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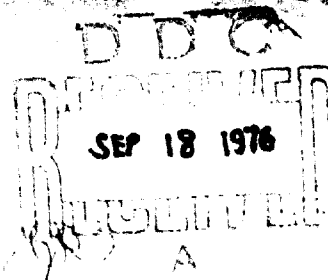
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HUMAN RELIABILITY PREDICTION SYSTEM USER'S MANUAL



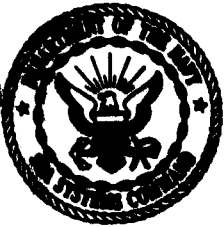
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**Human Reliability Prediction
System User's Manual.**

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1.0 INTRODUCTION

1.1 Background

The Human Reliability Prediction System Program was initiated by the Advanced Development Objective, 43-13X. The objective of this program was to develop a technology for predicting and demonstrating the system effectiveness parameters of combined man-machine systems. Specific parameters, such as system mission reliability and availability, and design oriented measures, such as human and equipment mean time between failure (MTBF) and mean time to repair (MTTR), were considered.

Before this program, no tools existed for measuring the impact of human reliability on system performance, and there was no effective procedure for predicting human reliability in a weapons systems environment.

Project W43 13X was established in FY 69. The Chief of Naval Material designated the Naval Air Systems Command (NAVAIR) as the Principal Development Activity and assigned supporting responsibilities to the Naval Ships Systems Command (NAVSHIPS) and other Navy organizations. In NAVAIR, the project was assigned to AIR 303.

The management responsibility for the Human Reliability Prediction System was given to Naval Sea Systems Command (NAVSEA). The project team consisted of personnel from Naval Underwater Systems Center (NUSC), Applied Psychological Services, and Tracor. These team members have developed a set of procedural tools which can be used by project managers to evaluate combined human, system, and equipment reliability and maintainability.

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1.2 Available Tools and Models

The Human Reliability Program has sponsored the development of a number of techniques for estimating the impact of human performance on system performance, reliability, and maintainability (see figure 1-1). The program has developed a set of simulation and empirical models based on an extensive analysis of fleet maintenance data and a concept of operational reliability which incorporates human and equipment factors.

1.2.1 Simulation Models. The simulation models (Siegel-Wolf), developed by Applied Psychological Services Wayne, Pa., permit human, equipment, and system reliability; availability; and MTTR to be estimated as a function of human proficiency, system design, and ships environmental parameters. An example of the results obtained by these models is presented in figure 1-2.

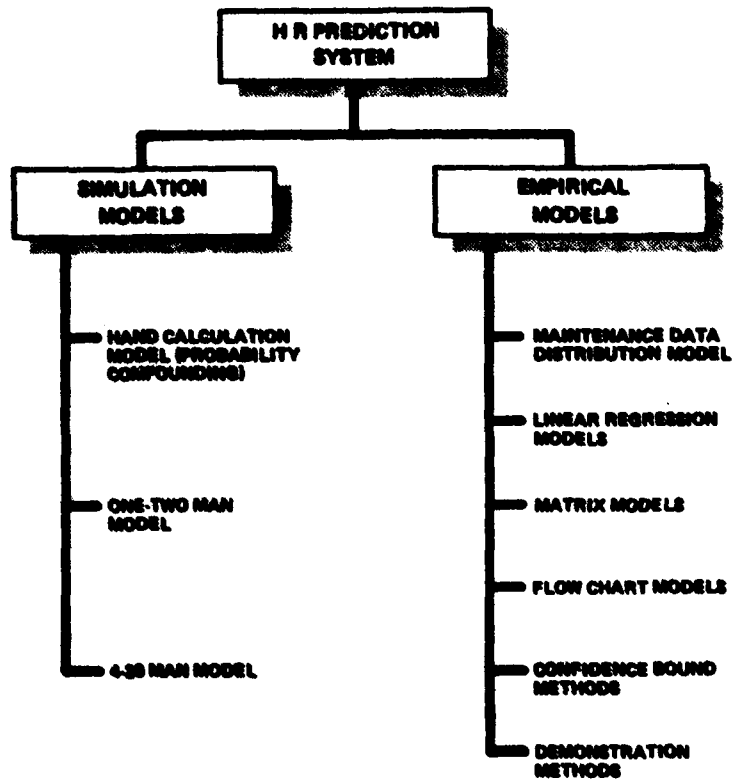


Figure 1-1. Human Reliability Prediction System Tools and Models

1.2.1.1 *Hand Calculation Model for Probability of Correcting a Malfunction.* This model provides a relatively simple hand procedure for calculating the probability of correcting a malfunction. A set of appropriate input factors is selected from the following list:

- Mental activity factor
- Physical repair activity
- Instruction factor
- Safety procedures
- Personnel management relationships
- Equipment operation
- Use of reference materials
- Equipment inspection

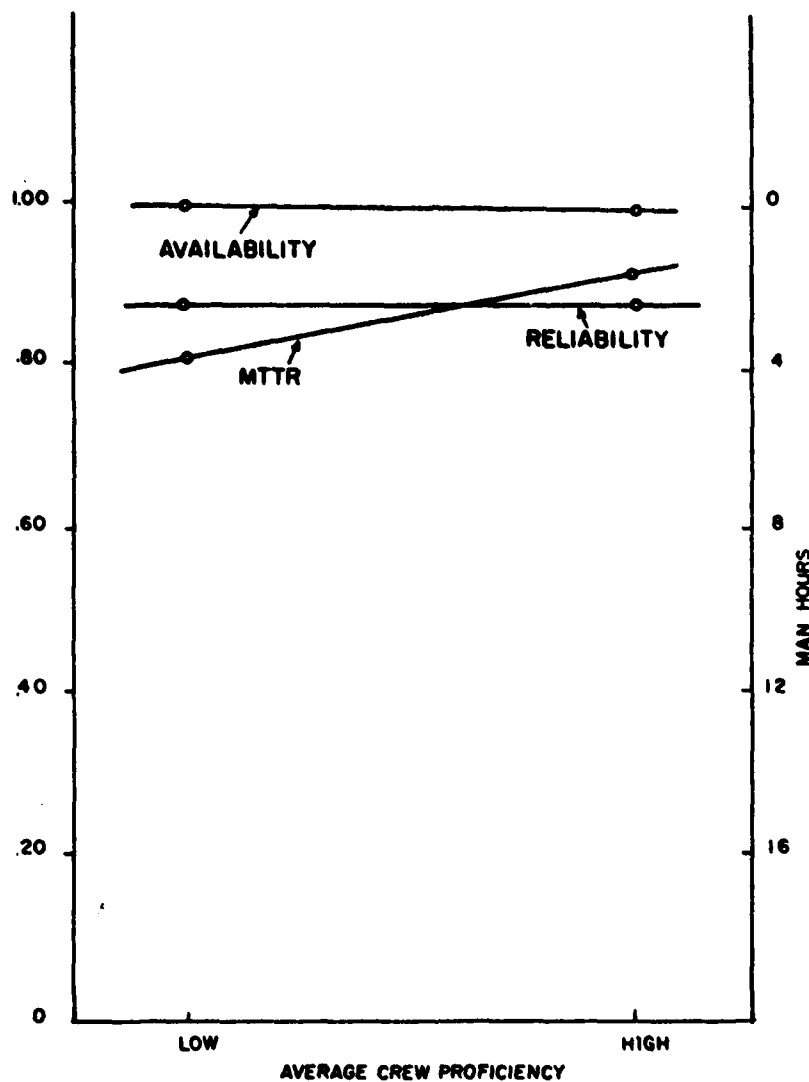


Figure 1-2. System MTTR (right scale), and Reliability and Availability (left scale) as a Function of Average Crew Proficiency and Manning Level

The probability of successful completion of each of these factors is determined, and the probability of correcting the malfunction is computed by multiplying these probabilities in the appropriate manner. Both series and parallel operations can be handled.

The methodology for computing the electronic maintenance factors listed above was developed based on data obtained from a fleet sample of 533 technicians.

1.2.1.2 One-Two Man Simulation Model for Calculating Malfunction Correction Time. A computer simulation model (figure 1-3) was developed to predict malfunction correction time. This model uses the same input data as the hand calculation procedure discussed previously. The model computes the time required to complete the actions measured by each of the factors and combines them to compute overall malfunction correction time (see figure 1-4).

This model was validated using extensive data on the AN/URC-35 and AN/APS-115 radio systems. The accuracy of this computational technique was found to be excellent.

1.2.1.3 Human and System Reliability Simulation Model (4 to 20 Men). This model simulates the behavior of a self-contained system manned by from 4 to 20 persons on missions which may vary from 1 to 30 days. This model can simulate the performance of as many as 80 jobs per day. Teams of up to 20 persons can be simulated along with the repairs of a maximum of 20 different equipments.

The typical data for this model are as follows:

- Number of men holding each rank (pay grade) and specialty (rating)
- Body weight
- Average proficiency in primary and secondary specialty
- Average work pace
- Average physical capability
- Average man's physical capability after a full work day and its effects on subsequent tasks performed.

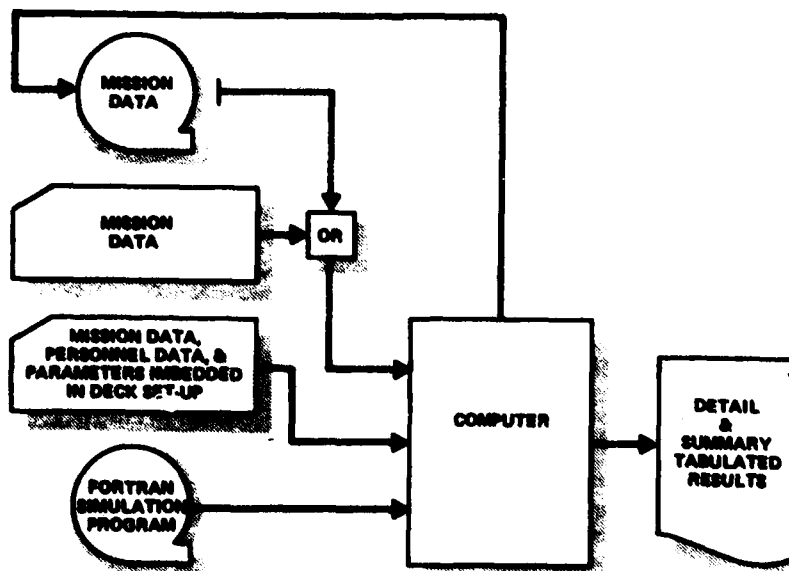


Figure 1-3. Computer Simulator System

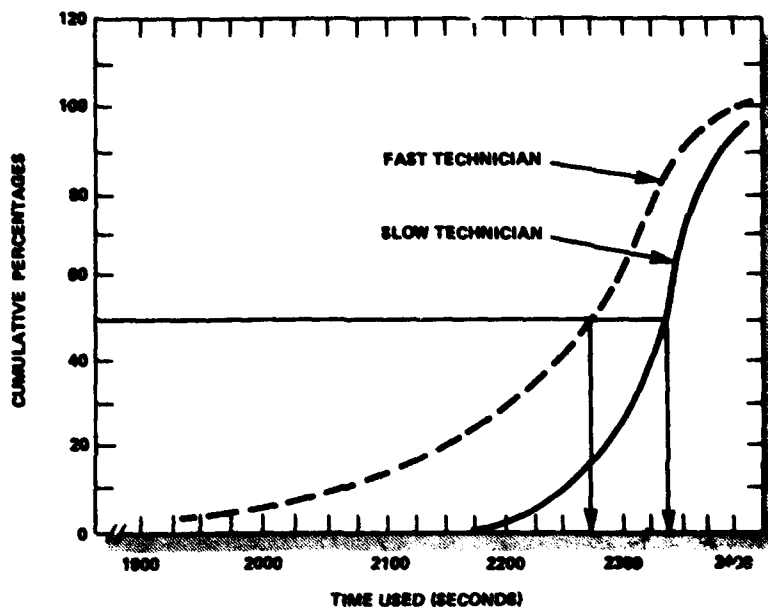


Figure 1-4. Predicted Malfunction Correction Time (Single Technician)

The equipment input data includes data such as:

- Equipment and failure rate
- Average repair time
- Standard deviation of repair time
- Number of men required to accomplish repair by type

The program calculates:

- Human reliability, availability, and MTTR
- Equipment reliability, availability, and MTTR
- System reliability, availability, and MTTR
- A variety of other parameters such as stress, fatigue, percent work completed, percent needing touchup, time for task completion, etc.

1.2.2 Empirical Models. The empirical models were developed, by Tracor, from fleet maintenance data on the AN/SQS-26 (CX) sonar. These models provide a simple means of relating repair time, maintenance man-hours, and maintenance man experience (see figure 1-5). An analysis of the data suggested a new parameter, called maintenance power, which tied repair time and experience together. Maintenance power is equal to the product of maintenance man experience and time spent on a repair; it was shown that

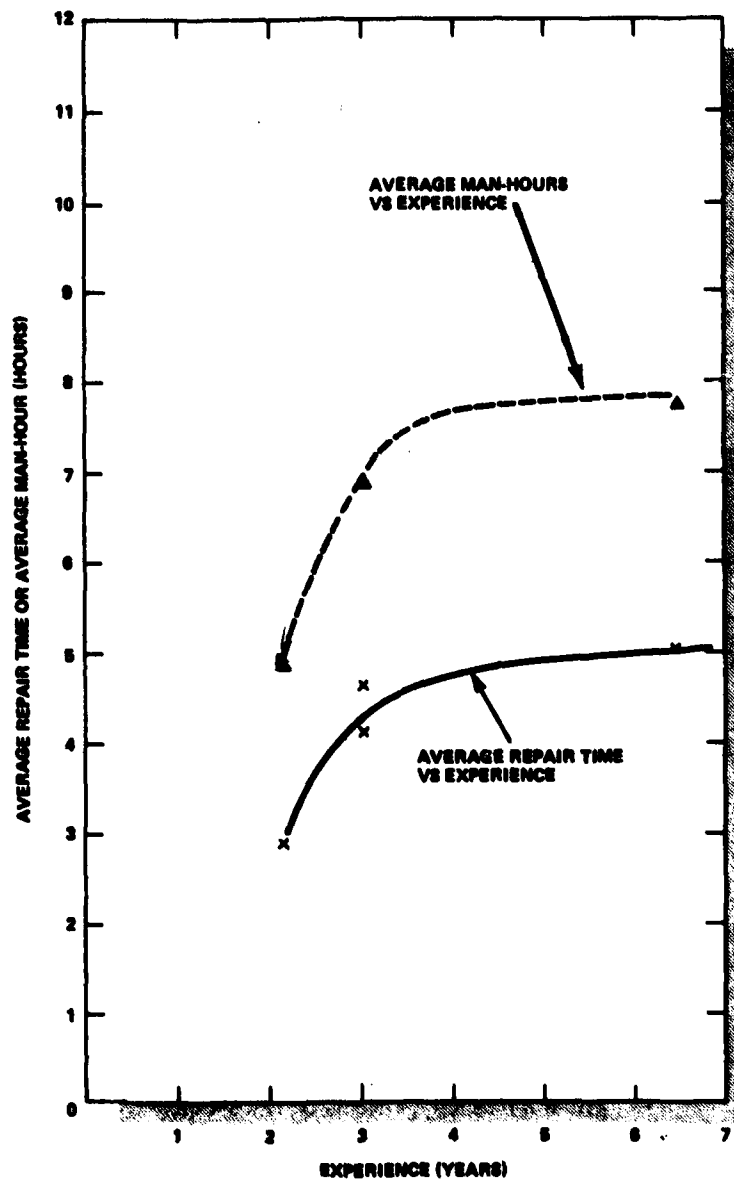


Figure 1-5. Average Repair Time and Man Hours Versus Experience

a simple relationship exists between maintenance power and the other parameters as shown in figure 1-6. This empirical model is useful to system designers during advanced development for making preliminary estimates of system MTTR, manning levels, and experience levels. Data for these studies were obtained by the Naval Weapons Engineering Support Agency (NAVWESA) under the sponsorship of NAVSEA. The specific models developed are described as follows:

- Lognormal distribution models for each major category of maintenance data
- Linear regression models relating the repair time to the new parameter, maintenance power
- A simple prediction technique based on lognormal assumptions
- A multiple repairman man-hour and repair time prediction model that employs matrix equations which incorporate repairman experience effects
- A flow chart maintainability prediction procedure that would overcome the weakness of MIL-HDBK-472 Procedure II and bridge the gap between theoretical maintainability prediction and the actual demonstration

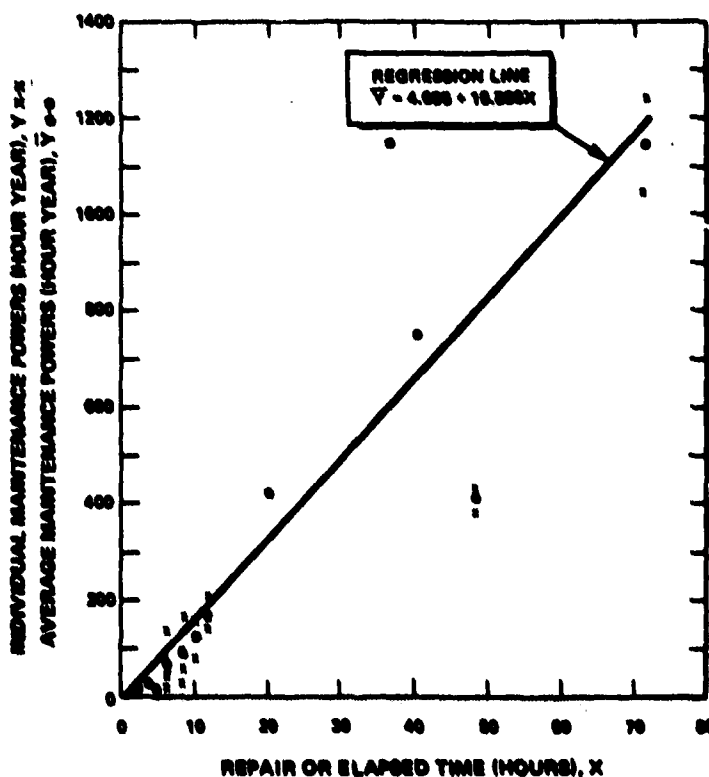


Figure 1-6. Maintenance Power Versus Repair Time

- Two methods of estimating the confidence bounds for variates that are roughly lognormally distributed (The first method predicts confidence bounds that account for parameter estimate variations, and the second method predicts confidence bounds that account for noise effects in the lognormal distribution.)
- Man-hour, repair time, and number of men per repair test demonstration methods

1.2.3 Allocation Model. The program also has developed a methodology for maximizing the operational reliability of man-machine systems. This model can be solved by means of standard dynamic programming techniques -- it makes use of the outputs of each of the models discussed previously. The model is unique in that it permits the interactions of all of the major parameters describing man-machine interactions and their effect on operational reliability to be computed.

1.3 Measures of Effectiveness

A set of relationships for computing human, equipment, and system availability, reliability, MTTR, and MTBF was developed and incorporated into the 4 to 20 man simulation model described in section 4. These equations are listed below. The computer names of the input variables of these equations are provided.

1. Human Reliability

$$HUMAN\ RELIABILITY = 1 - \frac{No.\ of\ failures}{No.\ of\ attempts} \quad (1-1)$$

2. Human Availability

$$HUMAN\ AVAILABILITY = 1 - \frac{Time\ lost\ or\ unmanned\ hours}{Total\ mission\ manhours} \quad (1-2)$$

3. Human MTTR

$$HUMAN\ MTTR = \frac{Total\ time\ of\ second\ try\ successes}{No.\ of\ second\ try\ successes} \quad (1-3)$$

4. Equipment Reliability

$$EQUIPMENT\ RELIABILITY = 1 - \frac{Total\ no.\ of\ failures\ during\ mission}{No.\ of\ missions \times Number\ of\ equipments} \quad (1-4)$$

5. *Equipment Availability*

$$\text{EQUIPMENT AVAILABILITY} = \frac{\text{Equipment up time}}{\text{Total mission time} \times \text{No. of equipments}} \quad (1-5)$$

6. *Equipment MTBF*

$$\begin{aligned} \text{EQUIPMENT MTBF} &= \frac{\Sigma \text{ times between failures}}{\text{No. of failures}} \\ &= \frac{\text{Mission time} \times \text{down time}}{\text{No. of failures}} \end{aligned} \quad (1-6)$$

7. *Equipment MTTR*

$$\text{EQUIPMENT MTTR} = \frac{\text{Total repair times for all missions}}{\text{No. of repairs}} \quad (1-7)$$

8. *System Reliability*

$$\text{SYSTEM RELIABILITY} = 1 - \frac{\text{No. of equipment failures} + \text{No. of people failures}}{\text{Iterations} \times \text{No. of equip} + \text{Human attempts}} \quad (1-8)$$

9. *System Availability*

$$\text{SYSTEM AVAILABILITY} = 1 - \frac{\text{System down time}}{\text{Mission time}} \quad (1-9)$$

10. System MTTR

$$\text{SYSTEM MTTR} = \frac{\Sigma \text{ time for repairs} + \Sigma \text{ time for second try successes}}{\text{No. of repairs} + \text{No. of second try successes}} \quad (1-10)$$

2.0 PROBABILITY COMPOUNDING (HAND CALCULATION)

2.1 Introduction

The probability compounding method of predicting human reliability provides a means of calculating the probability that a particular maintenance technician, or group of maintenance technicians, will successfully accomplish the sequence of tasks required to correct a particular malfunction on a given equipment or system. The method provides for hand computation of individual or group reliability indices. In section 3 this basic method is expanded into a computer simulation technique for predicting the time it will take to correct the malfunction. These predictions are based on a magnitude estimate of the ratio of the number of unusually effective to the number of unusually ineffective performances obtained in a sample of each of the required tasks. The probability compounding procedure involves the following steps as illustrated in figure 2-1.

- Multidimensional scaling
- Individual performance index computations
- Reliability index computation

These steps are discussed in detail in the following paragraphs. The probability compounding method is directly applicable to any activity which consists of a sequence of events. Therefore, it can also be used to compute human operator reliability. These techniques are discussed in the later sections of this user's manual.

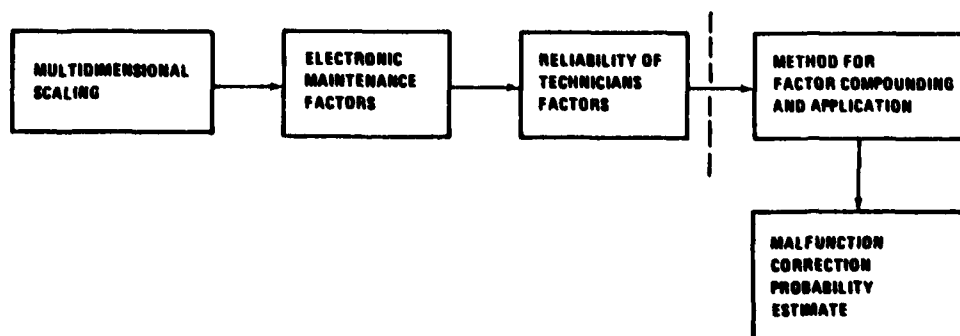


Figure 2-1. Flow of Events in Maintenance Technician Reliability Program

2.2 Multidimensional Scaling

Multidimensional scaling is a technique for identifying all of the job factors or tasks involved in the maintenance, servicing, and repair of the equipment or system. In implementing the human reliability prediction system, multidimensional scaling analyses have been performed to identify the complete spectrum of tasks and requirements involved in the maintenance of electronic equipments or systems. Equivalent factors have yet to be derived for mechanical systems.

To determine the structure of the job of the electronic maintenance technician, Siegel and Schultz (1963) performed a multidimensional scaling analysis of the job of electronic maintenance by naval technicians. The consensus of Fleet personnel interviewed indicated that the job of the technician was best described by some 29 different tasks. Examples of tasks were: using schematics for complex circuits and troubleshooting/isolating malfunctions in avionic equipments. The 29 tasks performed by both supervisory and line personnel constituted the sample which provided the basic data for the analysis. Sixty-five subjects distributed over 14 separate maintenance units were involved. The data was factor analyzed by the principal components method with rotation according to the equamax criterion (Saunders, 1962). Nine factors emerged. These factors were named: Electro-cognition (EC), Electro-repair (ER), Instruction (I), Electro-safety (ES), Personnel Relationships (PR), Electronic Circuit Analysis (ECA), Equipment Operation (EO), Using Reference Materials (URM), and Equipment Inspection (EI). These factors are fully defined in table 2-1. Numerical estimates are given in section 3. These should be used in all predictions.

Table 2-1. Definition of Factors

1. Electro-cognition	This factor is associated with any routine mental activity involved in the troubleshooting acts. It includes the mental formulation of simple hypotheses regarding the cause of a malfunction, the mental synthesis of elementary cause-effect relationships, logical thinking of a routine nature, and the integration of test results with pretest hypotheses. Simple sequential tests do not involve electro-cognition. For example, continuity tests would not involve this category. This is a "how to make it work" factor as opposed to electronic circuit analysis, which is a "why it doesn't work" factor. Tasks which might involve electro-cognition are: ● Making logic changes in a data processing unit ● Comparing an output waveform to an illustration in a technical manual ● Observing fault lights and inferring module to be replaced
2. Electro-repair	This factor includes the motor and manipulative aspects of physically repairing a component which has failed. It does not include module or component replacement, but does include module or component repair. Examples of tasks including electro-repair are: ● Replacing a broken solder joint ● Adjusting the contacts on a relay
3. Instruction	This factor involves teaching others how to inspect, repair, operate, or maintain electronic equipments. Examples of tasks involving this factor are: ● Instructing another technician on how to use test equipment ● Instructing a subordinate on how to perform a test or repair act ● Instructing an operator on how to work an equipment

Table 2.1. Definition of Factors (Continued)

4. Electro-safety	This factor involves implementation of special safety procedures to minimize the possibility of additional equipment damage. An example task involving this factor is: ● Observing high voltage protection instructions on equipment
5. Personnel Relationships	This factor includes the management and supervisory aspects of maintenance organization functions. Examples of tasks involving this factor are: ● Supervising the operation/inspection/maintenance of an electronic equipment ● Assigning personnel to an electronic repair ● Developing a repair schedule
6. Electronic Circuit Analysis	This factor is purely mental in nature. It includes the application of electronic principles to the correction of a fault. Electronic principles include the selection and use of circuit formulae and the application of the results of calculations, and application of principles of electrical/electronic diagnostic techniques. This factor is different from the electro-cognition factor in that electro-cognition is almost directly effect-cause related, whereas electronic circuit analysis involves more sophisticated consideration of intervening processes. For example, if in the case of a faulty output, the technician can decide that either module A, B, or C is malfunctioning and that he can complete the repair by sequential replacement of modules until the correct output is obtained, then the factor involved is electro-cognition. On the other hand, if the technician must perform a test on each of A, B, and C and then apply electronic theory to determine the faulty module, then electronic circuit analysis is involved. Electronic circuit analysis might also be involved in certain aspects of failure reporting. Examples of electronic circuit analysis are: ● Determining why an oscillator yields an improper frequency response ● Determining why the time delay of a timing circuit is too long ● Determining why a power supply goes into an over-voltage shut-down mode
7. Equipment Operation	This factor involves the operation or exercise of prime equipment and electrical and electronics test equipment. Examples of this factor are: ● Employing repaired equipment ● Using an oscilloscope

Table 2.1. Definition of Factors (Continued)

8. Using Reference Materials	This factor includes the use of supporting documentation. The use of schematics and block diagrams is included under either electro-cognition or electronics circuit analysis.
9. Equipment Inspection	This factor includes inspections of electronic equipment, including those inspections and examinations required after performing a correction or repair to the equipment.

2.3 Performance Indices

To apply the prediction system to a particular maintenance organization, each maintenance technician must be rated in each of the tasks identified in the multidimensional scaling analysis. Individual ratings were obtained by observing and evaluating a sufficient number of performances in each job factor to provide a valid sample of the technician's capability. Estimates based on previous experience will also be used. These estimates were derived by interviewing technicians who were experienced in each job factor. In each job factor, the technician's unusually effective (UE) and unusually ineffective (UI) performances were identified. The technician's performance index (or probability of successful job performance) for each job factor was then computed by the formula:

$$\frac{\sum UE}{\sum UE + \sum UI} \quad (2-1)$$

The calculations for determining technician performance index ratings are given in example 2-1.

Example 2-1. Performance Index Calculations

Procedure	Example
1. Identify $\sum UE$ and $\sum UI$ for each job factor	1. In 25 performances on a particular job factor, technician a was rated unusually effective in six performances and unusually ineffective in one performance $\sum UE = 6$ $\sum UI = 1$
2. Compute the technician's performance index (probability of successful performance) for the job factor $\left(\frac{\sum UE}{\sum UE + \sum UI} \right)$	2. $\frac{6}{6+1} = .86$ Technician a's Performance index (probability of successful performance) = .86

In practice, the data provided in table 2-2 should be used. Performance indices need not be recomputed for each new electronic system problem.

Table 2-2. Average Technician Reliability Ratings

Job Activity	Career Field							
	EM	ET	FT	IC	RD	RM	ST	TM
Electro Cognition	.55	.83	.86	.62	.33	.63	.92	.36
Electro Repair	.78	.99	.92	.70	.30	.71	.70	.40
Instruction	.75	.95	.97	.45	.57	.95	.51	.66
Electro Safety	.60	.98	.95	.65	.92	.70	.42	.62
Personnel Relationships	.74	.70	.79	.63	.40	.77	.85	.80
Electro Circuit Analysis	.63	.90	.95	.58	.40	.65	.74	.60
Equipment Operation	.92	.85	.95	.65	.90	.85	.92	.75
Using Reference Material	.73	.90	.87	.62	.95	.92	.88	.66

EM - Electrician's mate
 ET - Electronics Technician
 FT - Fire Control Technician
 IC - Interior Communications Electrician

RD - Radarman
 RM - Radioman
 ST - Sonar Technician
 TM - Torpedoman's mate

2.4 Reliability Index Computation

Given a multidimensional scaling of the equipment or system to be maintained and a complete set of performance indices for each technician, the human reliability for a given malfunction can be computed.

A malfunction in the equipment or system will involve some (not necessarily all) of the job factors identified in the multidimensional scaling analysis. After the factors which are involved in the malfunction are determined, the maintenance technician's performance indices in those factors can be used to compute the probability that the malfunction will be successfully corrected.

The actual method of computing reliability depends upon several variables: The reliability prediction technique used will depend on the interdependencies among the job factors involved in the correction of the malfunction and with the number of technicians assigned to the problem. Another variable is the method of assignment when more than one technician is assigned to a problem—whether they work independently on different job tasks or together on the same task.

2.5

Compounding Methods

2.5.1

Introduction. Several different job activities and persons may be involved in the performance of a task. Successful task performance may require the successful performance of all job activities by all persons or the successful performance of only some combination of job activities. The probability of successful task performance is increased when several persons are assigned to the same task, and perform the job activity in parallel with each other. In addition, the probability of successful performance will be increased if a technician is permitted to repeat the performance or one aspect of the performance.

Siegel and Miehle (1967) presented methods for calculating overall probability of successful task accomplishment when the probability of accomplishing each of the elements of the task is known. The methods are demonstrated below. They were developed to exploit the job factors identified in the multidimensional scaling studies and personnel reliability data on each factor collected originally by Siegel and Pfeiffer and later by Siegel and Federman.

Basic concepts are expressed as follows:

Let:

s = satisfactory task performance

r_{mn} = satisfactory performance of job activity m by technician n

R_{mn} = reliability of technician n on activity m

$P_r[r_{mn}]$ = probability that statement r_{mn} is true

Thus, $P_r[r_{mn}] = R_{mn}$ and $P_r[s]$ = reliability of task performance.

Suppose performance of a task involves technician b on three job factors (3, 4, and 6) and technician g on three factors (3, 5, and 8). Both technicians perform factor 3. The condition for satisfactory task performance is:

$$s \equiv (r_{3b} \vee r_{3g}) \wedge r_{4b} \wedge r_{6b} \wedge r_{5g} \wedge r_{8g} \quad (2-2)$$

$\vee$ is a symbol for inclusive *or* (inclusive disjunction)

$\wedge$ is a symbol for *and* (conjunction)

$\equiv$ is a symbol for "is equivalent to"

We are not limited to an "and" and "or" logic. Statements could conceivably be connected by conditional or biconditional symbols. These in turn can be expressed in terms of "and," "or," and negation. The negation of r_{ij} is $\bar{r}_{ij}$.

Electronic equipment maintenance can be performed by means of series or parallel tasks and by a single or a group of maintenance technicians. Several examples illustrating a number of different cases are given below.

2.5.2

The Series Case. The condition that all activities must be performed satisfactorily is expressed by joining all statements by "conjunction" ($\wedge$), $s = r_{1a} \wedge r_{2a}$. This is called a series task.

$$P_r[s] = P_r[r_{1a} \wedge r_{2a}] = P_r[r_{1a} | r_{2a}] P_r[r_{2a}] \quad (2-3)$$

$P_r[r_{1a} | r_{2a}]$ is a conditional probability which is read "the probability of r_{1a} , given r_{2a} ." It is the probability that r_{1a} is true under the condition of r_{2a} being true. When the truth of r_{1a} is independent of the truth of r_{2a} , we say that r_{1a} and r_{2a} are independent statements. In this case, $P_r[s] = P_r[r_{1a}] P_r[r_{2a}]$.

Let:

$$s \equiv r_{2a} \wedge r_{3d} \wedge r_{6a} \quad (2-4)$$

$$\begin{aligned} P_r[s] &= P_r[r_{2a} \wedge r_{3d} \wedge r_{6a}] \\ &= P_r[r_{2a} | r_{3d} \wedge r_{6a}] P_r[r_{3d} | r_{6a}] P_r[r_{6a}] \end{aligned} \quad (2-5)$$

If all statements are independent, this reduces to:

$$P_r[s] = P_r[r_{2a}] P_r[r_{3d}] P_r[r_{6a}] \quad (2-6)$$

Example 2-2 demonstrates the computations involved in technician reliability prediction for a 2 series task.

Example 2-2. Series Task

Task Description

The sample task involves job factors 1 (Electro-cognition) and 2 (Electro-repair). The task is performed by technician a, and both job factors must be completed for successful completion of the task.

Mathematical Expression of the Problem

$$s \equiv r_{1a} \wedge r_{2a} \quad (2-7)$$

Applicable Formula

$$P_r[s] = P_r[r_{1a}] P_r[r_{2a}] \quad (2-8)$$

Procedures

Procedure

Example

1. Determine the factors required to correct the problem	1. The malfunction involves job factors Electro-cognition (1) and Electro-repair (2) (Job factors are identified in table 2-1.)
2. Determine the technician's performance index ratings in the applicable job factors	2. Technician a is assigned to the problem. Applicable performance index ratings are:

$$EC(1) = .86$$

$$ER(2) = .90$$

3. Substitute the technician's performance index ratings into the formula and compute the probability that the technician can correct the malfunction

$$\begin{aligned} 3. \quad P_r[s] &= P_r[r_{1a}] P_r[r_{2a}] \\ &= [.86] [.90] \\ &= .774 \end{aligned}$$

Before concluding this discussion of the sample series case, it is important to note that all practical calculations assume that technician actions on each job factor are independent of the other job actions. This assumption is made because no data is available for the conditional case.

2.5.3 The Parallel Case. If the satisfactory performance of one or the other factor (or both) is required for the satisfactory performance of the task, then the task is called a parallel task. The satisfactory performance of parallel tasks is expressed as:

$$s \approx r_{3e} \vee r_{7e} \quad (2-9)$$

In this case, job factors 3 and 7 are involved and the task is performed by technician e.

When the same job factor is performed by two technicians and acceptable performance of either technician will constitute acceptable performance for the team, the condition is expressed as:

$$s \approx r_{3a} \vee r_{3c} \quad (2-10)$$

This condition is also referred to as a parallel performance. In the following formula, job factor 3 is performed by technicians a and c.

$$P_r[s] = P_r[r_{3a} \vee r_{3c}] = 1 - (1 - P_r[r_{3a}])(1 - P_r[r_{3c}]) \quad (2-11)$$

in the independent case.

A similar case involving three technicians is expressed as:

Let:

$$s \approx r_{1b} \vee r_{1c} \vee r_{1g} \quad (2-12)$$

then:

$$\begin{aligned} P_r[s] &= P_r[r_{1b} \vee r_{1c} \vee r_{1g}] \\ &= 1 - (1 - P_r[r_{1b}])(1 - P_r[r_{1c}])(1 - P_r[r_{1g}]) \end{aligned} \quad (2-13)$$

in the independent case.

Examples 2-3 and 2-4 demonstrate the computations involved in reliability prediction for parallel tasks. In example 2-3, two job factors are performed by a single technician. In example 2-4, two technicians work together on one job factor.

Example 2-3 Parallel Task for Single Technician

Task Description

The sample task involves job factors 1 (Electro-cognition) and 2 (Electro-repair). The task is performed by technician a, and satisfactory completion of either job factor will constitute successful completion of the task.

Mathematical Expression of the Problem

$$s \equiv r_{1a} \vee r_{2a} \quad (2-14)$$

Applicable formula

$$P_r[s] = 1 - (1 - P_r[r_{1a}])(1 - P_r[r_{2a}]) \quad (2-15)$$

Procedures

Procedure

Example

1. Determine the factors required to correct the problem 2. Determine the technician's performance index ratings in the applicable job factors 3. Substitute the technician's performance index ratings into the formula and compute the probability that the technician can correct the malfunction	1. The malfunction involves job factors Electro-cognition (1) and Electro-repair (2) (Job factors are identified in table 2-1.) 2. Technician a is assigned to the problem. Applicable performance index ratings are: $EC(1) = .82$ $ER(2) = .79$ 3. $P_r[s] = 1 - (1 - P_r[r_{1a}])(1 - P_r[r_{2a}])$ $P_r[s] = 1 - (1 - .82)(1 - .79)$ $= 1 - (.18)(.21)$ $= 1 - .038$ $= .962$

Example 2-4. Parallel Task for Two Technicians

Task Description

The sample task involves job factor 3 (Inspection). The task is performed by technicians a and b, and satisfactory performance by either technician will result in successful completion of the task.

Mathematical Expression of the Problem

$$s \equiv r_{3a} \vee r_{3b} \quad (2-16)$$

Applicable Formula

$$P_r[s] = 1 - (1 - P_r[r_{3a}]) \times (1 - P_r[r_{3b}]) \quad (2-17)$$

Procedures

Procedure

Example

1. Determine the factors required to correct the problem	1. The malfunction involves job factor 3 (Inspection) (Job factors are identified in table 2-1.)
2. Determine the technician's performance index ratings in the applicable job factors	2. Technicians a and b are assigned to the problem. Applicable performance index ratings are: a = .82, b = .88
3. Substitute the technicians' performance index ratings into the formula and compute the probability that the technicians can correct the malfunction	3. $P_r[s] = 1 - (1 - .82)(1 - .88)$ $= 1 - (.18)(.12)$ $= 1 - .022$ $= .978$

2.5.4 Complex Tasks. The series and parallel formulas can be extended to larger numbers of activities and performers. These formulas may be written in many forms. Some malfunctions may result in a combination of the series and parallel formulas. Examples 2-5 and 2-6 demonstrate the computations involved in complex tasks. In example 2-5 a complex task with series and parallel elements is performed by one technician. In example 2-6 two technicians work on a complex task. The technicians work together on some of the tasks and independently on others.

Example 2-5. Complex Task Performed by One Technician

Task Description

The sample task involves the following job factors:

- 1 (Electro-cognition)
- 2 (Electro-repair)
- 3 (Inspection)
- 4 (Electro-safety)
- 5 (Personnel relationships)

The task is performed by technician a and will be considered satisfactorily completed if, and only if, either (or both) factors 1 and 2 are performed satisfactorily, either (or both) factors 3 and 4 are performed satisfactorily, and factor 5 is performed satisfactorily.

Mathematical Expression of the Problem

$$s = (r_{1a} \vee r_{2a}) \wedge (r_{3a} \vee r_{4a}) \wedge r_{5a} \quad (2-18)$$

Applicable Formula

$$P_r[s] = \{ 1 - (1 - P_r[r_{1a}]) (1 - P_r[r_{2a}]) \} \{ 1 - (1 - P_r[r_{3a}]) (1 - P_r[r_{4a}]) \} P_r[r_{5a}] \quad (2-19)$$

Procedures

Procedure

1. Determine the factors required to correct the problem
2. Determine the technician's performance index ratings in the applicable job factors
3. Substitute the technician's performance index ratings into the formula and compute the probability that the technician can correct the malfunction

Example

1. The malfunction involves job factors EC, ER, 1, ES, and PR. (Job factors are identified in table 2-1.)

2. Technician a is assigned to the problem. Applicable performance index ratings are:

EC (1) = .86	ES (4) = .92
ER (2) = .90	PR (5) = .79
1 (3) = .82	

3. $P_r[s] = \{ 1 - (1 - .86) (1 - .90) \} \{ 1 - (1 - .82) (1 - .92) \} .79$
 $= \{ 1 - (.14)(.10) \} \{ 1 - (.18)(.08) \} .79$
 $= \{ 1 - .014 \} \{ 1 - .0144 \} .79$
 $= .768$

Example 2-8. Complex Task Performed by More Than One Technician

Task Description

The sample task involves the following job factors:

- 1 (Electro-cognition)
- 2 (Electro-repair)
- 3 (Inspection)
- 4 (Electro-safety)
- 5 (Personnel relationships)
- 6 (Electronic circuit analysis)
- 7 (Equipment operation)
- 8 (Using reference materials)

The task is performed by technicians a and b. Technician a performs job factors 1 through 4, technician b performs job factor 5, and both technicians work together on job factors 6, 7, and 8. All job factors must be performed satisfactorily for successful completion of the task, and satisfactory performance by either technician on a particular job factor constitutes satisfactory completion of that job factor.

Mathematical Expression of the Problem

$$s = r_{1a} \wedge r_{2a} \wedge r_{3a} \wedge r_{4a} \wedge r_{5b} \wedge (r_{6a} \vee r_{6b}) \wedge (r_{7a} \vee r_{7b}) \wedge (r_{8a} \vee r_{8b}) \quad (2-20)$$

Applicable Formula

$$P_r[s] = P_r[r_{1a}] P_r[r_{2a}] P_r[r_{3a}] P_r[r_{4a}] P_r[r_{5b}] \quad (2-21)$$

$$\left\{ 1 - (1 - P_r[r_{6a}]) (1 - P_r[r_{6b}]) \right\}$$

$$\left\{ 1 - (1 - P_r[r_{7a}]) (1 - P_r[r_{7b}]) \right\}$$

$$\left\{ 1 - (1 - P_r[r_{8a}]) (1 - P_r[r_{8b}]) \right\}$$

Procedures

Procedure

1. Determine the factors required to correct the problem
2. Determine the performance index ratings for the technicians assigned to the job

Example

1. The malfunction involves job factors EC, ER, I, ES, PR, ECA, EO, and URM (Job factors are identified in table 2-1.)

Factor	Technician Rating	
	a	b
EC (1)	.86	.92
ER (2)	.90	.89
I (3)	.82	.88
ES (4)	.92	.90
PR (5)	.79	.85
ECA (6)	.88	.86
EO (7)	.91	.93
URM (8)	.95	.94

3. Substitute the technicians' performance index ratings into the formula and compute the probability that the technicians can correct the malfunction

$$3. \quad P_r[s] = (.86)(.90)(.82)(.92)(.85)$$

$$\left\{ 1 - (1 - .88)(1 - .86) \right\}$$

$$\left\{ 1 - (1 - .91)(1 - .93) \right\}$$

$$\left\{ 1 - (1 - .95)(1 - .94) \right\}$$

$$= (.86)(.90)(.82)(.92)(.85)$$

$$\left\{ 1 - (.12)(.14) \right\} \quad \left\{ 1 - (.09)(.07) \right\}$$

$$\left\{ 1 - (.05)(.06) \right\}$$

$$\begin{aligned}
 &= (.86)(.90)(.82)(.92)(.85) \\
 &\quad (1 - .0168)(1 - .0063)(1 - .003) \\
 &= (.86)(.90)(.82)(.92)(.85) \\
 &\quad (.983)(.994)(.997) \\
 &= .484
 \end{aligned}$$

2.6

Summary

The probability compounding technique is summarized as follows:

- **Multidimensional Scaling**—Perform a multidimensional scaling analysis of the equipment or system to be maintained. Determine all of the job factors involved in all phases of corrective maintenance.
- **Personnel Evaluation**—Evaluate each maintenance technician in all of the identified job factors and develop a set of performance index ratings based on the formula:

$$\frac{\sum UE}{\sum UE + \sum UI} \quad (2-1)$$

NOTE: Performance index ratings must be recomputed periodically to to compensate for learning that takes place during repeated performances of the job factors.

- **Problem Analysis**—Analyze the malfunction to determine the job factors involved.
- **Personnel Assignment**—Select the maintenance technician or technicians to perform the task, and decide how they will be assigned to the task (number of technicians on each job factor, etc.).
- **Development of Probability Compounding Formula**—Identify the relationships between the factors involved in the task, mathematically state the requirements for satisfactory completion of the task(s), and develop the formula for computing the probability of successful task completion ($P_r[s]$).

3.0

DIGITAL SIMULATION MODEL (ONE AND TWO MAN MODEL)

3.1

Introduction

The Siegel-Wolf one and two man simulation model, developed at Applied Psychological Services, permits the simulation of maintenance or operator tasks for the purpose of predicting task completion time and the probability of successful completion. The model is capable of simulating distributions for one, either one of two, and two maintenance technicians or operators working together. In addition to this data, the model also provides answers to other questions such as:

- Can an average operator be expected to successfully complete all actions required in the performance of a task within a time limit for a given operator procedure and a given machine design?
- How does success probability change for slower or faster operators and longer or shorter periods of allotted time?
- How great a stress is placed on the operator during his performance and in which portions of the task is he overloaded or underloaded?
- What is the frequency distribution of operator failures as a function of various stress tolerances and operator speeds?
- What operator proficiency is required for the system?
- How much time does one operator spend waiting for the other operator?
- What is the optimum team composition?
- How frequently is each subtask failed?
- How cohesive is the team?
- What is the expected time for task completion, considering an "average" operator? A "fast" operator? A "slow" operator? Various operator combinations?
- How can the equipment design be modified to yield improved performance?

The model may be used to predict either operator or maintenance technician performance by simply identifying the personnel as operators or technicians and the tasks as operator tasks or maintenance tasks.

3.1.1 Simulation Program. The simulation model is programmed in FORTRAN. The program is 2972 steps long, requires 100 bytes of core, and typical problems (typically, consisting of approximately 75 subtasks and 100 iterations) are executed in 18 seconds of central processor time.

3.1.2 Model Operation. Figure 3-1 summarizes the procedures for using the model and shows the outputs that are available. The model simulates the acts and behaviors of a maintenance technician (or operator) during the performance of a malfunction correction (or operator task performance). As the computer simulates the performance of the tasks required for correction of the malfunction, results are recorded indicating the areas of technician overload, failure to complete subtasks, idle time, peak stress,

etc. For the purpose of predicting technician reliability, the prime concern is estimating the time it takes to complete the malfunction correction. The model records the time to complete each act, or subtask in the sequence of malfunction correction subtasks; the cumulative time for the completion of all required subtasks; and the total time involved in the malfunction correction. The model is designed to predict operator task performance or malfunction correction time on tasks requiring one and two operators or technicians, as described in the following paragraphs.

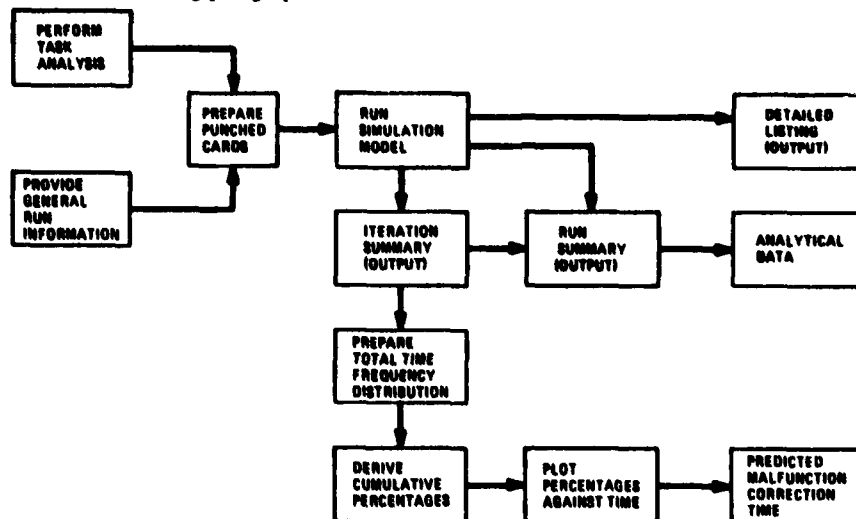


Figure 3-1. Flow Chart of Digital Simulation Model Operation

Note: All Output options may be exercised in the same simulation. They are not mutually exclusive.

3.2 Simulation Procedure (Maintenance Technicians)

The one and two man model is used to simulate malfunction correction tasks that do not require more than two maintenance technicians. The simulated tasks may be performed by one technician at a time, or by two technicians working together. The procedure for using this model to predict maintenance technician reliability is summarized as follows:

- Perform a task analysis to identify the subtasks involved in the correction of the malfunction, and prepare a sequentially numbered list of subtasks; identify the subtasks performed by each technician separately or jointly
- Prepare an input data sheet providing information about each subtask as required for the model
- Prepare a punched card for each subtask and a separate card punched to indicate the number of subtask cards prepared
- Prepare a general run information card and parameter input data cards as required
- Assemble the card deck and run the model

- Graphically summarize the data by malfunction and across malfunctions (the malfunction summaries show the estimated time to correct a particular type of malfunction; the across malfunction data summary shows the estimated time to repair for the system)

3.2.1 Task Analysis. A sequential list of the subtasks involved in the correction of a particular malfunction is required for the computer simulation. The list may be prepared from an available task analysis or by consultation with individuals familiar with the steps required to correct the malfunction. When a complete list of subtasks is not available, an in-depth task analysis must be performed to determine all of the steps required to correct the malfunction. The subtasks are then listed sequentially and all inter-relationships noted. A sample of a subtask list is presented in table 3-1.

Table 3-1. Sample List of Subtasks

Task: Repair Filter on AN/URC-35

Subtask Number	Description	Subtask Number	Description
1.	Open drawer (AM-3007)	29.	Remove old capacitor
2.	Defeat interlock switch	30.	Remove old choke
3.	Key handset to check power	31.	Install new capacitor
4.	Check power meter	32.	Install new choke
5.	Adjust APC on module and check meter	33.	Solder wires on new capacitor
6.	Turn off power at set	34.	Solder wires on new choke
7.	Test pin 2 with ohmmeter	35.	Check choke with ohmmeter
8.	Read ohmmeter	36.	Read ohmmeter
9.	Manual lookup	37.	Check capacitor with ohmmeter
10.	Test pin with ohmmeter	38.	Read ohmmeter
11.	Read ohmmeter	39.	Repair successful?
12.	Remove cable 1A2J21 on 618	40.	Repair unsuccessful?
13.	Manual lookup	41.	Walk to bulkhead and back
14.	Test pin with ohmmeter	42.	Turn on power at bulkhead
15.	Read ohmmeter	43.	Turn on power at set
16.	Remove filter box	44.	Turn Tune-Operate SW to tune
17.	Test for open coil with ohmmeter	45.	Read meter
18.	Read ohmmeter	46.	Remove screws from AM-3007
19.	Fill out requisition form for parts C39 and L10	47.	Pull AM-3007 out to lock position
20.	Walk to bulkhead and back	48.	Adjust APC Adjust on module
21.	Turn off power at bulkhead	49.	Replace plugs and screws on filter box cover
22.	Pull out chassis from 618 cabinet	50.	Lock chassis
23.	Tilt cabinet upward	51.	Push in chassis
24.	Unlock chassis	52.	Untilt chassis
25.	Remove chassis	53.	Replace chassis
26.	Remove plugs and screws from filter box cover	54.	Replace filter box
27.	Unsolder wires from capacitor	55.	Replace cable 1A2J21
28.	Unsolder wires from choke	56.	Close drawer (AM-3007)
		57.	Replace screws in AM-3007
		61.	Decision
		62.	Fill out failure report

3.2.2 Input Data Sheet Preparation. After completion of the task analysis and preparation of the list of subtasks, enter the subtasks on the input data sheet, and fill in the required input data in the appropriate columns. A sample input data sheet is shown in figure 3-2. Table 3-2 provides a step-by-step explanation of the data required in each column of the input data sheet.

Table 3-2. Input Data Sheet Preparation

Variable	Required Input Data
Task Type Essential	Enter D for a decision subtask. The model will simulate a choice or decision made by the technician. The probabilities of the next task (i.e., success or failure) are not affected by operator factors (i.e., stress) for decision tasks.
Nonessential	Enter N for all subtasks that are not essential to the successful completion of the malfunction correction. This information allows the computer to ignore non-essential subtasks during very urgent conditions.
Precedence Task	Any subtask which must be completed by a second technician before this subtask is attempted by this technician.
Precedence Time	Time before which this subtask cannot be started.
Next Success	Identifies the number of the subtask that the technician is to perform next if he succeeds on the current subtask. If the current subtask is successfully completed, the technician will proceed to the next specified subtask. All subtasks thus can cause program branching.
Next Fail	Identifies the number of the task that the technician is to perform next if he fails the current subtask. In the example, subtask 1 follows subtask 39 if the technician was unsuccessful in repairing the malfunction. Thus, all the trouble-shooting subtasks (1 through 18) will be repeated. In the decision subtask 40, the technician decides if he was partially unsuccessful with the repair. If so, he will loop to subtask 19 and redo all the repair acts (subtasks 19 through 40).
Average Time	The average time, in seconds, required by the technician performing this subtask. There are several sources for such information.* If the average time required is not provided in the literature, then referrals to knowledgeable people and/or timing technicians as they perform the behaviors over several occasions (and averaging the values) will provide the required data. There are no time entries for decision subtasks.
Time Deviation	The average standard deviation taken around the T_{ij} for the average operator. These data are also taken from standard sources.
Success Probability	The probability that the task will be performed successfully and, therefore, that the "Next Success" task will be performed next.

Table 3-2. Input Data Sheet Preparation (Continued)

Variable	Required Input Data
Time Remaining - Essential	The time required to perform all remaining essential subtasks (including the current one) at average execution times, assuming no failures. Calculate T_{ij}^E by starting with the last subtask. Enter its t_{ij} in the T_{ij}^E column. Continue up the subtask list until the first one is reached by adding the t_{ij} for each subtask to the T_{ij}^E for the preceding subtask. Notice that in figure 3-2 the T_{ij} recorded alongside a decision subtask is the same as the T_{ij}^E for the immediately following subtask.
Time Remaining - Nonessential	The time required to perform all remaining nonessential subtasks (including the current one) at average execution times, assuming no failures. Calculate these values by entering the t_{ij} alongside the last nonessential subtask, continue entering this value until the next preceding nonessential subtask is reached, add its t_{ij} to the value that is being repeated, and continue until the first subtask is reached.

- * Munger, S.J., Smith, R.W., & Payne, D. "An index of electronic equipment operability: Data store." Pittsburgh: American Institute for Research, 1962.

3.2.3 Calculation of Essential and Nonessential Time Remaining. In order to complete the required entries for the subtask data card, card type 3, T_{ij}^E and T_{ij}^N (the time remaining for completion of essential and nonessential subtask elements) must be calculated by hand. The symbol T_{ij}^E denotes the length of time in seconds the technician "j" expects to use to complete the remaining essential subtask elements "i" in a mission. T_{ij}^N denotes the length of time in seconds the technician expects to use for completion of the remaining nonessential subtask elements in the mission. This time includes the current subtask element in each case. The two values are calculated independently. The procedure for calculating T_{ij}^E and T_{ij}^N are presented in the following paragraphs.

3.2.3.1 Time Line Drawing. Except for very simple tasks, a time line drawing should be prepared to facilitate the calculation of the T_{ij}^E and T_{ij}^N values. A hypothetical sample mission is presented in table 3-3, and its corresponding time line drawing is shown in figure 3-3. Table 3-3 includes only those data elements required to determine T_{ij}^E and T_{ij}^N values. The following notes and conventions apply to the time line drawing shown in figure 3-3.

- Times used are average subtask execution times (t_{ij}).
- No random effects are considered.
- The top line in the drawing applies to technician 1, the lower line to technician 2.

TASK NUMBER 2
NUMBER OF RUNS 2

NUMBER OF ITERATIONS 100

TASK DATA FOR OPERATOR

TASK NO	TASK TYPE	NON ESS	PRECEDENCE TASK	TIME	NEXT-TASK SUC	FAIL	AVERAGE TIME	TIME DEV	PROB. SUC	TIME ESS	REMAINING NON-ESS	SPEC. CODE	JUMP OP1	TASK OP2	JAG.
1			-0	-0.00	2	1	198.460	34.820	.860	2109.480	300.000	-0	-0	-0	-0
2			-0	-0.00	3	2	3.860	1.120	.980	1911.020	300.000	-0	-0	-0	-0
3			-0	-0.00	4	3	23.650	1.900	.580	1907.160	300.000	-0	-0	-0	-0
4			-0	-0.00	5	4	1.560	.520	.990	1883.510	300.000	-0	-0	-0	-0
5			-0	-0.00	6	5	17.800	3.330	.890	1881.950	300.000	-0	-0	-0	-0
6			-0	-0.00	7	6	2.330	.650	.990	1864.150	300.000	-0	-0	-0	-0
7			-0	-0.00	8	7	8.120	2.220	.990	1861.820	300.000	-0	-0	-0	-0
8			-0	-0.00	9	8	1.200	.400	.990	1853.700	300.000	-0	-0	-0	-0
9			-0	-0.00	10	9	180.000	60.000	.500	1852.500	300.000	-0	-0	-0	-0
10			-0	-0.00	11	10	8.120	2.220	.990	1872.500	300.000	-0	-0	-0	-0
11			-0	-0.00	12	11	1.200	.400	.990	1864.380	300.000	-0	-0	-0	-0
12			-0	-0.00	13	12	12.960	4.320	.990	1663.180	300.000	-0	-0	-0	-0
13			-0	-0.00	14	13	180.000	.600	.500	1650.220	300.000	-0	-0	-0	-0
14			-0	-0.00	15	14	8.120	2.220	.990	1470.220	300.000	-0	-0	-0	-0
15			-0	-0.00	16	15	1.200	.400	.990	1462.100	300.000	-0	-0	-0	-0
16			-0	-0.00	17	16	55.120	20.080	.990	1460.900	300.000	-0	-0	-0	-0
17			-0	-0.00	18	17	8.120	2.220	.990	1405.780	300.000	-0	-0	-0	-0
18			-0	-0.00	18	18	1.200	.400	.990	1397.660	300.000	-0	-0	-0	-0
19			-0	-0.00	20	19	150.000	50.000	.990	1396.460	300.000	-0	-0	-0	-0
20			-0	-0.00	21	20	28.000	5.820	.980	1396.460	150.000	-0	-0	-0	-0
21			-0	-0.00	22	21	2.330	.650	.990	1368.460	150.000	-0	-0	-0	-0
22			-0	-0.00	23	22	5.000	1.000	.980	1366.130	150.000	-0	-0	-0	-0
23			-0	-0.00	24	23	1.100	.330	.990	1361.130	150.000	-0	-0	-0	-0
24			-0	-0.00	25	24	193.460	34.820	.880	1360.030	150.000	-0	-0	-0	-0
25			-0	-0.00	26	25	34.790	1.810	.790	1166.570	150.000	-0	-0	-0	-0
26			-0	-0.00	27	26	165.360	34.780	.980	1131.780	150.000	-0	-0	-0	-0
27			-0	-0.00	28	27	16.930	1.520	.890	966.420	150.000	-0	-0	-0	-0
28			-0	-0.00	29	28	16.930	1.520	.890	949.490	150.000	-0	-0	-0	-0
29			-0	-0.00	30	29	4.660	.920	.980	932.560	150.000	-0	-0	-0	-0
30			-0	-0.00	31	30	4.660	.920	.980	927.900	150.000	-0	-0	-0	-0
31			-0	-0.00	32	31	8.510	1.120	.970	923.240	150.000	-0	-0	-0	-0
32			-0	-0.00	33	32	8.510	1.120	.970	914.730	150.000	-0	-0	-0	-0
33			-0	-0.00	34	33	16.930	1.520	.890	906.220	150.000	-0	-0	-0	-0
34			-0	-0.00	35	34	16.930	1.520	.890	889.290	150.000	-0	-0	-0	-0
35			-0	-0.00	36	35	8.120	2.220	.990	872.360	150.000	-0	-0	-0	-0
36			-0	-0.00	37	36	1.200	.400	.990	864.240	150.000	-0	-0	-0	-0
37			-0	-0.00	38	37	8.120	2.220	.990	862.040	150.000	-0	-0	-0	-0
38			-0	-0.00	39	38	1.200	.400	.990	854.920	150.000	-0	-0	-0	-0
39			-0	-0.00	40	1	-0.000	-0.000	.950	853.720	150.000	-0	-0	-0	-0
40			-0	-0.00	41	19	-0.000	-0.000	.950	853.720	150.000	-0	-0	-0	-0
41			-0	-0.00	42	41	28.000	5.820	.980	853.720	150.000	-0	-0	-0	-0
42			-0	-0.00	43	42	2.330	.650	.990	825.720	150.000	-0	-0	-0	-0
43			-0	-0.00	44	43	2.330	.650	.990	823.390	150.000	-0	-0	-0	-0
44			-0	-0.00	45	44	2.710	1.060	.970	821.060	150.000	-0	-0	-0	-0
45			-0	-0.00	46	45	1.200	.400	.990	818.350	150.000	-0	-0	-0	-0
46			-0	-0.00	47	46	165.360	34.780	.890	817.150	150.000	-0	-0	-0	-0
47			-0	-0.00	48	47	5.000	1.000	.980	651.790	150.000	-0	-0	-0	-0
48			-0	-0.00	49	48	17.800	3.330	.890	646.790	150.000	-0	-0	-0	-0
49			-0	-0.00	50	49	165.360	34.780	.980	628.990	150.000	-0	-0	-0	-0
50			-0	-0.00	51	50	193.460	34.820	.880	463.630	150.000	-0	-0	-0	-0
51			-0	-0.00	52	51	5.000	1.000	.980	270.170	150.000	-0	-0	-0	-0
52			-0	-0.00	53	52	1.100	.330	.990	265.170	150.000	-0	-0	-0	-0
53			-0	-0.00	54	53	25.630	1.570	.810	264.079	150.000	-0	-0	-0	-0
54			-0	-0.00	55	54	55.120	20.080	.990	238.440	150.000	-0	-0	-0	-0
55			-0	-0.00	56	55	12.860	4.320	.990	183.320	150.000	-0	-0	-0	-0
56			-0	-0.00	57	56	5.000	1.000	.980	170.860	150.000	-0	-0	-0	-0
57			-0	-0.00	58	57	-0.000	4.751	.980	165.180	150.000	-0	-0	-0	-0
58			-0	-0.00	59	58	-0.000	-0.000	.800	1.000	150.000	-0	-0	-0	-0
59			-0	-0.00	60	59	-0.000	-0.000	.800	0.000	150.000	-0	-0	-0	-0
60			-0	-0.00	61	60	-0.000	-0.000	.880	0.000	150.000	-0	-0	-0	-0
61			-0	-0.00	62	61	-0.000	-0.000	.950	0.000	150.000	-0	-0	-0	-0
62			-0	-0.00	-0	62	150.000	50.000	.990	0.000	150.000	-0	-0	-0	-0

Figure 3-2. Sample Input Data Sheet

- This drawing is not to scale in time, but zero time starts at the left and when the two technicians are at the same point in time. A vertical line shows this synchronization and an encircled number shows the time, in seconds, at that point. It may be desirable to prepare the time line drawing to scale if the drawing is to be used for presentation or other study purposes, but is not required for calculation of T_{ij}^E and T_{ij}^N values.
- A double horizontal line for a technician indicates that the technician is waiting for another technician due to a specified d_{ij} value.
- The shaded semicircle, between tasks 2 and 3 for technician 2, indicates that technician 1 cannot begin his task 4 until technician 2 completes task 2. There is no waiting required because technician 2 will normally finish task 2 before technician 1 starts task 4.
- The average duration of all waits must now be calculated. They are shown above the double horizontal lines in parentheses. The first (left most) value is the sum of technician 1's tasks 1 and 2 (8.6). The next wait is the length of task 1 for technician 2 (5.0), the third was determined to be the difference between completion of task 5 by technician 1 and completion of task 3 by technician 2 = $25.7 - (13.6 + 2.0 + 4.2) = 5.9$.

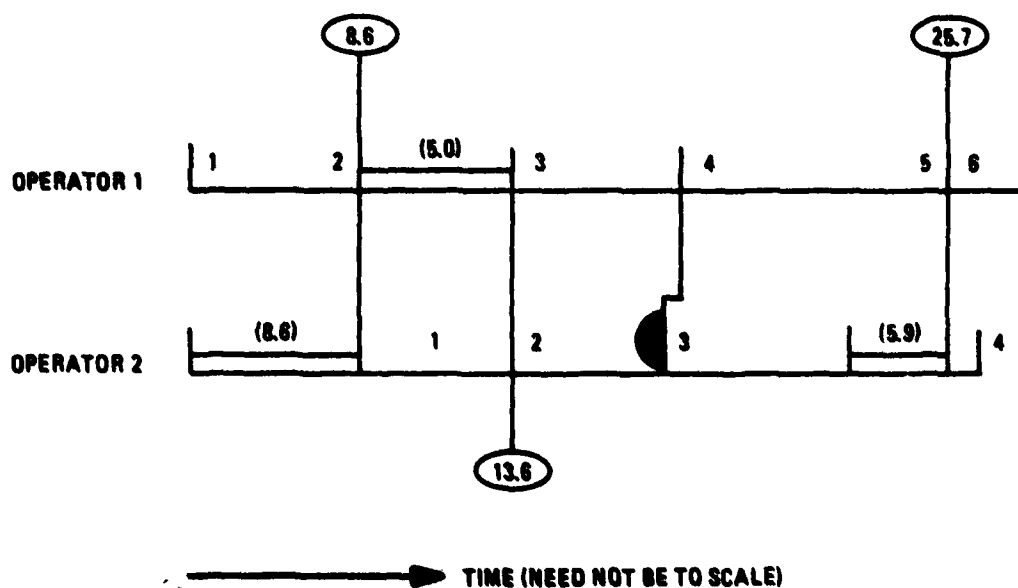


Figure 3-3. Sample Time Line Drawing

Table 3-3. Sample Hypothetical Task

Operator (j)	i	d_{ij}	$\bar{t}_{ij}$	Essential	T_{ij}^N	T_{ij}^E
1	1	0	6.5	Yes	2.1	31.8
	2	0	2.1	Yes	2.1	25.3
	3	1	3.8	Yes	2.1	18.2
	4	2	6.2	Yes	2.1	14.4
	5	2	2.1	No	2.1	8.2
	6	2	8.2	Yes	0	8.2
2	1	2	5.0	Yes	4.2	18.9
	2	2	2.0	Yes	4.2	13.9
	3	2	4.2	No	4.2	11.9
	4	5	6.0	Yes	0	6.0

3.2.3.2 *Calculation Method.* The general rule for calculating T_{ij}^E and T_{ij}^N is as follows:

Start at the end of the mission and add $\bar{t}_{ij}$ values successively, taking waiting times and essentiality into account. With no waiting time, the calculation for essential tasks is:

$$T_{i+1,j}^E = T_{ij}^E + \bar{t}_{ij} \quad (3-1)$$

For nonessential tasks with no waiting time, the calculation is:

$$T_{i+1,j}^N = T_{ij}^N + \bar{t}_{ij} \quad (3-2)$$

Table 3-4 presents a running account of T_{ij}^E and T_{ij}^N calculations for the sample task presented in table 3-3 and figure 3-3.

Checks:	Sum of execution times for operator 1	28.9
	Wait for operator 1	5.0
	Total	33.9
	$T_{ij}^E + T_{ij}^N$ for operator 1	33.9
	Average completion time for operator 1	33.9
	Sum of execution times for operator 2	17.2
	Wait for operator 2	14.5
	Total	31.7
	$T_{ij}^E + T_{ij}^N + \text{initial wait for operator 2}$	31.7
	Average completion time for operator 2	31.7

In the event of a decision (branch), the T_{ij}^E values should be calculated for all tasks following the branch first; then these times are multiplied by the probabilities for the respective branches and the products are added. This yields a single value to which the next earlier $\bar{t}_{ij}$ can be added to determine the T_{ij}^E for the task preceding the branch. T_{ij}^N is treated similarly.

Values of T_{ij}^E and T_{ij}^N are used in the method only for calculating stress. Since these values are cumulative, a calculational error results in T_{ij}^E values which are incorrect thereafter. Accordingly, double checks during the process are justified. For long tasks, in which T_{ij}^E values for early tasks are large, an error would result in only a small error in stress. For example, if the time allotted were 50 minutes (3000.0 seconds) and the value of T_{ij}^E for the first task was 2400.0, the stress would be 1.25 at the beginning of the mission (3000/2400). If, by error, T_{ij}^E was calculated to be 2410, the stress would be 1.245, an error of 0.005, resulting in little effect on execution times.

Table 3-4. T_{ij}^E and T_{ij}^N Calculations for Sample Task

Technician	Task	T_{ij}^E	T_{ij}^N	Comments
1	6	8.2	0	Last essential subtask for technician 1 - T_{ij}^E is the same as T_{ij}^E
2	4	6.0	0	Last essential subtask for technician 2 - T_{ij}^E is the same as T_{ij}^E
1	5	8.2	2.1	Nonessential subtask T_{ij}^E unchanged from subtask 6
1	4	14.4	2.1	Essential subtask - $T_{ij}^E = 8.2 + 6.2 - T_{ij}^N$ unchanged
1	3	18.2	2.1	Essential subtask - $T_{ij}^E = 14.4 + 3.8 - T_{ij}^N$ unchanged
2	3	11.9	4.2	Nonessential subtask during an essential waiting period of 5.9 seconds - $T_{ij}^E = 6.0 + 5.9$
2	2	13.9	4.2	Essential subtask - $T_{ij}^E = 11.9 + 2.0 - T_{ij}^N$ unchanged
2	1	18.9	4.2	Essential subtask - $T_{ij}^E = 13.9 + 5.0 - T_{ij}^N$ unchanged
1	2	25.3	2.1	Essential subtask including a waiting period - $T_{ij}^E = 18.2 + 2.1 + 5.0 - T_{ij}^N$ unchanged
1	1	31.8	2.1	Essential subtask - $T_{ij}^E = 25.3 + 6.5 - T_{ij}^N$ unchanged

3.2.4 Punched Card Preparation. Six types of punched cards are used in the computer simulation. These cards are designated Types 0 through 5, as shown in figure 3-4. Instructions for the preparation of cards 1 through 4 are presented in the following paragraphs.

3.2.4.1 Information Cards. The task and parameter inputs are preceded by information inputs that supply data on the general conditions of the run. The information cards are as follows:

- Card Type 1 - General information card provides run instruction codes
- Card Type 2 - Number of Subtasks Card

Card punch instructions for the information cards are presented in table 3-5.

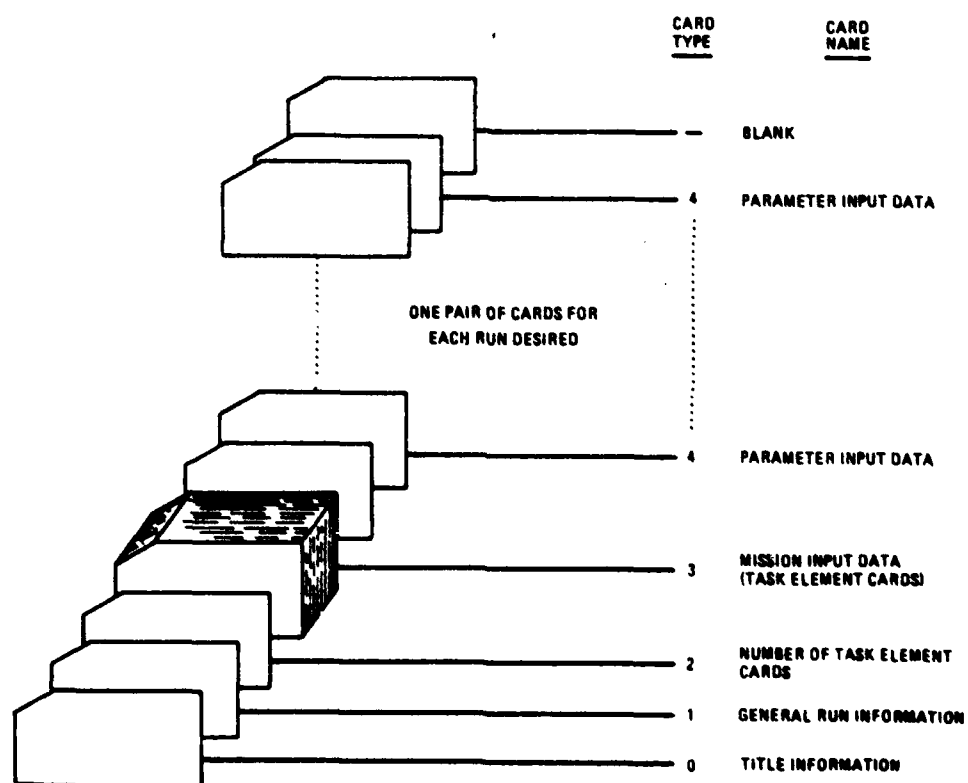


Figure 3-4. Card Deck Layout

Table 3-5. Preparation of Information Cards, Types 1 and 2 (Format 15)

Card Type and Symbolic FORTRAN Name	Card Columns	Contents	Remarks
Card Type 1:			General information card
NUMTRL	1- 5	Run number	Run identifier
NUMRUN	6-10	Number of runs	
NUMIT	11-15	Number of iterations	Per run (Symbol "N")
IND 1	16-20	Random number count	Number of times random number generator subroutine is called before run starts
IND 2	21-25	Type of output for first ICHG iterations (ICHG defined below)	0 = run summary etc.
IND 3	26-30	—	Subtracted from IND 2 after ICHG iterations
IND 4	31-35	Unit of time	value = 1
IND 5	36-40	—	0 = hours
			1 = seconds
			2 = minutes
ICHG	4-45	—	Number of iterations before changing type of output
Card Type 2:			
NINPC	1-5	Total number of mission input data (subtask) cards included in the run and the sum of the last task numbers for both operators	

3.2.4.2 *Subtask Input Data Card.* Using the input data sheet, prepare a subtask input data card (card Type 3) for each subtask listed. A limit of 300 subtasks for each technician has been established for the simulation model; do not exceed this limit. The content and format of the subtask input card is outlined in table 3-6. Table 3-7 provides an explanation of the data items included on the subtask input data card.

3.2.4.3 *Parameter Input Data Cards.* Prepare one parameter input data card (card Type 4) for each technician.

Four parameters are provided to the model on input cards in the format shown in table 3-6. A pair of cards, one card for each technician, is supplied for each computer run desired. A run is composed of the simulation of N task performances (iterations). The contents in table 3-5 are as follows:

- *Stress threshold* - The stress threshold is considered the technician's "breaking point." The model's simulation is based on the psychological concept that time stress organizes behavior up to a threshold point and disorganizes it beyond that point. Stress is calculated as the ratio of the average time to complete the remaining essential subtasks to the total time remaining to the technician. A value

Table 3-6. Content and Format for Subtask Input Data Cards
(Card Type 3)

Symbolic FORTRAN Name	Card Columns	Format	Contents	Symbol	Remarks
J	1	I1	operator number	j	1 or 2
I	3-5	I3	subtask element number	i	1, 2, ..., 300
J,E,D,C	7	A1	type of subtask element	.	J = Joint; E = Equipment, D = Decision; C = Cyclic
N; Blank	9	A1	essentiality indicator	E _{ij}	N = nonessential; Blank = essential
IPREC(I, J)	10-12	I3	subtask element precedence	d _{ij}	subtask element number of partner
TMBEG(I, J)	13-20	F8.2	time precedence	I _{ij}	earliest time task can start
NXTS(I, J)	21-24	I4	next subtask element success	(ij) _s	next subtask element number, if successful
NXTF(I, J)	25-28	I4	next subtask element failure	(ij) _f	next subtask element number, if failure
AVGTM(I, J)	29-37	F9.2	average time	t _{ij}	average subtask element execution time
AVGTMD(I, J)	38-45	F8.2	time deviation	σ _{ij}	average sigma for t _{ij}
PRBUSQ(I, J)	46-50	F5.2	probability of success	p _{ij}	probability that next subtask element will be (ij) _s
TMLE(I, J)	51-59	F9.2	time remaining, essential	T _{ij} ^E	sum of time of remaining essential subtask elements
TMLN(I, J)	60-67	F8.2	time remaining, nonessential	T _{ij} ^N	sum of time of remaining nonessential subtask elements
ISJT(I, J)	69	I1	special jump subtask element type	-	blank = none; 1 = special type, 1, 2 = special type 2 (Team Decision)
NXTJ(I, J)	70-72	I3	next subtask element for j, special	-	applied to j, special jump subtask element
NXTJP(I, J)	73-75	I3	next subtask element for j', special	-	applies to partner, special jump subtask element
JAG(I, J)	76	I1	job activity group	-	1 = Electro-cognition; 2 = Electro-repair 3 = Instruction; 4 = Electro-safety 5 = Personnel Relationships 6 = Electronic Circuit Analysis 7 = Equipment Operation 8 = Using Reference Material 9 = Equipment Inspection

of stress greater than unity but less than the threshold will increase the technician's speed and success probability. At the threshold, the effect of stress is reversed, simulating disorganization and confusion of the technician.

- **F factor** - The F factor for each technician is an individuality indicator representing technician speed or proficiency. An average technician is given an F factor of unity; faster and more proficient technicians have lower values; slower and less proficient technicians have higher F values.
- **Time available** - The total time available to complete the task is a time limit. This value is employed as the interim of task success.
- **Period** - The period refers to the period of time applicable to cyclic subtasks. A cyclic subtask is initiated only at a time that is a multiple of the period, P. The simulated technician waits, if necessary, until such time occurs.

Table 3-7. Preparation of Subtask Input Data Cards

Data Item	Description
Operation number	Operator designation (1 or 2)
Subtask element number	Sequential task number (1 through 300)
Type of subtask element	Type J: Joint subtask-Performed simultaneously by two technicians Type E: Equipment subtask-Causes a delay due to a factor other than technician performance Type D: Decision subtask-Allows for looping, skipping, or branching in the performance sequence i.e.: the next subtask is selected according to the results of the task being performed. Type C: Cyclic subtask-A subtask that cannot be started until the next cycle time in a series of equal time periods.
Essentiality indicator	Identifies optional items
Subtask element precedence	Identifies the subtask element that must be completed by the other member of the team before this subtask can be started
Time precedence	Indicates waiting time from the start of the malfunction correction process before this subtask can be started

Table 3-7. Preparation of Subtask Input Data Cards (Continued)

Data Item	Description
Next subtask element success	Indicates the next subtask to be started if this subtask is successfully completed
Next subtask element failure	Indicates the next subtask to be started if this subtask is failed
Average time	Average execution time for this subtask
Time deviation	Average standard deviation of subtask execution time
Probability of success	From task analytic data; use extent data banks
Time remaining, essential	Sum of time for remaining essential subtasks—calculated after other inputs are prepared
Time remaining nonessential	Sum of time for remaining nonessential subtasks—calculated after inputs are prepared
Special jump subtask element type	The special jump subtask type 1 enables both technicians to jump to an individually specified subtask if one of the technicians ignores a given subtask. If a subtask, so identified, is ignored, technician j will go to NXTJ (I, J) for his next subtask; his partner, technician j, will go to NXTJP (I, J). Special jump subtask type 2 provides a team decision capability to the model. If a subtask, so identified, is a success, technician j will go to NXTS (I, T) for his next subtask. If the subtask is failed, technician i goes to NXTJ (I, J) and his partner, technician j', goes to NXTP (I, J). Thus, one technician can make a decision which will determine the future sequence of subtasks for both technicians
Next subtask element for j, special	Indicates next subtask if this subtask is being performed as a special jump subtask
Next subtask element for j' special	Indicates next subtask for the other technician involved in a special jump subtask
Job activity group	Identifies the task associated with this subtask

**Table 3-8. Content and Format of Parameter Input Data Cards
(Card Type 4)**

Symbolic FORTRAN Name	Card Columns	Format	Content	Symbol	Remarks
J	1	I1	Technician number	j	1 or 2
STRM (J)	2-11	F10.0	Stress threshold	M _j	M _j > 1.9 < 2.8
SPEED (J)	12-21	F10.0	F factor	F _j	F _j < 1: faster F _j > 1: slower
TMAVA (J)	22-31	F10.0	Time available	T _j	Time remaining
PRD (J)	32-41	F10.0	Period	P _j	Period for cyclic tasks 9 (seconds)
JOT (J)	43	I1	Job technician type	-	0. None of the following 1. Electrician's mate 2. Electronic technician 3. Fire control technician 4. Interior communications electrician 5. Radarman 6. Radioman 7. Sonar technician 8. Torpedoman's mate

3.3 Results of Computer Simulation

The computer simulation model produces a variety of data which is typically recorded on magnetic tape for subsequent printout on a high speed line printer. The categories of results available are summarized in table 3-9. The probability of successful completion of mission tasks can be obtained by analyzing the computer printouts.

3.3.1 Iteration Summary. Figure 3-5 shows a portion of the iteration summaries for the sample task that was presented in table 3-1. The iteration summaries contain the following data for each simulated technician:

- The input stress threshold
- The input speed (proficiency)
- The total input available time

- The difference between the available time and the actual time used
- The time spent waiting for the other technician (two technician case only)
- Subtask on which the peak (maximum) stress occurred and the peak stress level reached
- The stress level of each technician at the end of the simulation
- Team cohesiveness at the end of the simulation
- Time spent waiting for a given equipment cycle

Table 3-9. Computer Simulation Results

Title	Frequency	Remarks
Detail listing	Every subtask	Optional, 1 line per subtask
Iteration summary	At end of each iteration	Optional, 7 lines per iteration iteration
Run summary	At end of run	9 lines plus 8 frequency distributions for each technician

3.3.1.1 Malfunction Correction Time Prediction. The iteration summaries provide the data needed to predict the time it will take the technicians to correct a given malfunction. The procedure for using the iteration summaries to predict total malfunction correction time is shown in figure 3-6 and described as follows:

- Prepare a frequency distribution of the total time used data for each iteration
- Convert the frequency data to cumulative proportions (stated in percent)
- Plot the cumulative percentages against time and draw a line of best fit on the plot
- Draw a horizontal line from the line of best fit to the 50 percent point on the ordinate of the graph.

OPR	THRES	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS VALUE	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	1399.00	1289.48	-109.5	0.0	1	1.00	1.00	0.00	0.00
2	2.30	.90	1399.00	.75-1398.2		0.0	1	1.00	1.00	0.00	0.00

SUMMARY OUTPUT OF ITERATION 2 RUN 1 TRIAL 4
OVER RUN TOTAL TIME USED 1415.24

OPR	THRES	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS VALUE	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	1399.00	1415.24	14.2	0.0	43	2.30	2.30	.30	0.00
2	2.30	.90	1399.00	.75-1398.2		0.0	1	1.00	2.30	0.00	0.00

SUMMARY OUTPUT OF ITERATION 3 RUN 1 TRIAL 4
UNDER RUN TOTAL TIME USED 1345.24

OPR	THRES	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS VALUE	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	1399.00	1345.24	-53.8	0.0	1	1.00	1.00	0.00	0.00
2	2.30	.90	1399.00	.75-1398.2		0.0	1	1.00	1.00	0.00	0.00

SUMMARY OUTPUT OF ITERATION 4 RUN 1 TRIAL 4
UNDER RUN TOTAL TIME USED 1277.00

OPR	THRES	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS VALUE	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	1399.00	1277.00	-121.0	0.0	1	1.00	1.00	0.00	0.00
2	2.30	.90	1399.00	.75-1398.2		0.0	1	1.00	1.00	0.00	0.00

SUMMARY OUTPUT OF ITERATION 5 RUN 1 TRIAL 4
OVER RUN TOTAL TIME USED 2789.58

OPR	THRES	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS VALUE	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	1399.00	2789.58	1390.6	0.0	1	5.00	2.30	.30	0.00
2	2.30	.90	1399.00	.75-1398.2		0.0	1	1.00	2.30	0.00	0.00

SUMMARY OUTPUT OF ITERATION 6 RUN 1 TRIAL 4
OVER RUN TOTAL TIME USED 3899.90

OPR	THRES	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS VALUE	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	1399.00	3899.90	2501.0	0.0	1	5.00	2.30	.30	0.00
2	2.30	.90	1399.00	.75-1398.2		0.0	1	1.00	2.30	0.00	0.00

SUMMARY OUTPUT OF ITERATION 7 RUN 1 TRIAL 4
UNDER RUN TOTAL TIME USED 1336.95

OPR	THRES	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS VALUE	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	1399.00	1336.95	-62.4	0.0	1	1.00	1.00	0.00	0.00
2	2.30	.90	1399.00	.75-1398.2		0.0	1	1.00	1.00	0.00	0.00

SUMMARY OUTPUT OF ITERATION 8 RUN 1 TRIAL 4
OVER RUN TOTAL TIME USED 2629.25

Figure 3-5. Sample of Iteration Summaries

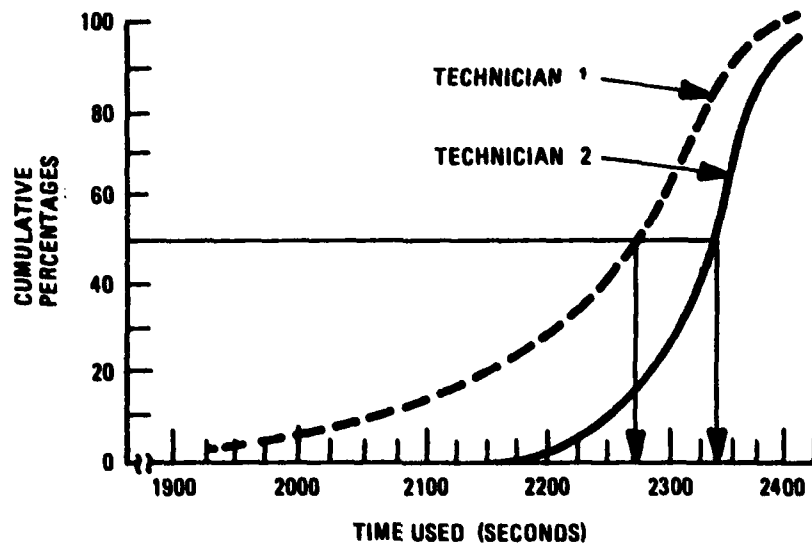


Figure 3-6. Predicted Malfunction Correction Time

The plot shown in figure 3-6 shows separate data for technicians 1 and 2. The data shows that technician 1 is a "fast" ($F = 0.9$) technician, and technician 2 is a "slow" ($F = 1.1$) technician. The predictions obtained from figure 3-6 are:

- Fifty percent of the malfunction corrections performed by technician 1 will be performed in 2280 seconds or less.
- Fifty percent of the malfunctions performed by technician 2 will be performed in 2330 seconds or less.
- The range of malfunction correction times for technician 1 will be from 1925 to 2425 seconds.
- The range of malfunction correction times for technician 2 will be from 2145 to 2425 seconds.

