AN EVALUATION OF THE EFFECT OF SPARES ALLOWANCE POLICY UPON SHI--ETC(U)

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THESIS

AN EVALUATION OF THE EFFECT OF SPARES ALLOWANCE POLICY UPON
SHIP AVAILABILITY AND RELIABILITY

by

John Edward Leather

September 1980

Thesis Advisor: F. Russell Richards

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An Evaluation of the Effect of Spares Allowance Policy Upon Ship Availability and Reliability

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An Evaluation of the Effect of Spares Allowance Policy Upon Ship Availability and Reliability

by

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ABSTRACT

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I. INTRODUCTION

The capability of a modern warship to be combat ready and maintain this readiness over a deployment period depends on logistics support. While this support includes such necessities as food, fuel, medical supplies etc., a crucial element in maintaining the sophisticated shipboard systems is the availability of repair parts. More important, of course, is the necessity of having a skilled technician capable of diagnosing any problems and effecting the required repairs. This thesis will focus entirely upon the 'part' side of this two-way problem, knowing full well that the desired technical expertise is not always available on all ships.

To provide for the capability of repairing equipment while away from port or support ships, each ship is provided a quantity of spares designed to enable it to be self sufficient for a period of 90 days. Budget and storage constraints prohibit stockpiling spares to cover all possible requirements, therefore a choice must be made as to the method to allocate the range and depth of spares to be provided.

Chapter II discusses the way the Navy is currently making this allocation. The method has been successful for a number of years, but less so recently due to changes in
provisioning model parameters. These changes were dictated by the 'high cost' of the allowance list generated by previous parameters.

Chapters III, IV, and V describe the use of a reliability block diagram simulation program to evaluate the effect of changing the spares suite upon the reliability/availability of a shipboard system over a 90 day period with no external spares replenishment. To obtain an upper bound on the spares effectiveness, the 90 day period was simulated with all repairs being instantaneous; thereby placing the entire burden of making the system available on the spares suite and not upon the speed of the repair. From this technique a measure of effectiveness of each given spares suite can be derived.

As an example, a particular reliability block diagram is analyzed in chapter VI using the simulation technique. The nature/configuration of this block diagram has a large effect on the figure of merit results. For example, three different items connected in series would be less reliable than the same three connected in parallel where only two are required to be functioning at once and the third was in cold standby. It is for this type of reason that a provisioning process based on parts counting rather than reliability may provide satisfactory results for one system and unsatisfactory results for another when both systems possibly consist of the same piece parts or perform the same function.
The simulation (called TIGER) is a general reliability simulation model and is capable of many other uses besides the one chosen for this thesis. With the help of the appendices, the program listing, and the TIGER manual (Ref. 1) further use of this program on the Naval Postgraduate School (NPS) computer system or any other FORTRAN IV compatible system with random number generation capability should be feasible.
II. THE COORDINATED SHIPBOARD ALLOWANCE LIST (COSAL)

A. NAVY POLICY FOR PROVIDING SUPPLY SUPPORT OF THE OPERATING FORCES

The amount of logistic support required to support the desired levels of fleet readiness are delineated in Ref. 2. Of concern here are the sections on Shipboard Stock Levels and Criteria for Shipboard Allowances.

All non-Fleet Ballistic Missile (FBM) self-sustaining ships have a stockage objective of 90 days, which is equated to the endurance for the ship. This objective is applicable to repair parts, spares, and equipment related consumables.

The specific criterion for developing a COSAL from a list of those items capable of being repaired by shipboard personnel is the subject of the next section of this thesis.

The measures of effectiveness for COSAL performance as stated in Ref. 2, are to 'fill from onboard stocks 65% (gross effectiveness) of all demands and to provide an overall availability for items allowed to be carried of 85% (net effectiveness)'. It is essential to note that no mention is made of such terms as reliability, availability, or readiness in the context of the supported ship as a measure of COSAL effectiveness.

Net effectiveness is often called 'system' effectiveness, in that it is the effectiveness of the entire logistics
system in replenishing shipboard spares once they are used and reordered. As this is not specifically related to the COSAL provisioning document, but is a function of such diverse items as order and shipping times, specific examination of this measure will not be attempted. Rather, certain stated assumptions will be made regarding the percentage of spares onboard when it is necessary to do so.

The objective of 65% gross effectiveness is the central issue which this thesis will focus upon. As will be shown in the next section, the COSAL mathematical model in no way can be substantiated as a '65% gross effectiveness model'. More important is the question of '65% gross effectiveness' as a measure of effectiveness for shipboard support. One could conceive of ways to fill 75% of the requisitions received in 90 days from shipboard stock and never be able to get underway. Alternatively, a low fill rate could result in a highly successful deployment. The key, obviously, is to stock those items which are important to the ships mission, and not to stock simply to maximize stock turn.

