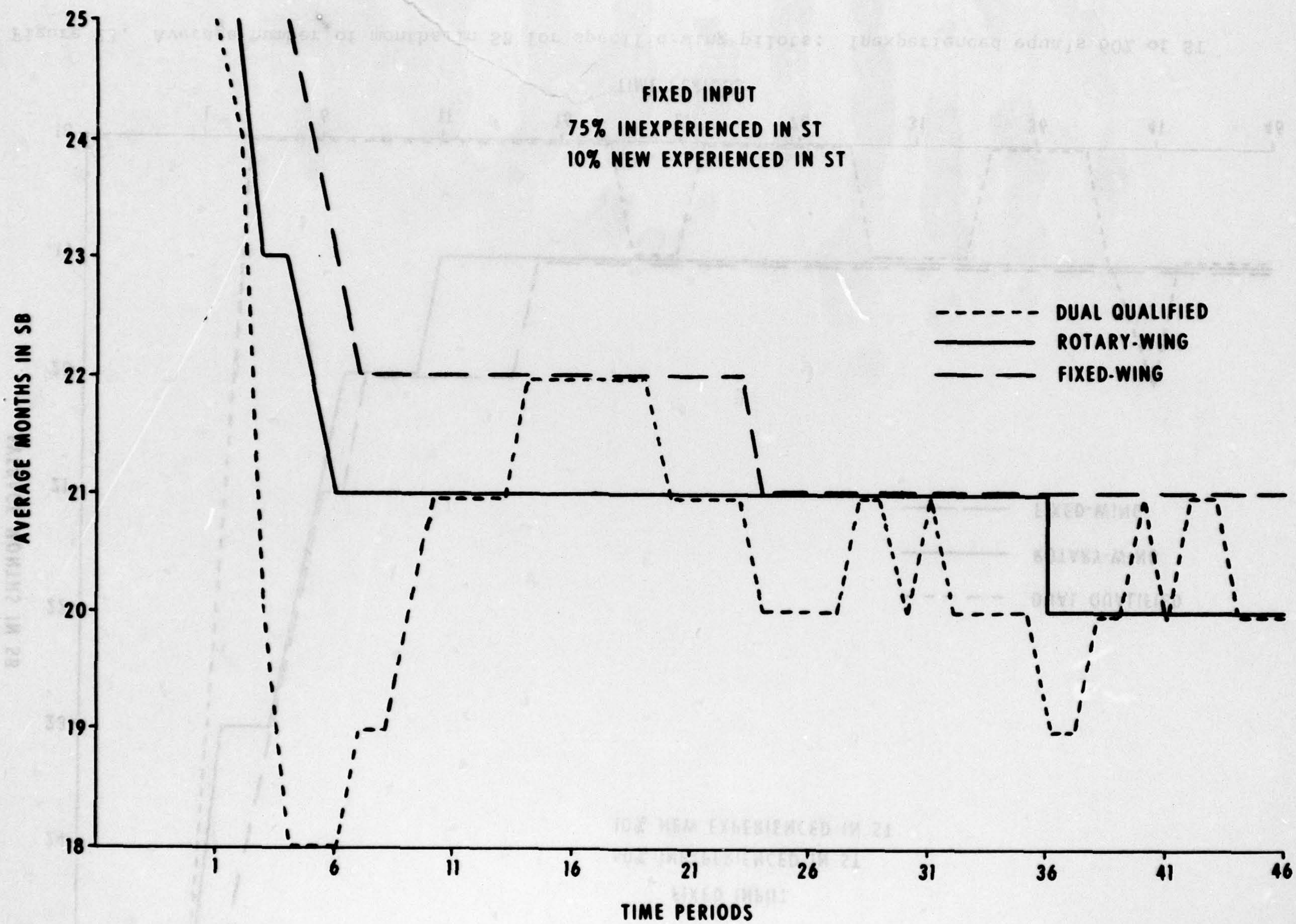


Figure 22. Average number of months in SB for specific-wing pilots: Inexperienced equals 75% of ST