3.3.2

Run Summary. Figure 3-7 shows a run summary for the sample task. The run summary contains the following data:

- Run number (1)
- Total number of iterations performed (100)
- Number of successful iterations (41)
- Percent successful iterations (41.0)

- Time available, T_j (2409.00)
- The following data are listed for each operator or technician (the results of operator 1 are presented in this case since the malfunction correction is a uni-technician function):
 - Operator number (1)
 - Stress threshold, M_j (2.30)
 - Speed factor, F_j (1.00)
 - Time available, T_j (2409.00)
 - Average time used over N iterations (3565.33)
 - Average time overrun, i.e., time used-time available (1156.33)
 - Average waiting time (0.00)
 - Average peak stress (2.88)
 - Average final stress (1.77)
 - Average cyclic waiting time (0.00)
- The following frequency distributions are displayed and values presented for each subtask and for each operator/technician.
 - Subtask number
 - A count for the number of times that subtask was the last one completed before finishing the iteration or running out of time. The last subtask, 62, was the last subtask completed 41 times.
 - A count of the number of times a subtask was failed
 - A count of the number of times a subtask was ignored
 - The time spent in repeating subtasks that were failed
 - A count of the number of times the peak stress occurred on each subtask
 - The average time, from the beginning of the malfunction correction, that the subtask was completed
 - The average stress prior to beginning each subtask
 - Average cohesiveness value on each subtask

The data provided by the run summary may be employed as a basis for gaining insight into areas for redesign so as to decrease maintenance time. For example, subtasks involving large times may be considered for redesign or for training emphasis. Similarly, subtask yielding high failure frequencies may be considered for special treatment. If the malfunction correction method is revised, the revision may be analyzed through the computer simulation method to indicate the extent of the reduction in estimated malfunction correction time brought about by the revision.

3.4 Summary of Use of Computer Simulation Technique

The steps involved in applying the computer simulation method for estimating time to repair for a given electronic system are:

- For the system under consideration select a representative and adequate sample of the malfunction correction situations
- For each malfunction correction in the sample, prepare a sequential list of the subtasks involved in malfunction correction
- Prepare the input data for each malfunction
- Run each simulation for a minimum of 100 iterations
- Graphically summarize the data by malfunction and across malfunctions
- The across malfunction data summary yields the estimated time to repair for the system

3.5 Simulation Program Data

Program data for the digital simulation one and two technician model are presented in the appendixes. These data are identified as follows:

- Definitions of the variables in the computer simulation program are presented in appendix A.
- The program listing for the simulation program is presented in appendix B.
- The program flow charts are presented in appendix C.

4.0

INTERMEDIATE SIMULATION MODEL (ISM)

4.1

Introduction

The ISM, also developed at Applied Psychological Services, provides digital simulation of task performance involving 4 to 20 performers and permits the calculation of Human Reliability (HR), Equipment Reliability (ER) and System Reliability (SR) factors, Human Availability (HA), Equipment Availability (EA), System Availability (SA), Human Mean Time to Repair (HMTTR), Equipment Mean Time to Repair (EMTR), and System Mean Time to Repair (SMTTR).

The ISM predicts the time required to complete the simulated task and is capable of predicting the effect of changes in a given variable on HR, ER, or SR. Using inputs for a specific equipment or system, the ISM provides answers to such questions as:

- What is its ER?
- What is its HR?
- Which components of ER contribute most to unreliability?
- Which components of HR contribute most to unreliability?
- What changes in equipment will lead to an increase in ER?
- What personnel changes will increase HR?
- What behavioral variables contribute most to HR?
- What part does ER and HR, respectively, contribute to SR?
- What system design changes will best contribute to an increase in reliability?
- How does crew proficiency affect HR? SR?
- What are the effects of such items as motion sickness, fatigue, morale, level of aspiration, etc., on HR? on SR?

4.1.1 *Advantages of the ISM.* The advantages of the ISM over the smaller (1 to 2 technician) model are listed in tables 4-1 through 4-4.

Table 4-1. Personnel Parameters

Characteristic	Small Model	Intermediate Model (ISM)
Quantity	1 or 2 men	3-20 men groups group leader
Categories/ type		primary/secondary specialties 10 personnel specialties and cross training command echelon

Table 4-1. Personnel Parameters (Continued)

Characteristic	Small Model	Intermediate Model (ISM)
Goals	goal aspiration	aspiration leaders expectation performance adequacy
Physical Attributes		physical workload motion sickness hazard (safety index) sleep physical incapability (sickness) physical workload
Performance Attributes	stress and stress thresholds cohesiveness individuality (speed) factor	competence fatigue pace stress and stress threshold mental load unmanned station hours

Table 4-2. Mission Parameters

Characteristic	Small Model	Intermediate Model (ISM)
Composition	1-300 tasks	200 events per day of 30 types
Duration	minutes-hours mission time limit	hours to 30 days shifts
Environment		sea state
Elements (tasks)	essentiality types (joint, equipment, decision, cyclic) precedence (task and time) execution time success/failure determination waiting, idling success probability time remaining	essentiality types (scheduled, emergency, repair) precedence (task and time) performance time fixed and variable event times mixed and variable event times touch up or repeat completion time limit

Table 4-3. Equipment Parameters

Characteristic	Small Model	Intermediate Model
Quantity		30 types
Capability	equipment tasks	failure and generation of repairs operator initiated failures
Performance/ Status		failure rates up time down time performance level consumables levels

Table 4-4. Output Measurements

Characteristic	Small Model	Intermediate Model
Mission Effectiveness	mission success probability performance repetitions peak stress tasks mission duration	system reliability level system performance level equipment performance efficiency system global effectiveness level consumables balances equipment and human MTBF & MTTR
Time Utilization	tasks failed, ignored average time used waiting time average time overrun peak and average stress number of tasks and last task completed	success, idle, sleep, repair no. of events, success, fail, ignore, primary, secondary
Personnel	goal aspiration performance average cohesiveness	performance adequacy physical and mental load health and safety indices performance
Report Frequency	task, mission, iteration, and run summary	event, day, mission iteration, and run summary

4.1.2 Flow Logic Sequencing. Figure 4-1 provides a summary of the flow logic sequencing for the model. The detailed logical flow diagram of the model is presented in appendix C. Figure 4-1 is compatible with the detailed flow chart presented in appendix C. Key points in the model are identified by circled lowercase letters in figure 4-1 and in the flow diagram in appendix C; the point identified by a particular letter in figure 4-1 is identical to the point identified by the same letter in appendix C.

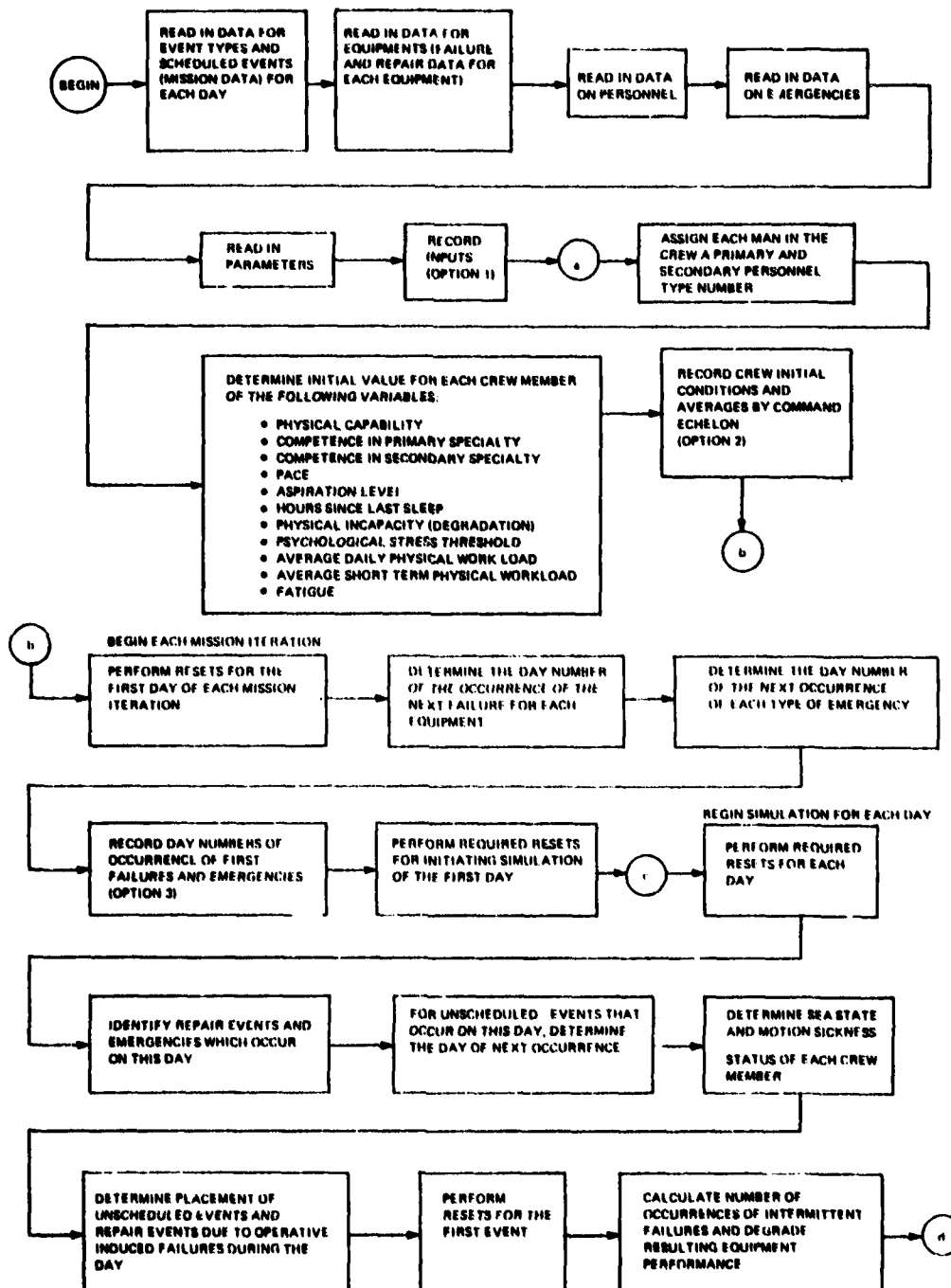


Figure 4-1 (Sheet 1). General Flow Logic Diagram of Model

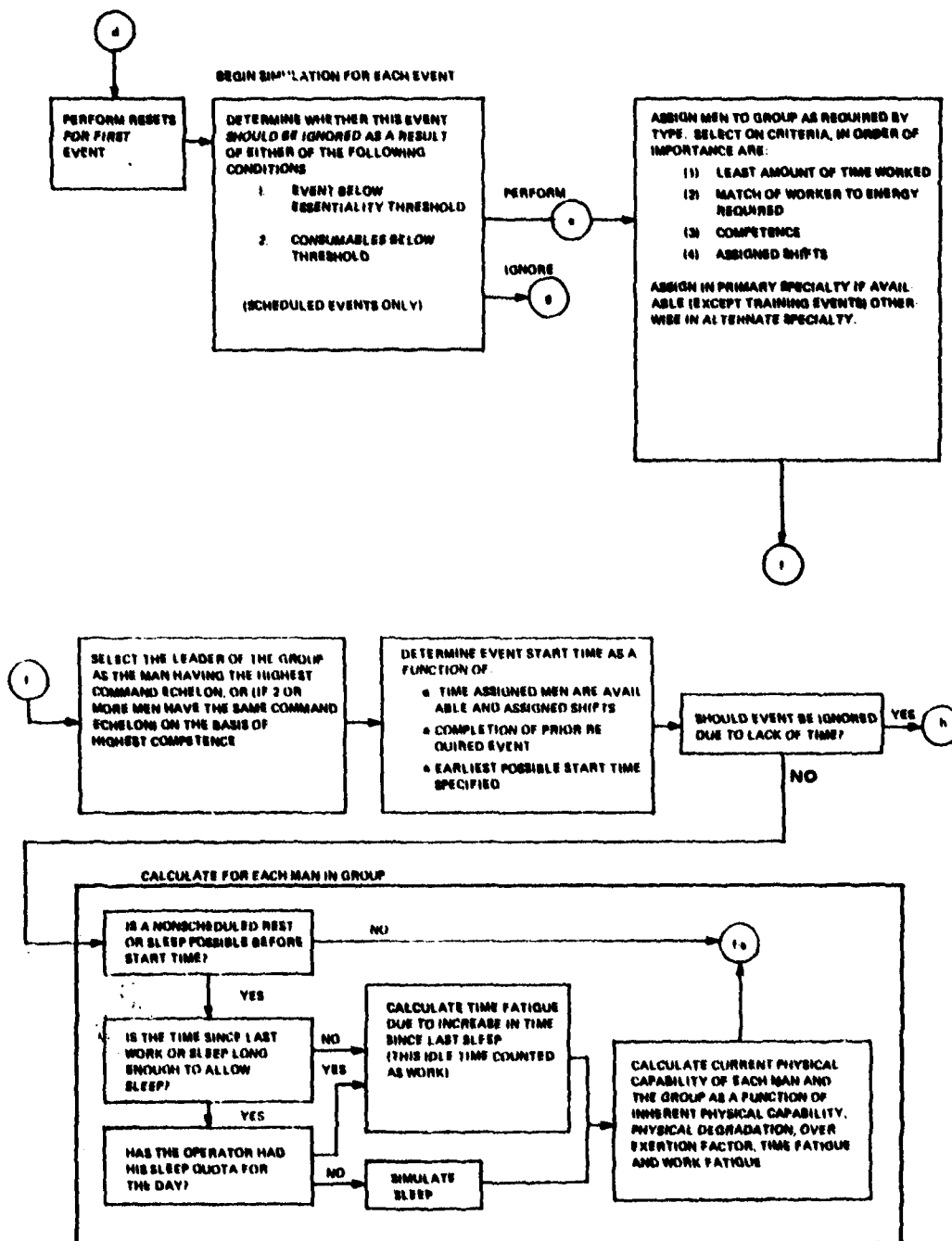


Figure 4-1 (Sheet 2). General Flow Logic Diagram of Model

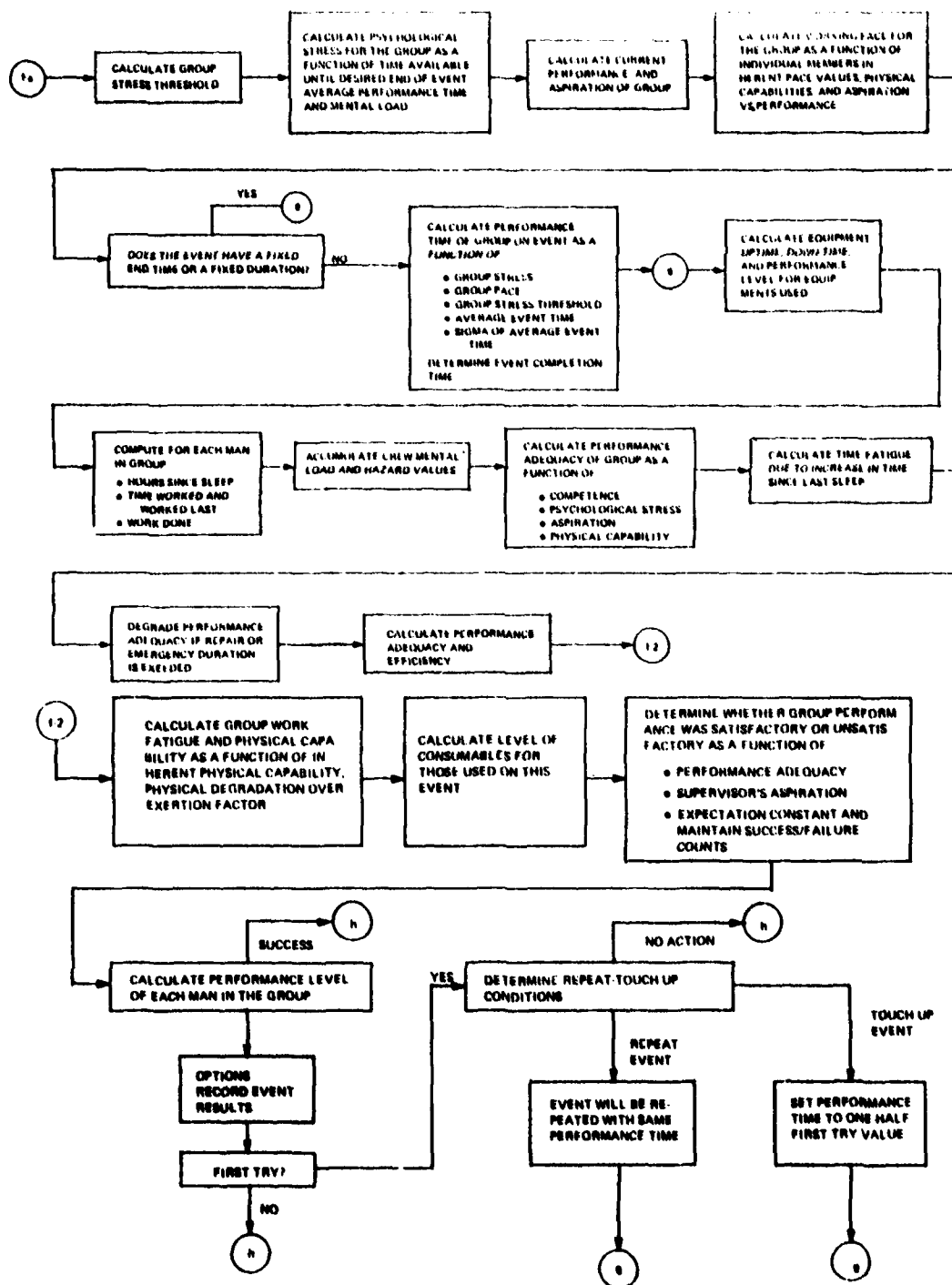


Figure 4-1 (Sheet 3). General Flow Logic Diagram of Mod. 1.

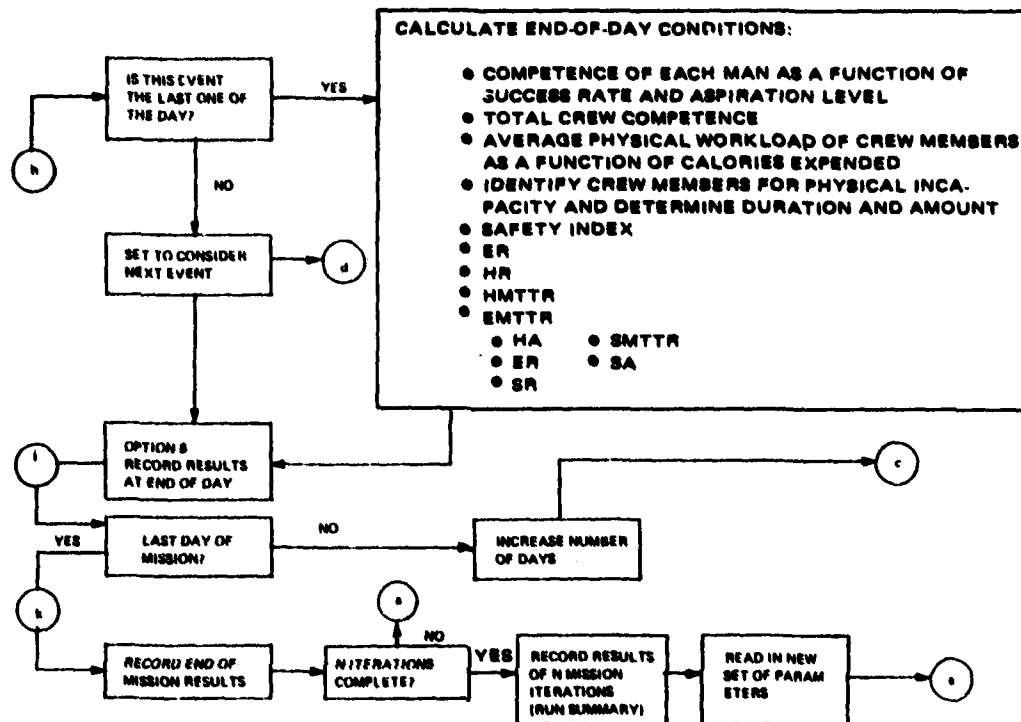


Figure 4-1 (Sheet 4). General Flow Logic Diagram of Model

4.2 Input Data

Each item of input data including other working variables in the input subroutine used in the model is defined in table 4-5. Table 4-5 gives the range and the average values for each input data item where applicable. The "Remarks" column of table 4-5 provides other pertinent data such as the unit of measure for quantitative items.

Table 4-5. Input Data

FORTTRAN	Description	Range	Average	Remarks
AASP	Average aspiration	.5-1.0	.9	Time in hours and hundreds
ACP	Average crew pace	5-1.5	1.0	
ADUR	Average duration of scheduled event	.001-24	—	
APST	Average psychological stress threshold	2.0-2.6	2.3	Time in hours
ART	Average repair time	0-24	—	
ASD	Average standard deviation of repair	0-999	—	
ASDE	Average standard deviation of emergency	0-24	—	Time in hours
BE	Effectivity of stress	.5-1.0	.9	

Table 4-5. Input Data (Continued)

FORTTRAN	Description	Range	Average	Remarks
CALRY	Number of calories required by average crewman per day	2000-3500	2750	
CN	Catnap length	.1 to 2	.3	Time in hours
DTE	Duration time of emergencies	0-24		Time in hours
DTR	Duration time of repairs	0-24		
EDCV	Data change value	0-10	—	
EMREVT	Emergency event data set			
EQREVT	Repair event data set			
ICLASS	Class	1-20		
IDES	Description array			
IDS	Number of duty shifts			
IEC	Expected energy consumption	0-1000	250	Calories per hour
IECE	Expected energy consumption for emergency	100-1000	250	Calories per hour
IEDC	Data change variable	0-10	—	
IEFN	Family number	1-20		
IESS	Essentiality	10-100		
IESS	Emergency essentiality	0-100		
IET	Essentiality threshold	0-99	70	
IETYP	Event type number	0-20		
IFOI	Event number in family	0-200		
IH	Event hazard class	1-9		
IHE	Event hazard class (emergency)	1-5		
IND	Printout option indicator array	0 or 1	1	
INT	Event code	1 or 2		
IPE	Prerequisite event	0-200		
IQR	Equipment list	1-10		
IRC	Consumable rate of expenditure (units/hours)	0.9999	—	
IRC1	Consumable rate of expenditure (units)	0-9999	—	
IRCE1	Consumable rate of expenditure (units)—emergencies	0-9999		
IRE	Number of repair events	0-200		
K1	Physical capacitation fraction	0-1.0	.75	
K7	Derating constant	.5-1.0	.9	
KE	Event end type	1 or 2		
KON	Initial level of consumables (units/hours)			
KONI	Initial level of consumables (units)	0-9999		
KONT	Threshold consumables (units/hours)	0-9999		
KONT1	Threshold consumables (units)	0-9999		
LODM	Mental load	1-9		
LODME	Mental load for emergency	1-9		
MAXSL	Maximum sleep	4-12	8	
MEN	Crew composition array	0-10		

Table 4-5. Input Data (Continued)

FORTTRAN	Description	Range	Average	Remarks
MPI	Average number of man days per incidence of physical incapacitation	0-120	30	
N	Number of iterations	1-999	20	
ND	Number of days	1-100		
NDBE	Number of days between emergencies	0-1000		
NDMAX	Maximum number of days	1-30	5	
NDS	Duty shift			
NIF	Number of family	1-10		
NIQR	Equipment used array	1-10		
NOSE	Number of scheduled events	1-200		
NREQ	Number of men required by type	0-10		
NREQE	Number of men required by type for emergency			
NX	Next event number for each alternative	1-200		
PID	Average duration of physical incapacity	0-30	3	Time in days
PPFQ	Percent fully qualified in primary specialty	0-100	25	
PPMQ	Percent moderately qualified in primary specialty	0-100	50	
PPUQ	Percent unqualified in primary specialty	0-100	25	
PRB	Probability of each alternative path	0-1.0		
PTT	Cross training probability table	0-1.0		
PWRRT	Average short term power output	200-500	350	Calories expended
RELH	Equipment reliability	0-1000		Time in days
RELI	Intermittent reliability	0-1.0		
RTU	Repair touchup code	1-3		
SESTA	Sea state	0-9	3	
SIGWT	Standard deviation of body weight	0-50	15	Deviation in pounds
SLEEP	Number of hours since last eight hour sleep period	0-20	4	
SPFQ	Percent fully qualified in secondary specialty	0-100	25	
SPMQ	Percent minimally qualified in secondary specialty	0-100	50	
SPUQ	Percent unqualified in secondary specialty	0-100	25	
ST	Earliest starting time allowed	0-24		Time in hours
TFAT	Fatigue threshold	.10-.35	.25	
TL	Time limit by which event must be completed	0-24		Time in hours
TS	Consumable threshold set identifier (units/hours)	0-9999		
TSI	Consumable threshold set identifier (units)	0-9999		

Table 4-5. Input Data (Continued)

FORTAN	Description	Range	Average	Remarks
TSE	Threshold set for consumables below which event is ignored (units/hours)	0-9999		
TSE1	Threshold set for consumables below which event is ignored (units)	0-9999		
TSR	Threshold set for consumables below which emergency is ignored (units/hours)	0-9999		
TSR1	Threshold set for consumables below which emergency is ignored (units)	0-9999		
TUI	Intermittent reliability	0-1000		Time in hours
WORK1	Number of hours worked after which no new work assignment is made	4-20	16	
WORK2	Number of hours worked after which no new work is authorized	4-16	10	
WT	Mean body weight	1-300	150	Weight in pounds
%PC	Physical capability constant	0-100	.25	

4.3

Use of the ISM

The model is designed to simulate a complete equipment or system mission or cruise cycle. The input data is used to simulate system operation, operator performance, equipment failure, and the performance of maintenance technicians during repair procedures. The procedure for using this model is summarized as follows:

- Perform an analysis for each task involved in the complete cycle and prepare a sequentially numbered list of subtasks for each task
- Develop other input data as outlined in table 4-5 and fill out input data forms provided in appendix D
- Prepare a "number of iterations" card (format 1)
- Prepare a Title card indicating the name of the mission being simulated (format 2)
- Prepare a tape input/number of days card (format 3)
- Prepare an input parameter card using information from the input data form for card format 4
- Prepare a personnel data card using the input data form for card format 5
- Prepare an equipment repair data card using the input data form for card format 6

- Prepare an emergency event data card for each anticipated emergency event using the input data forms for card format 7
- Prepare an event type data card for each event (from task analysis) using the input data forms for card format 8
- Prepare a scheduled event sequence data card for each scheduled event using the input data forms for card format 9
- Assemble the card deck and run the model

4.3.1 Task Analysis. A sequential list of the events involved in the simulated mission is required for the computer simulation. The list may be prepared from an available task analysis or by consultation with individuals knowledgeable in the events that occur during a mission such as the one being simulated. When all of the events have been identified, it is very helpful to prepare a time-line diagram which schedules the events over the duration of the mission, shown in figure 4-2. The time-line diagram must include scheduled task performance times for each operator or technician and all idle or waiting time. Each event is plotted on the time line, from the start of the mission, taking all relevant factors such as task interrelationships into account.

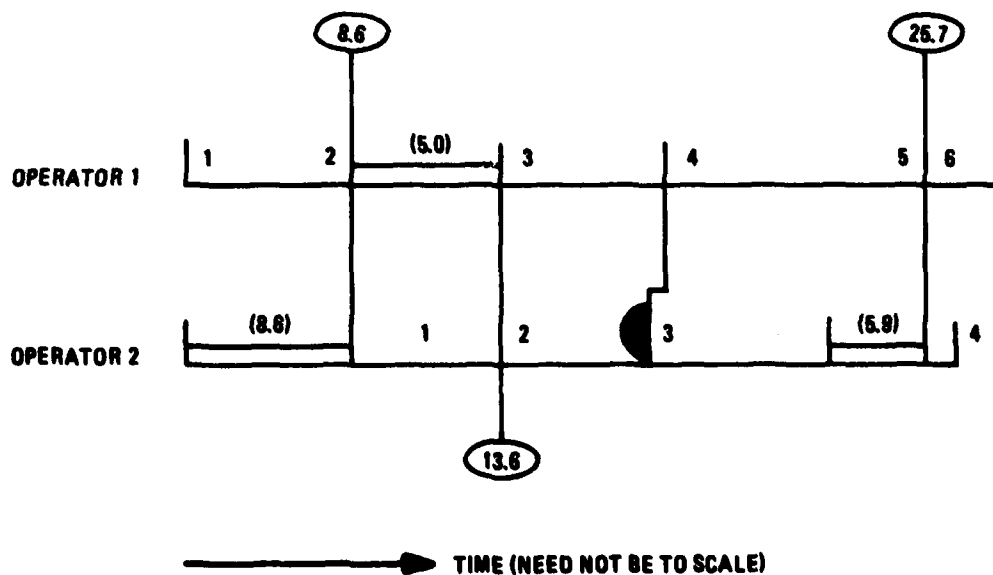


Figure 4-2. Time-Line Diagram

4.3.2 Input Data Forms. The input data forms in appendix B show the formats for preparing input data for card punching. The nine card formats used in the model are listed in table 4-6. In the NAME-LIST format, data are punched sequentially in card columns 2 through 72 without regard for column assignments. A comma separates each input number. Thus, all arrays must be completed with zeros. For example, the cross training probability matrix must have 10 x 10 entries even in the case that there are fewer than 10 types of personnel to be simulated.

If the simulation calls for more than one iteration, the input routine dumps all input data, except for the parameters and personnel data, onto a magnetic tape. This tape is then read in the subsequent iterations. A tape created in this fashion can be used to supply input for future simulations.

Table 4-6 Card Formats

Card Format	Type of Data
1	Number of iterations
2	Title
3	Tape input and number of days
4	Parameters
5	Personnel
6	Equipment repair events
7	Emergency events
8	Event type data
9	Sequence data

4.3.3 Number of iterations. The "number of iterations" card (card format 1) contains only one line of data and indicates the number of iterations for the run.

4.3.4 Title card. The title card (card format 2) contains one line of data punched in card columns 2 through 72 and gives the name of the mission for identification purposes.

4.3.5 Tape Input/Number of Days Card. The tape input/number of days card (card format 3) contains two lines of data. The first line is used to select tape or card input option. When the data has been subsequently run on the model and the simulation calls for more than one iteration, the input routine dumps all input data except parameters (format 4) and personnel data (format 5) onto a magnetic tape which is then read in the subsequent iterations. A tape created in this fashion may be used to supply input for future simulations by selecting the tape option (code 000 = card option, 001 = tape option). The second line of the card inputs the number of days in the simulated mission.

4.3.6 Input Parameter Card. The input parameter card (card format 4) must be punched exactly in accordance with the format 4 input data forms, presented on six pages in appendix B. The input data items, which are defined in table 4-5, run sequentially across the card columns with each input data item separated by a comma, without regard for card column assignments. All arrays must be completely filled in; if a particular item is not applicable, fill in the array with zeros. When no consumables are being simulated, input "1" in every position in the two "initial value" arrays and input zeroes in all of the "consumable threshold" arrays shown on the input data forms. The model provides for monitoring the level of up to 10 selected consumables, which may be monitored on a unit expenditure basis, or monitored on a rate of expenditure (units per hour) basis. For each group, a secondary input allows specification of up to 10 threshold levels for each consumable. The specified consumable threshold level causes the model to ignore all tasks involving a particular consumable when the value of that consumable drops below the specified threshold level (except for repairs and emergencies).

4.3.7 Personnel Data Card. The personnel data card (card format 5) must be punched exactly in accordance with the two-sheet format 5 input data form shown in appendix B. The input data items, which are defined in table 4-5, run sequentially across the card columns with each item separated by a comma. All arrays must be completely filled in. Zeroes must be used for all items that are not applicable to the mission being simulated. The first data item on card 5 is average population body weight (WT). If a specific system is being simulated in which the body weights of its personnel are known to differ from those of the general population or the general military population, the mean weight and standard deviation of that specific system's manning tables become the input data. For all other circumstances, the mean weight and standard deviation may be obtained from any appropriate anthropometric tabulation (e.g., Damon, Stoudt, & McFarland, 1966; Webb, 1964; Hertzberg, Daniels, & Churchill, 1950). The cross-training probability table provides the likelihood values of a man of each type having been crosstrained in each secondary specialty. This table is a 10 x 10 array which provides for the input up to 10 primary and 10 secondary specialties. Table 4-7 is an example of a crosstraining probability matrix for 9 specialties giving the probability of each specialist cross training into each of the other specialties. When these cross-training variables are printed out by the program they will have been converted to the cumulative probability format used in the processing. If fewer than 10 specialties are being considered, fill in the remaining spaces with zeroes.

Table 4-7 Personnel Cross-training Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	0	0.30	0.05	0	0.30	0	0	0	0.1	0	0	0	0	0	Radar/sonar
2	0.20	0	0	0	0.25	0.05	0	0	0.03	0	0	0	0	0	Electronics technician
3	0.20	0.05	0	0	0.05	0	0	0.05	0.03	0	0	0	0	0	Nuclear reactor technician
4	0.05	0	0	0	0	0	0.10	0	0.03	0	0	0	0	0	Steam fitter
5	0.20	0.50	0	0	0	0	0	0.10	0.03	0	0	0	0	0	Electricians mate
6	0.10	0.30	0	0	0.30	0	0	0	0.03	0	0	0	0	0	Gunners mate
7	0.10	0.01	0.02	0.08	0.02	0.10	0	0	0.03	0	0	0	0	0	Boatswains mate
8	0.05	0	0	0	0	0	0	0	0.20	0	0	0	0	0	Pharmacists mate
9	0.05	0	0	0	0	0	0.05	0	0	0	0	0	0	0	Cook/baker

4.3.8 Equipment Repair Data Cards. An equipment repair data card (card format 6) may be prepared for each equipment repair family identified in the task analysis. Repair event families are divided into four categories as shown in table 4-8, with eight event families in each category. Each event family is further subdivided into subevents. The model is limited to 12 subevents per repair event family. (Subevents under scheduled non-repair event families are unlimited in number.)

4.3.9 Emergency Event Cards. An emergency event data card (card format 7) must be prepared for each type of anticipated emergency event. The cards must be punched exactly in accordance with the format 7 input data form presented in appendix D. The input data items, which are defined in table 4-5, are punched sequentially across the card columns, with each input data item separated by commas, without regard for card column assignments. There is no limit on the number of emergencies which may be simulated each simulated day.

Table 4-8 Repair Event Codes

Repair Events	Code	
	Number	FORTTRAN
Electronic		
Uses reference manuals	6	EURM
Electronic cognition	7	EC
Electronic circuit analysis	8	ECA
Electronic repair	9	ER
Electronic equipment operation	10	EO
Electronic equipment inspection	11	EIP
Electronic instruction	12	EI
Electronic report	13	ERPT
Electrical		
Uses reference manuals	14	ELURM
Electrical cognition	15	ELC
Electrical analysis	16	ELA
Electrical repair	17	ELR
Electrical equipment operation	18	ELO
Electrical equipment inspection	19	ELEP
Electrical instruction	20	ELI
Electrical report	21	ELRPT
Electro-mechanical		
Uses reference manuals	22	EMRUM
Electro-mechanical cognition	23	EMC
Electro-mechanical analysis	24	EMA
Electro-mechanical repair	25	EMR
Electro-mechanical equipment operation	26	EMO
Electro-mechanical equipment inspection	27	EMEI
Electro-mechanical instruction	28	EMI
Electro-mechanical report	29	EMRPT
Mechanical		
Uses reference manuals	30	MURM
Mechanical cognition	31	MC
Mechanical analysis	32	MA
Mechanical repair	33	MR
Mechanical equipment operation	34	MO
Mechanical equipment inspection	35	MEI
Mechanical equipment instruction	36	MI
Mechanical report	37	MRPT

4.3.10 Event Type Cards. An event type data card (card format 8) must be prepared for each type of event scheduled for the mission. Input codes are given in the input data form presented in appendix B. Additional information about the event type input data items is provided in table 4-5.

4.3.11 Scheduled Event Sequence Cards. A scheduled events title card (card format 9) must be prepared for each iteration. The remaining scheduled events data shown on the format 9 input data form must be punched on a separate card for each scheduled event.

4.3.12 Card Deck Assembly. Assemble the card deck as shown in figure 4-3. The input data cards are arranged in numerical sequence with multiple event data cards of the same type arranged according to the time sequence in which they are to occur in the simulation.

4.4 Results of Computer Simulation

The ISM produces a variety of output data which are recorded on magnetic tape for subsequent printout on a high speed printer. The printouts available are listed and described in table 4-9. The model provides printouts of the input data for verification.

Table 4-9 Simulation Model Outputs

Type	Type of Printout	Frequency	Purpose
INPUT	Parameters	per run	Input verification
INPUT	Personnel data	per run	Input verification
INPUT	Equipment & repair events	per run	Input verification
INPUT	Emergencies	per run	Input verification
INPUT	Event type	per run	Input verification
OUTPUT	Start on mission crew data	per iteration	Crew rating data
OUTPUT	Failure/emerg. occurrences	per iteration	Simulated emergency data
OUTPUT	Scheduled event sequence	per day	Sequential listing of events
OUTPUT	Detail events	per event	
OUTPUT	End of day report	per day	
OUTPUT	End of iteration report	per iteration	
OUTPUT	Run summary	per run	

Various output printouts are available to present the results of the simulation. Recording and subsequent printout options are selected by the input data punched on card format 4, the input parameters card. The print options are given in table 4-10.

Table 4-10 Printout Options

Printout Description	FORTRAN	Input Codes	
		1	0
Parameter input data	IND (1)	Print all input data	Print parameter data only
Personnel input data	IND (1)	Print all input data	Print parameter data only
Equipment and repair event input data	IND (1)	Print all input data	Print parameter data only
Emergency event input data	IND (1)	Print all input data	Print parameter data only
Event type input data	IND (1)	Print all input data	Print parameter data only
Start of mission crew data	IND (2)	Print	Don't Print
Occurrences of failures and emergencies	IND (3)	Print	Don't Print
Scheduled event sequence	IND (4)	Print	Don't Print
Detail events	IND (5)	Print	Don't Print
End of day report	IND (6)	Print	Don't Print
End of iteration	IND (7)	Print	Don't Print
Run Summary	—	No option	No option

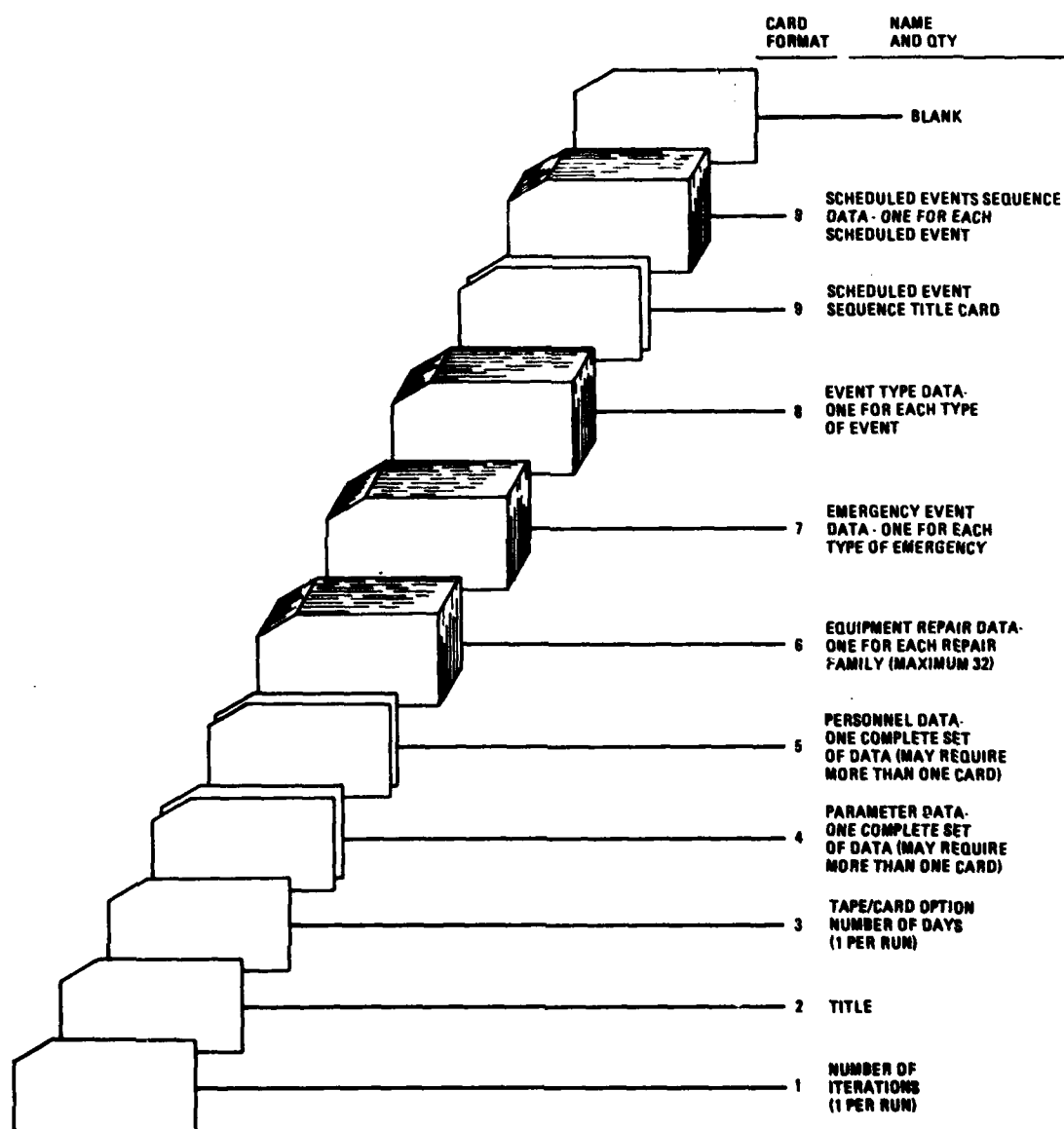


Figure 4-3. Card Deck Assembly

4.4.1 *Input Data Printouts.* Printouts of the input data are provided to allow the operator to verify source data. The following input data printouts are available:

- **Parameters**—The parameters printout (figure 4-4) provides a listing of the input parameter data from card format 4.
- **Personnel Data**—The personnel data printout (figure 4-5) provides a listing of the input personnel data from card format 5.
- **Equipment and Repair Events**—The equipment and repair events printout (figure 4-6) provides a listing of the input event data from card format 6.
- **Emergency Event Data**—The emergencies printout (figure 4-7) provides a listing of the input emergency event data from card format 7.
- **Event Type**—The event type printout (figure 4-8) provides a listing of the input event type data from card format 8.

4.4.2 *Start of Mission Crew Data.* The start of mission crew data printout, figure 4-9, combines the crew input data from the parameter and personnel input cards and provides a detailed listing of crew conditions as they exist at the start of the simulated mission. The last line of the listing shows average values which the model computes for the total crew.

4.4.3 *Failure and Emergency Occurrences.* The failure and emergency occurrences printout, figure 4-10 (print option 3), provides the simulated occurrence of the emergency events from format 7. The printout shows the first day in which each type of failure or emergency event will occur during the mission. The printout also shows the sea state at the start of the mission and the amount of personnel degradation resulting from sea sickness.

4.4.4 *Scheduled Event Sequence.* The scheduled event sequence data printout provides the information pertinent to the occurrence of events scheduled for the simulated mission. The scheduled events shown in figure 4-11 are divided into event type families, identified by numbers in the second column of the printout. If the event involves the use of consumables, information about the applicable consumables is provided in the next two columns (the threshold level and the number of units required for the event). The listing indicates the next event to be started after completion of each event (next event and probability) the event that must be completed before a particular event can be started (precedent event), the time after the beginning of the mission that the event should be started (start time), the time within the event must be completed (time limit), and the code for events not successfully completed on the first try: code 1 = Repeat, code 2 = touch-up, code 3 = go to next event.

4.4.5 *Detail Events.* If the option to record detailed event results is taken (print option 5, IND (5) = 1), the results are recorded and printed for analysis. Included in the printout are the following results for each event: successful/unsuccessful, men available, start time allowed, prior event requirements time finished, event start time, event duration, event end time, unmanned hours, group stress, physical capability, pace, aspiration, performance adequacy, hazard, consumables used and remaining, men on the job, and each man's fatigue, physical capacity, hours worked (cumulative), calories expended on this task, calories expended (cumulative) hours since sleep, idle hours, hours slept, cumulative performance, and aspiration, as shown in figure 4-12.

The printout for each event performed is concluded with data on each man who was assigned to the event. Here, an asterisk in the LDR column identifies the work group leader.

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PARAMETER INPUTS FOR THIS 1 DAY RUN OF 3 MISSION ITERATIONS
ENTITLED APS MURT VALIDATION - RUN 6

--- AVERAGE CREW DATA ---
PACE STRESS ASPIR- CALORIES RECD POWER RATE
THRESHOLD ACTION PER DAY CALS/MR.
1.00 2.30 0.90 2400. 4400.0

HOURS SINCE CATMAP MAXIMUM ---WORK LIMITS(HRS)---
LAST SLEEP LENGTH SLEEP NO MORE NO MORE FATHIGUE ESSENTIALITY
(HRS) PER DAY ASSIGNMENTS WORK 22.0 0.25 10 0.50
1.0 1.0 0.0 10.0 0.25 10 0.50

INITIAL VALUE OF CONSUMABLES (UNITS) 1 2 3 4 5 6 7 8 9 10
INITIAL VALUE OF CONSUMABLES (UNITS/MR) 1 1 1 1 1 1 1 1 1 1

CONSUMABLE THRESHOLDS (UNITS) SET
1 0 0 0 0 0 0 0 0 0
2 0 0 0 0 0 0 0 0 0
3 0 0 0 0 0 0 0 0 0
4 0 0 0 0 0 0 0 0 0
5 0 0 0 0 0 0 0 0 0
6 0 0 0 0 0 0 0 0 0
7 0 0 0 0 0 0 0 0 0
8 0 0 0 0 0 0 0 0 0
9 0 0 0 0 0 0 0 0 0
10 0 0 0 0 0 0 0 0 0

CONSUMABLE THRESHOLDS (UNITS/MR) 1 2 3 4 5 6 7 8 9 10
1 0 0 0 0 0 0 0 0 0
2 0 0 0 0 0 0 0 0 0
3 0 0 0 0 0 0 0 0 0
4 0 0 0 0 0 0 0 0 0
5 0 0 0 0 0 0 0 0 0
6 0 0 0 0 0 0 0 0 0
7 0 0 0 0 0 0 0 0 0
8 0 0 0 0 0 0 0 0 0
9 0 0 0 0 0 0 0 0 0
10 0 0 0 0 0 0 0 0 0

CUMULATIVE PROBABILITY OF SEA STATES 0.11 0.28 0.61 1.00 1.00 1.00 1.00 1.00 1.00 1.00
AVERAGE EQUIPMENT INTERMITTANT RELIABILITY 0.25 0.25 0.25 1 1 1 1 1 1 1
OUTPUT RECORDING OPTIONS 1 1 1 1 1 1 1 1 1 1

Figure 4-4. Sample of Parameter Output Format

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PHYSICAL CAPABILITY AVERAGES--
DAYS PER
INCIDENCE DURATION

PHYSICAL
CAPABILITY
CONSTANT

00:15

Figure 4-5. Sample of Output of Personnel Input Data

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EQUIPMENT AND REPAIR EVENT DATA

EQUIP TYPE	DESCRIPTION	-CONSUM. THRESHOLD SET- (LIMITS/MM) (LIMITS)										RELIABILITY (DAYS/FAIL)		TIME UNAVAIL		EVENTS/ FAMILY			
		0	0	0	0	0	0	0	0	0	0	0.750	0.06	0.06					
1	CONSOLE 1	EVENT	NEXT EVENT	PROBABILITY	REPEAT/ TOUCHUP	DATA	CHG	NO	DATA	CHANGE	VALUE	PREC. EVENT	FAMILY INDIC.	FAMILY NUMBER	DURATION TARGET	IN FAMILY	EVENT NUMBER		
		TYPE	1	2	3	1	2	3	1	2	3	0	1	1	1	1	201		
		1	202	202	0.30	0.70	0.	0.	0.	0.	0.	0.	0	1	1	1	201		
		6	203	203	1.00	0.	0.	0.	0.	0.	0.	0.	0	1	1	2	202		
		7	203	203	1.00	0.	0.	0.	0.	0.	0.	0.	0	1	1	3	202		
		11	204	204	0.60	0.	0.	0.	0.	0.	0.	0.	0	1	1	4	203		
		9	205	205	1.00	0.	0.	0.	0.	0.	0.	0.	0	1	1	4	204		
		10	206	207	0.50	0.	0.	0.	0.	0.	0.	0.	0	1	1	5	205		
		18	206	207	0.50	0.	0.	0.	0.	0.	0.	0.	0	1	1	5	205		
		12	207	207	1.00	0.	0.	0.	0.	0.	0.	0.	0	1	1	6	206		
		13	208	208	1.00	0.	0.	0.	0.	0.	0.	0.	0	2	1	7	207		
		2	CONSOLE 2	EVENT	NEXT EVENT	PROBABILITY	REPEAT/ TOUCHUP	DATA	CHG	NO	DATA	CHANGE	VALUE	PREC. EVENT	FAMILY INDIC.	FAMILY NUMBER	DURATION TARGET	IN FAMILY	EVENT NUMBER
		TYPE		1	2	3	1	2	3	1	2	3	0	1	2	1	1	213	
15	215	214		0.30	0.70	0.	0.	0.	0.	0.	0.	0	1	2	1	213			
14	215	215		1.00	0.	0.	0.	0.	0.	0.	0.	0	1	2	2	214			
18	216	216		1.00	0.	0.	0.	0.	0.	0.	0.	0	1	2	3	215			
16	217	217		1.00	0.	0.	0.	0.	0.	0.	0.	0	1	2	4	216			
17	218	219		1.00	0.	0.	0.	0.	0.	0.	0.	0	1	2	5	217			
19	219	219		1.00	0.	0.	0.	0.	0.	0.	0.	0	1	2	6	218			
20	212	212		1.00	0.	0.	0.	0.	0.	0.	0.	0	2	2	7	219			
3	CONSOLE 3	EVENT		NEXT EVENT	PROBABILITY	REPEAT/ TOUCHUP	DATA	CHG	NO	DATA	CHANGE	VALUE	PREC. EVENT	FAMILY INDIC.	FAMILY NUMBER	DURATION TARGET	IN FAMILY	EVENT NUMBER	
TYPE		1		2	3	1	2	3	1	2	3	0	1	3	1	1	225		
22		227		226	0.30	0.70	0.	0.	0.	0.	0.	0.	0	1	3	1	225		
21		227	227	1.00	0.	0.	0.	0.	0.	0.	0.	0	1	3	2	226			
25		228	228	1.00	0.	0.	0.	0.	0.	0.	0.	0	1	3	3	227			
23		229	229	1.00	0.	0.	0.	0.	0.	0.	0.	0	1	3	4	228			
24		230	231	0.50	0.	0.	0.	0.	0.	0.	0.	0	1	3	5	229			
26		231	231	1.00	0.	0.	0.	0.	0.	0.	0.	0	1	3	6	230			
27		224	224	1.00	0.	0.	0.	0.	0.	0.	0.	0	2	3	7	231			

Figure 4-6. Sample of Equipment and Repair Event Output Format

EMERGENCY EVENT DATA

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Figure 4-7. Sample of Emergency Event Output Format

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EVENT TYPE DATA												
TYPE IDENTIFIER	DURATION AVG. SIGMA	CLASS	NUMBER OF EQUIPS. RECD	EQUIPMENT NUMBERS RECD								
ESSEN- TIALITY	MENTAL LOAD	EVENT WIND CODE	HAZARD	NUMBER OF MEN REQUIRED	CONSUMABLE EXPENDITURE RATE (UNITS/HR.)							
CONSUMABLE EXPENDITURE RATE (UNITS)												
1 2 3 4 5 6 7 8 9 10												
CONSUMABLE EXPENDITURE RATE (UNITS/HR.)												
1 2 3 4 5 6 7 8 9 10												
1	CHECK LOSS AND GEAR	1	2.	1 0 0 0 0 0 0 0 0 0	0.430 0.050 3 0 0 0 0 0 0 0	1.2 3 0 0 0 0						
50	5.	2.		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.						
2	SEARCH AND DETECT	1	1.	0 1 0 0 0 0 0 0 0 0	0.500 0.116 3 0 0 0 0 0 0 0	1.2 3 0 0 0 0						
90	5.	2		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.						
3	PROSECUTE TARGET	1	1.	1 0 0 0 0 0 0 0 0 0	0.200 0.040 3 0 0 0 0 0 0 0	0.0 0.0 0.0 0.0						
60	5.	2		0 0 0 0 0 0 0 0 0 0	0. 150. 0. 0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0.						
4	LOST TARGET	2	1.	0 1 0 0 0 0 0 0 0 0	1.050 0.201 3 0 0 0 0 0 0 0	1.2 3 0 0 0 0						
70	3.	1		0 0 0 0 0 0 0 0 0 0	0. 100. 0. 0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0.						
5	CLEANUP	2	1.	0 0 1 0 0 0 0 0 0 0	0.120 0.030 4 0 0 0 0 0 0 0	0.0 0.0 0.0 0.0						
90	1.	2.		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.						
6	BT DROPS	2	1.	1 0 0 0 0 0 0 0 0 0	0.400 0.040 2 0 0 0 0 0 0 0	0.0 0.0 0.0 0.0						
80	3.	3.		0 0 0 0 0 0 0 0 0 0	150. 0. 0. 0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0.						
7	USES REFERENCE MANUALS	2	1.	0 1 0 0 0 0 0 0 0 0	0.100 0.020 3 0 0 0 0 0 0 0	1.0 0.0 0.0 0.0						
80	6.	2		0 0 0 0 0 0 0 0 0 0	0. 110. 0. 0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0.						
8	ELECTRONIC COGNITION	2	1.	0 1 0 0 0 0 0 0 0 0	0.000 0.010 3 0 0 0 0 0 0 0	1.0 0.0 0.0 0.0						
90	0.	2		0 0 0 0 0 0 0 0 0 0	0. 90. 0. 0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0.						

Figure 4-8. Sample of Event Type Output Data Format

START OF MISSION CREW DATA												
MAN	PHYS- NO. CAPABIL	COMPE- TENCE	PACE	ASPIR- ATION	WRS SINCE LAST SLEEP	PHYSIC INCAP	FAT- IGUE	STRESS THRESHOLD	CALOR- IES	POWER RATE	LEVEL	SPECIFIC PRIMARY SECONDARY
1	1.337	0.768	0.777	0.912	1.259	1.000	0	0.039	2.233	900.2	1	1
2	1.081	0.740	0.934	0.744	1.358	1.000	0	0	2.767	495.5	1	1
3	1.000	0.773	0.565	0.537	1.089	1.000	0	0.067	1.467	299.3	1	1
4	1.002	0.912	0.761	0.886	1.059	1.000	0	0.060	2.700	202.1	2	2
5	1.004	0.944	0.754	0.894	1.354	1.000	0	0.122	2.456	203.0	2	2
6	0.871	0.931	0.622	0.715	0.914	1.000	0	0.071	2.391	200.6	2	2
7	1.045	0.825	0.610	0.621	0.966	1.000	0	0.040	2.637	255.6	2	2
8	1.029	0.734	0.609	0.706	0.908	1.000	0	0.040	2.273	244.6	2	2
9	0.755	0.741	0.573	0.709	0.521	1.000	0	0	2.607	191.1	2	2
10	0.954	0.795	0.611	0.967	0.890	1.000	0	0.075	2.900	220.1	2	2
11	1.013	0.726	0.670	0.910	1.206	1.000	0	0	2.448	253.3	2	2
12	1.057	0.700	0.604	0.874	0.793	1.000	0	0.114	2.700	253.6	2	2
13	0.905	0.760	0.601	0.917	1.042	1.000	0	0	2.466	217.2	2	2
14	1.019	0.783	0.573	0.874	0.661	1.000	0	0	2.560	246.5	2	2
AVERAGE	1.025	0.813	0.661	0.827	1.021	1.000	0	0.046	2.350	240.0	0.71.1	

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Print Option Three - Occurrences of Failures and Emergencies, Sea State and Sickness

Equipment Type	Day of First Occurrence	Emergency Type	Day of First Occurrence	Initial Sea State	Sickness Degradation to Initial Competence
1	1	1	1	2	0.1110
2	1				
3	1				

Figure 4-10. Sample of Occurrences of Failures and Emergencies Output Format

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SCHEDULED EVENT SEQUENCE DATA										ATU CODE	
FOR 177 SCHEDULED EVENTS OF DAY 1 ENTITLED DAY 1 TEST										1-REPEAT	2-TOUCHUP
EVENT NO.	TYPE	THRESHOLD SET UNITS/HR	1	2	3	PRECEDENT EVENT NO.	START TIME	TIME LIMIT	REPEAT/TOUCHUP CODE		
1	1	0	0	2 1.00	2 0.	0	0.	4.00	2		
2	2	0	0	3 1.00	3 0.	0	0.	4.00	2		
3	2	0	0	4 1.00	4 0.	0	0.04	4.00	2		
4	4	0	0	5 1.00	5 0.	0	0.10	4.00	2		
5	6	0	0	6 1.00	6 0.	1	0.	4.00	2		
6	2	0	0	7 1.00	7 0.	0	0.61	4.00	2		
7	2	0	0	8 1.00	8 0.	0	0.06	4.00	2		
8	3	0	0	9 1.00	9 0.	2	0.	4.00	2		
9	3	0	0	10 1.00	10 0.	3	0.	4.00	2		
10	2	0	0	11 1.00	11 0.	0	1.15	4.00	2		
11	2	0	0	12 1.00	12 0.	0	1.19	4.00	2		
12	3	0	0	13 1.00	13 0.	4	0.	4.00	2		
13	3	0	0	14 1.00	14 0.	7	0.	4.00	2		
14	4	0	0	15 1.00	15 0.	0	1.47	4.00	2		
15	3	0	0	16 1.00	16 0.	10	0.	4.00	2		
16	2	0	0	17 1.00	17 0.	0	1.77	4.00	2		
17	3	0	0	18 1.00	18 0.	11	0.	4.00	2		
18	2	0	0	19 1.00	19 0.	0	1.99	4.00	2		
19	2	0	0	20 1.00	20 0.	0	2.35	4.00	2		
20	3	0	0	21 1.00	21 0.	16	0.	4.00	2		
21	2	0	0	22 1.00	22 0.	0	2.56	4.00	2		
22	3	0	0	23 1.00	23 0.	18	0.	4.00	2		
23	4	0	0	24 1.00	24 0.	0	2.86	4.00	2		
24	2	0	0	25 1.00	25 0.	0	2.94	4.00	2		

Figure 4-11. Sample of Scheduled Event Sequence Output Format

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Figure 4-12. Samples of Detail Event Output Format

4.4.6 End of Day Reports. If the option to print end-of day results is taken (print option 6, IND (6) = 1), the summarized results of the day just simulated are recorded for printout on the computer's high speed line printer. Figure 4-13 shows a sample tabulation. The first section provides summarized event and status information for the overall crew performance. Most of the headings shown are self explanatory. All times are given in hours. The AVG PERF ADEQ (average performance adequacy, third line) is a mean of the performance adequacy value of all events performed. The AVG FAIL DIFF (average failure difference) is a mean, taken only for failed events, indicating the difference between performance adequacy (PA) and the required performance level, CASP(LI) - K7. The second section shows important data summarized by man. These results are either totals for all daily activity (hours worked, slept, idle, number of events successfully performed), or represent end-of-day conditions (fatigue, aspiration, competence). Averages for all of the elements in the second section follow the individual crew member summaries and represent daily summaries for simulated variables for the member summaries and represent daily summaries for simulated variables for the day. These summaries include: the total number of events scheduled, events worked, repair events, emergency events, repeated events, successes, failures and ignores, total hours worked, time spent on scheduled and repair and emergency events, unmanned station hours, average performance adequacy, average failure difference percentage of tasks failed and succeeded on first try, percentage of tasks succeeded on second try, and percentage of tasks ignored and repeated. Also, presented are: the safety index, competence increase, confidence, hazard, consumable balances, maximum stress and on which event, maximum mental load and on which event, maximum calories expended and on which event. A summary table is presented including for each man his physical capacity, hours worked in primary specialty, hours worked in secondary specialty, hours slept, hours idle, fatigue level, health index, average physical workload, competence, aspiration, performance (cumulative) and number of successes. Each of these variables is also averaged across the entire crew. A summary table of these variables is also presented by type of man.

Eleven reliability related variables are also summarized in the end-of-day printout. These are: Human Reliability (HR), Human Availability (HA), Human Mean Time to Repair (HMTTR), Equipment Reliability (ER), Equipment Availability (EA), Equipment Mean Time Between Failures (EMTBF), Equipment Mean Time to Repair (EMTTR), System Reliability (SR), System Availability (SA), and System Mean Time to Repair (SMTTR).

These same items are given in the third section of the each of day recording as a mean by type of man, where type is generally synonymous with work specialty.

4.4.7 End of Iteration Reports. If the option to print end of iteration reports is taken (print option 7, IND (7) = 1), the summarized results each iteration are recorded for printout. Figure 4-14 shows a sample tabulation. The resulting printout contains such summary items as: number of events successful on first and second try, number of events failed and ignored, average man hours spent in primary specialty, in secondary specialty, hours spent sleeping and hours idle, consumables remaining, averages of physical load, mental load, competence, average performance adequacy, average fatigue, average aspiration, average health, and average safety. Each of these variables is also summarized as percentage of total, average per day, or percentage of original, whichever is appropriate. Summary by day (including an average across days) includes: number of repair or emergency events, average man hours spent doing repairs or handling emergencies, maximum stress, maximum mental load, confidence, hazard, average failure difference, number of successes and unmanned hours. A summary table by day and man type is provided for the following variables: physical capability, hours spent on primary and secondary specialties, sleep time, idle time, fatigue, health index, average physical work load, competence, aspiration, cumulative performance, and number of successes. Averages for these variables across types by day are also provided.

Reliability metrics provided at the end of each iteration are human mean time between failure (HMTBF), equipment mean time between failure (EMTBF), human mean time to repair (HMTTR), equipment mean time to repair (EMTTR), human availability (HAVAIL), and equipment availability (EAVAIL). A composite reliability metric system availability (SYSAVAIL) is also provided.

MAN	TYPE	PHYSICAL	HOURS	WORKED	SLEPT	IDLE	FATIGUE	HEALTH	AVG	PHYS	COMPETENCE	ASPIRATION	PERFORM	NUMBER
		CAP	PRIM	2ND				INDEX	WORKLOAD				CUM.	SUCC.
1	1	1.235	4.93		7.7	11.3	0.10	1.00	0.02		0.918	0.77	1.00	22.
2	1	1.038	4.95	0.	3.6	15.4	0.66	1.00	0.05		0.975	0.79	1.00	23.
3	1	0.945	6.34	0.	7.5	10.2	0.13	1.00	0.06		0.943	0.80	1.00	20.
4	2	1.002	7.90	0.	7.5	6.6	0.94	0.94	0.23		0.969	0.99	1.00	9.
5	2	1.029	7.90	0.	7.5	6.6	0.98	0.98	0.22		0.997	0.96	1.00	8.
6	2	0.989	7.92	0.	7.5	6.6	0.04	1.00	0.26		0.938	0.96	1.00	11.
7	2	1.045	7.36	0.22	7.5	0.9	0.50	1.00	0.24		0.990	0.94	1.00	10.
8	2	1.132	7.74	0.	3.5	12.0	0.54	1.00	0.23		0.941	0.87	1.00	12.
9	2	0.833	7.65	0.	6.4	9.9	0.35	1.00	0.26		0.955	0.94	1.00	15.
10	2	0.834	8.60	0.	6.9	8.4	0.10	1.00	0.35		0.930	0.86	1.00	13.
11	2	1.012	8.60	0.	7.6	7.6	0.17	1.00	0.31		0.957	0.86	1.00	10.
12	3	1.007	0.26	0.	9.0	15.7	0.	1.00	0.00		0.969	1.00	1.00	2.
AVERAGES		1.007	6.69	0.02	6.0	10.5	0.24	0.99	0.19		0.940	0.89	1.00	14.75

[illegible]

AVERAGES BY TYPE

DAILY PERFORMANCE OF EQUIPMENT		UP	PERFORMANCE
	AVG. REPAIR TIME		
1	1.5	100	100
2	1.5	100	100
3	1.5	100	100
4	1.5	100	100
5	1.5	100	100
6	1.5	100	100
7	1.5	100	100
8	1.5	100	100
9	1.5	100	100
10	1.5	100	100
11	1.5	100	100
12	1.5	100	100
13	1.5	100	100
14	1.5	100	100
15	1.5	100	100
16	1.5	100	100
17	1.5	100	100
18	1.5	100	100
19	1.5	100	100
20	1.5	100	100
21	1.5	100	100
22	1.5	100	100
23	1.5	100	100
24	1.5	100	100
25	1.5	100	100
26	1.5	100	100
27	1.5	100	100
28	1.5	100	100
29	1.5	100	100
30	1.5	100	100
31	1.5	100	100
32	1.5	100	100
33	1.5	100	100
34	1.5	100	100
35	1.5	100	100
36	1.5	100	100
37	1.5	100	100
38	1.5	100	100
39	1.5	100	100
40	1.5	100	100
41	1.5	100	100
42	1.5	100	100
43	1.5	100	100
44	1.5	100	100
45	1.5	100	100
46	1.5	100	100
47	1.5	100	100
48	1.5	100	100
49	1.5	100	100
50	1.5	100	100
51	1.5	100	100
52	1.5	100	100
53	1.5	100	100
54	1.5	100	100
55	1.5	100	100
56	1.5	100	100
57	1.5	100	100
58	1.5	100	100
59	1.5	100	100
60	1.5	100	100
61	1.5	100	100
62	1.5	100	100
63	1.5	100	100
64	1.5	100	100
65	1.5	100	100
66	1.5	100	100
67	1.5	100	100
68	1.5	100	100
69	1.5	100	100
70	1.5	100	100
71	1.5	100	100
72	1.5	100	100
73	1.5	100	100
74	1.5	100	100
75	1.5	100	100
76	1.5	100	100
77	1.5	100	100
78	1.5	100	100
79	1.5	100	100
80	1.5	100	100
81	1.5	100	100
82	1.5	100	100
83	1.5	100	100
84	1.5	100	100
85	1.5	100	100
86	1.5	100	100
87	1.5	100	100
88	1.5	100	100
89	1.5	100	100
90	1.5	100	100
91	1.5	100	100
92	1.5	100	100
93	1.5	100	100
94	1.5	100	100
95	1.5	100	100
96	1.5	100	

EQUIPMENT	Avg. Expected	Actual Time	UP	PERFORMANCE
1	0.82	1.12	61.79	0:98
2	0.82	0.97	61.79	0:98
3	0.82	0.83	61.79	0:99

0.82	0.98	61.79	0.98	0.83

SUMMARY BY EVENT CLASS			HOURS WORKED		--PERCENTY OF TIME--		PERFORM. ADEQUACY		AVG. FAILURE DIFFERENCE	
EVENT CLASS	NO. OF EVENTS	1ST	2ND	SUC1	SUC2	FAIL	IGNORE			
1	0	0.47	0	100	0	0	0	0.91		-0.17
2	150	0.46	0	91	0	0	9	0.84		-0.17
3	0	0.12	0.01	89	0	0	11	0.82		-0.09
4	1	2.00	0	100	0	0	0	1.02		-0.30

Figure 4-13. Sample of End of Day Output Format

4-29

Figure 4-14. Sample of End of Iteration Output Format

4.4.8 Run Summary. After each mission iteration, the model instructs the computer to make a check to determine whether all required iterations have been completed, if not, the process continues to the next iteration. If all scheduled iterations have been completed, the results of all iterations are summarized. The run summary tabulation (as shown in figure 4-15) is presented in a form similar to the iteration summary.

4.5 Use of Simulation Data

The simulation model is used to measure system and personnel effectiveness for a given set of parameters, or to measure the result of changes in variable input items. Examples are provided in the following paragraphs showing the effects of changes in input values for:

- Workday length and proficiency
- Average crew pace
- Sea state
- Crew size

The nominal input values for these parameters are shown in table 4-11. The matrix shown in table 4-7 was used in the assignment of personnel crosstraining probabilities. This matrix presents the probability of a personnel type with a given primary specialty being crosstrained in a given secondary specialty (the values in this matrix were used by Applied Psychological Services (APS) to validate the model). The examples presented in the following paragraphs are based on the results of simulation model sensitivity tests performed by APS, in which selected input parameters were varied to measure the resulting changes in system effectiveness. The parameters tested are shown in table 4-12 and the tests are described in the following paragraphs.

Table 4-11 "Standard" Parameter Set Run Conditions

Parameter	FORTTRAN	Value
Average psychological stress threshold	APST	2.30
Workday, assignment limit	WORK 1	varied
Workday, maximum	WORK 2	22.00
Hours since last sleep at start	SLEEP	1.00
Catnap threshold	CN	1.00
Maximum sleep permitted per day	MAXSL	8.00
Fatigue threshold	TFAT	0.25
Average crew pace	ACP	varied
Average daily calories per crew member	CALRY	2700.00

Table 4-11 "Standard" Parameter Set Run Conditions (Continued)

Parameter	FORTTRAN	Value
Average short term power rate (cals/hr)	PWRRT	440.00
Acceptable performance constant	K7	1.00
Work factor constant	K1	0.95
Consumable levels: (units/hr)	KON(1)	15150.00
	KON(2)	10000.00
	KON(3)	6000.00
	KON(4)	500.00
	KON(5)	500.00
	KON(6)	500.00
	KON(7)	500.00
	KON(8)	500.00
	KON(9)	500.00
	KON(10)	500.00
Consumable levels: (units)	KON1(1)	100.00
	KON1(2)	100.00
	KON1(3)	100.00
	KON1(4)	100.00
	KON1(5)	100.00
	KON1(6)	100.00
	KON1(7)	100.00
	KON1(8)	100.00
	KON1(9)	100.00
	KON1(10)	100.00
Initial aspiration level	AASP	0.85
Number of iterations	N	5.00
Essentiality threshold	IET	0.30
Sea state	SESTA	varied
Personnel Data	FORTTRAN	Value
Mean body weight of total population	WT	160.50
Standard deviation of population body weight	SIGWT	20.00
% crew fully qualified in prime specialty	PPFQ	varied
% crew minimally qualified in prime specialty	PPMQ	varied
% crew unqualified in prime specialty	PPUQ	varied
% crew fully qualified in second specialty	SPFQ	varied
% crew minimally qualified in second specialty	SPMQ	varied
% crew unqualified in second specialty	SPUQ	varied
Avg. N man days between physical incapacitations	MPI	5.00
Avg. duration of incapacity (days)	PID	5.00
Physical capability constant, a value yielding zero	ZPC	2.00
Physical capability due to over exertion	MEN(ICE, NI)	varied
Number of men by type		

Table 4-12 Sensitivity Test Runs

Parameters Varied	Parameter Set--Test Run							Comparison
	1	2	3	4	5	6	7	
Workday length (hours)	18	18	18	12	12	12	18	Average vs. long workday
Primary proficiency								
1. Percent fully qualified	0	0	0	90	90	90	0	High proficiency vs. low proficiency crew
2. Percent minimally qualified	10	10	10	10	10	10	10	
3. Percent unqualified	90	90	90	0	0	0	90	
Secondary proficiency								
1. Percent fully qualified	0	0	0	90	90	90	0	High proficiency vs. low proficiency crew
2. Percent minimally qualified	10	10	10	10	10	10	10	
3. Percent unqualified	90	90	90	0	0	0	90	
Average crew pace	1.0	1.0	1.0	1.0	1.0	1.0	1.25	Average vs. slow crew
Sea state	9	9	0	0	9	0	0	Calm vs. rough seas
Crew size	14	9	9	14	9	9	9	Large vs. small crew

4.5.1 *Workday Length and Proficiency Variations.* One of the many uses of the model can be phrased symbolically as:

$$A \cap B \approx C \cap D$$

That is, the occurrence of conditions A and B is approximately equivalent to conditions C and D (in terms of some criterion such as number of successful events). For example, an analyst might be interested in determining whether a crew of lesser proficiency, given more time to work, would perform as well as a crew of greater proficiency given less time. This type of analysis is illustrated in the sensitivity tests reported here. In this aspect of the sensitivity tests, proficiency and workday length were varied concurrently. Table 4-13 presents the workday length-proficiency parameter combinations investigated.

Parameter sets 2 and 3 include a long work day with a crew of low proficiency, while parameter sets 5 and 6 include a short work day with high proficiency. Comparisons between the results from parameter sets 2 and 5 and between parameter sets 3 and 6, accordingly, provide the desired data.

Figures 4-16, 4-17 and 4-18 present the simulation output resulting from the workday length-proficiency variation. The first of these figures indicates an increase in the average physical workload with the shorter workday-higher proficiency. For parameter set 2 in comparison with parameter set 5, as well as for parameter set 3 in comparison with parameter set 6, the increase amounted to better than 25 percent. It is possible that the faster crew has to work harder during the shorter time period allotted to them to complete the day's work and that their greater proficiency does not offset the necessary increase in physical labor. Parameter sets 3 and 6 indicated a much greater degree of physical load than the parameter sets 2 and 5. This result probably, as has been noted earlier, reflects the greater number of events ignored under adverse weather conditions.

Table 4-13. Workday Length and Proficiency Parameter Values for Parameter Sets 2, 3, 5, and 6

Parameters	Parameter Set			
	2 and 3		5 and 6	
Workday length (hours)	18		12	
Primary proficiency				
Percent fully qualified	0		90	
Percent minimally qualified	10		10	
Percent unqualified	90		0	
Secondary proficiency				
Percent fully qualified	0		90	
Percent minimally qualified	10		10	
Percent unqualified	90		0	
Sea state	$\frac{2}{9}$	$\frac{3}{0}$	$\frac{5}{9}$	$\frac{6}{0}$
Crew size	9	9	9	9

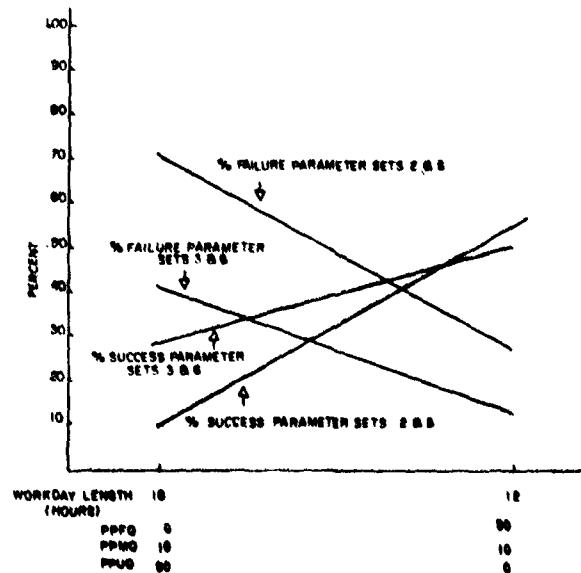


Figure 4-16. Event Success and Failure Percentage as a Function of Workday Length and Proficiency

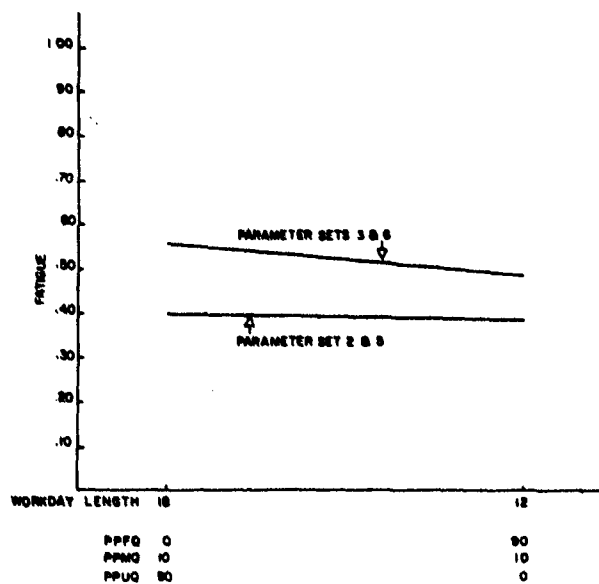


Figure 4-17. Average Fatigue as a Function of Workday Length and Proficiency

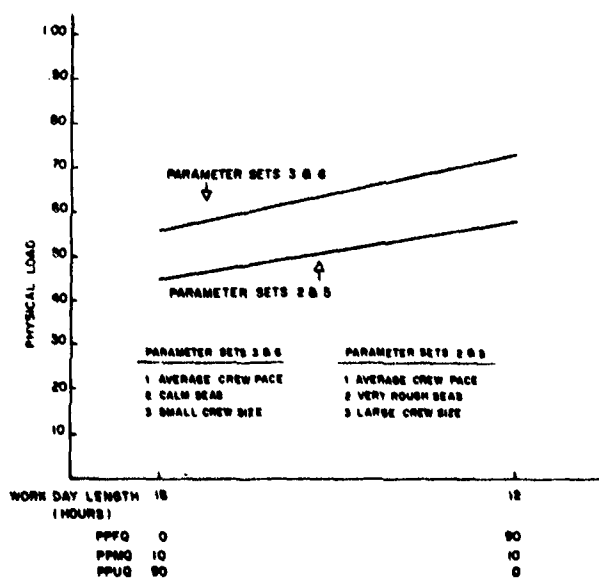


Figure 4-18. Average Physical Load as a Function of Workday Length and Proficiency

Figure 4-16 presents the effects on event success and failure percentages as the result of the workday length-proficiency variation. The percentage of event success increased dramatically for the higher proficiency crews. Analogously, percentage of event failure decreased with the increase in proficiency. While the shorter workday would probably have an effect, in and of itself, prior results with an earlier version of this model (Siegel, Wolf, & Cosentino, 1971) suggest that the large variations observed in event success and failure is primarily a function of the variation in proficiency.

Figure 4-17 presents the effect of varying the workday length and proficiency on average end-of-mission fatigue. No effect is indicated for the comparison of parameter sets 2 and 5. For parameter set 3, compared with parameter set 6, a drop of approximately .07 in fatigue was indicated in the higher proficiency-shorter workday combination. Coupled with the results presented in figure 4-18, this suggests that while the average physical load may increase because of the shorter workday, the fatigue level at the end of the day has actually been depressed. The higher average fatigue for parameter sets 3 and 6 is, once again, probably reflective of the large number of events ignored during adverse weather conditions.

4.5.2 Average Crew Pace Variations. Figure 4-19 shows the effect of varying average crew pace on event success and failure for parameter sets 3 and 7. The percentage of events failed increased and the percentage of events successfully completed decreased as the average pace of the simulated crew decreased. The percentage of events failed as a result of a 25 percent decrease in average crew pace (defined as a slow crew) increased approximately 13 percent, and the percentage of events successfully completed approximately 8 percent.

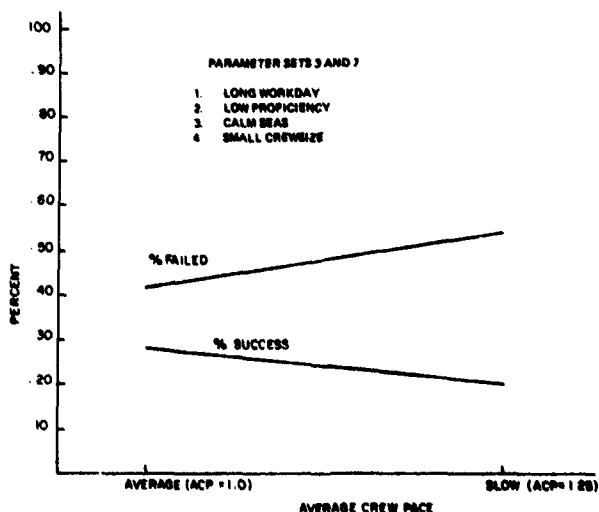


Figure 4-19. Event Success and Failure as a Function of Average Crew Pace

4.5.3 Variations in Sea State. The effect of variations in sea state on the model's output is illustrated in a comparison of the simulation results from parameter sets 2 and 3, and parameter sets 5 and 6. Parameter sets 2 and 3 are characterized by: long workdays, low proficiency crews, average crew pace, and small crews. Parameter sets 5 and 6 are characterized by: short workdays, high proficiency crews, average crew pace, and small crews. Parameter sets 2 and 5 have sea state values equal to 9 (rough seas) while parameter sets 3 and 6 have sea state values equal to 0 (calm and glassy) seas.

The effects of variation in the sea state parameter are shown in figures 4-20, 4-21, and 4-22. Figure 4-20 shows the effect of sea state variation on the average failure difference. As anticipated, both parameter sets indicated a larger margin between actual and acceptable performance (the failure difference) for the rough sea state condition. The larger failure differences observed for parameter set 2 as compared with parameter set 3 suggest that, according to the model, a lower proficiency crew working a longer worker day will suffer a significant performance degradation in rough seas and that this degradation is higher than for the short workday, high proficiency crews.

Figure 4-21 presents the effects on the percentage of events successfully completed or failed as a function of difference in sea state. Percentage of failure appears to increase significantly with adverse weather conditions. The effects on percentage of success appear to have been greatest in the comparison of parameter set 2 with parameter set 3. Here, a 14 percent decrease was indicated. The slight increase in percentage of successful events observed for parameter set 5 as compared with parameter set 6 (adverse weather conditions) (4 percent) is consistent with the prior indication of the model that higher proficiency crews working shorter workdays are less affected by the sea state.

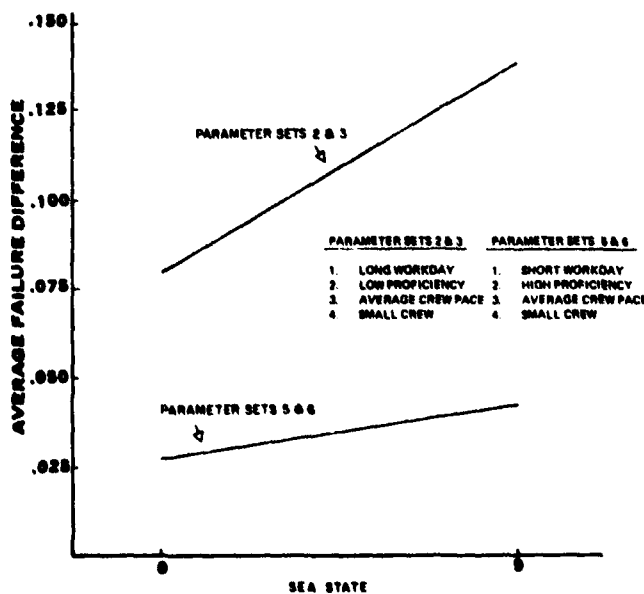


Figure 4-20. Average Failure Difference as a Function of Sea State

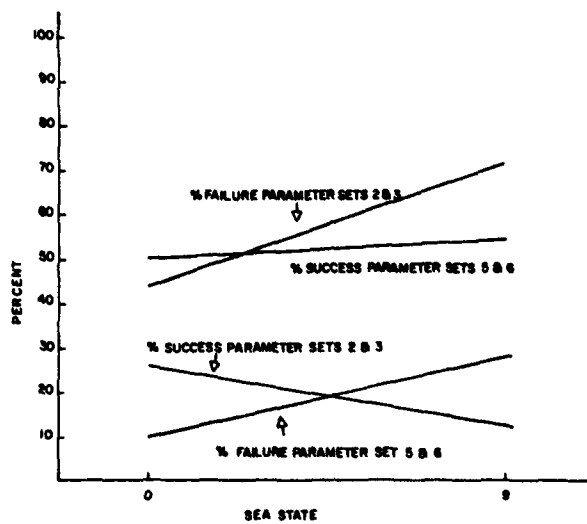


Figure 4-21. Event Success and Failure as a Function of Sea State

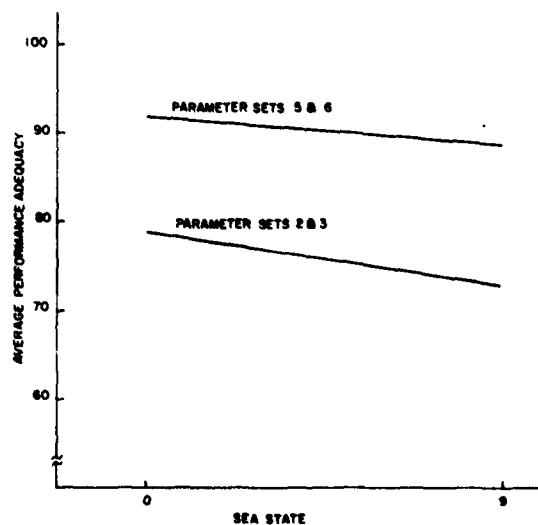


Figure 4-22. Average Performance Adequacy as a Function of Sea State

Figure 4-22 presents the effects of varying sea state on average performance adequacy (APA). Both parameter sets are in agreement. Each indicates a decrease in APA with increasing weather turbulence. Also, as predicted, the better crew (higher proficiency) of parameter sets 5 and 6 demonstrated higher APA. In summary, it appears from the average failure difference, percentage success/failure, and average performance adequacy data that the model yields results which are directionally sensitive in the anticipated direction when the new sea state variable is implemented.

4.5.4 Crew Size Variations. The results from parameter set 1 versus 2 and 4 versus 6 represent the effects of variations in crew size on the completion of the events in the simulated day's work. Parameter sets 2 and 6 include crew sizes of 9 men, while parameter sets 1 and 4 are simulations of crews with 14 men. Parameter sets 1 and 2 both involve: long workdays, low proficiency crews, average crew pace, and rough seas. Parameter sets 4 and 6 both include: short workdays, high proficiency crews, average crew pace, and calm seas.

Figures 4-23, 4-24, 4-25, and 4-26 present the effects of crew size variation on selected simulation output. Figure 4-23 indicates an increasing percentage of tasks successfully completed with increasing crew size for both comparisons. The percentage of tasks failed decreased from 71.2 to 65.9 with increasing crew size for parameter sets 1 and 2, while the percentage of tasks failed for parameter sets 4 and 6 remained relatively constant. The effects of crew size variation on task performance accordingly seems to have had its greatest impact on the percentage of tasks successfully completed. Task success percentage increased approximately 10 percent for parameter sets 1 and 2 (less than optimal conditions) and approximately 15 percent for parameter sets 4 and 6 (with more optimal conditions). Increases in the number of events failed with smaller crews seems to be coupled with less than optimal conditions. Large simulated crews were more able to handle the increased workload.