B. CURRENT COSAL MATHEMATICAL MODELS

Several mathematical models are currently being used to generate COSALs. The Fleet Logistic Support Improvement Program (FLSIP) model is used for surface ships and Fast Attack Submarines (SSN) and is the most extensively used technique. The TRIDENT model is used on Fleet Ballistic
Missile Submarines (FBM) and is similar to the Maintenance Criticality Oriented (MCO) COSAL being implemented on the FFG-7 Lo-Mix class of ships.

1. FLSIP Model

The FLSIP model has been in use for many years and has proven to be a rapid, workable, and understandable method of generating the large quantity of COSALS that must be run (approximately 50 per month). This model simply processes a list of all repair parts applicable to the particular ship and capable of being replaced by the ship's force. Each part is individually totaled for its' entire installed shipwide population and then is multiplied by its' Best Replacement Factor (BRF) (explained in chapter IV). The resultant value is called the 'mean', and this mean is used with the essentiality of the parent equipment to determine the final allowance quantity. A FLSIP logic diagram is shown in figure 1.

The attempt to incorporate essentiality into this model has been negated by the migration of over 90 percent of the parts on file into the 'vital' category. Technical Overides (TORS) have been frozen by the Chief of Naval Operations (CNO) as a cost reduction measure.

The currently used model is called a .25 FLSIP model since the insurance cut point is .25 (one expected demand in four years). As over 90 percent of the items stocked on-board a ship are stocked at a depth of one, this cut point is critical to the ability of the model to provide sufficient
Definitions:

Item Pop - Consolidated population of the item throughout the ship's systems

BRF - Best replacement factor

s - minimum stocking depth such that \( Pr(\text{Actual 90-day demand} \geq s) = 0.90 \) (Assuming Poisson distribution)

MRU - Minimum replacement 'unit' quantity, if any

PMR - Required preventative maintenance quantity for planned maintenance

TOR - Technical override quantity, if any; determined by engineers/designers during equipment provisioning review

Vital-Vital code - Item vital to its parent component, and its component vital to a primary mission
support. This cut point was changed from a previous value of .15 due to various budgetary pressures.

Aside from the arbitrary nature of the value chosen as the cut point the main problems which continue to exist are the effectiveness criteria established in Ref. 2 and the fact that the FLSIP model (Figure 1) has no mathematical relationship to these criteria. If the FLSIP is to be continued in use, and indications are that it will (Ref. 3), meaningful effectiveness criteria must be established and a means developed to justify the use of the FLSIP model to meet these criteria.

2. TRIDENT Model

The TRIDENT model incorporates military essentiality codes (MEC) assigned to the parent equipment into the stockage allowance decision. The more essential the equipment, the better it will be supported. The following equation is used to calculate the allowance quantity:

\[ \text{Allowance quantity} = \mu + (Z\mu) \]

Where \( \mu \) is the mean of the assumed Poisson distribution of repair part requirements in 90 days).

The multiplier \( Z \) is a function of essentiality and to a lesser degree the unit price of the part. As in the FLSIP model each candidate part is processed individually and is not subject to budget constraints (although the levels may be adjusted through the manipulation of the various factors which comprise \( Z \)).
This model is currently in use; takes essentiality of equipment into account; and provides excellent support. But as could be expected, the resulting COSAL provides generous allocation of spare parts and its cost would be hard to justify outside of the FBM arena.

3. Maintenance Criticality Oriented (MCO) Model

The MCO model is an allowance list to be implemented on an increment of the new FFG-7 Lo-Mix class of ships. The mathematical technique is very similar to the TRIDENT model, the main difference being that essentiality is carried all of the way to the part level. The documentation required to achieve this is extensive and costly and must be maintained throughout the life of the ship. The documentation required to backfit the MCO model to older classes of ships does not exist.
III. THE NAVAL SEA SYSTEMS COMMAND TIGER SIMULATION PROGRAM

A. INTRODUCTION

TIGER is the generic name for a family of computer simulation programs which can be used to evaluate a complex system in order to estimate various reliability, readiness, and availability measures. This program was developed by the Naval Sea Systems Command (NAVSEA) reliability branch. The reliability block diagram of the system/component under study is the foundation from which a TIGER simulation run is constructed. This block diagram may be for a large system (ship) with each block representing a component of the system; or it may be for a single component with each block representing a lowest replacement unit part; or the block diagram may be any type of combination of both. As an input for each block the Mean Time Between Failures (MTBF) and Mean Time to Repair (MTTR) must also be known.

The unique feature about TIGER is the flexibility incorporated into the program. Scenarios with block diagram configurations which change during the time period being simulated are evaluated through a series of different time-line 'phases' in the input. A phase is a specific reliability configuration for the ship being studied. The simulation will accept up to six different phases, and they may be sequenced in any order and be of any interval of time. The
phases may be strung together until the simulation capacity of 95 total phases is reached. MTBF, MTTR, and spares multiplier factors may be entered to perform sensitivity analyses on the system under study.

TIGER uses Monte Carlo random number methods to evaluate the input block diagram. The random numbers are generated through the use of the NPS LLRANDOM routine (Ref.4).