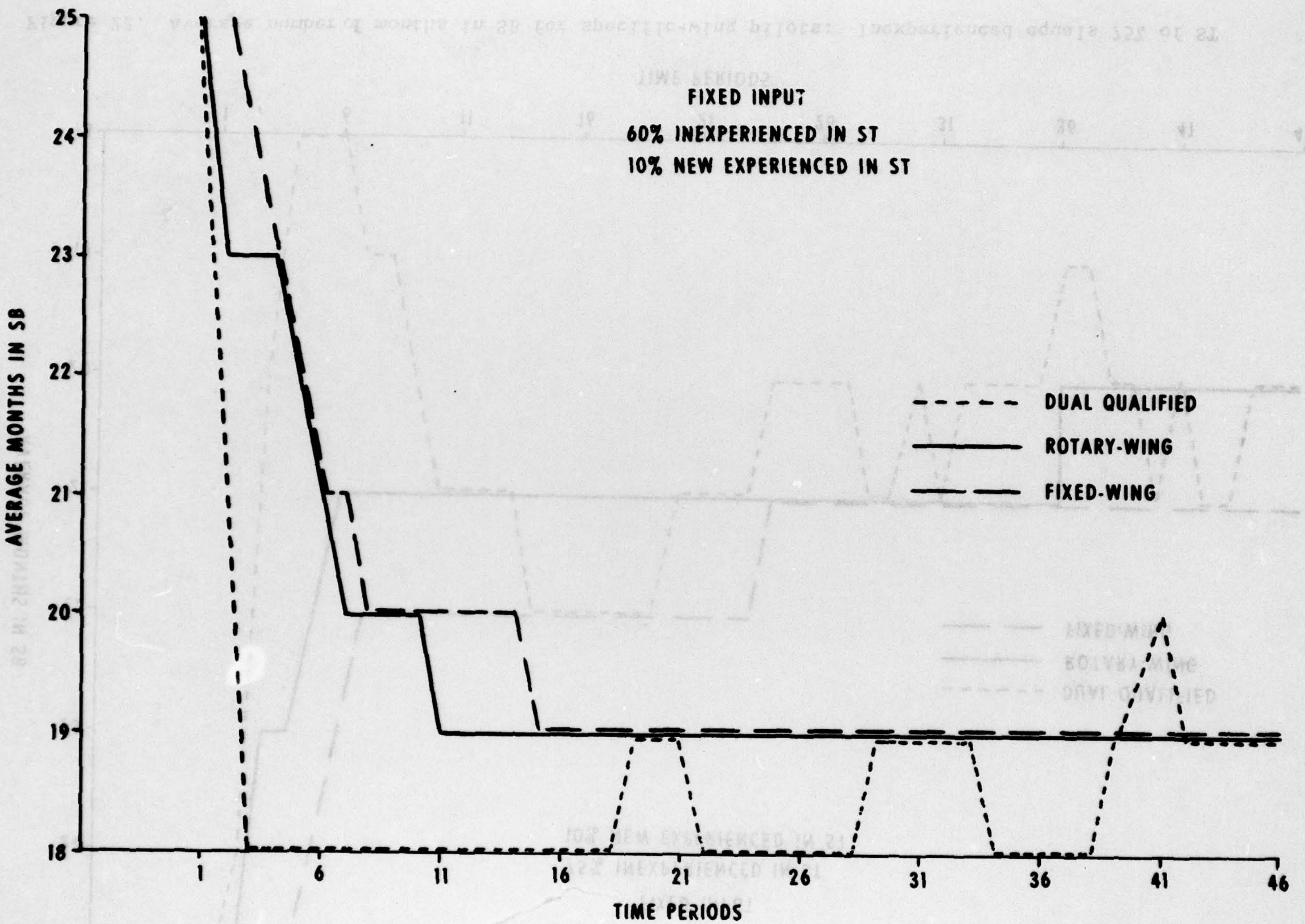


Figure 23. Average number of months in SB for specific-wing pilots: Inexperienced equals 60% of ST

Table 25

TOTAL COMPUTER RUNNING TIME FOR A 46-MONTH SIMULATION

Model	Intermediate and Summary	Summary
I	34.5 min.	Not Available
II	22.8 min.	10.8 min.
III	26.9 min.	Not Available
IV	32.8 min.	15.8 min.

Nonetheless, the four models are valuable tools. The objective approach of DYNAMOD can aid management in many of its decision-making processes. Effects of policies which might not be immediately obvious to management may be uncovered by these analyses. New policies, furthermore, may be suggested by the output and evaluated prior to implementation. Modern management cannot afford to make subjective decisions which might affect the future of its organization or of the nation. Decisions based on experience coupled with objective data should increase the probability of success because the outcomes can be predicted and analyzed in advance.

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