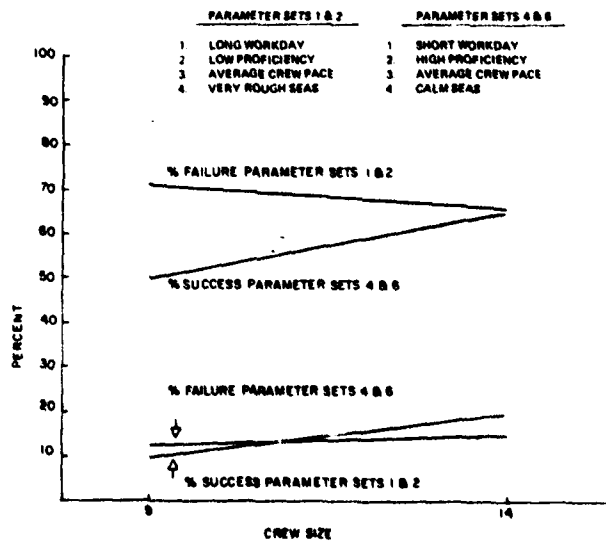


Figure 4-23. Event Success and Failure Percentage as a Function of Crew Size

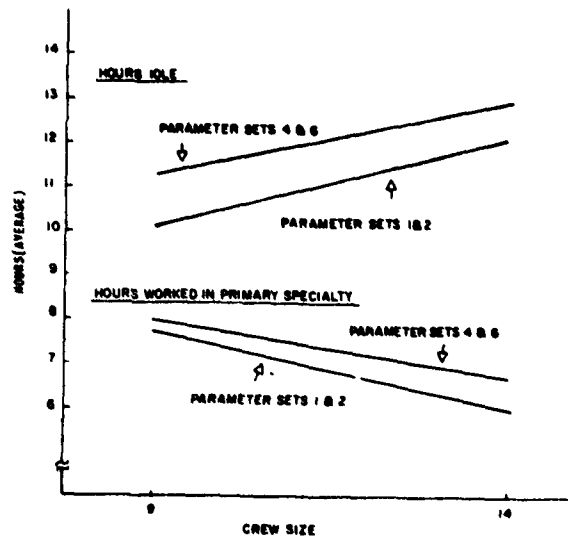


Figure 4-24. Hours (Average) Worked in Primary Specialty and Hours Idle as a Function of Crew Size

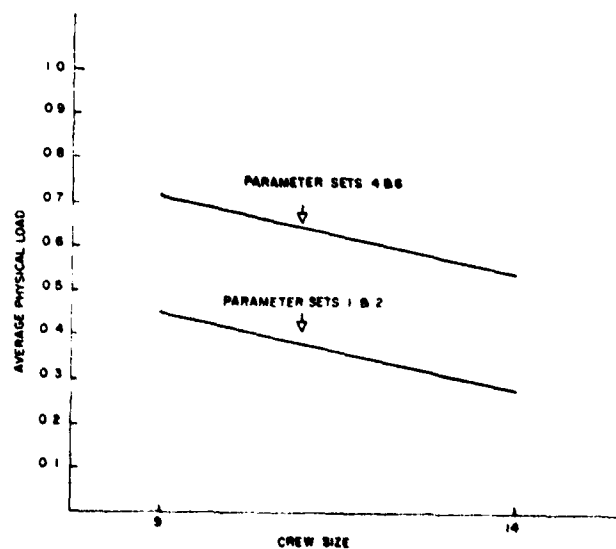


Figure 4-25. Average Physical Load as a Function of Crew Size

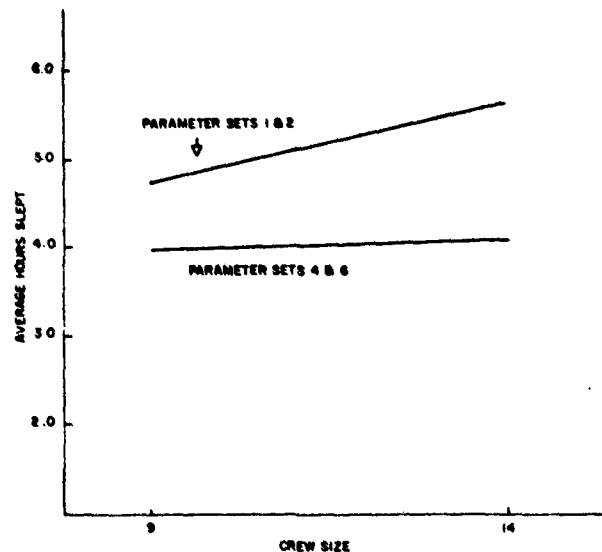


Figure 4-26. Average Hours Slept as a Function of Crew Size

Figure 4-24 indicates that more idle hours and less work by crew members in their primary proficiency accompanies larger crew sizes. Idle time was about 20 percent greater for parameter set 1 as compared with parameter set 2 and about 10 percent greater for parameter set 4 as compared with parameter set 6. The decrease in time worked in primary specialty is reflective of the general decrease in work time per crew man with increasing crew size.

Figure 4-25 shows the effect of crew size on average physical workload. Increasing the size of the crew results in a simulation output which indicated less physical workload per crew member. The difference in workload between parameter sets 1 and 2 (less than optimal conditions) and parameter sets 4 and 6 (more optimal conditions) reflects the greater number of events attempted (not ignored) and successfully performed (see figure 4-23) by the simulated crew under the more optimal conditions.

The effect of variations in crew size on average hours slept is shown in figure 4-26. With increasing crew size, the average number of hours slept increases for parameter sets 1 and 2, and parameter sets 4 and 6. The effect is marginal for parameter sets 4 and 6. For parameter sets 1 and 2, approximately a 20 percent increase in sleep time available under the more adverse conditions (parameter sets 1 and 2) is a function of more events being ignored.

4.5.5 Reliability Data. Human reliability, equipment reliability, and system reliability are provided in the run summary printout, figure 4-15. The reliability data are presented on the last line of the printout which is prepared after completion of all iterations of each run. The reliability data obtained during the tests described in paragraphs 4.5.1 through 4.5.4 are presented in tables 4-14 through 4-16.

Parameter sets 2 and 3 differed only in sea conditions. The sea state in parameter sets 2 and 3 was 9 and 0 respectively. Table 4-14 presents the reliability values for these parameter sets.

*Table 4-14 Overall Reliability Metrics for Parameter Sets 2 and 3 **

Parameter Set	MTBF		MTTR		Availability		System
	Human	Equipment	Human	Equipment	Human	Equipment	Availability
2	0.744	3.384	2.71	20.889	0.215	0.139	0.181
3	2.226	3.367	3.06	21.339	0.421	0.136	0.313

Table 4-15 presents the various reliability metrics comparing the results from parameter sets 3 and 7. These two parameter sets differed only in the assigned average crew pace. Parameter set 7 represented the slower crew. All the metric comparisons, with the exception of the HMTTR comparison, indicate superiority for the faster crew. There was a considerable increase in system availability as the result of manning the simulated system with a faster crew. However, again there is a reversal for the HMTTR comparison. The present thinking relative to this reversal is the same as that discussed for the prior parameter set comparison.

*Table 4-15 Overall Reliability Metrics for Parameter Sets 3 and 7 **

Parameter Set	MTBF		MTTR		Availability		System
	Human	Equipment	Human	Equipment	Human	Equipment	Availability
3	2.226	3.367	3.06	21.339	0.421	0.136	0.313
7	1.649	3.536	2.86	18.130	0.366	0.163	0.283

The effect of the crew size variable with a short workday, high proficiency crews, average crew pace, and calm seas is shown in table 4-16. Parameter set 4 includes a crew of 14 men, while parameter set 6 has a smaller crew (9 men).

*Table 4-16 Overall Reliability Metrics for Parameter Sets 4 and 6 **

Parameter Set	MTBF		MTTR		Availability		System
	Human	Equipment	Human	Equipment	Human	Equipment	Availability
4	5.314	2.829	1.88	18.754	0.739	0.131	0.531
6	6.953	3.157	4.60	15.829	0.602	0.166	0.441

The larger crew indicated a shorter HMTBF, a shorter HMTTR, a higher AVAIL, and a higher system availability. Here, all numerics are in the anticipated direction with a 20.4 percent increase in system availability resulting from the increase in crew size.

*Since this report was prepared, a number of additions have been incorporated in the model in the calculation of human reliability, MTTR, and availability indices. Corresponding changes have also been incorporated into the calculation of the various system metrics.

5.0

EMPIRICAL MODELS

5.1

Introduction

This section describes several useful empirical models and techniques developed during the Human Reliability Prediction System Program. These techniques can be used to provide useful system planning, design, and test information at several points in the system life cycle. The following tools are described:

- Lognormal distribution models which permit the maintenance parameters of systems to be estimated
- A simple regression model, called the maintenance power model, which relates repair time, man-hours, and repairman experience
- Multiple repairmen prediction models based on a matrix approach
- A flow chart maintainability prediction model which can be used in the multiple repairman case and with PM/FL
- A demonstration procedure which can be used with human reliability

These methods are generally applicable and examples are provided for several system types.

In this section, a new parameter called maintenance power is introduced. Maintenance power is the product of repair time, man-hours, and years of experience of the repairman. The average of this product over all repair actions provides a simple means of relating maintenance man-hours, mean experience, and mean repair time for any system. Maintenance power will be discussed in Section 5.3.2, below.

5.2

Lognormal Distributions of Maintenance Parameters

Maintenance parameters for any electronic equipment can be accurately described by the lognormal distribution. The one exception to this rule is the repair time for large systems. In this case, the full set of data points is frequently bi-modal—modes are identified for distinct sets of repair times of over and under some specific value. For large sonars this value is 10 hours.

The following maintenance parameters are described by a lognormal distribution:

- Repair time
- Man-hours
- Maintenance power
- Men assigned per repair
- Experience assigned per repair

The data in table 5-1 presents maintenance parameters for three typical electrical equipments and one typical mechanical equipment. The distributions of repair time and man-hours are plotted in figures 5-1 and 5-2. These examples are based on field data. Predictive models will be provided below.

Table 5-1. Maintenance Parameter Distributions

Equipment	Maintenance Parameter	Sample Size	Arithmetic Mean	Median	95th Percentile	Std Dev Log X
Large Sonar	Repair Time (≤ 10 hrs)	237	3.22 hrs	2.30 hrs	8.88 hrs	0.357
	Repair Time (all times)	283	8.55 hrs	3.46 hrs	31.70 hrs	0.585
	Man Hours (≤ 10 hrs)	237	5.23 hrs	3.29 hrs	16.10 hrs	0.419
	Man Hours ($\leq$ all times)	283	19.50 hrs	13.90 hrs	53.90 hrs	0.378
	Maintenance Power Men	283	68.10 hr-yrs	19.40 hr-yrs	3.25 hr-yrs	0.685
	Assigned	283	1.78 men	1.63 men	3.25 men	0.182
	Experience	283	3.80 yrs	3.59 yrs	6.27 yrs	0.148
Nose Landing Gear	Repair Time	82	0.74 hrs	0.70 hrs	1.24 hrs	0.149
	Man Hours	82	1.51 hrs	1.34 hrs	2.96 hrs	0.209
Airborne Digital Comp.	Repair Time	108	1.89 hrs	1.49 hrs	4.65 hrs	0.300
	Man-hours	108	2.72 hrs	1.89 hrs	7.67 hrs	0.369
Airborne Radio Set	Repair Time	108	0.88 hrs	0.72 hrs	2.09 hrs	0.280
	Man-hours	108	1.50 hrs	1.21 hrs	3.58 hrs	0.287
Airborne Radar Set	Repair Time	108	1.69 hrs	1.34 hrs	4.12 hrs	0.297

Some important properties of the lognormal distribution are shown in equations 5-1 through 5-5. If x is truly lognormally distributed, the parameters of the x distribution may be estimated as follows:

$$\bullet \text{ Estimate of median of } x = \text{geometric mean of } x = \text{Antilog } \left[\left(\sum_{i=1}^n \log x_i \right) / n \right] \quad (5-1)$$

where:

n is the sample size

$$\bullet \text{ Estimate of standard deviation of } \log x = \sigma$$

$$= \sqrt{\frac{1}{1.15} \left[\log \left(\frac{\text{Mean}}{\text{Median}} \right) \right]} \quad (5-2)$$

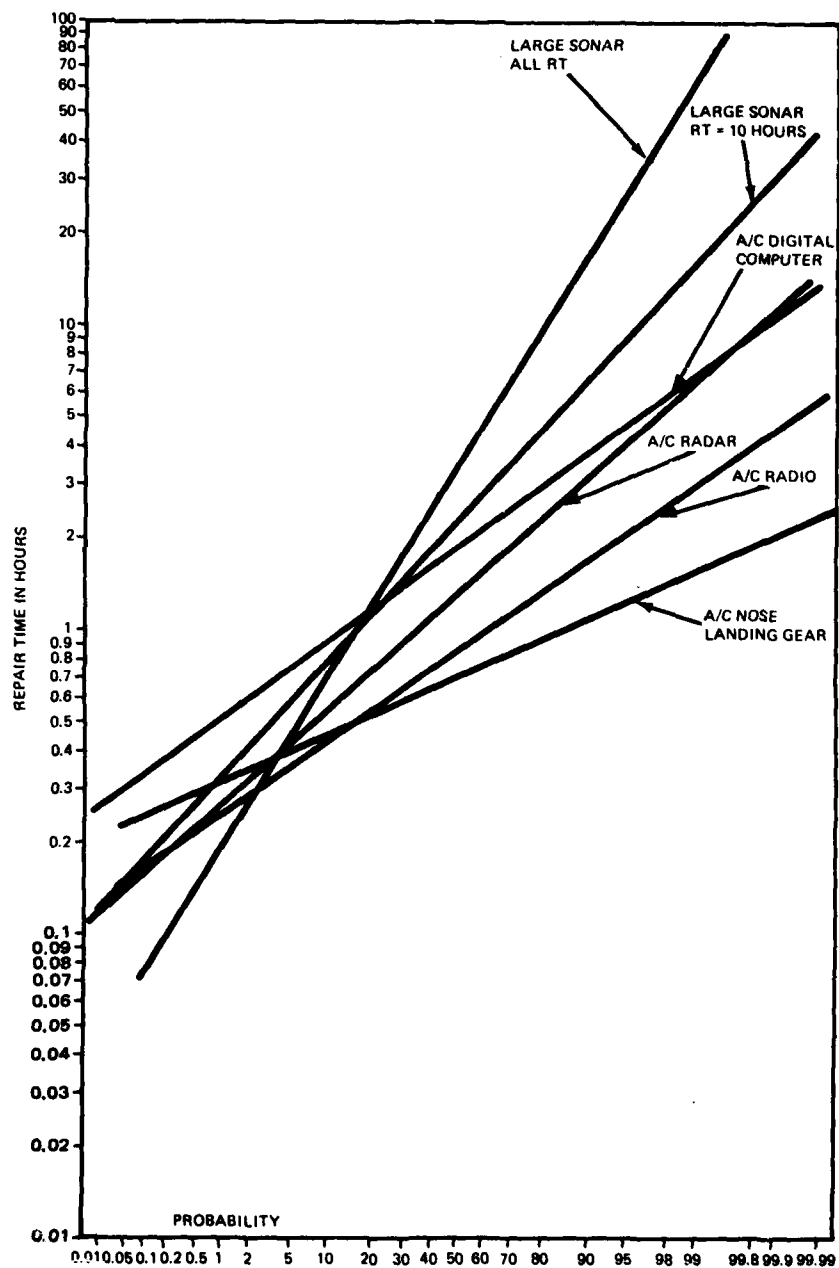


Figure 5-1. Repair Time Distribution for Large Sonar and Aircraft and Electronic and Mechanical Equipment

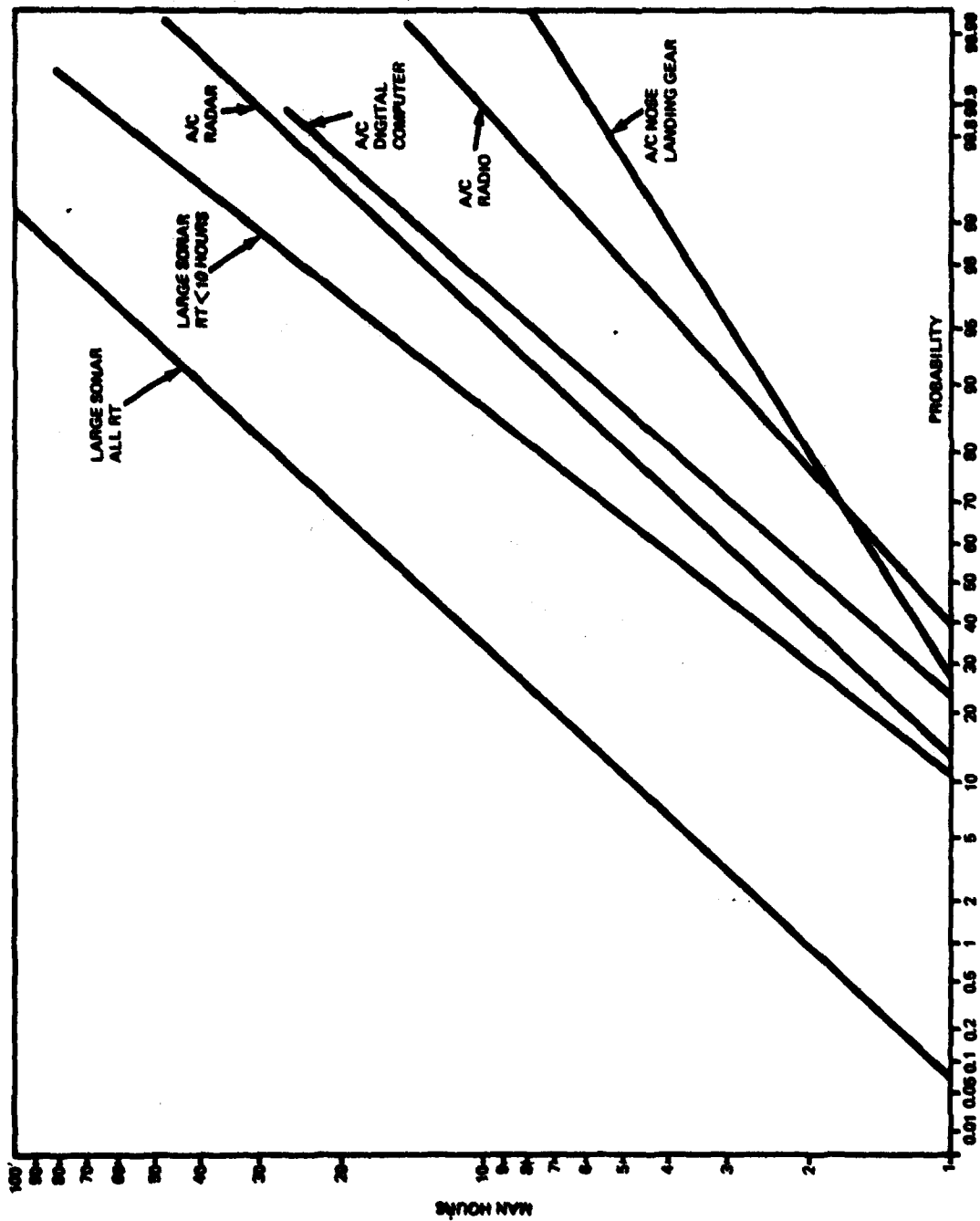


Figure 5-2. Man-Hour Distributions Large Sonar and Aircraft Electronics and Mechanical Equipment

- $x_{\max}$ (95th percentile)
 $= (\text{Median}) \exp [1.645\sigma/0.434]$ (5-3)

- Mode of $x = (\text{Median}) \exp [-(\sigma/0.434)^2]$ (5-4)

- $Z = [0.434/\sigma] [\ln(x/\text{MED})]$ (5-5)
 $Z = \text{standard normal variate with mean equal to zero and variance 1}$

These equations provide a convenient way to describe the distribution of the key maintenance parameters.

Figure 5-3 is a histogram of repair times for a large sonar. This chart clearly indicates the bi-modal nature of the repair time distribution.

Figure 5-4 presents a plot of average experience vs. repair time and man-hours. A useful finding is that average experience increases with repair time. Above 10 hours, average experience seems to decrease with repair time and man-hours. This finding indicates that more complex repair actions (as indicated by greater repair time) have more experience applied to them. It may, however, indicate the reverse; that more experienced repairmen are actually less proficient and take longer at repairs. More experimental work is needed to resolve this issue. Sufficient funds were not available in the Human Reliability Prediction System Program to obtain the data to draw conclusions about the curves' behavior above 10 hours.

5.3 Simple Lognormal Prediction Models

5.3.1 Simple Maintainability Prediction Techniques. These prediction methods make use of coefficients derived from service-wide maintainability data for specific system types. Predictions can be made for equipments as a function of repair crew size and experience. The prediction models described are designed to be independent of one another.

The models are used to estimate the following important maintainability parameters:

- Maintenance power (man-hours and experience as a function of repair time)
- Distribution of repair time per repair as a function of average repair crew experience
- Distribution of man-hours per repair as a function of average repair crew experience
- Number of repairmen per repair
- Repair crew experience
- Annual man-hours
- Average number of repairmen appearing within each experience category

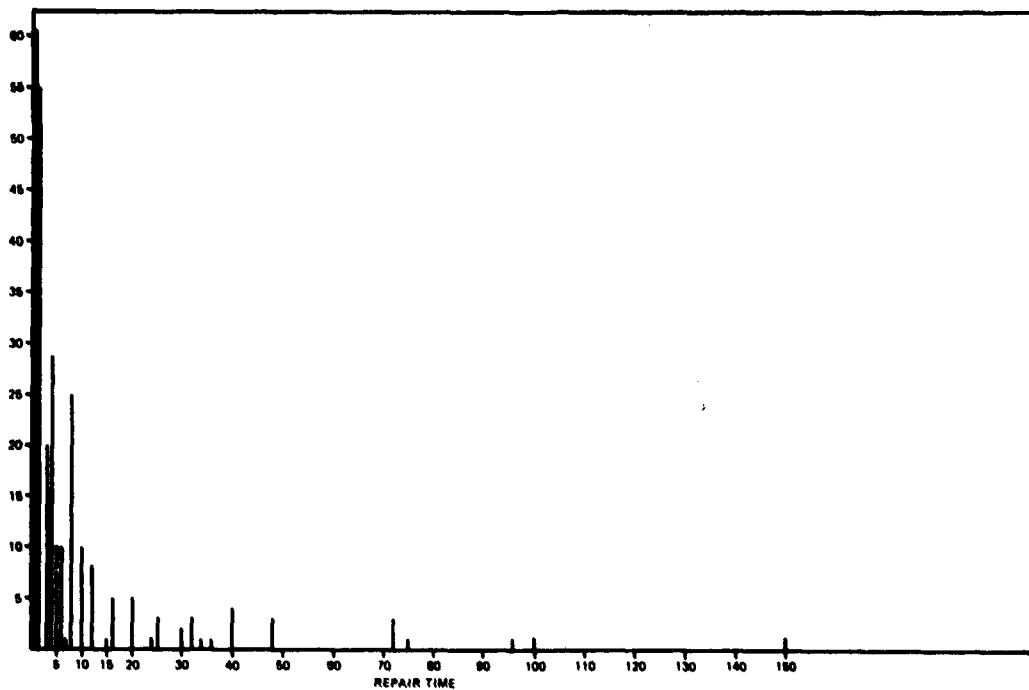


Figure 5-3. Histogram of Large Sonar Repair Time

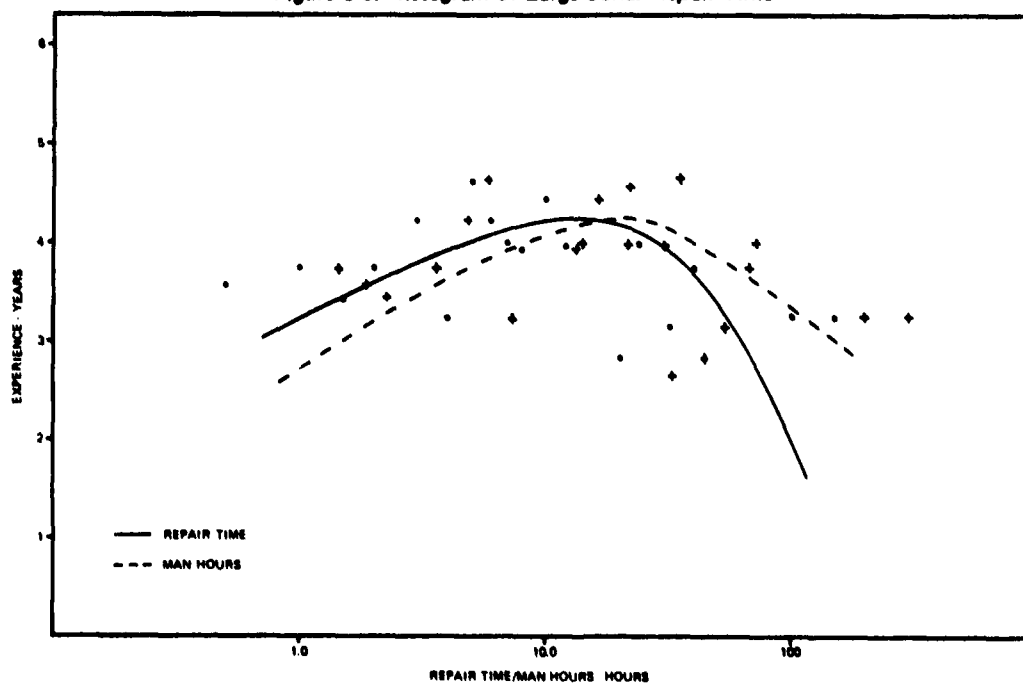


Figure 5-4. Experience vs Repair Time, Large Sonar

The prediction method described makes use of the following items, which can be derived by system type from service data:

- MTTR, geometric MTTR ($MTTR_G$), 95th percentile repair time, standard deviation of the logarithm of repair time (σ_R)
- Mean man-hour (MMH), geometric mean of man-hour (MMH_G), 95th percentile man-hour, standard deviation of the logarithm of man-hour (σ_M)
- Average number of repairmen per repair ($\bar{K}$), geometric mean of number of repairmen per repair ($\bar{K}_G$), 95th percentile number of repairmen per repair, standard deviation of the logarithm of number of men per repair (σ_K)
- Average repair crew experience ($\bar{E}$), geometric mean of experience ($\bar{E}_G$), 95th percentile of experience, standard deviation of the logarithm of experience (σ_E)

Each of the prediction methods is described in the following paragraphs.

5.3.2 Model for Maintenance Power. Maintenance power relates mean man-hours, mean repair time (MTTR), and mean experience levels. The maintenance power applied to a repair of any given repair time is equal to the average of the product of the experience levels (years) applied to the repair and the time expended (hours), within each experience level, over all repairs having that repair time.

Statistical analyses of fleet repair data for a large sonar system indicate a very close fit to a straight line equation of the form:

$$MP = \beta R_T = 8R_T \quad (5-6)$$

where

MP = Maintenance power

$\beta = 8$ = The slope of the regression curve

R_T = Repair time

The data indicates that equation 5-6 also describes the relationship between mean values, i.e.:

$$MP = 8 \cdot MTTR, \text{ or } MMH \bar{E} = 8 \cdot MTTR \quad (5-7)$$

where:

MMH = Mean man-hours

$\bar{E}$ = Average repair crew experience

The second form of equation 5-6 is very useful for early system planning for trade-off studies of maintenance man-hours, technician experience, repair time, availability, and life cycle support cost.

5.3.3 Repair Time Distribution Prediction. Using this model, the equipment repair time distribution can be estimated as a function of average repair crew experience. The curve in figure 5-4 gives average repair time as a function of average crew experience. This curve is limited in scope because it was derived from just one large sonar; however, it can be used to illustrate the method. The assumptions underlying the use of this model are as follows:

- Repair time is lognormally distributed.
- The standard deviation of the repair time distribution is not affected by changes in average number of repairmen per repair ($\bar{K}$) and average crew experience ($\bar{E}$). It appears reasonable to assume that the standard deviation is invariant across all systems in the service, for any given system type (σ_R).
- Experience and repair time relationships given in figure 5-4 are known.

The procedure for using the model to predict repair time distribution is demonstrated in example 5-1.

Example 5-1. Repair Time Distribution

Task Description

First, figure 5-4 can be used to estimate the average repair time for a given average experience level. For a hypothetical $\bar{E} = 4$ years, the average repair time ($MTTR$) = 4.9 hours.

The derived repair time distribution has $\sigma_R = 0.585$ hours. It is assumed that this value does not change. The other characteristics of the repair time distribution (except for σ_R) can be estimated as follows:

Applicable Formulas

$$MTTR_G = \text{Antilog} [\log MTTR - 1.15 \sigma_R^2] \quad (5-8)$$

$$\text{Maximum Repair Time} = MTTR_G \exp [1.645 \sigma_R / 0.434] \quad (5-9)$$

Procedures

Procedure

1. Substitute $MTTR$ and σ_R into the formula
2. Compute $MTTR_G$
3. Using $MTTR_G$, compute Maximum repair time ($MTTR_G \times \exp [1.645 \sigma_R / 0.434]$)

Example

1. $MTTR_G = \text{Antilog} [\log 4.9 - 1.15 \times (0.585)^2]$
2. $\text{Antilog} [\log 4.9 - 1.15 \times (0.585)^2]$
= 1.98 hours
3. Maximum Repair Time
= $1.98 \times \exp [1.645 \times 0.585 / 0.434]$
= $1.98 \times \exp 2.22$
= 1.98×9.18
= 18.18 hours

5.3.4 Man-hours Prediction. The distribution of man-hours per repair can be predicted as a function of average repair crew experience. Again, use is made of a figure such as 5-4. The assumptions for this model are as follows:

- Man-hours are lognormally distributed.
- The standard deviation of the man-hours distribution (σ_M) remains the same and is not affected by $\bar{E}$ and $\bar{K}$ changes. Changes in $\bar{E}$ appear to have very little effect on σ_M ; however, $\bar{K}$ changes do have some effect on man-hour characteristics. This is at least true when $\bar{K}$ values remain fairly close to the minimum required value dictated by the inherent maintainability characteristics of the equipment.
- Total man-hours = $\bar{K} \times (\text{MTTR}) \times \text{Number of Failures}$ (5-10)

The procedure for using the model to predict the distribution of man-hours per repair is demonstrated in example 5-2.

Example 5-2. Distribution of Man-hours Per Repair

Task Description

Compute the man-hour distribution where $\sigma_M = 0.378$ and average technician experience is 4 years.

Applicable Formulas

$$\text{Median man-hours (geometric mean: } MMH_G) = \text{Antilog} [\log MMH - 1.15 \sigma_M^2] \quad (5-11)$$

$$\begin{aligned} \text{Maximum man-hours} &= MMH_G \times \exp [1.645 \times \sigma_M / 0.434] \\ \text{(95th percentile)} & \end{aligned} \quad (5-12)$$

Procedures

Procedure

Example

1. Estimate mean man-hours (MMH) from graph in figure 5-4.	1. $MMH = 8.00$ hours
2. Compute median man-hours (geometric mean)	2. $MMH_G = \text{Antilog} [\log 8.00 - 1.15 \sigma_M^2]$ $= \text{Antilog} [\log 8.00 - 1.15 \times (0.378)^2]$ $= 5.48$ hours
3. Compute maximum man-hours (95th percentile)	3. Maximum man-hours (95th percentile) $= MMH_G \times \exp [1.645 \times \sigma_M / 0.434]$ $= 5.48 \times \exp [1.645 \times 0.378 / 0.434]$ $= 5.48 \times \exp [1.433]$ $= 5.48 \times 4.19$ $= 22.96$ hours

5.3.5 Prediction of Number of Repairmen per Repair. This model is used to predict the median and maximum (95th percentile) number of repairmen per repair based on knowledge of the average number of repairmen per repair ($\bar{K}$). For the sonar fleet data, $\bar{K} = 1.78$. The assumptions for this model are as follows:

- Number of repairmen per repair is lognormally distributed.
- σ_K is not affected by $\bar{E}$ and $\bar{K}$ changes. Experience with much data indicates that this is valid. $\sigma_K = 0.182$.

The procedure for using the model to predict the number of repairmen per repair is demonstrated in example 5-3.

Example 5-3. Repairmen per Repair

Task Description

Given $\sigma_K = 0.182$ compute repairmen per repair.

Applicable Formulas

Median repairmen per repair ($\bar{K}_G$):

$$\bar{K}_G = \text{Antilog} [\log \bar{K} - 1.15 \sigma_K^2] \quad (5-13)$$

$$\text{Maximum Repairmen per Repair} = \bar{K}_G \times \exp [1.645 \times \sigma_M / 0.434] \quad (5-14)$$

Procedures

Procedure

1. Compute $\bar{K}_G$

2. Compute maximum repairmen per repair (MRR)

Example

$$\begin{aligned} 1. \quad \bar{K}_G &= \text{Antilog} [\log \bar{K} - 1.15 \sigma_K^2] \\ &= \text{Antilog} [\log 1.78 - 1.15 \times (0.182)^2] \\ &= 1.63 \text{ Repairmen} \end{aligned}$$

$$\begin{aligned} 2. \quad \text{MRR} &= \bar{K}_G \times \exp [1.645 \times \sigma_M / 0.434] \\ &= 1.63 \times \exp [1.645 \times (0.182) / 0.434] \\ &= 3.25 \text{ Repairmen} \end{aligned}$$

5.3.6 Prediction of Repair Crew Experience. This model is used to predict the median and maximum experience level per repair. This model is based on the following assumptions:

- Repair crew experience is lognormally distributed.

- The standard deviation of the experience distribution (σ_E) remains constant and is not affected by $\bar{E}$ and K changes. For the purposes of simplicity in prediction, it is not unreasonable to make this assumption, $\sigma_E = 0.148$, from the available data.

The procedure for using the model to predict experience level per repair is demonstrated in example 5-4.

Example 5-4 Experience Level Per Repair

Task Description

The prediction is made using the average experience level per repair ($\bar{E}$) assumed as the input to the illustrative examples in this section. $\bar{E} = 4$ years. The model permits the median experience per repair and maximum experience per repair to be estimated.

Applicable Formulas

Median experience per repair ($\bar{E}_G$):

$$\bar{E}_G = \text{Antilog} [\log \bar{E} - 1.15 \sigma_E^2] \quad (5-15)$$

$$\text{Maximum experience per repair} = \bar{E}_G \times \exp [1.645 \sigma_E / 0.434] \quad (5-16)$$

Procedures

1. Compute $\bar{E}_G$	1. $\bar{E}_G = \text{Antilog} [\log \bar{E} - 1.15 \sigma_E^2]$ $= \text{Antilog} [\log 4 - 1.15 \times (0.148)^2]$ $= 3.77 \text{ years}$
2. Compute maximum experience per repair	2. Maximum experience per repair $= \bar{E}_G \times \exp [1.645 \sigma_E / 0.434]$ $= 3.77 \times \exp [1.645 \times (0.148) / 0.434]$ $= 6.61 \text{ years}$

5.3.7 Prediction of Annual Man-hours and Average Number of Repairmen Appearing at Each Experience Level. These parameters are very useful to logistics system planners. They provide data for manning level and life cycle cost estimates. In order to perform these calculations, it is assumed that:

- Repair crew experience and man-hour distributions have been calculated.
- Accumulated Man-hours at Experience Level E = Mean Man-hours/Man/Repair x Men Appearing at Experience Level E .

The procedure for using the model to predict annual man-hours and average number of repairmen at each experience level is demonstrated in example 5-5.

Example 5-6 Annual Man-Hours and Average Number of Repairmen in Each Experience Level

Task Description

Predict the experience distribution and plot the results as in figure 5-5. For the example, $E(\text{median}) = 3.77$ years and $E(95\text{th percentile}) = 6.61$ years.

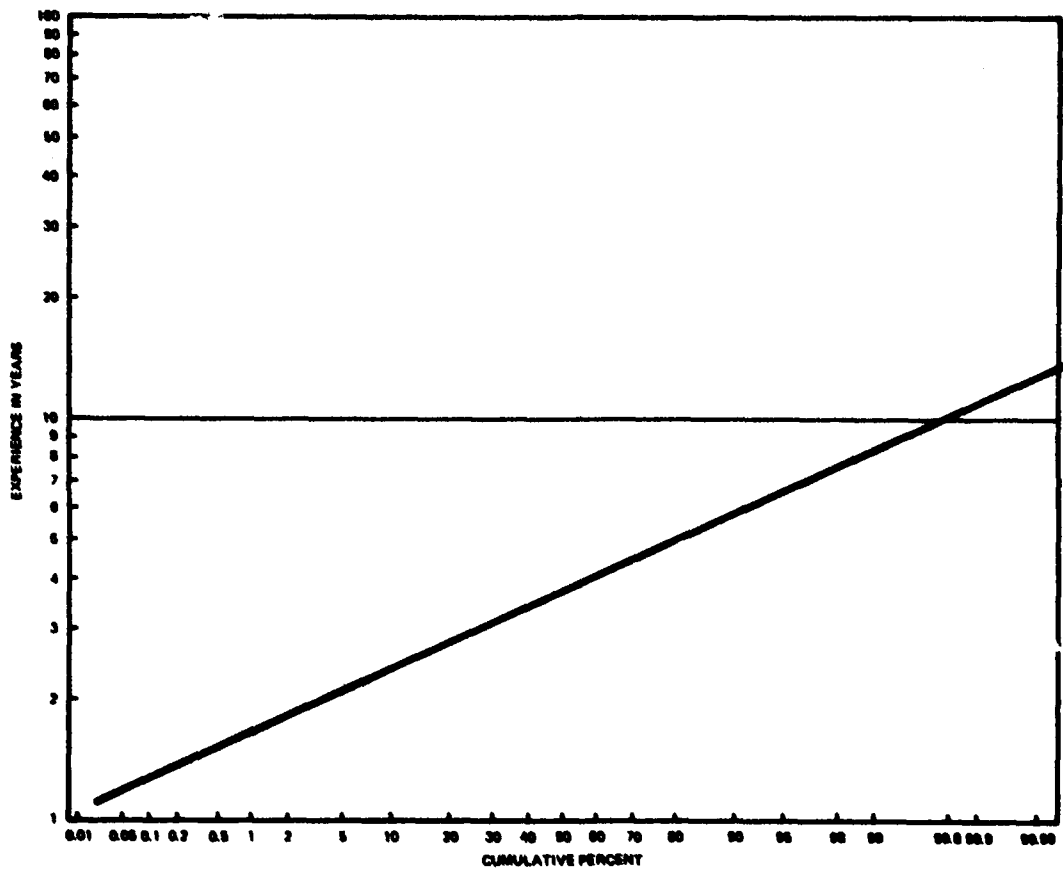


Figure 5-5. Typical Experience Cumulative Distribution

Given data:

- Average repairmen/repair ($\bar{K}$) = 1.78
- Annual operating time = 5,000 hours
- MTBF = 500 hours

Applicable Formulas

$$\begin{aligned} &\text{Average Annual Number of Repairmen} \\ &= (\text{Average Repairmen/Repair}) \times \left(\frac{\text{Annual Operating Time}}{\text{MTBF}} \right) \end{aligned} \quad (5-17)$$

$$\text{Total annual man-hours} = \text{Mean man-hours} \times \left(\frac{\text{Annual Operating Time}}{\text{MTBF}} \right) \quad (5-18)$$

$$\begin{aligned} &\text{Apportioned Repairmen} = \text{Percent in Experience Interval} \\ &\quad \times \text{Average Total Repairmen} \end{aligned} \quad (5-19)$$

$$\begin{aligned} &\text{Apportioned Annual Man-hours in Experience Interval} \\ &= \text{Percent in Experience Interval} \times \text{Annual Man-hours} \end{aligned} \quad (5-20)$$

Procedures

Procedure

1. List the ship's repair crew experience. Show range of experiences, cumulative percent and percent of each interval from the lognormal plot given in figure 5-5.
2. Compute average total annual number of repairmen in repair actions using formula 5-17.

Example

1. See table 5-2

2. Average annual number of repairmen

$$\begin{aligned} &= (\text{Average Repairmen/Repair}) \times \\ &\quad \left(\frac{\text{Annual Operating Time}}{\text{MTBF}} \right) \\ &= 1.78 \times \frac{5000}{500} \\ &= 17.8 \text{ repairmen in repair actions} \end{aligned}$$

3. Estimate the expected total accumulated annual man-hours using formula 5-18.

3. Total annual man-hours

$$\begin{aligned} &= \text{Mean man-hours} \times \left(\frac{\text{Annual Operating Time}}{\text{MTBF}} \right) \\ &= 8.0 \times \frac{5000}{500} = 80 \text{ hours} \end{aligned}$$

4. Use the experience distribution results (table 5-2) to compute the average number of repairmen in each experience level category (formula 5-19) and the associated number of man-hours (formula 5-20).

4. Computed for the 3 year experience interval

- a. Apportioned repairmen
 = percent in experience interval
 x Average total repairmen
 = 0.42×17.8
 = 7.48 repairmen

- b. Apportioned annual man-hours in
 experience interval
 = percent in experience interval
 x Annual man-hours
 = 0.42×80.00
 = 33.6 man-hours

Table 5-2. Experience Distribution Summary

Experience level (years)	3	4	6	8	10
Range of Experience (years)	0-3.5	3.5-5	5-7	7-9	9 or greater
Accumulative Percent (at upper band of experience range)	42%	87%	96.5%	99.5%	100%
Percent for each Interval	42%	45%	9.5%	3%	0.5%

5.3.8 Trade-off Relationships. The relationships presented above can be used for simple but efficient trade-off analyses between repair time, man-hours, experience levels, failure rates, spares stockage levels, availability, and costs.

Basic relationships presented in this section are:

$$MMH \cdot \bar{E} = \beta MTTR \quad (5-21)$$

$$MTTR = f(\bar{E}) \quad (5-22)$$

$$MMH = g(\bar{E}) \quad (5-23)$$

$$\text{Total man-hours} = \bar{K} \cdot MTTR \times \text{No. of failures} \quad (5-24)$$

$\bar{K}$ = Some known value

To these can be added the following relationship from classical reliability theory:

The reliability of the i th subsystem is $R_i(t) = e^{-\lambda_i t}$ (5-25)

where:

λ = failure rate of i th subsystem

System reliability calculations are adequately covered in many standard texts.

The subsystem availability is:

$$A_i(t) = \frac{1}{1 + \left(\frac{\lambda_i}{\mu_i} \right)} \quad (5-26)$$

where:

μ_i = repair rate of i th subsystem

The system availability is:

$$A_S(t) = A_1 \cdot A_2 \cdots A_N \quad (5-27)$$

The probability of running out of spares in mission of time T for each module type

i is:

$$P(\text{spares}) = \frac{e^{-\lambda_i T} (\lambda_i T)^S}{S!} \leq 0.1 \quad (5-28)$$

where:

S = number of spares

Simple equations for life cycle support costs or models such as the LOR model (MIL-STD-1390A) can be used to relate costs to design and support system parameters. These models and the above equations can be used to perform trade-offs.

5.4 Multiple Repairman Maintainability Prediction Model - The Matrix Model

5.4.1 Introduction. At the present time, the conventional maintainability prediction and demonstration procedures described in MIL-HDBK-472 and MIL-STD-471A are only associated with single man repair tasks. Also, differences in training and experience between the repairmen are not adequately accounted for in these prediction models. This section introduces a mathematical model for maintainability prediction that takes into consideration the effects of utilizing multiple repairmen, as well as considering differences in training and experience.

In the single-man repair situation, the man-hours and active repair (or elapsed) time are always identical; therefore, the maintainability characteristics of an equipment can be adequately expressed in terms of its repair time characteristics. In the situation of complex systems, repairs usually require the services of more than one repairman. Consequently, system maintainability characteristics can no longer be adequately defined by repair time characteristics alone; constraints on other characteristics (such as man-hours and number of repairmen) must also be defined.

The fact that repair time, man-hours, and the number of repairmen can all be approximated by lognormal distributions permits the assumption that multiple repairman actions may be shown to consist of a simple combination of single repairman actions using a matrix model. The matrix method of predicting MTTR's and MMH's is described in the next paragraph.

5.4.2. Matrix Calculations. The matrix method of maintainability prediction is best described by a series of illustrations for the parameter types of interest.

5.4.2.1 Calculation of MTTR_S. The arithmetic system MTTR, MTTR_S, is calculated by the following relationship:

$$MTTR_S = \sum_{i=1}^K \alpha_i \bar{M}_{AX_i} = \text{The mean time to repair the system} \quad (5-29)$$

where:

α_i = Probability that i repairmen are assigned.

i = Denotes the number of repairmen associated with a repair; i ranges from 1 through K .

$$\text{Note } \sum_{i=1}^K \alpha_i = 1. \quad (5-30)$$

$\bar{M}_{AX_i} = C_{X_i} \bar{M}_i$ = Human factor adjusted average system repair time for i men repair team.

C_{X_i} = Repair time human adjustment factor for i men repair team. This is a team-work factor reflecting gain in efficiency due to team-work. $0 < C_{X_i} \leq 1$.

Typical values of C_{X_i} for a large sonar system are:

$C_{X_1} = 1$, This is obvious for a 1-man team.

$C_{X_2} = 0.306$ for 2-man teams.

$C_{X_3} = 0.244$ for 3-man teams.

The equation for MTTR_S can be rewritten as:

$$MTTR_S = \sum_{i=1}^K \alpha_i \bar{M}_{AX_i} = \underline{\alpha}^T \underline{M}_{AX} = \underline{\alpha}^T \underline{A}_X \underline{M}_1 \quad (5-31)$$

where:

a^T = The transpose of a

I = Unit matrix

$$\Delta X = \begin{bmatrix} C_{X_1} & 0 & 0 \\ 0 & C_{X_2} & 0 \\ 0 & 0 & C_{X_3} \end{bmatrix}$$

The parameters of a typical large sonar problem are:

a_1 = Probability of 1-man per repair = 0.1

a_2 = Probability of 2-men per repair = 0.7

a_3 = Probability of 3-men per repair = 0.2

M = Mean repair time of 1-man repairs = 4.1 hours

Therefore, the $MTTR_g$ is obtained as follows:

$$a = \begin{bmatrix} 0.1 \\ 0.7 \\ 0.2 \end{bmatrix}$$

$$a^T = [0.1, 0.7, 0.2]$$

$$\Delta X = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.306 & 0 \\ 0 & 0 & 0.244 \end{bmatrix}$$

$$M = 4.1$$

$$I = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}, \quad I = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$

therefore:

$$\begin{aligned} \text{MTTR}_S &= [0.1, 0.7, 0.2] \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.306 & 0 \\ 0 & 0 & 0.244 \end{bmatrix} [4.1] \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \\ &= 1.49 \text{ hours} \end{aligned}$$

5.4.2.2 Calculation of Mean Man-hours per System Repair (MMH_S). The mean value of man-hours per system repair is given by:

$$\text{MMH}_S = \sum_{i=1}^K a_i \overline{\text{MH}}_{\text{AY}i} = a^T \overline{\text{MH}}_{\text{AY}} \quad (5-33)$$

where:

$$\overline{\text{MH}}_{\text{AY}M} = A_Y \overline{\text{MH}} \quad (5-34)$$

$$A_Y = \begin{bmatrix} C_{Y1} & 0 & 0 \\ 0 & C_{Y2} & 0 \\ 0 & 0 & C_{Y3} \end{bmatrix} \quad (5-35)$$

C_{Yi} = Human factor adjustment factor on man-hours. $0 < C_Y \leq 1$

Typical values for a large sonar system are:

$$\begin{aligned} C_{Y1} &= 1 \\ C_{Y2} &= 0.526 \\ C_{Y3} &= 0.451 \\ \overline{\text{MH}} &= [\text{MH}_1] \end{aligned} \quad (5-36)$$

Consider the large sonar of the previous example. If all parameters remain the same and the mean man-hours for a single repairman situation, $\text{MH}_1 = 4.1$ hours, the mean system man-hours can be calculated from

$$\begin{aligned} \text{MMH}_S &= [0.1, 0.7, 0.2] \begin{bmatrix} 1.0 & 0 & 0 \\ 0 & 0.526 & 0 \\ 0 & 0 & 0.451 \end{bmatrix} [4.1] \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \\ &= 2.29 \text{ hours} \end{aligned}$$

5.5

Flow Chart Maintainability Prediction

5.5.1 *Introduction.* At the present time, Procedure II in MIL-HDBK-472 is probably the most popular maintainability prediction procedure. However, because of its reliance on table 2-2 of that handbook the procedure can only be used for preliminary maintainability prediction studies,* since this table is rather insensitive to hardware design changes and totally insensitive to maintenance procedure improvements. Therefore, the Flow Diagram Maintainability Prediction Method is presented in order to estimate the maintenance times for a given system more realistically. This method improves maintainability prediction accuracy, helps to standardize troubleshooting procedures, reduce the expected number of maintenance steps, and establish a troubleshooting priority that is roughly consistent with circuit criticality. The method can be used for maintainability growth monitoring and man-hour prediction. Because the flow diagram can simulate most of the maintenance tasks, it is a highly desirable prediction method for contracts that require maintainability demonstration.

Another important characteristic of the method is that it can be used to predict arithmetic mean repair time and mean man-hours independent of the distribution of repair time. In addition, it can be used for analog and digital systems.

5.5.2

Basic Concepts. The following steps are used when applying the flow chart model.

- Conduct a Level of Repair analysis to determine the system's modular and replaceable part structure.
- Conduct a Failure Mode and Effects Analysis to determine the symptoms resulting from the failure of each replaceable item or module.
- Evaluate the results of the first two steps and construct a troubleshooting flow diagram which defines the logic and physical actions of the repair process. Rules which should be followed are:
 - Whenever feasible, each test point indication should eliminate from suspicion roughly half of the potentially faulty circuits. This rule is consistent with decision theory concepts using failure rates as the weighting factors.
 - Troubleshooting actions should consist of a logical deduction from visual analysis of selected signal outputs, the BITE/PMFL readings obtained while manipulating front panel controls and limited groups of modules/replaceable items. In some cases, testing by simple replacement may be necessary.

The flow chart is constructed under the assumption that only one independent circuit fault can occur in the receiver at a time, because the probability of two simultaneous independent faults is extremely low.

* Localization, isolation, alignment, and checkout times in MIL-HDBK-472, table 2-2, are based on the average maintenance test times of a wide variety of naval electronic equipments of vintage lots prior to 1965.

Determine the time required for each analytic and physical step in the flow chart:

- Test equipment setup time (t_s).
- Overall system diagnosis time (t_{od}) (This is the time required to determine the starting point of the analysis from system level indications.)
- Module isolation/localization time (t_{iLM}) (This is the average time required to trace through the logic paths to determine if a module is faulted. If several paths lead to the same module, they must all be included in the analysis.)
- Replaceable item isolation/localization time (t_{iLR}); same definition as for modules.
- Module replacement and check time (t_m) (This is the time to check the test points, jacks, and visual indicators on the suspected module, replace the module, and check its functioning. For some modules, alignment time is needed.)
- Replaceable item checkout time includes time to remove, replace, and check replaceable items.

Specific time elements can be derived from tables 2-2 to 2-5 in MIL-HDBK-472 and from the best judgment of the maintainability engineer, after consultation with design and maintenance personnel.

The MTTR is computed from the following equation:

$$MTTR = t_s + t_{od} + \frac{\sum \lambda_i R_{pi}}{\lambda_T} \quad (5-37)$$

where:

- t_s = test equipment setup time
- t_{od} = overall system diagnosis time
- λ_i = failure rate of the i 'th module or repairable/replaceable item
- λ_T = $\sum \lambda_i$
- $R_{pi} = t_{ii} + t_m$ = the time required to isolate, check, repair/replace, and check the i 'th module/part. This is derived by tracing through each path in the flow diagram.

The geometric mean of repair time (or median) is computed from:

$$MTTR_G = \text{Antilog} \left[\log t_s + \log t_{od} + \frac{\sum (\lambda_i \log R_{pi})}{\lambda_T} \right] \quad (5-38)$$

The standard deviation can be computed from:

$$\sigma = \sqrt{\frac{1}{1.15} \left(\log \frac{MTTR}{MTTR_G} \right)} \quad (5-39)$$

The 95th percentile can be computed from:

$$R_T(95) = MTTR_G \exp [1.645 \sigma / 0.434] \quad (5-40)$$

The procedure described above can be extended to the multiple repairman case quite simply, by assuming that certain groups of tasks can be performed in parallel. Each man works on a specific group of logical steps and physical activities, either completely in parallel or alternating. This allows the case of repairmen working at different locations (i.e., CIC and equipment room) to be evaluated. The case where several technicians must work together on heavy mechanical gear can also be considered.

5.5.3 Examples. The flow chart method can be illustrated by means of a simple example for a digital system which includes a power converter, two module groups, and a rack assembly. Organizational maintenance is performed by means of module replacement. Some visual fault locating is provided by means of an indicator lamp on the front face of critical modules. However, most fault locating must be accomplished by measuring the signals at a large number of test points which are brought out to the front face of the modules.

The flow chart procedure is illustrated as follows:

1. Figure 5-6 defines the overall troubleshooting procedure. If the system contained a sophisticated PM/FL, many logical steps in the analysis of the module groups would be zero, and the block "Overall System Diagnosis" might be slightly larger than three men.
2. Figure 5-7 illustrates the logical and physical steps used to isolate faulty power supply modules. The mean repair time calculation for the power converter is summarized below:
 - The process illustrated in figure 5-7 and step 2 is repeated for each module group and the rack assembly.
 - The MTTR calculation is summarized as follows:

Module Group at End of Line	λ_i	$\lambda_i R_{pi}$
Power Converter	2.9637836	8.112905
Module Group I	28.481625	329.996866
Module Group II	11.226419	126.5552210
Rack Assembly	0.841026	50.46156
Totals	43.512853	515.126552

$$\begin{aligned}
 MTTR &= 2 \text{ min} + 3 \text{ min} + \frac{515.126552}{43.512853} \\
 &= 16.84 \text{ min}
 \end{aligned}$$

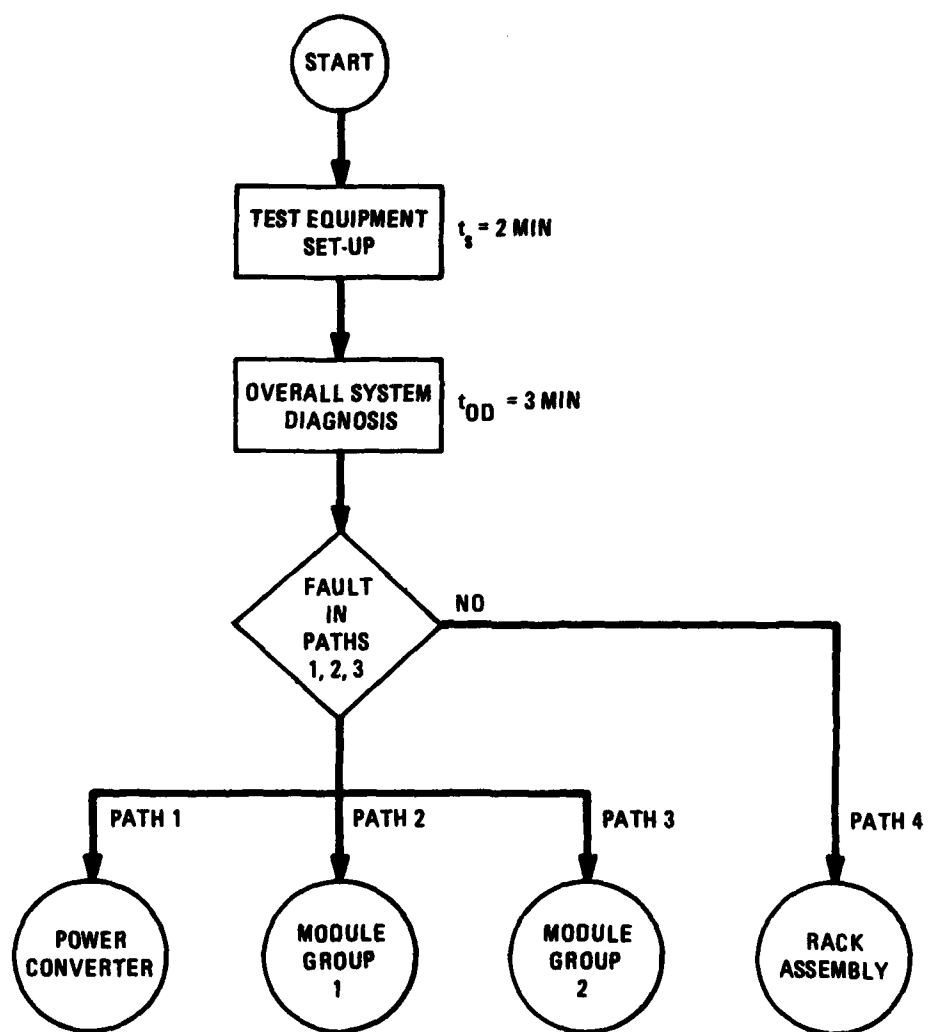


Figure 5-6. Digital System Maintenance Flow Chart



5.5.4 Impact of PM/FL System on Flow Chart Maintainability Prediction. If the system is equipped with a PM/FL system, the maintenance times associated with many of the diamond shaped decision blocks in the flow diagram will be reduced to zero. The system checkout time will also be reduced accordingly. When the troubleshooting and checkout times become negligible, the repair time characteristics, being dominated by the assembly/disassembly times, will generally become a normal distribution. However, when a PM/FL is not fully effective, the influence of troubleshooting times will remain substantial and the lognormal principle could still be applied for maintainability prediction.

At the present time, a common practice in PM/FL design is to enable the system to localize faults to a small number of modules; consequently, manual troubleshooting is still commonly used. In such cases, the system flow diagram shown may be broken down into a number of discrete flow diagrams, each being associated with a group of potentially faulty modules designated by the PM/FL system; consequently, the maintainability prediction approach will remain the same as that described in the previous paragraphs.

In case a group of faulty modules cannot be troubleshot by logical deduction of circuit functions, a common practice is to try the random spare module substitution method. In such a case, maintenance flow diagram may be abbreviated and the following mathematical model may be applied.

Given the following input parameters:

n = Number of modules in the group

λ_i = Failure rate of i^{th} module

i = The order of module substitution, that is:

Module 1 is substituted with a spare first. If it is not the faulty module, Module 2 will be substituted with its spare, etc., i has a range from 1 through n .

t_i = The estimated total repair time for the i^{th} module including all the wrong module substitution and checkout times.

The following may be calculated:

$$\frac{\lambda_i}{\sum_{i=1}^n \lambda_i} = \text{The probability the } i^{\text{th}} \text{ module is defective} \quad (5-41)$$

$$\text{Expected Group Repair Time} = \sum_{i=1}^n t_i \lambda_i / \sum_{i=1}^n \lambda_i \quad (5-42)$$

If $\bar{k}$ is the average module removal time plus spare insertion and checkout time, the total repair time for 2, 3, . . . n modules is given by:

$$\begin{aligned}
 t_2 &= t_1 + [k] \\
 t_3 &= t_1 + 2[k] \\
 t_n &= t_1 + (n-1)[k]
 \end{aligned}
 \tag{5-43}$$

If $\lambda_1 = \lambda_2 = \lambda_n$, the equation for Expected Group Repair Times becomes:

$$\sum_{i=1}^n t_i/n = t_1 + \frac{(n-1)}{2}[k]
 \tag{5-44}$$

If $t_1 = [k] + \text{Cover Removal \& Installation Time}$

$$\text{Expected Group Repair Time} = \frac{(n+1)}{2}[K] + \text{Cover}
 \tag{5-45}$$

5.6 Maintenance Parameter Demonstration

5.6.1 Introduction. Since repair time, man-hours, and number of men per repair are the inherent maintainability characteristics of an equipment, they should be specified in contract requirements and tested in maintainability demonstration. Repair times, man-hours, maintenance power, repairman experience, and men per repair are lognormally distributed. Consequently, the demonstration plan described in the following paragraphs can be used to test each of these maintainability parameters.

5.6.2 Demonstration Procedure Model 1 - The Median. This demonstration tests the acceptability of the median of a lognormal variate (x) when the requirement is specified in terms of both a specified median (M_0) and a maximum median (M_1). The basic test model is derived from Test Plan 4 of MIL-STD-471A (sample size = 20). The hypothesis testing model is shown in figure 5-8.

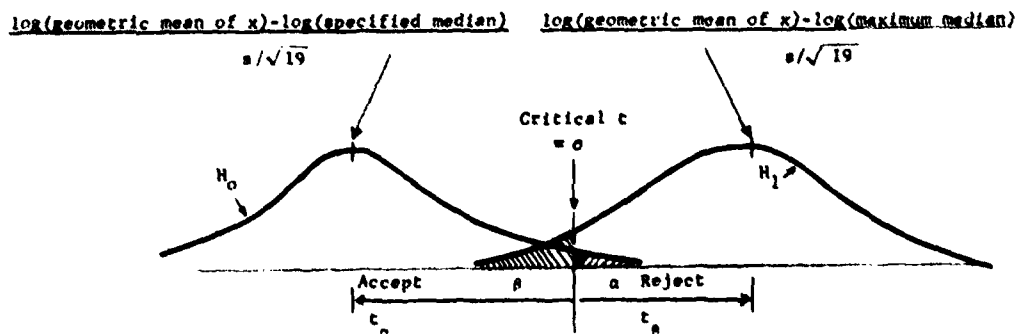


Figure 5-8. Hypothesis Testing of the Median

The null hypothesis is

$$H_0: M \leq M_0 = \text{specified median} \quad (5-46)$$

The alternate hypothesis is

$$H_1: M > M_1$$

This accept-reject criteria requires that both of the following be true:

$$\left[\frac{\log(\text{geometric mean of } x) - \log(\text{specified median})}{s} \sqrt{19\Delta - t_\alpha} \right] \quad (5-47)$$

indicates H_0 is true with $\Delta(1-\alpha)$ probability

$$\left[\frac{\log(\text{geometric mean of } x) - \log(\text{maximum median})}{s} \sqrt{19\Delta - t_\beta} \right] \quad (5-48)$$

indicates H_1 is true with $\Delta \leq \beta$ probability

where:

α = producer's risk that the system will be rejected even if $M < M_0$

β = consumer's risk that the system will be accepted even if $M > M_1$

M_0 = Specified median of x

M_1 = Specified maximum median of x

Geometric Mean of x = $\text{Antilog } \sum_{i=1}^n (\log x_i)/n$

s = Estimate of the standard deviation of logarithm of x

$$s = \sqrt{\frac{\sum_{i=1}^n (\log x_i)^2 - n \left[\log(\text{geometric mean of } x) \right]^2}{n-1}}$$

t_α, t_β = values of student's t distribution at percentage points α, β i.e.

$$t_\alpha = 1.729 \text{ for } \alpha = 0.1$$

$$t_\beta = 1.328 \text{ for } \beta = 0.2$$

$n = \text{sample size} = 20$

5.6.3 Demonstration Procedure Model 2 - The Mean. This demonstration model tests the acceptability of the mean of a lognormal variate (x) when the requirement is stated in terms of a minimum acceptable or specified mean (μ_0) and a specified maximum mean (μ_1). The basic model is the same as that outlined in MIL-STD-471A Test Plan 1A. The detailed hypothesis testing model is shown in figure 5-9.

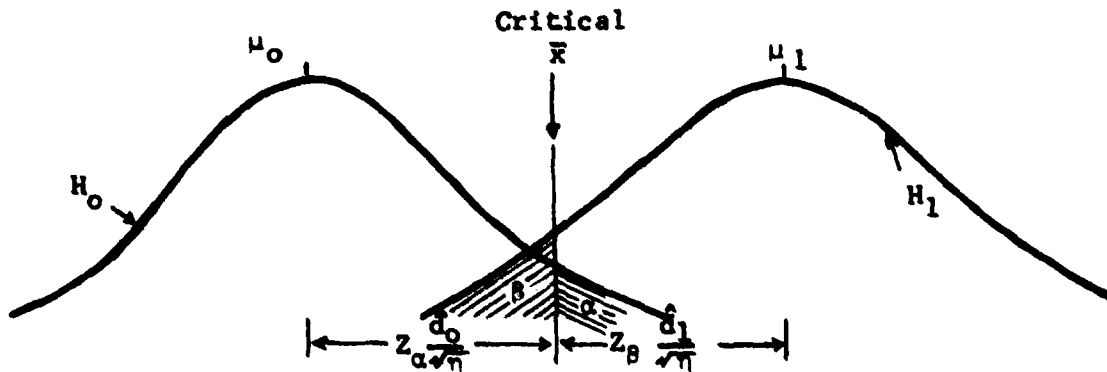


Figure 5-9. Hypothesis Testing of the Mean

This method assumes σ^2 (the variance of $\ln X$) is unchanged regardless of whether the null hypothesis H_0 or alternate hypothesis H_1 is true; however, because of the assumption that x is lognormally distributed, the variances of the maintenance times d_0^2 and d_1^2 are not equal.

The null hypothesis is

$$H_0: \mu \leq \mu_0 = \text{specified mean of } x \quad (5-50)$$

The alternate hypothesis is

$$H_1: \mu \geq \mu_1 = \text{specified mean of } x \quad (5-51)$$

The accept-reject rules are

$$\text{Accept } H_0 \text{ if } \bar{X} \leq \mu_0 + Z_\alpha \frac{d_0}{\sqrt{n}} \text{ and } \bar{X} \leq \mu_1 - Z_\beta \frac{d_1}{\sqrt{n}}$$

Reject H_0 otherwise.

where:

$$d_0 = \mu_0 \sqrt{\exp \sigma^2 - 1}$$

$$d_1 = \mu_1 \sqrt{\exp \sigma^2 - 1}$$

$$\hat{\theta}^2 = \sum_{i=1}^n \frac{\ln x_i - [\ln (\text{geometric mean of } x)]^2}{n-1}$$

$$\bar{X} = \sum_{i=1}^n X_i/n$$

n = the sample size which should be at least 30 or larger

6.0

ALLOCATION OF MAN-MACHINE RELIABILITY

6.1

Introduction

This chapter presents an allocation methodology which is based on conventional optimization techniques and permits equipment acquisition and human operator/maintainer constraints to be readily addressed. The methodology incorporates the human as a part of the system by combining the human reliability results described in the previous chapters with conventional hardware reliability models. A simple example is provided to illustrate application of the methodology.

6.2

Basic Concepts

The central concept of the man-machine allocation is the "Operational Reliability" concept (Ref 37).

The Operational Reliability concept extends conventional reliability concepts. It considers the human as an integral part of the system and considers the fact that systems are frequently developed for more than one mission. Operational Reliability is defined as the probability of successful operation of a total man-machine system over all mission employments of that system. The man-machine system consists of the system hardware, software, interfaces and personnel. In quantitative terms, Operational Reliability is written as:

$$R_{op} = \sum_i p_i r_i \quad (6-1)$$

where the p_i 's represent the probabilities that certain missions will be employed and the r_i 's are the mission reliabilities. The expressions selected for the mission reliabilities will include the human element. The Operational Reliability concept can be combined with cost and personnel constraints and the human reliability models to permit the optimal allocation of reliability to man-machine system elements.

6.3

Formulation of the Allocation Method

Mission reliability and operational readiness are the best parameters for optimization because of their wide applicability. Other parameters that could be selected are mean-time-to-failure and mean-time-to-repair, but these should only be used as a descriptor of mission reliability and operational readiness. Availability may be used in place of operational readiness depending on the planned use of the system. Bazovski (Ref. 4) provides an excellent discussion for distinguishing between readiness and availability. The parameters selected provide a direct link between high level effectiveness requirements and component oriented design parameters such as MTBF, MTTR, and numbers and skill level of personnel.

To apply mission reliability and operational readiness to the allocation, first identify critical functions and their reliability and maintainability design parameters and use these to write expressions for the mission reliability and operational readiness of the man-machine system. The mission reliability expression plays a dual role since it provides an input to the expression for operational reliability and to the mission reliability constraint. One mission reliability constraint equation and one operational readiness equation must be written for each mission.

Cost and personnel constraints must also be constructed. Personnel can be specified many ways. For purposes of the allocation, the most convenient way is to specify numbers of men at discrete skill level. This method allows clear definition of the effect of the human component on system mission reliability and operational readiness. For example, crew size and skill level can be related to MTTR, which also impacts operational readiness and mission reliability (where repair is a factor). Numbers and skill levels are critical parameters in the human reliability models.

Acquisition cost, support cost, and life cycle cost can all be used as constraints. One important consideration is that optimizing against one type of cost constraint does not necessarily optimize against the others. Regardless of the cost constraint selected, the cost of the system must be defined in terms of human and hardware contributions and in terms of the basic design parameters to be allocated.

The allocation problem can be written as an optimization problem. The parameters to be optimized would be, for example, function MTBF, function MTTR, and numbers and skill levels of personnel. The problem formulation would be:

$$\text{Maximize } R_{op} = \sum_i p_i r_i \quad (6-2)$$

subject to

$$\text{Mission reliability} = R_m > \bar{R}_m$$

$$\text{Operational readiness} = P_{or} > \bar{P}_m$$

$$\text{Personnel} = N \leq \bar{N}$$

$$\text{Cost} = C \leq \bar{C}$$

Constraints are written as vectors to represent the fact that there will be one set of constraint equations for each mission. Equation 6-2 leads directly to the standard form for optimization problems. Additional equations which can be used in the optimization process were given as equations 5-21 through 5-28.

Conventional methods can be employed to solve the allocation problem for the design parameters which are used as the basic set of variables. Dynamic programming is the most straightforward method of solution. Other methods can also be used.

The presentation of the formulation of the allocation problem has been quite general. Any number of practical situations in both the commercial and military fields can be represented according to the choice of requirements and constraints. To show how one might apply this general formulation to a practical situation, a simple example has been provided in the following section. The example also shows how the mathematics becomes rather complicated even when a simple system is analyzed.

6.4 Sample Allocation Problem

In this section the formulation of a specific allocation problem will be illustrated. A very simple system configuration, shown in figure 6-1, will be used. Here, the λ 's and μ 's correspond to failure rates and repair rates for their respective system components. At this point, no assumption is made about their mathematical characteristics.

For simplicity, the simple system has no human operator functions, but does have human maintainer functions, defined by repair rates. The maintainers are of two skill levels, represented by E_1 and E_2 .

The system will be employed on only two missions, A and B, with mission probabilities p_A and p_B , and mission times T_A and T_B . Each mission requires a mission reliability, r_A and r_B , and an operational reliability, X_A , and X_B . Regardless of mission, the number of maintenance men cannot exceed N and the cost of the entire system, men and machines, cannot exceed C .

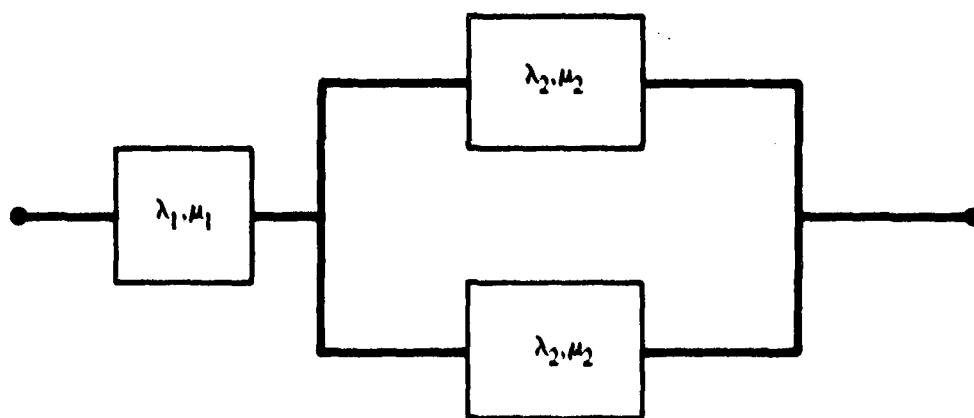


Figure 6-1. System Configuration for Sample Problem

For our "first order" approach, the repair rate is considered a constant, and the probability of correct repair is represented by:

$$P_{\mu}(t) = 1 - e^{-\mu t} \quad (6-3)$$

Note that according to chapter 5, μ , mean time to repair, is a function of personnel number and skill level so that $\mu = \mu(n_1, n_2, \mu_0)$, where n_1 and n_2 are numbers of maintainers at each skill level and μ_0 is the equipment configuration impact. $P_{\mu}(t)$, then, is actually, $P(n_1, n_2, \mu_0; t)$. The maintenance power model can be manipulated to show that

$$MTTR = MMH \cdot E_{ave} \cdot \frac{1}{\beta} \quad (6-4)$$

where, for the example

$$E_{ave} = \text{average skill level} = \frac{n_1 E_1 + n_2 E_2}{n_1 + n_2}$$

is derived from assignment probabilities and equipment repair characteristics as they impact repairs by given numbers of men as described in the discussion of basic concepts.

The reliability function for the system is given by:

$$R(Z, t) = R(\lambda_1, \lambda_2, n_1, n_2, \mu_0, t) = \frac{s_1 e^{s_2 t} - s_2 e^{s_1 t}}{s_1 - s_2} \times e^{-\lambda_1 t} \quad (6-5)$$

where

$$s_1 = -\frac{1}{2} [3(\lambda_2 + \mu_2) - \sqrt{\lambda_2^2 + 6\lambda_2\mu_2 + \mu_2^2}]$$

$$s_2 = -\frac{1}{2} [3(\lambda_2 + \mu_2) + \sqrt{\lambda_2^2 + 6\lambda_2\mu_2 + \mu_2^2}]$$

To write operational readiness, Bazovsky's expression must be modified to account for preventive maintenance.

The following equation provides the appropriate expression for operational readiness.

$$P_{OR}(Z, t) = P_{OR}(\lambda_1, \lambda_2, n_1, n_2, \mu_0, t) = R(Z, t) + \sum_i Q_i(Z, t) P_i(t_r < t_c) + \sum_i F_i(Z, t) P_i(t_r < t_c) \quad (6-6)$$

where the latter summation is the preventive maintenance analog to the corrective maintenance summation of Bazovsky. For the example under consideration:

$$P_{OR}(Z, t) = R(Z, t) + Q_1(Z, t) P(\mu_1, t_c) + 2Q_2(Z, t) P(\mu_2, t_c) + F_1(Z, t) P_1(t_c) + 2F_2(t) P_2(t_c) \quad (6-7)$$

From equations 6-5 and 6-7, the operational reliability expression, the mission reliability and the operational readiness constraints can be written as:

$$R_{OP} = P_A R(Z; T_A) + P_B R(Z; T_B) \quad (6-8)$$

$$e^{-\lambda_1 T_A} \frac{s_1 e^{s_2 T_A} - s_2 e^{s_1 T_A}}{s_1 - s_2} > r_A$$

$$e^{-\lambda_1 T_B} \frac{s_1 e^{s_2 T_B} - s_2 e^{s_1 T_B}}{s_1 - s_2} > r_B$$

$$\begin{aligned}
& R(Z;T_A) + Q_1(Z;T_A)P(\mu_1, t_c) + 2Q_2(Z;T_A)P(\mu_2, t_c) \\
& + F_1(Z;T_A)P_1(t_c) + 2F_2(Z;T_A)P_2(t_c) \geq X_A \\
& R(Z;T_B) + Q_1(Z;T_B)P(\mu_1, t_c) + 2Q_2(Z;T_B)P(\mu_2, t_c) \\
& + F_1(Z;T_B)P_1(t_c) + 2F_2(Z;T_B)P_2(t_c) \geq X_B
\end{aligned}$$

The personnel constraint is easier to write as follows:

$$n_1 + n_2 \leq N \quad (6-9)$$

The cost model can be written a variety of ways, depending on the choice of cost model. For this simplified example, costs are modeled by:

$$C_{\text{hardware}} = K/\lambda \quad (6-10)$$

$$C_{\text{personnel}} = kn$$

For the example, the total system cost constraint is given by:

$$K_0 \left(\frac{1}{\lambda_1} + \frac{1}{\lambda_2} \right) + K_1 n_1 + K_2 n_2 \leq C \quad (6-11)$$

Even with the simplifications made, a dynamic programming solution is required.

Simulation models can also be used to allocate man-machine reliability. The outputs of the human reliability prediction simulations described in chapters 3 and 4 can be combined with dynamic programming algorithms for optimum allocation (figure 6-2). These programs provide output of sufficient detail to permit suboptimization.

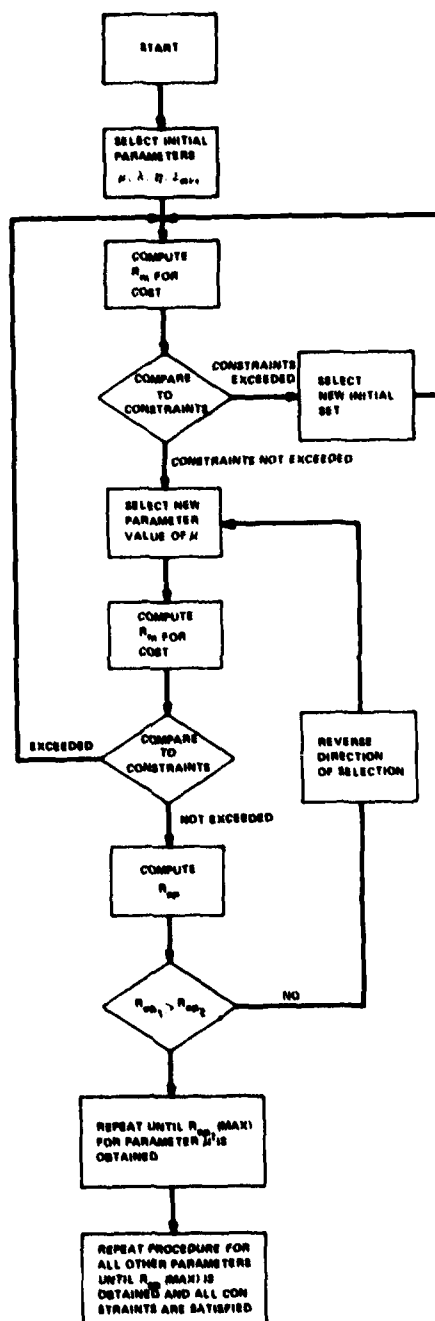


Figure 6-2. Simplified Dynamic Programming Procedures

REFERENCES

1. Applied Psychological Services. *The logic and processing of human behavioral variables in the HASSLE program*. Wayne, Pa: February 1966.
2. Balaban, H.S., & Costello, D.L. *System effectiveness--concepts and analytic techniques*. 267-01-7-419. Annapolis: ARINC Research Corporation, 1964.
3. Bard, P. *Physiological investigations of causes and nature of motion sickness*. Report No. 485, September 30, 1945, National Research Council Committee on Aviation Medicine.
4. Barnes, R.M. *Motion and time study*. New York: Wiley, 1954.
5. Bazovski, I., Sr., *Weapon Systems Operational Readiness*, Proceedings, 1975 Reliability and Maintainability Symposium Washington, D.C. 28-30 January 1975, pp 174-178.
6. Bekey, G.A., & Gerlough, D.I. Simulation. In R.E. Machol (Ed.), *Systems engineering handbook*. New York: McGraw Hill, 1965.
7. Birren, J.E. *Motion sickness: Its psychophysical aspects. A survey report on human factors in undersea warfare*. Washington, D.C.: Committee on Undersea Warfare, 1949.
8. Blanchard, R.E. *Survey of Navy user needs for human reliability models and data*. Santa Monica, Calif.: Behaviormetrics, 1972.
9. Bruner, J.M. Seasickness in a destroyer escort squadron. *U.S. Armed Forces Medical Journal*, 1955, 6, 469-490.
10. Bryan, G.L. In M.E. Dunnette, G.T. Milkovich, and S.J. Motowildo (Eds.), *Possible approaches for development of a naval personnel status index (NPSI)*. Minneapolis: Personnel Decisions, 1973.
11. Caldwell, L.S. Relative muscle loading and endurance. *Journal of Engineering Psychology*, 1963, 2, 155-161.
12. Campbell, D.T., & Fiske, D.W. Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, 1959, 56, 81-105.
13. Chinn, H.I. What is motion sickness? In *Symposium on Motion Sickness with Special Reference to Weightlessness*. Wright-Patterson AFB, Ohio: Aerospace Medical Research Laboratories, 1963.
14. Damon, A., Stoudt, H.W., & McFarland, R.A. *The human body in equipment design*. Cambridge, Mass.: Harvard University Press, 1966.
15. Deutsch, M. Field theory in social psychology. In G. Lindzey (Ed.), *Handbook of social psychology*. Cambridge, Mass.: Addison-Wesley, 1954.
16. Dunnette, M.E., Milkovich, G.T., & Motowildo, S.J. (Eds.), *Possible approaches for development of a naval personnel status index (NPSI)*. Minneapolis: Personnel Decisions, 1973.
17. Fagan, T.L., & Wilson, M.A. *Monte Carlo simulation of system reliability*. Undated.
18. Federman, P.J., & Siegel, A.I. *Prediction of human reliability. II. Validation of a set of human reliability prediction techniques*. Wayne, Pa: Applied Psychological Services, 1973.

19. Fleishman, E.A. *The dimensions of physical fitness--the nationwide normative and developmental study of basic tests*. New Haven: Yale University Department of Industrial Administration and Department of Psychology, 1962.
20. Fleishman, E.A., Kremer, E.J., & Shoup, G.W. *The dimensions of physical fitness--a factor analysis of strength tests*. New Haven: Yale University Department of Industrial Administration and Department of Psychology, 1961.
21. Fleishman, E.A., Levine, J.M., Glickman, A.S., Siegel, A.I., Lautman, M., Alluisi, E.A., & Goldstein, I.L. *A program for research in human performance*. AIR-33700-6173-FR. Washington, D.C.: American Institutes for Research, 1973.
22. Friedman, M. *Essays in positive economics*. Chicago: University of Chicago Press, 1953.
23. Ghiselli, E.E., & Brown, C.W. *Personnel and industrial psychology*. New York: McGraw-Hill, 1955.
24. Hamilton, R.L. & Bennett, M. *Reliability, availability, and maintainability (RAMA)*. NSRDL Letter Report No. 1-22, Annapolis: Naval Ship Research and Development Center, 1970.
25. Hansen, R., Cornog, D.Y. *Annotated bibliography of applied physical anthropology in human engineering*. Wright-Patterson AFB, Ohio: Wright Air Development Center, Technical Report 56-30, 1958.
26. Hare, A.P. *Handbook of small group research*. New York: Free Press Macmillian, 1962.
27. Harris, W., Mackie, R.R., & Wilson, C.C. *Performance under stress: a review and critique of recent studies*. Los Angeles: Human Factors Research, 1956.
28. Hemingway, A., & Green, E.L. Airsickness during early flight training. *Journal of Aviation Medicine*, 1945, 16, 406-416.
29. Hertzberg, H.T.E., Daniels, G.S., & Churchill, E. *Anthropometry of flying personnel--1950*. Wright-Patterson AFB, Ohio: Wright Air Development Center, Technical Report 52-321, 1954.
30. Kavanagh, M.J., MacKinney, A.C., & Wolins, L. Issues in managerial performance: Multitrait-multi-method analyses of ratings. *Psychological Bulletin*, 1971, 75, 34-49.
31. Kelley, H.H., & Thibaut, J.W. Experimental studies of group problem solving and process. In G. Lindzey (Ed.), *Handbook of social psychology*. Cambridge, Mass.: Addison-Wesley, 1954.
32. Kleitman, N. *Sleep and wakefulness*. Chicago: University of Chicago Press, 1963.
33. Krech, D., & Crutchfield, R.S. *Theory and problems of social psychology*. New York: McGraw-Hill, 1948.
34. Lamb, J. Test of a basic assumption of human performance modeling. *Proceedings 1971 US Navy Human Reliability Workshop*, NUSC Technical Document 4437, 19-22.
35. Lamb, J.C., & Williams, K.E. *Prediction of operator performance for sonar maintenance*. IEEE Transactions on Reliability, Vol. R-22, No. 3, August 1973.

36. LaSala, K.P. and Jenkins, J.P. Operational Reliability to Secure Reliable Systems, *1975 SOLE Proceedings*, August 1975, p 269.
37. LaSala, K.P., Siegel, A.I., & Sontz, C. Allocation of man-machine reliability. *Proceedings 1976 Annual Reliability and Maintainability Symposium*, IEEE No. 76CHO 1044-7RQC.
38. Leuba, H.R. *The human factors ingredient in system effectiveness*. Annapolis: ARINC Research Corporation, 1968.
39. Lewin, K. Time perspective and morale. In G. Watson (Ed.), *Civilian Morale*. Boston: Houghton, 1942. Cited by D. Krech and R.S. Crutchfield, *Theory and problems of social psychology*. New York: McGraw-Hill, 1948.
40. Meister, D. *Criteria for development of a human reliability methodology*. Paper presented at U.S. Navy Human Reliability Workshop, Naval Ship Systems Command, Washington, D.C., 1970.
41. Orbach, S. *Generalized effectiveness methodology (GEM) analysis program*. LP 920-72-1, SF-013-14-03. Brooklyn, N.Y.: Naval Applied Sciences Laboratory, 1968.
42. Osgood, C.E., & Suci, G.J. A measure of relation determined by both mean difference and profile information. *Psychological Bulletin*, 1952, 49, 251-262.
43. Siegel, A.I. Paper prepared for Naval Ships Command Symposium, 1973.
44. Siegel, A.I., & Federman, P.J. *Development of performance evaluative measures: Investigation into and application of a Fleet posttraining performance evaluative system*. Wayne, Pa.: Applied Psychological Services, 1970.
45. Siegel, A.I., & Federman, P.J. *Prediction of human reliability. Part I: Development and test of a human reliability predictive technique for application in electronic maintainability prediction*. Warminster, Pa.: Naval Air Development Center, Contract N63369-71-C-0014, 1971.
46. Siegel, A.I., Lautman, M.R., & Wolf, J.J. *A multimethod-multitrait validation of a digital simulation model*. Wayne, Pa.: Applied Psychological Services, 1972.
47. Siegel, A.I., Lautman, M.R., & Wolf, J.J. *Digital simulation of the performance of intermediate size crews: A multimethod-multitrait validation of a digital simulation model*. Wayne, Pa.: Applied Psychological Services, 1972.
48. Siegel, A.I., & Miehle, W. *Extension of a prior personnel subsystem reliability determination technique*. Wayne, Pa.: Applied Psychological Services, 1967.
49. Siegel, A.I., & Miehle, W. *Maintenance personnel subsystem reliability prediction for the HIND-SIGHT system*. Wayne, Pa.: Applied Psychological Services, 1967.
50. Siegel, A.I., & Schultz, D. *A multidimensional scaling analysis of the job performance of naval aviation electronics technician*. Wayne, Pa.: Applied Psychological Services, 1962.
51. Siegel, A.I., & Schultz, D.G. *Post-training performance criterion development and application: A comparative multidimensional scaling analysis of the tasks performed by Naval electronics technicians at two job levels*. Wayne, Pa.: Applied Psychological Services, 1963.