The TIGER simulation is a discrete event step simulation. Exponential failure and repair times are generated using the MTBF and MTTR input data. As equipments fail spares are used; repairs effected (if allowed in the phase); standby equipment turned on/off if required; and different block diagrams initiated as the different phases are encountered during the timeline. Statistics are collected as a result of each event and change of configuration.

The TIGER output includes estimates of reliability, readiness, availability, and critical components which caused the most severe degradation of reliability and availability. The user may change the random number seed and replicate a timeline as many as 1000 times in a single TIGER run. TIGER will calculate and provide a lower confidence limit for the point estimate of reliability.

The inherent limitations to the use of this type of simulation include both the problem of providing accurate input data (MTBF, MTTR) and the exponential failure/repair rate assumption used in the program. Under many scenarios and for many types of equipment this exponential assumption is valid.
but certainly many types of equipment exhibit wearout and not all repair times are exponentially distributed.

In addition to the output mentioned above, spares usage may also be displayed as well as several standard and optional outputs of the progress of the simulation. The detail can vary from every event being shown to a much simpler management summary.

Two subroutines of TIGER were omitted in this thesis research but may be useful in different types of analysis. One of these, the GAMMA option, assumes that the system being evaluated has a gamma failure distribution and calculates the two parameters (shape and scale) for the gamma distribution which would exhibit the same mean and variance of mission failure times as the system being modeled. The DEMO option of TIGER provides the capability of generating a sequential probability test ratio plan for the system as prescribed in MIL-STD-781. Detailed information about TIGER including GAMMA; DEMO; and a TIGER/MANNING personnel requirements type program is found in Ref. 1.

B. PRESENT NAVSEA TIGER UTILIZATION

The TIGER program is being used by NAVSEA to evaluate Reliability, Maintainability, Availability (RMA) performance characteristics of new ship classes (Ref. 5). This analysis is performed only on the major mission-essential systems: Navigation, Auxiliary, Electrical, Ship Control, Propulsion,
Exterior Communications, and Combat. Only these systems and equipment which impact the operational readiness of the ship and the ship's ability to perform its assigned primary combatant mission are included in the analysis.

All surface ships constructed since 1970 have reliability block diagrams available (in computer readable form). This eliminates the major undertaking of having to construct the reliability block diagrams prior to using TIGER. The necessary MTBF and MTTR data for existing equipment is found in the Reliability/Maintainability/Availability Design Data Bank (Ref. 6), which is a compilation of data from both engineering design and fleet feedback. Engineering estimates must be used for the many new systems found on a new class of ship, where no feedback data yet exists.

Along with the various reliability block diagram configurations (steaming, in-port, ASW, etc.) and MTBF/MTTR data, the operating rules for the equipment must also be provided. These rules include allowable downtime, spares, mission timelines, and maintenance policy.

A sample RMA timeline (Ref. 5) is shown in figure 2. Timelines are tailored to the class of ship and its designed usage in a period of combat.

Allowable downtime is the time that the system or equipment can be down for maintenance without causing a mission abort. During simulated combat periods this time is usually zero for most mission essential systems.
| DAY  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| ENGAGEMENT CODE| 7  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| MISSION | TRANSIT | CONVOY ESCORT | TRANSIT | CARRIER TASK FORCE | CARRIER TASK FORCE | TRANSIT | AMPHIBIOUS OPERATIONS | TRANSIT | IN PORT | TRANSIT | IN PORT | TRANSIT | IN PORT |
| DAY  | 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 |
| ENGAGEMENT CODE| 3  | 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5| 2/5|
| MISSION | CARRIER TASK FORCE | TRANSIT | AMPHIBIOUS OPERATIONS | TRANSIT | IN PORT | TRANSIT | IN PORT |

**Table:**

- **Phase Codes:**
  - **A:** Wartime Cruising
  - **B:** Engage
  - **C:** In Port

**Engagement Codes:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Engagement Type</th>
<th>Duration (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AEW</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>AEW</td>
<td>0.5</td>
</tr>
<tr>
<td>3</td>
<td>AAW</td>
<td>0.25</td>
</tr>
<tr>
<td>4</td>
<td>AAW</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>AAW</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>AAW</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>ASW</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>ASW</td>
<td>3</td>
</tr>
</tbody>
</table>

**Figure 2**
Maintenance policy limits certain equipment to being capable of repair only during certain phases. For example, repair of the main engine would not be permitted while hunting a submarine, but would be permitted while in-port.

Spares are assumed to be available as needed for initial TIGER analysis. Supportability tradeoff studies are conducted separately to evaluate the effect of different spares efficiency percentages and off-ship logistic delay times.

The results of the TIGER simulation are compared with design specifications to see if any inherent (non-spares related) reliability problems exist. Critical equipments are then identified and closely monitored during the final phases of design and construction.