52. Siegel, A.I., & Wolf, J.J. *Man-machine simulation models: Performance and psychological interaction*. New York: Wiley, 1969.
53. Siegel, A.I., & Wolf, J.J. *Techniques for evaluating operator loading in man-machine systems. A description of a model and the results of its first application*. Wayne, Pa.: Applied Psychological Services, 1959.
54. Siegel, A.I., & Wolf, J.J. *Man-machine simulation models, psychological and performance interaction*. New York: Wiley, 1969.
55. Siegel, A.I., Wolf, J.J., & Cosentino, J. *Digital simulation of the performance of intermediate size crews: Application and validation of a model for crew simulation*. Wayne, Pa.: Applied Psychological Services, 1971.
56. Siegel, A.I., Wolf, J.J., & Cosentino, J. *Application and validation of a model for crew simulation*. Wayne, Pa.: Applied Psychological Services, 1971.
57. Siegel, A.I., Wolf, J.J., & Fischl, M.A. *Digital simulation of performance of intermediate size crews: Logic of a model for simulating crew psychosocial and performance variables*. Wayne, Pa.: Applied Psychological Services, 1969.
58. Siegel, A.I., Wolf, J.J., & Lautman, M.R. *A model for predicting integrated man-machine systems reliability*. Wayne, Pa.: Applied Psychological Services, 1974.
59. Siegel, A.I., Wolf, J.J., & Lautman, M.R. A Family of Models for Measuring Human Reliability, *Proceedings, 1975 Reliability and Maintainability Symposium*, Washington, DC, 28-30 January 1975, pp 110-115.
60. Smith, R.L., Westland, R.A., & Crawford, B.M. The status of maintainability models: A critical review. *Human Factors*, 1970, 12, 271-284.
61. Sontz, C., & Lamb, J.C. *Predicting system reliability from human data*. Proceedings of 1975 Reliability and Maintainability Symposium. January 1975.
62. Sontz, C., & Lamb, J.C. Predicting system reliability from human data. *Proceedings 1975 Annual Reliability and Maintainability Symposium*, IEEE No. 75 CHO 918-3 RQC, 105-109.
63. Tappen, N.C. An anthropometric and constitutional study of championship weight lifters. *American Journal of Physical Anthropology*, 1950, 8, 49-64.
64. Torrance, E.P. A theory of leadership and interpersonal behavior. In L. Petrullo and B.M. Bass (Eds.), *Leadership and interpersonal behavior*. New York: Holt, Rinehart & Winston, 1961.
65. Tyler, D.B. The influence of placebo, body position, and medication on motion sickness. *American Journal of Physiology*, 1946, 146, 458-466.
66. Webb, P. (Ed.), *Bioastronautics data book*. Yellow Springs, Ohio: Webb Associates, 1964.

67. Wechler, D. *The range of human capacities*. Baltimore: Williams & Wilkins, 1935.
68. Whitlock, G.H. Application of the psychophysical law to performance evaluation. *Journal of Applied Psychology*, 1963, 47, 15-23.
69. WSEIAC (Weapon System Effectiveness Industry Advisory Committee), *Final Report of Task Group II. Prediction-measurement*. AFSC-TR-65-2, Vols. I, II, and III. Andrews AFB, Maryland: Air Force Systems Command, 1965.

APPENDIX A VARIABLES AND FORTRAN CODES

This appendix lists and defines the variables in the digital simulation program as follows:

- Appendix A1 - variables in the program for the 1-2 man digital simulation model
- Appendix A2 - principal subscript variables and FORTRAN codes for the 4-20 man digital simulation model

APPENDIX A1: LIST OF VARIABLES FOR PREPROCESSOR

This appendix lists and defines the variables in the digital simulation program for the 1-2 technician model.

Variable List for Preprocessor
(Subroutine RAM)

<u>FORTRAN IV</u> <u>Program Name</u>	<u>Description</u>
AID(I,J)	Average increase or decrease in $\bar{P}_{ij}$ for individual task elements.
ICE(I,J)	It's close enough indicator, adjustment to within .01 of the theoretically perfect combination of probabilities was considered sufficient.
IOK	Counter to determine when all probabilities have been adjusted to acceptable values.
JAG(I,J)	Technician type of each crewman.
NG(JAG,J)	Number of task element success probability before manipulation.
PG(JAG,J)	Cummulative probability of success of task elements within each job activity group.
INR(JAG,J)	The NG^{th} root of SPOG.
IP(JAG,J)	The total potential increase for all task elements in each job activity group.
SPOG(JOG,JOT)	The overall success probability of each technician type on each job activity group.

Variable List for Main Routine

<u>FORTRAN IV</u> <u>Program Name</u>	<u>Description</u>	<u>Symbol Used</u> <u>in Reports</u>
A1	Average time at which a task was completed by operator 1, taken over a run (summary run output).	
A2	Average time at which a task was completed by operator 2, taken over a run (summary run output).	
A3	Frequency distribution-average stress over a run at the beginning of each task for operator 1, (summary run output).	
A4	Frequency distribution-average stress over a run at the beginning of each task for operator 2, (summary run output).	
ADDSTR	Stress additive.	A_{ij}
AFS	Average final stress over N iterations (summary run output).	
ALPH	Joint task indicator (detailed output).	
APS	Average peak stress over N iterations (summary run output).	
ASTS	Average starting total stress per task, per operator.	
ATMU	Average time to complete each task and all preceding tasks.	
ATU	Average time used over N iterations (summary run output).	
ATW	Average waiting time over N iterations (summary run output).	
AUGSTR	Augmented stress= total stress.	S_{ij}
AVD	Average final goal aspiration difference over N iterations.	

Variable List for Main Routine (cont.)

AVGCOH	Frequency distribution-average cohesiveness for each task over a run (summary run output).	
AVGTM	Average task execution time (input)	$\bar{t}_{ij}$
AVGTMD	Time deviation-average sigma (input).	$\bar{\sigma}_{ij}$
BLK	Temporary storage block for the calculation of a success probability modifier.	
BLOCK	Average of ISUMF and ISUMI.	
COHES	Cohesiveness.	C_{ij}
COHLAS	Last cohesiveness value (summary iteration output).	
CONVER	Conversion constants for time scaling.	
CWAIT	Total time spent for cyclic wait during an iteration (summary iteration output).	
DT	Difference (time used-time available).	
ESS	Essentiality indicator (input).	E_{ij}
FO2	Constant= 0.02.	
GOF	Total number of task failures during iteration.	
GOSF	Total number of all tasks during an iteration.	
HEAD	Designator for title of plotted results.	
I	Task number.	i
IASTS	Count of the number of tasks per iteration.	
IAVG	Count of successful tasks per iteration.	
ICALI	Indicator for entry/reentry to input subroutine.	
ICHNG	Number of iterations before output type is changed (input).	

Variable List for Main Routine (cont.)

IFREQ	Frequency distribution-number of items that each task was ignored (summary run output).
IFREQF	Frequency distribution-number of times that each indicated task was failed (summary run output).
IFREQL	Frequency distribution-number of times that each task was the last task completed (summary run output).
IGNORE	Flag for essential/non essential tasks.
IN	Standard system input tape number= 5.
IND1	Indicator for number of times random number generator is called before run starts (input).
IND2	Type of output for first ICHNG iterations (input).
IND3	Subtracted from IND2 after ICHNG iterations. Controls level of detail of output for first ICHNG iterations (input).
IND4	Always equal 1 (input) (could be deleted).
IND5	Unit code for time units (input).
IO	Standard system output magnetic tape number= 6.
IP	Other operator= partner
IPKF	Frequency distribution-number of times peak stress occurred on specific task (summary run output).
IPREC	Task precedence (input).
IPRECS	Temporary for IPREC.
IQ	Temporary for NXTS.
IRET	Indicator for goal aspiration program segment entry.
ISTRS	Task number on which peak stress occurred (summary iteration output).

j'

d_{ij}

Variable List for Main Routine (cont.)

ISUC	Indicator for task success or failure.	
ISUMI	Total number of tasks ignored over a run (summary run output).	
ISUMF	Total number of task failures over a run (summary run output).	
ITASK	Current task number.	
ITER	Iteration number (iteration summary output).	
ITMUP	Iterim variable in the calculation of the staring time for cyclic task.	
J	Operator number.	j
JP	Other operator designator.	
JT	Temporary location for JP,J.	
K	Operator number (iteration summary output).	
NINPC	Number of task data cards, also the sum of the last task number for each operator (input).	
NMAX	Number of tasks for the operator who possess the greater number of tasks.	
NOTSK	Average number of all tasks per iteration over N iterations.	
NRUN	Run number.	
NTASK	Number of tasks assigned to each operator.	
NUMCOH	Number of tasks in which cohesiveness is calculated.	
NUMIT	Number of iterations per run (input).	N
NUMRUN	Number of runs (input).	
NUMSUC	Number of iteration successes per run.	
NUMTRL	Trial number.	
NXTF	Number of next task if current task is failed (input).	(i,j) _f

Variable List for Main Routine (cont.)

NXTJ	Next task indicator for current operator on special jump task.	
NXTJP	Next task indicator for partner on special jump task.	
NXTS	Number of next task if current task is successful (input).	$(i,j)_s$
OT	Indicator of task success (blank), failure (F), or ignore (I).	
OV	Overrun/underrun indicator (iteration summary output).	
PERF	Performance= number of success/total number of tasks.	
PI	Constant= 3.141...	
PRBSUC	Average probability of task success, probability that next task will be NXTS.	$\bar{P}_{ij}$
PRD	Period for cyclic tasks (input parameter).	P_j
PRSUC	Percentage of iteration successes in a run.	
PV1	Three dimensional array for storage of dependent variable plots.	
PV2	Three dimensional array for storage of independent variable plots.	
RDEV	Random number normally distributed with mean= 0, and sigma= 1.	
SFI	Success/failure indicator.	
SPEED	Individuality factor (input parameter).	F_j
STRM	Stress threshold (input parameter).	M_j
STR	Stress, also final stress at end of iteration.	s_{ij}
STRS	Peak stress of an iteration (summary iteration output).	

Variable List for Main Routine (cont.)

SUMCOH	Sum of cohesiveness values over an iteration.	
SUMTF	Total time of all failed tasks over a run (run summary output).	
SWAIT	Average cyclic wait over N iterations (summary run output).	
T1	Temporary for total time remaining.	
T2	Temporary for time remaining for essential tasks.	
T3	Temporary for time remaining for non-essential tasks.	
TEMP	Larger of two operators' time available.	
TIME	Task execution time.	t_{ij}
TITLE	First card of input.	
TMAVA	Time available for mission (input parameter).	T_j
TMBEG	Temporary for the time of beginning a task.	
TMLE	Sum of time remaining for essential tasks.	$\sum T_{ij}$
TMLN	Sum of time remaining for non-essential tasks.	$\sum T_{ij}^N$
TMU	Total time used for all prior tasks for current operator	$\sum T_{ij}^U$
TOTALT	Total time used for iteration (summary iteration output).	
TOTIMI	Task waiting time (detail output).	
TOTIMS	Total waiting time (summary iteration output).	
TSUMTF	Frequency distribution-total time spent in failed tasks (summary run output), also average of above over a run).	
TWOPI	$2 \cdot \pi = 6.28...$	
XRAND	Random number uniformly distributed in interval 0 - 1.	

APPENDIX A2 - PRINCIPAL SUBSCRIPT VARIABLES AND FORTRAN CODES

Principle Subscript Variables

	<u>FORTRAN Variable</u>	<u>Maximum Value</u>	<u>FORTRAN Maximum Value</u>
Event number*	IE	200	IEMAX
Event type	IETYP	30	—
Day number	ND	30	NDMAX
Consumable	L	10	LMAX
Spare parts	L1	10	LMAX1
consumable			
Type of personnel	NT	10	NTMAX
Next event alternative	IA	3	—
Command echelon	ICE	4	—
(Also called level or rank)			
1. officer			
2. senior p.o.			
3. junior p.o.			
4. unrated			
Type of emergency	K	10	KMAX
Equipment	IQ	30	IQMAX
Crew member	M	20	IC
Consumable threshold	ITS1	10	ITMAX1
(units)			
Consumable threshold set	ITS	10	ITSMAX
(units/time)			
Sea state	IS	9	ISMAX
Group member	IG	20	NB
Duty shifts	NDS	6	NDSMAX
Equipment type	JET	4	JETMAX
1. mechanical			
2. electromechanical			
3. electrical			
4. electronic			
Data change value	IEDCV	3	IEDCUM

*Scheduled events are numbered 1-200. Repair event families are given numbers 201-560 since each of the 30 equipment repairs may call for a family of up to 12 repair events. Emergency events are given numbers 561-570 by the program corresponding to emergency types 1-10.

INPUT Subroutine

FORTRAN	Description
AASP	Average aspiration
ACP	Average crew pace
ADUR	Average duration of scheduled event
ADURIO	Internal variable
APST	Average psychological stress threshold
ART	Average repair time
ASD	Average standard deviation of repair
ASDE	Average standard deviation of emergency
BE	Effectivity of stress
CALRY	Number of calories required by average crewman per day
CN	Catnap length
DI	Alphanumeric descriptor array
DTBE	Duration time between emergencies
DTE	Duration time of emergencies
DTR	Duration time of repairs
DUMY	Internal variable
EDCV	Data change value
EMREVT	Emergency event data set
EQREVT	Repair event data set
FP1	Internal variable
FP2	Internal variable
FP3	Internal variable
FP4	Internal variable
FP5	Internal variable
GBG	Internal variable
I	Internal variable
ICLASS	Class
IDES	Description array
IDF	Day number of next failure for each piece of equipment
IDS	Number of duty shifts
IEC	Expected energy consumption
IECE	Expected energy consumption for emergency
IEDC	Data change variable
IEFN	Family number
IEFNX	Temporary variable
IERR	Error branch
IESS	Essentiality
IESSE	Emergency essentiality
IET	Essentiality threshold
IETYP	Event number
IFOI	Event number in family
IGRG	Internal array
IH	Event hazard class
IHE	Event hazard class (emergency)
II	Index variable
IND	Printout option indicator array
INT	Event code
IP1	Internal variable
IP2	Internal variable

FORTRAN	Description	INPUT Subroutine
IP3	Internal variable	
IP4	Internal variable	
IP5	Internal variable	
IPE	Prerequisite event	
IPERCT	Internal variable	
IQR	Equipment list	
IRC	Consumable rate of expenditure (units/hours)	
IRC1	Consumable rate of expenditure (units)	
IRCE	Consumable rate of expenditure (units/hours)--emergencies	
IRCE1	Consumable rate of expenditure (units)--emergencies	
IRE	Number of repair events	
IREX	Repair event number maximum	
ITEM	Temporary variable	
ITER	Iteration number	
J	Index variable	
JJ	Index variable	
K	Type of emergency	
K1	Physical capacitation fraction	
K7	Derating constant	
KASE	Case number	
KE	Event end type	
KK	Index variable	
KON	Initial level of consumables (units/hours)	
KON1	Initial level of consumables (units)	
KONT	Threshold consumables (units/hours)	
KONT1	Threshold consumables (units)	
LODM	Mental load	
LODME	Mental load for emergency	
MAXSL	Maximum sleep	
MEN	Crew composition array	
MM	Internal variable	
MPI	Average number of man days per incidence of physical incapacitation	
N	Number of iterations	
ND	Number of days	
NDBE	Number of days between emergencies	
NDMAX	Maximum number of days	
NDS	Duty shift	
NEME	Number of emergencies	
NEQRE	Number of equipments required	
NFP1	Internal variable	
NFP2	Internal variable	
NFP3	Internal variable	
NFP4	Internal variable	
NFP5	Internal variable	
NIF	Number of family	
NIP1	Internal variable	
NIP2	Internal variable	
NIP3	Internal variable	
NIP4	Internal variable	

INPUT Subroutine

FORTRAN	Description
NIP5	Internal variable
NIQR	Equipment used array
NOSE	Number of scheduled events
NREQ	Number of men required by type for emergency
NTYPES	Number of types
NX	Next event number for each alternative
PARAM	Common block
PERSNL	Common block
PID	Average duration of physical incapacity
PPFQ	Per cent fully qualified in primary specialty
PPMQ	Per cent moderately qualified in primary specialty
PPUQ	Per cent unqualified in primary specialty
PRB	Probability for each alternative path
PTT	Cross training probability table
PTTT	Common block
PWRRT	Average short term power output
RELH	Equipment reliability
RELI	Intermittent reliability
RTU	Repair touchup code
SCHEVT	Internal variable
SESTA	Sea state
SIGWT	Standard deviation of body weight
SLEEP	Number of hours since last eight hour sleep period
SPFQ	Per cent fully qualified in secondary specialty
SPMQ	Per cent minimally qualified in secondary specialty
SPUQ	Per cent unqualified in secondary specialty
ST	Earliest starting time allowed
TFAT	Fatigue threshold
TL	Time limit by which event must be completed
TS	Consumable threshold set identifier (units/hours)
TSI	Consumable threshold set identifier (units)
TSE	Threshold set for consumables below which event is ignored (units/hours)
TSE1	Threshold set for consumables below which event is ignored (units)
TSR	Threshold set for consumables below which emergency is ignored (units)
TSR1	Threshold set for consumables below which emergency is ignored (units/hours)
TUI	Intermittent reliability
TYPE	Internal variable
USHLIM	Per cent threshold for unmanned station hours
WORK1	Number of hours worked after which no new work assignment is made
WORK2	Number of hours worked after which no new work is authorized
WT	Mean body weight
ZPC	Physical capability constant

MAIN Program

FORTTRAN	Description
EF	Goodness of physical capability value
EH	Event hazard
EMTBF	Equipment meantime between failures
EMTTR	Equipment meantime to repair
EPEFF	Equipment performance effectiveness
EPL	Equipment performance level
ES	Goodness of stress value
ESSS	Temporary variable
ETEM	Temporary variable
EXER	Overexertion factor used in physical capability calculation
FAT	Fatigue level for each man in crew
FDIFF	Failure difference
FLIC	Number of men in crew
FLIG	Number of crew members in group participation in current event
FLOAT	Conversion to real
FUNC	Function
GASP	Group aspiration level
GPACE	Group pace value used in performance time calculation
GPCC	Group physical capability
GPERF	Group performance
GSTR	Group stress
GSTRM	Group stress threshold
HEADR	Program header
HR	Hazard ratio used in SI calculations
HRSE	Total man hours worked on emergency events for the day
HRSR	Total man hours worked on repair events for the day
HRSS	Total man hours worked on scheduled events for the day
HSLS	Number of hours since last slept for each man in crew
I	Index variable
IAA	Number of men in crew for each echelon
IC	Maximum number of crewmen
ICE	Command echelon for each crewman
ICLASS	Class
ICML	Event with maximum CML for the day
ICSS	Current sea state
IDC	Calories expended for the day for each crewman
IDCMX	Event with maximum calories expended for the day
IDE	Day number of next occurrence for each emergency event
IDF	Day number of next failure for each piece of equipment
IDFFF	Internal variable
IDIFR	Internal variable
IDIFR	Internal variable
IDIFF	Internal variable
IDS	Number of duty shifts
IE	Event number
IEC	Expected energy consumption during event (calories per hour)
IECE	Expected energy consumption during emergency event (calories per hour)
IEDC	Data change variable
IEFN	Family number

MAIN Program

FORTTRAN	Description
AASP	Average aspiration
ABS	Absolute value
ACAL	Calories expended since last slept for each man in crew
ACART	Average repair time per day
ACP	Average crew pace
ACDT	Average dow time per day
ACUT	Average up time per day
ADUR	Average duration of scheduled event (hours)
ADUR2	One half of average duration
ADURIO	Average duration of scheduled event in type data
AEPL	Average equipment performance level
AMAX1	Maximum value
AMIN1	Minimum value
APA	Average performance adequacy
APST	Average psychological stress threshold
APW	Average physical workload for the day for each man in crew
ART	Average repair time
ASD	Standard deviation of ADUR
ASDE	Average standard deviation (emergency)
ASP	Level of aspiration at beginning of iteration for each man in crew
ATEM	Temporary variable
BE	Effectivity stress on performance on a no-stress state
BLANK	Temporary variable
BTEM	Temporary variable
CAL	Average calories expended per day for each man in crew
CALR	Intermediate calculation used in crew selection process
CALRY	Number of calories required by average crewman per day
CART	Current average repair time
CASP	Current level of aspiration for each man in crew
CCAL	Calories expended for the event for each man in crew
CCI	Initial crew competence
CDT	Current downtime
CLSDTA	Internal array for summary by event class
CLSDTR	Internal array for summary by event class
CML	Crew mental load
CMLMX	Maximum crew mental load obtained for an event during the day
CN	Catnap length. Below considered rest. Above is sleep.
CTEM	Temporary variable
CUT	Current uptime
DEPEFF	Average equipment performance effectiveness
DI	Alphanumeric descriptor array
DS	Amount of sleep for the day for each man in crew
DTBE	Duration time between emergencies
DTE	Duration time of emergencies
DTM	Temporary variable
DTR	Duration time of repair
EA	Goodness of aspiration value
EC	Goodness of competence value
EDCV	Data change value

MAIN Program

FORTTRAN	Description
IEIE	Counter for number of different events attempted for the day
IEMAX	Maximum number of events
IESS	Event essentiality
IESSE	Emergency event essentiality
IET	Essentiality threshold. Determines ignores.
IETYP	Event type number
IEVENT	Event to be simulated for the day
IFIRST	Temporary variable
IFOI	Group member
IGAP	Internal variable
IGIND	Indicator for cause of ignored event
IGNOR	Indicator for ignored event (1= event ignored)
IH	Event hazard class (1-3= low, 4-6= medium, 7-9= heavy)
IHE	Event hazard class (emergency)
II	Index variable
III	Index variable
IKONC	Internal variable
IKONE	Internal variable
IND	Indicators for output recording options
INIF	Internal variable
INIQ	Internal variable
INT	Event code (1= normal, 2= training)
INVS	Inverse pointer array
IOIF	Operator induced failure
IPE	Prerequisite event
IPET	Previous event indicator
IPI	Incomplete processing indicator
IPS	Primary specialty for each crewman
IPSS	First 20 slots same as IPS, second 20 slots same as ISS
IPTR	Pointer array for events
IQMAX	Maximum number of pieces of equipment for repair events
IQR	Equipment list
IRC	Consumable rate of expenditure (units/hours)
IRCl	Consumable rate of expenditure (units)
IRCE	Consumable rate of expenditure for emergencies (units/hours)
IRCEl	Consumable rate of expenditure for emergencies (units)
IRE	Number of repair events
ISIE	Internal variable
ISS	Secondary specialty for each man in crew
IST	Internal variable
ISWl	Internal variable
ITAP	Tape option
ITEM	Temporary variable
ITER	Current interaction
ITRY	Counter for number of attempts with current event
ITYPE	Type for which man was selected for event for each man in group
IXDF	Internal variable
IXDF1	Internal variable
J	Internal variable

MAIN Program

FORTRAN	Description
JI	Internal variable
JJ	Internal variable
JNDS	Internal variable
K	Type of emergency
K1	Fraction to which a man's physical capability is reduced
K7	Derating constant for acceptable performance
KA	Number of crew members available for selection for current event
KASE	Case number
KE	Event end time type (1= fixed end, 2= variable end)
KIND	Indicator in group selection process (0= searching primary specialties, 1= secondary)
KK	Internal variable
KMAX	Maximum number of types of emergency events
KON	Initial level of consumable (units/hours)
KON1	Initial level of consumable (units)
KONC	Current consumable level for each consumable (units/hours)
KONC1	Current consumable level for each consumable (units)
KONE	Consumables expended for the event for each man in group
KONE1	Consumables expended (units)
KONT	Consumable threshold (units/hours)
KONT1	Consumable threshold (units)
KOUNT	Internal variable
LI	Crewman chosen as leader for this event
LL	Internal variable
LMAX	Maximum number of consumables (units/hours)
LMAX1	Maximum number of spare parts consumables (units)
LODM	Event mental load (1-3 light, 4-6 medium, 7-9 heavy)
LODME	Mental load (emergencies)
LSHIFT	Internal variable
M	Crewman number
MA	Man selected for the event by type
MAT	Man selected for the event
MAVAIL	Man selected for the event
MAXSL	Maximum sleep permitted per day (hour)
MAXST	Maximum stress obtained for any event during the day
MAXSTE	Event on which maximum stress was obtained
MCHSN	Indicator for man selected for the event (0= not selected; 1= selected)
MEN	Crew composition, number of men of each type by crew selection
MPCC	Maximum physical capability for the day for each man in crew
MPI	Average number of man days per indices of physical incapacitation
N	Number of mission iterations per computer run
ND	Number of days, current number
NDAYS	Total number of days in the simulation (updated after each iteration completed)
NDBE	Number of days between emergencies
NDMAX	Maximum number of days

MAIN Program

FORTTRAN	Description
NDS	Duty shifts
NE	Number of emergency events to be simulated this day
NEME	Temporary variable
NEQRE	Number of equipments (emergencies)
NFALE	Number of failures for this day
NIF	Number in family
NIGNR	Number of ignored events for this day
NIQR	Number of equipments in repair
NKASES	Number of cases
NKOUNT	Internal variable
NN	Temporary variable
NOFAIL	Number of failures for iteration for each crewman
NOIF	Number of operator induced failures (counter)
NOIFT	Total number of operator induced failures
NOSE	Number of scheduled events
NOSE1	Temporary variable
NOSUC	Number of successes for iteration for each man in crew
NPI	Number of crewmen to be incapacitated this day
NPRFM	Number of events performed
NPTR	Pointer array if in event sequencing
NR	Repair number, number of repair events to be simulated this day
NREPT	Number of events repeated this day
NREQ	Number of men of each type required by event
NREQE	Number of men of each type required for an emergency
NREQT	Number of men required for the event for each type
NS	Sickness indicator for each man in crew (0= well, 1= sick)
NSUC1	Number of successes on the first try this day
NSUC2	Number of successes on the second try this day
NTMAX	Maximum number of types of personnel
NU	Number of successes for the day for each crewman
NUMFAM	Number of families
NX	Next event number for each alternative
PA	Performance adequacy
PACE	Working pace for each man in crew
PAF	Pace adjustment factor used in calculations GPACE
PC	Physical capability at iteration start for each crewman
PCC	Current physical capability for each crewman
PCDUM	Equipment to PPFQ, PPMQ, PPU, SPFQ, SPMQ, SPUQ
PCOM	Primary competence for each crewman
PEA	Temporary variable
PEFF	Performance effectiveness
PERF	Performance level for each crewman
P1	Physical incapacity for each crewman
PI2	Number of future days of physical incapacity for each crewman
PID	Average duration of physical incapacity (days)
PPFQ	Per cent of crew fully qualified in primary specialty
PPMQ	Per cent of crew minimally qualified in primary specialty
PPUQ	Per cent of crew unqualified in primary specialty
PRB	Probability of each alternative path after current event
PSCOM	PCOM (1-20) and SCOM (1-20)

MAIN Program

FORTRAN	Description
PSESIC	Per cent seasick
PT	Performance time for each event
PTR	Sequential order of events for the day
PTT	Cross training probability table. Given primary by secondary.
PWR	Average short term power output rate for each crewman
PWRRT	Average short term power output rate for average crewman (calories/hours)
RELH	Equipment reliability
RELI	Intermittent reliability
REPAIR	Variable to determine if event is repair event
REPTM	Repair time
RSSUC2	Number of repair successes on second try
RTEMP	Temporary variable
RTU	Action if event performance is unsatisfactory (1= repeat, 2= touchup, 3= no action)
SCOM	Secondary competence for each man in crew
SCDTIQ	Summation of down time
SEF	Efficiency factor
SESTA	Sea state
SF	Slowness factor used in computing GSPACE
SFDIFF	Failure difference
SFTHRS	Shift hours
SGEM	System general effectiveness measure
SI	Safety index
SIDC	Total calories expended this event
SIDCMX	Maximum SIDC for any event this day
SIGWT	Standard deviation for work time
SLEEP	Number of hours since last 8 hour sleep period
SFPQ	Per cent of crew fully qualified by crewman at mission start
SPL	System performance level
SPMQ	Per cent of crew minimally qualified in secondary specialty
SFUQ	Per cent of crew unqualified in secondary specialty
SRL	System reliability level
ST	Earliest starting time allowed (hours)
STAR	Star
STRM	Psychological stress for each crewman
SUCC	Evaluation indicators for each man eligible for the event
TAVAIL	Testing criterion for each man eligible for the event
SUCC	Evaluation indicators for each man eligible for the event
TEH	Total event hazard for the day
TEM1	Temporary variable
TEM2	Temporary variable
TEM3	Temporary variable
TEMP	Temporary variable
TFAT	Fatigue threshold below which sleep is not authorized
TIM	Total hours worked for the crew for the day
TITLE	Program title
TL	Time limit by which event must be completed (hours)
TPCOM	Temporary primary competence

MAIN Program

FORTTRAN	Description
TPSCOM	Temporary/secondary competence array
TS	Consumable threshold set identifier (units/hour)
TS1	Consumable threshold set identifier (units)
TSCOM	Temporary secondary competence
TSE	Consumable threshold for emergencies (units/hours)
TSE1	Consumable threshold emergencies (units)
TUI	Intermittent failure rate
TW	Working time for the day for each crewman
TWP	Working time in primary specialty for each crewman
TWS	Working time in secondary specialty for each crewman
USH	Unmanned station hours for the current event
USHLIM	Per cent threshold for unmanned station hours
USHT	Total unmanned station hours for the day
V	Value of time function used in computing performance time
WH	Time since last event participation for each crewman, wait hours
WORK1	Number of hours worked after which no new assignments are made
WORK 2	Number of hours worked after which further work is not authorized
WT	Mean body weight of total population (lbs)
YU	Internal variable
Z	Last real time worked this day for each crewman
Z1	Earliest time when all group members are available
Z2	Earliest time current event can begin
ZC	Real time of completion for each event
ZPC	Physical capability constant
ZTEMP	Temporary variable

IPUYSM Function Subprogram

FORTRAN	Description
IPUYSM	Uniform probability test function
K	Temporary probability variable
PAR	Type of emergency
TEST	Temporary variable
Y	Temporary variable

FBUILD Function Subprogram

FORTRAN	Description
FBUILD	Function subprogram
H	Temporary variable
HSLS	Hours since last slept
TEM1	Temporary variable

OUTPUT Subprogram

FORTRAN	Description
AASP	Average aspiration
ACART	Average repair time per day
ACDT	Average down time per day
ACP	Average crew pace
ACUT	Average up time per day
ADALY	Internal array for daily summary
AEPL	Average equipment performance level
APA	Average performance adequacy
APST	Average psychological stress threshold
APW	Average physical workload
ASP	Aspiration
ASPA	Temporary aspiration
AVACA	Total ACART per day
AVACD	Total ACDT per day
AVACU	Total ACUT per day
AVAEP	Total AEPL per day
AVDEP	Total DEPEFF per day
BE	Effectivity of stress on performance
CAL	Average calories expended per day for each man in crew
CALRY	Number of calories required by average crewman per day
CART	Current average repair time
CARTI	Internal array for average repair time
CASP	Current aspiration
CCAL	Current calorie level
CDT	Current down time
CDTI	Internal array for downtime
CI	Blanks
CLSDTA	Internal array for summary by event class
CISDTI	Internal array for summary by event class
CLSDTR	Internal array for summary by event class
CML	Crew mental load
CMLMX	Crew mental load (maximum)
CN	Catnap length
CUT	Current up time
CUTI	Internal array for uptime
DALY	Output array
DEPEFF	Average equipment performance effectiveness
DI	Alphanumeric description array
DS	Amount of sleep for the day
EDCV	Data change value

OUTPUT Subroutine

FORTRAN	Description
EMTBF	Equipment mean time between failures
EMTTR	Equipment mean time to repair
EPEFF	Equipment performance effectiveness
EPL	Equipment performance level
EQYPTA	Equipment availability
EQYPTA	Equipment reliability
FAT	Fatigue
FD	Temporary variable
FEMTBF	Equipment MTTR
FLIC	Crew size (floating point)
FLITER	Iteration (floating point)
FLOAT	Floating point
FNTE	Number of total events (floating point)
HMNAV	Human availability
HMNRL	Human reliability
HMTTR	Human MTTR
HRSE	Hours worked on emergency
HRSR	Hours worked on repairs
HRSS	Hours worked on scheduled events
HSLS	Hours since last slept
HSLSA	Reinitialization of hours since last slept
I	Internal variable
IAA	Crew echelon number
IC	Maximum number of crewmen
ICF	Command echelon
ICML	Crew mental load
ICSS	Current sea state
IDALY1	Internal array for daily summary
IDC	Data change
IDCMX	Data change maximum
IDFR	Repair identification
IEDC	Data change variable
IEFN	Family number
IET	Essentiality threshold
IETYP	Event type number
IPOI	Event number in family code
IITEH	Temporary variable
IJ	Internal variable
IKANC	Internal variable
IMTAB	Output array
IND	Indicators
IPE	Prerequisite event
IPS	Primary specialty
IQMAX	Maximum number of pieces of equipment or repair events
ISS	Secondary specialty for each man in crew
ITER	Iteration
J	Temporary variable
JITER	Internal array for daily summary
K	Type of emergency
K1	Fraction to which a man's physical capability is reduced after daily quota is done

OUTPUT Subroutine

FORTRAN	Description
K7	Derating constant for acceptable performance
KK	Internal variable
KON	Initial level of consumable (units/hours)
KON1	Initial level of consumables (units)
KONC	Current consumable level (units/hours)
KONC1	Current consumable level (units)
KONT	Consumable threshold (units/hours)
KONT1	Consumable threshold (units)
MAXSL	Maximum sleep permitted per day
MAXST	Maximum stress for any event
MAXSTE	Event of maximum stress
MPCC	Maximum physical capability
N	Number of iterations
N1S1	Internal variable
ND	Number of days
NDAYS	Days in simulation
NDMAX	Maximum number of days
NE	Number of emergency events
NEME	Temporary variable
NEQRE	Number of equipments emerging
NFALE	Number of failures this day
NIF	Number in family
NIGNR	Number of events ignored
NOSE	Number of scheduled events
NPRFM	Number of events performed
NR	Number of repairs
NREI	Total repairs for the run
NREPT	Number of repeats
NSUC1	Number of successes in first try
NSUC2	Number of successes in second try
NTF	Total number of events
NTIPL	Number of men in each type
NU	Number of daily successes by crewman
NX	Next event number for each alternative
OUTA	Internal array
OUTB	Output array
PACE	Working pace
PACEA	Reinitialization of work pace
PC	Physical capability
PCA	Reinitialization of physical capability
PCC	Current physical capability
PCOM	Primary competence
PCOMA	Reinitialization of primary competence
PEFF	Performance effectiveness
PERF	Performance level by crewman
PI	Physical incapability
PI2	Number of future days of physical incapacity for each crewman
P1A	Reinitialization of physical capacity by crewman
PRR	Probability for each alternative path after current event

OUTPUT Subroutine

FORTRAN	Description
PWR	Average short term output for average crewman
PWRRT	Average short term output for average crewman
RELI	Intermittent reliability
REMT	Temporary variable for equipment mean time between failure
RENT	Temporary variable for equipment mean time to repair
REPTM	Repair time
REPTMD	Repair time per day
RSSUCZ	Number repair successes on second try
RSSUC2D	Internal variable
RSTOT	Total number of successes on second try for all iterations
RTU	Action if event performance is unsatisfactory
SCDTIQ	Summation of CDT
SCOM	Secondary competence
SCOMA	Secondary competence reinitialized
SESTA	Sea state
SFDIPF	Failure difference
SGEM	General system measure
SI	Safety index
SIDMX	Maximum calories expended for this event
SLEEP	Number of hours since last 8 hour sleep period
SPL	System performance level
SRL	System reliability level;
ST	Earliest starting time allowed (hours)
STRM	Stress threshold
SYSA	System availability
SYSRL	System reliability
TJ	Temporary variable
TDALY	Daily total output array
TEH	Total daily event hazard
TEM1	Temporary variable
TEM3	Temporary variable
TFAT	Fatigue threshold
TIITER	Iteration summary array
TL	Time limit by which event must be completed (hours)
TOT	Internal variable
TOUTA	Internal array
TPCOM	Temporary primary competence
TS	Consumable threshold set identification (units/hours)
TS1	Consumable threshold set identifier (units)
TSCOM	Temporary secondary competence
TW	Time worked
TWP	Time worked in primary
TWS	Time worked in secondary
USHT	Unmanned station hours
USHLIM	Per cent threshold for unmanned station hours
WORK1	Number of hours worked after which no new assessment is made
WORK2	Number of hours worked after which further work is not authorized
ZTEM	Temporary variable

APPENDIX B PROGRAM LISTINGS

This appendix contains the program listings for the digital simulation models as follows:

- Appendix B1 - Program listing for the 1-2 man digital simulation model
- Appendix B2 - Program listing for the 4-20 man digital simulation model

APPENDIX B1 - PROGRAM LISTING

This appendix contains the program listing for the 1-2 man digital simulation program.

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B-5

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CDC 6600 FTN V3.0-P2A3 OPT=1 3/24/71 11.51.36

```

PROGRAM      PAR4
C            C      MOL(3) = N
C            C      MOL(10) = G
C            C      MOL(11) = JOINT
60           C      MOL(12) = TASK
C            C      MOL(13) = S
C            C      MOL(14) = UNDER
C            C      MOL(15) = OVER
C            C      MOL(16) = C
70           7011 FORMAT (11ZAR)

65           READ(5,7011) (TITLE(I),I=1,12)
           IN=5
           IO = 6
           P1=3.1415926536
           TWOP1=6.2831853072
           CONVER(1)=3400.
           CONVER(2)=1.
           CONVER(3)=60.
           ICHK=0

75           NIJJP = 0
           MRUN=1
           ICALL = 1

80           MUMSUC = 0
           PRSUC = 0.0

85           TOTTHI(1) = 0.0
           TOTTHI(2) = 0.0

           IFLG1 = 0
           TSUMF(1) = 0
           TSUMF(2) = 0
           TSUMI(1) = 0
           TSUMI(2) = 0
           TSUMIF(1) = 0.0
           TSUMIF(2) = 0.0

95           DO 10 I=1,300
           DO 10 J=1,2
           ESS(I,J) = MOL(6)
           ATMU(I,J) = 0.0
           ASTS(I,J) = 0.0
           SUMTF(I,J) = 0.0
           IASTS(I,J) = 0
           IAVG(I,J) = 0
           IPRF(I,J) = 0
           NUMCOM(I,J) = 0
           SUMCUH(I,J) = 0.0
           10 CONTINUE

100          600 CALL INPUT(ICALL)

110          C      PRG-RUN THE RANDOM NUMBER GENERATORS INDI TIMES

```

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```

CDC 6600 FTM V3.0-P243 OPT=1 3/24/71 11.51.36.

PROGRAM      PARA
XRAMD = RAMP (IND1)
MBASE = 3192471
CALL SETBASE (MBASE)
  0 = 1.
  5 CONTINUE

  115
    INDX=IND2
    CONNCONVERT (IND5:1)
    650 CALL RESET (1, TIMEINT)
    GO TO 850

  120
    700 (CALL=2
    CALL INDTTICALL)
    INDX=IND2
    CONNCONVERT (IND5:1)
    IF (ICALL (C, EQ=1) NRUN=1
    NUMSUC=0

  125
    750 CALL RESET (1, TIMEINT)
    GO TO 850

  130
    C      800 JS THE START OF THE NEXT ITERATION FROM STATEMENT 6053
    800 CALL RESET (2, TIMEINT)
    IPRECSTY=0
    IPRECS (2)=0

  135
    C      C ARE TASK DETAILS REQUIRED
    850 IF (INDX.LE.1) GO TO 1030
    C

  140
    WRITE (100,905) ITER=NRUN, NRUNTRC
    905 FORMAT (11H1/28H DETAIL OUTPUT OF ITERATION,14,3X,3HRUN,14,5X,
    1 5H TASK,14//
    2 22X,10H OPERATOR 1,58X,10H OPERATOR 2//
    3 362H TASK TASK NON STRESS ----- T I M E S ----- S F I C O N E S.
    4 7X.
    5 62H TASK TASK NON STRESS ----- T I M E S ----- S F I C O N E S.
    6 49H NO TYPE ESS IND TOT WALL TASK CUM,20X.
    7 49H NO TYPE ESS IND TOT WALL TASK CUM)

  145
    1030 IF (TMU(J).LE.TMU(JP)) GO TO 1050

  150
    1040 JTB3
    J=JP
    JP=J1

  155
    1050 I=1TASK(J)
    ICHONE=0
    ISUC=0
    IP=1TASK(JP)

  160
    1060 IF (TYPE(T,J).NE.MOL(1)) GO TO 1060
    C DECISION SINTASK

```

CDC 6600 FTM V3.0-P243 OPT=1 ^3/24/71 11.51.36.

PROGRAM PAR4

```

ISUC = 0
IRAND = RAND(IND1)
IF (IRAND.LE.PRBSUC(1:J)) TSUC=1
TIME(J) = 0.0
GO TO 406

```

021

C DOES SPECIAL JUMP TASK CODE = 2

~~1080 IF (ISJIT).NE.2) GO TO 1084~~

175

```

      TIME(J) = 0.0
      IF (XRANN .GT. PRNSUC(I,J)) GO TO 1082

```

C SUCCESSFUL

03

ISUC = 1
GO TO 4061

C **FAILURE**

IAS

1087 TSUC 5 0
KEEP COUNT OF TOTAL SPECIAL JUMP TASKS, CODES 1 AND/OR 2
WITHIN EACH ITERATION

061

$$\begin{aligned} \text{N1J1JP} &= \text{N1J1JP} + 1 \\ \text{ISET1}(\text{N1J1JP}) &= 1 \\ \text{ISETJ}(\text{N1J1JP}) &= J \\ \text{ISETIP}(\text{N1J1JP}) &= \text{IP} \\ \text{ISETJP}(\text{N1J1JP}) &= \text{JP} \end{aligned}$$

195

```

VSETF (N1J1JP) = NKT5(I,J)
VSET5 (N1J1JP) = NKT5(I,J)
VSETFP(N1J1JP) = NKT5(IP,JP)
VSETSP(N1J1JP) = NKT5(IP,JP)

```

000

```

NEXTJ(I,J) = NEXTJ(I,J)
NEXTS(I,J) = NEXTJ(I,J)

```

205

```

IP = NEXT JP(1,JP)
TASK(JP) = IP
GO TO 4051

```

019

```

(CHECK = ICHECK+1
II=IPREF(I,J) .....
F(II,LF=0) GO TO 2000
F(IIACK(JH) .GT.1) GO TO 2000

```

515

IF (CHECK .LT. 3) GO TO 1040
WRITE(6,1041)
FORMAT(777730X,9H*****
*****//47X,25H***** PA

629

CONFIDENTIAL
F (IMU(J),GE,TMFG(I,J)) GO TO 2010

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CDC 6680 FTM V3.0-P243 OPT=1 -3/24/71 11.51.36.

PROGRAM PARA

TOTTIME(J)=TOTTIME(J)+TIMEG(I,J)-TMU(J)
TMU(J)=TIMEG(I,J)

GO TO 1030

2010 IF (TYPE(I,J).NE. MOL(2)) GO TO 2300

IF (TYPE(I,P).NE. MOL(2)) GO TO 1040

JWAIT=J

JWAIT=P

IF (TMU(J).LT.TMU(P)) GO TO 2020

JWAIT=J

JWAIT=P

2020 TOTTIME(JWAIT)=TOTTIME(JWAIT)+TMU(JWAIT)-TMU(JWAIT)

TMU(JWAIT)=TMU(JWAIT)

C

C EQUIPMENT REPAIR TASK

235

2300 CONTINUE

IF (TYPE(I,J).NE. MOL(4)) GO TO 2500

STR(J)=I

RDEV = RDEV(I)

TIME(J)=AVGTIME(I,J)+RDEV*AVGTIME(I,J)

GO TO 3000

2500 IF (TMU(J).LE.TMUNA(J)) GO TO 2505

STR(J)=STR(J)

IF (STR(J).LE.STRS(J)) GO TO 2620

STRS(J)=STR(J)

ISTRS(J)=I

GO TO 2620

2505 JJ=J

II=I

IGONE=I

2510 II=TMUNA(JJ)-TMU(JJ)

I2=TIME(I,J)

I3=TIME(I,J)

IF (SPEC(I,J)*(I2+I3).GT.I1) GO TO 2600

STR(J)=I

GO TO (2700,2710):IGONE

2600 IF (SPEC(I,J)*(I2+I3).GT.I1) GO TO 2610

STR(J)=I

GO TO (2620,2710):IGONE

2610 STR(J)=I2/I1

IF (STR(J).LT.I1) STR(J)=I1

IF (STR(J).GT.5) STR(J)=5

IF (JJ.FO.P) GO TO 2615

IF (STR(J).GE.STRS(J)) GO TO 2615

ISTRS(J)=STR(J)

ISTRS(J)=I

2615 CONTINUE

GO TO (2620,2710):IGONE

2620 IF (ESS(I,J).NE. MOL(3)) GO TO 2700

IGONE=I

ISUCH=I

TIME(J)=6/CON

TIME(J)=0

IF (REPT(J).NE. IFREQ(I,J))

270

275

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CDC 6600 FTM V3.0-P243 OPT=1 3/24/71 11.51.36.

PROGRAM PAP% IF (ISJ(I,J).NE.1) GO TO 3050

280 C KEEP COUNT OF TOTAL SPECIAL JUMP TASKS. CODES 1 AND/OR 2

C WITHIN EACH ITERATION

285 NIJLP = NIJLP + 1

ISJ(I,NIJLP) = 1

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

ISJ(I,NIJLP) = J

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CDC 6600 FTN V3.0-P243 001=1
-3/24/71 11.51.36.
... (S10M1P)-1.)

[illegible]

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```

PROGRAM      PARA      CDC 6600 FIN V3.0-P243 OPT=1  -3/24/71  11.51.36.

TIME=72/COM
TIME(J)=AMAX1(TIME(J),TIME(J))
4000  TIME(J)=TIME(J)
IF (TYPE(I,J) .NE. MOL(2)) GO TO 4020
TIME(J)=TIME(J)
4020  IF (I-OT:TIMEC(IP,J)) GO TO 4060
IF (TIME(J).GT.TIME(J)) GO TO 4040
4030  JPM(J)=1
GO TO 4060
4040  TIME=TIME(J)-TIME(J)
TIME(J)=TIME(J)
TOTTIME(J)=TOTTIME(J)+TIME
GO TO 4030
4060  JPM(J)=0
4080  IF (TIME(J).LT.TIME(J)) GO TO 4080
IF (FLAG(J).EQ.1) GO TO 4080
FLAG(J)=1
IFREQ(I,J)=IFREQ(I,J)+1
4080  IF (TYPE(I,J) .NE. MOL(2)) GO TO 5000
IF (TIME(J).LT.TIME(J)) GO TO 5000
IF (FLAG(J).GT.0) GO TO 5000
FLAG(J)=1
IFREQ(IP-1,J)=IFREQ(IP-1,J)+1
C
C      5000 CONTINUE
C
SFT=TIME(J)
IF (ISUC .EQ. 1) SFT = MOL(6)
IF (IGNORE .EQ. 1) SFT = MOL(7)
IF (SFT .NE. MOL(5)) GO TO 9010
C      DO NOT AND FAILURES OF FOLLOWING 2 TYPES
C      (1) A DECISION TASK -- TYPE 0
C      (2) SPECIAL JUMP TASK -- CODE 2
IF (TYPE(I,J) .EQ. MOL(1) .OR. ISJT(I,J) .EQ. 2) GO TO 9010
IFREQ(I,J) = IFREQ(I,J) + 1
IF (TYPE(I,J) .EQ. MOL(2)) IFREQ(IP,J) = IFREQ(IP,J) + 1
9010  OT = MOL(6)
IF (TIME(J) .GT. TIME(J)) OT = MOL(8)
ALPH(1) = MOL(6)
ALPH(2) = MOL(6)
ALPH(3) = MOL(6)
IF (JPM(J) .EQ. 1) ALPH(3) = MOL(9)
C      CALCULATE AVERAGE START TOTAL STRESS PER TASK PER OPERATOR
ASTS(I,J) = ASTS(I,J)+AUGSTR(J)
C      KEEP COUNT OF NUMBER OF TASKS
IASTS(I,J) = IASTS(I,J)+1
C      CALCULATE SUMMATION OF FAILURE TIMES
MUL(5) IS F
IF (SFT .NE. MOL(5)) GO TO 5000
FAILURE
SUMT(I,J) = SUMT(I,J)+TIME(J)

```

```

CDC 6600 FIM V3.0-0243 OPT=1 3/24/71 11.51.36.

PROGRAM      PARA
C             IF (TYPE(I,J).EQ. MOL(2)) SUMTF(IP,JP) = SUMTF(IP,JP)+TIME(I,J)
C             THEN GO TO 5001
C             GO TO 5001

445 C          CALCULATE AVERAGE CUMULATIVE TASK TIMES COMPLETED
C          OF SUCCESSFUL TASKS.
C          5003 ATMU(I,J) = ATMU(I,J)+TMU(I,J)
C          KEEP COUNT OF SUCC. TASKS.
C          TAVG(I,J) = TAVG(I,J)+1

450 C
C
C          ARE TASK DETAILS REQUIRED
C          5001 IF (INDX .LE. 1) GO TO 5050
C
C          495 C
C          IF (TYPE(I,J).NE. MOL(2)) GO TO 5002
C          ALPHA(1) = MOL(11)
C          ALPHA(2) = MOL(12)
C          5002 IF (J.GT.2) GO TO 5000
C          WRITE(6,5005) I,TYPE(I,J),ESS(I,J),STR(I,J),AUGSTR(I,J),TOTTM(I,J),
C          1 TIME(I,J),TMU(I,J),OT,SFI,COMES(I,J),ALPH
C          460 5005 FORMAT (I6,X,A1,3X,A1,F6.2,F5.2,F8.2,F10.2,A1,2X,A1,F8.2,
C          1 9X,2A6.1,2X,A6)
C          GO TO 5050

470 5000 WRITE(6,5009) ALPHA,I,TYPE(I,J),ESS(I,J),STR(I,J),AUGSTR(I,J),
C          1 TOTTM(I,J),TIME(I,J),TMU(I,J),OT,SFI,COMES(I,J)
C          5009 FORMAT (2X,2A6.1,1X,A6,3X,A1,4X,A1,3X,A1,F6.2,F5.2,F8.2,F10.2,F5.2,F8.2,
C          1 F10.2,A1,2X,A1,F8.2)
C          475 5050 CONTINUE
C          IF (SFI.EQ. MOL(6)) SFI = MOL(13)
C          ISAVE=1
C          TPRECSTJ=TPREC(I,J)
C          TOTMS(J)=TOTMS(J)+TOTTM(I,J)
C          TOTMI(I)=0.
C          IF (ISUR.NE.1) GO TO 5200
C          LST(J)=1
C          IF (IGNORE.FO.1) GO TO 5060
C          IF (TYPE(I,J).NE. MOL(2)) GO TO 5060
C          LST(J)=1P
C          5060 IF (TYPE(I,J).NE. MOL(2)) GO TO 5000
C          IF (IP.NE. NTASK(JP)) GO TO 5070
C          IF (JFLAG(JP).EQ.1) GO TO 5090
C          IF REUL(IP,JP)=IF REOL(IP,JP)+1
C          GO TO 5000
C          5070 IP=NTASK(IP,JP)
C          ITASK(JP)=IP
C          5080 IF (TIME.NTASK(J)) GO TO 5100
C          IF (JFLAG(J).EQ.1) GO TO 5090
C          495

```

PROGRAM PARA

IFRQL(I,J)=IFRQL(I,J)+1
5090 IF (LST(JP),EQ,NTASK(JP)) GO TO 6000

5100 I=NTASK(I,J)
5200 I=NTASK(I,J)
5300 ITASK(J)=I

TIME = 0

IF (LST(JP),EQ,NTASK(JP)) GO TO 1060
IF (IPRCL(I,P),EQ,ISAVE .AND. TYPE(I,P,JP) .NE. MOL(2))JPV(JP)=0
IF (JPV(JP),EQ,1)GO TO 1060
GO TO 1030

510 C WRITE ITERATION SUMMARY
6000 CONTINUE

OV = MOL(14)
IF (FLAG(1),EQ,1 .OR. FLAG(2),EQ,1) OV = MOL(15)
IF (OV .EQ. MOL(14)) NUMSUC = NUMSUC+1
STABLE(ITER)=(IFLOAT(NUMSUC)/FLOAT(ITER))*100.
TOTALT=AMAX1(TMU(1),TMU(2))

520 C COMPUTE PEAK STRESS FREQUENCY
IZ = ISTRS(1)
IPKF(IZ,1) = IPKF(IZ,1)+1
IZ = ISTRS(2)
IPKF(IZ,2) = IPKF(IZ,2)+1

525 C IF OVER RUN, SET STRESS TO STRESS THRESHOLD
C MOL(14) = UNDER

530 IF (OV .EQ. MOL(14)) GO TO 6009
STR(1) = STRM(1)
STR(2) = STPM(2)

535 C IS ITERATION SUMMARY REQUIRED

6009 IF (INDX .LE. 0) GO TO 6051
WRITE (10,6010) ITER,NUM,NUMTOL,OV,TOTALT
6010 FORMAT (1H,77 29H SUMMARY OUTPUT OF ITERATION ,I4,GX,4HRLIM ,
2 14,GX,4HTRIAL ,14,GX,4G,4H RUN,5X,17H TOTAL TIME USED,F11.2//
3 10H OPN THRES SPEED,40H - - - - - TIME S - - - - -
4 10H OPN STRESS,4X,5HFINAL,4X,4HLAST,4X,6HNCYCLIC/
5 10H NO HOLD,13X,5HAVAIL,7X,4HUSED,4X,4HDIFF,3X,4HWAIT,3X,
6 4HTASK,4X,5HVALUE,3X,6HSTRESS,3X,5HCONES,4X,4HWAIT)

545 DO 6050 K=1,2
N1=TMU(K)-TMVA(K)
WRITE (10,6040) K,STRM(K),SPEED(K),TMVA(K),TMU(K),OT,TOTTRS(K),
2 ISTRS(K),STRS(K),STRM(K),CONLAS(K),CWAIT(K)

6040 FORMAT (13,F8.2,F7.2,2F11.2,2F7.1,17,2F9.2,2F8.2)
6050 CONTINUE

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PROGRAM PAR4

6051 CONTINUE

555 C TEST TO SEE IF EITHER/OR A CODE 1 OR 2 SPECIAL JUMP TASK
C WAS EXECUTED

IF (N1J1.P .EQ. 0) GO TO 9000

DO 8000 K1T1N1J1J1P

K1 = ISFT1(K1K1)

KJ = ISFTJ(K1K1)

KIP = TSETIP(K1K1)

KJP = TSETJP(K1K1)

565 K1T1 (K1,KJ) = NSETF (K1K1)

K1T1 (K1,KJ) = NSETF (K1K1)

K1T1 (K1,KJ) = NSETF (K1K1)

K1T1 (K1,KJ) = NSETF (K1K1)

8000 CONTINUE

570 C RESET COUNTER FOR NEXT ITERATION ON RUN

N1J1P = 0

9000 DO 6052 K=1,2

ATU(K)=ATU(K)+TMU(K)

APS(K)=APS(K)+SIRS(K)

APST(K)=APST(K)+STW(K)

6052 ATW(K)=ATW(K)+TOTMS(K)

ITER=ITER+1

580 C DOES OUTPUT FORMAT CHANGE

IF (ITER .LE. 1000) GO TO 6053

IF (INDX .NE. 1) GO TO 6053

INDX = INDX+1

595 C DO WF GO BACK FOR ANOTHER ITERATION

6053 IF (ITER .LE. 1000) GO TO 600

C WRITE RUN DATA

FLTWTF=1

DO 6054 K=1,2

ATU(K)=ATU(K)/FLIT

APS(K)=APS(K)/FLIT

APST(K)=APST(K)/FLIT

6054 ATW(K)=ATW(K)/FLIT

TEMP=MAX(THRAV(1),THRAV(2))

PRSDC=IFLOAT(NUMSUC)/FLIT*100.

DO 6055 K=1,2

PV1THRU(K,1)=ATU(K)

PV1THRU(K,2)=APS(K)

PV1THRU(K,3)=APST(K)

PV1THRU(K,4)=PRSDC

PV1THRU(K,5)=ATW(K)

PV2THRU(K,1)=THRAV(K)

PV2THRU(K,2)=STPM(K)

6055 PV2THRU(K,3)=SPEED(K)

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CDC 6600 FTN V3.0-P243 OPT=1 3/24/71 11.51.36.

PROGRAM PARA

610 WRITE (10,6070) NRUN,NUMIT,NUMSUC,PKSUC, TEMP
--6070 FORMAT (1M // 23M SUMMARY OUTPUT OF RUN // 14/ 23M NUMBER OF ITERATT
20MS // 14/ 23M NUMBER OF SUCCESSES // 14/ 23M PER CENT SUCCESSES
3 // 6.1. 7A. 19M FOR TIME DURATION // 9.2)
WRITE (10,6080)

6080 FORMAT (1/ 43M OPR THRES SPEED - - - - - AVERAGE TIMES - - - -
1 - - - - - PEAK FINAL CYCLIC/
2 10M NO - - - - - HOLDIT/3A/5NAVAL/7A/6WSE/5A/6WDIFF/4A/4HWAIT,
3 3A/6WSTRESS/3A/6WSTRESS/4A/4HWAIT)

615 DO 4090 K=1,2
TEMP1=ATU(K)-TMAVA(K)
6090 WRITE (10,6090) K,STRN(K),SPEED(K),TMAVA(K),ATU(K),TEMP1,ATM(K),
2 APS(K),AFS(K),SWAIT(K)

620 6094 FORMAT (13//8.2,F7.2,F11.2,F9.2,F9.2)
WRITE (10,6097)
6097 FORMAT (1M // 15M FREQUENCY DATA/ 73M TASK LAST TASK COMPLETED
2 - - - - - TASK FAILED - - - - - TASK IGNORED - - - - - / 73M NO OP 1
3 OP 2 OP 1 OP 2 OP 1 NE OP 2 NE)

625 MAX=MAX(INTASK(1),NTASK(2))
I1=0.0
I2=0.0
DO 6020 K=1,NMAX

630 DO SUMMATION OF TASKS FAILED AND IGNORED.
ISUMF(1) = ISUMF(1)+IFREQ(K,1)
ISUMF(2) = ISUMF(2)+IFREQ(K,2)
ISUMI(1) = ISUMI(1)+IFREQ(K,1)
ISUMI(2) = ISUMI(2)+IFREQ(K,2)

640 6020 WRITE (10,6030) K, IFREQ(K,1),IFREQ(K,2),IFREQ(K,1) +IFREQ
2 (K,2) +IFREQ(K,1)+ESS(K,1),IFREQ(K,2)+ESS(K,2)
6030 FORMAT (14//10.17,11.6A // 16.6A // 15.3A,17.3A,11)

645 C ADN TO PLOT
C SUM OF TASKS IGNORED
C SUM OF TASKS FAILED
PVI(NRUN,1,6) = ISUMI(1)
PVI(NRUN,2,6) = ISUMI(2)
PVI(NRUN,1,7) = ISUMF(1)
PVI(NRUN,2,7) = ISUMF(2)

650 C FLOAT THE SUMMATION OF TASKS FAILED AND IGNORED
BLOCK(1) = ISUMF(1)
BLOCK(2) = ISUMF(2)
BLOCK(3) = ISUMI(1)
BLOCK(4) = ISUMI(2)

655 C CALCULATE AVERAGES OF

C

B-17

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CUC 6600 FTM V3.0-P243 OPT=1 3/24/71 11.51.36.

PROGRAM PAR4

7006 FORMAT (14.2F9.2,4X,13.4X,13.2X,2F9.2,F11.2,F12.2,F9.2,F8.2)

3330 CONTINUE

720

C CALCULATE TOTAL OF FAILURE TIMES

DO 22 K=1,NMAX

TSUMTF(1)=TSUMTF(1)+SUMTF(K,1)

TSUMTF(2)=TSUMTF(2)+SUMTF(K,2)

22 CONTINUE

725

WRITE(6,7008) TSUMTF(1),TSUMTF(2)

7008 FORMAT (7X,16H-----/4X,2F9.2,7H TOTAL//)

730

C CALCULATE AVERAGE OF FAILURE TIMES

TSUMTF(1)=TSUMTF(1)/FLIT

TSUMTF(2)=TSUMTF(2)/FLIT

735

WRITE(6,7009) TSUMTF(1),TSUMTF(2)

7009 FORMAT (4X,2F9.2,9H AVERAGE)

DO 25 K=1,300

DO 25 L=1,2

ATM(K,L)=0.0

SUMTF(K,L)=0.0

ASTS(K,L)=0.0

AVG(K,L)=0.0

IPKF(K,L)=0.0

EASTS(K,L)=0.0

CONF(S(K,L))=0.0

SUMCONF(L)=0.0

NUMCON(K,L)=0.0

25 CONTINUE

740

TSUMF(1)=0

TSUMF(2)=0

TSUMI(1)=0

TSUMI(2)=0

TSUMTF(1)=0.0

TSUMTF(2)=0.0

NRUN=NRUN+1

GO TO 700

END

745

750

755

760

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CDC 6600 FTM V3.0-P243 OPT1-1 3/24/71 11.51.36.

PROGRAM PAR4

CARD NO.	SEVERITY	DIAGNOSTIC
111	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
167	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
168	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
175	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
177	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
373	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
377	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
381	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
384	1	ARRAY NAME OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED

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CDC 6600 FTN V3.0-P243 OPT=1 3/24/71 11.51.36.

PROGRAM PAD4

SYMBOLIC REFERENCE MAP

ENTRY POINTS
4052 PAR4

VARIABLES	SM	TYPE	RFLOCATION	6	AFS	REAL	ARRAY	R4
1152 ANDSTR	REAL	ARRAY	B3		AFS	REAL	ARRAY	R4
6761 ALPH	REAL	ARRAY	NEW	4	APS	REAL	ARRAY	R4
4545 ASTS	REAL	ARRAY	NEW	2265	ATMU	REAL	ARRAY	NEW
0 ATU	REAL	ARRAY	B4	2	ATM	REAL	ARRAY	B4
1154 AUGSTR	REAL	ARRAY	B3	11311	AVGCOM	REAL	ARRAY	NEW
7020 AVGTH	REAL	ARRAY	B1	10150	AVGTHD	REAL	ARRAY	B1
6754 A1	REAL	ARRAY		6755	A2	REAL	ARRAY	
6756 A3	REAL	ARRAY		6757	A4	REAL	ARRAY	
7011 WLOCK	REAL	ARRAY		1156	CONES	REAL	ARRAY	B3
11307 COMLAS	REAL	ARRAY	NEW	6710	CON	REAL	ARRAY	B3
6766 CONVER	REAL	ARRAY		11	CHAIT	REAL	ARRAY	NEW
6786 D	REAL	ARRAY		12441	DFMAX	REAL	ARRAY	B1
6742 DT	REAL	ARRAY		1130	ESS	REAL	ARRAY	PIT
6750 FLIT	REAL	ARRAY		764	HEAD	REAL	ARRAY	B2
6771 HOL	REAL	ARRAY	NEW	3446	I	INTEGER	ARRAY	NEW
5675 IASTS	INTEGER	ARRAY		3415	IARG	INTEGER	ARRAY	
6701 ICALL	INTEGER	ARRAY	NEW	6700	ICHECK	INTEGER	ARRAY	
4 TCHNG	INTEGER	ARRAY	NEW	6704	IFLG1	INTEGER	ARRAY	
2312 IFRFO	INTEGER	ARRAY	B3	10	IFRFOF	INTEGER	ARRAY	R4
22 IFRFO	INTEGER	ARRAY	B3	3454	IGNORE	INTEGER	ARRAY	B3
6721 IGO	INTEGER	ARRAY		6714	II	INTEGER	ARRAY	
3460 IN	INTEGER	ARRAY	B3	6707	INDX	INTEGER	ARRAY	B3
3450 IM01	INTEGER	ARRAY	B3	3451	IND2	INTEGER	ARRAY	B3
3452 IM03	INTEGER	ARRAY	B3	3453	IND4	INTEGER	ARRAY	B3
3464 IM05	INTEGER	ARRAY	B3	3465	IND6	INTEGER	ARRAY	B3
3461 IO	INTEGER	ARRAY	B3	3447	IP	INTEGER	ARRAY	B1
5 IPKF	INTEGER	ARRAY	NEW	2260	IPREC	INTEGER	ARRAY	B3
6764 IPRECS	INTEGER	ARRAY		4	IRAND	INTEGER	ARRAY	NEW
6735 ISAVE	INTEGER	ARRAY		311	ISSTI	INTEGER	ARRAY	NEW
455 ISFTIP	INTEGER	ARRAY	NEW	373	ISFTJ	INTEGER	ARRAY	NEW
537 ISFTJP	INTEGER	ARRAY	NEW	14712	ISJT	INTEGER	ARRAY	B1
20 ISFS	INTEGER	ARRAY	B3	6713	ISUC	INTEGER	ARRAY	NEW
0 ISUMF	INTEGER	ARRAY	NEW	2	ISUMI	INTEGER	ARRAY	B3
2 ITASK	INTEGER	ARRAY	B3	3457	ITER	INTEGER	ARRAY	B3
6726 J	INTEGER	ARRAY		6740	IZ	INTEGER	ARRAY	B3
3444 J	INTEGER	ARRAY	B3	2310	JFLAG	INTEGER	ARRAY	B3
6720 JJ	INTEGER	ARRAY		6716	JWAIT	INTEGER	ARRAY	B3
3445 JP	INTEGER	ARRAY	B3	2306	JW	INTEGER	ARRAY	UNDEF
6712 JT	INTEGER	ARRAY		6715	JWAIT	INTEGER	ARRAY	
6741 K	INTEGER	ARRAY		7015	KHLK	INTEGER	ARRAY	
6744 K1	INTEGER	ARRAY		6743	KIKI	INTEGER	ARRAY	
6746 KIP	INTEGER	ARRAY		6745	KJ	INTEGER	ARRAY	
6747 KJP	INTEGER	ARRAY		6740	L	INTEGER	ARRAY	
3442 LST	INTEGER	ARRAY	B3	6705	MMASE	INTEGER	ARRAY	
0 MIJJP	INTEGER	ARRAY	NEW	6753	MMAX	INTEGER	ARRAY	NEW
7 MPUN	INTEGER	ARRAY	B2	1	NSETF	INTEGER	ARRAY	NEW
145 NSFIFP	INTEGER	ARRAY	NEW	63	NSETS	INTEGER	ARRAY	NEW
227 NSFTSP	INTEGER	ARRAY	NEW	14710	NTASK	INTEGER	ARRAY	B1

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CDC 6600 FTN V3.0-P243 OPT=1 -3/24/71 11.51.36.

PROGRAM PARA

VARIABLES	SN	TYPE	ARGV	NEW	LOC	UNIT	INTEGER	REAL	PLT	ARRAY	NEW
7027 NUMCON	10	INTEGER									
6702 NUMSUC	6	INTEGER									
5670 NMTF	16042	INTEGER									
17172 NMTJP	4540	INTEGER									
6734 OT	6736	REAL									
3455 P1	11300	REAL									
15 PPD	6703	REAL									
6 PVI	536	REAL									
6717 RNFV	6733	REAL									
6727 SOM	2	REAL									
774 STABLE	1614	REAL									
14 STP	0	REAL									
1135 SHMTF	10157	REAL									
6725 TEM	6751	REAL									
6752 TEMPI	12	REAL									
6732 TIMEB	0	REAL									
4 TMABA	3410	REAL									
6731 TMIN	6711	REAL									
12430 TMLC	13560	REAL									
6 TMU	17	REAL									
6737 TOTALT	10	REAL									
3462 TOTIMS	7025	REAL									
3456 TNOPI	0	REAL									
6722 T1	6723	REAL									
6724 T3	12443	REAL									
6 XRAMU	6730	REAL									

FILE NAMES

EXTERNALS
DEV
RAMF
SFTRASE

INLINE FUNCTIONS
AMAXI
FLOAT

STATEMENT LABELS

0 5
4136 700
4108 850
4200 1040
4230 1080
6366 1087
4356 2020
4414 2505
4456 2610
4555 2700
4635 2715
4720 2730

2022 OUTPUT

TYPE
REAL
REAL
REAL

ARGV
1
1
1

INACTIVE

0 5
4136 700
4108 850
4200 1040
4230 1080
6366 1087
4356 2020
4414 2505
4456 2610
4555 2700
4635 2715
4720 2730

0 TAPF5

INPUT
HFSET

ARGV
1
2

INACTIVE
INACTIVE
FMT

0 10
0 600
0 750
6323 905
4203 1050
4246 1082
4317 2000
4363 2300
4420 2510
4502 2615
4607 2705
4664 2716
4726 3000

2022 TAPE6

FMT

INTRIN
INTRIN

0 23
0 650
4154 800
4174 1830
4210 1840
4276 1944
4334 2010
4402 2500
4442 2600
4510 2620
4614 2710
4702 2720
4750 3020

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CDC 6600 FTN V3.0-P243 OPT=1 3/24/71 11.51.36.

PROGRAM PARA

STATEMENT LABELS

4766 3040	4776 3050	6122 3303	
6125 3304	6132 3305	6135 3306	
6142 3307	6145 3308	6152 3309	
6155 3310	6162 3311	6165 3312	
6171 3313	6174 3320	0 3330	
0 4000	5013 4020	5023 4030	
5025 4040	5033 4060	5035 4061	
5090 4080	5071 5000	5210 5001	FMT
5223 5002	5202 5003	6402 5005	
5270 5008	6412 5009	5331 5050	
5364 5060	5405 5070	5412 5080	
5425 5090	5431 5100	5435 5200	
5441 5300	5464 6000	5521 6009	
6422 6010	0 6020	6563 6030	FMT
6462 6040	0 6050	5603 6051	
0 6052	5652 6053	0 6054	
0 6055	6470 6070	5511 6080	FMT
0 6090	6533 6094	6540 6097	FMT
6570 7000	6604 7002	6611 7004	FMT
6636 7006	6644 7008	6652 7009	FMT
6321 7011	0 8888	5627 9800	
5131 9010			

COMMON BLOCKS

PL1	LENGTH
R1	1008
R2	8402
R3	17
R4	1846
NEW	604
NEW	5413
NEW	401
ARCD	12

STATISTICS

PROGRAM LENGTH	27578	1519
BUFFER LENGTH	40448	204
COMMON LENGTH	424538	1707

CDC 6600 FTM V3.0-P243 OPT=1 3/24/71 11.51.36.

```

      1 SUBROUTINE RESET - A35 VERSION
      2 SUBROUTINE RESET(CALL,IMINT)
      3 * THIS POINT CAN BE USED TO RETURN TIME OF A RANDOM INTERRUPT CALCULATED FOR
      4 * EACH ITERATION)

```

```
COMMON /A1/ TYPE(300,2), ESS(300,2), IPREC(300,2), TMBEG(300,2),
1 NATS(300,2), NATF(300,2), AVGTW(300,2), AVGTMD(300,2),
2 PHASUC(300,2), TME(300,2), TMLN(300,2), NTASK(2), ISJT(300,2),
3 NATJTMD(2), NATJP(300,2)
```

COMMON /B2/ STAM(2),SPEED(2),THAVA(2),NUMTRL,NRUN,NUNIT,
1 CNAIT(2),SWAIT(2),PRD(2),TMUP(2)

```
COMMON/PI3/ IPU(2) , ITASK(2) , IRAND(2) , XRAND(2)
TOTIMT(2) , ITIME(2) , STRT(2) , STRS(2) , ISTRS(2) ,
IPREL(300,2) , ADJUST(2) , AUGSP(2) , COMES(300,2) , JPW(2) ,
JLAG(2) , IFREQ(300,2) ,
LST(2) , J , JP , I , IP , IND1
IND2 , IND3 , IND4 , IGNORE , PI , TWOPI
ITFR , IN , IO , TOTIMS(2) , INDS , IND6
```

COMMON /B4/ ATU(2), ATW(2), APS(2), AFS(2), IFREQ(300,2)

```
COMMON /NEW/ TSUMF(2), ISUMI(2), ICHNG, IPKF(300,2),
1  ISMTF(300,2), ATMU(300,2), IAVG(300,2), ASTS(300,2), IASTS(300,2),
2  TSUMTF(2), MUMCON(300,2), SUMCON(300,2), COMLAS(2),
3  AVSCON(300,2), DFMAT(2), VGOAL(2)
```

```
ISUC=0
J=1
```

JP=2
IGNORE=0

```
DO 20 K=1,2
  CWAIT(K) = 0.0
  ITASK(K)=1
  TMU(K)=0.
  JPU(K)=0
  JFLAG(K)=0
  TOTWMSI=0.
```

```

LSI(K)=0
TIME(K)=0.

```

SIR5(K)=1.

15145(K)=1
A005145(K)=0.

```

AUGSTR(K)=0.
20 CONTINUE
IF (CICR0-1) 30,40,30

```

IF (ICM[1]) 30440,30
30 RETURN
40 IF EMAY01NIASK(1)-NIASK(2)...

DO-50 K=1.2
SWALL(K) = 0.0

$$ATU(K) \equiv \eta.$$
$$ATW(K) = 0.$$

• **USEFUL**

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CDC 6680 FTN V3.0-P243 OPT=1 7/24/71 11.51.36.

SUBROUTINE RESET

AFS(1)=0
DO 50 L=1,ITEM
IF (ZOTL(KY)=0)
IF (ZOL(1,KY)=0)
IF (ZOL(1,KY)=0)
50 CONTINUE
ITEM=1
RETURN
END

60

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CDC 6400 FTM V3.0-P243 OPT=1 3/24/71 11.51.36.

SYMBOLIC REFERENCE MAP

ENTRY POINTS
2 RESET

VARIABLES	SM	TYPE	RELOCATION
1152 ADSTR	AFAL	ARRAY	B3
4 APS	AFAL	ARRAY	B4
2265 ATW	REAL	ARRAY	NEW
2	REAL	ARRAY	B4
11311 AVCOM	REAL	ARRAY	NEW
10150 AVTMD	REAL	ARRAY	B1
11307 COMLAS	REAL	ARRAY	NEW
12441 DPMAX	REAL	ARRAY	NEW
3444 I	INTEGER	ARRAY	B3
3415 IAVG	INTEGER	ARRAY	NEW
4 ICHNG	INTEGER	ARRAY	NEW
10 IFREQ	INTEGER	ARRAY	B4
3454 IGNORE	INTEGER	ARRAY	B3
3450 IND1	INTEGER	ARRAY	B3
3452 IND3	INTEGER	ARRAY	B3
3464 IND5	INTEGER	ARRAY	B3
3461 I0	INTEGER	ARRAY	B3
5 IPHF	INTEGER	ARRAY	NEW
4 ITRND	INTEGER	ARRAY	B3
20 ISTRS	INTEGER	ARRAY	B3
0 ISUMF	INTEGER	ARRAY	NEW
2 ITASK	INTEGER	ARRAY	B3
3457 ITER	INTEGER	ARRAY	B3
2310 FLAG	INTEGER	ARRAY	B3
2306 JPV	INTEGER	ARRAY	B3
56 L	INTEGER	ARRAY	B3
7 MOUN	INTEGER	ARRAY	B2
7027 MUMCOM	INTEGER	ARRAY	NEW
6 MUMTHL	INTEGER	ARRAY	B2
16042 MXTJ	INTEGER	ARRAY	B1
4540 NRTS	INTEGER	ARRAY	B1
11300 PPSUC	REAL	ARRAY	B1
2 SPEED	REAL	ARRAY	B2
0 STRN	REAL	ARRAY	B2
10157 SUMCOM	REAL	ARRAY	B2
13 SWAIT	REAL	ARRAY	NEW
4 THAVA	REAL	ARRAY	B2
0 TRINT	REAL	ARRAY	B2
13560 TMLN	REAL	ARRAY	F.P.
17 TWUP	REAL	ARRAY	B1
3462 TOTMS	REAL	ARRAY	B2
3456 TWOPT	REAL	ARRAY	B3
12443 VGOAL	REAL	ARRAY	NEW

INLINE FUNCTIONS
MAX0
TYPE
INTEGEN
0
INTMIN

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UDC 6600 FTM V3.0-0243 OPT=1 -3/24/71 11.51.36.

SUBROUTINE RESET

STATEMENT LABELS

0 20
0 50

INACTIVE

0 30

27 40

COMMON BLOCKS LFNSTH

R1 R402

R2 17

R3 1846

R4 1808

NEW 5413

STATISTICS

PROGRAM LENGTH 578

COMMON LENGTH 376368

16296

47

2

B-27

3

11

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CDC 6400 FTM V3.0-9243 OPT=1 -3/24/71 11.51.36.

SUBROUTINE INPUT

```

252 DO 250 K=1,2
255 READ (10,250) JSTNR(J),SPEED(J),THAVE(J),PDB(J), JOT(J)
256 FORMAT (I1,4F10.0, I1)
115 IF (J.EQ.0) GO TO 50
250 CONTINUE
250 WRITE (10,250)
250 FORMAT (I1)
250 WRITE (10,250) STNR,SPEED,THAVE,PDB,JOT
120 260 FORMAT (5I, 17H) STNR,THAVE,PDB,JOT,2F11.3/165. 4H) SPEED,2F11.3/
2 4H) 14H) TIME ALLOTTED,2F11.3/15H) 7H) PERIOD,2F11.3/17H.
3 5H) TYPE,2 ( I7, 4H)
IF (JOT(1) .GT. 0) CALL RANITUM)
RETURN
END
125

```

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CDC 6400 FTN V3.0-0243 OPT=1 -3/24/71 11.51.36.

SUBROUTINE INPUT

SYMBOLIC REFERENCE MAP

ENTRY POINTS
2 INPUT

VARIABLES	SN	TYPE	RELOCATION	6	AS	REAL	ARRAY	NEW
1152 ADDSTR	4	REAL	APDAY B3	4545	ASIS	REAL	ARRAY	B4
4 APS	2209	REAL	APDAY B4	0	ATU	REAL	ARRAY	NEW
2 ATU	1131	REAL	APDAY B4	1154	AUGSTR	REAL	ARRAY	B1
11311 AVGCOM	10150	REAL	APDAY B1	7020	AVGTH	REAL	ARRAY	B1
10150 AVGTH	11307	REAL	APDAY B1	3356	COMES	REAL	ARRAY	B2
11307 COMES	1244	REAL	APDAY B1	11	CHAIT	REAL	ARRAY	B1
1244 CHAIT	704	REAL	APDAY B1	1110	LSS	REAL	ARRAY	B1
704 DEAN	3446	REAL	APDAY B1	516	REL	REAL	ARRAY	NEW
3446 I	3415	INTEGER	APDAY B3	5675	IASIS	INTEGER	ARRAY	E.P.
3415 IAVG	4	INTEGER	APDAY B4	676	ICALL	INTEGER	ARRAY	NEW
4 ICHMG	637	INTEGER	APDAY B4	101	ICALL	INTEGER	ARRAY	NEW
637 ID2	641	INTEGER	APDAY B4	648	ID3	INTEGER	ARRAY	NEW
641 ID4	10	INTEGER	APDAY B4	2312	IFREQ	INTEGER	ARRAY	NEW
10 IFREQ	3454	INTEGER	APDAY B4	22	IFREQ	INTEGER	ARRAY	NEW
3454 IGNORE	3450	INTEGER	APDAY B3	3460	IN	INTEGER	ARRAY	NEW
3450 IND1	3452	INTEGER	APDAY B3	3451	IND2	INTEGER	ARRAY	NEW
3452 IND3	3464	INTEGER	APDAY B3	3453	IND4	INTEGER	ARRAY	NEW
3464 IND5	3461	INTEGER	APDAY B3	3465	IND6	INTEGER	ARRAY	NEW
3461 IO	5	INTEGER	APDAY B3	3447	IP	INTEGER	ARRAY	NEW
5 IPNF	4	INTEGER	APDAY B3	2240	IPREC	INTEGER	ARRAY	NEW
4 IRAND	20	INTEGER	APDAY B3	14712	ISJT	INTEGER	ARRAY	NEW
20 ISUM1	3457	INTEGER	APDAY B3	0	ISUMF	INTEGER	ARRAY	NEW
3457 ITER	1130	INTEGER	APDAY B3	2	ITASK	INTEGER	ARRAY	NEW
1130 JAG	2206	INTEGER	APDAY B3	3444	J	INTEGER	ARRAY	NEW
2206 JOT	2306	INTEGER	APDAY B3	2310	JFLAG	INTEGER	ARRAY	NEW
2306 JPN	644	INTEGER	APDAY B3	3445	JP	INTEGER	ARRAY	NEW
644 KM	3442	INTEGER	APDAY B3	645	K	INTEGER	ARRAY	NEW
3442 LST	7027	INTEGER	APDAY B3	650	L	INTEGER	ARRAY	NEW
7027 MUMCOM	642	INTEGER	APDAY B3	643	NIMPC	INTEGER	ARRAY	NEW
642 MUMCOM	5670	INTEGER	APDAY B3	14710	NTASK	INTEGER	ARRAY	NEW
5670 NITF	17172	INTEGER	APDAY B3	10	NUNIT	INTEGER	ARRAY	NEW
17172 NITF	11300	INTEGER	APDAY B3	10042	NUTJ	INTEGER	ARRAY	NEW
11300 PROSUB	0	REAL	APDAY B3	4540	NUTS	REAL	ARRAY	NEW
0 PVI	2	REAL	APDAY B3	3455	P1	REAL	ARRAY	NEW
2 SPEED	1014	REAL	APDAY B3	15	PHD	REAL	ARRAY	NEW
1014 STAX	0	REAL	APDAY B3	530	PV2	REAL	ARRAY	NEW
0 STRM	10157	REAL	APDAY B3	774	STABLE	REAL	ARRAY	NEW
10157 SUMCOM	13	REAL	APDAY B3	14	STR	REAL	ARRAY	NEW
13 SWAIT	12	REAL	APDAY B3	10	SIRS	REAL	ARRAY	NEW
12 TIME	4	REAL	APDAY B3	1135	SUMTF	REAL	ARRAY	NEW
4 TMVA	12430	REAL	APDAY B3	647	TLS	REAL	ARRAY	NEW
12430 TMLE	0	REAL	APDAY B3	0	TITLE	REAL	ARRAY	NEW
0 TMU	10	REAL	APDAY B3	3410	TNEG	REAL	ARRAY	NEW
10 TOTTIME	0	REAL	APDAY B3	13540	TMLN	REAL	ARRAY	NEW
0 TOTTIME	10	REAL	APDAY B3	17	TMUP	REAL	ARRAY	NEW
10 TOTTIME	0	REAL	APDAY B3	3462	TOTTIME	REAL	ARRAY	NEW

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CDC 6600 FTM V3.0-0243 OPT=1 3/24/71 11.51.36.

SUBROUTINE INPUT

VARIABLES	SN	TYPE	RELOCATION
7025 TSUMIF		REAL	
3436 TROPI		REAL	
12443 VGOAL		REAL	

FILE NAMES	MODE	TAPE6	FTM
TAPES	FMT		

EXTERNALS	TYPE	WORDS
RAN		1

STATEMENT LABELS

STATEMENT	SN	TYPE	WORDS	INACTIVE	INACTIVE	INACTIVE
0	2	FMT	21 50			
517	75	FMT	43 76			
523	101	FMT	0 105			
0	122	FMT	0 130			
271	150	FMT	274 151			
307	210	FMT	550 220			
0	230	FMT	602 240			
617	250	FMT	436 252			
614	256	FMT	0 258			
525	1000	FMT	612 2000			

COMMON BLOCKS

PLT	LENGTH
R1	1000
R2	0402
R3	17
R4	1046
R5	600
NEW	5413
ARC0	12
RANS	1202

STATISTICS

PROGRAM LENGTH	6530	427
COMMON LENGTH	44148	10548

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CRANSU SUBROUTINE NAM - RELIABILITY AND MAINTAIN ADJUSTMENT
SUBROUTINE NAM

05 C THE PURPOSE OF THIS SUBROUTINE IS TO ADJUST THE TASK ELEMENT
C SUCCESS PROBABILITIES SUCH THAT THE MULTIPLICATIVE SUM OF ALL
C TASK ELEMENTS IN A PARTICULAR GROUP IS EQUAL TO A PREDETERMINED VALUE
C THIS VALUE IS GIVEN IN MATRIX SPOG-SUCCESS PROBABILITY OF GROUP

10 COMMON /B1/ TYPE(300.2), ESS(300.2), IPREC(300.2), TMBEG(300.2),
1 MATS(300.2), NATF(300.2), AVGN(300.2), AVGTMD(300.2),
2 PMSUC(300.2), TML(300.2), TMLN(300.2), NTASK(2), ISJT(300.2),
3 NATJ(300.2), NATP(300.2)

15 COMMON /B2/ STRM(2), SPEED(2), TRVA(2), NUTRL, NUTRL, NUTRL,
1 CVALT(2), SVALT(2), PHD(2), TMAP(2)

20 COMMON /B3/ TNU(2), ITASK(2), IRAND(2), XRAND(2),
2 TOTTM(2), TIME(2), STR(2), STRS(2), ISTRS(2),
3 IFREL(300.2), ADDSTR(2), AUGSTR(2), CONES(300.2), JPU(2),
4 JPLAST(2), IPRED(300.2),
5 LST(2), J, JP, I, IND4, IGNORE, PI, IND1,
6 IND2, IND3, IND4, TOTTMS(2), IND5, IND6
7 ITER, IN, IO

25 COMMON /RAMS/ OLPROB(300.2), JAG(300.2), JOT(2)

COMMON /SPEC/ M6(8.2), PG(8.2), TP(8.2),

1 ICE(8.2), THR(8.2), AIO(8.2)

DIMENSION SPOG(8.8)

DATA SPOG / .021, .791, .73, .091, .70, .55, .92, .74,
2 .90, .90, .91, .97, .70, .83, .86, .95,
3 .94, .92, .87, .93, .70, .86, .96, .97,
4 .56, .72, .63, .65, .64, .62, .65, .44,
5 .41, .30, .97, .91, .30, .32, .91, .56,
6 .60, .73, .93, .71, .77, .64, .85, .96,
7 .74, .72, .87, .44, .89, .94, .93, .53,
8 .63, .30, .65, .06, .04, .30, .74, .67/

C INITIALIZATION

DO 7 J = 1, 2

DO 5 JA = 1, 0

NOTJAS(J) = 0

PG(JA, J) = 0

TP(JA, J) = 0

ICE(JA, J) = 0

THR(JA, J) = 0

AIO(JA, J) = 0

5 CONTINUE

7 CONTINUE

J = 1

I = 1

IOK = 0

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-----LINE RAM

CDC 6600 FTM V3.0-P243 OPT=1 3/24/71 11:51.36.

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10 CONTINUE
  J1 = J1 + 1
  IF (JA - LE. 0 .OR. JA - GT. 0) GO TO 20
  NG(JA,J) = NG(JA,J) + 1
  IF (PG(JA,J) - LE. 0 .OR. PG(JA,J) - GT. 0) GO TO 15
  PG(JA,J) = PG(JA,J) + PROSUC(J,J)
  GO TO 20
15 PG(JA,J) = PROSUC(J,J)
20 CONTINUE
  IF (PROSUC(J,J) - LE. .5 .AND. NRTF(1,J) - NE. 1) GO TO 25
  I = NRTF(1,J)
  GO TO 30
25 I = NRTF(1,J)
30 CONTINUE
  IF (I - GT. 0) GO TO 10
  IF (I - EQ. 2) GO TO 40
  J = 2
  I = 1
  GO TO 10
40 CONTINUE
  DO 62 J = 1, 2
  J1 = J1 + 1
  DO 80 J1 = 1, 52, 60, 56
  IF (NG(JA,J) - 1) 52, 60, 56
  52 ICE(JA,J) = 1
  10K = 10K + 1
  GO TO 60
56 CONTINUE
  TEST = ABS( SPOG(JA,J1) - PG(JA,J1) )
  IF (TEST - GE. .01) GO TO 58
  ICE(JA,J) = 1
  10K = 10K + 1
  GO TO 60
58 CONTINUE
  FN = NG(JA,J1)
  TMM(JA,J) = SPOG(JA,J1) ** (1. / FN)
60 CONTINUE
62 CONTINUE
  DO 70 J = 1, 2
  J1 = J1 + 1
  IF (J1 - LE. 0) GO TO 70
  WRITE(10, 1000) J
  1000 FORMAT(10, 45H ORIGINAL DATA BEFORE ADJUSTMENT FOR OPERATOR,
  1 15/75, 2NJA, 5X, 2HNG, 5X, 2HNG, 5X, 2HNSP, 5X, 2HOK,
  10 45 JA = 1, 6
  
```

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CDC 6600 FTN V3.0-P243 OPT=1 3/24/71 11.51.36.

SUBROUTINE RAM

WRITE(10, 1010) JA, NG(JA,J), PG(JA,J), SPOG(JA,JT), ICE(JA,J)

1010 FORMAT(10, 16, 17, F7.3, F7.2, 17)

85 CONTINUE

78 CONTINUE

80 CONTINUE

J = 1

I = 1

JT = JOT(J)

90 CONTINUE

JA = JAR(I,J)

IF (JA .LE. 0 .OR. JA .GT. 8) GO TO 100

IF (ICE(JA,J) .EQ. 1) GO TO 100

IF (INST(JT) .NE. 1) GO TO 95

PRBSUC(I,J) = SPOG(JA,JT)

ICE(JA,J) = 1

10K = 10K + 1

GO TO 100

95 AID(JA,J) = AID(JA,J) + (INST(JA,J) - PRBSUC(I,J))

IP1JA(JT) = IP1JA(JT) + (1. - PRBSUC(I,J))

PG(JA,J) = 0

100 CONTINUE

IF (PRBSUC(I,J) .LE. .5 .AND. NATF(I,J) .NE. 1) GO TO 110

I = NATF(I,J)

GO TO 120

110 I = NATF(I,J)

120 CONTINUE

IF (I .GT. 8) GO TO 90

IF (J .EQ. 2) GO TO 130

J = 2

I = 1

JT = JOT(J)

GO TO 90

130 CONTINUE

J = 1

I = 1

JT = JOT(J)

140 CONTINUE

JA = JAR(I,J)

IF (JA .LE. 0 .OR. JA .GT. 8) GO TO 150

IF (ICET(JT) .EQ. 1) GO TO 150

PRBSUC(I,J) = PRBSUC(I,J) + (1. - PRBSUC(I,J)) *

1. (AID(JA,J) / IP1JA(JT))

IF (PG(JA,J) .LE. 0) GO TO 145

PG(JA,J) = PG(JA,J) + PRBSUC(I,J)

GO TO 150

145 PG1JA(JT) = PRBSUC(I,J)

150 CONTINUE

IF (PRBSUC(I,J) .LE. .5 .AND. NKTF(I,J) .NE. 1) GO TO 160

I = NATF(I,J)

160 CONTINUE

J = 1

I = 1

JT = JOT(J)

170 CONTINUE

JA = JAR(I,J)

IF (JA .LE. 0 .OR. JA .GT. 8) GO TO 150

IF (ICET(JT) .EQ. 1) GO TO 150

PRBSUC(I,J) = PRBSUC(I,J) + (1. - PRBSUC(I,J)) *

1. (AID(JA,J) / IP1JA(JT))

IF (PG(JA,J) .LE. 0) GO TO 145

PG(JA,J) = PG(JA,J) + PRBSUC(I,J)

GO TO 150

145 PG1JA(JT) = PRBSUC(I,J)

150 CONTINUE

IF (PRBSUC(I,J) .LE. .5 .AND. NKTF(I,J) .NE. 1) GO TO 160

I = NATF(I,J)

160 CONTINUE

J = 1

I = 1

JT = JOT(J)

170 CONTINUE

JA = JAR(I,J)

IF (JA .LE. 0 .OR. JA .GT. 8) GO TO 150

IF (ICET(JT) .EQ. 1) GO TO 150

PRBSUC(I,J) = PRBSUC(I,J) + (1. - PRBSUC(I,J)) *

1. (AID(JA,J) / IP1JA(JT))

IF (PG(JA,J) .LE. 0) GO TO 145

PG(JA,J) = PG(JA,J) + PRBSUC(I,J)

GO TO 150

145 PG1JA(JT) = PRBSUC(I,J)

150 CONTINUE

IF (PRBSUC(I,J) .LE. .5 .AND. NKTF(I,J) .NE. 1) GO TO 160

I = NATF(I,J)

160 CONTINUE

J = 1

I = 1

JT = JOT(J)

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CDC 6600 FTN V3.0-P243 OPT=1 -3/24/71 11.51.36.

SUBROUTINE NAM

```

160 1 = MATF(I,J)
    GO TO 170
170 CONTINUE
    IF (I.EQ. 0) GO TO 140
    IF (J.EQ. 2) GO TO 180
    J = 2
    I = 1
    JI = JOT(J)
    GO TO 140
175
180 CONTINUE
    DO 210 J = 1,2
    JI = JOT(J)
    DO 200 JA = 1,6
    IF (ICE(JA,J) .EQ. 1) GO TO 190
    TEST = ABS( SP06(JA,JI) - PG(JA,JI) )
    IF (TEST .GE. .01) GO TO 190
    ICE(JA,J) = 1
    10K = 10K + 1
190 CONTINUE
200 CONTINUE
210 CONTINUE
    IF (10K .GE. 16) GO TO 300
    DO 220 J = 1,2
    DO 220 JA = 1,6
    AID(JA,J) = 0.
    IP(JA,J) = 0.
220 CONTINUE
    GO TO 310
300 CONTINUE
    DO 320 J = 1,2
    JI = JOT(J)
    IF (JI .EQ. 0) GO TO 320
    WRITE(10,1020) J
1020 FORMAT('ZSKREVISED DATA FOR OPERATOR: 14/11.
1 4THIAK-EL GROUP N-GRP GRPSUC OLDPROB NEWPROB)
    N = NIACK(J)
    DO 310 I = 1,N
    JA = JAG(I,J)
    IF (JA .EQ. 0) JA = 0.
    JA = 0.
    WRITE(10,1030) 1, JA, NG(JA,JI), SPUG(JA,JI), OLPROB(I,JI), PRRSUC(I,JI)
1030 FORMAT(1H, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000)
305 WRITE(10,1040) 1, JA, OLPROB(I,JI), PRRSUC(I,JI)
1040 FORMAT(1H, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000)
310 CONTINUE
320 CONTINUE
    RETURN
END

```

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SUBROUTINE RAM CDC 6600 FTM V3.0-P243 OPT=1 3/24/71 11.51.36.

CARD NO. SEVERITY DIAGNOSTIC

204 I 53CD 204 X-FIELD PRECEDED BY A BLANK. IX ASSUMED

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SUBROUTINE RAM
SYMBOLIC REFERENCE MAP
CDC 6600 FTM V3.0-2243 OPT=1 3/24/71 11.51.36.

ENTRY POINTS
1 RAM

VARIABLES	SM	TYPE	RELOCATION	120	A10	REAL	ARRAY	SPEC
1152 ADOSTR	REAL	ARRAY	B3	7020	AVGTM	REAL	ARRAY	B1
1154 AUGSTR	REAL	ARRAY	B3			REAL	ARRAY	B3
10150 AVGTMO	REAL	ARRAY	B1	1156	COSES	REAL	ARRAY	B1
11 CVAIT	REAL	ARRAY	B2	1130	ESS	REAL	ARRAY	B3
633 FN	REAL	ARRAY	B2	3446	1	INTEGER	ARRAY	B3
60 ICE	INTEGER	ARRAY	SPEC	2312	IFREQ	INTEGER	ARRAY	B3
22 IFREQ	INTEGER	ARRAY	B3	3454	IGNORE	INTEGER	ARRAY	B3
3460 IN	INTEGER	ARRAY	B3	3450	IND1	INTEGER	ARRAY	B3
3451 IND2	INTEGER	ARRAY	B3	3452	IND3	INTEGER	ARRAY	B3
3453 IND4	INTEGER	ARRAY	B3	3464	IND5	INTEGER	ARRAY	B3
3465 IND6	INTEGER	ARRAY	B3	3461	10	INTEGER	ARRAY	B3
630 IND	INTEGER	ARRAY	B3	3467	1P	INTEGER	ARRAY	B3
2260 IPREC	INTEGER	ARRAY	B1	4	IRAND	INTEGER	ARRAY	B3
14712 ISJT	INTEGER	ARRAY	B1	20	ISTR	INTEGER	ARRAY	B3
2 ITASK	INTEGER	ARRAY	B3	3457	ITER	INTEGER	ARRAY	B3
3444 J	INTEGER	ARRAY	B3	627	JA	INTEGER	ARRAY	B3
1130 JAG	INTEGER	ARRAY	RAMS	2310	JFLAG	INTEGER	ARRAY	B3
2260 JOT	INTEGER	ARRAY	RAMS	3445	JP	INTEGER	ARRAY	B3
2366 JPM	INTEGER	ARRAY	RAMS	631	JT	INTEGER	ARRAY	B3
3442 LST	INTEGER	ARRAY	B3	634	N	INTEGER	ARRAY	B3
0 M8	INTEGER	ARRAY	SPEC	7	NRUN	INTEGER	ARRAY	B1
14710 NTASK	INTEGER	ARRAY	B1	10	NUMIT	INTEGER	ARRAY	B2
6 NUMITL	INTEGER	ARRAY	B2	5670	NATF	INTEGER	ARRAY	B1
16042 NNTJ	INTEGER	ARRAY	B1	17172	NATJP	INTEGER	ARRAY	B1
4540 NNTS	INTEGER	ARRAY	B1	0	ULPROR	REAL	ARRAY	RAMS
20 PG	REAL	ARRAY	SPEC	3455	P1	REAL	ARRAY	B3
11300 PROSUC	REAL	ARRAY	B1	15	PRO	REAL	ARRAY	B1
2 SPEED	REAL	ARRAY	B2	635	SPOG	REAL	ARRAY	B3
14 STR	REAL	ARRAY	B3	0	STRM	REAL	ARRAY	B3
16 STRS	REAL	ARRAY	B3	13	SWAIT	REAL	ARRAY	B3
632 TEST	REAL	ARRAY	B3	12	TIME	REAL	ARRAY	B3
4 TMAVA	REAL	ARRAY	B2	3410	THREG	REAL	ARRAY	B1
12430 TMLE	REAL	ARRAY	B1	13560	TMEN	REAL	ARRAY	B1
0 TNU	REAL	ARRAY	B3	17	TMUP	REAL	ARRAY	B2
100 TNR	REAL	ARRAY	SPEC	10	TOTMI	REAL	ARRAY	B3
3462 TOTMIS	REAL	ARRAY	B3	40	TP	REAL	ARRAY	SPEC
3456 TMOPI	REAL	ARRAY	B3	0	TYPE	REAL	ARRAY	B1
6 XRAMD	REAL	ARRAY	B3			REAL	ARRAY	B1

INLINE FUNCTIONS
ANS
TYPE
REAL
1
INTIN

STATEMENT LABELS

0 5	0 7
45 15	52 20
71 30	100 40
115 56	132 58
0 62	0 65

20 10	28 10
65 28	0 52
0 52	144 60
144 60	215 70

INACTIVE

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CDC 6600 FTM V3.0-P243 OPT=1 -3/24/71 11.51.36.

STATEMENT LABELS	SUMROUTING	RAM
222 00	225 90	256 95
274 100	307 110	313 130
324 130	327 140	365 145
372 150	405 160	411 170
422 180	442 190	0 200
0 210	0 220	462 300
536 305	556 310	561 320
500 1000 PNT	576 1010 PNT	607 1020 PNT
616 1030 PNT	620 1040 PNT	

COMMON BLOCKS	LENGTH
B1	9402
P2	17
B3	1000
RAMS	1702
SPEC	96

STATISTICS	PROGRAM LENGTH	7350	477
COMMON LENGTH	204530	11563	

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CDC 6600 FTH V3.0-9243 0P1=1 3/24/71 11.51.36.

FUNCTION DEV