C. PROPOSED TIGER UTILIZATION FOR COSAL PREPARATION

Reference 7 describes a methodology of using the TIGER program to evaluate a COSAL with respect to reliability. The inputs to the TIGER program would be the same as those in the last section with the exception of the spares input and the indenture level of the reliability block diagram. The diagram must not stop at the equipment level, but be carried out to the repair part level. MTBF/MTTR data must also be provided at the repair part level.

As may be readily apparent, the block design for just the essential equipment of an entire ship would be very cumbersome and unworkable. This type of TIGER analysis must
be done on a system or equipment basis. The spares input would be that generated by the COSAL model under evaluation, usually FLSIP.

A deployment timeline is simulated and the resulting reliability/availability figures are compared to the design goals. If the goals are not achieved the 'bad apples' list of repair parts indicates the particular parts which caused the most degradation. Additional quantities of these parts are added to the spares suite and the process is repeated until the goal is attained. This method may also be used in reverse, removing spares and observing the resulting changes to reliability/availability.

While this methodology is feasible and would certainly provide better support than an unaugmented FLSIP COSAL, it has several drawbacks. One is the lack of reliability block diagrams down to the repair part level. Although new equipment procurement contracts may specify that this documentation must be provided, the task of assembling it for just one ship's essential equipment would be awesome.

Another problem is the lack of MTBF/MTTR data for each part. Reference 8 may be used to estimate the required parameters, but again this is a large undertaking. As was mentioned earlier in this thesis, current provisioning processes use a BRF vice MTBF to determine logistic support. A further clarification of the differences between these two and a proposed solution will follow in a later section.
A final problem results from the fact that repeated computer runs on a vast network of reliability block diagrams are required to produce a single COSAL. The computer system at the Ships Parts Control Center (SPCC) is saturated and could not begin to process the large quantity of simulation runs necessary to use this proposed method on all COSALs. In addition, a significant number of manhours would be required to review each run and decide which parts to augment and in what quantity. Though this process would undoubtedly produce a COSAL superior to the FSLIP model, practicality prevents its adaption at the present time.
IV. BEST REPLACEMENT FACTOR (BRF)

A. BRF - WHAT IS IT?

The BRF is the projected annual replacement rate for one installed unit of a repair part. Only one BRF exists for each part even if it is used in numerous applications throughout a given ship or the fleet or ashore. The BRF is found by dividing the annual reported usage in the fleet by the total installed population. This yields annual failures per installation. Before any calculations are made the input data are adjusted for inaccuracies caused by bad reporters and inactive ships in overhaul. The BRF is calculated annually for each item in the SPCC files. To prevent rapid fluctuations from occurring the previous value on file is updated with the new value by the use of exponential smoothing.

To illustrate this process suppose that 105 ships in the fleet were each recorded as having two of part 'A' installed. Five ships were in overhaul for this particular year so their data is not used for BRF update. The remaining 100 ships reported a total of 400 failures for item 'A'. Since there are 200 of 'A' installed and 400 were used, the unsmoothed BRF is 400/200 = 2.0. If the BRF currently on file is 2.4 and exponential smoothing with smoothing constant .25 is used, the updated BRF would be 2.4x.75 + 2.0x.25 = 2.3.
This BRF would be put on file for use in all COSALS which contain part 'A'.

B. MEAN TIME BETWEEN FAILURE (MTBF)

MTBF is the expected value of the operating time between failures of an item. It is estimated by dividing the total time in service by the number of failures:

\[
\text{MTBF} = \frac{\text{total time in service}}{\text{number of failures}}
\]

Sometimes the expression Mean Time to Failure (MTTF) is used for the expected value. Another related measure is the failure (hazard) rate which is the conditional probability that an item surviving to age \(t\) will fail in the interval \((t, t+dt)\). A constant failure rate is equivalent to having a failure distribution which is exponential; and for an exponential distribution the failure rate is the reciprocal of MTBF.

C. DIFFERENCES BETWEEN MTBF AND BRF

A MTBF provides an expected value of the length of time an item will operate until failure. It is based on operating time; and failures are not possible while the equipment is not in use or turned on. A BRF is the average number of times an item will fail in an average year in an average installation. Since these differences and similarities are crucial to the analysis in section VI of this thesis, the following example taken from Ref. 9 provides an insight into the MTBF/BRF relationship.
A piece of equipment (lamp) has four repair parts (bulb, socket/switch, cord, plug). It is operated for 1000 hours per year. An arbitrary MTBF and corresponding Failure Rate (expressed in failures per year) are shown below:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MTBF</th>
<th>FAILURE RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Bulb</td>
<td>750 HRS</td>
<td>1.333</td>
</tr>
<tr>
<td>Socket/Switch</td>
<td>10,000 HRS</td>
<td>0.100</td>
</tr>
<tr>
<td>Electric Cord</td>
<td>15,000 HRS</td>
<td>0.066</td>
</tr>
<tr>
<td>Plug</td>
<td>10,000 HRS</td>
<td>0.100</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>1.599</td>
</tr>
</tbody>
</table>

As shown, the lamp is expected to fail 1.599 times per year. This would be a BRF for the lamp if the maintenance policy were to replace the whole lamp no matter what the cause of the failure. The following table shows how maintenance philosophy can have a pronounced effect on the five BRFs. The 'Replace Failed Part' column represents the way repairs are usually accomplished at the shipboard level. Only catastrophic failure would lead to the attempted replacement of the entire item, usually unsuccessful because the entire assembly would not likely be stocked due to the low BRF.