```

C      FUNCTION DFV(D)
C      DIMENSION XTAB(17),YTAB(17)
C      1.      SCALE(1)=AMPY(1)*BASE(1)
C      C
C      C      INTEGER BASE=0
C      C
C      DATA (XTAB(1),1)=1.171/0.0,0.0,1.554/0.0,2580/0.0,3159/0.0,3666/0.0,4032/
C      1 0.4192/0.0,4332/0.0,4452/0.0,4554/0.0,4641/0.0,4713/0.0,4772/0.0,4821/0.0,4878/
C      2 0.4928/0.0,5000/
C      DATA (YTAB(1),1)=1.171/0.0,0.0,4.0,7.0,9.0,1.1,1.3,1.4,1.5,1.6,1.7,
C      1 1.8,1.9,2.0,2.1,2.2,2.5,2.584,9/
C      15 DATA SCALE=AMPY*BASE/8, 30000000.1,95312500.1,27679/
C      C
C      C      HOLD = FLOAT(BASE)*AMPY
C      BASE = IFIX(HOLD) .AND. 3777777
C      AT = IFIX(BASE/77SCALE) - 825
C      A2 = ANK(A1)
C      DO 50 J=1,17
C      IF (A2 .LT. XTAB(1)) GO TO 70
C      25 CONTINUE
C      DEV = 0.0
C      RETURN
C      70 TEMP = YTAB(1-1) + ((YTAB(1) - YTAB(1-1))*((A2 - XTAB(1-1)))/
C      1 (XTAB(1) - XTAB(1-1)))
C      DEV = TEMP
C      IF (A1 .GE. 0.0) GO TO 90
C      DEV = -TEMP
C      30 RETURN
C      C
C      C      ENTRY SFTBASE
C      BASE = 0
C      RETURN
C      END

```

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CDC 6400 FTM V3.0-P243 OPT-1 3/24/71 11.51.30.

FUNCTION DEV

CARD NO.	SEVERITY	DIAGNOSTIC
19	1	BASE OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
19	1	AMPY OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
20	1	BASE OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
21	1	BASE OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
21	1	SCALE OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED
37	1	BASE OPERAND NOT SUBSCRIPTED. FIRST ELEMENT WILL BE USED

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FUNCTION DEV CDC 6600 FTH V3.0-P243 OPT=1 3/24/71 11.51.36.

SYMBOLIC REFERENCE MAP

ENTRY POINTS		45 SETRASE	
2	DEV		
VARIABLES		SN	TYPE
134	AMPY	REAL	RELOCATION
66	A2	REAL	ARRAY
6	D	INTEGER	F.P.
64	HOLD	REAL	
133	SCALE	REAL	ARRAY
71	XTAB	REAL	ARRAY
INLINE FUNCTIONS		TYPE	ARGS
ABS	REAL	1	INTRIN
IFIX	INTEGER	1	INTRIN
STATEMENT LABELS			
0	50		
STATISTICS			
PROGRAM LENGTH		1368	94
		27	70
			42
			98

[illegible]

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RAM	055153	INPUT	054650	
DEV	056111	PARA	047333	047146
SETRASE	056154	PARA	046701	
GRIRA	056244	SIO	056537	
CIOI.	057327			
RCLI.	057350	SYSTEMS	064045	
DAT.	056266	INPUTCS	057676	057746 057754
		MODERS	060112	060671
		KRAKERS	061503	062112 062174 062202
		OUTPTCS	063078	063122 063132
		SYSTEMS	063556	063601 063710 063721 063744
			063756	063775
SIO.CIL	056514	SYSTEMS	063776	063716 063665 064027 063672 063711 063350
INITL.	056535	INPUTCS	057705	
		OUTPTCS	063103	
		SYSTEMS	064025	
SIO.	056601	INPUTCS	057750	
		OUTPTCS	063126	
		SYSTEMS	063670	063776 063714
SIO.END	057302	SYSTEMS	064042	
OPEN.	057357	SYSTEMS	064014	
RDRU.	057420			
BSPRU.	057435			
ADVIN.	057442	SYSTEMS	064041	
POSF1.	057470			
RVWDS.	057615			
ACGOER.	057631	PARA	047260	047226 047212
INPUTCI.	057703	PARA	046627	
		INPUT	054600	054250 054241 054206 054163
INPUTC.	057720	PARA	046632	046631
		INPUT	054615	054612 054610 054606 054602
			054351	054344 054340 054334 054324
			054320	054316 054304 054300 054270
			054244	054240 054234 054230 054216
			054230	054226 054224 054222 054214
			054212	054210 054176 054175 054171 054167
			054165	
MODER.	057762	OUTPTCS	063076	063110

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NAME	061756	057730	057701	057724
FRSETS	062060	051075	051013	050750
OPUTCL	063100	050547	050515	050506
		047066	046737	046737
		050002	054625	054572
		054631	055661	055642
		055712		
OUTPTC	063107	051032	051031	051027
		050776	050774	050772
		050740	050756	050754
		050656	050655	050653
		050641	050637	050612
		050601	050577	050575
		050541	050537	050535
		050476	050474	050472
		050343	050341	050337
		050325	050323	050313
		050302	050103	050102
		050060	050064	050062
		050041	050040	050036
		050022	050020	050016
		046746	046745	046743
INPUT		054044	054043	054041
		054573	054562	054561
		054535	054531	054525
		054501	054475	054471
		054443	054441	054437
RAM		055727	055726	055722
		055701	055675	055671
		055363	055362	055356
		055333		

NAME	063143	063250
ALOG	063143	063250
EXP	063203	063200
RANDOM	063247	063253
RANMLT	063250	
RANFS	063252	
XTOY	063261	
XTOYS	063261	
QNTTRY	063271	
ZND	063347	
EXITS	063372	
STOP	063400	
		047071
		054236

NAME	047582	047582	047582
ALOG	047582	047582	047582
EXP	047582	047582	047582
RANDOM	047582	047582	047582
RANMLT	047582	047582	047582
RANFS	047582	047582	047582
XTOY	047582	047582	047582
XTOYS	047582	047582	047582
QNTTRY	047582	047582	047582
ZND	047582	047582	047582
EXITS	047582	047582	047582
STOP	047582	047582	047582

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ANALOG.	063411	ACGERS INPUTS KUNERS KRAKERS OUTPUTS	057634 057723 061051 062372 063142	062464			
SYSTEM	063430						
SYSTEMS	063454						
SYSTEM.	063460						
SYSTEM:	063512						
		ACGERS INPUTS KUNERS KRAKERS OUTPUTS	057633 057722 061035 062206 062461 063141	061046 062221	061050 062321	061020 062345	062407 062433 062450
SYS1:	063700	KRAKERS	062133	062323	062140		
SYS2:	063674	KRAKERS	062327	062463	062313		
LOT:	064105	KRAKERS	062325	062331			

DRGFEI. 064125
-----UNSATISFIED EXTERNAL S-----
REFERENCES

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TASK NUMBER	NUMBER OF RUNS	NUMBER OF ITERATIONS
1	1	5

TASK DATA FOR OPERATOR !

TASK NO	TASK TYPE	TASK NON FSS	PREFERENCE	NEXT-TASK	AVERAGE TIME	TIME PROB. DEV	SUC	TIME REMAINING	SPEC. CODE	JUMP OPI	TASK NO2	JAG	
1			-0	-0.00	2	1	2,710	1,060	.970	1070.640	0.000	-0	7
2			-0	-0.00	3	2	8,780	1,250	.970	1067.930	0.000	-0	7
3			-0	-0.00	4	3	2,710	1,060	.970	1059.150	0.000	-0	7
4			-0	-0.00	5	4	3,000	1,000	.980	1056.440	0.000	-0	7
5			-0	-0.00	6	5	2,710	1,060	.970	1053.440	0.000	-0	7
6			-0	-0.00	7	6	3,000	1,000	.980	1050.730	0.000	-0	7
7			-0	-0.00	8	7	2,710	1,060	.970	1047.730	0.000	-0	7
8			-0	-0.00	9	8	8,780	1,000	.980	1045.020	0.000	-0	7
9			-0	-0.00	10	9	150,000	60,000	.500	1036.240	0.000	-0	9
10			-0	-0.00	11	10	14,340	1,640	.890	886.240	0.000	-0	7
11			-0	-0.00	44	11	1,200	.400	.990	871.900	0.000	-0	7
12			-0	-0.00	13	12	150,000	50,000	.990	870.780	0.000	-0	9
13			-0	-0.00	14	13	2,330	.650	.990	720.780	0.000	-0	7
14			-0	-0.00	15	14	20,000	5,820	.980	718.370	0.000	-0	-0
15			-0	-0.00	16	15	2,330	.650	.990	690.370	0.000	-0	7
16			-0	-0.00	17	16	115,240	20,420	.940	680.840	0.000	-0	-0
17			-0	-0.00	18	17	1,100	.330	.990	572.800	0.000	-0	-0
18			-0	-0.00	19	18	65,380	21,760	.970	571.780	0.000	-0	-0
19			-0	-0.00	20	19	6,760	2,250	.980	506.320	0.000	-0	-0
20			-0	-0.00	45	20	60,120	20,110	.970	499.560	0.000	-0	-0
21			-0	-0.00	22	21	2,330	.650	.990	439.640	0.000	-0	7
22			-0	-0.00	23	22	20,000	5,820	.980	437.110	0.000	-0	-0
23			-0	-0.00	24	23	2,330	.650	.990	409.110	0.000	-0	-0
24			-0	-0.00	25	24	14,320	4,770	.980	406.780	0.000	-0	7
25			-0	-0.00	26	25	8,600	3,000	.930	392.460	0.000	-0	7
26			-0	-0.00	27	26	2,710	1,060	.970	383.860	0.000	-0	7
27			-0	-0.00	28	27	8,780	1,250	.970	381.150	0.000	-0	7
28			-0	-0.00	29	28	16,720	5,540	.920	372.370	0.000	-0	7
29			-0	-0.00	30	29	4,060	1,350	.990	355.650	0.000	-0	7
30			-0	-0.00	31	30	2,710	1,060	.970	351.590	0.000	-0	7
31			-0	-0.00	32	31	3,000	1,250	.970	348.880	0.000	-0	7
32			-0	-0.00	33	32	16,720	5,540	.920	345.880	0.000	-0	7
33			-0	-0.00	34	33	4,060	1,350	.990	329.160	0.000	-0	7
34			-0	-0.00	35	34	2,710	1,060	.970	325.100	0.000	-0	7
35			-0	-0.00	36	35	3,000	.025	.970	322.390	0.000	-0	7
36			-0	-0.00	37	36	16,720	5,540	.920	319.390	0.000	-0	

1

C

C



B-47

1

JA	NG	PG	SP	OK
1	6	.456	.62	0
2	0	0.000	.76	1
3	0	0.000	.73	1
4	0	0.000	.60	1
5	0	0.000	.74	1
6	0	0.000	.55	1
7	32	.336	.92	0
8	6	.306	.78	0

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REVISED DATA FOR OPERATOR 1

TASK-EL	GROUP	N-GPP	GRPSUC	ON DPHOR	NFMPHOR
1	7	32	.92	.970	.998
2	7	32	.92	.970	.998
3	7	32	.92	.970	.998
4	7	32	.92	.940	.998
5	7	32	.92	.970	.998
6	7	32	.92	.940	.998
7	7	32	.92	.970	.998
8	7	32	.92	.980	.998
9	9	32	.92	.500	.500
10	7	32	.92	.890	.991
11	7	32	.92	.990	.999
12	9	32	.92	.940	.990
13	7	32	.92	.940	.999
14	-0			.980	.980
15	7	32	.92	.990	.999
16	-0			.940	.940
17	-0			.990	.990
18	-0			.970	.970
19	-0			.980	.980
20	-0			.970	.970
21	7	32	.92	.940	.999
22	-0			.980	.980
23	7	32	.92	.990	.999
24	7	32	.92	.940	.998
25	7	32	.92	.930	.995
26	7	32	.92	.970	.998
27	7	32	.92	.970	.998
28	7	32	.92	.920	.994
29	7	32	.92	.990	.999
30	7	32	.92	.970	.998
31	7	32	.92	.970	.994
32	7	32	.92	.920	.994
33	7	32	.92	.940	.999
34	7	32	.92	.970	.998
35	7	32	.92	.970	.998
36	7	32	.92	.920	.994
37	7	32	.92	.940	.999
38	7	32	.92	.970	.998
39	7	32	.92	.970	.998
40	7	32	.92	.920	.994
41	7	32	.92	.990	.999
42	-0			.990	.990
43	-0			.940	.940
44	1	6	.62	.788	.803
45	1	6	.62	.450	.967
46	1	6	.62	.950	.967
47	1	6	.62	.800	.849
48	1	6	.62	.940	.967
49	1	6	.62	.950	.967
50	9			.990	.998

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DETAIL OUTPUT OF ITERATION									
OPERATOR 1					OPERATOR 2				
TASK NO	TASK NO	STRESS	TIME	SFI	TASK NO	TASK NO	STRESS	TIME	SFI
IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
1	1	1.00	1.00	0.00	1	1	1.00	1.00	0.00
2	2	1.00	1.00	0.00	2	2	1.00	1.00	0.00
3	3	1.00	1.00	0.00	3	3	1.00	1.00	0.00
4	4	1.00	1.00	0.00	4	4	1.00	1.00	0.00
5	5	1.00	1.00	0.00	5	5	1.00	1.00	0.00
6	6	1.00	1.00	0.00	6	6	1.00	1.00	0.00
7	7	1.00	1.00	0.00	7	7	1.00	1.00	0.00
8	8	1.00	1.00	0.00	8	8	1.00	1.00	0.00
9	9	1.00	1.00	0.00	9	9	1.00	1.00	0.00
10	10	1.00	1.00	0.00	10	10	1.00	1.00	0.00
11	11	1.00	1.00	0.00	11	11	1.00	1.00	0.00
12	12	1.00	1.00	0.00	12	12	1.00	1.00	0.00
13	13	1.00	1.00	0.00	13	13	1.00	1.00	0.00
14	14	1.00	1.00	0.00	14	14	1.00	1.00	0.00
15	15	1.00	1.00	0.00	15	15	1.00	1.00	0.00
16	16	1.00	1.00	0.00	16	16	1.00	1.00	0.00
17	17	1.00	1.00	0.00	17	17	1.00	1.00	0.00
18	18	1.00	1.00	0.00	18	18	1.00	1.00	0.00
19	19	1.00	1.00	0.00	19	19	1.00	1.00	0.00
20	20	1.00	1.00	0.00	20	20	1.00	1.00	0.00
45	45	1.00	1.00	0.00	45	45	1.00	1.00	0.00
46	46	1.00	1.00	0.00	46	46	1.00	1.00	0.00
21	21	1.00	1.00	0.00	21	21	1.00	1.00	0.00
22	22	1.00	1.00	0.00	22	22	1.00	1.00	0.00
23	23	1.00	1.00	0.00	23	23	1.00	1.00	0.00
24	24	1.00	1.00	0.00	24	24	1.00	1.00	0.00
25	25	1.00	1.00	0.00	25	25	1.00	1.00	0.00
26	26	1.00	1.00	0.00	26	26	1.00	1.00	0.00
27	27	1.00	1.00	0.00	27	27	1.00	1.00	0.00
28	28	1.00	1.00	0.00	28	28	1.00	1.00	0.00
29	29	1.00	1.00	0.00	29	29	1.00	1.00	0.00
30	30	1.00	1.00	0.00	30	30	1.00	1.00	0.00
31	31	1.00	1.00	0.00	31	31	1.00	1.00	0.00
32	32	1.00	1.00	0.00	32	32	1.00	1.00	0.00
33	33	1.00	1.00	0.00	33	33	1.00	1.00	0.00
34	34	1.00	1.00	0.00	34	34	1.00	1.00	0.00
35	35	1.00	1.00	0.00	35	35	1.00	1.00	0.00
36	36	1.00	1.00	0.00	36	36	1.00	1.00	0.00
37	37	1.00	1.00	0.00	37	37	1.00	1.00	0.00
38	38	1.00	1.00	0.00	38	38	1.00	1.00	0.00
39	39	1.00	1.00	0.00	39	39	1.00	1.00	0.00
40	40	1.00	1.00	0.00	40	40	1.00	1.00	0.00
41	41	1.00	1.00	0.00	41	41	1.00	1.00	0.00
42	42	1.00	1.00	0.00	42	42	1.00	1.00	0.00
43	43	1.00	1.00	0.00	43	43	1.00	1.00	0.00
47	47	1.00	1.00	0.00	47	47	1.00	1.00	0.00

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1	1.00	1.00	0.00	3.05	448.53	0.00
2	1.00	1.00	0.00	7.11	805.66	0.00
3	1.00	1.00	0.00	1.69	157.13	0.00
4	1.00	1.00	0.00	2.65	359.97	0.00
5	1.00	1.00	0.00	4.23	804.21	0.00
6	1.00	1.00	0.00	2.24	464.65	0.00
7	1.00	1.00	0.00	3.07	609.52	0.00
8	1.00	1.00	0.00	7.63	877.14	0.00
9	1.00	1.00	0.00	132.34	1009.48	0.00
9	1.00	1.00	0.00	48.29	1057.78	F
9	1.00	1.00	0.00	110.50	1100.20	F
9	1.00	1.00	0.00	21.35	1109.63	0.00
10	1.00	1.00	0.00	15.57	1205.20	0.00
11	1.00	1.00	0.00	1.03	1206.83	0.00
44	1.00	1.00	0.00	0.00	1206.83	F 0557.54
1	1.00	1.00	0.00	2.67	1209.58	0.00
2	1.00	1.00	0.00	0.41	1217.91	0.00
3	1.00	1.00	0.00	3.93	1221.05	0.00
4	1.00	1.00	0.00	2.57	1224.42	0.00
5	1.00	1.00	0.00	3.04	1228.25	0.00
6	1.00	1.00	0.00	2.35	1230.61	0.00
7	1.00	1.00	0.00	1.89	1232.10	0.00
8	1.00	1.00	0.00	4.14	1241.25	0.00
9	1.00	1.00	0.00	164.93	1400.10	F
9	1.00	1.00	0.00	165.80	1553.97	F
9	1.00	1.00	0.00	107.02	1600.99	F
9	1.00	1.00	0.00	159.07	1820.06	F
9	1.00	1.00	0.00	123.26	1843.32	0.00
10	1.00	1.00	0.00	15.65	1950.97	0.00
11	1.00	1.00	0.00	1.50	1960.53	0.00
44	1.00	1.00	0.00	0.00	1960.53	F 0557.58
1	1.00	1.00	0.00	3.01	1963.54	0.00
2	1.00	1.00	0.00	4.96	1972.50	0.00
3	1.00	1.00	0.00	7.75	1973.25	0.00
4	1.00	1.00	0.00	5.65	1976.70	0.00
5	1.00	1.00	0.00	1.77	1980.40	0.00
6	1.00	1.00	0.00	2.78	1983.26	0.00
7	1.00	1.00	0.00	1.65	1984.91	0.00
8	1.00	1.00	0.00	7.12	1992.03	0.00
9	1.00	1.00	0.00	177.89	2109.52	F
9	1.00	1.00	0.00	109.04	2270.50	F
9	1.00	1.00	0.00	151.00	2431.55	F
9	1.00	1.00	0.00	41.78	2473.33	0.00
10	1.00	1.00	0.00	14.64	2487.98	0.00
11	1.00	1.00	0.00	0.90	2488.88	0.00
44	1.00	1.00	0.00	0.00	2488.88	F 0557.58
12	1.00	1.00	0.00	196.70	2645.66	0.00
13	1.00	1.00	0.00	2.17	2687.83	0.00
14	1.00	1.00	0.00	29.81	2717.64	0.00
15	1.00	1.00	0.00	3.02	2721.47	0.00
16	1.00	1.00	0.00	105.10	2826.57	0.00
17	1.00	1.00	0.00	1.22	2827.78	0.00
18	1.00	1.00	0.00	97.79	2925.50	0.00
19	1.00	1.00	0.00	5.26	2930.04	0.00
20	1.00	1.00	0.00	33.78	2944.62	0.00

[illegible]

SUMMARY OUTPUT OF ITERATION	I	KIM	TOTAL
	1	1	1
UNOFFER RUN	TOTAL TIME USED	3618.81	

UPPER	THICKNESS	SPEED	TIME S					PEAK STRESS	FINAL STRESS	LAST COMPRESS	CYCLIC WAIT
NO	MM IN		AVAIL.	UPPER	DIFF	WAIT	TASK	VALUE			
1	2.30	1.00	10000.00	7412.01	-6541.2	0.0	1	1.00	1.00	0.00	0.00
2	2.30	1.00	10000.00	.75	-4499.2	0.0	1	1.00	1.00	0.00	0.00

DETAIL OUTPUT OF ITERATION 2 RUN 1 TASK 1

OPERATOR 1										OPERATOR 2									
TASK NO	TASK NO	STRESS	IND TOT	WAIT	T I M E S	CUM	SFI	COMES	TASK NO	TASK NO	STRESS	IND TOT	WAIT	T I M E S	CUM	SFI	COMES	TASK NO	TASK NO
1	1	1.00	1.00	0.00	3.85	3.85	0.00	0.00	1	1	1.00	1.00	0.00	.75	.75	0.00	0.00	1	1
2	2	1.00	1.00	0.00	9.02	12.87	0.00	0.00											
3	3	1.00	1.00	0.00	2.21	15.08	0.00	0.00											
4	4	1.00	1.00	0.00	1.83	16.91	0.00	0.00											
5	5	1.00	1.00	0.00	1.86	18.77	0.00	0.00											
6	6	1.00	1.00	0.00	2.72	21.49	0.00	0.00											
7	7	1.00	1.00	0.00	1.74	23.29	0.00	0.00											
8	8	1.00	1.00	0.00	4.31	32.59	0.00	0.00											
9	9	1.00	1.00	0.00	116.29	148.89	0.00	0.00											
10	10	1.00	1.00	0.00	12.93	161.81	0.00	0.00											
11	11	1.00	1.00	0.00	.41	162.62	0.00	0.00											
12	12	1.00	1.00	0.00	0.00	162.62	0.00	0.00											
13	13	1.00	1.00	0.00	172.71	335.33	0.00	0.00											
14	14	1.00	1.00	0.00	2.20	337.53	0.00	0.00											
15	15	1.00	1.00	0.00	37.02	374.55	0.00	0.00											
16	16	1.00	1.00	0.00	3.85	377.61	0.00	0.00											
17	17	1.00	1.00	0.00	62.19	439.80	0.00	0.00											
18	18	1.00	1.00	0.00	45.60	485.39	0.00	0.00											
19	19	1.00	1.00	0.00	1.14	486.53	0.00	0.00											
20	20	1.00	1.00	0.00	129.81	616.34	0.00	0.00											
21	21	1.00	1.00	0.00	5.41	621.75	0.00	0.00											
22	22	1.00	1.00	0.00	50.34	672.09	0.00	0.00											
23	23	1.00	1.00	0.00	0.00	672.09	0.00	0.00											
24	24	1.00	1.00	0.00	0.00	672.09	0.00	0.00											
25	25	1.00	1.00	0.00	0.00	672.09	0.00	0.00											
26	26	1.00	1.00	0.00	2.20	729.29	0.00	0.00											
27	27	1.00	1.00	0.00	9.94	739.22	0.00	0.00											
28	28	1.00	1.00	0.00	12.88	752.10	0.00	0.00											
29	29	1.00	1.00	0.00	26.81	761.24	0.00	0.00											
30	30	1.00	1.00	0.00	1.34	762.58	0.00	0.00											
31	31	1.00	1.00	0.00	15.56	778.16	0.00	0.00											
32	32	1.00	1.00	0.00	6.93	785.09	0.00	0.00											
33	33	1.00	1.00	0.00	2.20	787.29	0.00	0.00											
34	34	1.00	1.00	0.00	4.05	791.34	0.00	0.00											
35	35	1.00	1.00	0.00	2.74	794.08	0.00	0.00											
36	36	1.00	1.00	0.00	3.81	797.89	0.00	0.00											
37	37	1.00	1.00	0.00	15.74	813.63	0.00	0.00											
38	38	1.00	1.00	0.00	4.13	817.76	0.00	0.00											
39	39	1.00	1.00	0.00	3.63	821.39	0.00	0.00											
40	40	1.00	1.00	0.00	10.63	832.02	0.00	0.00											
41	41	1.00	1.00	0.00	15.44	847.46	0.00	0.00											
42	42	1.00	1.00	0.00	7.18	854.64	0.00	0.00											
43	43	1.00	1.00	0.00	1.41	856.05	0.00	0.00											
44	44	1.00	1.00	0.00	41.02	897.07	0.00	0.00											
45	45	1.00	1.00	0.00	0.00	897.07	0.00	0.00											
46	46	1.00	1.00	0.00	0.00	897.07	0.00	0.00											
47	47	1.00	1.00	0.00	0.00	897.07	0.00	0.00											

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4A 0 1.00 1.00 0.00 0.00 0.00 0.00 0.00
49 0 1.00 1.00 0.00 0.00 0.00 0.00 0.00
50 1.00 1.00 0.00 0.00 0.00 0.00 0.00

SUMMARY OUTPUT OF ITERATION 2 RUN 1 TRIAL 1
TOTAL TIME USED 1114.00

OPR	TIME'S	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	10000.00	1104.00	0015.9	0.0	1	1.00	1.00	0.00	0.00
2	2.30	1.00	10000.00	0.75	9999.2	0.0	1	1.00	1.00	0.00	0.00

SUMMARY OUTPUT OF ITERATION 3 RUN 1 TRIAL 1
TOTAL TIME USED 1117.04

OPR	TIME'S	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	10000.00	1117.04	0002.2	0.0	1	1.00	1.00	0.00	0.00
2	2.30	1.00	10000.00	0.75	9999.2	0.0	1	1.00	1.00	0.00	0.00

SUMMARY OUTPUT OF ITERATION 4 RUN 1 TRIAL 1
TOTAL TIME USED 1919.02

OPR	TIME'S	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	10000.00	1919.02	0000.2	0.0	1	1.00	1.00	0.00	0.00
2	2.30	1.00	10000.00	0.75	9999.2	0.0	1	1.00	1.00	0.00	0.00

SUMMARY OUTPUT OF ITERATION 5 RUN 1 TRIAL 1
TOTAL TIME USED 1315.04

OPR	TIME'S	SPEED	AVAIL	USED	DIFF	WAIT	TASK	PEAK STRESS	FINAL STRESS	LAST COMES	CYCLIC WAIT
NO	HOLD										
1	2.30	1.00	10000.00	1315.04	0004.2	0.0	1	1.00	1.00	0.00	0.00
2	2.30	1.00	10000.00	0.75	9999.2	0.0	1	1.00	1.00	0.00	0.00

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SUMMARY OUTPUT OF RUN 1
NUMBER OF ITERATIONS 5
NUMBER OF SUCCESSFULS 5
PER CENT SUCCESSFULS 100.0 FOR TIME DURATION 10000.00

OPR	THRES	SPEED	AVAIL	USCD	DIFF	WAIT	PEAK	FINAL	CYCLIC
NO	HOLD						STRESS	STRESS	WAIT
1	2.30	1.00	10000.00	1791.28	8708.72	0.00	1.00	1.00	0.00
2	2.30	1.00	10000.00	.75	9999.25	0.00	1.00	1.00	0.00

FREQUENCY DATA

TASK NO	LAST TASK COMPLETED		TASK FAILED		TASK IGNORED	
	OP 1	OP 2	OP 1	OP 2	OP 1	OP 2
1	0	5	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	1	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	0	0

	AVERAGE	4.0	9.0	9.0	9.0	9.0	9.0
42	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0
50	5	0	0	0	0	0	0
TOTAL		20	9	9	9	9	9
AVERAGE	4.0	9.0	9.0	9.0	9.0	9.0	9.0

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SUMMARY OUTPUT OF RUN 1

TASK NO	FAILTIME	OP 1	OP 2	PEAK STRESS	OP 1	OP 2	AVG TIME	OP 1	OP 2	AVG START TOT STRESS	OP 1	OP 2	AVG COR-SIVE	OP 1	OP 2
1	0.00	0.00	0.00	5	5	75	504.24	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0	0	0.00	512.82	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0	0	0.00	515.90	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0	0	0.00	519.61	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0	0	0.00	521.88	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0	0	0.00	524.66	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0	0	0.00	526.61	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0	0	0.00	535.20	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
9	2450.29	0.00	0.00	0	0	0.00	952.54	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0	0	0.00	966.82	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0	0	0.00	968.06	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0	0	0.00	985.19	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0	0	0.00	987.20	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0	0	0.00	937.12	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0	0	0.00	939.96	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
16	62.19	0.00	0.00	0	0	0.00	1037.91	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0	0	0.00	1038.88	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0	0	0.00	1114.97	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0	0	0.00	1121.39	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0	0	0.00	1165.86	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0	0	0.00	1167.27	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0	0	0.00	1196.18	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0	0	0.00	1198.22	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0	0	0.00	1214.65	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0	0	0.00	1225.48	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
26	1.33	0.00	0.00	0	0	0.00	1228.41	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0	0	0.00	1236.94	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0	0	0.00	1251.83	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0	0	0.00	1254.31	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0	0	0.00	1257.52	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0	0	0.00	1268.35	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0	0	0.00	1281.81	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0	0	0.00	1284.92	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0	0	0.00	1287.61	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0	0	0.00	1298.62	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0	0	0.00	1306.21	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0	0	0.00	1310.22	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0	0	0.00	1313.52	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
39	0.00	0.00	0.00	0	0	0.00	1322.82	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0	0	0.00	1336.51	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
41	0.00	0.00	0.00	0	0	0.00	1339.42	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
42	0.00	0.00	0.00	0	0	0.00	1348.42	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
43	0.00	0.00	0.00	0	0	0.00	1447.51	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
44	0.00	0.00	0.00	0	0	0.00	762.86	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0	0	0.00	1164.86	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
46	0.00	0.00	0.00	0	0	0.00	1165.86	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
47	0.00	0.00	0.00	0	0	0.00	1567.91	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
48	0.00	0.00	0.00	0	0	0.00	1567.91	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
49	0.00	0.00	0.00	0	0	0.00	1567.91	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00

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50	0.00	0.00	0	0	1791.24	0.00	1.00	0.00	0.00	0.00
	2513.01	0.00	TOTAL							
	502.76	0.00	AVERAGE							

END-OF-FILE ENCOUNTERED. FILNAME: INPUT
 ERROR NUMBER: 0005 DETECTED BY INPUTC AT ADDRESS 000048
 CALLED FROM INPUT AT LINE 0051
 CALLED FROM PARA AT LINE 0125

ERROR SUMMARY
 ERRORS 00
 TIMES 0001
 00 00 00

Deep I.

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51500 64114 51400 63411
54217 12723 54777 74260
56170 03110 63423 36642
04000 63366 46000 46000
61200 00164 07210 63430
61227 03320 63444 43020
54227 12424 12434 46000
20354 03320 63451 43052
54227 03320 04000 63430
10744 54740 04000 46000
04000 63513 46000 46000
51000 63503 51700 63504
10755 51600 63502 54740

61700 00001 51300 54062
51100 64115 10711 54767
56170 03110 63422 54770
71600 10224 20452 46000
53510 63150 53240 46000
03020 63444 03030 63444
03330 63447 11202 17424
03020 63447 46000 46000
51600 64057 46000 46000
10644 51600 63512 51110
51100 63460 10733 46000
51700 63505 74140 36614

04000 57724 00000 00000
52247 77776 53120 21322
71300 64111 20452 12743
04000 63366 46000 46000
61700 00001 50410 46000
76370 20723 15443 46000
20264 03120 61443 54327
43014 20054 15440 20240
54227 03120 63453 10622
50210 00001 51400 63454
74700 51700 63510 10611
73120 51500 63471 53430

00000 00000 00000 00000
12621 21434 54030 46000
76700 54777 10274 20452
56670 71600 00000 00000
03510 64176 03320 63437
51410 21044 15220 10122
15440 00002 03320 63447
50220 00002 12441 46000
11404 15120 12441 46000
00000 00000 00000 00000
55552 33033 55374 03702
21134 52217 77774 53720

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C

APPENDIX B2 - PROGRAM LISTING

This appendix contains the program listing for the 4-20 man digital simulation model.

C

C

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CX4AIN	XHAIN	MAIN0010
	COMMON/PRSNEL/WT,SIGWT,PPFQ,PPHQ,PPUQ,SPFQ,SPHQ,SPUQ,	MAIN0020
1	MPI,PID,ZPC,PTT(10,10),MEN(10,4),NDS,IDS(6,20)	MAIN0030
	COMMON/PAHAM/APST,WORK1,WORK2,SLEEP,CN,MAXSL,TFAT,ACP,	MAIN0040
1	CALRY,PWHRT,K7,K1,3E,AASP,USLIM,KON(10),KONT(10,10),KON1(10),	
2	KONT1(10,10),SESTA(10),RELI(4),N,IET,IND(7),NDMAX,IDFR(38,12)	
	COMMON/EOREVNT/ IDF(30),RELH(30),DTR(570),TUI(30),IRE(30)	MAIN0070
	COMMON/ELMEX/ART(10),ASDE(10),DTE(10),IESSE(10),NREQE(10,10),	MAIN0090
1	LODME(10),IRCE(10,10),IRCE1(10,10),TSE(10),TSE1(10),IHE(10),	MAIN0100
1	IECE(10,10),DTRE(10),NDBE(10)	MAIN0110
	COMMON/ETYPE/ADUR,ASD,IESS,NREQ(10),LODM,KE,INT,IRC(10),IRC1(10),	MAIN0120
1	IM,IEC(10),NIDR,IDR(6),ICLASS	MAIN0130
	COMMON/SEVENT/IETYP(570),TL(570),ST(570),EDCV(3,570),IPE(570),	MAIN0140
1	TS(570),TS1(570),NX(3,570),RTU(570),IFOI(570),IEFN(570),NIF(570),	MAIN0150
2	IEDC(3,570),PRR(3,570),NDE,NEORE,NEHE,DI(9)	MAIN0160
	COMMON/SCOM/PCOM(20),SCOM(20),IPS(20),ISS(20),TPCOM(20),TSCOM(20)	MAIN0170
	COMMON/OPP1/ IAA(4),PC(20),PACE(20),ASP(20),HSL(20),PI(20)	MAIN0180
1	P12(20),ICE(20)	MAIN0190
	COMMON/OPP2/ TW(20),TWP(20),TWS(20),DS(20),APW(20),PCC(20),	MAIN0200
1	CASP(20),IDC(20), NSUC1,NSUC2,NFALE,NIGNR,	MAIN0210
2	KONC(10),KONC1(10), SI,CMLND,ITER,NDAYS,MPCC(20),FAT(20)	MAIN0220
3	STRM(20),CAL(20),PWR(20),CCAL(20),NU(20),PERF(20),NPRFM(4)	MAIN0230
4	APA,SFDIFF,CLSDTA(10,40)	MAIN0240
	COMMON/OPP3/IC,FLIC,NREPT,HRSE,HRSR,HRSS,PEFF,	MAIN0250
1	MAXST,MAXST,USHT,NR,NTE,NE,TFH,CMLMX,ICML,SIDCMX,IDCMX,ICSS	MAIN0260
	COMMON/OPP4/EPL(30),CDT(30),CART(30),CUT(30),	
1	EPEFF,EHTRF,EMTR,SRL,SPL,SGEM,RSSUC2,SCDT10,REPTH,	
1	ACART(10),ACDT(10),ACUT(10), AEPL(10),DEPEFF(10)	MAIN0290
C	1 AEPL,EPEFF,EMTRF,EMTR,SRL,SPL,SGEM	
	INTEGER HEADR	
	INTEGER TS,TS1,RTU,TSE,TSE1,TSR,TSR1	MAIN0290
	INTEGER P12,PTR(240),IOIF(10)	MAIN0300
	REAL KONC,NDSUC(20),NOFAIL(20),IDC,KONE(20),MPCC ,MAXST,NU	MAIN0310
	REAL MPI,MAXSL,K7,K1,IEC,LODM,IM,IRC,KON,KON1,KONT,KONT1	MAIN0320
	REAL IECE,IHE,IRCE,LODME,IST	MAIN0330
	DIMENSION NPTR(580),ADUR(10,55)	MAIN0340
1	KONE1(20),IKONC(20),IKONE(20)	MAIN0350
	DIMENSION PSCOM(40),IPSS(40),PCDUH(6),TPSCOM(40)	MAIN0360
	EQUIVALENCE (PCDUH,PPFQ),(PSCOM,PCOM),(IPSS,IPS),(TPSCOM,TPCOM)	MAIN0370
	EQUIVALENCE (ADUR,ADUR10)	MAIN0380
	DIMENSION NS(20),IDE(10),	MAIN0390
1	Z(20),ZC(570),IEVENT(570),NREQT(10),MAVAIL(20),	MAIN0400
2	TAVAIL(20),MA(20,10),ITYPE(20),MAT(20),WH(20),ACAL(20),	MAIN0410
3	RT(570),TITLE(9)	MAIN0420
	DIMENSION MCHSN(20),IVVS(570)	
	DIMENSION HEADR(12),IDFFF(30)	MAIN0440
	DATA HEADR(1)/72H APPLIED PSYCHOLOGICAL SERVICES WAYNE, PENNA	MAIN0450
1	ARTHUR T. SIEGEL/	MAIN0460
	DATA TITLE/6H SCHEDU,6H LED EV,6H ENT ,6H REPAIR,6H EVENT,	MAIN0470
16H	,6H EMERGE,6H NNCY EV,6H ENT /	MAIN0480
	DATA YU,ESSS,PEA/6H U,6H S,6H P/	MAIN0490

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DATA STAR, BLANK/64	0.6H	/	MAIN0500
DATA REPAIR/SHREPAIR/			
FUNC(A,B,D) = (A + (A*B)/4.) * D			MAIN0510
CALL RANS(2(12.55)			MAIN0520
READ(5,9050) NKASES			MAIN0530
KASE = 0			MAIN0540
10 KASE = KASE+1			MAIN0550
IF(KASE.GT. NKASES) CALL EXIT			MAIN0560
READ(5,9045) HEADR			MAIN0570
9045 FORMAT(12A6)			MAIN0580
DO 20 I=1,12			
IDFR(1,I)=HEADR(I)			
20 CONTINUE			
CALL SPGMDR(HEADR)			MAIN0590
LMAX=10			MAIN0600
LMAX1=10			MAIN0610
NTHMAX=10			MAIN0620
ITER=0			MAIN0630
NKOUNT = 0			MAIN0640
READ(5,9050) ITAP, NDMAX			MAIN0650
CALL XXIN			MAIN0660
50 ITER=ITER+1			MAIN0670
ITAP = ITAP+1			MAIN0680
NDAYS = 0			MAIN0690
9050 FORMAT (2I3)			MAIN0700
CALL INPUT(ITAP,KASE)			MAIN0710
KMAX=NEHE			MAIN0720
IQMAX=NEQRE			MAIN0730
IEHAX=NOSE+NEQRE+NEHE			MAIN0740
C***COUNT THE CREW FOR EACH ECHELON AND ASSIGN			MAIN0750
C***EACH MAN A CREW ECHELON			MAIN0760
IC = 0			MAIN0770
DO 110 I = 1,4			MAIN0780
IAA(I) = 0			MAIN0790
DO 100 J = 1,NTHMAX			MAIN0800
100 IAA(I) = IAA(I)+HEV(J,I)			MAIN0810
110 IC = IAA(I)+IC			MAIN0820
FLIC = IC			MAIN0830
II = 1			MAIN0840
JJ = 0			MAIN0850
DO 120 I = 1,4			MAIN0860
JJ = IAA(I)+JJ			MAIN0870
IF (JJ.LT. II) GO TO 120			MAIN0880
DO 115 J = II, JJ			MAIN0890
115 ICE(J) = I			MAIN0900
II = JJ+1			MAIN0910
120 CONTINUE			MAIN0920
C***ASSIGN PRIMARY SPECIALTIES			MAIN0930
M = 1			MAIN0940
DO 160 J = 1,4			MAIN0950
DO 160 I = 1,NTHMAX			MAIN0960

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11 = MEN(I,J)	MAIN0970
IF (I1.EQ.0) GO TO 160	MAIN0980
DO 155 K = 1,I1	MAIN0990
IRS(K) = 1	MAIN1000
155 M = M+1	MAIN1010
160 CONTINUE	MAIN1020
C***ASSIGN SECONDARY SPECIALTIES	MAIN1030
DO 220 I = 1,IC	MAIN1040
I1 = IRS(I)	MAIN1050
TEM1 = UNIFORM(0,0)	MAIN1060
TEM1 = TEM1+PTT(NTHAX,I1)	MAIN1070
DO 210 J = 1,NTHAX	MAIN1080
IF (PTT(J,I1),LT,TEM1) GO TO 210	MAIN1090
IRS(I) = J	MAIN1100
GO TO 220	MAIN1110
210 CONTINUE	MAIN1120
220 CONTINUE	MAIN1130
C***PC,CAL,PHR,PAGE,ASP,WSLS,FAY,STRM FOR	MAIN1140
C***EACH MAN	MAIN1150
DO 300 I = 1,IC	MAIN1160
TEM1 = DNORM1(0,0)	MAIN1170
PC(I) = (WT+TEM1*SIGHT)/WT	MAIN1180
CAL(I) = PC(I)*CALRY	MAIN1190
PHR(I) = PC(I)*PHRRY	MAIN1200
PAGE(I) = ACP + DNORM1(0,0) * 0.11	MAIN1210
ASP(I) = AMIN1(AASP+AASP*DNORM1(0,0)/10,0,1,0)	MAIN1220
WSLS(I) = SLEEP+DNORM1(0,0)*SLEP*0.25	MAIN1230
FAT(I) = FBUILD(WSLS(I))	MAIN1240
300 STRM(I) = APST+DNORM1(0,0)*APST/6.0	MAIN1250
C***CALCULATE PRIMARY AND SECONDARY COMPETANCE	MAIN1260
C***FOR EACH MAN AND CCI=INITIAL CREW COMPETANCE	MAIN1270
CALL PSCAP(IAA,PCDUM,PCOM)	MAIN1280
CCI = 0.0	MAIN1290
DO 360 I = 1,IC	MAIN1300
360 CCI = CCI+PCOM(I)	MAIN1310
CCI = CCI/FLIC	MAIN1320
C***CALCULATE PHYSICAL INCAPACITIES	MAIN1330
365 DO 370 I = 1,IC	MAIN1340
P1(I) = 1.0	MAIN1350
370 P12(I) = 0	MAIN1360
NPI = IPUSN(FLIC/4PI)	MAIN1370
IF (NPI.EQ.0) GO TO 390	MAIN1380
DO 380 I = 1,NPI	MAIN1390
I1 = UNIFORM(0,0)*FLIC	MAIN1400
P1(I1) = 0.2*UNIFORM(0,0)*0.75	MAIN1410
380 P12(I1) = IPUSN(PID)	MAIN1420
390 CALL OUTP	MAIN1430
C***FIRST DAY OF ITERATION--INITIALIZATIONS	MAIN1440
390 ND = 1	MAIN1450
DO 560 I = 1,KMAX	MAIN1460
560 IDE(I) = 0	MAIN1470

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DO 570 I = 1, IQMAX	MAIN1487
570 IDF(1) = 0	MAIN1492
DO 580 I = 1, LMAX	MAIN1500
580 KONG(1) = KINH(1)	MAIN1510
DO 585 I = 1, LMAX1	MAIN1520
585 KONG1(1) = KONG1(1)	MAIN1530
DO 590 I = 1, IC	MAIN1540
NS(1) = 0	MAIN1550
ACAL(1) = HSLS(1)*CAL(1)/24.0	MAIN1560
CASP(1) = ASP(1)	MAIN1570
PERF(1) = ASP(1)	MAIN1580
QOSUC(1) = 0.0	MAIN1590
590 NOFAIL(1) = 0.0	MAIN1600
C	MAIN1610
C DETERMINE DAY OF OCCURRENCES OF NEXT FAILURES AND EMERGENCIES FOR	MAIN1620
C FAILURE AND EQUIPMENT	MAIN1630
C	MAIN1640
WRITE(6,8001) IQMAX	MAIN1650
8001 FORMAT(' *****IQMAX=', I7)	MAIN1660
WRITE(6,8002) (RELW(I), I=1, IQMAX)	MAIN1670
8002 FORMAT(' ***** RELW=', (HF10,3))	MAIN1680
DO 605 I = 1, IQMAX	MAIN1690
II = RELW(I) * ALOG(UNIFM1(0.0)) - 0.5	MAIN1700
IF(II.EQ.0) II = -1	MAIN1710
605 IDF(1) = IDF(1) - II	MAIN1720
WRITE(6,8004) (IDF(I), I=1, IQMAX)	MAIN1730
8004 FORMAT(' ***** IDF=', (F10,3))	MAIN1740
WRITE(6,8005) KMAX	MAIN1750
8005 FORMAT(' ***** KMAX=', I7)	MAIN1760
WRITE(6,8006) (NDRE(I), I=1, KMAX)	MAIN1770
8006 FORMAT(' ***** NDRE=', (F10,3))	MAIN1780
DO 610 I = 1, KMAX	MAIN1790
II = NDRE(I) * ALOG(UNIFM1(0.0)) - 0.5	MAIN1800
IF(II.EQ.0) II = -1	MAIN1810
610 IDE(1) = IDE(1) - II	MAIN1820
WRITE(6,8007) (IDE(I), I=1, KMAX)	MAIN1830
8007 FORMAT(' ***** IDE=', (F10,3))	MAIN1840
IF (IND(3).EQ.0) GO TO 650	MAIN1850
C***** SIMULATION FOR EACH DAY---INITIALIZATIONS	MAIN1860
650 RIGNR=0	MAIN1870
C RESUC2=0.	MAIN1880
C SDDTIG=0.	MAIN1890
C REPTM=0.	MAIN1900
NSUC1=0	MAIN1910
NSUC2=0	MAIN1920
NFAIL=0	MAIN1930
NREPT=0	MAIN1940
DO 655 I=1,4	MAIN1950
655 NPRFM(I)=0	MAIN1960
DO 658 J=1,10	MAIN1970
DO 658 J=1,10	MAIN1980
DO 658 J=1,10	MAIN1990
DO 658 J=1,10	MAIN2000
DO 658 J=1,10	MAIN2010
DO 658 J=1,10	MAIN2020
DO 658 J=1,10	MAIN2030
DO 658 J=1,10	MAIN2040

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TSKOM (1) = TSKOM (1) + (1- ICSS+ 0.0555)	4AIN2563
690 CONTINUE	4AIN2570
IXDF=IND(IOMAX,KMAX)	
I=1	
WRITE(6,9610) (I,IXDF(I),I,IDE(I),ICSS,PSES(C)	
IF(IXDF.LY.2) GO TO 682	
DO 681 I=2,IXDF	
WRITE(6,9620) I,IXDF(I),I,IDE(I)	
681 CONTINUE	
682 CONTINUE	
9610 FORMAT(1H1,'PRINT OPTION THREE - OCCURANCES OF FAILURES AND EMERGE	
INCIES, SEA STATE AND SICKNESS'//,'EQUIPMENT DAY OF FIRST EMERGEN	
2CY DAY OF FIRST INITIAL SEA SEASICKNESS DEGRADATION'//,	
3 I TYPE OCCURANCE',4X,'TYPE',4X,'OCCURANCE',7X,'STATE',5X,	
4 ITO INITIAL COMPETANCE'//15,10X,12,11X,12,10X,12,12X,12,15X,F7.4)	
9620 FORMAT(15,9X,13,10X,13,9X,13)	
9621 FORMAT(15,9X,13)	
684 FORMAT(24X,16,6X,16)	
IXDF1=IXDF+1	
IDIFF=IOMAX-KMAX	
IF(IDIFF) 695,696,699	
699 WRITE(6,9621)(J,IXDF(J),J=IXDF1,IOMAX)	
GO TO 696	
695 WRITE(6,684) (J,IDE(J),J=IXDF1,KMAX)	
696 CONTINUE	
CALL DINPUT	4AIN2600
IF(IND,GE,IND(4)) WRITE(6,6502)	4AIN2610
6502 FORMAT(1H1)	4AIN2620
C=0 IDENTIFY FAILURES AND EMERGENCIES FOR THE DAY	4AIN2630
C=0 AND COMPUTE NEXT OCCURRENCE FOR EACH	4AIN2640
700 NR = 0	4AIN2650
KK = NOSE	4AIN2660
DO 710 I = 1,IOMAX	4AIN2670
IF (IXDF(I),NE,ND) GO TO 710	4AIN2680
IDIFF(I)=ND	
NR = NR+1	4AIN2690
KK = KK+1	4AIN2700
IEVENT(KK)=200*(I-1)+12 + 1	4AIN2710
II=RELH(I)*ALOG(UNIFM1(0.0))-0.5	4AIN2720
IF(II,EG,0)II=-1	4AIN2730
IXDF(I) = IXDF(I)-II	4AIN2740
710 CONTINUE	4AIN2750
750 NE = 0	4AIN2760
DO 760 I = 1,KMAX	4AIN2770
IF (IDE(I),NE,ND) GO TO 760	4AIN2780
NE = NE+1	4AIN2790
KK = KK+1	4AIN2800
IEVENT (KK) = I + 960	4AIN2810
II = NDRE(I) * ALOG (UNIFM1(0.0)) - 0.5	4AIN2820
IF(II,EG,0)II=-1	4AIN2830
IDE (I) = IDE(I) - II	4AIN2840

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768 CONTINUE	4A1N2957
NUMFAN = 0	4A1N2960
NOIFY = 0	4A1N2977
IST = (ICSS + 1) / 10.	4A1N2980
DO 697 I=1, NOSE	4A1N2997
IF (NR + NOIFY, SE, 30) GO TO 697	4A1N2997
NOIF = 0	4A1N2910
IF (IFOI (1), NE, 1) GO TO 697	4A1N2920
NUMFAN = NUMFAN + 1	4A1N2930
IF (NOIFY, GT, 10) GO TO 697	4A1N2940
C	4A1N2950
C ACCESS TYPE DATA FROM DISC	4A1N2960
ITEM=IETYP(1)	4A1N2970
READ(12, ITEM, ERR=3000) ADUR10	4A1N2980
C	4A1N2990
C IF (NIOR, EQ, 0) GO TO 697	4A1N3000
II=IQR(NIOR)	4A1N3017
IF (IDFFF(II), EQ, ND) GO TO 697	
DO 698 INQ = 1, NIOR	4A1N3027
IF (NOIF, EQ, 1) GO TO 698	4A1N3030
RY2 = UNIFM1 (0.0)	4A1N3047
BYEM = 0.001	4A1N3057
IF (LODM, GT, 3) BYEM=0.01	4A1N3060
IF (LODM, GT, 6) BYEM=0.03	4A1N3077
ATEM = FUNC(BYEM, RY2, IST)	4A1N3087
IF (ATEM, LT, UNIFM1(0.0)) GO TO 698	4A1N3090
NOIF = 1	4A1N3107
KK = KK + 1	4A1N3110
C	4A1N3127
C COUNTER	4A1N3130
C	4A1N3147
NOIFY = NOIFY + 1	4A1N3150
C	4A1N3167
C WHICH REPAIR SEQUENCE	4A1N3170
C	4A1N3180
ISEVENT(KK)=200+12*(IQR(NIOR)-1)+1	4A1N3190
IDFFF(II)=ND	
C	4A1N3207
C WHICH SCHEDULED EVENT HAS AN OIF	4A1N3210
C	4A1N3227
161F (NOIFY) = 1	4A1N3230
698 CONTINUE	4A1N3247
697 CONTINUE	4A1N3250
C	4A1N3260
C NR IS NUMBER OF REPAIR FAMILIES	4A1N3270
C	4A1N3280
NR = NR + NOIFY	4A1N3290
NOSE1 = 0	4A1N3307
NTE = NR + NE + NOSE	4A1N3310
DO 770 I = 1, NOSE	4A1N3327

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IF (IPTR(1), NE, 1) GO TO 770	4A1N3330
INVENT (1) = 1	4A1N3340
NOSE1 = NOSE1 + 1	4A1N3350
770 CONTINUE	4A1N3360
C	4A1N3370
C	4A1N3380
C	4A1N3390
C	4A1N3400
0005 GENERATE POINTERS FOR EVENTS FOR THIS DAY	4A1N3410
775 DO 780 I = 1, NTE	4A1N3420
780 PTR(I) = 0	4A1N3430
JJ = NOSE + 1	4A1N3440
YEM1 = NTE - 1	4A1N3450
DO 810 I = JJ, NTE	4A1N3460
II = UNIFORM(0,0), YEM1 + 1.0	4A1N3470
IF(PTR(II)) 785, 805, 785	4A1N3480
785 KK = II	4A1N3490
790 II = II + 1	4A1N3500
IF (II, 0, NTE) GO TO 795	4A1N3510
IF(PTR(II)) 790, 805, 790	4A1N3520
795 II = KK	4A1N3530
800 II = II - 1	4A1N3540
IF (PTR(II), NE, 0) GO TO 800	4A1N3550
805 KK = INVENT(II)	4A1N3560
PTR(II) = KK	4A1N3570
INVS(KK) = II + 1	4A1N3580
810 CONTINUE	4A1N3590
KK = 1	4A1N3600
DO 820 I = 1, NOSE	4A1N3610
IF (IPTR(I), NE, 1) GO TO 820	4A1N3620
815 IF(PTR(KK), EQ, 0) GO TO 818	4A1N3630
KK = KK + 1	4A1N3640
GO TO 815	4A1N3650
818 PTR(KK) = 1	4A1N3660
820 CONTINUE	4A1N3670
C	4A1N3680
C	4A1N3690
C	4A1N3700
IGAP = 0	4A1N3710
KOUNT = 0	4A1N3720
DO 831 I = 1, NTE	4A1N3730
IPTR = PTR (I)	4A1N3740
IF (IPTR, NE, 0) GO TO 841	4A1N3750
IGAP = IGAP + 1	4A1N3760
GO TO 831	4A1N3770
841 CONTINUE	4A1N3780
NPTR (I) = KOUNT - IGAP + IPTR	4A1N3790
IF (IPTR, GE, 561) GO TO 831	4A1N3800
C	4A1N3810
C	4A1N3820
C	4A1N3830
ISW1 = 0 SCHEDULED AND REPAIR EVENTS	
ISW1 = 1 REPAIR EVENTS FOR OIF	

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C		MAIN3840
	ISW1 = 0	MAIN3850
835	IF (IPTR,GT, 200) GO TO 842	MAIN3860
	INIF = NIF (IPTR) - 1	MAIN3870
	IF (INIF,EQ, 0) GO TO 834	MAIN3880
	GO TO 843	MAIN3890
842	INIF = IRE ((IPTR-200) /12 + 1) + 1	MAIN3900
	IF (INIF,EQ, 0) GO TO 834	MAIN3910
843	DO 832 J=1,INIF	MAIN3920
	KOUNT = KOUNT + 1	MAIN3930
	NPTR (J) + KOUNT = IGAP = IPTR + J	MAIN3940
	832 CONTINUE	MAIN3950
C		MAIN3960
C	CHECK IF SECOND TIME THROUGH	MAIN3970
C		MAIN3980
834	IF (ISW1,EQ, 1) GO TO 831	MAIN3990
	IF (NOIFT,EQ, 0) GO TO 831	MAIN4000
	IF (IPTR,GT, 200) GO TO 831	MAIN4010
	ISW1=1	MAIN4020
	DO 833 J=1,NOIFT	MAIN4030
	IF (IPTR,NE, 10IF(J)) GO TO 833	MAIN4040
C		MAIN4050
C	HAVE AN OIF	MAIN4060
C		MAIN4070
	KOUNT = KOUNT + 1	MAIN4080
	IPTR= Ievent(NTE+J)	MAIN4090
	GO TO 835	
833	CONTINUE	MAIN4110
831	CONTINUE	MAIN4120
C		MAIN4130
C	THIS LOOP COUNTS TOTAL NO. OF EVENTS	MAIN4140
	DO 8 I=1,570	MAIN4150
	IF(NPTR(I),EQ,0) GO TO 9	MAIN4160
8	CONTINUE	MAIN4170
9	NTE=I-1	MAIN4180
C		MAIN4190
	DO 821 I=1,NTE	MAIN4200
	IF(NPTR(I),LE,200) GO TO 826	MAIN4210
821	CONTINUE	MAIN4220
826	KK=561	MAIN4230
	NX(1,KK)=NPTR(I)	MAIN4240
	PRB(1,KK)=1,1	MAIN4250
	DO 824 I=1,NTE	MAIN4260
	K=NPTR(I)	MAIN4270
	INVS(K)=1 +1	MAIN4280
	IF(K,LE,200) GO TO 823	MAIN4290
	IF(K,GT,560) GO TO 822	MAIN4300
	IF ((IRE((K-201) /12 + 1) ,EQ, 1 ,OR, 1FOI(K) ,EQ, 2) GO TO 822	MAIN4310
	GO TO 824	MAIN4320
822	NX(1,K)=NX(1,KK)	MAIN4330
	NX(2,K)=NX(2,KK)	MAIN4340

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RK(3,K)=NK(3,KK)	4A1N4350
PRB(1,K)=PRB(1,KK)	4A1N4360
PRB(2,K)=PRB(2,KK)	4A1N4370
PRB(3,K)=PRB(3,KK)	4A1N4380
GO TO 824	4A1N4390
823 RK=K	4A1N4400
824 CONTINUE	4A1N4410
830 IRIE = 1	4A1N4420
840 IE = NPYN (IEIE)	4A1N4430
WRITE(6,845) (JI,CDT(JI),JI=1,IQMAX)	
845 FORMAT(1H1,'INTERMITTANT DOWN TIME',/,',', 10 CDT(10),',/,',	
1 (13,F10,2))	
WRITE(6,846)(JI,TPCON(JI),JI=1,IC)	
846 FORMAT(1H1,'MAN COMPETANCE',/,',',IC) TPCON(M) TSCON(M)',/,',	
1 (13,F10,2))	
IFIRST = 1	4A1N4440
COOB RESETS FOR EACH EVENT	4A1N4450
850 INT = 0	4A1N4460
IQ=0	4A1N4470
ITRY = 0	4A1N4480
IGNOR = 0	4A1N4490
USH=0	
COOB DETERMINE WHETHER EVENT SHOULD BE IGNORED	4A1N4530
C	4A1N4540
ACCESS TYPE DATA FROM DISC	4A1N4550
COOB=000 EMERGENCY IF TYPE= -1	4A1N4560
ITEN=ITYPT(IE)	4A1N4570
IF(ITEN,EO,(-1)) GO TO 851	4A1N4580
READ(12,ITEM,ERR=3000) ADUR10	4A1N4590
GO TO 854	4A1N4600
851 ADUR=ART(IE-560)	4A1N4610
ASD=ASDE(IE-560)	4A1N4620
ISS=IESSE(IE-560)	4A1N4630
LODM=LODME(IE-560)	4A1N4640
KE=2	4A1N4650
INT=1	4A1N4660
NIGR=0	4A1N4670
IN=IHE(IE-560)	4A1N4680
ICLASS=3	4A1N4690
DO 852 I=1,10	4A1N4700
NREQ(I)=NREQE(I,IE-560)	4A1N4710
INC(I)=INCE(I,IE-560)	4A1N4720
INC1(I)=IRCE1(I,IE-560)	4A1N4730
852 IEC(I)=IECH(I,IE-560)	4A1N4740
C	4A1N4750
854 IF (IE ,GT, 200) GO TO 862	4A1N4760
IF (ISS ,NE, IET) GO TO 855	4A1N4770
IEIND = 1	4A1N4780
GO TO 1815	4A1N4790
855 KK = TS(IE)	4A1N4800
IGIND=4	4A1N4810

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DO 800 I = 1, LMAX	4AIN4820
IF (KONC(I), LY, KONT(I, KK)) GO TO 1015	4AIN4830
800 CONTINUE	4AIN4840
ISIND = 5	4AIN4850
KK = TS1(I)	4AIN4860
DO 801 I = 1, LMAX1	4AIN4870
IF (KONC1(I), LY, KONT1(I, KK)) GO TO 1015	4AIN4880
801 CONTINUE	4AIN4890
C COMPUTE NUMBER OF HOURS PER SHIFT	4AIN4900
C	4AIN4910
C	4AIN4920
802 SFYHNS = 24, /FLOAY(INDS)	4AIN4930
C	4AIN5110
C DETERMINE EARLIEST SHIFT JOB CAN BE STARTED ON AND LATEST TIME BY	4AIN5120
C 1 JOB MUST BE COMPLETED	4AIN5130
C	4AIN5140
JJ = IPE(I)	
III = (AMAX1(ZC(JJ), SY(I))) / SFYHNS + 1	4AIN5150
C LSHIFT = 0--FIRST SORT THROUGH ALL POSSIBLE SHIFTS	4AIN5170
C LSHIFT = 1-- SECOND SORT WITH DESIRED SHIFT	4AIN5180
C	4AIN5190
LSHIFT = 0	4AIN5200
800 IS IS TOTAL NUMBER OF MEN REQUIRED FOR EVENT	4AIN5200
C WRITE(4,1066) KYEMP, III, JNDS	4AIN5300
C1066 FORMAT(1H04110)	4AIN5310
J1 = III	
LSHIFT = 0	
IS = 0	4AIN5320
IN1 = 0	4AIN5330
IGNOR = 0	4AIN5340
DO 800 I = 1, NTHAX	4AIN5350
800 NREQ(I) = NREQ(I)	4AIN5360
C800 SELECTION OF PERSONNEL FOR EACH TYPE	4AIN5370
C800 KIND = 0 WHEN SELECTING PRIMARY SPECIALTIES	4AIN5380
C800 KIND = 1 WHEN SELECTING SECONDARY SPECIALTIES	4AIN5390
DO 805 I = 1, IC	4AIN5400
805 NQMN(I) = 0	4AIN5410
KIND = 0	4AIN5420
II = 1	4AIN5430
KA = 0	4AIN5440
IF (INT, EQ, 2) GO TO 1020	4AIN5450
808 IF (NREQ(II), NE, 0) GO TO 925	4AIN5460
910 IF (II, EQ, NTHAX) GO TO 920	4AIN5470
II = II + 1	4AIN5480
KA = 0	4AIN5490
GO TO 900	4AIN5500
920 IF (IPI, EQ, 0) GO TO 1060	4AIN5510
IF (KIND) 1060, 1020, 1060	4AIN5520
925 IF (KA, NE, 0) GO TO 990	4AIN5530
TEMP1 = TL(I)	4AIN5540
LL = KIND = 20	4AIN5550

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	DO 930 I = 1,IC	4A1N5560
	LL = LL+1	4A1N5570
	IF (MCHSN(I),NE,0) GO TO 930	4A1N5580
C	TRIVIAL CASE IS IDS(JI,1) = 1 FOR ALL JI	4A1N5590
C	THIS CASE IS ORIGINAL --NO SWIFT--MODEL	4A1N5600
C		4A1N5610
	IF (IE,GT,200) GO TO 930	4A1N5620
	IF (IDS(JI,1),NE,1) GO TO 930	4A1N5630
930	IF (IPSS(LL),NE,1) GO TO 950	4A1N5640
	IF (Z(I),GT,TEM1) GO TO 950	4A1N5700
	IF (YH(I),GT,WORK2) GO TO 950	4A1N5790
	KA = KA+1	4A1N5800
	MAVAIL(KA) = 1	4A1N5810
	CALR = MNR(I)	4A1N5820
	TEM2 = IEC(1)	4A1N5830
	IF (CALR,LE,TEM2) GO TO 935	4A1N5840
	CALR = 1.0	4A1N5850
	GO TO 940	4A1N5860
935	CALR = CALR/TEM2	4A1N5870
940	MAVAIL(KA) = 1000.0-10.0*YH(I)+CALR*IPSCON(LL)	4A1N5880
950	CONTINUE	4A1N5890
	IF (KA,NE,0) GO TO 960	4A1N5900
955	IP1 = 1	4A1N5910
	IF (KIND,EO,0) GO TO 910	4A1N5920
955	USH = USH + ADUR * FLOAT(NREQT(1))	
	GO TO 910	4A1N5950
960	KK = KA-1	4A1N5960
	IF (KK,EO,0) GO TO 990	4A1N5970
	DO 980 I = 1,KK	4A1N5980
	LL = KA-1	4A1N5990
	DO 970 J = 1,LL	4A1N6000
	TEM1 = MAVAIL(J)	4A1N6010
	IF (TEM1,LE,MAVAIL(J+1)) GO TO 970	4A1N6020
	MAVAIL(J) = MAVAIL(J+1)	4A1N6030
	MAVAIL(J+1) = TEM1	4A1N6040
	NN = MAVAIL(J)	4A1N6050
	MAVAIL(J) = MAVAIL(J+1)	4A1N6060
	MAVAIL(J+1) = NN	4A1N6070
970	CONTINUE	4A1N6080
980	CONTINUE	4A1N6090
990	IF (KA,EO,0) GO TO 955	4A1N6100
	NN = MAVAIL(KA)	4A1N6110
	KA = KA-1	4A1N6120
	IF ((IE,GE,561).OR.(IESS,EO,100)) GO TO 1000	4A1N6130
	IF (TW(NN)+ADUR,LE,WORK1) GO TO 1000	4A1N6140
995	IF (KIND,EO,1) GO TO 958	4A1N6150
	IP1 = 1	4A1N6160
	GO TO 910	4A1N6170
1000	IF (TW(NN),GT,WORK2) GO TO 995	4A1N6180
	IG=IG+1	4A1N6190

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	ACHSN(NN)=1	4A1N6200
	MA(IG,II) = NN	4A1N6210
	MAT(IG) = NN	4A1N6220
	ITYPE(NN) = II	4A1N6230
	NREQ(III) = NREQ(III)-1	4A1N6240
	IF(KA,NE,0) GO TO 900	4A1N6250
	IF(NREQ(III)) 955,910,955	4A1N6260
C	RESET FOR SECONDARY SEARCH	4A1N6270
C		4A1N6280
	1020 KIND = 1	4A1N6290
	II = 1	4A1N6300
	KA=0	4A1N6310
	GO TO 900	
C	SELECT LEADER	4A1N6320
	1060 CONTINUE	4A1N6330
	IF(LSHIFT,EU,1) GO TO 1063	4A1N6340
	ITEM=0	
	DO 1061 I=1,NYMAX	
	ITEM=ITEM+NREQ(I)	
	1061 IF(USH,LY,USHLN*FLOAT(ITEM)*ADUM) GO TO 1063	
	IF(JI,GE,NDX) GO TO 1063	
	USH=0	
	JI=III-1	
	LSHIFT=1	
	KIND=0	
	II=1	
	KA=0	
	GO TO 900	
	1063 FLTG916	
	IF(IG,NE,0) GO TO 1065	4A1N6620
	IBIND = 2	4A1N6630
	DO 1062 I=1,NYMAX	
	1062 IG=IG+NREQ(I)	
	USH=USH+ADUM*FLOAT(IG)	
	GO TO 1015	
	1065 LI = MAT(1)	4A1N6670
	JJ = ICE(LI)	4A1N6680
	IF (IG,EO,1) GO TO 1150	4A1N6690
	DO 1080 I = 2,IG	4A1N6700
	KK = MAT(I)	4A1N6710
	IF(ICE(KK)-JJ) 1075,1070,1090	4A1N6720
	1070 IF (TPCOM(KK) .LF. TPCOM(LI)) GO TO 1080	4A1N6730
	1075 LI = KK	4A1N6740
	JJ = ICE(KK)	4A1N6750
	1080 CONTINUE	4A1N6760
C		4A1N6770
C	DETERMINE Z1 = EARLIEST TIME ALL GROUP IS AVAILABLE	4A1N6780
		4A1N6790
	1150 KK = 0	4A1N6800
	Z1 = 0.C	4A1N6810
		4A1N6820

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DO 1160 I = 1,IG	4AIN6830
JJ = MAY(I)	4AIN6840
1160 Z1 = AMAX1(Z1,Z(JJ))	4AIN6850
C===== DETERMINE EARLIEST TIME WHEN THE EVENT CAN BEGIN	4AIN6860
JJ = IPE(IE)	4AIN6870
TEM2=0	4AIN6880
IF(JJ,NE,0) TEM2=ZC(JJ)	4AIN6890
C ATEM = KTEMP *SFTHRS	4AIN6900
C Z2=AMAX1(Z1,TEM2,SY(IE),ATEM)	4AIN6910
Z2=AMAX1(Z1,TEM2,ST(IE))	
IR(Z2,LT,TL(IE),OR,IE,GT,560) GO TO 1162	4AIN5920
C IF(Z2,LT,TL(IE)) GO TO 1162	4AIN6930
IGIND = 3	4AIN6940
USH=USH*ADUN*FLIG	
GO TO 1015	4AIN6960
C	4AIN6970
1162 DO 1165 I = 1,IG	4AIN6980
JJ = MAY(I)	4AIN6990
C===== IS A NON-SCHEDULED REST OR SLEEP REQUIRED DUE TO START TIME	4AIN7000
WH(JJ) = Z2-Z(JJ)	4AIN7010
IF (WH(JJ),NE,0,0) KR = 1	4AIN7020
1165 CONTINUE	4AIN7030
IF(KR,EQ,0) GO TO 1200	4AIN7040
TEM2=CN2,5	4AIN7050
C===== IS THE TIME SINCE LAST EVENT LONG ENOUGH TO ALLOW SLEEP	4AIN7060
DO 1260 I=1,IG	4AIN7070
JJ = MAY(I)	4AIN7080
IF(WH(JJ),LT,TEM2) GO TO 1240	4AIN7090
C===== IS SLEEP QUOTA FOR DAY USED	4AIN7100
IF(DS(JJ),GE,MAXSL) GO TO 1240	4AIN7110
C===== OR == IS FATIGUE UNDER THRESHOLD	4AIN7120
IF(FAT(JJ),LE,TFAT) GO TO 1240	4AIN7130
C===== NEITHER == SUM SLEEP THIS DAY FOR EACH M IN G	4AIN7140
TEM1=MAXSL-DS(JJ)	4AIN7150
C===== LIMIT WH(JJ) SO THAT DS,LE,MAXSL	4AIN7160
DS(JJ)=AMIN1(DS(JJ)+WH(JJ)-5,MAXSL)	4AIN7170
C===== CALCULATE TIME FATIGUE DUE TO SLEEP RELIEF FOR EACH M IN G	4AIN7180
TEM1=AMIN1(WH(JJ),TEM1)-5	4AIN7190
IF(TEM1,LE,9,0) GO TO 1205	4AIN7200
1200 FAT(JJ) = 0,0	4AIN7210
GO TO 1220	4AIN7220
1205 IF(TEM1,LT,1,0) GO TO 1210	4AIN7230
FAT(JJ) = FAT(JJ)+((138,0-19,0*TEM1)/140,0+0,2*UNIFM1(0,0))	4AIN7240
GO TO 1220	4AIN7250
1210 FAT(JJ) = FAT(JJ)+((0,9-0,05*TEM1+0,2*UNIFM1(0,0))	4AIN7250
1220 IF(FAT(JJ),LT,0,0) FAT(JJ) = 0,0	4AIN7270
IF(FAT(JJ),GT,1,0) FAT(JJ) = 1,0	4AIN7280
AFAT(JJ) = 0,0	4AIN7290
TEM1 = FAT(JJ)	4AIN7300
IF(TEM1,GT,0,9) GO TO 1225	4AIN7310
IF(TEM1,GT,0,15) GO TO 1224	4AIN7320

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MSLS(JJ) = 53.333333 * FAT(JJ)	YAIN7330
GO TO 1260	YAIN7342
1224 MSLS(JJ) = 14.666667 * TEM1 * 5.8	YAIN7350
GO TO 1260	YAIN7360
1225 MSLS(JJ) = AMAX1(310.0 * TEM1 - 260.0, 0.0)	YAIN7370
GO TO 1260	YAIN7380
C*** ADJUST HOURS SINCE LAST SLEEP FOR THIS *	YAIN7390
1240 MSLS(JJ) = MSLS(JJ) * WH(JJ)	YAIN7400
C CALCULATE FATIGUE BUILDUP FOR THIS MAN DUE TO REST	YAIN7410
FAT(JJ) = FBUILD(MSLS(JJ))	YAIN7420
1260 CONTINUE	YAIN7430
C*** CALCULATE PHYSICAL CAPABILITY OF EACH MAN IN GROUP	YAIN7440
C*** SAVE MAX PHYS CAPABILITY FOR EACH MAN	YAIN7450
1280 GRCC = 0.0	YAIN7460
DO 1295 I = 1, IG	YAIN7470
JJ = MAT(I)	YAIN7480
KK = IPS(JJ)	YAIN7490
YEM2 = IEC(KK) / PWR(JJ)	YAIN7500
IF (YEM2, GE, 1.0) GO TO 1285	YAIN7510
EXER = 1.0	YAIN7520
GO TO 1290	YAIN7530
1285 EXER = (ZPC - YEM2) / (ZPC - 1.0)	YAIN7540
IF (EXER, LT, 0.) WRITE(6, 9900) ND, IE, PCC	
1290 YEM1 = (ACAL(JJ) / CAL(JJ)) ** 2	YAIN7550
TEM1 = PC(JJ) * PI(JJ) * (1.0 - (1.0 - K1) * TEM1) * EXER * (1.0 - 0.1 * FAT(JJ))	YAIN7560
IF (YEM1, LT, 0.0) TEM1 = 0.0	YAIN7570
IF (YEM1, GT, 2.0) TEM1 = 2.0	YAIN7580
MPCC(JJ) = AMAX1(MPCC(JJ), TEM1)	YAIN7590
RCC(JJ) = YEM1	YAIN7600
1295 GPCC = GPCC * YEM1	YAIN7610
GPCC = GPCC / FLIG	YAIN7620
C*** CALCULATE GROUP STRESS THRESHOLD AND GROUP STRESS	YAIN7630
GSTRM = 0.0	YAIN7640
DO 1370 I = 1, IG	YAIN7650
JJ = MAT(I)	YAIN7660
1370 GSTRM = GSTRM + STPM(JJ)	YAIN7670
GSTRM = GSTRM / FLIG	YAIN7680
1375 IF (IE, GE, 560) GO TO 1377	YAIN7690
GSTR = (ADUR * (.875 * LODM * (.025)) / (TL(IE) - Z2))	YAIN7700
GO TO 1379	YAIN7710
1377 GSTR = GSTRM	YAIN7720
1378 IF (GSTR, GT, 5.0) GSTR = 5.0	YAIN7730
IF (GSTR, LT, 1.0) GSTR = 1.0	YAIN7740
C*** CALCULATIONS FOR PERFORMANCE TIME AND END TIME	YAIN7750
1300 IF (ASD, NE, 0.0) GO TO 1380	YAIN7760
IF (KE, NE, 1) GO TO 1310	YAIN7770
IF ((Z2 * ADUR) , GT, TL(IE)) GO TO 1320	YAIN7780
PY(IE) = ADUR	YAIN7790
ZG(IE) = TL(IE)	YAIN7800
GO TO 1350	YAIN7810
1310 PY(IE) = ADUR	YAIN7820

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	ZC(IE) = Z2*PY(IE)	4AIN7830
	GO TO 1550	4AIN7840
1320	PT(IE) = TL(IE)-Z2	4AIN7850
	ZC(IE) = TL(IE)	4AIN7860
	GO TO 1550	4AIN7870
1380	PAF = 1.0	4AIN7880
C***	CALCULATE GROUP PERFORMANCE, GROUP ASPIRATION LEVEL	4AIN7890
	GPERF = 0.0	4AIN7900
	GASP = 0.0	4AIN7910
	DO 1390 I = 1,IG	4AIN7920
	JJ = MAT(I)	4AIN7930
	GPERF = GPERF+PEFF(JJ)	4AIN7940
1390	GASP = GASP+CASP(JJ)	4AIN7950
	GPERF = GPERF/FLIG	4AIN7960
	GASP = GASP/FLIG	4AIN7970
C***	SELECT ONE OF FIVE CASES COMPARING GASP WITH GPERF	4AIN7980
C***	AND GSTR WITH GSTRM	4AIN7990
	TEM1 = GASP-GPERF	4AIN8000
	IF (ABS(TEM1),LE,0.02) GO TO 1460	4AIN8010
	TEM2 = GSTR-GSTRM	4AIN8020
	IF (TEM1,GT,0.0) GO TO 1395	4AIN8030
	IF (TEM2) 1410,1450,1450	4AIN8040
1395	IF (TEM2) 1400,1430,1430	4AIN8050
1400	PAF = 1.0-0.4*TEM1	4AIN8060
	GO TO 1460	4AIN8070
1410	DO 1420 I = 1,IG	4AIN8080
	JJ = MAT(I)	4AIN8090
	TEM3=PERF(JJ)-CASP(JJ)	4AIN8100
	IF(TEM3,LE,0.0) GO TO 1420	4AIN8110
	TEM3=CASP(JJ)+0.1*TEM3+DNCR41(0.0)	4AIN8120
	IF (TEM3,GT,1.0) TEM3 = 1.0	4AIN8130
	CASP(JJ)=TEM3	4AIN8140
1420	CONTINUE	4AIN8150
	GO TO 1460	4AIN8160
1430	DO 1440 I = 1,IG	4AIN8170
	JJ = MAT(I)	4AIN8180
1440	CASP(JJ) = PERF(JJ)	4AIN8190
	PAF = 1.0+0.4*TEM1	4AIN8200
	GO TO 1460	4AIN8210
1450	GSTR = 0.9*GSTRM	4AIN8220
C***	CALCULATE PERFORMANCE TIME	4AIN8230
1460	IF (GPCC,GE,1.0) GO TO 1470	4AIN8240
	SF = 2.0-GPCC	4AIN8250
	GO TO 1480	4AIN8260
1470	SF = 1.5-GPCC+0.5	4AIN8270
1480	TEM3 = 0.0	4AIN8280
	DO 1490 I = 1,IG	4AIN8290
	JJ = MAT(I)	4AIN8300
1490	TEM3 = TEM3+PACE(JJ)	4AIN8310
	GRACE = TEM3/FLIG+SF+PAF	4AIN8320
C		4AIN8330

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C	TEST FOR REPAIRS	4AINB340
C	IF (IE,LT,201) GO TO 1492	4AINB350
	IF (IE,GT,560) GO TO 1492	4AINB360
	TEM1 = 1 + (ASD * ASD) / (ADUR * ADUR)	4AINB370
	V = EXP(ALOG(ADUR / SORT(TEM1)) * DNDHM1(0,0) * SORT(ALOG(TEM1)))	4AINB380
	GO TO 1493	4AINB390
1492	V = ADUR * UNORM1(0,0) * ASD	4AINB400
1493	CONTINUE	4AINB410
	ADUR 2 = ADUR / 2,	4AINB420
	V = AMAX1(ADUR2,V)	4AINB430
C	IF (TEM2,GE,0,0) GO TO 1500	4AINB440
	TEM3 = (GSTRM-1,0) / (GSTRM-1,0)	4AINB450
	PT(IE) = GPACE * V * ((- 2,3075 * TEM3) + (3,4722 * TEM3 * TEM3))	4AINB460
	1 + (-1,829 * TEM3 * TEM3 * TEM3) + 1	4AINB470
C	PT(IE) = GPACE * V * ((- 2,3075 * TEM3) + (3,4722 * TEM3 * TEM3))	4AINB480
	GO TO 1535	4AINB490
1500	IF (TEM2,GT,1,0) GO TO 1510	4AINB500
	PT(IE) = GPACE * ((2,0 * TEM2 + 1,0) * V - TEM2 * ADUR)	4AINB510
	GO TO 1535	4AINB520
1510	PT(IE) = (3,0 * V - ADUR) * GPACE	4AINB530
C	LIMIT PT(IE)	4AINB540
1535	IF (PT(IE),GE,0,0) GO TO 1537	4AINB550
	PT(IE) = 0,0	4AINB560
	GO TO 1539	4AINB570
1537	TEM1 = 4,0 * ADUR	4AINB580
	IF (PT(IE),LE,TEM1) GO TO 1539	4AINB590
	PT(IE) = TEM1	4AINB600
C	CALCULATE REAL TIME OF EVENT COMPLETION	4AINB610
1539	ZC(IE) = Z2 + PT(IE)	4AINB620
	IF (ZC(IE),LE,TL(IE)) GO TO 1545	4AINB630
	PT(IE) = TL(IE) - Z2	4AINB640
	USH = USH + FLIG * (ZC(IE) - TL(IE))	4AINB650
	ZC(IE) = TL(IE)	4AINB660
1545	IF (ZC(IE),LE,24,0) GO TO 1550	4AINB670
	PT(IE) = 24,0 - Z2	4AINB680
	ZC(IE) = 24,0	4AINB690
1550	CONTINUE	4AINB700
C	UPDATE HSLG, TW, Z, CCAL, ACAL, IDC FOR EACH MAN	4AINB710
1560	ITRY = ITRY + 1	4AINB720
	IF (IE,GT,560) GO TO 1566	4AINB730
	DO 1565 I=1,NIOR	4AINB740
	ITEM = IQR(I)	4AINB750
	IF (IE,GE,201) GO TO 1562	4AINB760
	CUT(ITEM) = CUT(ITEM) + PT(IE)	4AINB770
	GO TO 1565	4AINB780
1562	COT(ITEM) = COT(ITEM) + PT(IE)	4AINB790
	SCDTIQ = SCDTIQ + PT(IE)	4AINB800
	WRITE(6,800H) SCDTIQ,COT(ITEM)	4AINB810
8009	FORMAT(' ***** SCDTIQ=',F7,2,' COT(ITEM)=',F7,2)	4AINB820
		4AINB830
		4AINB840

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	CART (ITEM) = CART (ITEM) + ADHR	MAIN9850
1565	BPL(ITEM)=CUT(ITEM)/(CUT(ITEM)+CDT(ITEM))	MAIN9860
1566	CONTINUE	MAIN9870
	TEM1 = PT(IE)	MAIN9880
	TEM2 = ZC(IE)	MAIN9890
	TEM3=TEM1	MAIN9900
	SIDC=0.0	MAIN9910
	DO 1580 I = 1,16	MAIN9920
	JJ = MAY(I)	MAIN9930
	MSLS(JJ) = MSLS(JJ)+TEM1	MAIN9940
	Z(JJ) = ZC(IE)	MAIN9950
	KK = ITYPE(JJ)	MAIN9960
	CCAL(JJ) = IEC(KK) *TEM3*(.95+UNIFM1(0.0)/10.)	MAIN9970
	ACAL(JJ) = ACAL(JJ)+CCAL(JJ)	MAIN9980
	IDC(JJ) = IDC(JJ)+CCAL(JJ)	MAIN9990
	TM(JJ) = TM(JJ)+TEM1	MAIN9000
	IF(KK,EO,IPS(JJ)) GO TO 1570	MAIN9010
	CLSDTA(7,ICLASS)= CLSDTA(7,ICLASS) + PT(IE)	MAIN9020
	TMS(JJ)=TMS(JJ)+PT(IE)	MAIN9030
	GO TO 1580	MAIN9040
1570	THP(JJ)=THP(JJ)+PT(IE)	MAIN9050
	CLSDTA(6,ICLASS)= CLSDTA(6,ICLASS) + PT(IE)	MAIN9060
1580	SIDC = SIDC + CCAL(JJ)	MAIN9070
	IF(SIDC,LE,SIDCMX) GO TO 1582	MAIN9080
	SIDCMX=SIDC	MAIN9090
	IDCMX=IE	MAIN9100
1582	TEM2=LDM *TEM1	MAIN9110
C=	ACCUMULATE CML AND SAVE MAX	MAIN9120
	IF(CMLMX,GE,TEM2) GO TO 1585	MAIN9130
	CMLMX=TEM2	MAIN9140
	ICML=IE	MAIN9150
1585	CML=CML+TEM2	MAIN9160
C=	EVENT HAZARD AND SUM FOR DAY (TEM)	MAIN9170
	EH = TEM1+IH	MAIN9180
	TEM = TEM+EH	MAIN9190
C=	CALCULATE PERFORMANCE ADEQUACY	MAIN9200
1600	IF(ITRY,GT,1) GO TO 1645	MAIN9210
	IF (GSTRM,GE,GSTR) GO TO 1610	MAIN9220
	IF (GSTR,LE,5.0) GO TO 1620	MAIN9230
	ES = 0.0	MAIN9240
	GO TO 1630	MAIN9250
1610	ES = (1.0-BE)/(GSTRM-1.0)+GSTR*BE	MAIN9260
	GO TO 1630	MAIN9270
1620	ES = (5.0-GSTR)/(5.0-GSTRM)	MAIN9280
1630	TEM1 =TSCOM(LI)	MAIN9290
	IF (ITYPE(LI),NE,IPS(LI)) TEM1 =TSCOM(LI)	MAIN9300
	EB = 2.0*TEM1	MAIN9310
	EA = 2.0+CASP(LI)	MAIN9320
	DO 1640 I = 1,16	MAIN9330
	JJ = MAY(I)	MAIN9340
	IF (ITYPE(JJ),NE,IPS(JJ)) TEM2 =TSCOM(JJ)	MAIN9350

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TEM2 = TPCOM(JJ)	MAIN9360
EC = EC+TEM2	MAIN9370
1640 EA = EA+CASP(JJ)	MAIN9380
TEM2 = FLIG+2.0	MAIN9390
ES = EC/TEM2	MAIN9400
EA = EA/TEM2	MAIN9410
BP=AMIN1(1.0,GPCC)	MAIN9420
GO TO 1647	MAIN9430
1643 EC=AMIN1(EC+2.1,0)	MAIN9440
1647 TEM1 = EF+EA	MAIN9450
C WRITE (6,1090) PA,TEM1,ES,EF,EA,EC	MAIN9460
PA = SORT((3.0+EC*(TEM1+ES)+ES*TEM1+EF+EA)/12.0)	MAIN9470
C WRITE (6,1090) PA,TEM1,ES,EF,EA,EC	MAIN9480
APAPAPA=PA	MAIN9490
C--- COMPUTE EFFICIENCY FACTOR	MAIN9500
C	MAIN9510
SEP = SEP + (PA*FLOAT(1ESS))/(CASP(L1)*K7)	MAIN9520
C WRITE (6,1090) PA,CASP(L1),K7,SEP	MAIN9530
61090 FORMAT(5H SEP OF10.5)	MAIN9540
C WRITE (6,1099) 1ESS	MAIN9550
61099 FORMAT(5H 1ESS 9110)	MAIN9560
1878=1318+1ESS	MAIN9570
C--- CALCULATE TIME FATIGUE AND PHYS CAP FOR ALL MEN IN GROUP	MAIN9580
1700 BRCC=0	MAIN9590
DO 1740 I = 1,18	MAIN9600
JJ = MAY(I)	MAIN9610
FAT(JJ) = FBUILD(MSL(JJ))	MAIN9620
KH = ITYPE(JJ)	MAIN9630
TEM2=IEC(KH) /PWR(JJ)	MAIN9640
IF (TEM2,GE,1.0) GO TO 1725	MAIN9650
EXER = 1.0	MAIN9660
GO TO 1730	MAIN9670
1725 EXER = (2PC-TEM2)/(2PC-1.0)	MAIN9680
IF(EXER,LT,0.)WRITE(6,9900) ND,IF,PCC	
1730 TEM18(ACAL(JJ)/CAL(JJ))*2	MAIN9690
TEM1 = PC(JJ)*PT(JJ)*(1.0-(1.0-K1)*TEM1)*EXER*(1.0-0.1*FAT(JJ))	MAIN9700
IF (TEM1,GT,2.0) TEM1 = 2.0	MAIN9710
IF (TEM1,LT,0.0) TEM1 = 0.0	MAIN9720
MPCC(JJ)=AMAX1(MPCC(JJ),TEM1)	MAIN9730
PCC(JJ) = TEM1	MAIN9740
1740 BRCC = BRCC+TEM1	MAIN9750
BPCC = BPCC/FLIG	MAIN9760
C--- CALCULATE NEW CONSUMABLE LEVELS	MAIN9770
TEM1 = PT(IE)	MAIN9780
DO 1750 I = 1,LMAX	MAIN9790
KONE(I)=IRC(I) *TEM1	MAIN9800
KONG(I) = KONG(I)-KONE(I)	MAIN9810
1750 CONTINUE	MAIN9820
DO 1752 I=1,LMAX1	MAIN9830
KONE1(I)=IRC1(I)	MAIN9840
KONG1(I)=KONG1(I)-KONE1(I)	MAIN9850

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1752	CONTINUE	MAIN9860
C=	NO CONSUMABLES USED UP	MAIN9870
C=	DETERMINE SUCCESS OR FAILURE FOR EVENT	MAIN9880
1755	SUCC = YU	MAIN9890
	FDIFF=CASP(1,1)*K7-PA	MAIN9900
	IF(FDIFF,LT,0.0) SUCC=ESSS	MAIN9910
	CLSDTA(1,ICLASS)= CLSDTA(1,ICLASS) + 1	MAIN9920
	CLSDTA(8,ICLASS)= CLSDTA(8,ICLASS) + PA	MAIN9930
	CLSDTA(9,ICLASS)= CLSDTA(9,ICLASS) + FDIFF	MAIN9940
	IF (SUCC,EQ,ESSS) GO TO 1770	MAIN9950
	SFDIFF=SFDIFF+FDIFF	MAIN9960
C=	FAILED	MAIN9970
	DO 1760 I = 1,10	MAIN9980
	JJ = MAY(1)	MAIN9990
1760	NOFAIL(JJ) = NOFAIL(JJ)+1.0	MAIN0000
	NFALE=NFALE+1	MAIN0010
	CLSDTA(4,ICLASS)= CLSDTA(4,ICLASS) + 1	MAIN0020
	GO TO 1770	MAIN0030
C=	SUCCESS	MAIN0040
1770	DO 1780 I = 1,10	MAIN0050
	JJ = MAY(1)	MAIN0060
	NU(JJ)=NU(JJ)+1.0	MAIN0070
1780	NOSUC(JJ)=NOSUC(JJ)+1.0	MAIN0080
	NR = 1	MAIN0090
	IF(1TRY,EQ,1) GO TO 1775	MAIN0100
	NSUC2=NSUC2+1	MAIN0110
	CLSDTA(3,ICLASS)= CLSDTA(3,ICLASS) + 1	MAIN0120
	GO TO 1790	MAIN0130
1775	NSUC1=NSUC1+1	MAIN0140
	CLSDTA(2,ICLASS)= CLSDTA(2,ICLASS) + 1	MAIN0150
C=	CALCULATE PERFORMANCE LEVEL FOR MEN IN GROUP	MAIN0160
1790	DO 1800 I = 1,10	MAIN0170
	JJ = MAY(1)	MAIN0180
	YEM1 = NOSUC(JJ) + NOFAIL(JJ)	MAIN0190
	IF(YEM1,GT,5.0 AND, NOSUC(JJ),GT,0.0)	MAIN0200
	X PERF(JJ) = NOSUC(JJ)/YEM1	MAIN0210
1800	CONTINUE	MAIN0220
	NPRFH(1)=NPRFH(1)+1	MAIN0230
	USHT=USHT+USH	
C=	UPDATE MAX STRM FOR THE DAY	MAIN0250
	IF(MAXST,GE,GSTR) GO TO 1805	MAIN0260
	MAXST=GSTR	MAIN0270
	BAXSTE=IE	MAIN0280
1805	GO TO 1820	MAIN0290
C=	COME HERE FOR IGNORE LOGIC	MAIN0300
1815	IGNOR = 1	MAIN0310
	NIGNR=NIGNR+1	MAIN0320
	PV(IE) = 0.0	MAIN0330
	CLSDTA(1,ICLASS)= CLSDTA(1,ICLASS) + 1	MAIN0340
	CLSDTA(5,ICLASS)= CLSDTA(5,ICLASS) + 1	MAIN0350
	GO TO 1824	MAIN0360

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C*** TEST FOR PRINT OPTION AFTER UPDATING HOURS SPENT IN ACTIVITIES MAIN0370
1820 IF(IE,GT,200) GO TO 1821 MAIN0380
      HRSR=PT(IE)*FLIG+HRSR MAIN0390
      NPRFH(2)=NPRFH(2)+1 MAIN0400
      GO TO 1824 MAIN0410
1821 IF(IE,GT,560) GO TO 1822 MAIN0420
      HRSR=PT(IE)*FLIG+HRSR MAIN0430
      REPTH=REPTH+PT(IE) MAIN0440
      WRITE(6,1818) REPTH,PT(IE) MAIN0450
1818 FORMAT(1H,'**** REPTH,PT(IE)=',2F10.2) MAIN0460
      IF(FO(IE),NE,1) GO TO 1824 MAIN0470
      NPRFH(3)=NPRFH(3)+1 MAIN0480
      GO TO 1824 MAIN0490
1822 HRSR=HRSR+PT(IE)*FLIG MAIN0500
      NPRFH(4)=NPRFH(4)+1 MAIN0510
1824 IF(ND=IND(4)) 1890,1825,1830 MAIN0520
1825 IF(IE,LT,IND(5)) GO TO 1890 MAIN0530
1830 IF(IE,GT,560) GO TO 1850 MAIN0540
      IF(IE,GT,200) GO TO 1840 MAIN0550
      KK = 1 MAIN0560
      LL = IE MAIN0570
      IF(IGNOR,LU,1) GO TO 1840 MAIN0580
      GO TO 1860 MAIN0590
1840 KK = 4 MAIN0600
      LL=(IE - 201)/12+1 MAIN0610
      IF(IGNOR,EU,1) GO TO 1840 MAIN0620
      GO TO 1860 MAIN0630
1850 KK = 7 MAIN0640
      LL=IE-560 MAIN0650
      IF(IGNOR,EU,1) GO TO 1840 MAIN0660
C*** PRINT EVENT DATA MAIN0670
1860 II = KK+2 MAIN0680
      IPET = IPET(IE) MAIN0690
      TEM1 = 0.0 MAIN0700
      IF (IPET,NE,0) TEM1 = ZC(IPET) MAIN0710
      DO 1865 I=1,10 MAIN0720
      IKONC(I)=KONC(I) MAIN0730
      IKONE(I)=KONE(I) MAIN0740
1865 CONTINUE
      IF(TITLE(KK),NE,REPAIR) GO TO 1867
C IF(IEFN(IE),NE,IFFN(IE-1)) IKDF=IKDF+1
C IF(IDFR(IKDF,1),EQ,0) IKDF=1
      WRITE(6,9861)
      1 LL, IETYP(IE),SUCC,(IDFR(LL,I),I=1,12),
      1 Z1,ST(IE),IPET,
      1 TEM1,Z2,PT(IE),ZC(IE),USH, 'STR,GPC,GPAC,GASP,PA,FM,
      1 ICLASS,
      2 (IKONE(I),I=1,10),(IKONC(I),I=1,10),(KONE1(I),I=1,10),(KONC1(I),I=
      2 1,10)
9861 FORMAT(1H0,'REPAIR OF EQUIPMENT TYPE',I2,' EVENT TYPE',I3,4X,
      1 IAG,/,2X,'IDENTIFIER ',I2A6/

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1 10H MEN AVAIL ,F5,2,15H START ALLOWED,F6,2,12H PRIOR EVENT,
2 14,0H FINISHED,F6,2,13H EVENT STARTS,F6,2,6H LASTS,F6,2,
3 5H ENDS,F6,2,13H UNMANNED HRS,F7,2/
4 13H GROUP STRESS,F5,2,9H PHYS CAP,F5,2,5H PACE,F4,1,5H ASP,F5,2,
5 8H PERF AD,F6,2, HAZARD',F4,1,6X, EVENT CLASS',15,
6 /1X,22HCONS, USED(UNITS/HR,) 1016,
7 /1X,22HCONS, LEFT(UNITS/HR,) 1016,/1X,22HCONS, USED(UNITS)
8 1016,/1X,22HCONS, LEFT(UNITS) 1016,/
9 11HMAN TYPE SPEC LDR RANK FATIGUE PHYS CAP HRS WKWD CALORIES
7 CALS+HRS SINCE SLEEP IDLE HRS SLEPT CUM PERF ASP)
GO TO 1868
1867 CONTINUE
WRITE(6,9860) (TITLE(1),I=KK,11),LL,ND,ITER,SUCC,
1 21,ST(IE),IPET, MAIN0770
1 TEM1,22,PT(IE),ZC(IE),USH, GSTH,GPCC,GPACF,GASP,PA,TH,
1 JCLASS,
2 (IKONE(1),I=1,10), (IKONC(1),I=1,10), (IKONE1(1),I=1,10), (IKONC1(1),I=1,10) MAIN0790
2 1,10) MAIN0430
9860 FORMAT(/1H03A6,13,5H DAY,13,11H ITERATION,13,2X,1A6,/,
1 10H MEN AVAIL ,F5,2,15H START ALLOWED,F6,2,12H PRIOR EVENT,
2 14,0H FINISHED,F6,2,13H EVENT STARTS,F6,2,6H LASTS,F6,2,
3 5H ENDS,F6,2,13H UNMANNED HRS,F7,2/ MAIN0850
4 13H GROUP STRESS,F5,2,9H PHYS CAP,F5,2,5H PACE,F4,1,5H ASP,F5,2, MAIN0860
5 8H PERF AD,F6,2, HAZARD',F4,1,6X, EVENT CLASS',15,
6 /1X,22HCONS, USED(UNITS/HR,) 1016,
7 /1X,22HCONS, LEFT(UNITS/HR,) 1016,/1X,22HCONS, USED(UNITS) MAIN0880
8 1016,/1X,22HCONS, LEFT(UNITS) 1016,/ MAIN0890
9 11HMAN TYPE SPEC LDR LEVEL FATIGUE PHYS CAP HRS WKWD CALORIES MAIN0900
7 CALS+HRS SINCE SLEEP IDLE HRS SLEPT CUM PERF ASP) MAIN0910
1868 CONTINUE
DO 1870 I = 1,10 MAIN0920
11 = MAT(1) MAIN0930
KK = ITYPE(11) MAIN0940
TEM1 = PEA MAIN0950
IF(KK,NE,1PS(11)) TEM1=ESSS MAIN0960
TEM2 = BLANK MAIN0970
IF (11,ED,11) TEM2 = STAR MAIN0980
TEM3=IEC(KK) MAIN0990
WRITE(6,9865) 11,KK,TEM1,TEM2,ICF(11),FAT(11),PCC(11),TH(11),
1 CCAL(11),ACAL(11),MSLS(11),WH(11),DS(11),PERF(11),CASP(11) MAIN1010
9865 FORMAT (13,15,2A6,16,F6,3,F9,3,F9,2,F9,1,F10,1,F11,1,F2,1,F10,1, MAIN1030
1 F9,2,F5,2) MAIN1040
C
1870 CONTINUE MAIN1050
GO TO 1890 MAIN1060
C... PRINT IGNORE DATA MAIN1070
1880 11 = KK+2 MAIN1080
WRITE(6,9880) (TITLE(1),I=KK,11),LL,ND,ITER MAIN1090
9880 FORMAT(/1H03A6,13,5H DAY,13,11H ITERATION,13, MAIN1100
1 10H IS IGNORED DUE TO) MAIN1110
IF(IGIND ,GT, 1) GO TO 1881 MAIN1120

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WRITE(6,9001) IE55	MAIN1140
9001 FORMAT(1H,63X,20HLOW ESSENTIALITY OF 12)	MAIN1150
GO TO 1090	MAIN1160
1001 IF(10IND,01,2) GO TO 1002	MAIN1170
WRITE(6,9002)	MAIN1180
9002 FORMAT(1H,63X,10HNULL GROUP)	MAIN1190
GO TO 1090	MAIN1200
1002 IF(10IND,01,3) GO TO 1003	MAIN1210
WRITE(6,9003)	MAIN1220
9003 FORMAT(1H,63X,17HNO TIME AVAILABLE)	MAIN1230
GO TO 1090	MAIN1240
1003 IF(10IND,01,4) GO TO 1004	MAIN1250
KK = Y5(IE)	MAIN1260
WRITE(6,9004) (KONT(1,KK),1=1,10)	MAIN1270
9004 FORMAT(1H,63X,30HCONSUMABLE (UNIT/HOUR) BELOW THRESHOLD/1H0,10F0,	MAIN1280
1 0)	MAIN1290
GO TO 1090	MAIN1300
1004 KK = Y5(IE)	MAIN1310
WRITE(6,9005) (KONT(1,KK),1=1,10)	MAIN1320
9005 FORMAT(1H,63X,34HCONSUMABLE (UNITS) BELOW THRESHOLD/1H0,10F0,0)	MAIN1330
000 CHECK IF REPLY OF EVENT IS NECESSARY	MAIN1340
1000 IF(SUCC.E0,KSS) GO TO 1009	MAIN1350
IF(1TRY,01,1) GO TO 1002	MAIN1360
IF(1GN0N,00,1) GO TO 1002	MAIN1370
IF(RTU(IE),E0,3) GO TO 1002	MAIN1380
Z1=ZC(IE)	MAIN1390
Z2=Z1	MAIN1400
NREPT=NREPT+1	MAIN1410
IF(RTU(IE),NE,1) GO TO 1010	
RSUC2=RSSUC2+PT(IE)	
WRITE(6,1012) RSSUC2,PT(IE)	
GO TO 1039	
1010 PT(IE)=0.5*PT(IE)+ASD *PRM1(0,0)	MAIN1430
RSUC2=RSSUC2+PT(IE)	MAIN1440
WRITE(6,1012) RSSUC2,PT(IE)	MAIN1450
1012 FORMAT(1H,63X,34HCONSUMABLE (UNITS) BELOW THRESHOLD/1H0,10F0,2)	MAIN1460
GO TO 1039	MAIN1470
000 INCREMENT EVENT COUNTER AND TEST FOR END OF DAY	MAIN1480
1002 IE1E = INVT(IE)	MAIN1490
KK = NPTR(IE1E)	MAIN1500
IF(NPTR(IE1E),0,0) GO TO 1020	MAIN1510
IF(NPTR(IE1E),LE,200) GO TO 1000	MAIN1520
KK = IE	MAIN1530
IE = NPTR(IE1E)	MAIN1540
000 IF EVENT IS NOT SCHEDULED WE MUST PRESERVE CHOICE OF FOLLOWING	MAIN1550
000 EVENT FROM KK AND PRD FOR CURRENT EVENT	MAIN1560
0 DO 1005 I = 1,3	MAIN1570
0 NX(I,IE) = NX(I,KK)	MAIN1580
01005 PRD(I,IE) = PRD(I,KK)	MAIN1590
GO TO 090	MAIN1600
000 DETERMINE NEXT EVENT USING NX AND PRD	MAIN1610

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1900	TEM1 = UNIFM1(0,0)	MAIN1620
	KK = 1	MAIN1630
	IF (TEM1,LY,PRR(1,IE)) GO TO 1910	MAIN1640
	KK = 2	MAIN1650
	IF (TEM1,LY,PRB(1,IE)+PRB(2,IE)) GO TO 1910	MAIN1660
	KK = 3	MAIN1670
1910	CONTINUE	
	IS = NX(KK,IE)	MAIN1680
	IF (IE,EO,0) GO TO 1920	
	GO TO 850	MAIN1690
C=	CALCULATE AVE PHYS WORKLOAD AND COMPETANCE FOR EACH CREW MEMBER	MAIN1700
1920	CONTINUE	
	EYEM = 0.0	MAIN1720
	TEMP = IC	MAIN1730
	DO 1930 I = 1,IC	MAIN1740