<table>
<thead>
<tr>
<th>MAINTENANCE PHILOSOPHY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEM</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>LAMP</td>
</tr>
<tr>
<td>BULB</td>
</tr>
<tr>
<td>CORD</td>
</tr>
<tr>
<td>S/SWITCH</td>
</tr>
<tr>
<td>PLUG</td>
</tr>
</tbody>
</table>
D. BRF AS AN INPUT TO TIGER

When MTBF is used as an input to TIGER, various timelines are used to provide scenarios in which the equipment configurations and usage rates are required. When equipment is on, it fails exponentially with the given MTBF, unless the duty cycle is less than 100 percent, in which case the MTBF is divided by the duty cycle. The BRF has incorporated the various reasons the timeline approach must be used with the MTBF; equipment being turned off and on; duty cycles for equipment with cycles of less than one; and the various configuration dependent usage rates for an average installation in an average year.

Consider, for example, an equipment with a duty cycle of one-half (operating 50 percent of the time) exhibiting five failures in a ten year period. The MTBF is calculated as before; total time in-service/failures = (10x.5)/5 = 1 year. Since the duty cycle is one-half, we would expect to see a failure every other year, or .5 per year. The BRF calculation yields the same result; 5 failures/10 years = .5 failures/year.

To use a BRF in TIGER requires that the entire block diagram, in a typical configuration, be used and equipment/parts be allowed to fail at an annual rate (BRF) which takes the numerous operating scenarios into account. While the results from this type of analysis would be very difficult to defend as providing entirely accurate reliability/
availability measures; they should be suitable for deriving a 'figure of merit' evaluation for the support provided by different COSAL models.
V. TIGER USED TO EVALUATE THE EFFECT OF SPARES ALLOWANCE POLICY UPON RELIABILITY AND AVAILABILITY

A. INTRODUCTION

The current utilization of gross effectiveness as a measure of COSAL effectiveness has been studied in previous sections. An alternative measure will now be proposed. The TIGER program calculates reliability, availability, and readiness figures for each simulation run. The definitions for these three measures, as found in Ref. 1, are summarized below.

B. RELIABILITY (REL)

For a given timeline the reliability (REL), as estimated by TIGER, is the probability that the ship will successfully complete the entire timeline. For example, if the timeline previously shown in figure 2 were used, REL would be the probability of the ship completing all of the different missions assigned during the 60 day period, in the sequence shown.

Reliability is calculated by TIGER as follows:

\[ \text{REL (EST)} = 1 - \frac{\text{Number of mission failures (aborts)}}{\text{Total number of simulated missions}} \]

Note that this calculation incorporates logistics support considerations.
C. AVAILABILITY (AVA)

TIGER calculates two AVA parameters: Instantaneous and average. Instantaneous availability is the probability that the system will be 'up' at a specific point in time. Average availability is the probability that the system will be up at a random point in time. Because of the way TIGER is used, average availability is the relevant measure.

Average AVA is estimated as the ratio of total system 'uptime' to the total time simulated. These times are totaled for the entire number of missions simulated (up to 1000). The calculation is made as follows:

\[
AVA \text{ (EST)} = \frac{\text{Summation of uptime for all missions simulated}}{\text{Summation of total mission calendar time for all missions simulated}} = \frac{\text{Uptime}}{\text{Calendar time}}
\]

D. READINESS (RED)

RED, like AVA can be measured as instantaneous or average readiness. It is a measure of the probability that there is neither a mission abort nor a system down. The forthcoming methodology for the use of TIGER results in RED equaling AVA, so RED will not be considered any further as an alternative measure of effectiveness.
E. RELIABILITY VS AVAILABILITY AS A MEASURE OF EFFECTIVENESS

A very common measure of effectiveness in use by the Navy today is 'Operational Availability' (Ao). Ao is defined as the probability that an equipment is ready when you need it. MIL-HDBK-217C (Ref. 8) dictates that it be calculated by:

\[ \text{Ao} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}} \]

An alternative form of this equation results from breaking the MTTR up into the repair time (MTTR) plus the Mean Supply Response Time (MSRT); the time necessary to provide the required repair part(s). This yields:

\[ \text{Ao} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR} + \text{MSRT}} \]

There are problems with the use of this formula for estimating system operational availability (Ref. 10). From a mathematical point of view the formula yields the correct result for the limiting value of operational availability when one considers a single component that transitions between up and down states as an alternating renewal process. If one is interested in the operational availability after a fixed period of time for a system whose components have limited spares support, the formula does not yield correct results. In fact, the formula makes little sense. A simulation like TIGER is precisely what is needed to estimate Ao for a complex system with limited spares support.

Since AVA implicitly considers component reliability, maintenance, spare parts support, system configuration and...
operational scenario, it is used in this thesis to evaluate COSAL models.

F. ALLOWANCE POLICY EFFECT

1. Reliability Block Diagram of System

The effect of a parts-counting type allowance policy upon reliability/availability is dependent on the configuration of the system being supported. Parts counting is a method of allocating spares in proportion to the number of each specific repair part in the equipment. In an environment of limited budgets and storage space, a more 'critical' spare (in terms of reliability/availability) may be sacrificed to provide unwarranted depth for another spare. Figure 3 shows a simple reliability block diagram with two

Figure 3

of part A in parallel with each other and then in series with part B. Both A and B have a BRF of 1. If A cost the same as B, and only one spare could be provided, provisioning by parts counting would provide one spare of type A, since there are twice as many A as B. However, the availability of this system would be much greater (all other things considered the same) if the one spare purchased were of type B, due to the parallel redundancy.
2. Proposed Allowance Policy Input

There are two methods of entering the quantity of spares for each part type into the TIGER simulation. One is to input that quantity as part of the input data. For small systems this may be the most efficient method. For larger systems or for those systems requiring a complicated mathematical model, a subroutine has been added to TIGER to calculate the COSAL.

For the FLSIP COSAL, the cut point is input with the other system data and the spares subroutine is used to generate the COSAL for the system. The MTBF is derived from the BRF in the following manner:

\[ MTBF = \left( \frac{1}{BRF} \right) \times 8766 \]  (yr/fail)x(hr/year) = hr/fail

This MTBF is used as the exponential failure rate input for the simulation, and converted back to BRF when necessary to determine COSAL support.

3. Figure of Merit Results

Several simplifying assumptions are made by using TIGER to obtain the output availability measure. The most important are exponential failures; BRF converted to MTBF; zero repair times; a full allowance of spares onboard at the beginning of the mission; and the use of a 'typical' reliability block diagram configuration for the duration of a single mission. Because of these assumptions, the availability figure provided by TIGER should not be considered as the true value for system availability. However, this figure
should be useful as a 'Figure of Merit' for comparisons with
the figure derived for the same system using a different
methodology or level of logistics support. When used in
this context, the figure should provide an accurate assess-
ment of the relative effectiveness of two spares allowance
policies.
VI. EXAMPLE OF TIGER ANALYSIS

A. EQUIPMENT CONFIGURATION AND FAILURE RATES

1. Block Diagram and Operating Rules

As an example of the use of TIGER proposed in this thesis a hypothetical video display unit will be analyzed. The unit consists of a power section; signal processing section; and video display section. The required reliability block diagram is shown in figure 4.

POWER SECTION

SIGNAL PROCESSING SECTION

VIDEO SECTION

Figure 4
The three sections are connected in series to form the entire unit. Only one of circuit board A is required to be 'up' in the power section, and two of circuit board B in the signal processing section. The failure of two of either circuit board A or B or the failure of any other single part will cause system failure.

2. Failure Rates

The following is a list of the BRF for each part and corresponding MTBF:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>BRF</th>
<th>MTBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch</td>
<td>.09</td>
<td>97400</td>
</tr>
<tr>
<td>Fuse - A</td>
<td>2.50</td>
<td>3506</td>
</tr>
<tr>
<td>Transformer</td>
<td>.17</td>
<td>51565</td>
</tr>
<tr>
<td>Circuit Board - A</td>
<td>2.10</td>
<td>4174</td>
</tr>
<tr>
<td>Coupler</td>
<td>.23</td>
<td>38113</td>
</tr>
<tr>
<td>Circuit Board - B</td>
<td>2.50</td>
<td>3506</td>
</tr>
<tr>
<td>Fuse - B</td>
<td>3.60</td>
<td>2435</td>
</tr>
<tr>
<td>Rheostat</td>
<td>.12</td>
<td>73050</td>
</tr>
<tr>
<td>Circuit Board - C</td>
<td>1.20</td>
<td>7305</td>
</tr>
<tr>
<td>Circuit Board - D</td>
<td>2.20</td>
<td>3985</td>
</tr>
<tr>
<td>Circuit Board - E</td>
<td>1.70</td>
<td>5156</td>
</tr>
<tr>
<td>Video Screen</td>
<td>.20</td>
<td>43830</td>
</tr>
</tbody>
</table>

B. LOGISTIC SUPPORT (COSAL) MODELS USED

The COSAL models evaluated were the standard .25 FLSIP and a modified FLSIP as proposed by the CNO Shipboard Parts Allowance Policy Study (Ref. 3). This modification consists of changing the FLSIP cut point to .1 (one demand in ten years) and providing an allowance quantity of two (vice one) for those items with a BRF between 2.0 and 4.0.
C. RESULTS OF ANALYSIS

1. Results of TIGER Simulation

The following tables provide a summary of the relevant output from the two TIGER simulation runs for 90 day missions. The actual computer output is self explanatory and a sample is included as a separate section of this thesis. The percent unavailability column indicates the percent of unavailability caused by each item.