	ARM(I) = IDC(I)/CAL(I)*TW(I)/WORK1	MAIN1750
	IF (TW(I),GT, 0.001) GO TO 1921	MAIN1760
	TEMP = TEMP + 1.0	MAIN1770
	GO TO 1922	MAIN1780
1921	EYEM = EYEM + PERF(I)	MAIN1790
1922	IF (PCOM(I),GE,CAS(I)) GO TO 1930	MAIN1800
	PCOM(I)=(CASP(I)-PCOM(I))*NU(I)+0.0017*PCOM(I)	MAIN1810
1930	CONTINUE	
	EYEM = EYEM/TEMP	MAIN1840
C=	PERFORMANCE EFFICIENCY	MAIN1850
	TEM1=(1.0-(USHT/(WORK1*FLIC)))*(SEF/FLOAT(1SIE))	MAIN1860
C	WRITE(6,1066) NIGNR,NSUC1,NSUC2,NFAL	MAIN1870
C	WRITE(6,1063) TEM1	MAIN1890
	REFF=TEM1*(1.0-(FLOAT(NIGNR)/FLOAT(NSUC1+NSUC2+NFAL)))	MAIN1890
C		MAIN1900
C	COMPUTE EQUIP AND HUMAN STATS FOR MURT	MAIN1910
	ATEM=0.	MAIN1920
	BYEM=0.	MAIN1930
	CYEM=0.	MAIN1940
	DYEM=0.	MAIN1950
	YEM1=1.0MAX	MAIN1960
	DO 1932 I=1,10MAX	MAIN1970
	IF (CDT(I)+CUT(I),GT, 0.001) GO TO 1931	MAIN1980
	YEM1 = YEM1 - 1.0	MAIN1990
	GO TO 1932	MAIN2000
1931	CONTINUE	MAIN2010
	ATEM=ATEM+EPL(I)	MAIN2020
	BYEM=BYEM+CART(I)	MAIN2030
	CYEM=CYEM+CDT(I)	MAIN2040
	DYEM=DYEM+CUT(I)	MAIN2050
1932	CONTINUE	MAIN2060
	AEPL(ND)=ATEM/TEM1	
	EPEFF=AEPL(ND)/CYEM+BYEM	
	IF (EPEFF,LT,0.) EPEFF=0.	MAIN2090
	IF (EPEFF,GT,1.) EPEFF=1.	MAIN2100
	ERYB=DYEM/(YEM+CYEM)	MAIN2110

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C	ENTN=BTEN/FL0AT(NR)	4A1N2120
		4A1N2130
C	IF(ND,ED,NDHAX) GO TO 1860	4A1N2140
C	CALCULATE PHYS INCAPACITIES	4A1N2200
	NP1 = IPVYSN(FLIC/MP1)	4A1N2210
	IF (NP1,EO,0) GO TO 1860	4A1N2220
	DO 1950 I = 1, NP1	4A1N2230
	II = UNIFM1(0,0)+FLIC	4A1N2240
	PI(II) = 0.2*UNIFM1(0,0)+0.75	4A1N2250
	KK = IPVYSN(PIID)	4A1N2260
	IF(KK,EO,0) PI(II)=1.0	4A1N2270
	IF (KK,EO,1) KK = KK-1	4A1N2280
1950	PI2(II) = KK	4A1N2290
C	CALCULATE SAFETY INDEX	4A1N2300
1860	CONTINUE	4A1N2310
	THW=0.0	4A1N2320
	DO 1970 I=1,IC	4A1N2330
1970	THW=THW+YH(I)	4A1N2340
	NR = TEM/(9.0+THW)	4A1N2350
	CHL = CHL/(9.0+THW)	4A1N2360
	SI = 0.70*(1.-NR)	4A1N2370
1980	CONTINUE	4A1N2380
	TEM2=CN*.5	4A1N2390
	DO 2260 JJ=1,IC	4A1N2400
	WH(JJ)=24.0-2(JJ)	4A1N2410
	IF (WH(JJ),LT,TEM2) GO TO 2240	4A1N2420
	IF (DS(JJ),NR,MAXSL) GO TO 2240	4A1N2430
	TEM1=MAXSL-DS(JJ)	4A1N2440
	DS(JJ)=AMIN1(DS(JJ),WH(JJ)-.5,MAXSL)	4A1N2450
	YEM1=AMIN1(WH(JJ),YEM1)+.5	4A1N2460
	IF (TEM1,LE,9.0) GO TO 2205	4A1N2470
2205	FAT(JJ) = 0.0	4A1N2480
	GO TO 2220	4A1N2490
2205	IF (TEM1,LT,1.0) GO TO 2210	4A1N2500
	FAT(JJ) = FAT(JJ)+((138.0-10.0*TEM1)/140.0+0.2*UNIFM1(0,0))	4A1N2510
	GO TO 2220	4A1N2520
2210	FAT(JJ) = FAT(JJ)+(0.9-0.05*TEM1+0.2*UNIFM1(0,0))	4A1N2530
2220	IF (FAT(JJ),LT,0.0) FAT(JJ) = 0.0	4A1N2540
	IF (FAT(JJ),GT,1.0) FAT(JJ) = 1.0	4A1N2550
	ACAL(JJ) = 0.0	4A1N2560
	TEM1 = FAT(JJ)	4A1N2570
	IF (TEM1,GT,0.0) GO TO 2225	4A1N2580
	IF (TEM1,GT,0.15) GO TO 2224	4A1N2590
	HSLSI(JJ) = 5.333333 + FAT(JJ)	4A1N2600
	GO TO 2260	4A1N2610
2224	HSLSI(JJ) = 14.666667+TEM1+.9	4A1N2620
	GO TO 2260	4A1N2630
2225	HSLSI(JJ)=MAX1(10.0+TEM1-240.0,0.0)	4A1N2640
	GO TO 2260	4A1N2650
2240	HSLSI(JJ) = HSLSI(JJ) + WH(JJ)	4A1N2660
	FAT(JJ) = FWHI(D(HSLSI(JJ)))	4A1N2670

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2260	CONTINUE	MAIN2680
	GO 2295 JJ=1,1C	MAIN2690
	KK = IPS(JJ)	MAIN2700
	TEM2=IEC(KK) /PHR(JJ)	MAIN2710
	IF (TEM2,GE,1.0) GO TO 2285	MAIN2720
	EXER = 1.0	MAIN2730
	GO TO 2290	MAIN2740
2285	EXER = (ZPC-TEM2)/(ZPC-1.0)	MAIN2750
	IF (EXER,LT,0.) WRITE(6,9900) ND,IE,PCC	
9900	FORMAT(1H,'OVEREXERTION FACTOR EXCEEDED, DAY ',I3,'. EVENT ',	
	1,14,' WORK RATE EXCEEDS PEAK WORK RATE ',F10.3)	
2290	TEM1=(ACAL(JJ)/CAL(JJ))**2	MAIN2760
	TEM1 = PC(JJ)*PI(JJ)*(1.0-(1.0-K1)*TEM1)*EXER*(1.0-0.1*FAT(JJ))	MAIN2770
	IF (TEM1,LT,0.0) TEM1 = 0.0	MAIN2780
	IF (TEM1,GT,2.0) TEM1 = 2.0	MAIN2790
2295	PCC(JJ)=TEM1	MAIN2800
	IF (NFALE,NE,0) SFDIFF=SFDIFF/FLOAT(NFALE)	MAIN2810
	APA=APA/FLUAT(NSUC1+NSUC2+NFALE)	MAIN2820
	CALL OUTP2	MAIN2830
	IF (ND,GE,NDMAX) GO TO 2030	MAIN2840
	ND=ND+1	MAIN2850
	GO TO 650	MAIN2860
2030	CALL OUTP3	MAIN2870
	IF ((ITAP,EG,1) .AND. (N,GT,1)) ENDFILE 10	MAIN2880
	NDAYS=NDAYS+ND	MAIN2890
	IF (ITER,LT,N) GO TO 50	MAIN2900
	CALL OUTP4	MAIN2910
	GO TO 10	MAIN2920
3000	WRITE(6,3001) ITEM	MAIN2930
3001	FORMAT(26H1FATAL I/O ERROR FOR REC, - (6)	MAIN2940
	STOP	MAIN2950
	END	MAIN2960
CFBLD	FUNCTION FBUILD	FBLD0010
	FUNCTION FBUILD(M)	FBLD0020
	MSLS=M	FBLD0030
	TEM1=0.2*UNIFR(0.0)	FBLD0040
	IF (MSLS,LT,0.0) GO TO 20	FBLD0050
	IF (MSLS,LT,19.0) GO TO 10	FBLD0060
	FBUILD=(MSLS-220.0)/310.0*TEM1	FBLD0070
	GO TO 3000	FBLD0080
10	FBUILD=(15.0*MSLS-109.0)/220.0*TEM1	FBLD0090
	GO TO 3000	FBLD0100
C//////////		FBLD0110
20	FBUILD = 0.01875 * MSLS - 0.1 * TEM1	FBLD0120
3000	IF (FBUILD,GE,5.0) GO TO 3002	FBLD0130
	FBUILD = 0.0	FBLD0140
	GO TO 3335	FBLD0150
3002	IF (FBUILD,GT,1.5) FBUILD = 1.0	FBLD0160
3335	RETURN	FBLD0170
	END	FBLD0180
CIPDY	FUNCTION IPOYSH	IPDY0010

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FUNCTION IMIYSH(PAR)	IPUY0020
YLSI=EXP(-PAR)	IPUY0030
K=0	IPUY0040
V=UNIFM1(0,0)	IPUY0050
1000 IF(V,LE,TEST) GO TO 5000	IPUY0060
K=K+1	IPUY0070
V=UNIFM1(0,0)	IPUY0080
GO TO 1000	IPUY0090
5000 IPUYN=K	IPUY0100
RETURN	IPUY0110
END	IPUY0120
CPSCAP SUBROUTINE PSCAP	IPUY0140
SUBROUTINE PSCAP(IAA,PCDUM,PSCOM)	IPUY0150
DIMENSION IAA(4),PCDUM(6),PSCOM(40),TEM(5),L(3),LL(3),DATR(3)	IPUY0160
DATA DATR/0.95,0.75,0.60/	IPUY0170
NN=1	IPUY0180
DO 330 J=1,4,3	IPUY0190
DO 340 J=1,4	IPUY0200
LJ=IAA(J)	IPUY0210
TEM1=LJ	IPUY0220
K1=1	IPUY0230
DO 110 K=1,3	IPUY0240
TEM(K)=TEM1+PCDUM(K1)	IPUY0250
L(K)=TEM(K)	IPUY0260
K1=K1+1	IPUY0270
110 L1=L1-L(K)	IPUY0280
IF(L1,EQ,0)GO TO 275	IPUY0290
K1=1	IPUY0300
DO 130 K=1,3	IPUY0310
TEM(K)=TEM(K)-PLDAY(L(K))	IPUY0320
IF(TEM(K),LT,(.5)) GO TO 130	IPUY0330
L(K)=L(K)+1	IPUY0340
L1=L1-1	IPUY0350
IF(L1,EQ,0)GO TO 275	IPUY0360
130 CONTINUE	IPUY0370
DO 135 K=1,3	IPUY0380
LL(K)=K	IPUY0390
DO 150 K=1,2	IPUY0400
KK=3+K	IPUY0410
DO 140 I1=1,KK	IPUY0420
IF(TEM(I1),GE,TEM(I1+1))GO TO 140	IPUY0430
TEMP=TEM(I1)	IPUY0440
LT=LL(I1)	IPUY0450
TEM(I1)=TEM(I1+1)	IPUY0460
TEM(I1+1)=TEMP	IPUY0470
LL(I1)=LL(I1+1)	IPUY0480
LL(I1+1)=LT	IPUY0490
140 CONTINUE	IPUY0500
150 CONTINUE	IPUY0510
DO 160 K=1,3	IPUY0520
KK=LL(K)	IPUY0530

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L(KK)=L(KK)+1	IPUY0540
L1=L1-1	IPUY0550
IF(L1,EQ,0)GO TO 275	IPUY0560
160 CONTINUE	IPUY0570
KK=LL(1)	IPUY0580
L(KK)=L(KK)+L1	IPUY0590
275 DO 310 K=1,3	IPUY0600
KK=L(K)	IPUY0610
IF(KK,EQ,0)GO TO 310	IPUY0620
TEMP = DATR(K)	IPUY0630
DO 305 N=1,AK	IPUY0640
RSCONT(NN)=AH*IN1(.99,TEMP+DNORM1(0,0)+0.03)	IPUY0650
305 NN=NN+1	IPUY0660
310 CONTINUE	IPUY0670
340 CONTINUE	IPUY0680
350 NN=21	IPUY0690
RETURN	IPUY0700
END	IPUY0710
CINPUT SUBROUTINE INPUT	INPT0010
SUBROUTINE INPUT(ITER,KASE)	INPT0020
COMMON/PKSNEL/WT,STGWT,PPFD,PPHQ,PPUG,SPFD,SPHQ,SPUG,	INPT0030
1MPI,PID,ZPC,PTT(10,10),MEN(10,4),NDS,IDS(6,20)	INPT0040
COMMON/IPAHAM/APST,WORK1,WORK2,SLEEP,CN,MAXSL,TFAT,ACP,	INPT0050
1CALRY,PWRRT,K7,K1,BE,AASP,USHL,TH,KON(10),KONY(10,10),KONI(10),	
2 KONT1(10,10),SESTA(10),RELI(4),N,IET,IND(7),NDMAX,INDR(38,12)	
COMMON/EQREVT/ IDF(30),RELH(30),DTR(570),TUI(30),IRE(30)	INPT0090
COMMON/EEHEVT/ARY(10),ASDE(10),NKE(10),IESSE(10),NREGE(10,10),	INPT0090
1 LODME(10),IRCE(10,10),IRCF1(10,10),TSE(10),TSE1(10),IHE(10),	INPT0100
1 IECE(10,10),DTRF(10),NOBE(10)	INPT0110
COMMON/ETYPE/ADUP,ASD,IESS,NREQ(10),LODM,KE,INY,IRC(10),IRC1(10),	INPT0120
1 IH,IEC(10),NIQR,IJR(6),ICLASS	INPT0130
COMMON/SEVENT/IETYP(570),TL(570),ST(570),EDCV(3,570),IPE(570),	INPT0140
1 YS(570),YS1(570),YX(3,570),RYH(570),IF01(570),IEFN(570),NIP(570),	INPT0150
2 IEDC(3,570),PRH(3,570),NOSE,MEQRE,NEME,DI(9)	INPT0160
DIMENSION IP1(11),IP1(16),FP2(249),IP2(9),FP3(220),IP3(220),	INPT0170
1 FP4(3880),IP4(3400),FP5(600),IP5(2000),DUMV(12),IDES(12)	INPT0180
DIMENSION PITT(10,10)	INPT0190
DIMENSION ADURIO(55),IPERCT(10)	
EQUIVALENCETADURIO,ADUR)	INPT0210
EQUIVALENCE (HT,FP1),(MEN,IP1),(APST,FP2),(N,IP2),	INPT0220
1 (FP3,FP4),(FP3,FP5),(IP3,IP4),(IP3,IP5),(IP3,GBG),(FP3,GRG)	INPT0230
INTEGER YS,YS1,RYU,YSE,YSE1,YSR,YSR1	INPT0240
REAL MPI,MAXSL,K7,K1,IEC,LODM,IH,IRC,KON,KON1,KONT,KONT1	INPT0250
REAL IECE,IHE,IRCE,LODM	INPT0260
NAMELIST/PKSNEL/NFP1,FP1,NIP1,IP1	INPT0270
NAMELIST/PAHAM/NFP2,FP2,NIP2,IP2	INPT0280
NAMELIST/SCHEVT/NFP3,FP3,NIP3,IP3	INPT0290
NAMELIST/EQREVT/NFP4,FP4,NIP4,IP4	INPT0300
NAMELIST/EEHEVT/NFP5,FP5,NIP5,IP5	INPT0310
NAMELIST/ETYPE/NFP5,FP5,NIP5,IP5	INPT0320
IERR = 0	INPT0330

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IF(ITER,GI,1) GO TO 225                                INPT0340
100 NFP2 = 0                                             INPT0350
NIP2 = 0                                                 INPT0350
READ (5,PARAM1)                                         INPT0370
IF((NFP2,NE,249).OR.(NIP2,NE,9)) GO TO 9010          INPT0390
101 WRITE(6,8100) NMAX,IP2(1),(IP2(1),I=1,12),
1   FP2(8),FP2(1),FP2(14),FP2(9),   FP2(10)
WRITE(6,8101) FP2(4),FP2(5),FP2(6),FP2(2),FP2(3),FP2(7),IP2(2),
2   FP2(15),(FP2(1),I=11,13),(FP2(1),I=16,25),(FP2(1),I=126,135),
3   (FP2(1),I=26,125),(FP2(1),I=136,249),(IP2(1),I=3,9)
8100 FORMAT(1H,'PARAMETER INPUTS FOR THIS',I3,' DAY RUN OF',I3,
1   ' MISSION ITERATIONS',I7,5X,'ENTITLED ',I2A6,/,
2   ' - - - AVERAGE CREW DATA - - - ',I7,1X,'PACE STRESS ASPIR-
3   ' CALORIES REQD POWER RATE',/,
4   ' 7X,'THRESHOLD ATION',6X,'PER DAY',6X,
5   'ICALS/HR',I7,F5.2,F6.2,F10.2,F13.0,F13.1,
6   'HOURS SINCE CATNAP MAXI
7   ' WORK LIMITS(HRS)-- -----THRESHOLDS-----CO
8   'Nstants-----)
8101 FORMAT(1H, 'LAST SLEEP LENGTH SLEEP NO MORE
7NO MORE FATIGUE ESSENTIALITY UNMANNED LEADERS PHYSICAL
8 STRESS',I4X,'(HRS) PER DAY ASSIGNMENTS WORK',27X,'STATION
9 HNS EXPECTATION CAPABILITY',F7.1,F11.1,F8.1,2F11.1,F9.2,I13,
10  F13.2,F9.2,/,F1X,'NUMBER',I4X, '1',7X,'2',
11  7X,'3',7X,'4',7X,'5',7X,'6',7X,'7',7X,'8',7X,'9',6X,'10',/,
12  ' INITIAL VALUE OF CONSUMABLES (UNITS) ',I10F8.0,/,
13  ' INITIAL VALUE OF CONSUMABLES (UNITS/HR)',F7.0,9F8.0,/,32X,'SEY',
14  ' CONSUMABLE THRESHOLDS (UNITS)',4X,'1',4X,I10F8.0,/,33X,'2',4X,
15  I10F8.0,/,33X,'3',4X,I10F8.0,/,33X,'4',4X,I10F8.0,/,33X,'5',4X,
16  I10F8.0,/,33X,'6',4X,I10F8.0,/,33X,'7',4X,I10F8.0,/,33X,'8',4X,
17  I10F8.0,/,33X,'9',4X,I10F8.0,/,32X,'10',4X,I10F8.0,/'CONSUMABLE THRESHOL
18  'DS (UNITS/HR) 1',4X,I10F8.0,/,33X,'2',4X,I10F8.0,/,33X,'3',4X,
19  I10F8.0,/,33X,'4',4X,I10F8.0,/,33X,'5',4X,I10F8.0,/,33X,'6',4X,
20  I10F8.0,/,33X,'7',4X,I10F8.0,/,33X,'8',4X,I10F8.0,/,33X,'9',4X,
21  I10F8.0,/,32X,'10',4X,I10F8.0,/'CUMULATIVE PROBABILITY OF SEA ST
22  'ATES ',I10F8.2,/, 'AVERAGE EQUIPMENT INTERMITTANT RELIABILITY',
23  N6.2,3F8.2, 'OUTPUT RECORDING OPTIONS',I3X,7I8)
200 IF(KASE,LE,1) GO TO 201                                INPT0480
DO 205 I=1,10                                           INPT0490
DO 205 J=1,10                                           INPT0500
PTT(I,J) = PTT(I,J)                                     INPT0510
205 CONTINUE                                             INPT0520
201 NFP1 = 0                                             INPT0530
NIP1 = 0                                                 INPT0540
READ (5,PERSNL)                                         INPT0550
IF ((NFP1,NE,111).OR.(NIP1,NE,161)) GO TO 9020        INPT0560
IF(KASE,NE,1) GO TO 209                                INPT0570
DO 208 I=1,10                                           INPT0580
DO 208 J=1,10                                           INPT0590
PTT(I,J) = PTT(I,J)                                     INPT0600
208 CONTINUE                                             INPT0610

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209 DO 220 I=1,10	INPT0620
DO 210 J=2,10	INPT0630
PTT(J,I)=PTT(J,I)+PTT(J-1,I)	INPT0640
210 CONTINUE	INPT0650
220 CONTINUE	INPT0660
225 IF (IND(1),E1,0,OR, IYFR,41,1) GO TO 299	INPT0670
WRITE(6,8200) (FP1(I),I=1,4),(IP1(I),I=1,10),(FP1(I),I=6,8),	
1(IP1(I),I=11,40),(FP1(I),I=12,21),(IP1(6+I),I=7,26),	
2(FP1(I),I=22,31),(IP1(6+I+1),I=7,26),(FP1(I),I=32,41),	
3(IP1(6+I+2),I=7,26),(FP1(I),I=42,51),(IP1(6+I+3),I=7,26),	
4(FP1(I),I=52,61),(IP1(6+I+4),I=7,26),(FP1(I),I=62,71),	
5(IP1(6+I+5),I=7,26),(FP1(I),I=72,111)	
8200 FORMAT(1H1,56X,'PERSONNEL DATA',//,' - BODY WEIGHT - SPECIALTY	
1 FRACTION OF CREW QUALIFIED LEVEL NUMBER OF MEN IN CREW BY TYP	
2E1//, 'MEAN SIGMA',17X,'FULLY MINIMALLY UN',15X,11 2 3 4	
3 5 6 7 8 9 10',//,F6,1;F8,1,6X,'PRIMARY',4X,F6,2,2X,	
1 2F8,2,6X,'1',5X,10I3,/,20X,'SECONDARY',2X,F6,2,2X,	
4 2F8,2,6X,'2',5X,10I3,/,61X,13,5X,10I3,/,61X,14,5X,10I3,/,	
5 1 MAN CUMULATIVE CROSS TRAINING PROBABILITIES',20X,	
6 CREW ASSIGNMENT TO SHIFTS BY MAN',/, 'TYPE',5X,	
7 11 2 3 4 5 6 7 8 9 10 SHIFT 1 2	
93 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20',//,' 1',5X,	
9 10(F4,2,1X),, 1 ',20I3,/, 2',5X,10(F4,2,1X),, 2 ',20I3,	
A /, 3',5X,10(F4,2,1X),, 3 ',20I3,/, 4',5X,10(F4,2,1X),	
B 1 4 ',20I3,/, 5',5X,10(F4,2,1X),, 5 ',20I3,/, 6',5X,	
C 10(F4,2,1X),, 6 ',20I3,/, 7',5X,10(F4,2,1X),/, 8',5X,	
D 10(F4,2,1X),10X, (1 - ASSIGNED 0 - UNASSIGNED)',/, 9',5X,	
E 10(F4,2,1X),/, 10',5X,10(F4,2,1X))	
WRITE(6,8300) MP1,PID,ZPC	
8300 FORMAT(1H1,77X,'--PHYSICAL CAPABILITY AVERAGES--',10X,	
1 'PHYSICAL',/, 'MAN DAYS PER', 9X, 'DURATION',12X, 'CAPABILITY',/,	
2 ' INCIDENCE',33X, 'CONSTANT',//,F7,2,16X,F3,1,18X,F4,2)	
299 IF (IYFR,E1,1) GO TO 300	INPT0840
REWIND 10	INPT0850
READ(10) NFP4,NIP4,NEORE,(FP4(I),I=1,NFP4),(IP4(I),I=1,NIP4)	INPT0860
GO TO 301	INPT0870
300 NFP4 = 0	INPT0880
NIP4 = 0	INPT0890
READ (5,EQREVT)	INPT0900
NEORE=IP4(1)	INPT0910
IF(N,LE,1) GO TO 301	INPT0920
REWIND 10	INPT0930
WRITE(10) NFP4,NIP4,NEORE,(FP4(I),I=1,NFP4),(IP4(I),I=1,NIP4)	INPT0940
301 KM = 2	INPT0950
MM = 1	INPT0960
IF (IND(1),ME,0,AND, IYFR,LE,1) WRITE (6,8329)	INPT0970
DO 350 I = 1,NEORE	INPT0980
8329 FORMAT(1H1,49X,'EQUIPMENT AND REPAIR EVENT DATA')	INPT0990
DO 305 J=1,12	INPT1000
IDES(J)=IP4(KK)	INPT1010
IDFRT(J)=IP4(KK)	

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309 KK=KK+1                                INPT1020
    TSR = IP4 (KK)                          INPT1030
    TSR1 = IP4 (KK + 1)                     INPT1040
    IREX=IP4(KK+2)                          INPT1050
    IRE(1)=IREX                             INPT1060
    IEFNX=IP4(KK+3)                         INPT1070
    KK=KK+3                                 INPT1080
    RELH(1)=FP4(MM)                         INPT1090
    TUI(1)=FP4(MM+1)                       INPT1100
C    DTR(1)=FP4(MM+2)                       INPT1110
    MM=MM+2                                 INPT1120
    J=200+(1-1)*12                          INPT1130
    ITEM=J                                  INPT1140
    DO 310 JJ=1,IREX                         INPT1150
    TS(J)=TSR                               INPT1160
    J=J+1                                    INPT1170
    TS1(J)=TSR1                             INPT1180
    ITYP(J) = IP4 (KK + 1)                  INPT1190
    IRE(J) = IP4 (KK + 2)                   INPT1200
    IPE(J)=IREX,0) IPE(J)=IPE(J)+ITEM       INPT1210
    NX (1,J) = IP4 (KK + 3)                 INPT1220
    NX (2,J) = IP4 (KK + 4)                 INPT1230
    NX(3,J) = IP4 (KK + 5)                  INPT1240
    NX(1,J)=NX(1,J)+ITEM                    INPT1250
    NX(2,J)=NX(2,J)+ITEM                    INPT1260
    NX(3,J)=NX(3,J)+ITEM                    INPT1270
    RTU(J) = IP4 (KK + 6)                   INPT1280
    IPOI(J) = IP4 (KK + 7)                  INPT1290
    IEFN(J)=IEFNX                           INPT1300
    DYN(J)=FP4(MM)                          INPT1310
    PRB(1,J) = FP4 (MM + 1)                 INPT1320
    PRB(2,J) = FP4 (MM + 2)                 INPT1330
    PRB(3,J)= FP4 (MM + 3)                  INPT1340
    TEDC(1,J)=FP4(MM+4)                     INPT1350
    TEDC(2,J)=FP4(MM+5)                     INPT1360
    TEDC(3,J)=FP4(MM+6)                     INPT1370
    EDCV(1,J)=FP4(MM+7)                     INPT1380
    EDCV(2,J)=FP4(MM+8)                     INPT1390
    EDCV(3,J)=FP4(MM+9)                     INPT1400
    ST(J) = 0.0                             INPT1410
    TL(J) = 24.0                            INPT1420
    KK=KK+7                                 INPT1430
    MM=MM+10                                INPT1440
310 CONTINUE                               INPT1450
    JJ=J                                    INPT1460
    KK = KK + 1                             INPT1470
    MM = MM + 1                             INPT1480
C    II=J+IREX+1                            INPT1490
    IF (IND(1),HE,0,AND,ITFR,LE,1) WRITE(6,8330) INPT1500
    1 I,IDES,TSR,TSR1,RELH(1),TUI(1), IREX,ITYP(J),(NX(K,J),K=1,3), INPT1510
    2 (PRB(K,J),K=1,3),RTU(J),TEDC(K,J),K=1,3), INPT1520

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3 (EDCV(K,J),K=1,3),IPE(J),IF01(J),IEFN(J),DTR(J),(J-200-(1-1)*12),	
4 J,J=1,JJ)	
8330 FORMAT(1H0//EQUIP DESCRIPTION'5X,'-CONSUM, THRESHOLD SET- REL	
11ABILITY TIME EVENTS/'1X,'TYPE',72X,'(UNITS/HR) (UNITS)',	
2 9X,'(DAYS/FAIL) UNAVAIL FAMILY'/'14,3X,12A6,14,111,8X,FR,3,6X,	
3 F5,2,5X,12,77,	
4 EVENT NEXT EVENT PROBABILITY REPEAT/ DATA CHG NO DATA C	
5HANGE VALUE PREC. FAMILY FAMILY DURATION EVENT NUMREN',/,	
6 1 TYPE 1 2 3 1 2 3 TOUCHUP 1 2 3 1	
7 2 3 EVENT INDIC. NUMBER TARGET IN FAMILY COMPUTER:	
7 ,/,1H,13,3X,314,3F5,2,16,4X,314,3F6,0,217,19,F10,2,19,110))	
350 CONTINUE	1NPT1630
399 IF (ITER,EQ,1) GO TO 400	1NPT1640
NFP5=NEME*3	1NPT1650
NIP5=NEME*47	1NPT1660
READ(10) (FP5(I),I=1,NFP5):(IP5(I),I=1,NIP5)	1NPT1670
GO TO 401	1NPT1680
400 NFP5 = 0	1NPT1690
NIP5 = 0	1NPT1700
READ (5,EMREVT)	1NPT1710
NRE = NFP5/3	1NPT1720
NFP3=NIP5/58	1NPT1730
IF((NFP5,NE,NEME*3),OR,(NIP5,NE,NFP3*58)) GO TO 9040	1NPT1740
IF(N,GT,1) WRITE(10) (FP5(I),I=1,NFP5):(IP5(I),I=1,NIP5)	1NPT1750
401 KK = 1	1NPT1760
MM = 1	1NPT1770
IF (IND11) ,NE, 0 ,AND, ITER ,LE, 1) WRITE(6,8429)	1NPT1780
8429 FORMAT(1H1,49X,'EMERGENCY EVENT DATA')	
DO 450 I = 1,NEME	1NPT1840
ART(I) = FP5(KK)	1NPT1850
ASDE(I) = FP5(KK + 1)	1NPT1860
DTE(I) = FP5(KK + 2)	1NPT1870
DO 405 J=1,12	1NPT1880
IDES(J)=IP5(MM)	1NPT1890
405 MM=MM+1	1NPT1900
ISSSE(I)=IP5(MM)	1NPT1910
DO 410 J =1,10	1NPT1920
MM = MM + 1	1NPT1930
410 MREGE (J,I) = IP5(MM)	1NPT1940
MM=MM+1	1NPT1950
LODME(I)=IP5(MM)	1NPT1960
DO 420 J=1,10	1NPT1970
MM = MM + 1	1NPT1980
420 IRCE (J,I) = IP5(MM)	1NPT1990
MM = MM + 1	1NPT2000
TSE(I) = IP5 (MM)	1NPT2010
DO 425 J=1,10	1NPT2020
MM = MM + 1	1NPT2030
425 IRCE1(J,I) = IP5 (MM)	1NPT2040
TSE1(I) = IP5(MM + 1)	1NPT2050
THE(I) = IP5 (MM + 2)	1NPT2060

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MM = MM + 3
DO 430 J = 1,10
TECE(J,1) = IPS (MM)
430 MM = MM + 1
DO 435 J = 1,10
IRENCY(J) = TECE(J,1)
435 CONTINUE
NDDE(1) = IPS (MM)
MM = MM + 1
KK = KK + 3
ISTYP(1:560) = -1
ST(1:560) = 0.
TL(1:560) = 24.0
TS(1:560) = TSE(1)
TS1(1:560) = TSE1(1)
RTU(1:560) = 1
IPO(1:560) = 1
IPN(1:560) = 0
NIF(1:560) = 1
EDC(1,1:560) = 0.
EDC(2,1:560) = 0.
EDC(3,1:560) = 0.
IF (IND(1) .NE. 0 .AND. ITER .LE. 1)
1WRITE(6,6440) I,IDES,ARY(1),ASHE(1),YSE(1),YSE1(1),ESSE(1),
1 LOME(1),IME(1),NREQE(J,1),J=1,10),IRCE(J,1),J=1,10),NDDE(1),
2 OTE(1),IPERCT(J),J=1,10),IRCE(J,1),J=1,10)
6440 FORMAT(///'EHER DESCRIPTION',T28,1--REPAIR TIME-- CONSUM THR
18SHOLD SET,/,/,NO,'T86,'AVG SIGMA',6X,'(UNITS/MM)',6X,
2 'UNITS',/,/,13.4X,
2 '2A6,T85,F4,2,Y94,F4,2,Y107,12,T121,12,/,/,ESSEN- MENTAL HAZAR
30 NUMBER OF MEN REQUIRED',T72,CONSUMABLE EXPENDITURE RATE(MN
4ITS/HR) DAYS/ DURATION',/,TIALITY LOAD,T28,
5 'EXPECTED ENERGY CONSUMPTION (CAL/HR,/,
5 T72,CONSUMABLE EXPENDITURE RATE(MN
6ITS)',T111,EMERGENCY TARGET,/,T29,1 2 3 4 5 6 7
7 8 9 10,T72,1 1 2 3 4 5 6 7 8 9 10,/,/,15,2(6X,F2,0),
8 9X,1014,T72,10(F3,0),T115,12,6X,F4,2,/,T27,1014,T71,1013)
450 CONTINUE
601 IF(ITER,GT,1) GO TO 451
NFP3=0
NIPS=0
READ(5,TYPE)
IF(IND(1),NE,0 .AND. ITER,LE,1) WRITE(6,9601)
9601 FORMAT(1H1/50X,'EVENT TYPE DATA',/,/,
1 '1',128(' '),11,/,/,117X,EQUIPMENT 1,/,/,
2 '1 TYPE IDENTIFIER',64X,DURATION CLASS NUMBER OF NUM
3ERS RECD',11,/,/,1179X,AVG SIGMA',11X,EQUIPS. RECD, 1 2 3
4 5 6,/,/,117128X,11,/,/,117128(' '),11,/,/,117128X,11,/,/,
5 '1 ESSEN- MENTAL EVENT TRAIN HAZARD',9X,NUMBER OF MEN REQUIR-
6D',16X,CONSUMABLE EXPENDITURE RATE (UNITS/HR)',6X,11,/,/,1 TIALI
7TV LOAD KIND CODE',99X,11,/,/,117128X,11,/,/,117128(' '),

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8 '11',/,',11',128X,'11',/,',11',40X,'CONSUMABLE EXPENDITURE RATE (UNITS)
9',14X,'EXPECTED ENERGY CONSUMPTION',12X,'11',/,',11',40X,'1 2 3
A 4 5 6 7 8 9 10 1 2 3 4 5 6 7
88 9 101',/,',11',128X,'11',/,',11',128('11',',11',/,/,)
NTYPES=NIP5/65 INPT2460
MM = 1 INPT2475
KK = 1 INPT2480
DO 650 I=1,NTYPES INPT2495
DO 605 J=1,12 INPT2500
IDES(J)=IP5(MM) INPT2510
605 MM=MM+1 INPT2520
TESS=IP5(MM) INPT2530
MM=MM+1 INPT2540
ADUR = FP5 (KK) INPT2550
ASD = FP5 (KK + 1) INPT2560
DO 610 J=1,10 INPT2570
NREQ(J) = IP5 (MM) INPT2580
610 MM = MM + 1 INPT2590
LODM = IP5 (MM) INPT2600
KE = IP5 (MM + 1) INPT2610
INT = IP5 (MM + 2) INPT2620
MM = MM + 3 INPT2630
DO 615 J=1,10 INPT2640
IRC (J) = IP5 (MM) INPT2650
IRC1(J) = IP5 (MM + 10) INPT2660
615 MM = MM + 1 INPT2670
IH=IP5(MM+10) INPT2680
MM=MM+11 INPT2690
DO 620 J=1,10 INPT2700
IEC (J) = IP5 (MM) INPT2710
620 MM = MM + 1 INPT2720
NIQR = IP5 (MM) INPT2730
DO 625 J=1,6 INPT2740
MM = MM + 1 INPT2750
625 IQR(J) = IP5 (MM) INPT2760
ICLASS = IP5 (MM + 1) INPT2770
WRITE(12',ERR=9060) ADUR10 INPT2780
IF(IND(1),NE'0',AND,ITER,LE'1) INPT2795
1 WRITE(6,9650) I,IDES,ADUR,ASD,ICLASS,NIQR,((IQR(J),J=1,6),TESS, INPT2800
1 LODM,KE,INT,IH, (NREQ(J),J=1,10), (IRC(J),J=1,10), (IRC1(J),J=1,10 INPT2810
2), (IEC(J),J=1,10) INPT2820
9650 FORMAT(14,3X,12A6,2F7.3,16,7X,14,7K,6I27.15,F8.0,16,16,F7.0,4X, INPT2830
1 10I4,2X,10F5.0/38X,10I4,2X,10F5.0) INPT2840
KK = KK + 2 INPT2850
650 MM = MM + 2 INPT2860
651 RETURN INPT2870
ENTRY DINPUT INPT2880
IF(ITER,EQ,1) GO TO 500 INPT2890
READ(10) ND,NOSE,(DUMY(I),I=1,11) INPT2900
475 NFP3=NOSE+11 INPT2910
VFP3=NOSE+11 INPT2920

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READ(10) (FP3(1),I=1,NFP3),(IP3(1),I=1,NIP3)	INPT2930
GO TO 901	INPT2940
900 NFP3 = 0	INPT2950
NIP3 = 0	INPT2960
READ (5,8500)ND,NOSE,(DUMY(1),I = 1,11)	INPT2970
9500 FORMAT (2I3,11A6)	INPT2980
READ (5,SCHVT)	INPT2990
IF((NFP3,NE,NOSE=11),OR,(NIP3,NE,NOSE=11)) GO TO 9050	INPT3000
IF(N,LE,1) GO TO 901	INPT3010
WRITE(10) ND,NOSE,(DUMY(1),I=1,11)	INPT3020
WRITE(10) (FP3(1),I=1,NFP3),(IP3(1),I=1,NIP3)	INPT3030
901 KK = 1	INPT3040
NR = 1	INPT3050
DO 960 I = 1,NOSE	INPT3060
IETYP(I)=IP3(KK)	INPT3070
IPE(I)=IP3(KK+1)	INPT3080
TS(I)=IP3(KK+2)	INPT3090
TS1(I)=IP3(KK+3)	INPT3100
RTU(I)=IP3(KK+4)	INPT3110
IFOL(I)=IP3(KK+5)	INPT3120
NIF(I)=IP3(KK+6)	INPT3130
IFNI(I)=IP3(KK+7)	INPT3140
KK=KK+8	INPT3150
TL(I)=FP3(MH)	INPT3160
ST(I)=FP3(MH+1)	INPT3170
MH=MH+2	INPT3180
DO 510 J = 1,3	INPT3190
NX(J,1)=IP3(KK)	INPT3200
PRB(J,1)=FP3(MH)	INPT3210
MH=MH+1	INPT3220
910 KK = KK+1	INPT3230
DO 520 J=1,3	INPT3240
EDC(J,1)=FP3(MH)	INPT3250
EDCV(J,1)=FP3(MH+3)	INPT3260
920 NH = MH + 1	INPT3270
NH = NH + 3	INPT3280
960 CONTINUE	INPT3290
IF((ND(1),EQ,0,OR,ITER,GT,1) GO TO 4999	INPT3300
WRITE(6,8501) NOSE,ND,(DUMY(1),I=1,11)	
8501 FORMAT(1H1,45X,'SCHEDULED EVENT SEQUENCE DATA',//,'FOR',14,	
1 '1 SCHEDULED EVENTS OF DAY',13,' ENTITLED# '11A6,7X,'INTU CODE',/	
2 118X,'1-REPEAT',/, 'EVENT TYPE THRESHOLD SET NEXT EVENT A'	
3D PROBABILITY PRECEDENT START TIME REPEAT/TOUCHUP',	
4 13X,'2-TOUCHUP',/, 'NO',11X,'UNITS/HR UNITS',6X,'1', 9X,'2',10X,	
5 13,'7X,'EVENT NO.',3X,'TIME',4X,'LIMIT',7X,'CODE',11X,	
6 '3-NEXT EVENT')	
WRITE(6,8560) (I,IETYP(I),TS(I),TS1(I),NX(1,1),PRB(1,1),NX(2,1),	
1 PRB(2,1),NX(3,1),PRB(3,1),IPE(I),ST(I),TL(I),RTU(I),I=1,1)	
DO 8600 I=2,NOSE	
WRITE(6,8560) I,IETYP(I),TS(I),TS1(I),NX(1,1),PRB(1,1),NX(2,1),	
1 PRB(2,1),NX(3,1),PRB(3,1),IPE(I),ST(I),TL(I),RTU(I)	

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      IF(MOD(I,24).EQ,0) WRITE(6,9901) NOSE,ND,(NUHY(J),J=1,11)
8890 CONTINUE
8960 FORMAT(1H, 1H ,13,18,16,18,2X,3(19,F6,2),(10,F10,2,F7,2,114)
4999 CONTINUE
5000 IF (IERR,EQ,0) RETURN
      STOP
9010 IERR = 1
      WRITE (6,9011)
9011 FORMAT (30HERROR IN FOLLOWING INPUT LIST/25HPROGRAM WILL NOT CONTINUE)
      WRITE (6,PARAM)
      GO TO 200
9020 IERR = 1
      WRITE (6,9011)
      WRITE (6,PERSNL)
      GO TO 300
9030 IERR = 1
      WRITE (6,9011)
      WRITE (6,EONEVT)
      GO TO 400
9040 IERR = 1
      WRITE (6,9011)
      WRITE (6,EMNEVT)
      GO TO 601
9050 IERR = 1
      WRITE (6,9011)
      WRITE(6,SCHEVT)
      GO TO 9000
9060 WRITE(6,9012)
9012 FORMAT(20HID, A, ERROR--OUT)
      RETURN
      END
COUTP1 SUBROUTINE OUTP1
      SUBROUTINE OUTP1
      INTEGER P12
      COMMON/UCOM/PCOM(20),SCOM(20),IP(20),ISS(20),IPCOM(20),TSCOM(20)
      COMMON/SEVENT/IETYP(570),TL(570),ST(570),EDCV(3,570),IPE(570),
1 TS(570),TS1(570),NX(3,570),RTU(570),IFDI(570),IEFN(570),NIF(570),
2 IEDC(3,570),PHR(3,570),NOSE,NEORE,NEHE,DI(4)
      COMMON/OPP1/ IAA(4),PC(20),PACE(20),ASP(20),HSL(20),PI(20)
1,P12(20),ICE(20)
      COMMON/OPP2/ TH(20),YHP(20),YWS(20),DS(20),APW(20),PCC(20),
1 CASP(20),IDC(20), NSUC1,NSUC2,HFALE,NIGNR,
2 KONC(10),KONC1(10), SI,CHL,ND,ITER,NDAYS,MPCC(20),FAT(20)
3 ,STRT(20),CAL(20),PHR(20),CCA(20),NUT(20),PERF(20),HPRFH(4)
4 ,APA,SFOIFF,CLSDTA(10,40)
      COMMON/OPP3/IC,FLIC,NREPT,HRSE,HRSR,HKSS,PEFF,
1 MAXST,MAXSTF,USHT,NR,NTE,PE,TFH,CHLMX,ICHL,SINCHX,INCHX,ICSS
      COMMON/OPP4/EPL(30),CDT(30),CART(30),CUT(30),
1 EPEFF,ENTRF,ENTTR,SRL,9PL,SGEM,RSSUC2,SCDT10,REPTM,
1 ACART(10),ACDT(10),ACUT(10), AEPL(10),DEPEFF(10)

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C	1 AEPL,EPEFF,EMTBF,EMTTR,SRL;SPL,SGEM	OUTPC190
	REAL MAXST,IITER,JITER	OUTP0200
	COMMON/TPARAM/APST,WORX1,WORX2,SLEEP,CN,MAXSL,TFAT,ACP,	OUTP0210
	1CALRY,PWRRT,K7,K1,DE,AASP,USHLIN,KON(10),KONT(10,10),KON1(10),	
	2 KONT(10,10),SESTA(10),REL(14),N,IET,IND(7),NDMAX,IOFK(36,12)	
	REAL IDC, KON, KONG, MPCC, NU, IMYAB(13,21,10),KON1	OUTP0240
	DIMENSION OUTA(39),TEM3(20),DALY(39,30),IITER(35,10),T3(10)	OUTP0250
	DIMENSION TOUTA(13,10),NTIP(10),TDALY(13,10,30),TITER(13,10,10)	OUTP0260
	1 ,ADALY(10,30),IDALY(10,30),JITER(20,10),OUTB(20),IKONC(10)	OUTP0270
	DIMENSION CLSNME(37),CLSDTI(10,40),CLSDTR(10,40),IPERCT(10)	OUTP0280
	DATA CLSNME/ 1HC,1HO,1HD,1HA,2HEY,4HEURN,2HEC	OUTP0290
	1,3HECA,2HER,2HEO,3HEIP,2HEI,4HERPY,5HELURN,5HELRH,	OUTP0300
	2,3HELC,3HELA,3HELR,3HELO,4HELEP,3HELI,5HELRPT,	OUTP0310
	3,5HEURN,3HEMC,3HEMA,3HEMR,3HEMO,4HEMEI,3HEMI,	OUTP0320
	4,5HEMRPY,4HHRUH,2HMC,2HMA,2HMR,2HMO,3HMEI,	OUTP0330
	5,2HMI,4HMRPT,	OUTP0340
	DATA C1/6H /	OUTP0350
	DO 380 I=1,10	OUTP0360
380	RTYPE(I)=0	OUTP0370
	DO 390 I=1,10	OUTP0380
	K=IPB(I)	OUTP0390
390	NTYPE(K)=NTYPE(K)+1	OUTP0400
	IF(IND(2),EQ,0) RETURN	OUTP0410
	WRITE(6,9414)	OUTP0420
9414	FORMAT(1H1,'START OF MISSION CREW DATA BY TYPE:',//,	
	1TYPE,PHYS,COMPET	
	1ANCE,PACE,ASPIR,HNS SINCE,PHYSICAL,4X,CAPABIL,PRIN	
	2ARY SECONDARY,10X,ATION, LAST SLEEP, INCAPACITY')	
	K = 0	OUTP0450
	DO 420 J = 1,4	OUTP0460
	KK = IAA(I)	OUTP0470
	IF (KK,EQ,0) GO TO 420	OUTP0480
	K = K+1	OUTP0490
	PBA = PC(K)	OUTP0500
	PCOMA = PCOM(K)	OUTP0510
	SCOMA = SCOM(K)	OUTP0520
	PACEA = PACE(K)	OUTP0530
	ASPA = ASP(K)	OUTP0540
	HLSA = HSL(K)	OUTP0550
	PIA = PI(K)	OUTP0560
	IF (KK,EQ,1) GO TO 415	OUTP0570
	DO 410 J = 2,KK	OUTP0580
	K = K+1	OUTP0590
	PBA = PCA+PC(K)	OUTP0600
	PCOMA = PCOMA+PCOM(K)	OUTP0610
	SCOMA = SCOMA+SCOM(K)	OUTP0620
	PACEA = PACEA+PACE(K)	OUTP0630
	ASPA = ASPA+ASP(K)	OUTP0640
	HLSA = HLSA+HSL(K)	OUTP0650
410	PIA = PIA+PI(K)	OUTP0660
	TEM1 = KK	OUTP0670

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PCA = PCA/TEM1	OUTP0680
PCOMA = PCOMA/TEM1	OUTP0690
SCOMA = SCOMA/TEM1	OUTP0700
PACEA = PACEA/TEM1	OUTP0710
ASPA = ASPA/TEM1	OUTP0720
MSLSA = MSLSA/TEM1	OUTP0730
PIA = PIA/TEM1	OUTP0740
415 WRITE (6,9415)1,PCA,PCOMA,SCOMA,PACEA,ASPA,MSLSA,PIA	OUTP0750
9415 FORMAT(3, F8.3,F9.3,F10.3,F7.3,F8.3,F11.3,F12.3)	
420 CONTINUE	
WRITE(6,9416) (1,PC(1),PCOM(1),SCOM(1),PACE(1),ASP(1),MSLS(1),	OUTP0770
1 PI(1),PI2(1),FAT(1),STRM(1),CAL(1),PWR(1),ICE(1),IPS(1),ISS(1),	OUTP0780
2 I=1,IC)	OUTP0800
9416 FORMAT(1H ,,,, 'START OF MISSION CREW DATA BY MAN',,,	
1 'MAN PHYS- COMPETANCE PACE ASPIR- HRS	
2 SINCE PHYSIC INCAP FAT- STRESS CALOR- POWER LEVEL	
3 SPECIALTY',/,	
4 'NO, CAPABIL PRIMARY SECONDARY',,X,'AYION LASY SLEEP DUR	
4AYION EXTENT IGUE THRESHOLD IES RATE',	
4 'PRIMARY SECONDARY',,113,	
4 2X,F5.3,F9.3,F10.3,F7.3,F8.3,F12.3,F8.3,F5.3,F10.3,F9.0,F7.1,	
5 17,2X,216))	
DO 425 I=1,12	OUTP0840
425 OUTA(1) = 0.0	OUTP0850
DO 430 I=1,IC	OUTP0860
OUTA(1) = OUTA(1)+PC(1)	OUTP0870
OUTA(2) = OUTA(2)+PCOM(1)	OUTP0880
OUTA(3) = OUTA(3)+SCOM(1)	OUTP0890
OUTA(4) = OUTA(4)+PACE(1)	OUTP0900
OUTA(5) = OUTA(5)+ASP(1)	OUTP0910
OUTA(6) = OUTA(6)+MSLS(1)	OUTP0920
OUTA(7) = OUTA(7)+PI(1)	OUTP0930
OUTA(8) = OUTA(8)+FLOAT(PI2(1))	OUTP0940
OUTA(9) = OUTA(9)+FAT(1)	OUTP0950
OUTA(10) = OUTA(10)+STRM(1)	OUTP0960
OUTA(11) = OUTA(11)+CAL(1)	OUTP0970
OUTA(12) = OUTA(12)+PWR(1)	OUTP0980
DO 435 I=1,12	OUTP0990
435 OUTA(I) = OUTA(I)/FLIC	OUTP1000
WRITE(6,9417) (OUTA(I),I=1,12)	OUTP1010
9417 FORMAT(1 AVRS/MAN',/,2X,F8.3,F9.3,F10.3,F7.3,F8.3,F12.3,F8.3,F5.3,	
1 F8.3,F10.3,F9.0,F7.1)	
TOUTA(3,K)=TOUTA(3,K)+TNS(1)	
RETURN	OUTP1043
ENTRY XXIN	OUTP1050
	OUTP1065
NREI=0	OUTP1070
OUTI=0.0	OUTP1080
CARTI=0.0	OUTP1090
CDTI=0.0	OUTP1100
DO 437 I=1,40	OUTP1110
	OUTP1120

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DO 437 J=1,10	OUTP1130
437 CLSDY1(J,1)=0.0	OUTP1140
DO 440 I=1,10	OUTP1150
DO 440 J=1,35	OUTP1160
440 IITER(J,1)=0.0	OUTP1170
DO 460 KK=1,13	OUTP1180
DO 450 J=1,21	OUTP1190
450 INTAB(KK,J,1) = 0.0	OUTP1200
DO 460 J=1,10	OUTP1210
460 TITER(KK,J,1)=0.0	OUTP1220
RETURN	OUTP1230
ENTRY OUTP2	OUTP1240
DO 2000 J=1,13	OUTP1250
DO 1998 I=1,10	OUTP1260
1998 TOUTA(I,J,1)=0.0	OUTP1270
2000 OUTA(IJ)=0.0	OUTP1280
DO 2010 I=1,1C	OUTP1290
K=IP5(I)	OUTP1300
TEM3(I)=24.0-DS(I)-TW(I)	OUTP1310
INTAB(1, I, ITER) = INTAB(1, I, ITER) + PCC(I)	OUTP1320
OUTA(1)=OUTA(1)+PCC(I)	OUTP1330
TOUTA(1,K)=TOUTA(1,K)+PCC(I)	OUTP1340
INTAB(2, I, ITER) = INTAB(2, I, ITER) + TWP(I)	OUTP1350
OUTA(2)=OUTA(2)+TWP(I)	OUTP1360
TOUTA(2,K)=TOUTA(2,K)+TWP(I)	OUTP1370
INTAB(3, I, ITER) = INTAB(3, I, ITER) + TNS(I)	OUTP1380
OUTA(3)=OUTA(3)+TNS(I)	OUTP1390
TOUTA(3,K)=TOUTA(3,K)+TNS(I)	OUTP1400
INTAB(4, I, ITER) = INTAB(4, I, ITER) + DS(I)	OUTP1410
OUTA(4)=OUTA(4)+DS(I)	OUTP1420
TOUTA(4,K)=TOUTA(4,K)+DS(I)	OUTP1430
INTAB(5, I, ITER) = INTAB(5, I, ITER) + TEM3(I)	OUTP1440
OUTA(5)=OUTA(5)+TEM3(I)	OUTP1450
TOUTA(5,K)=TOUTA(5,K)+TEM3(I)	OUTP1460
INTAB(6, I, ITER) = INTAB(6, I, ITER) + FAT(I)	OUTP1470
OUTA(6)=OUTA(6)+FAT(I)	OUTP1480
TOUTA(6,K)=TOUTA(6,K)+FAT(I)	OUTP1490
INTAB(7, I, ITER) = INTAB(7, I, ITER) + PI(I)	OUTP1500
OUTA(7)=OUTA(7)+PI(I)	OUTP1510
TOUTA(7,K)=TOUTA(7,K)+PI(I)	OUTP1520
INTAB(8, I, ITER) = INTAB(8, I, ITER) + APW(I)	OUTP1530
OUTA(8)=OUTA(8)+APW(I)	OUTP1540
TOUTA(8,K)=TOUTA(8,K)+APW(I)	OUTP1550
INTAB(9, I, ITER) = INTAB(9, I, ITER) + PCOM(I)	OUTP1560
OUTA(9)=OUTA(9)+PCOM(I)	OUTP1570
TOUTA(9,K)=TOUTA(9,K)+PCOM(I)	OUTP1580
INTAB(10, I, ITER) = INTAB(10, I, ITER) + CASP(I)	OUTP1590
OUTA(10)=OUTA(10)+CASP(I)	OUTP1600
TOUTA(10,K)=TOUTA(10,K)+CASP(I)	OUTP1610
OUTA(11)=OUTA(11)+IDC(I)	OUTP1620
INTAB(11, I, ITER) = INTAB(11, I, ITER) + PERF(I)	OUTP1630

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	OUTA(12)=OUTA(12)+PERF(1)	OUTP1640
	TOUTA(11,K)=TOUTA(11,K)+PERF(1)	OUTP1650
	INTAB(12,1,ITER) = INTAB(12,1,ITER) + NU(1)	OUTP1660
	TOUTA(12,K) = TOUTA(12,K)+NU(1)	OUTP1670
2010	OUTA(13)=OUTA(13)+NU(1)	OUTP1680
	DO 2020 I=1,13	OUTP1690
	DO 2019 J=1,10	OUTP1700
	K=NTYPE(J)	OUTP1710
	IF (K,NE, 0) TOUTA(1,J)=TOUTA(1,J)/FLOAT(K)	OUTP1720
2019	CONTINUE	OUTP1730
	OUTA(1)=OUTA(1)/FLIC	OUTP1740
2020	CONTINUE	OUTP1750
	DALY(1,ND)=NSUC1	OUTP1760
	DALY(2,ND)=NSUC2	OUTP1770
	DALY(3,ND)=NFALE	OUTP1780
	DALY(4,ND)=NIGNR	OUTP1790
	DALY(5,ND)=OUTA(2)	OUTP1800
	DALY(6,ND)=OUTA(3)	OUTP1810
	DALY(7,ND)=OUTA(4)	OUTP1820
	DALY(8,ND)=OUTA(5)	OUTP1830
	DALY(9,ND)=KONC(1)	OUTP1840
	DALY(10,ND)=KONC(2)	OUTP1850
	DALY(11,ND)=KONC(3)	OUTP1860
	DALY(12,ND)=OUTA(6)	OUTP1870
	DALY(13,ND)=CHL	OUTP1880
	DALY(14,ND)=OUTA(9)	OUTP1890
	DALY(15,ND) = APA	OUTP1900
	DALY(16,ND)=OUTA(6)	OUTP1910
	DALY(17,ND) = OUTA(10)	OUTP1920
	DALY(18,ND)=OUTA(7)	OUTP1930
	DALY(19,ND)=SI	OUTP1940
	DALY(20,ND) = NPRF4(3)	OUTP1950
	DALY(21,ND) = NPRF4(4)	OUTP1960
	DALY(22,ND)=NHREY	OUTP1970
	DALY(23,ND) = HRSR	OUTP1980
	DALY(24,ND) = HRSE	OUTP1990
	DALY(25,ND) = MAXST	OUTP2000
	DALY(26,ND) = CHLMX	OUTP2010
	DALY(27,ND)=PEFF	OUTP2020
	DALY(28,ND) = TEH	OUTP2030
	DALY(29,ND) = SFDIFF	OUTP2040
	DALY(30,ND) = NSUC1 + NSUC2	OUTP2050
	DALY(31,ND) = USMT	OUTP2060
	DALY(32,ND) = ICSS	OUTP2070
	IGMAX = NEURE	OUTP2080
	DO 2034 I=1,IGMAX	OUTP2090
	CUTI=CUTI + CUT(1)	OUTP2100
	CDYI=CDYI + CDY(1)	OUTP2110
2034	CARTI=CARTI + CART(I)	OUTP2120
	NREI=NREI + NH	OUTP2130
	DO 2032 I=1,10	OUTP2140

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ADALY(I,ND) = KONC(I)                                OUTP2150
IDALY1(I,ND) = KONC1(I)                                OUTP2160
2032 CONTINUE                                           OUTP2170
DO 2025 J=1,10                                         OUTP2180
DO 2025 I=1,12                                         OUTP2190
2025 IDALY(I,J,ND)=YOUTA(I,J)                         OUTP2200
DO 2022 I=1,40                                         OUTP2210
DO 2022 J=1,9                                          OUTP2220
CLSDYR(J,I)=CLSDYR(J,I) + CLSDYA(J,I)               OUTP2230
2022 CLSDTI(J,I)=CLSDTI(J,I) + CLSDTA(J,I)           OUTP2240
IF(I=ND(6),UT,ND) RETURN                             OUTP2250
1990 NMPFH(I) = NMPFH(I).NIGNR                        OUTP2260
FNTE = NMPFH(I)                                        OUTP2270
NIS1=NSUC1+NSUC2                                       OUTP2280
TEM1=NRSS+NRSR+NRSE                                     OUTP2290
T3(1)=FLOAT(NFALE)/FNTE*100.0                         OUTP2300
T3(2)=FLOAT(NSUC1)/FNTE*100.0                         OUTP2310
T3(3)=FLOAT(NSUC2)/FNTE*100.0                         OUTP2320
T3(4)=FLOAT(NIGNR)/FNTE*100.0                         OUTP2330
T3(5)=FLOAT(NREPT)/FNTE*100.0                         OUTP2340
DO 2026 I=1,10                                         OUTP2350
IKONC(I)=KONC(I)                                       OUTP2360
2026 CONTINUE                                           OUTP2370
WRITE(6,9984) ND,IYER,(NMPFH(I),I=1,4),NREPT,NIS1,NFALE,NIGNR, OUTP2380
1 TEM1,NRSS,NRSR,NRSE,USMT,APA,SFDIFF,                OUTP2390
1 (T3(I),I=1,5),S1,C1,CHL,PEFF,TEH,REPTH,             OUTP2400
1 MAXS1,MAXSTE,CHLCH,ICHL,SIDCHX,UDCHX,ICSS           OUTP2410
3 , (KONC1(I),I=1,10),(IKONC(I),I=1,10)              OUTP2420
9984 FORMAT(15H1REPORT FOR DAY13,11H, ITERATION13/19H NO. EVENTS--TOTAL OUTP2430
114,12H SCHEDULED14,9H REPAIR14,12H EMERGENCY14,10H REPEAT OUTP2440
2514,12H SUCCESSES14,11H FAILURES14,10H IGNORES14/22H HOURS OUTP2450
3WORKED---TOTALF6,1,11H SCHEDULEDF6,1,9H REPAIRF6,1,7H EMER, OUTP2460
4F6,1,10H UNMANNEDF7,1,15H AVH PERF ADEUF5,2,14H AVH FAIL DFF OUTP2470
5 F6,3/ 25H PERCENTAGE OF---FAILUREF5,1, 15H SUCC OUTP2480
6, 1ST TRYF5,1,15H SUCC, 2ND TRYF5,1,9H IGNOREDF5,1,9H REPEATSF5 OUTP2490
7,17/14H SAFETY INDEXF6,2,16(1H ),1A6,13H MENTAL LOAN OUTP2500
8 F6,2,10H PERF EFF F9,3,8H HAZARD,F7,0,' EQUIPMENT REPAIR', OUTP2510
8 1 TIME 'F4,1/ OUTP2520
913H MAX, STRESSF6,2,9H ON EVENT14,18H MAX. MENTAL LOANF4,0, OUTP2530
A9H ON EVENT14,20H MAX, CAL, EXPENDED0,0,9H ON EVENT14,10H SEA ST OUTP2540
DATE 13/23H CONS, BAL, (UNITS) 1017/23H CONS, BAL, (UNITS/HR) 100 OUTP2550
C 17) OUTP2560
WRITE(6,9985) OUTP2570
9985 FORMAT(125HUMAN TYPE PHYSICAL HOURS WORKED SLEPT IDLE FATIGUE OUTP2580
1E HEALTH AV3 PHYS COMPETENCE ASPIRATION PERFORM NUMBER OUTP2590
2 /4H NO.,10X,4HCAP,4X,12HPRIN; 2ND,25X,5HINDEX,2X,RHWORKLOAD OUTP2600
329X,4HCUM,,4X,5HSUCC,) OUTP2610
DO 1991 I=1,10 OUTP2620
WRITE(6,9987) 1,IPS(I),PCC(I),TWP(I),TWS(I),DS(I),TEM3(I),FAT(I), OUTP2630
1P(I),APW(I),PCOM(I),CASP(I), PERF(I),NU(I) OUTP2640
9987 FORMAT(1H ,13,16,F10.3,2F9.2,F7,1,F6,1,F9.2,F6.2,F10.2,F12.3, OUTP2650

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1F12,2; F9,2,F9,0)	OUTP2660
1991 CONTINUE	OUTP2670
WRITE(6,9988) (OUTA(I),I=1,10),OUTA(12),OUTA(13)	OUTP2680
9988 FORMAT(9H0AVERAGES/9H PER MANF11,3,2F7,2,F7,1,F6,1,F9,2,F8,2,	OUTP2690
1 F10,2,F12,3,F12,2,F9,2,F10,2)	OUTP2700
WRITE(6,9989)	OUTP2710
9989 FORMAT(1H0//17H0AVERAGES BY TYPE/11H NO TYPE)	OUTP2720
DO 1995 I=1,10	OUTP2730
K=NTYPE(I)	OUTP2740
IF(K.EQ,0) GO TO 1995	OUTP2750
WRITE(6,9990) K,1,(TOUTA(J,I),J=1,12)	OUTP2760
9990 FORMAT(2F5, F10,3,2F7,2,F7,1,F6,1,F9,2,F8,2,F10,2,F12,3,F12,2,	OUTP2770
1 F9,2,F8,2)	OUTP2780
1995 CONTINUE	OUTP2790
WRITE(6,1996) (I,CART(I),CDT(I),CUT(I),EPL(I),I=1,10MAX)	OUTP2800
1996 FORMAT(//1H0,'DAILY PERFORMANCE OF EQUIPMENT',/,	OUTP2810
1 17X,'AVG. REPAIR TIME UP PERFORMANCE',/,	
2 7X,'EQUIPMENT EXPECTED ACTUAL TIME LEVEL EFFICI,	
3 /,(11X,12,5X,F5,2,5X,F5,2,1X,F5,2,2X,F9,2,' -'))	
ACART(I)=0,	
ACDT(I)=0,	
ACUT(I)=0,	
DEPEFF(ND)=EPEFF	
DO 2150 I=1,10MAX	OUTP2880
ACART(ND)=CART(I)/10MAX+ACART(ND)	
ACDT(ND)=ACDT(ND)+CDT(I)/10MAX	
ACUT(ND)=ACUT(ND)+CUT(I)/10MAX	
2150 CONTINUE	OUTP2920
WRITE(6,1997) ACART(ND),ACDT(ND),ACUT(ND),AEPL(ND),	
1 DEPEFF(ND)	
1997 FORMAT(1H0,/, 'AVERAGES',10X,F5,2,5X,F5,2,1X,F5,2,2X,F5,2,	OUTP2940
1 2X,F5,2,)	
C 1 2X,F5,2,1X, // ' SYSTEM RELIABILITY LEVEL ',F5,2,10X,	OUTP2950
C 2 ' SYSTEM PERFORMANCE LEVEL ',F5,2,10X,' SYSTEM EFFECTIVENESS ME	OUTP2960
C 3ADURE ',F5,2)	OUTP2970
WRITE(6,2159)	OUTP2980
2159 FORMAT(1H1,'SUMMARY BY EVENT CLASS',/, ' EVENT NO. OF HOURS	
1WORKED ----PERCENT OF TIME----R PERFORM, AVG, FAILURE!/' CLASS	
2 EVENTS PRIM 2ND SUC1 SUC2 FAIL IGNORE ADEQUACY	
3 DIFFERENCE')	OUTP3020
DO 40 I=1,40	OUTP3030
IF(CLSDTA(I,1),LE,0.0) GO TO 40	OUTP3040
DO 30 J=2,9	OUTP3050
30 CLSDTA(J,I)= CLSDTA(J,I)/CLSDTA(I,1)	OUTP3060
DO 35 J=2,9	OUTP3070
IPERCT(J)=CLSDTA(J,I)*100.,.5	OUTP3080
35 CONTINUE	OUTP3090
WRITE(6,2160) I,CLSDTA(I,1),CLSDTA(6,I),CLSDTA(7,I),	OUTP3100
1 IPERCT(2),IPERCT(3),IPERCT(4),IPERCT(5),	OUTP3110
2 CLSDTA(8,I),CLSDTA(9,I)	OUTP3120
2160 FORMAT(16,F10,0,F10,2,F9,2,15,216,18, F9,2,F12,2)	OUTP3130

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40 CONTINUE                                OUTPUT3140
   RETURN                                OUTPUT3150
   ENTRY OUTP3                            OUTPUT3160
2030 WRITE(6,9029) ITER,NOMAX             OUTPUT3170
9029 FORMAT(21H1NEPORT FOR ITERATION13,3H OF13,15H DAY MISSION,--/  OUTPUT3180
2 127H DAY      NUMBER OF EVENTS          AVE. MAN HOURS SPENT      OUTPUT3190
3 -----END OF DAY AVERAGES----- INDICES OUTPUT3200
4/9X,125H SUC1 SUC2 FAIL IGNORE PRIM, SECOND SLEEP IDLE          OUTPUT3210
5      PHYS LD MEN LD COMP APA  FAT.  ASP  HLTH  SFT OUTPUT3220
6Y/)                                OUTPUT3230
   DO 2031 J=1,NOMAX                      OUTPUT3240
2031 WRITE(6,9030) J, (DALY(I,J),I=1,8), (DALY(I,J),I=12,19)      OUTPUT3250
9030 FORMAT (14,1X,3F9.0,F7.0,4F7.2,24X,  F8.2,F8.2,F6.3,F6.2,  OUTPUT3260
1 F6.2,F5.2,2F6.2)                                OUTPUT3270
   FD=NOMAX                                OUTPUT3280
   TOT=0.0                                OUTPUT3290
   DO 2055 I=1,NOMAX                        OUTPUT3300
   DO 2055 J=1,4                            OUTPUT3310
   TOT=TOT+DALY(J,I)                        OUTPUT3320
2055 ITER(J,ITER)=ITER(J,ITER)+DALY(J,I)  OUTPUT3330
   DO 2056 J=1,4                            OUTPUT3340
2056 ITER(J,ITER)=ITER(J,ITER)/TOT*100.0  OUTPUT3350
   DO 2058 J=5,8                            OUTPUT3360
   DO 2057 I=1,NOMAX                        OUTPUT3370
2057 ITER(J,ITER)=ITER(J,ITER)+DALY(J,I)  OUTPUT3380
2058 ITER(J,ITER)=ITER(J,ITER)/FD          OUTPUT3390
   DO 2061 I=1,10                          OUTPUT3400
   JITER(I,ITER) = KONC(I)/KON(I) *100.0  OUTPUT3410
   ZITER = KONC(I)                          OUTPUT3420
   JITER(I*10,ITER) = ZITER /KON(I) *100.0 OUTPUT3430
2061 CONTINUE                                OUTPUT3440
   DO 2060 J=12,19                          OUTPUT3450
   DO 2059 I=1,NOMAX                        OUTPUT3460
2059 ITER(J,ITER)=ITER(J,ITER)+DALY(J,I)  OUTPUT3470
2060 ITER(J,ITER)=ITER(J,ITER)/FD          OUTPUT3480
   WRITE(6,9031) (ITER(I,ITER),I=1,8), (ITER(I,ITER),I=12,19)  OUTPUT3490
9031 FORMAT(14H /5X,22H---PERCENT OF TOTAL---4X,1AVERAGE PER DAY PER MA
1N,49X,1AVERAGE PER DAY, /
2 5X,3F9.1,F7.1,4F7.2,24X, 2F8.2,F6.3,F6.2,F6.2,F5.2,2F6.2,/)  OUTPUT3520
   DO 3010 J=1,NOMAX                        OUTPUT3530
   DO 3035 I=1,10                          OUTPUT3540
   IPERCT(I)=ADALY(I,J)*.5                 OUTPUT3550
3035 CONTINUE                                OUTPUT3560
   WRITE(6,3040) (IPERCT(I),I=1,10)        OUTPUT3570
3040 FORMAT(24H CONS. BAL. (UNITS/HR) 1017)
3010 CONTINUE                                OUTPUT3590
   DO 3015 I=1,10
   IPERCT(I)=JITER(I,ITER)*.5
3015 CONTINUE
   WRITE(6,93050) (IPERCT(I),I=1,10)
93050 FORMAT(24H PERCENT OF ORIGINAL ,1017)                                OUTPUT3640

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DO 3020 J=1,NDMAX	OUTP3650
WRITE (6,3030) (IDALY(1,J),I=1,10)	OUTP3660
3030 FORMAT(24H CONS, BAL. (UNITS) 1017)	OUTP3670
3020 CONTINUE	OUTP3680
DO 3025 I=1,10	OUTP3690
IPERCT(I)=JITER(I+10,ITER)+.5	OUTP3700
3025 CONTINUE	OUTP3710
WRITE(6,9030) (IPERCT(I),I=1,10)	OUTP3720
WRITE(6,9031)	OUTP3730
90315 FORMAT(//9X,'-----NUMBER OF EVENTS----- AVE. MAN HOURS SPENT ',	
1 'REPAIR MAX, MAX, PFRF, '11X,'AVE,FL NUMBER UNMANNED'	
2, ' SEAT/4X,'DAY SCHLD REPAIR ERER REPEAT REPAIR SUC2 EMERGENCY'	OUTP3760
3, ' TIME STRESS MEN LD EFF; HAZARD DIFF SUCC,1.5X,	OUTP3770
4 'HOURS STATE'//)	OUTP3780
DO 2062 J=1,NDMAX	OUTP3790
DO 3050 I=1,3	OUTP3800
IPERCT(I)=DALY(I+10,J)+.5	OUTP3810
3050 CONTINUE	OUTP3820
IPERCT(4)=DALY(30,J)	OUTP3830
C C WRITE(6,90316) J,NOSE,(DALY(1,J),I=20,23),RSSUC2,DALY(24,J),	OUTP3840
C 1 REPTH,(DALY(1,J),I=25,32)	OUTP3850
WRITE(6,90316) J,NOSE,(IPERCT(I),I=1,3),DALY(23,J),	OUTP3860
1 RSSUC2,DALY(24,J),REPTH,(DALY(1,J),I=25,29),	OUTP3870
2 IPERCT(4),(DALY(1,J),I=31,32)	OUTP3880
DO 2062 I=20,32	OUTP3890
2062 IITER(1,ITER) = IITER(1,ITER)+DALY(1,J)	OUTP3900
90316 FORMAT(4X,13,3X,13,15,2X,15,1X,15,5X,F4,1, F6,2,1X,F4,1,6X,	OUTP3910
1F6,2,4X,F4,2,3X,F5,2,3X,F5,3,3X,F6,2,2X,F5,2,3X, .14,6X,F6,2,F7,1)	OUTP3920
DO 2063 I=20,29	OUTP3930
-2063 IITER(1,ITER) = IITER(1,ITER)/FD	OUTP3940
IITER(32,ITER) = IITER(32,ITER)/FD	OUTP3950
IITER(31,ITER) = IITER(31,ITER)/FD	OUTP3960
90317 FORMAT(1H0, 'AVG/DAY',215,17,16,F9,1,	
1 F6,2,F5,1,F12,2,2F8,2,	
2 F8,3,F9,2,F7,2,17,F12,2,F7,1)	
DO 2068 I=1,3	OUTP4000
2068 CONTINUE	OUTP4010
IPERCT(I)=IITER(I+19,ITER)	OUTP4020
REPTH=REPTH/ND	OUTP4030
RSSUC2D=RSSUC2/ND	OUTP4040
RSTOT=RSTOT+RSSUC2D	
IPERCT(4)=IITER(30,ITER)	OUTP4050
WRITE(6,90317) NOSE,(IPERCT(I),I=1,3),IITER(23,ITER),RSSUC2D,	OUTP4060
1 IITER(24,ITER),REPTH,(IITER(1,ITER),I=25,29),IPERCT(4),	OUTP4070
2 (IITER(1,ITER),I=31,32)	OUTP4080
WRITE(6,9034)	OUTP4090
9034 FORMAT(/// 30H0AVERAGES BY TYPE OF PERSONNEL//)	OUTP4100
WRITE(6,9032)	OUTP4110
9032 FORMAT(127H0NO. TYPE PHYSICAL HOURS WORKED SLEPT INLE FA	
1TIGUE HEALTH AVG PHYS COMPETENCE ASPIRATION PERFORM	
2 NUMBER,714X,4HCAP,4X,12HPRIM; 2ND,25X,5HINDEX,2X,	

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3	BMWORKLOAD,30X,4HCUM,,13X,5HSUCC,)	
DO 2065	I=1,NDMAX	OUTP4160
DO 2065	J=1,10	OUTP4170
	K=NTIPE(J)	OUTP4180
	IF(K,EQ,0) GO TO 2065	OUTP4190
9833	FORMAT(1H 12,16,F11,3,2F7,2,F7,1,F6,1,F9,2,F8,2,F10,2,F12,3,	OUTP4200
1	F12,2,10X,F9,2,F8,2)	OUTP4210
DO 2064	KK=1,12	OUTP4220
2064	YIITER(KK,J,ITER)=YIITER(KK,J,ITER)+TDALY(KK,J,1)	OUTP4230
2065	CONTINUE	OUTP4240
DO 2067	J=1,10	OUTP4250
	K=NTIPE(J)	OUTP4260
	IF(K,EQ,0) GO TO 2067	OUTP4270
DO 2066	I=1,11	OUTP4280
2066	YIITER(I,J,ITER)=YIITER(I,J,ITER)/FD	OUTP4290
	WRITE(6,9991)K,J,(YIITER(I,J,ITER),I=1,12)	OUTP4300
9991	FORMAT(14,15,F11,3,F10,3,2F7,2,F7,1,F6,1,F9,2,F8,2,F10,2,F12,3,	
1	F12,2,10X,F9,2)	
2067	CONTINUE	OUTP4330
2070	CONTINUE	OUTP4340
	T3(1)=CUT1/(CUT1+CUT2)	OUTP4350
	T3(2)=CART1/FLOAT(NRE1)	OUTP4360
	REMYB=REMYR + T3(1)	OUTP4370
	REMYN=REMYR + T3(2)	OUTP4380
	IF(IND(7),EQ,0) RETURN	OUTP4390
	WRITE(6,9275)	OUTP4400
9275	FORMAT(30HOAVERAGES PER DAY FOR EACH MAN/)	OUTP4410
DO 2072	I=1,12	OUTP4420
2072	OUTA(I)=0,0	OUTP4430
DO 2080	I=1,10	OUTP4440
DO 2075	J=1,12	OUTP4450
	INTAB(J,I,ITER) = INTAB(J,I,ITER)/FD	OUTP4460
2075	OUTA(J)=OUTA(J)+INTAB(J,I,ITER)	OUTP4470
2080	WRITE(6,9991) I,IPS(I),(INTAB(J,I,ITER),J=1,12)	OUTP4480
DO 2082	I=1,12	OUTP4490
2082	OUTA(I)=OUTA(I)/FLTC	OUTP4500
	WRITE(6,9996) (OUTA(I),I=1,12)	OUTP4510
9996	FORMAT(10HOAVERAGES	OUTP4520
1	2F10,3,2F7,2,F7,1,F6,1,F9,2,F8,2,F10,2,F12,3,F12,2,10X,F9,2)	
C	WRITE(6,9997) T3(1), T3(2)	OUTP4550
C9997	FORMAT(//1HO, 'EQUIPMENT MEAN TIME BETWEEN FAILURES ',F8,3,	OUTP4560
C	1 'EQUIPMENT MEAN TIME TO REPAIR',F8,3)	OUTP4570
	AVACA=0,	
	AVACD=0,	
	AVACU=0,	
	AVAEP=0,	
	AVDEP=0,	
DO 2095	I=1,NDMAX	
	AVACA=ACART(I)/NDMAX+AVACA	
	AVACD=ACDT(I)/NDMAX+AVACD	
	AVACU=ACUT(I)/NDMAX+AVACU	

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AVAEP=AEPL(1)/NDMAX+AVAEP
AVDEP=DEPEFF(1)/NDMAX+AVDEP
2085 CONTINUE
WRITE(6,2159)
DO 2084 I=1,40
IF( CLSDT(1,1),LE. 0.0) GO TO 2084
DO 2083 J=2,9
2083 CLSDT(J,1)= CLSDT(J,1) / CLSDT(1,1)
DO 2090 IFM=1,4
IPERCT(IFM)=CLSDT(IFM+1,1)*100./5
2090 CONTINUE
WRITE(6,2160) I,CLSDT(1,1),CLSDT(6,1),CLSDT(9,1),
1 (IPERCT(IFM),IFM=1,4),CLSDT(6,1),CLSDT(9,1)
2084 CONTINUE
WRITE(6,9800)ITER, (1,ACARY(1),ACDY(1),ACUY(1),AEPL(1),DEPEFF(1),
1 I=1,NDAYS)
C 1 DENTBF(1),DENTTR(1),I=1,NDAYS)
9800 FORMAT(1H,7777,EQUIPMENT PERFORMANCE FOR ITERATION',I3,77,
1 'DAY AVG, REPAIR TIME/EQUIP UP PERFORMANCE',/,
2 7X,'EXPECTED ACTUAL',6X,'TIME LEVEL EFFIC',/
3 (12,2F11.2,F10.2,F9.2,F8.2))
WRITE(6,9805) AVACA,AVACD,AVACU,AVAEP,AVDEP
9805 FORMAT(1H,77,AVG,1, F9.2,F11.2,F10.2,F9.2,F8.2)
RETURN
ENTNY OUTP4
FLITER=ITER
WRITE(6,9555) ITER,NDMAX
9555 FORMAT(16H1RUN SUMMARY FOR 13,14H ITERATIONS OF 13,12H-DAY MISSION/OUTP4730
1 127H ITER NUMBER OF EVNTS AVE, MAN HOURS SPENT
-----END OF DAY AVERAGES----- INDICES
2/5X,125H SUC1 SUC2 FAIL IGNORE PRIM, SECOND SLEEP IDLE
3 PHYS LD MEN LD COMP APA FAT, ASP MLTH SFTOUTP4750
47/5X,22H---PERCENT OF TOTAL---6X,15HAVERAGE PER DAY7X,
5 24H 18X,15HAVERAGE PER DAY)
DO 2105 J=1,32
2105 OUTA(J)=0
DO 2110 I=1,ITER
WRITE(6,9556) I,(ITER(J,1),J=1,8),(ITER(J,1),J=12,19)
9556 FORMAT(14,1X,3F9.1,F7.1,4F7.2,24X, 2F8.2,F6.3,F6.2,FA,2,F5.2,
12F6.2)
DO 2108 J=1,32
2108 OUTA(J)=OUTA(J)+ITER(J,1)
DO 2109 J=1,10
OUTB(J) = OUTB(J) + JITER(J,1)
OUTB(J+10) = OUTB(J+10) + JITER(J+10,1)
2109 CONTINUE
2110 CONTINUE
DO 2115 J=1,32
2115 OUTA(J)=OUTA(J)/FLITER
WRITE(6,9557) (OUTA(I),I=1,8),(OUTA(I),I=12,19)
9557 FORMAT (19H0AVERAGES/ITERATION)

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1      5X,3F5,1,      3F7,2,24X,  F8,2,F8,2,FA,3,F6,2,F6,2,F5,2,  OUTP4970
2 2F6,2)  OUTP4980
WRITE(6,3070) (I,I=1,10), (I,I=1,10), (I, (J,ITER(J,I),J=1,20),  OUTP4990
1 I=1,ITER)  OUTP5000
3070 FORMAT(// 'CONSUMABLES BALANCE - PERCENTAGE OF ORIGINAL',26X,  OUTP5010
1 ((UNITS PER HOUR),49X, '(UNITS)',//ITER,1X,10I6,4X,10I6,/,
2 (13,3X,10F6,1,4X,10F6,1))
DO 3075 I=1,20  OUTP5040
OUTB(I)=OUTB(I)/ITER  OUTP5050
3075 CONTINUE  OUTP5060
WRITE(6,3080) (OUTB(I),I=1,20)  OUTP5070
3080 FORMAT(1H,/, 'AVG.', 10F6,1,4X,10F6,1)
WRITE(6,9115)  OUTP5090
9115 FORMAT (//131H ITER NUMBER OF EVENTS AVE. MAN HOURS SPENT  OUTP5100
1AX STRESS MAX MEN LD PERF EFF HAZARD AVE FAIL NUMBR UN
2MANNED SEA / 8X,40HREPAIR EMER REPT REPAIR EMERGENCY,32X,
3 'DIFF',5X, 'SUCC' HOURS STATE')
DO 9116 I=1,ITER  OUTP5140
DO 9117 J=1,3  OUTP5150
IPERCY(I,J)=ITER(I,J+19,1)  OUTP5160
9117 CONTINUE  OUTP5170
IPERCY(4)=ITER(30,1)  OUTP5180
WRITE(6,90416) I, (IPERCY(J),J=1,3), (ITER(J,I),J=23,29),  OUTP5190
1 IPERCY(4), (ITER(J,I),J=31,32)  OUTP5200
9116 CONTINUE  OUTP5210
90416 FORMAT(15,1X,18,1X,16,17, 1X,F7,1,1X,F8,1,7X,F8,2,4X,F8,2,4X,  OUTP5220
1F8,3,F8,3,4X,F8,3,1X, 18,2X,FA,3,F7,1)  OUTP5230
WRITE(6,90318) (OUTA(I),I=20,32)  OUTP5240
90318 FORMAT(1H0, 'AVERAGES/ITERATION/DAY',/,  OUTP5250
1 8X,4F7,1,FV,1,F15,2,F12,2,F12,3,F7,2,F13,3,F10,2,F8,2,F8,1)
DO 2120 I=1,11  OUTP5270
DO 2120 J=1,10  OUTP5280
2120 TOUTA(I,J) = 0.0  OUTP5290
9120 FORMAT(//30H0AVERAGES BY TYPE OF PERSONNEL/)  OUTP5300
WRITE(6,9120)  OUTP5310
WRITE(6,955H)  OUTP5320
955H FORMAT ( 125H0 TYPE PHYSICAL HOURS WORKED SLEPT IDLE FA  OUTP5330
1TIGUE HEALTH AVG PHYS COMPETENCE ASPIRATION PERFORM  OUTP5340
2 /14X ,4HCAP,4X,12HPRIN, 5ND,25X,5IINDEX,2X,  OUTP5350
3 8HWORKLOAD,30X,4HCUM,)  OUTP5360
DO 2125 I=1,ITER  OUTP5370
DO 2124 J=1,10  OUTP5380
IF(NTYPE(J),EQ,0) GO TO 2124  OUTP5390
DO 2123 K=1,11  OUTP5400
2123 TOUTA(K,J)=TOUTA(K,J)+ITER(K,J,I)  OUTP5410
2124 CONTINUE  OUTP5420
2125 CONTINUE  OUTP5430
OUTP5440
DO 2140 J=1,10  OUTP5450
IF(NTYPE(J),EQ, 0) GO TO 2140  OUTP5460
DO 2130 I=1,11  OUTP5470

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2130 TOUTA(1,J) = TOUTA(1,J)/FLITER                                OUTP5480
      WRITE(6,9993) J,(TOUTA(1,J),I=1,11)                        OUTP5490
9993 FORMAT(5X,15, F10,3,2F7,2,F7,1,F6,1,F9,2,F8,2,F10,2,F12,3,F12,2, OUTP5500
      1 F9,2,F8,2)                                                OUTP5510
2140 CONTINUE                                                        OUTP5520
      WRITE(6,2139)                                                OUTP5530
      DO 2144 I=1,40                                                OUTP5540
      IF(CLSDTR(1,I),LE,0.0) GO TO 2144                            OUTP5550
      DO 2143 J=2,9                                                OUTP5560
2143 CLSDTR(J,I) = CLSDTR(J,I) / CLSDTR(1,I)                      OUTP5570
      DO 4150 IFM=1,4                                                OUTP5580
      IPERCY(IFM)=CLSDTR(IFM+1,I)*100.+5                          OUTP5590
4150 CONTINUE                                                        OUTP5600
      CLSDTR(1,I)=CLSDTR(1,I)/ITER                                OUTP5610
      WRITE(6,2180) I,CLSDTR(1,I),CLSDTR(6,I),CLSDTR(7,I),      OUTP5620
      1 (IPERCY(IFM),IFM=1,4),CLSDTR(8,I),CLSDTR(9,I)          OUTP5630
2144 CONTINUE                                                        OUTP5640
C   T3(1) = OUYA(1)/(OUYA(1)+OUYA(2)+OUYA(3)) + (OUYA(5)+OUYA(6)) OUTP5650
C   T3(2) = OUYA(2)/(OUYA(5)+OUYA(6))                            OUTP5660
C   T3(3) = T3(1)/(T3(1) + T3(2))                                OUTP5670
C   T3(4) = REMTB                                                OUTP5680
C   T3(5) = REMTR                                                OUTP5690
C   T3(6) = T3(4)/(T3(4) + T3(5))                                OUTP5700
C   T3(7) = SQRT(8.5*(T3(3)+.02 + T3(6)+.2))                    OUTP5710
C   WRITE(6,9140) (T3(I),I=1,7)                                  OUTP5720
C9140 FORMAT(1H0,9HMTBF =,F8,3,9X,8HMTTR =,F8,3,              OUTP5730
      1 9X,9HMAVAIL =,F8,3/                                       OUTP5740
C   2 1X,9HMTBF =,F8,3,9X,8HMTTR =,F8,3,9X,8HMAVAIL =,F8,3/   OUTP5750
C   3 1X,9HMSYSAVAIL=,F8,3)                                       OUTP5760
C                                                                    OUTP5770
      SMTTR=(SCDT10+ RSTOT)/(ITER*NDAYS*(OUTA(20)+OUTA(2)/100.))
      EQUIPTR=1,-OUTA(20)/24.
      HMMNL=1,-(OUTA(2)+OUTA(3)+HMAVS/100.
      SYSRL=1,-NDAYS/24.+(OUTA(20)+OUTA(2)+OUTA(3))/100.)
      EQUIPTA=(24,-OUTA(23)/(OMAX)/(24.+NDAYS))                  OUTP5830
      HMAVS=1,-OUTA(31)+ITER/(IC*24.)                            OUTP5840
      SYSA=1,-(SCDT10/(24.+ITER*OMAX*NDAYS))
      1 +(OUTA(31)/(IC*24.+NDAYS))
      IF(OUTA(20),EQ,0.) GO TO 8280
      FMTBF=(OMAX*ITER*NDAYS+24,-SCDT10)/(OUTA(20)+ITER*NDAYS)  OUTP5860
      GO TO 8210
8280 FMTBF=0,
8210 CONTINUE
      MTTR= RSTOT/(OUTA(2)+ITER*NDAYS)
      MTTR=HMTTR/ITER
      WRITE(6,8111)
8111 FORMAT(1H0,2X,'SUMMARY OF MEASURES OVER ALL ITERATIONS'//,15X, OUTP5870
C   1- - - - - EQUIPMENT - - - - - HUMAN - OUTP5880
C   2- SYSTEM - - - - -',,2X,' RELIABILITY AVAILABILITY "OUTP5890
C   3TYR RELIABILITY AVAILABILITY MTBF MTTR RELIABILITY AVAILOUTP5900

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65686 01 09-27-76 14.083

4ABILITY HTTH')	OUTP5950
WRITE(6,8112) HMNRL, HMNAV, HMNTR, EQUIPTR, EQUIPTA,	OUTP5960
1 FEMTBF, EMNTR, SYSEL, SYSA, SMNTR	OUTP5970
8112 FORMAT (1X, 6X, 10X, F6, 3, 7X, F6, 3, 3X, F6, 2, 6X, F6, 3, 7X, F6, 3, 3X,	OUTP5980
1 F6, 1, 1X, F6, 1, 6X, F6, 3, 7X, F6, 3, 3X, F7, 2)	OUTP5990
WRITE(6,8113) RSTOT, SCDTIO	OUTP6000
8113 FORMAT(1H1, ' RSSUC2=', F8, 1, ' SCDTIO=', F8, 1)	OUTP6010
WRITE(6,8114) NDAYS, ITER, OUTA(23), OUTA(20), OUTA(31),	OUTP6020
1 OUTA(2), OUTA(3)	OUTP6030
8114 FORMAT(1H, ' NDAYS=', 13, 10X, ' ITER=', 13, 10X, ' A=', F6, 2,	OUTP6040
1 ' C=', F6, 2, ' D=', F6, 2, 10X, ' G=', F6, 2, 10X, ' H=', F6, 2)	OUTP6050
RETURN	OUTP6060
END	OUTP6070

C

APPENDIX C PROGRAM FLOWCHARTS

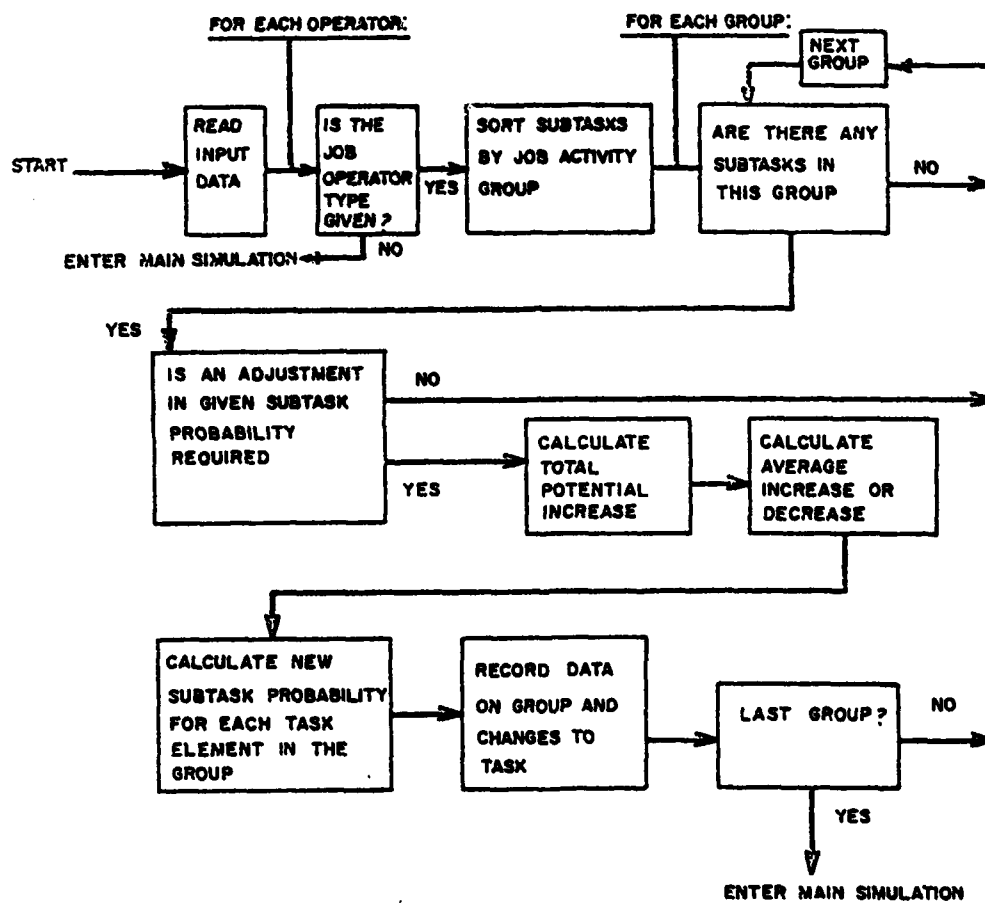
This appendix contains the program flowcharts for the digital simulation models as follows:

- Appendix C1 - 1-2 man digital simulation model
- Appendix C2 - 4-20 man digital simulation model

C

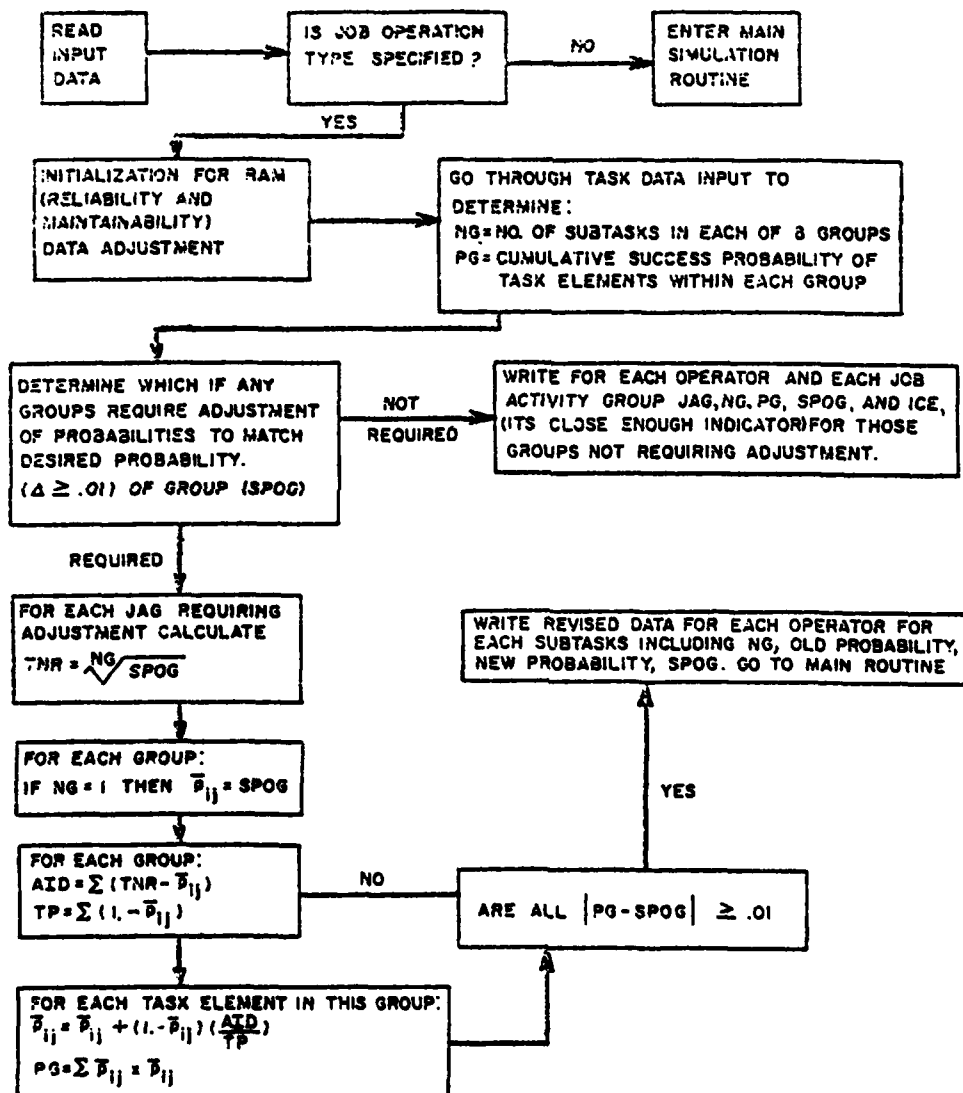
APPENDIX C1 - PROGRAM FLOWCHART

This appendix contains the flowchart for the digital simulation program.



Summary flow chart of preprocessor

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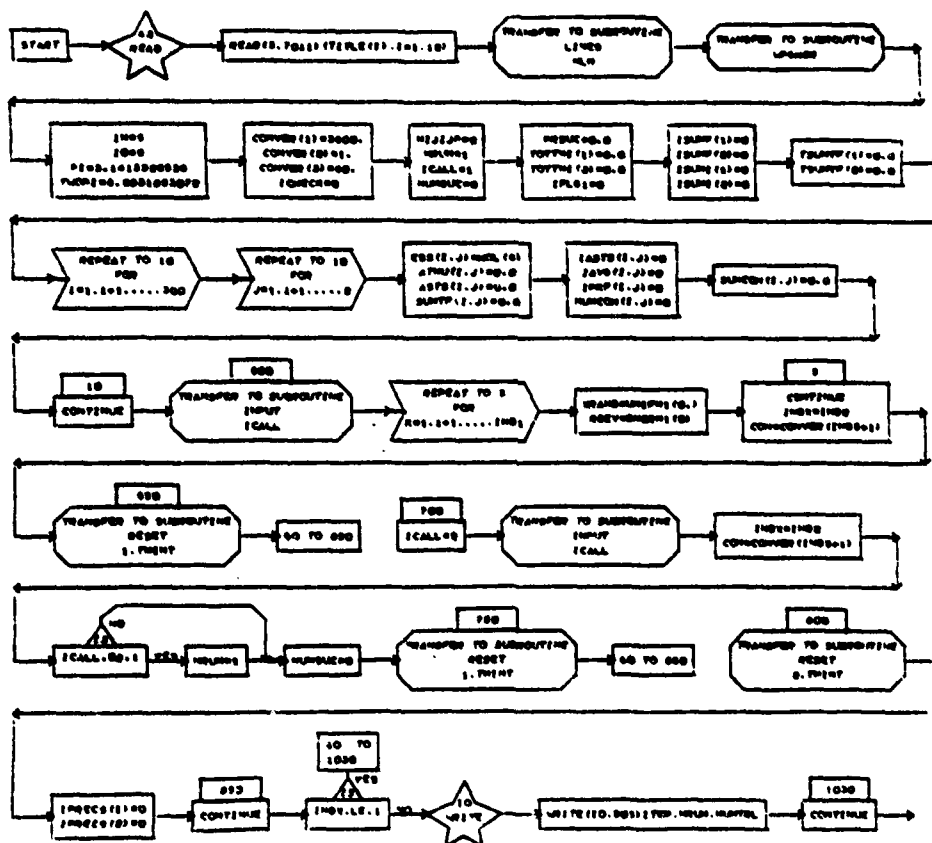


Basic programming elements for preprocessor

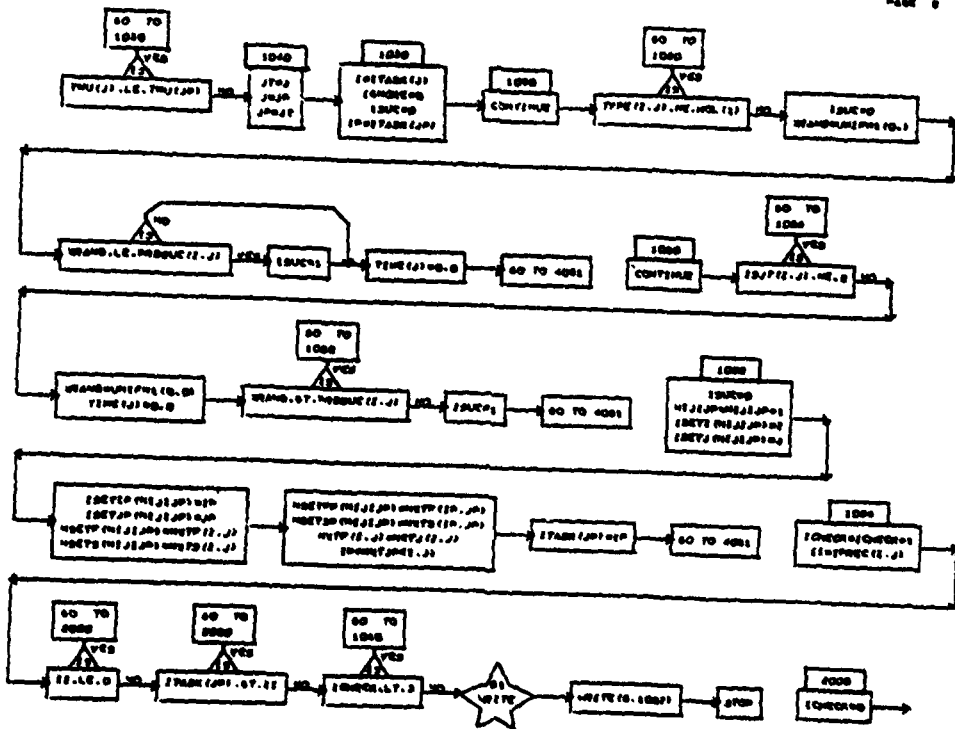
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Main Routine

Page 1

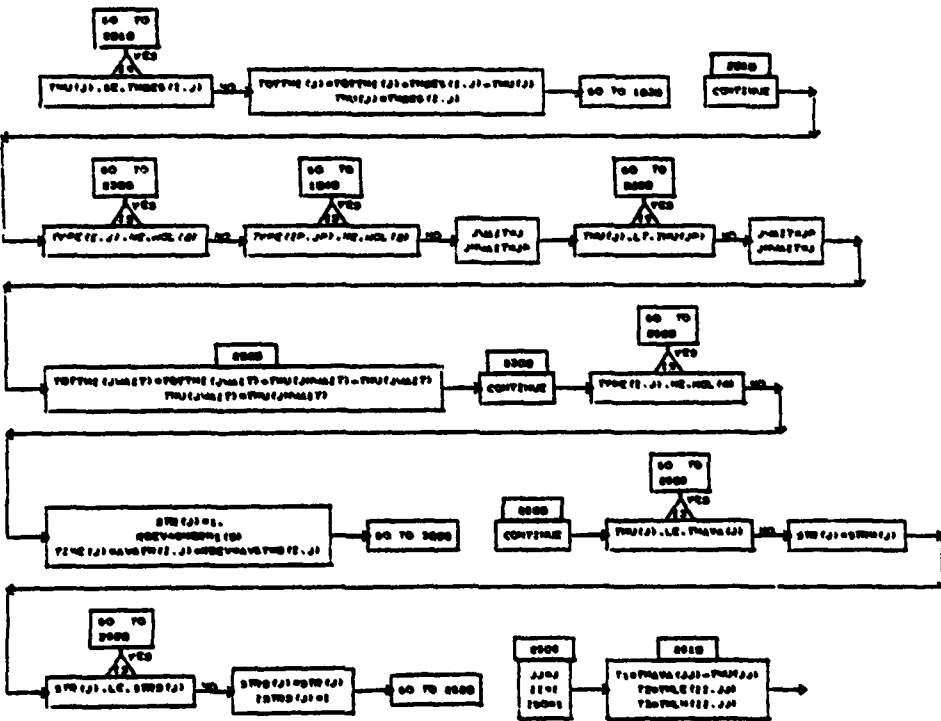


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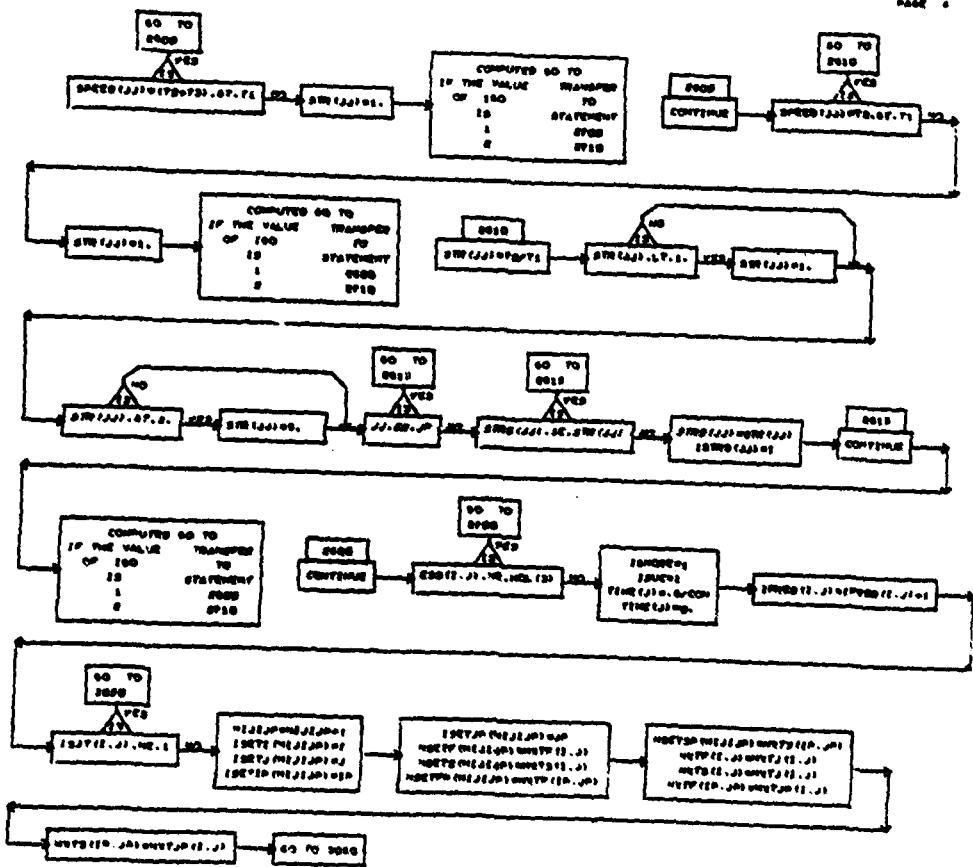


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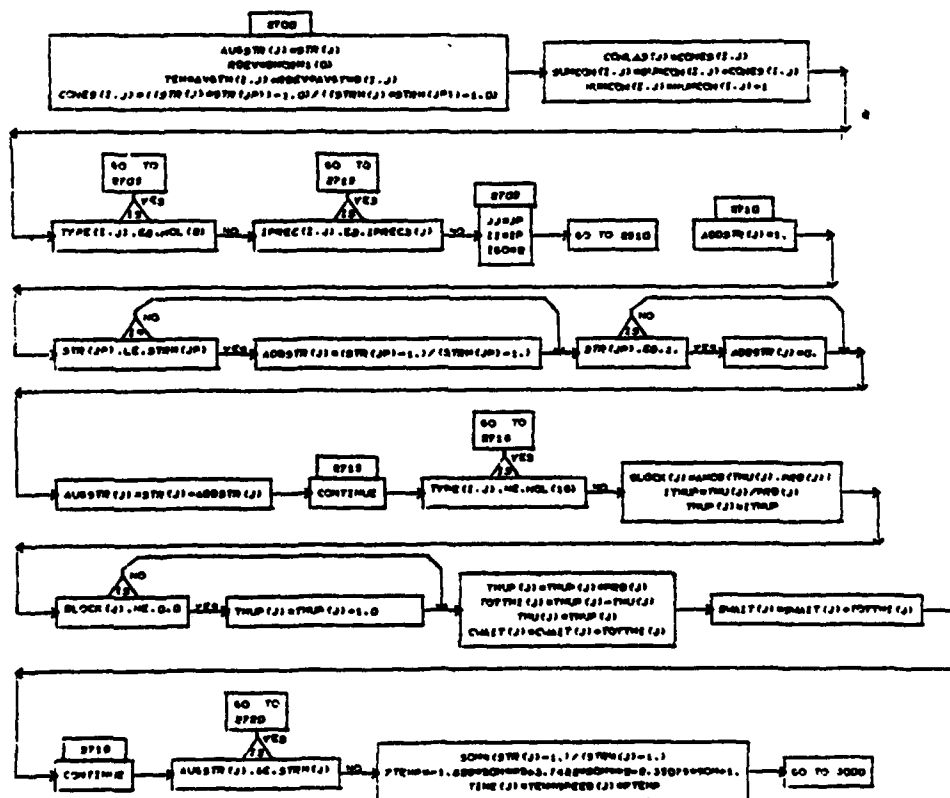


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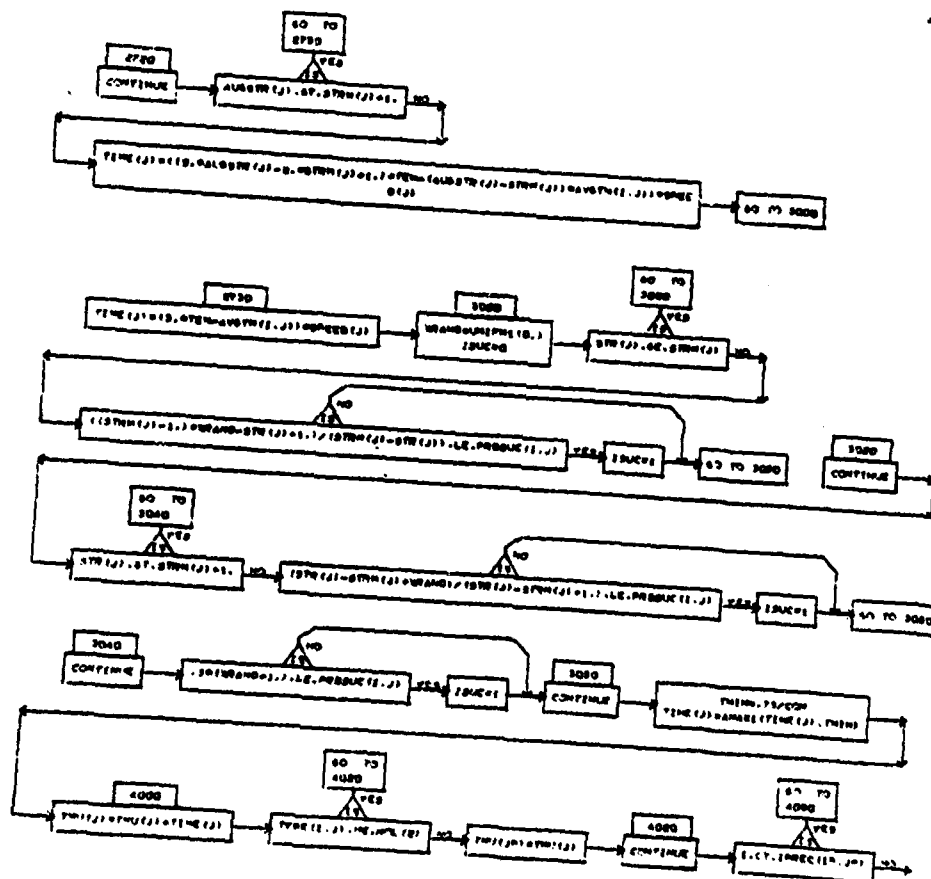


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PAGE 3

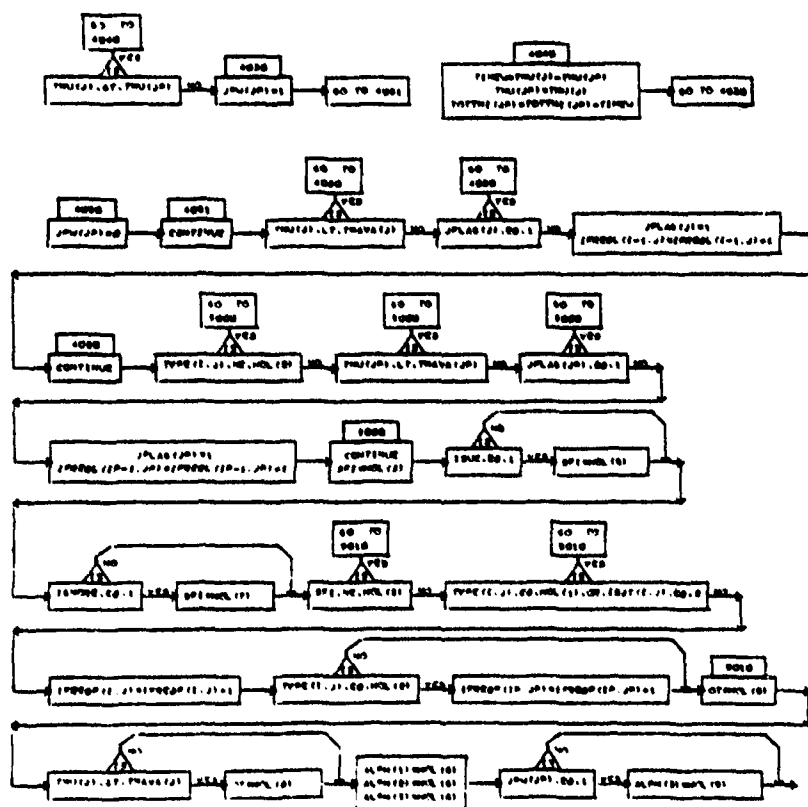


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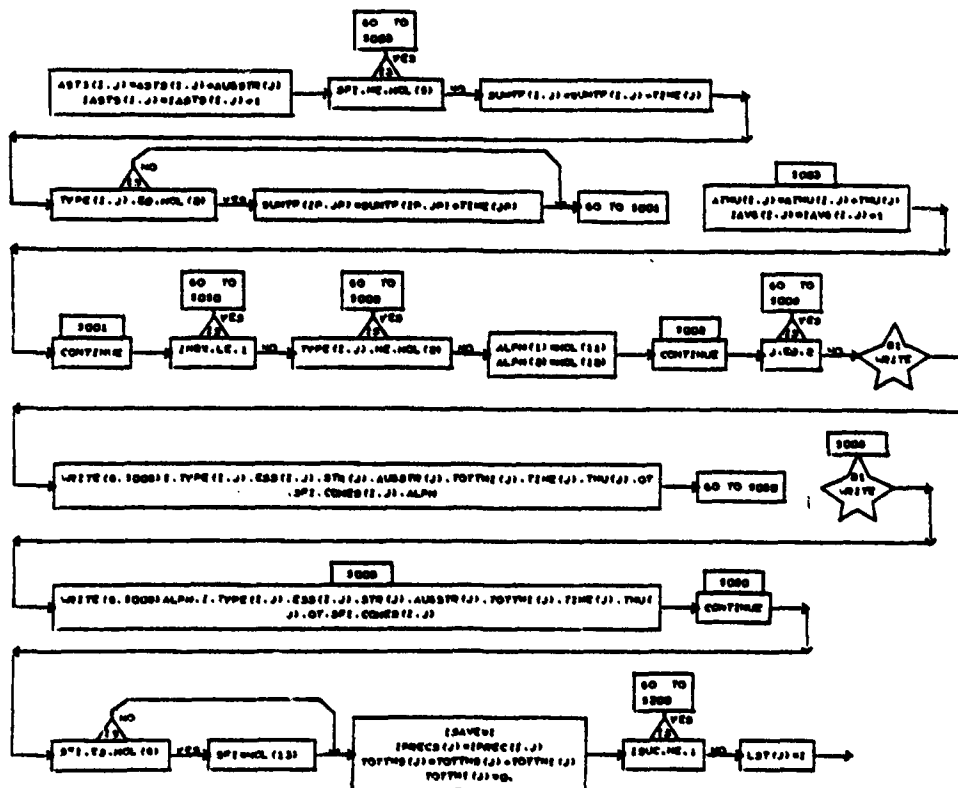
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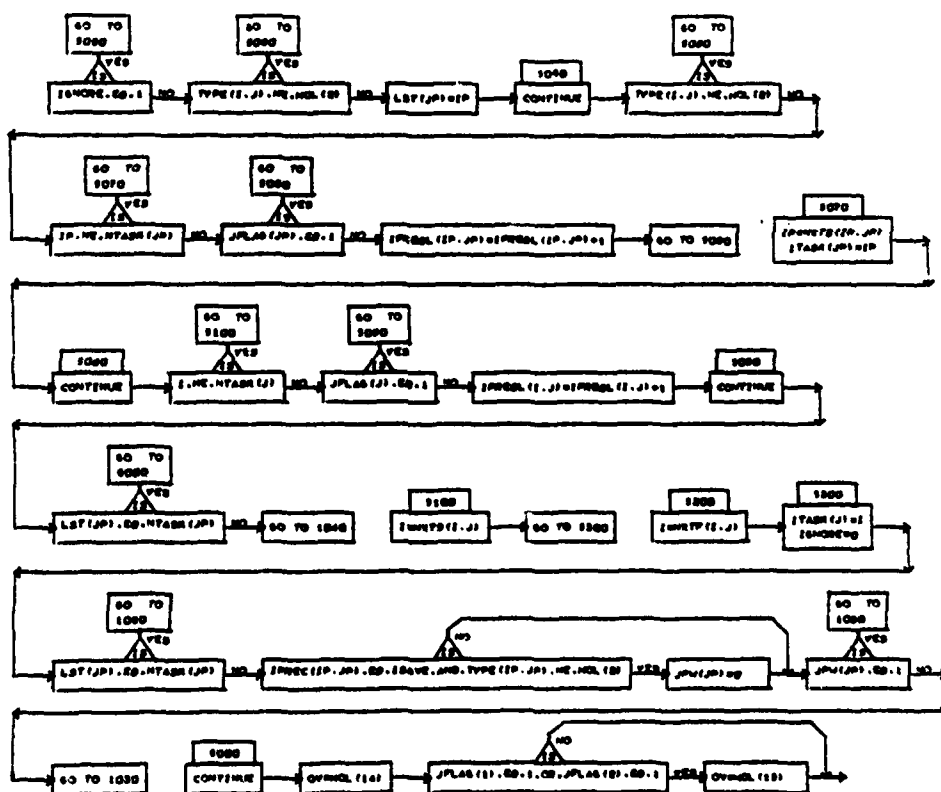


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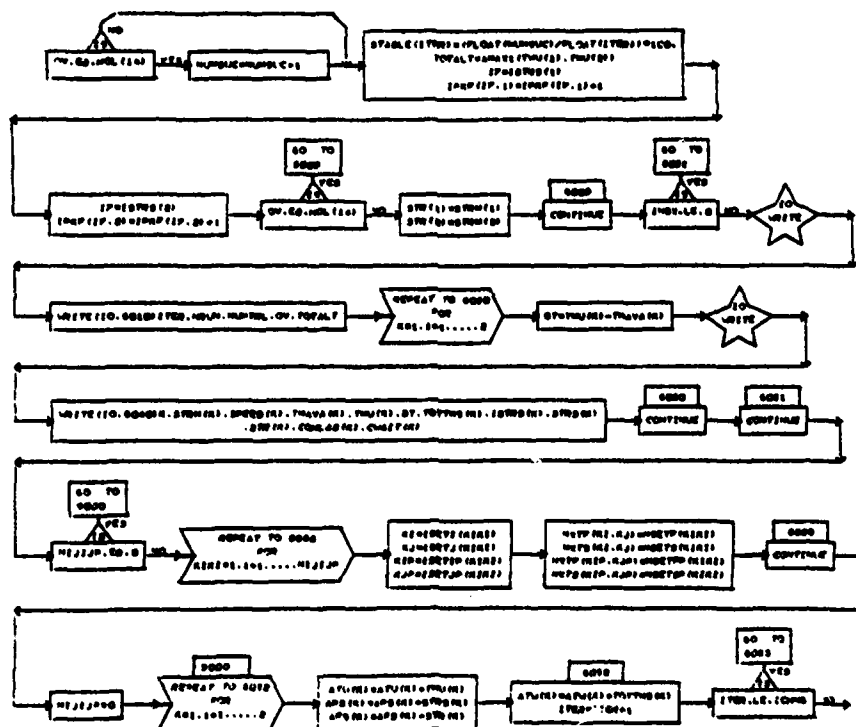


C-15



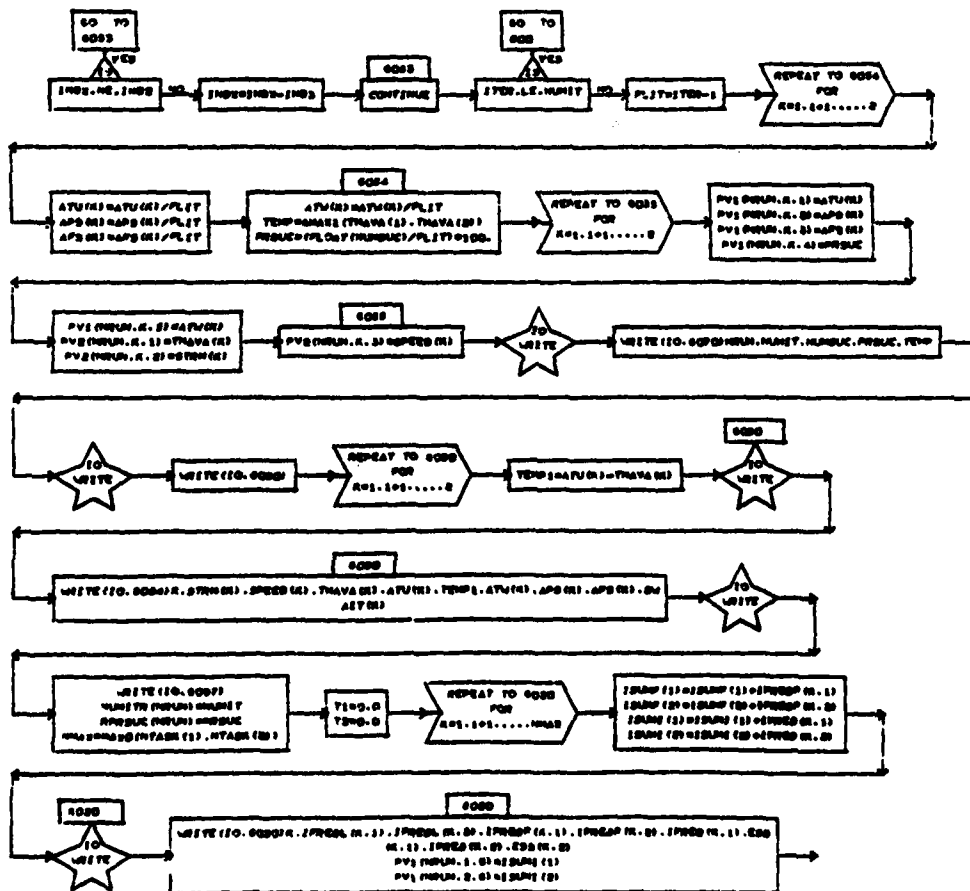
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PAGE 10



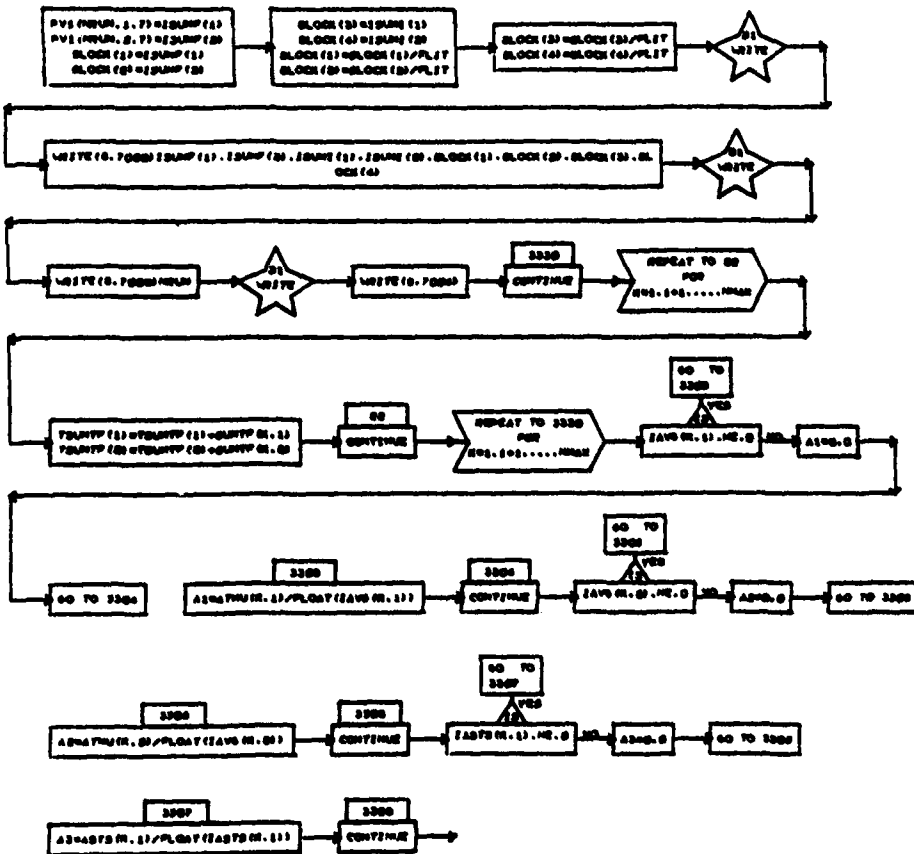
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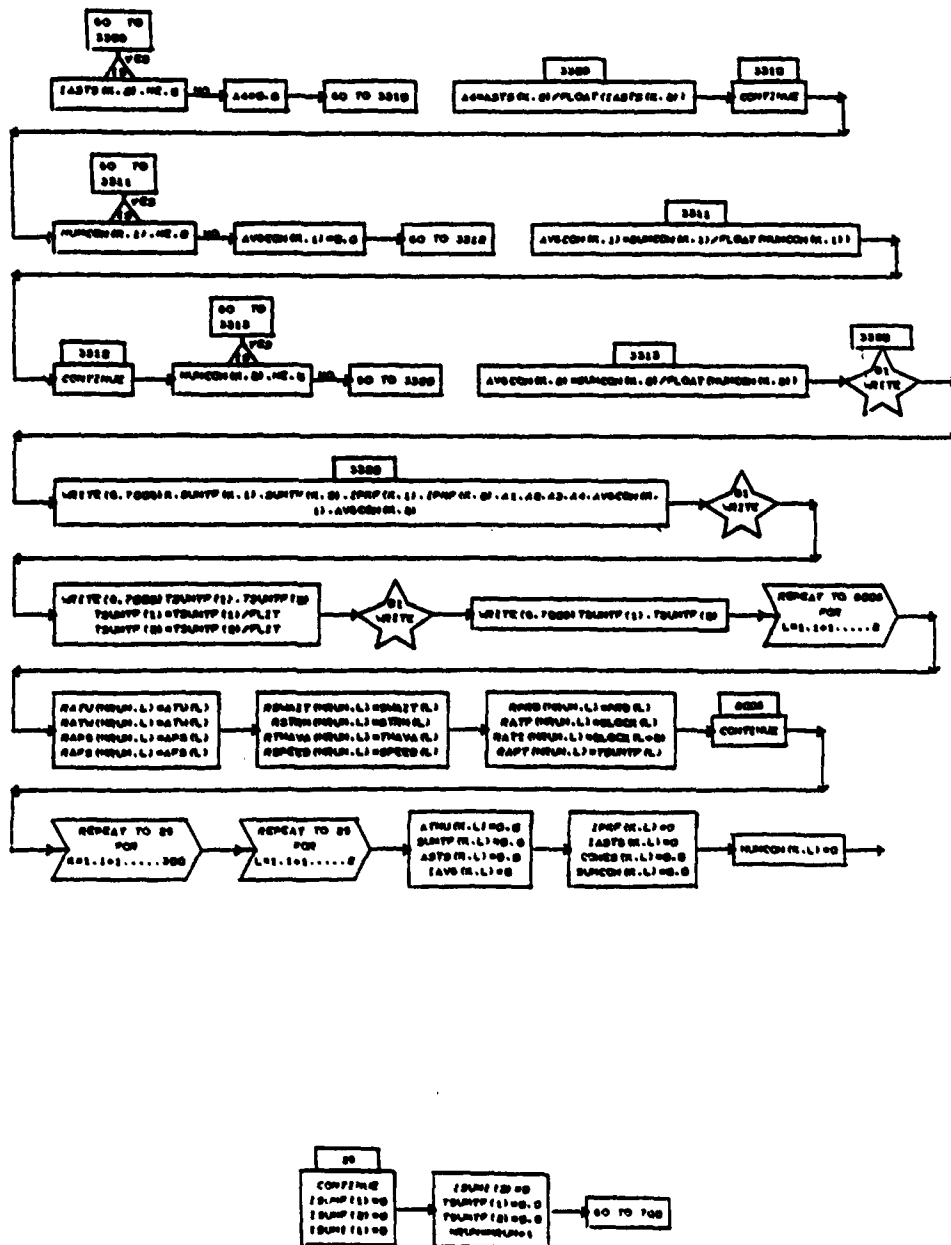
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PAGE 13

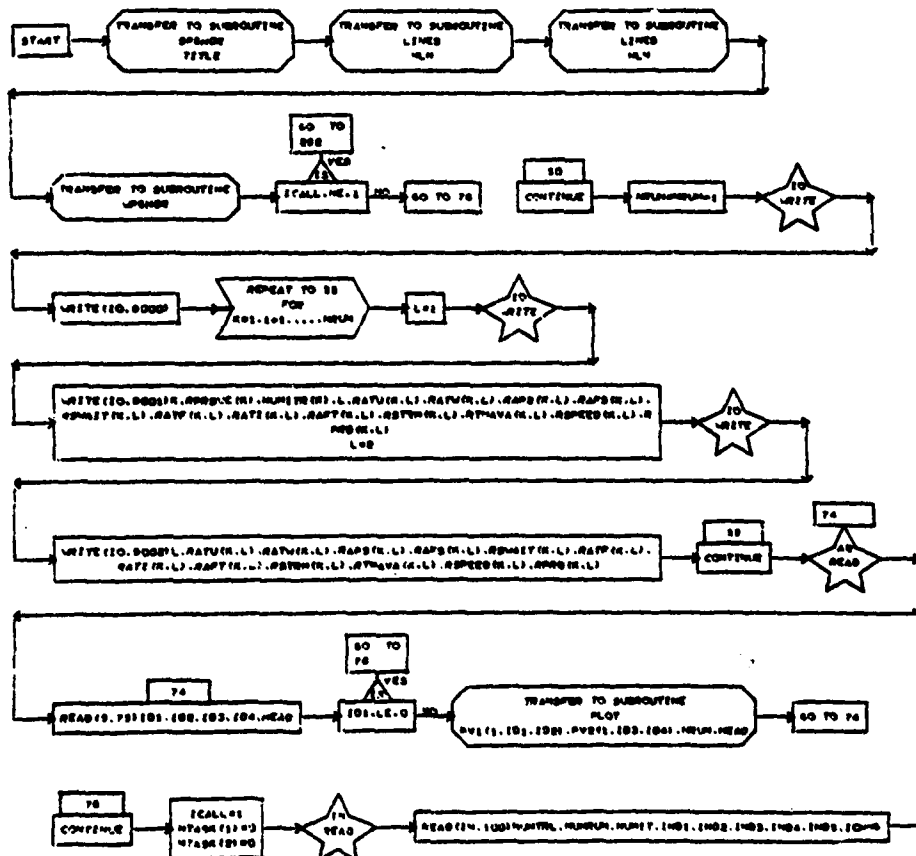




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SUBROUTINE INPUT (CALL)

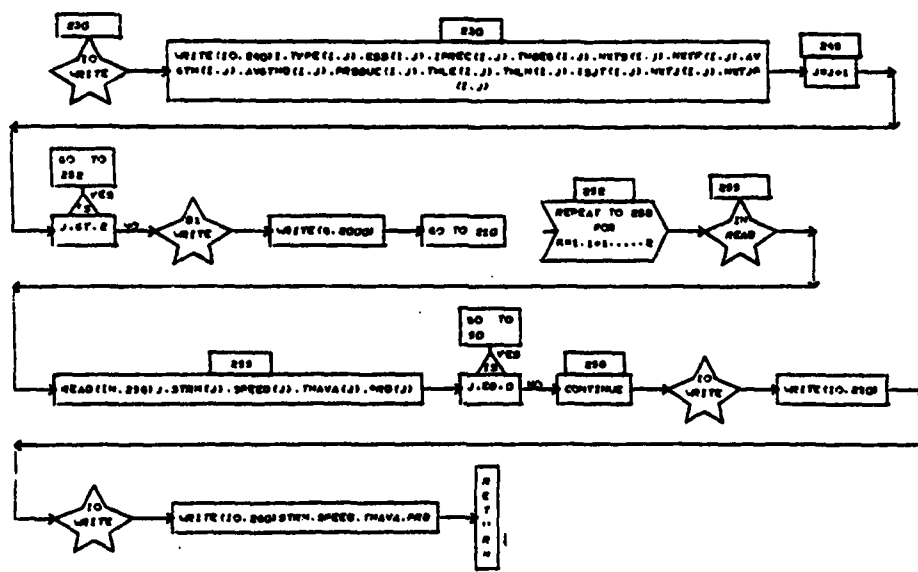
PAGE 1



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SUBROUTINE INPUT (CALL)

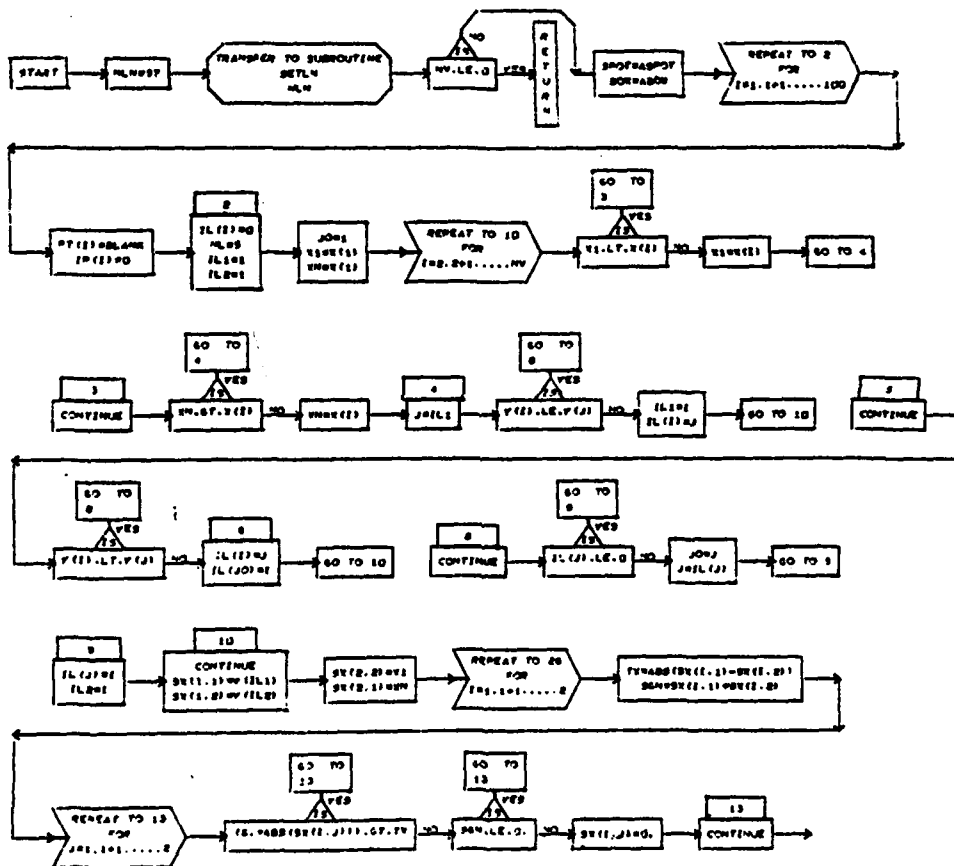
PAGE 3



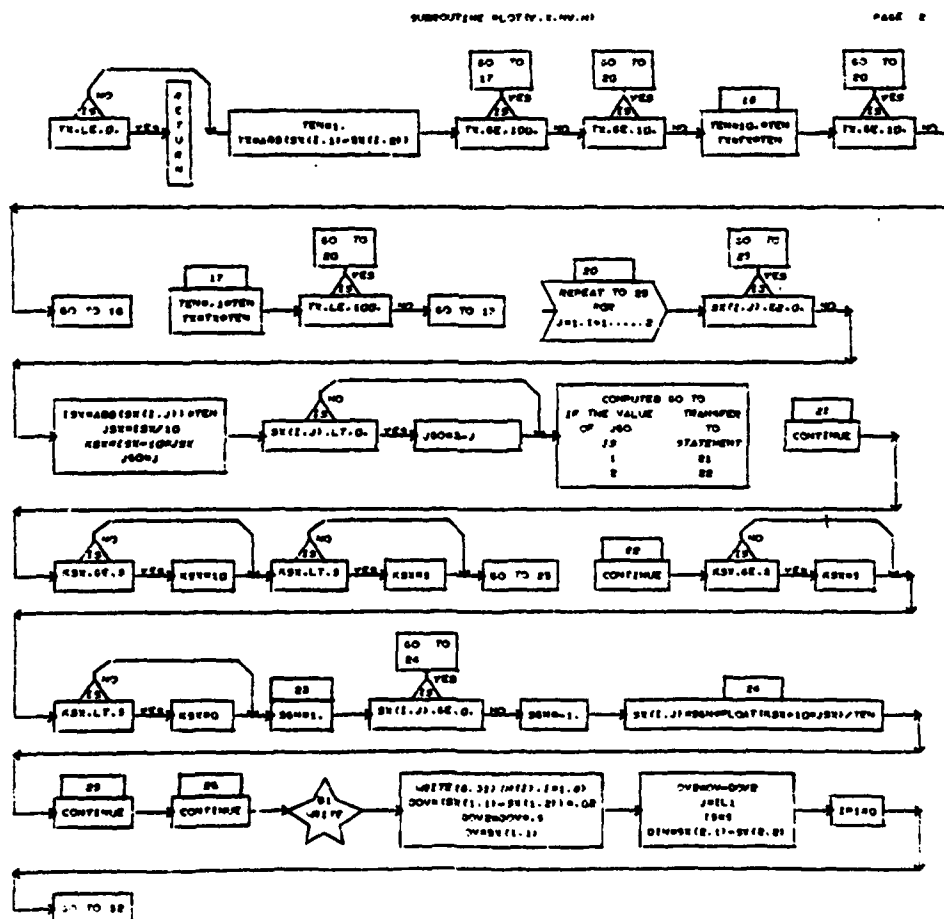
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SUBROUTINE PLOT OF R. E. H. H.

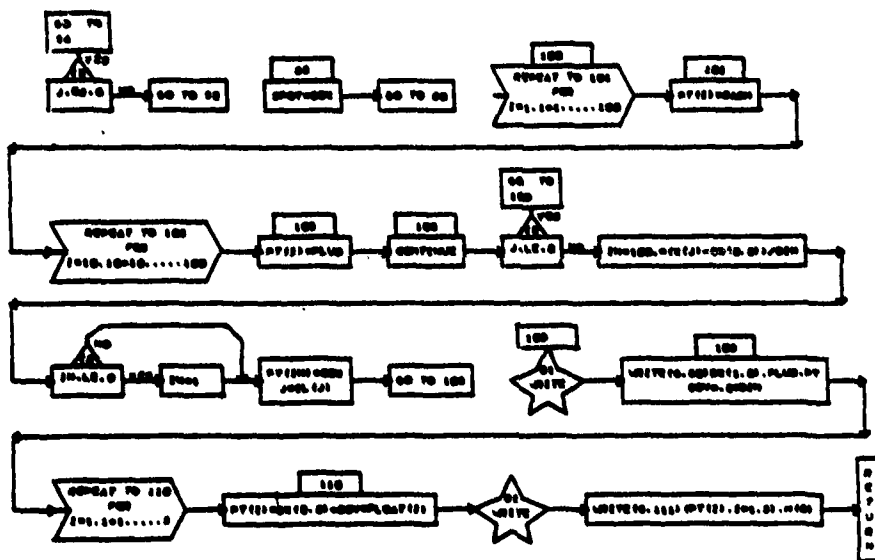
PAGE 1



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4



APPENDIX C2 - PROGRAM FLOWCHART

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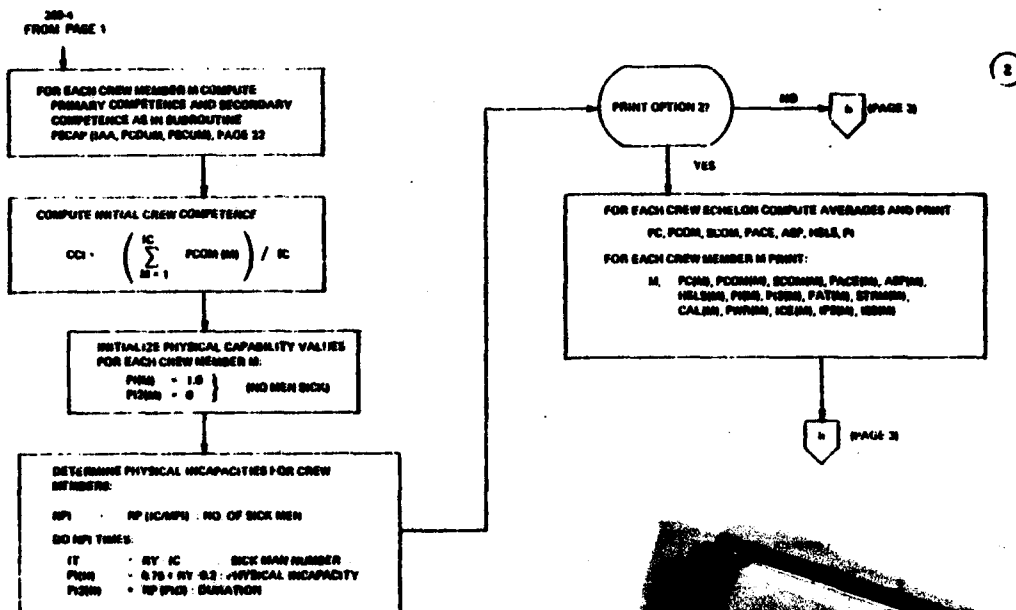
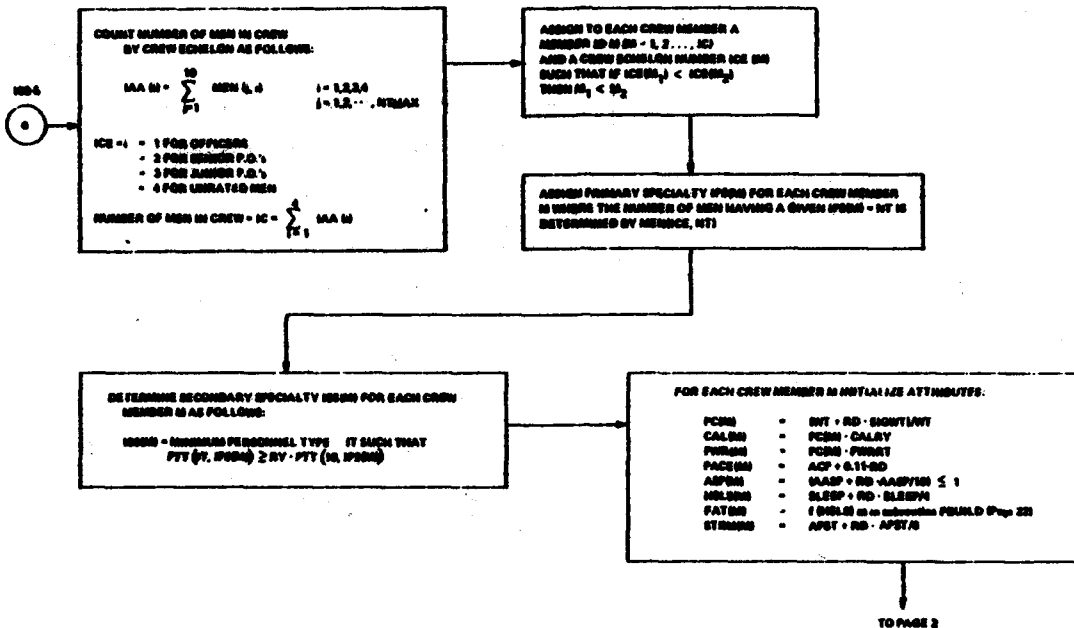
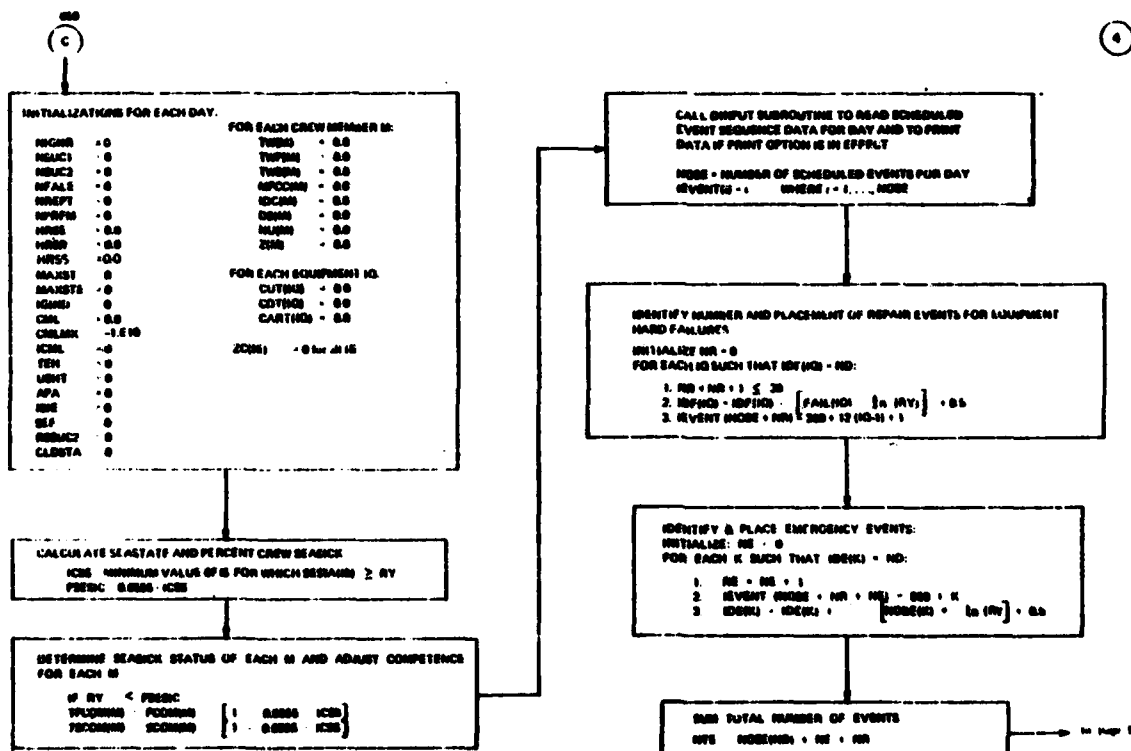
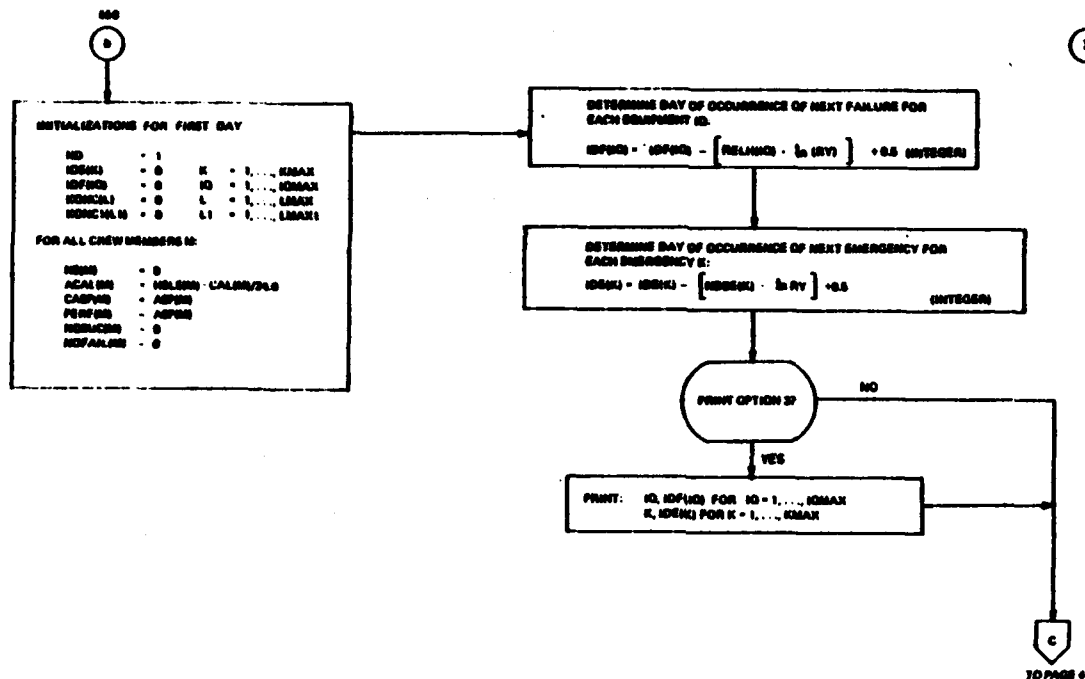
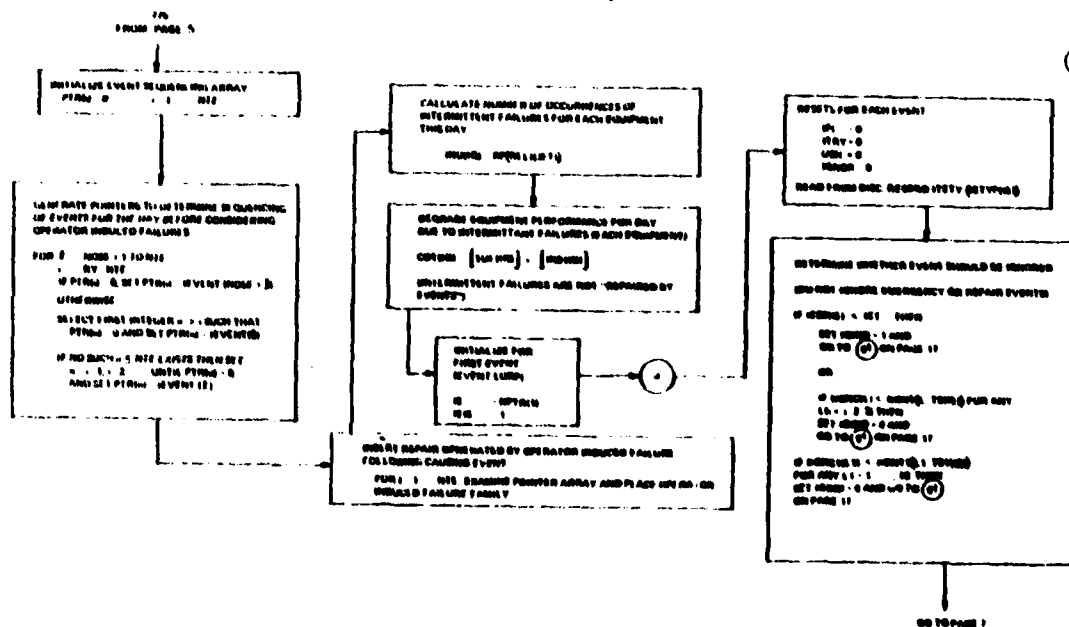
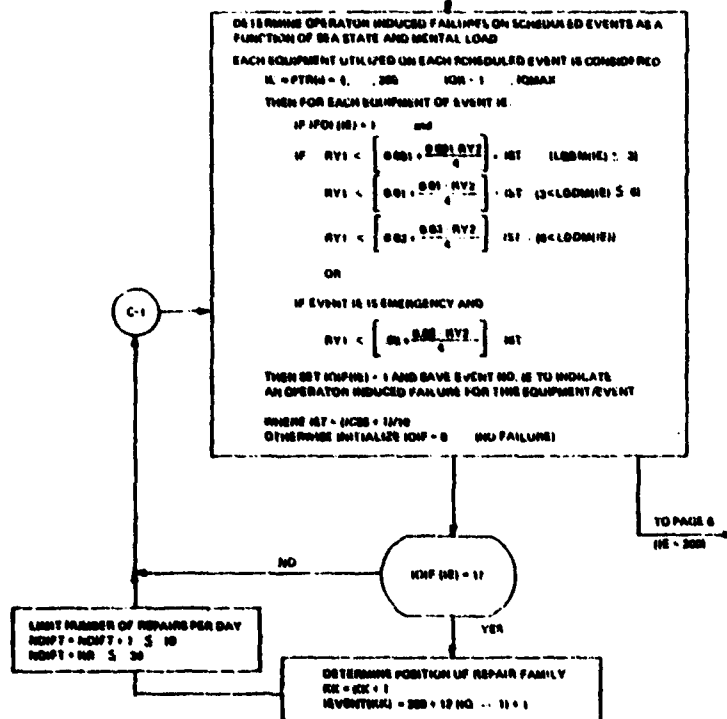


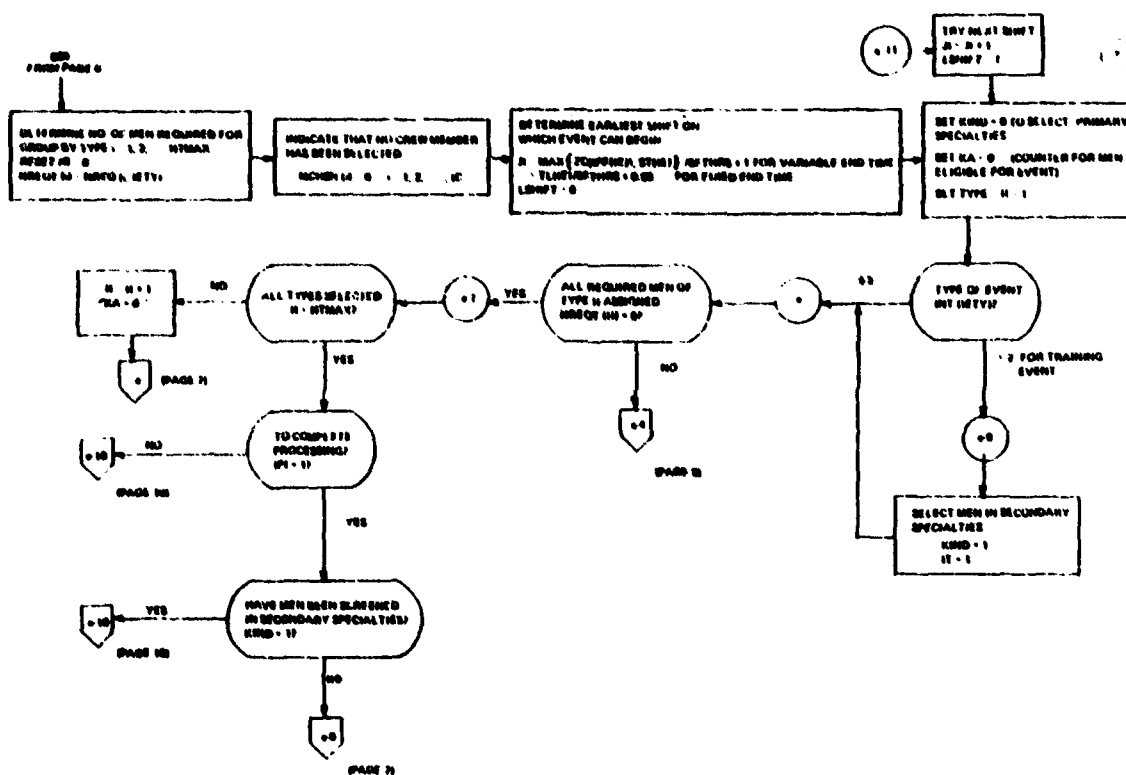
Figure 1



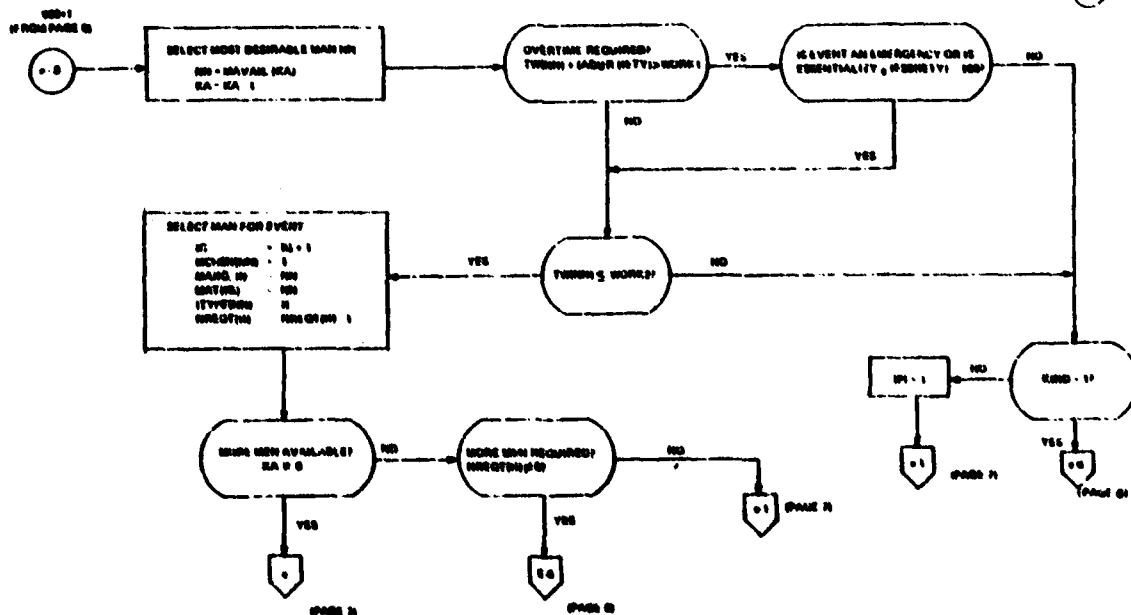
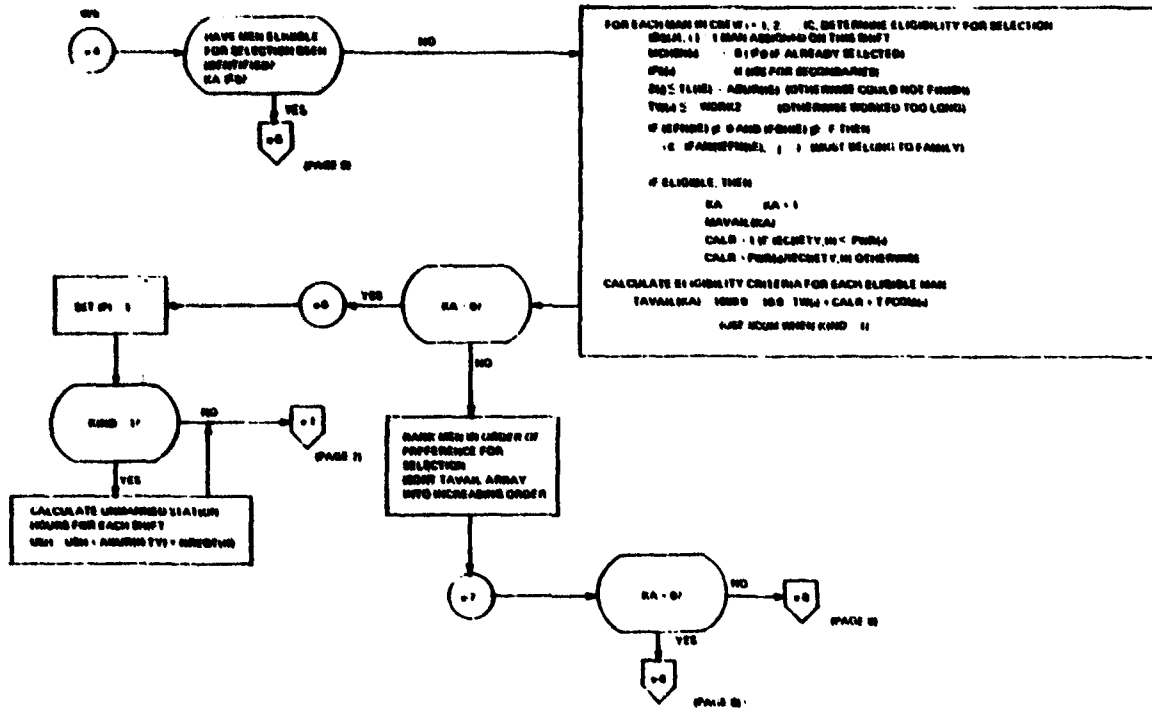
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FROM PAGE 4



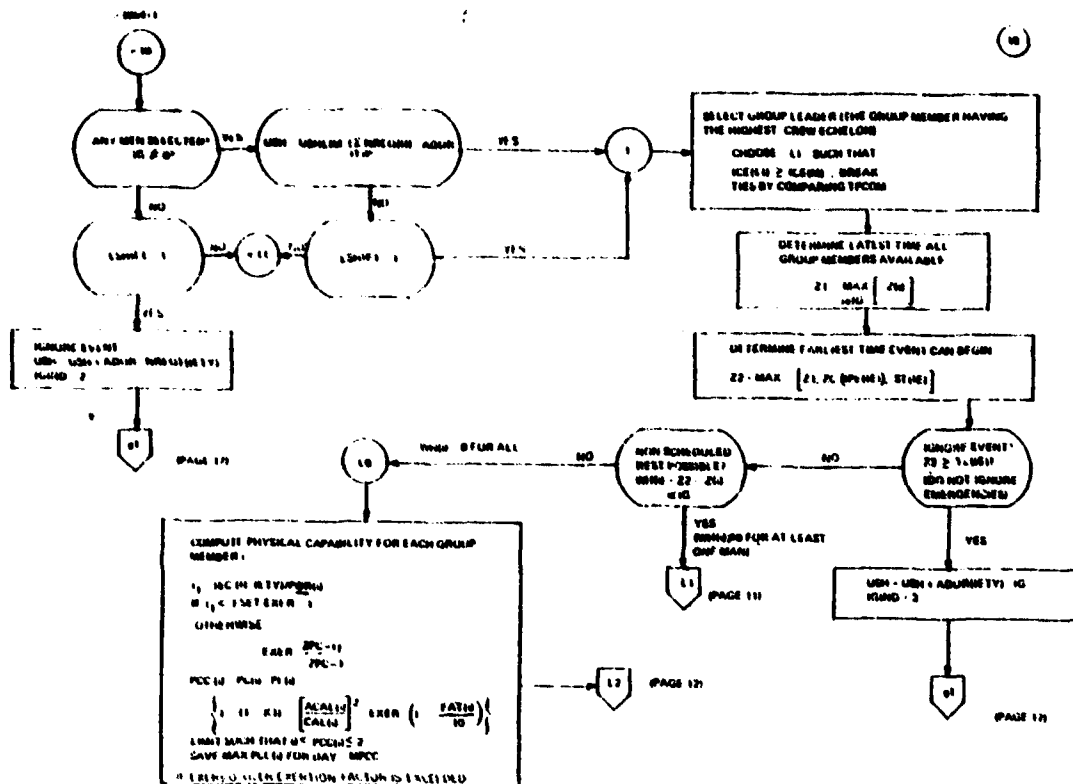
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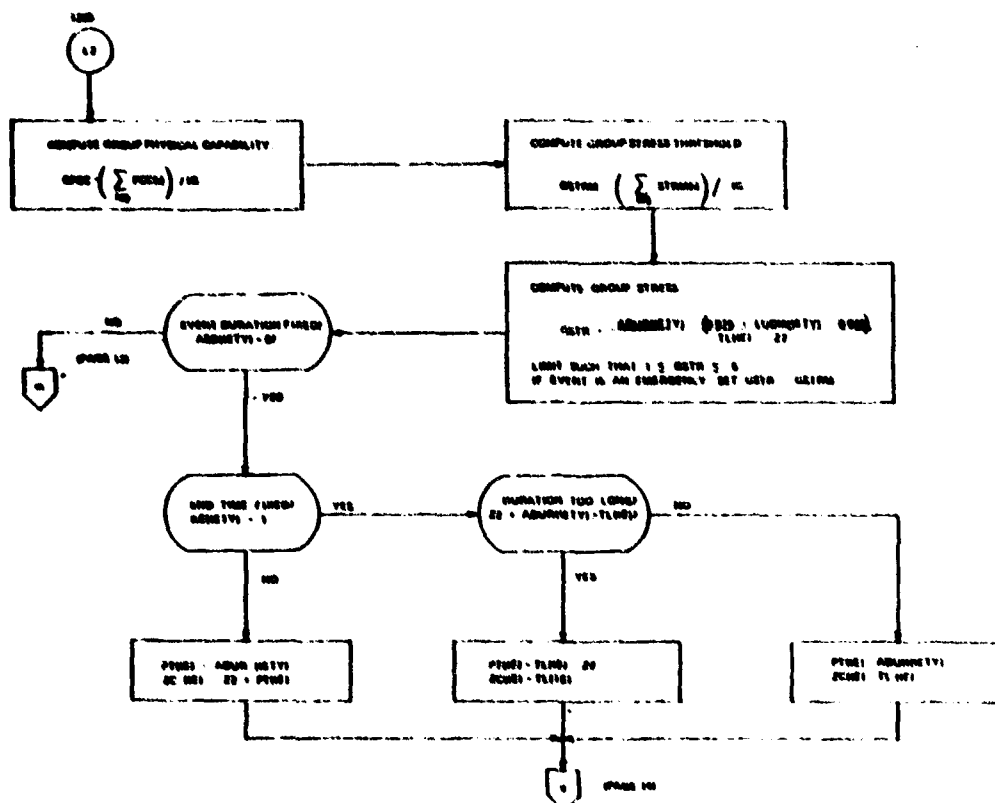
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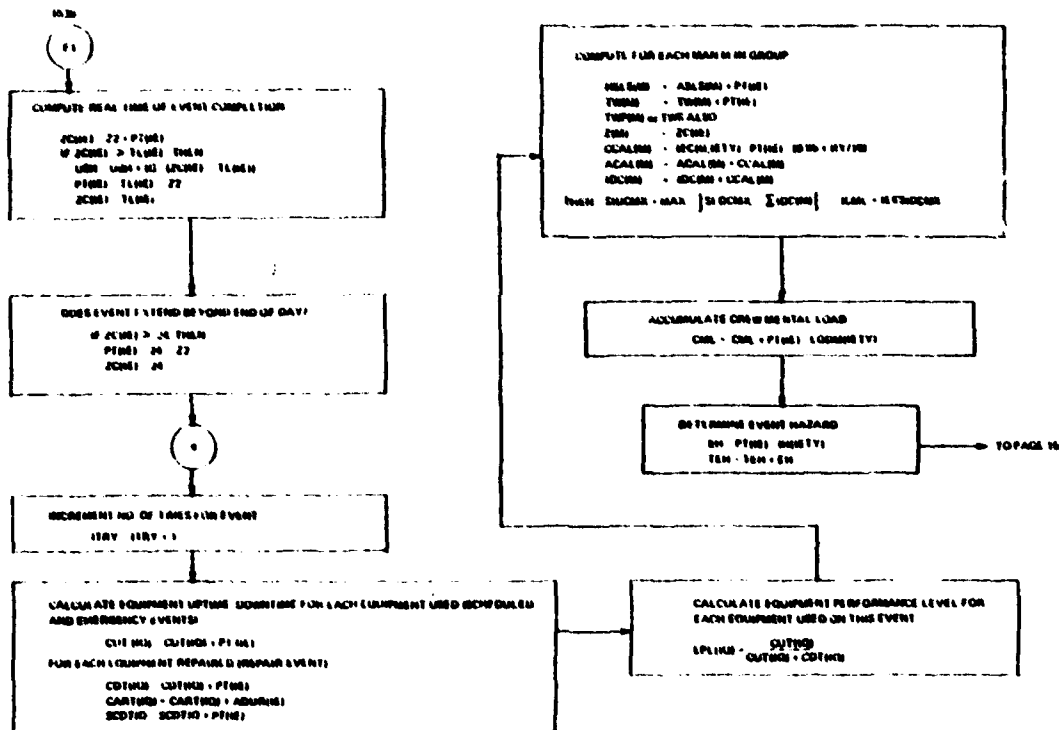
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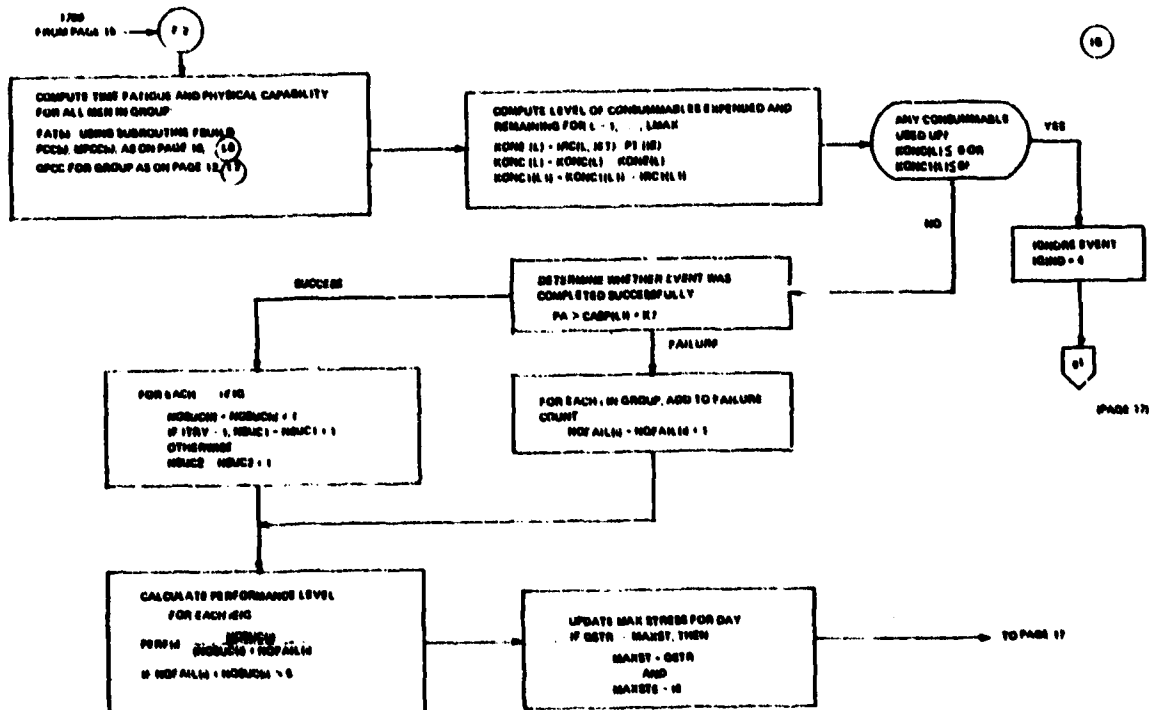
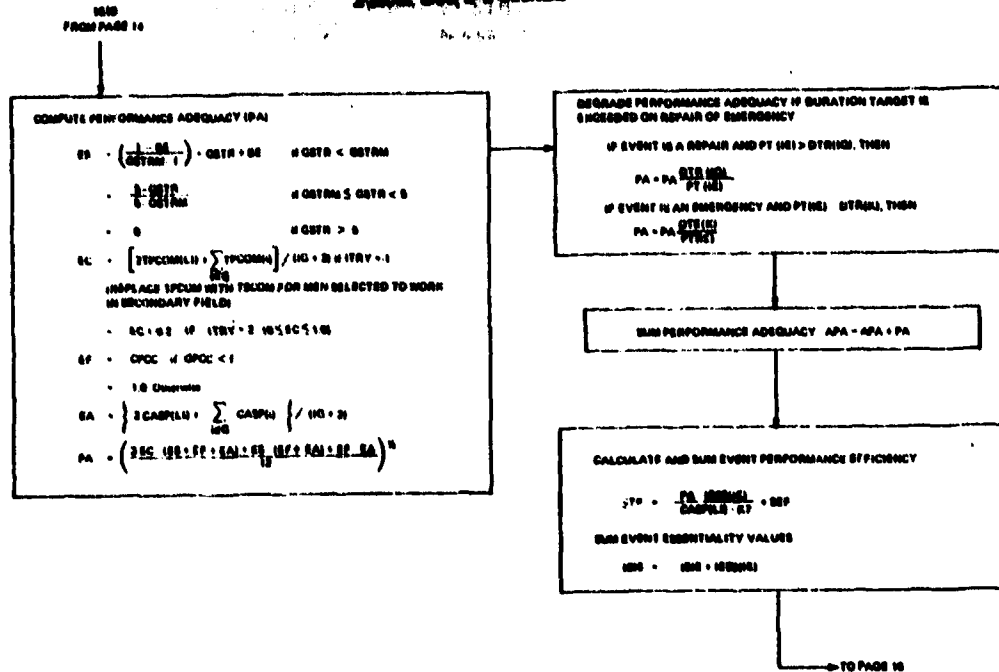
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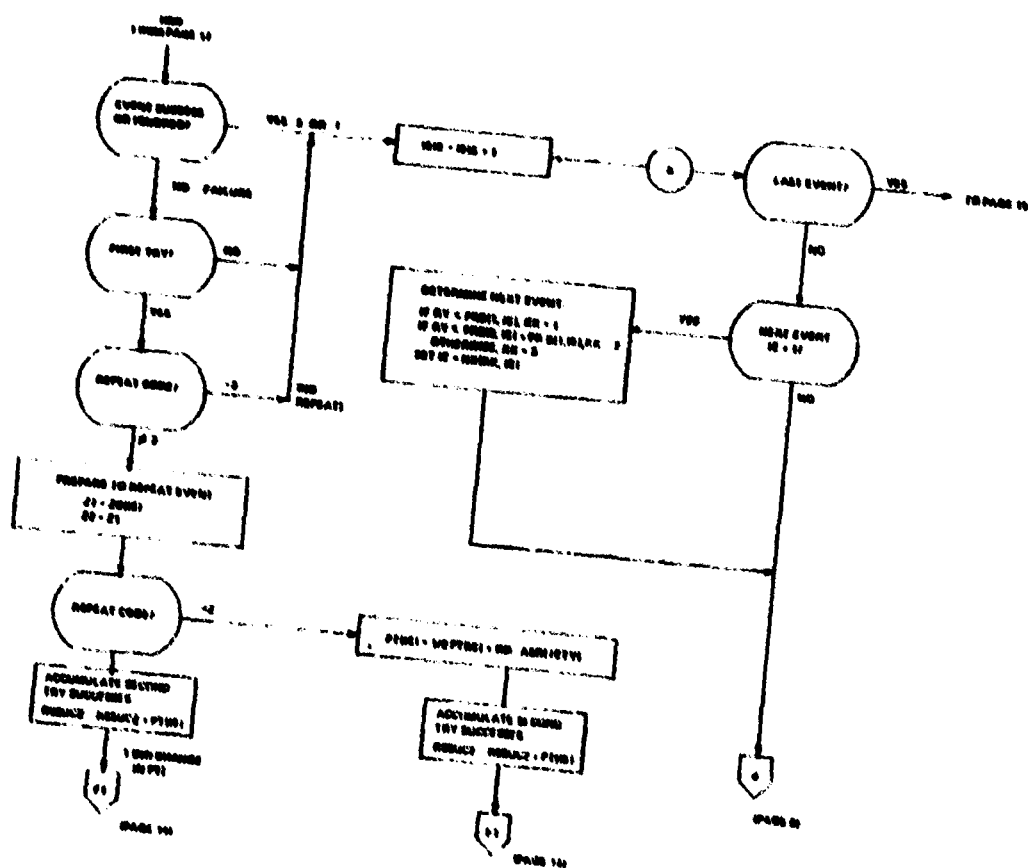


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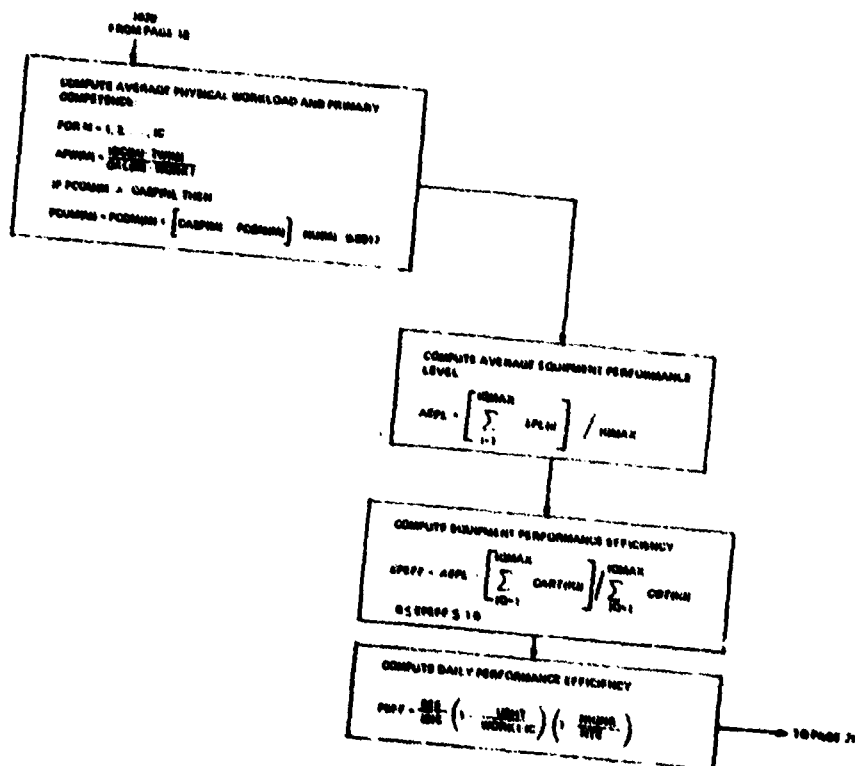




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APPENDIX D INPUT DATA CARD FORMATS FOR 4-29 MAN DIGITAL SIMULATION MODEL

Simulation Input Data Preparation

Input for the intermediate size crew simulation model are initially prepared in NAMELIST and final field formats. Actual card layout and sequencing information for these formats are given in detail in this Appendix, and correspond to the types of data presented in Table B-1.

Table B-1

Types of Punched Card Format

Card Format	Type of Data
1	Number of iterations
2	Title
3	Tape input and number of days
4	Parameters
5	Personnel
6	Equipment repair events
7	Emergency events
8	Event type data
9	Sequence data

In the NAMELIST format, data are punched sequentially in card columns 2 through 72 without regard for column assignments. A comma separates each input number. Thus, all arrays must be completed with zeros. For example, the cross training probability matrix must have 10 x 10 entries even in the case that there are fewer than 10 types of personnel to be simulated.

If the simulation calls for more than one iteration, the input routine dumps all input data, except for the parameters and personnel data, onto a magnetic tape. This tape is then read in the subsequent iterations. A tape created in this fashion can be used to supply input for future simulations.

The sequencing, content and structure of the input data rules follow:

Title Cards		FORTRAN	Format	Value
Description				
Card Format 1	Number of iterations	NKASES	I3	_____
Card Format 2	Title	HEADR	12A6	72 spaces
Card Format 3	Tape input option (000= card, 001= tape)	ITAP	I3	___
	Number of days simulated	NDMAX	I3	___

Input Parameter - Card Format 4

		SPARAM	
		NFP2/FP2=	
Average psychological stress threshold	APST	_____	,
Number of hours worked after which no new assignments are made	WORK1	_____	,
Number of hours worked after which further work is unauthorized	WORK2	_____	,
Number of hours since last sleep period by average crew member at start of mission	SLEEP	_____	,
Catnap length number of hours below which is rest, and above which is sleep	CN	_____	,
Maximum sleep permitted per day (hours)	MAXSL	_____	,
Fatigue threshold-below which sleep is not authorized	TFAT	_____	,
Average crew pace (average= 1, Fast <1; Slow >1)	ACP	_____	,
Number of calories required by average crew member per day	CALRY	_____	,
Average short term power output for average crew member (calories/hour)	PWRRT	_____	,
Derating constant for acceptable performance	K7	_____	,
Fraction to which man's physical capability reduced when daily quota of work is done	K1	_____	,
Effect of stress on performance on a	BE	_____	,
~~and stress state~~	~~ASAP~~	_____	,
Average Aspiration Level	USHLIM	_____	,
Per cent threshold for unmanned station	KON(1)	_____	,
hours	KON(2)	_____	,
Initial value of consumables on	KON(3)	_____	,
hand at start of mission for	KON(4)	_____	,
those expended on a units	KON(5)	_____	,
per hour basis	KON(6)	_____	,
	KON(7)	_____	,
	KON(8)	_____	,
	KON(9)	_____	,
	KON(10)	_____	,

Title Cards
Description

FORTRAN

VALUE

Consumable threshold for consumable 1, threshold 1

2 KONT(1,1)
3 KONT(2,1)
4 KONT(3,1)
5 KONT(4,1)
6 KONT(5,1)
7 KONT(6,1)
8 KONT(7,1)
9 KONT(8,1)
10 KONT(9,1)
KONT(10,1)

consumable 1, threshold 2

2 KONT(1,2)
3 KONT(2,2)
4 KONT(3,2)
5 KONT(4,2)
6 KONT(5,2)
7 KONT(6,2)
8 KONT(7,2)
9 KONT(8,2)
10 KONT(9,2)
KONT(10,2)

consumable 1, threshold 3

2 KONT(1,3)
3 KONT(2,3)
4 KONT(3,3)
5 KONT(4,3)
6 KONT(5,3)
7 KONT(6,3)
8 KONT(7,3)
9 KONT(8,3)
10 KONT(9,3)
KONT(10,3)

consumable 1, threshold 4

2 KONT(1,4)
3 KONT(2,4)
4 KONT(3,4)
5 KONT(4,4)
6 KONT(5,4)
7 KONT(6,4)
8 KONT(7,4)
9 KONT(8,4)
10 KONT(9,4)
KONT(10,4)

consumable 1, threshold 5

2 KONT(1,5)
3 KONT(2,5)
4 KONT(3,5)
5 KONT(4,5)
6 KONT(5,5)
7 KONT(6,5)
8 KONT(7,5)
9 KONT(8,5)
10 KONT(9,5)
KONT(10,5)

Title Cards
Description

FORTRAN

VALUE

Consumable threshold for consumable 1, threshold 6

2 KONT(2,6)
3 KONT(3,6)
4 KONT(4,6)
5 KONT(5,6)
6 KONT(6,6)
7 KONT(7,6)
8 KONT(8,6)
9 KONT(9,6)
10 KONT(10,6)

consumable 1, threshold 7

2 KONT(2,7)
3 KONT(3,7)
4 KONT(4,7)
5 KONT(5,7)
6 KONT(6,7)
7 KONT(7,7)
8 KONT(8,7)
9 KONT(9,7)
10 KONT(10,7)

consumable 1, threshold 8

2 KONT(2,8)
3 KONT(3,8)
4 KONT(4,8)
5 KONT(5,8)
6 KONT(6,8)
7 KONT(7,8)
8 KONT(8,8)
9 KONT(9,8)
10 KONT(10,8)

consumable 1, threshold 9

2 KONT(2,9)
3 KONT(3,9)
4 KONT(4,9)
5 KONT(5,9)
6 KONT(6,9)
7 KONT(7,9)
8 KONT(8,9)
9 KONT(9,9)
10 KONT(10,9)

consumable 1, threshold 10

2 KONT(2,10)
3 KONT(3,10)
4 KONT(4,10)
5 KONT(5,10)
6 KONT(6,10)
7 KONT(7,10)
8 KONT(8,10)
9 KONT(9,10)
10 KONT(10,10)

Title Cards
Description

FORTRAN

VALUE

Initial value of consumable:
(units)

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____
9 _____
10 _____

KON1(1)
KON1(2)
KON1(3)
KON1(4)
KON1(5)
KON1(6)
KON1(7)
KON1(8)
KON1(9)
KON1(10)

Consumable threshold for consumable 1, threshold 1

2
3
4
5
6
7
8
9
10

KONT1(1)
KONT1(2)
KONT1(3)
KONT1(4)
KONT1(5)
KONT1(6)
KONT1(7)
KONT1(8)
KONT1(9)
KONT1(10)

consumable 1, threshold 2

2
3
4
5
6
7
8
9
10

KONT1(1,2)
KONT1(1,2)
KONT1(3,2)
KONT1(4,2)
KONT1(5,2)
KONT1(6,2)
KONT1(7,2)
KONT1(8,2)
KONT1(9,2)
KONT1(10,2)

consumable 1, threshold 3

2
3
4
5
6
7
8
9
10

KONT1(1,3)
KONT1(2,3)
KONT1(3,3)
KONT1(4,3)
KONT1(5,3)
KONT1(6,3)
KONT1(7,3)
KONT1(8,3)
KONT1(9,3)
KONT1(10,3)

consumable 1, threshold 4

2
3
4
5
6
7
8
9
10

KONT1(1,4)
KONT1(2,4)
KONT1(3,4)
KONT1(4,4)
KONT1(5,4)
KONT1(6,4)
KONT1(7,4)
KONT1(8,4)
KONT1(9,4)
KONT1(10,4)

Title Cards
Description

FORTRAN

VALUE

Consumable threshold for consumable 1, threshold 5

2 KONT1(1,5)
3 KONT1(2,5)
4 KONT1(3,5)
5 KONT1(4,5)
6 KONT1(5,5)
7 KONT1(6,5)
8 KONT1(7,5)
9 KONT1(8,5)
10 KONT1(9,5)
10 KONT1(10,5)

consumable 1, threshold 6

2 KONT1(1,6)
3 KONT1(2,6)
4 KONT1(3,6)
5 KONT1(4,6)
6 KONT1(5,6)
7 KONT1(6,6)
8 KONT1(7,6)
9 KONT1(8,6)
10 KONT1(9,6)
10 KONT1(10,6)

consumable 1, threshold 7

2 KONT1(1,7)
3 KONT1(2,7)
4 KONT1(3,7)
5 KONT1(4,7)
6 KONT1(5,7)
7 KONT1(6,7)
8 KONT1(7,7)
9 KONT1(8,7)
10 KONT1(9,7)
10 KONT1(10,7)

consumable 1, threshold 8

2 KONT1(1,8)
3 KONT1(2,8)
4 KONT1(3,8)
5 KONT1(4,8)
6 KONT1(5,8)
7 KONT1(6,8)
8 KONT1(7,8)
9 KONT1(8,8)
10 KONT1(9,8)
10 KONT1(10,8)

consumable 1, threshold 9

2 KONT1(1,9)
3 KONT1(2,9)
4 KONT1(3,9)
5 KONT1(4,9)
6 KONT1(5,9)
7 KONT1(6,9)
8 KONT1(7,9)
9 KONT1(8,9)
10 KONT1(9,9)
10 KONT1(10,9)

Title Cards	Description

FORTRAN

VALUE

Consumable threshold for consumable 1, threshold 10

2	KONT1(2,10)
3	KONT1(3,10)
4	KONT1(4,10)
5	KONT1(5,10)
6	KONT1(6,10)
7	KONT1(7,10)
8	KONT1(8,10)
9	KONT1(9,10)
10	KONT1(10,10)

Sea State

Description and height of waves
in feet)