### .25 FLSIP (Availability = .7229)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>SPARES STOCKED</th>
<th>SPARES USED</th>
<th>FAIL/MISSION</th>
<th>PERCENT UNAVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch</td>
<td>0</td>
<td>.00</td>
<td>0.025</td>
<td>3.35</td>
</tr>
<tr>
<td>Fuse - A</td>
<td>1</td>
<td>.50</td>
<td>.637</td>
<td>14.54</td>
</tr>
<tr>
<td>Transformer</td>
<td>0</td>
<td>.00</td>
<td>.042</td>
<td>6.42</td>
</tr>
<tr>
<td>Cir Bd - A</td>
<td>2</td>
<td>.96</td>
<td>1.05</td>
<td>6.77</td>
</tr>
<tr>
<td>Coupler</td>
<td>0</td>
<td>.00</td>
<td>.064</td>
<td>9.35</td>
</tr>
<tr>
<td>Cir Bd - B</td>
<td>4</td>
<td>1.84</td>
<td>1.897</td>
<td>.81</td>
</tr>
<tr>
<td>Fuse - B</td>
<td>1</td>
<td>.57</td>
<td>.793</td>
<td>24.01</td>
</tr>
<tr>
<td>Rheostat</td>
<td>0</td>
<td>.00</td>
<td>.030</td>
<td>3.74</td>
</tr>
<tr>
<td>Cir Bd - C</td>
<td>1</td>
<td>.27</td>
<td>.318</td>
<td>3.64</td>
</tr>
<tr>
<td>Cir Bd - D</td>
<td>1</td>
<td>.43</td>
<td>.541</td>
<td>11.99</td>
</tr>
<tr>
<td>Cir Bd - E</td>
<td>1</td>
<td>.34</td>
<td>.416</td>
<td>7.07</td>
</tr>
<tr>
<td>V. Screen</td>
<td>0</td>
<td>.00</td>
<td>.052</td>
<td>8.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.865</td>
<td>99.98</td>
</tr>
</tbody>
</table>

### .1 MOD FLSIP (Availability = .9064)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>SPARES STOCKED</th>
<th>SPARES USED</th>
<th>FAIL/MISSION</th>
<th>PERCENT UNAVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch</td>
<td>0</td>
<td>.00</td>
<td>0.017</td>
<td>8.53</td>
</tr>
<tr>
<td>Fuse - A</td>
<td>2</td>
<td>.59</td>
<td>.607</td>
<td>5.41</td>
</tr>
<tr>
<td>Transformer</td>
<td>1</td>
<td>.05</td>
<td>.054</td>
<td>.75</td>
</tr>
<tr>
<td>Cir Bd - A</td>
<td>2</td>
<td>.92</td>
<td>1.015</td>
<td>24.70</td>
</tr>
<tr>
<td>Coupler</td>
<td>1</td>
<td>.06</td>
<td>.067</td>
<td>1.23</td>
</tr>
<tr>
<td>Cir Bd - B</td>
<td>4</td>
<td>1.84</td>
<td>1.897</td>
<td>2.58</td>
</tr>
<tr>
<td>Fuse - B</td>
<td>2</td>
<td>.79</td>
<td>.844</td>
<td>18.19</td>
</tr>
<tr>
<td>Rheostat</td>
<td>1</td>
<td>.04</td>
<td>.044</td>
<td>.00</td>
</tr>
<tr>
<td>Cir Bd - C</td>
<td>1</td>
<td>.27</td>
<td>.310</td>
<td>13.43</td>
</tr>
<tr>
<td>Cir Bd - D</td>
<td>2</td>
<td>.53</td>
<td>.553</td>
<td>5.42</td>
</tr>
<tr>
<td>Cir Bd - E</td>
<td>1</td>
<td>.35</td>
<td>.414</td>
<td>18.99</td>
</tr>
<tr>
<td>V. Screen</td>
<td>1</td>
<td>.04</td>
<td>.046</td>
<td>.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.868</td>
<td>99.97</td>
</tr>
</tbody>
</table>
2. Interpretation of Results

As would be expected, the .1 Mod FLSIP provided a greater depth and range of spares than the .25 FLSIP. The addition of seven more spares resulted in an increase in AVA from .7229 to .9064, a significant increase. For the .25 FLSIP run, the item accounting for highest percentage of availability is fuse - B, with 24.01 percent. Since FLSIP provides a 90 percent confidence level of protection for those items with a BRF $\leq 4.0$ ($\leq 1$/qtr), the BRF of 3.60 places the fuse just below this cut and therefore it is allocated only one spare. For the .1 Mod FLSIP run fuse - B no longer is the largest contributor to unavailability. Circuit board - A is the largest, accounting for 24.70 percent of the unavailability. If further incremental improvements were to be made to the .1 Mod FLSIP COSAL, the first additional spare should be circuit board - A followed by circuit board - B, fuse - B, and so on down the list of unavailability percentages.