```

0 -- calm, glassy
1 -- rippled, 0-1
2 -- smooth, 1-2
3 -- slight, 2-4
4 -- moderate, 4-8
5 -- rough, 8-13
6 -- very rough, 13-20
7 -- high, 20-30
8 -- very high, 30-45
9 -- exceptionally
    high, over 45

```

```
SESTA(1)
SESTA(2)
SESTA(3)
SESTA(4)
SESTA(5)
SESTA(6)
SESTA(7)
SESTA(8)
SESTA(9)
SESTA(10)
```

Intermittent reliability--electronic equipment
Intermittent reliability--electrical equipment
Intermittent reliability--electromechanical equipment
Intermittent reliability--mechanical equipment

RELI(1)
RELI(2)
RELI(3)
RELI(4)

Number of mission iterations

Number of iterations per computer run

Essentiality threshold, below which an event is ignored (1-100)

**N
IET**

NIP2/IP2=

Indicators for output recording options

Print all inputs (1), or parameters only (0)

```
Print (1), or don't print (0): crew initial conditions
                                : day numbers of 'st. re-
                                : pair, emergencies
```

IND(1)
IND(2)
IND(3)
IND(4)

Print detailed event results for all events beginning with day

```
Print end of day results for all days beginning with day
Print (1), or don't print (0) mission results by individual man
```

IND(5)
IND(6)
IND(7)

Personnel Data-Card Format 5

<u>Title Cards</u> <u>Description</u>	<u>FORTRAN</u>	<u>VALUE</u> <u>SPERSNL</u> <u>NFP1/FP1</u>
Mean body weight of total population (lbs.)	WT	_____
Standard deviation of population body weight (lbs.)	SIGWT	_____
Fraction of the crew fully qualified in prime-specialty	PPFQ	_____
Fraction of the crew minimally qualified in prime specialty	PPMQ	_____
Fraction of the crew unqualified in prime specialty	PPUQ	_____
Fraction of the crew qualified in second specialty	SPFQ	_____
Fraction of the crew minimally qualified in second specialty	SPUQ	_____
Avg. number of man days between physical incapacitations	MFI	_____
Avg. duration of incapacity (days)	PID	_____
Physical capability constant, a value yielded zero physical capability due to over exertion	ZPC	_____

Crosstraining probability - enter fractional values representing the probability of man with a given specialty also being trained in each other specialty. Diagonal elements are usually zero if a man is not to have the same primary and secondary specialty.

		<u>prime specialty</u>									
<u>second specialty</u>	<u>FORTRAN</u>	1	2	3	4	5	6	7	8	9	10
_____	PTT(1-10,1)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,2)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,3)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,4)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,5)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,6)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,7)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,8)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,9)	___	___	___	___	___	___	___	___	___	___
_____	PTT(1-10,10)	___	___	___	___	___	___	___	___	___	___

Crew composition
number of men in each specialty at each crew echelon (rank or level)

		<u>prime specialty</u>									
<u>echelon or level</u>		1	2	3	4	5	6	7	8	9	10
_____	<u>NIP1/IP1=</u>										
_____	MEN(1-10,1)	___	___	___	___	___	___	___	___	___	___
_____	MEN(1-10,2)	___	___	___	___	___	___	___	___	___	___
_____	MEN(1-10,3)	___	___	___	___	___	___	___	___	___	___
_____	MEN(1-10,4)	___	___	___	___	___	___	___	___	___	___

Title Cards

Description

Number of duty shifts per 24 hour day
Crew duty shift assignment

Man

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

FORTTRAN

NDS

IDS(1-6,1)
IDS(1-6,2)
IDS(1-6,3)
IDS(1-6,4)
IDS(1-6,5)
IDS(1-6,6)
IDS(1-6,7)
IDS(1-6,8)
IDS(1-6,9)
IDS(1-6,10)
IDS(1-6,11)
IDS(1-6,12)
IDS(1-6,13)
IDS(1-6,14)
IDS(1-6,15)
IDS(1-6,16)
IDS(1-6,17)
IDS(1-6,18)
IDS(1-6,19)
IDS(1-6,20)

VALUE

For each man enter $\frac{24}{\text{NDS}}$ IDS of one or zero, i.e., one value for each shift:

0 (man not assigned to this shift)
1 (man is assigned to this shift)

Fill in matrix with zeros if necessary.

EQUIPMENT REPAIR DATA - CARD FORMAT 6

Complete the following data for each equipment repair family.

Equipment Name _____ Equipment Number _____

Title Cards

Description
Equipment repair

FORTTRANVALUE

* ~~SECRET~~
* ~~NTP4/FP4~~

Reliability (days between hard failure)
Intermittent failure duration (hours)

RELH
TUI

For each event in the repair family

Event 1

Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value

DTR
PRB(1-3,1)
IEDC(1-3,1)
EDCV(1-3,1)

_____,_____
_____,_____
_____,_____

Event 2

Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value

DTR
PRB(1-3,2)
IEDC(1-3,2)
EDCV(1-3,2)

_____,_____
_____,_____
_____,_____

Event 3

Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value

DTR
PRB(1-3,3)
IEDC(1-3,3)
EDCV(1-3,3)

_____,_____
_____,_____
_____,_____

Event 4

Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value

DTR
PRB(1-3,4)
IEDC(1-3,4)
EDCV(1-3,4)

_____,_____
_____,_____
_____,_____

Event 5

Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value

DTR
PRB(1-3,5)
IEDC(1-3,5)
EDCV(1-3,5)

_____,_____
_____,_____
_____,_____

Event 6

Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value

DTR
PRB(1-3,6)
IEDC(1-3,6)
EDCV(1-3,6)

_____,_____
_____,_____
_____,_____

Event 7

Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value

DTR
PRB(1-3,7)
IEDC(1-3,7)
EDCV(1-3,7)

_____,_____
_____,_____
_____,_____

*Punch these cards for first equipment repair family only.

Title Cards
Description

FORTTRAN

Value

Event 8
Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value
Event 9
Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value
Event 10
Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value
Event 11
Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value
Event 12
Repair maximum duration (minutes)
Probability of next event
Data change number
Data change value

DTR	_____
PRB(1-3,8)	_____._____._____
IEDC(1-3,8)	_____._____._____
EDCV(1-3,8)	_____._____._____
DTR	_____
PRB(1-3,9)	_____._____._____
IEDC(1-3,9)	_____._____._____
EDCV(1-3,9)	_____._____._____
DTR	_____
PRB(1-3,10)	_____._____._____
IEDC(1-3,10)	_____._____._____
EDCV(1-3,10)	_____._____._____
DTR	_____
PRB(1-3,11)	_____._____._____
IEDC(1-3,11)	_____._____._____
EDCV(1-3,11)	_____._____._____
DTR	_____
PRB(1-3,12)	_____._____._____
IEDC(1-3,12)	_____._____._____
EDCV(1-3,12)	_____._____._____

Equipment Repair Data

Complete the following data sheet for each equipment repair family, i.e., each equipment type.

Title Cards

<u>Description</u>	<u>FORTRAN</u>	<u>VALUE</u> <u>NIP4/IP4=</u>
Total number of equipments	NEQRE	
Complete the following data sheet for each equipment repair in family, i.e. each equipment type		
<u>Repair description</u>		
Description (72 digits)		67 _____
Consumable threshold see number (units/hour)	TSR	_____
Consumable threshold (units)	TSR1	_____
Number of repair events in family	IRE	_____
Family number	IEFN	_____
<u>Event family members</u>		
Event 1 Type number	IETYP	_____
Precedent events	IPE	_____
Next events	NX(1-3,1)	_____
Repair/Touch up (1,2,3)	RTU	_____
Event family indicator (0,1,2)	IFOI	_____
Event 2 Type number	IETYP	_____
Precedent events	IPE	_____
Next events	NX(1-3,2)	_____
Repair/Touch up	RTU	_____
Event family indicator	IFOI	_____
Event 3 Type number	IETYP	_____
Precedent events	IPE	_____
Next events	NX(1-3,3)	_____
Repair/Touch up	RTU	_____
Event family indicator	IFOI	_____
Event 4 Type number	IETYP	_____
Precedent events	IPE	_____
Next events	NX(1-3,4)	_____
Repair/Touch up	RTU	_____
Event family indicator	IFOI	_____
Event 5 Type number	IETYP	_____
Precedent events	IPE	_____
Next events	NX(1-3,5)	_____
Repair/Touch up	RTU	_____
Event family indicator	IFOI	_____
Event 6 Type number	IETYP	_____
Precedent events	IPE	_____
Next events	NX(1-3,6)	_____
Repair/Touch up	RTU	_____
Event family indicator	IFOI	_____
Event 7 Type number	IETYP	_____
Precedent events	IPE	_____
Next events	NX(1-3,7)	_____
Repair/Touch up	RTU	_____
Event family indicator	IFOI	_____

Title Cards

Description

Event 8 Type number
 Precedent events
 Next events
 Repair/Touch up
 Event family indicator
 Event 9 Type number
 Precedent events
 next events
 Repair/Touch up
 Event family indicator
 Event 10 Type number
 Precedent events
 Next events
 Repair/Touch up
 Event family indicator
 Event 11 Type number
 Precedent events
 Next events
 Repair/Touch up
 Event family indicator
 Event 12 Type number
 Precedent events
 Next events
 Repair/Touch up
 Event family indicator

FORTTRAN

VALUE

IETYP	_____.
IPE	_____.
NX(1-3,8)	_____.
RTU	_____.
IFOI	_____.
IETYP	_____.
IPE	_____.
NX(1-3,9)	_____.
RTU	_____.
IFOI	_____.
IETYP	_____.
IPE	_____.
NX(1-3,10)	_____.
RTU	_____.
IFOI	_____.
IETYP	_____.
IPE	_____.
NX(1-3,11)	_____.
RTU	_____.
IFOI	_____.
IETYP	_____.
IPE	_____.
NX(1-3,12)	_____.
RTU	_____.
IFOI	_____.

*Punch only after end of all equipment repair data.

EMERGENCY EVENT DATA - CARD FORMAT 7

Repeat following data for each emergency type.

Emergency Number _____

Title Cards
Description

FORTRAN

Value

Emergencies

Emergency: Description

Essentiality

Number of men required (by type)

Mental load

Rate of consumable expenditure for those
expended on a units/hour basis

Threshold set for units/hours/consumables

Rate of consumable expenditures (units)

Threshold set for units/consumables

Hazard class

Energy consumption by personnel types
(calories/hr)

Mean number of days between occurrence of this
type of emergency

IESSE

NREQE(1-5,1)

NREQE(6-10,1)

LODME

IRCE(1-5,1)

IRCE(6-10,1)

TSE

IRCE1(1-5,1)

IRCE1(6-10,1)

TSE1

IHE

IECE(1-5,1)

IECE(6-10,1)

NDBE

\$EMREVT
NIP5/IP5=

67H _____,

_____,

_____,

_____,

_____,

_____,

_____,

_____,

_____,

_____,

_____,

_____,

_____,

_____,

_____,

Repeat following data for each emergency

Average recovery time (hours)

Average standard deviation of recovery time (hours)

Duration target for recovery from this emergency

type (hours)

ART

ASDE

DTE

NFP5/FPS=

_____,

_____,

_____, \$

EVENT TYPE DATA - CARD FORMAT 8

Event type number _____

Title Cards
Description

FORTTRAN

Value

Event type data

\$TYPE
NIP5/IP5=

Description of event type

Essentiality (0 to 100)

Number of men required (by type)

Mental load

Kind of event end time (1= fixed end;
2= variable end)

Kind of event (1= normal; 2= training)

Rate of expenditure of consumables (units/hours)

Rate of expenditure of consumables (units)

Hazard class (1-3 low, 4-6 medium, 7-9 heavy)

Energy consumption (cal./hr.)

Number of equipments required*

Equipments required*

Class

Complete entry of all Event type data, IEES to ICLASS,
for all Event types before entering duration data.

Precede duration data by NFPS/FP5 =

Note: Each NAMELIST entry (ex \$TYPE NIP5/IP5 =)
occurs only once. It is not repeated before each
task type.

Average duration (hours)

Average standard deviation

IESS

NREQ(1-5,1)

NREQ(6-10,1)

LODM

KE

INT

IRC(1-5,1)

IRC(6-10,1)

IRC1(1-5,1)

IRC1(6-10,1)

IH

IEC(1-5,1)

IEC(6-10,1)

NIQR

IQR(1-6)

ICLASS

ADUR

ASD

67H _____,

_____,

_____,

_____,

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*For event type data which are for equipment repair, NIQR must be 1 (one equipment being repaired) and IQR(1-6) should be of the form (X,0,0,0,0,0) where X is the number of the equipment to be repaired. For scheduled event types where, say equipment numbers 1,3, and 11 are to be used in the event, NIQR= 3 and IQR(1-6)= (1,3,11,0,0,0).

SCHEDULED EVENT SEQUENCE DATA - CARD FORMAT 9

<u>Scheduled events title card</u>	<u>FORTRAN</u>	<u>Format</u>	<u>Value</u>
(Input card not free format)			
Day number for this iteration	ND	I3	_____
Number of scheduled events this iteration	NOSE	I3	_____
Title for this day		11A6	(66 spaces)

Complete the following data for each scheduled event:

Scheduled Event Name _____ Scheduled Event Number _____

<u>Scheduled Events</u>	<u>FORTRAN</u>	<u>Value</u>
Event type	IETYP	<u>SSCHEVT</u>
Precedent event sequence number which must be completed before current event	IPE	<u>NIP3/IP3=</u>
Threshold set (units/hour)	TS	_____
Threshold set (units)	TS1	_____
Repeat/Touchup code (1= repeat; 2= touchup, 3= no action)	RTU	_____
Event family indicator	IFOI	_____
Number in family	NIF	_____
Family number	IEFN	_____
Next events	NX(1-3,1)	_____,_____,_____
(Repeat for each scheduled event)		
Time limit	TL	<u>NFP3/FP3=</u>
Start time (hours)	ST	_____
Probability of alternatives	PRB(1-3,1)	_____
Data change number	IEDC(1-3,1)	_____
Data change value	EDCV(1-3,1)	_____, _____ \$

(Repeat for each scheduled event)

APPENDIX E CONFIDENCE BOUND ESTIMATION

APPENDIX E
CONFIDENCE BOUND ESTIMATION

E.1 Introduction

In this section, two methods for estimating the confidence bounds of a lognormal distribution are described. The first method estimates the confidence bound due to the expected sample variations of the parameter estimates. The second method estimates the confidence bound due to the noise effect, which is the random variations from the smooth envelope of a true lognormal distribution. Normally, when the random sample deviations from the true lognormal distribution are negligible, only the first method will be required. Otherwise, the confidence bounds of methods 1 and 2 should be combined to provide a conservative result.

In order to clearly illustrate the estimation procedures, the the sample elapsed (or repair) times (x) of table E-1 are used.

Initially, the lognormal regression line is estimated, by a shortcut method, as a straight line connecting the estimated median and the 95th percentile point.

The estimated median of repair time = $MTTR_G = x(50\%) = 1.234^*$

The expected x (95%) = $MTTR_G \exp(1.645\sigma/0.434)$. $\hat{\sigma}$ (the estimate of σ) is computed from equation (E-2) and is equal to $0.623/2.3$, or roughly 0.271. Therefore, the expected x (95%) = $1.234 \exp[1.645(0.271)/0.434] = 3.443$.

The regression line can then be plotted on lognormal paper in figure E-1 by joining the two points $x(50\%)$ and $x(95\%)$. The detailed procedures for estimating the other data points in figure E-1 are explained in the following sections.

E.2 Procedure for Estimating Confidence Bound Due To Variations of Parameter Estimates (Method 1)

E.2.1 Calculation Procedure. This method assumes the random variation between x and a true lognormal distribution is negligible so that equation (E-1) holds.

*From Table E-1, $MTTR_G = e^{\hat{\mu}} = 1.234$.

Legend

Data Source

△ - △ Estimated Lognormal Regression Line	Paragraph X-1
X X X Discrete Sample Data Points	Table X-1, 2, Columns (3) & (5)
● - ● 95% Confidence Bound, Method 2	Table X-2, Columns (3) & (12) or (13)
□ - □ 96% Confidence Bound, Method 1	Table X-1, Columns (3) & (8) or (9)
c - c 95% Confidence Bound, Combined Methods 1 & 2	Table X-3, Columns (3) & (1) or (2)

Note: X Sample data points are either above or below the regression line depending on whether c is positive or negative - see Table X-2, Column (7).

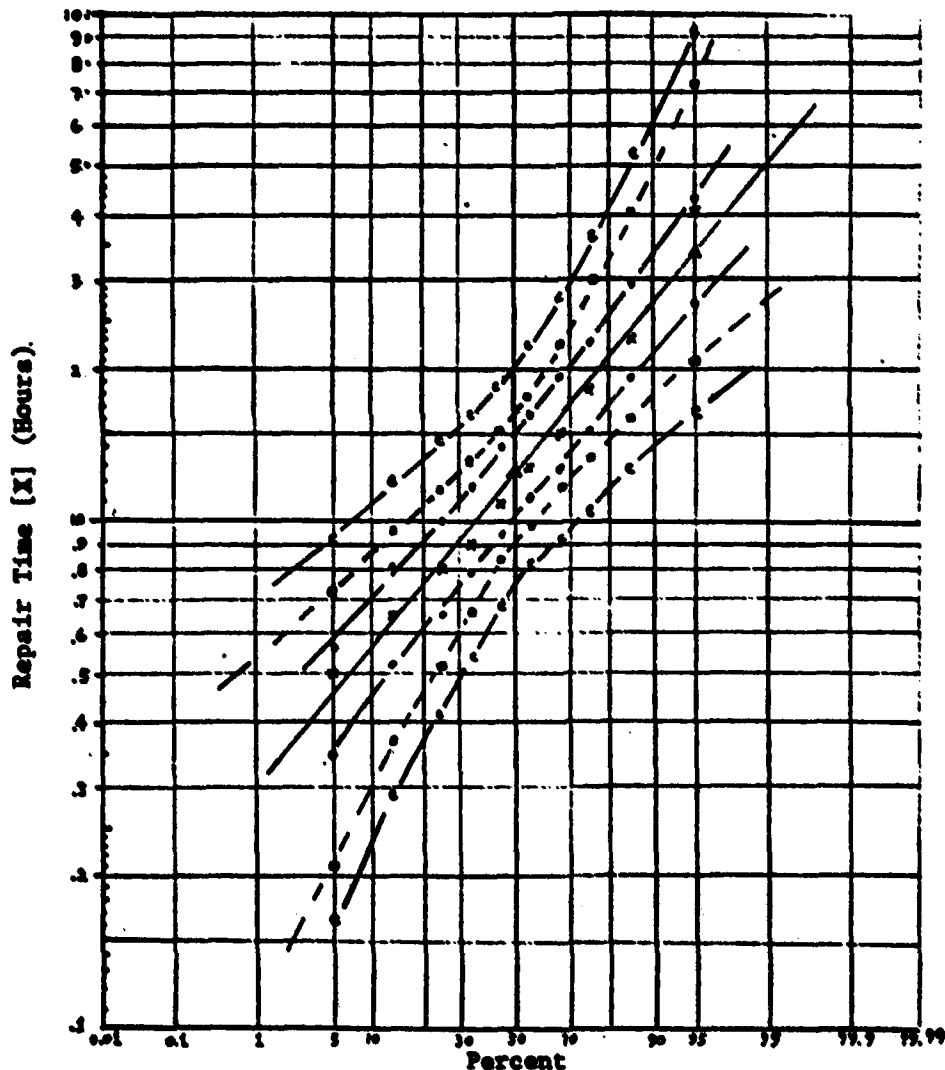


Figure E-1. Illustrated Lognormal Regression Line and Confidence Bounds

$$\ln X = Y' = \mu' + \sigma'Z \quad (E-1)$$

X - random variable of the entire population; X is lognormally distributed

x - sampled random variable from the population

Y' - normally distributed with a mean μ' and variance σ'^2

$$\mu' - \text{true mean of } Y' = \sum_{N} \ln X / N = \sum_{N} Y' / N$$

$$\hat{\mu}' - \text{estimate of } \mu' = \sum_{n} \ln X / n$$

$$\sigma' - \text{true standard deviation of } \ln X = \sqrt{\frac{\sum_{N} (\ln X - \mu')^2}{N}}$$

$\hat{\sigma}'$ - estimate of σ' [see equations (E-2) and (E-3)]

y' - natural logarithm of x or $\ln x$

N - population size (in many cases N is extremely large)

n - sample size, in this section n is assumed to equal M.

σ - true standard deviation of $\log X$

$\hat{\sigma}$ - estimate of σ

Z - standardized normal variate

α - significance level

M - interval size

$$\begin{aligned} \hat{\sigma}' &= \sqrt{\frac{\sum_{n} (\ln x)^2 - (\sum_{n} \ln x)^2 / n}{n - 1}} \\ &= 2.3\hat{\sigma} = 2.3 \sqrt{\frac{\sum_{n} (\log x)^2 - (\sum_{n} \log x)^2 / n}{n - 1}} \quad (E-2)* \end{aligned}$$

*Equation (E-2) should be used when sample size is small; equation (E-3) is easier to estimate σ' , but sample size should be equal or greater than 20.

For n (sample size) ≥ 20 , $\ln(10) = 2.3$

$$\hat{\sigma} = 2.3\hat{\sigma} = 2.3 \sqrt{\frac{M}{M-1}} \sqrt{\frac{1}{1.15} \log \left(\sum_{n} x/n \right) / D} \quad (E-3)*$$

when $D = \text{Antilog} \left(\sum_{n} \log x/n \right)$

Since $\hat{\mu}'$ is a random variable which (according to the central limit theorem) is normally distributed with the mean μ' and the standard deviation $\sigma' / \sqrt{n}$, the confidence interval of μ' can be estimated by:

$$\begin{aligned} & \text{Probability } (\hat{\mu}'_L < \mu' < \hat{\mu}'_H) \\ &= \text{probability} \left\{ \left(\hat{\mu}' - t_{\alpha/2(n-1)} \frac{\hat{\sigma}'}{\sqrt{n}} \right) < \mu' < \left(\hat{\mu}' + t_{\alpha/2(n-1)} \frac{\hat{\sigma}'}{\sqrt{n}} \right) \right\} = 1 - \alpha \end{aligned} \quad (E-4)$$

Since $\ln x$ is normally distributed, and $(n-1) \hat{\sigma}'^2$ is equal to $\sum_{n} (\ln x - \hat{\mu}')^2$, the confidence bound of σ'^2 can be estimated by equation (E-5). Note that one degree of freedom is lost due to the estimate of μ' .

$$\begin{aligned} & \text{Probability } (\hat{\sigma}'^2_L < \sigma'^2 < \hat{\sigma}'^2_H) \\ &= \text{probability} \left\{ \frac{(n-1) \hat{\sigma}'^2}{\chi^2_{\alpha/2} (n-1, \text{d.f.})} < \sigma'^2 \right. \\ & \quad \left. < \frac{(n-1) \hat{\sigma}'^2}{\chi^2_{1-\alpha/2} (n-1, \text{d.f.})} \right\} \quad (E-5) \\ &= 1 - \alpha \end{aligned}$$

*In equation (E-3), the correction factor $\sqrt{M/(M-1)}$ is derived empirically. For instance, using the example illustrated in page 80 of "Maintainability Principles and Practices," Blanchard and Lowery, the standard deviation estimate based on 27 samples without correction factor resulted in 1.724 percent error. When correction factor is used, the error is reduced to 0.155 percent.

According to the proof provided in section 10.4 of "Introduction to the Theory of Statistics," (Mood, A. and Graybill, F., McGraw-Hill, 1963), the estimates of the mean and variance of x are statistically independent; consequently, their covariance is zero. This permits us to set up a deterministic confidence bound of x values for a fixed standard normal variate Z by estimating the worst combinations of $\hat{\mu}'_L$, $\hat{\mu}'_H$, $\hat{\sigma}'_L$ and $\hat{\sigma}'_H$.

$$\left. \begin{aligned} \hat{X} \text{ (upper)} &= \exp \left[Z(\hat{\sigma}'_H) + \hat{\mu}'_H \right] \\ \hat{X} \text{ (lower)} &= \exp \left[Z(\hat{\sigma}'_L) + \hat{\mu}'_L \right] \end{aligned} \right\} \begin{aligned} &\text{for all } Z \geq 0 \\ &\text{(Z positive)} \end{aligned} \quad (\text{E-6})$$

$$\left. \begin{aligned} \hat{X} \text{ (upper)} &= \exp \left[Z(\hat{\sigma}'_L) + \hat{\mu}'_H \right] \\ \hat{X} \text{ (lower)} &= \exp \left[Z(\hat{\sigma}'_H) + \hat{\mu}'_L \right] \end{aligned} \right\} \begin{aligned} &\text{for all } Z \leq 0 \\ &\text{(Z negative)} \end{aligned} \quad (\text{E-7})$$

Since the probability of a parameter equal to (or exceeding) its estimated limits is α (or $< \alpha$), the joint probability of both parameters (μ' and σ') equaling (or exceeding) their respective limits is α^2 (or $< \alpha^2$); consequently, equation (E-8) can be established.

$$\text{Probability} \left[\hat{X}(\text{lower}) < X < \hat{X}(\text{upper}) \right] \geq 1 - \alpha^2 \quad (\text{E-8})$$

E.2.2 Example. Using the data from table E-1, rearrange the sample elapsed time (x) in the ascending order as recorded in table E-1, column (5). The remaining columns of table E-1 are described as follows: Columns (1) and (2) are self-explanatory, and column (3) records the midpoint of accumulative frequency of column (2). For instance, midpoint of 0 and 0.1 is 0.05, midpoint of 0.1 and 0.2 is 0.15, etc. A simple formula for estimating midpoint accumulative frequency (F') is shown in equation (E-9).

$$\frac{2i-1}{2M} = F' \quad (\text{E-9})$$

i = the sample sequence, which ranges from 1 to n

M = the total interval size, which is 10 in this example

F' = the midpoint accumulative frequency

Column (4) records the standardized normal variate value Z , which can be derived from a cumulative normal table with F' values as the inputs. Column (5) records sample data (x) in ascending order. Columns (6) through (9) data can be computed using equations (E-6) and (E-7).

TABLE E-1. CONFIDENCE BOUND DUE TO RANDOM SAMPLE VARIATIONS OF
PARAMETER ESTIMATES, METHOD 1 DATA

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
k	Accum. Freq. (F)	Midpoint F'	Z	Repair Time x	lnx (upper)	lnx (lower)	$\hat{x}$ (upper)	$\hat{x}$ (lower)
1	0.1	0.05	-1.645	0.5	-0.319	-1.565	0.727	0.209
2	0.2	0.15	-1.04	0.65	-0.024	-1.013	0.976	0.363
3	0.3	0.25	-0.675	0.8	0.154	-0.679	1.166	0.507
4	0.4	0.35	-0.386	0.9	0.295	-0.416	1.343	0.660
5	0.5	0.45	-0.125	1.1	0.422	-0.177	1.525	0.838
6	0.6	0.55	0.125	1.25	0.597	-0.001	1.817	0.999
7	0.7	0.65	0.386	1.5	0.836	+0.126	2.306	1.134
8	0.8	0.75	0.675	1.8	1.100	0.267	3.004	1.306
9	0.9	0.85	1.04	2.3	1.43	0.445	4.195	1.560
10	1.0	0.95	1.645	4.1	1.987	0.740	7.294	2.095
			$\Sigma Z=0$					

In order to use equations (E-6) and (E-7), μ'_H , μ'_L , σ'_H , and σ'_L must first be computed. The computation procedures are illustrated as follows:

$$n = 10 = M$$

$$MTTR_G = \text{Antilog} \left(\sum_{i=1}^n \log x/n \right) = 1.234$$

$$\hat{\mu} = \ln (MTTR_G) = 0.210$$

$$\hat{\sigma} \text{ estimated from equation (E-2)} = 0.623$$

Let $\alpha = 20$ percent. From a student's t table,

$$t_{0.2/2(10-1, \text{d.f.})} = 1.383.$$

From equation (E-4):

$$\hat{\mu}'_L = \hat{\mu}' - t_{\alpha/2(n-1)} \frac{\hat{\sigma}}{\sqrt{n}} = -0.062$$

$$\hat{\mu}'_H = \hat{\mu}' + t_{\alpha/2(n-1)} \frac{\hat{\sigma}}{\sqrt{n}} = 0.483$$

From equation (E-5):

$$\begin{aligned}\hat{\sigma}'_H &= \hat{\sigma}' \sqrt{\frac{(n-1)}{\chi^2_{(\alpha/2)(n-1) \text{ d.f.}}}} \\ &= 0.623 \times \sqrt{\frac{10-1}{4.17}} = 0.915 \\ \hat{\sigma}'_L &= \hat{\sigma}' \sqrt{\frac{(n-1)}{\chi^2_{(1-0.2/2)(n-1) \text{ d.f.}}}} \\ &= 0.623 \times \sqrt{\frac{10-1}{14.7}} = 0.487\end{aligned}$$

To compute data in columns (6) and (8) for $Z = +1.645$, equation (E-6) can be used as follows:

$$\ln \hat{X} \text{ (upper)} = Z (\hat{\sigma}'_H) + \hat{\mu}'_H = 1.645 \times (0.915) + 0.483 = 1.987$$

$$\hat{X} \text{ (upper)} = \exp [1.987] = 7.294$$

To compute columns (7) and (9) data for $Z = +1.645$, equation (E-6) can be used as follows:

$$\ln \hat{X} \text{ (lower)} = Z (\hat{\sigma}'_L) + \hat{\mu}'_L = 1.645 \times (0.487) - 0.062 = 0.739$$

$$\hat{X} \text{ (lower)} = \exp [0.739] = 2.095$$

Similarly, the other data of columns (6) through (9) can be computed; however, notice that equation (E-6) should be used for all positive Z values, and equation (E-7) should be used for all negative Z values.

The $\hat{X}$ (upper) and $\hat{X}$ (lower) values with their corresponding F' values are plotted in figure E-1 to provide Method 1 confidence bounds.

E.3 Procedures for Estimating Confidence Bound Due to Random Deviation from a True Lognormal Distribution, Method 2

Method 2 is based on a classical linear regression confidence bound computation procedure. The basic notations stated in section E-2 are unchanged; however, because the method is intended to estimate the confidence bound due to the random deviations from the smooth envelope of a true lognormal distribution, equation (E-1) in section E.2 should be replaced by equation (E-10) below:

$$\ln X = Y' = \mu' + \sigma'Z + \epsilon \quad (\text{E-10})$$

ϵ is a nuisance variable that is assumed to be normally distributed about the regression line with a variance equal to σ_ϵ^2 and a mean roughly equal to zero. If the true values of μ' , σ' , and σ_ϵ are known, the 95th percentile prediction interval for Y'_0 would be simply:*

$$\mu' + \sigma'Z_0 - 1.96\sigma_\epsilon \text{ to } \mu' + \sigma'Z_0 + 1.96\sigma_\epsilon$$

Because all three parameters are unknown, we shall attempt to establish an interval in terms of their estimates. The variate $\hat{\epsilon}\Delta = Y'_0 - \hat{\mu}' - \hat{\sigma}'Z_0$ (or $\hat{\epsilon} = y'_0 - \hat{\mu}' - \hat{\sigma}'Z_0$)** must also be normally distributed because it is a linear function of the normal variates Y'_0 (or y'_0), $\hat{\mu}'$, and $\hat{\sigma}'$. The mean of $\hat{\epsilon}$ is zero and its variance $\sigma_{\hat{\epsilon}}^2$, is:

$$\begin{aligned}\sigma_{\hat{\epsilon}}^2 &= E(\hat{\epsilon}^2) \\ &= E(y'_0 - \hat{\mu}' - \hat{\sigma}'Z_0)^2 \\ &= \sigma_\epsilon^2 \left[1 + \frac{1}{n} + \frac{Z_0^2}{\sum Z^2} \right] \quad (E-11)^\dagger\end{aligned}$$

The meaning of the terms on the right hand side of equation (E-11) are explained as follows: the first term is the expected variance of y'_0 or simply σ_ϵ^2 , the second term is the variance contribution to $\sigma_{\hat{\epsilon}}^2$ due to the random variable $\hat{\mu}$, and the third term is the variance contribution to $\sigma_{\hat{\epsilon}}^2$ due to the random variable $\hat{\sigma}'$.

Since the variate $\hat{\epsilon}/\sigma_{\hat{\epsilon}}$ is normally distributed with zero mean and unit variance and is distributed independent of $\sigma_{\hat{\epsilon}}^2$ $(n-2)/\sigma^2$ which has a chi-square distribution, equations (E-12) and (E-13) can be established:††

$$t = \frac{\hat{\epsilon}/\sigma_{\hat{\epsilon}}}{\sqrt{\hat{\sigma}_\epsilon^2 / \sigma_\epsilon^2}} \quad (E-12)$$

* Y'_0 indicates a specific Y' value, that corresponds with Z_0 , which is a specific value of Z ; y' is a subset of Y' .

** $\hat{\epsilon}$ is the estimate of ϵ ; $\hat{\epsilon}$ is an estimate of $\hat{\epsilon}$.

†Equation (E-11) is true only when $\sum_{i=1}^n Z/n$ or $\bar{Z}$ is zero. For the lognormal distribution application, this condition is quite appropriate because at the median (50th percentile) of a distribution, Z is always zero. See derivation in: (1) Mood, A., and Graybill, F., "Introduction to the Theory of Statistics," McGraw-Hill, 1963, Section 10.4; and (2) NBS HDBK 91, "Experimental Statistics," August 1963, Chapter 5.

†† $\hat{\sigma}_\epsilon^2 = \sum_{i=1}^n (y'_i - \hat{\mu}' - \hat{\sigma}'Z_i)^2 / (n-2)$; two degrees of freedom are lost due to the estimates of μ' and σ' .

$$\text{Probability } \left\{ (\hat{\mu}' + \hat{\sigma}' z_0 - A) < y'_0 < (\hat{\mu}' + \hat{\sigma}' z_0 + A) \right\} = 1 - \alpha$$

where:

(E-13)

$$A = t_{\alpha/2}(n-2 \text{ d.f.}) \hat{\sigma}_e \sqrt{1 + \frac{1}{n} + z_0^2 / \sum z^2}$$

E.3.1 Comments on Equation (E-13). Note that y'_0 is a subset of Y'_0 , or simply its estimate. The y'_0 range predicted by equation (E-13) is only a subset of Y'_0 range—not the expected maximum range of Y'_0 with $(1 - \alpha)$ probability. The sample result shown in figure E-1 points out that equation (E-13) only effectively predicts the confidence interval for the random sample deviations from the smooth envelope of the lognormal distribution. To predict the expected maximum Y'_0 range, equation (E-14) in section E.4 should be consulted. In other words, equation (E-13) holds only for a single prediction based on μ , σ , and σ_e ; the relation has meaning only if μ' , σ' , and σ_e are re-estimated each time a prediction on y'_0 is made.

E.3.2 Illustrative Example (Method 2). Again, the repair time data from table E-1 are used for the illustrated example. As explained in section E.2, μ' is 0.210, $\hat{\sigma}$ is 0.623, and n is 10. α is chosen to be 0.10 and $t_{\alpha/2}(n-2, \text{d.f.})$ is 2.306. Table E-2 data computation procedures are explained as follows.

Columns (1) through (5) data of tables E-1 and E-2 are identified; the descriptions of these data are the same as that stated in section E.2.

Columns (6) through (8) are self-explanatory. Note that sum of column (7) data should be close to zero to ensure that the regression line achieved by the shortcut method shown in section E.1 is roughly equivalent to that by the classical linear regression line estimation approach. Also, note that the unbiased estimate of σ_e is:

$$\begin{aligned} \hat{\sigma}_e &= \sqrt{\frac{\text{Sum of Column (8) table E-2}}{n-2}} \\ &= \sqrt{\frac{0.062}{10-2}} = 0.088 \end{aligned} \quad (E-14)$$

Column (9) "A" data can be computed by inserting the appropriate parameter values into equation (E-13). Note that in this illustrated example $\sum z^2$ is roughly 8.800.

Columns (10) through (13) data derivation procedures are self-explanatory. Columns (10) and (11) provide y'_0 ranges defined by equation (E-13). Columns (12) and (13) convert these y'_0 range values to x values so that they can be plotted on figure E-1.

TABLE E-2. CONFIDENCE BOUND DUE TO RANDOM SAMPLE
DEVIATIONS FROM A TRUE LOGNORMAL DISTRIBUTION
(METHOD 2)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
h	Accum. Freq. (P)-h/n	Midpoint of Y' y'	z	Repair Times x	W = $\mu' + \sigma' z$	ln W-0	z^2	A (at $\sigma' = 0$), see Equation (E-13)	W-A	W+A	n(high)= exp(W-A)	n(lower)= exp(W+A)
1	0.1	0.05	-1.645	0.5	-0.814	0.121	0.015	0.240	-1.034	-0.374	0.348	0.344
2	0.2	0.15	-1.04	0.65	-0.437	0.006	0.000	0.234	-0.661	-0.213	0.516	0.608
3	0.3	0.25	-0.675	0.8	-0.210	-0.013	0.000	0.217	-0.427	+0.007	0.652	1.007
4	0.4	0.35	-0.386	0.9	-0.030	-0.075	0.006	0.214	-0.244	+0.184	0.784	1.202
5	0.5	0.45	-0.125	1.1	+0.133	-0.037	0.001	0.213	-0.060	0.346	0.923	1.413
6	0.6	0.55	0.125	1.25	+0.288	-0.065	0.004	0.213	+0.075	0.501	1.078	1.638
7	0.7	0.65	0.386	1.5	+0.451	-0.045	0.002	0.214	0.237	0.665	1.267	1.944
8	0.8	0.75	0.675	1.8	+0.631	-0.043	0.002	0.217	0.414	0.848	1.513	2.333
9	0.9	0.85	1.04	2.3	+0.858	-0.025	0.001	0.224	+0.634	1.082	1.885	2.938
10	1.0	0.95	1.645	4.1	+1.234	+0.177	0.031	0.240	+0.994	1.474	2.702	4.367

E.4 Comment on Figure E-1 and the Procedure for Combining
Methods 1 and 2

After observing the regression line confidence bounds shown in figure E-1, we can see that the method 2 prediction is effective only in predicting the confidence interval for the noise effect alone. According to table E-2, column (9), the A values are nearly constant, which is roughly equivalent to the product of $t_{\alpha/2}(n-2, d.f.)$ and $\hat{\sigma}_e$.^{*} As a sample size (n) increases, this phenomenon will be even more noticeable. This is because table E-2, column (9) data is computed assuming $\hat{\mu}'$, $\hat{\sigma}'$ are constants so that the computed A value will predict the range of y'_o (which is a subset of Y') at a given confidence level. If equation (E-13) is modified to predict the confidence interval of Y'_o instead of y'_o , the worst expected combination of maximum ranges of $\hat{\mu}'$ and $\hat{\sigma}'$ values should be used so that the probability

$$(V_L < Y'_o < V_H) = \text{probability} \left\{ \hat{\mu}' () + \hat{\sigma}' () z_o - A < Y'_o < \hat{\mu}' () + \hat{\sigma}' () z_o + A \right\} \geq 1 - \alpha \quad (E-15)$$

^{*}The A value is the repair time interval between confidence bound and regression time.

In this case $\hat{\mu}(\)$ can be either $\hat{\mu}'_H$ or $\hat{\mu}'_L$, and $\hat{\sigma}'(\)$ can be either $\hat{\sigma}'_H$ or $\hat{\sigma}'_L$ depending on which combination provides the maximum range of Y'_O . The rules for selecting the proper pair of $\hat{\mu}'$ and $\hat{\sigma}'$ limits are as follows:

$$V_H = \ln \hat{X} \text{ (upper)} + A = \hat{\mu}'_H + Z_O(\hat{\sigma}'_H) + A \text{ for } Z_O \geq 0 \quad (E-16)$$

$$V_H = \ln \hat{X} \text{ (upper)} + A = \hat{\mu}'_H + Z_O(\hat{\sigma}'_L) + A \text{ for } Z_O \leq 0 \quad (E-17)$$

$$V_L = \ln \hat{X} \text{ (lower)} - A = \hat{\mu}'_L + Z_O(\hat{\sigma}'_L) - A \text{ for } Z_O \geq 0 \quad (E-18)$$

$$V_L = \ln \hat{X} \text{ (lower)} - A = \hat{\mu}'_L + Z_O(\hat{\sigma}'_H) - A \text{ for } Z_O \leq 0 \quad (E-19)$$

This rule is identified with that shown in equations (E-6) and (E-7).

Since the value of $\hat{\mu}'_H$, $\hat{\mu}'_L$, $\hat{\sigma}'_H$ and $\hat{\sigma}'_L$ can be estimated by equations (E-4) and (E-5), and A'_R value can be estimated by equation (E-13), the confidence bound predicted by equation (E-15) is equivalent to the combined results of Methods 1 and 2. To illustrate how combined Methods 1 and 2 can be used, table E-3 is constructed. The procedures for computing the data in table E-3 are explained as follows:

Column (1) and (2) data are obtained from table E-1 or E-2, columns (3) and (4).

To estimate the data in row 1 of columns (3) and (4):

$$\hat{\mu}'_H \text{ (from page 7-8 computation)} = 0.483$$

$$\hat{\sigma}'_L \text{ (from page 7-8 computation)} = 0.487$$

$$A \text{ (from table E-2, row 1, column (9))} = 0.240$$

$$V_H = 0.483 - 1.645(0.487) + 0.240 = -0.078$$

$$\hat{\mu}'_L \text{ (from page 7-7 computation)} = -0.062$$

$$\hat{\sigma}'_H \text{ (from page 7-8 computation)} = 0.915$$

$$V_L = \mu'_L - 1.645(\sigma'_H) - 0.240 = -1.807$$

To estimate the data in row 1 of columns (5) and (6):

$$\hat{X}_{\text{high}} = \exp(V_H) = \exp(-0.078) = 0.925$$

$$\hat{X}_{\text{low}} = \exp(V_L) = \exp(-1.807) = 0.164$$

TABLE E-3. COMBINED METHODS 1 AND 2 CONFIDENCE BOUND PREDICTION

(1)	(2)	(3)	(4)	(5)	(6)
F'	Z	$V_H = \ln X$ (upper) + A	$V_L = \ln X$ (lower) - A	Combined $\hat{X}_{high} = \exp V_H$	Combined $\hat{X}_{low} = \exp V_L$
0.05	-1.645	-0.078	-1.807	0.925	0.164
0.15	-1.04	+0.200	-1.237	1.221	0.290
0.25	-0.675	+0.371	-0.897	1.449	0.408
0.35	-0.386	0.509	-0.629	1.663	0.533
0.45	-0.125	0.634	-0.389	1.886	0.678
0.55	0.125	0.810	-0.214	2.247	0.808
0.65	0.386	1.050	-0.088	2.857	0.916
0.75	0.675	1.317	0.050	3.733	1.051
0.85	1.04	1.658	0.221	5.248	1.247
0.95	1.645	2.227	0.499	9.276	1.647

E.4.1 Final Comment on Combined Methods 1 and 2. Note that α used in method 1 (table E-1) is 20 percent while α used in method 2 (table E-2) is 5 percent. Proof that these methods are compatible is that according to equation (E-8), the ultimate confidence level of method 1 is $1 - (20\%)^2$, or 96 percent, while that by method 2 is $1 - (5\%)$, or 95 percent. Since c defined by equation (E-10) is independent of μ' and σ' , the combined confidence level according to equation (E-15) should be equal to or greater than 95 percent.