The difference in AVA for the two COSALS is the most important statistic. If availability in the range of .9 were required for the system, the .1 Mod FLSIP should be used. If however, the system were not that essential, the .7 availability provided by FLSIP should be used to enable scarce spares funding resources to be used on more essential systems.
VII. SUMMARY AND CONCLUSIONS

This thesis focused on one basic problem; that of providing logistics support for Naval units afloat. Current guidelines and measures of effectiveness were presented along with several of the methodologies by which the policies are being carried out.

The NAVSEA TIGER reliability block diagram simulation program was introduced as a currently used method of evaluating ship reliability and also as a proposed method of generating allowance documents. A key input to any reliability calculation is the MTBF. The use by the Navy of a BRF vice MTBF was reviewed and a solution proposed to enable BRF to be used as an input to the TIGER simulation.

A technique for using TIGER to evaluate the effect of various spares allowance policies upon system availability was introduced, followed by an example of such an analysis.

The Navy is interested in providing logistics support so as to maximize the operational availability of its ships within given resource constraints. Mathematical models designed to allocate spares while maximizing system availability require extensive amounts of data (much of which is either not available or retrievable by computer). They are computationally infeasible to implement on a Navy-wide basis. Thus, it appears that the Navy will continue to use simpler
parts-counting models such as those described in this thesis. No claim of optimality with respect to 'system availability' can be made with such simple models that make no attempt to consider the system as anything other than a collection of parts.

The models that are being used are regulated by controlling the values of certain parameters such as FLSIP cut points or essentiality codes. Since there is no way to analytically relate these models to system effectiveness, a tool such as the TIGER simulator is needed to evaluate the future impact on system availability of a given provisioning or support policy. The assumptions required to perform this type of evaluation have been discussed throughout this thesis.

The following are recommendations for additional work in the topic of this thesis or for additional uses of the TIGER simulation:

1. Use as an evaluation tool for various provisioning models.

2. Use to evaluate maintenance policies and their effect on required manning levels.

3. Use as a system design tool.

4. Use on new equipment being introduced into the fleet to establish a FLSIP cut point. Code equipment with this cut point instead of the vital/non-vital codes currently in use, and use this cut point when preparing the COSAL.
5. Evaluate the effect of the assumptions made in this thesis and other problems such as the gradual degradation of equipment (not simply up or down) and the effect of the annual revisions to the BRFs.
## APPENDIX A

### ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ao</td>
<td>Operational Availability</td>
</tr>
<tr>
<td>AVA</td>
<td>Availability</td>
</tr>
<tr>
<td>BRF</td>
<td>Best Replacement Factor</td>
</tr>
<tr>
<td>COSAL</td>
<td>Coordinated Shipboard Allowance List</td>
</tr>
<tr>
<td>CNO</td>
<td>Chief of Naval Operations</td>
</tr>
<tr>
<td>EST</td>
<td>Estimate</td>
</tr>
<tr>
<td>FBM</td>
<td>Fleet Ballistic Missile</td>
</tr>
<tr>
<td>FFG</td>
<td>Guided Missile Frigate</td>
</tr>
<tr>
<td>FLSIP</td>
<td>Fleet Logistics Support Improvement Program</td>
</tr>
<tr>
<td>MCO</td>
<td>Maintenance Criticality Oriented</td>
</tr>
<tr>
<td>MEC</td>
<td>Military Essentiality Code</td>
</tr>
<tr>
<td>MRU</td>
<td>Minimum Replacement Unit</td>
</tr>
<tr>
<td>MTBF</td>
<td>Mean Time Between Failure</td>
</tr>
<tr>
<td>MTTF</td>
<td>Mean Time to Failure</td>
</tr>
<tr>
<td>MTTR</td>
<td>Mean Time to Repair</td>
</tr>
<tr>
<td>NAVSEA</td>
<td>Naval Sea Systems Command</td>
</tr>
<tr>
<td>NPS</td>
<td>Naval Postgraduate School</td>
</tr>
<tr>
<td>PMR</td>
<td>Preventative Maintenance Requirement</td>
</tr>
<tr>
<td>RED</td>
<td>Readiness</td>
</tr>
<tr>
<td>REL</td>
<td>Reliability</td>
</tr>
<tr>
<td>RMA</td>
<td>Reliability/Maintainability/Availability</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>SPCC</td>
<td>Ships Parts Control Center</td>
</tr>
<tr>
<td>SSN</td>
<td>Fast Attack Submarine (Nuclear)</td>
</tr>
<tr>
<td>TIGER</td>
<td>Simulation Program Name</td>
</tr>
<tr>
<td>TOR</td>
<td>Technical Override</td>
</tr>
</tbody>
</table>
APPENDIX B

TIGER PROGRAM VARIABLES LIST

The following is a list of the variables used in the TIGER program and their respective usage/definition. All variables which were used in this thesis are included along with some from other optional parts of the TIGER program. Numbers at the right indicate the data card on which the variable is input into the program.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Card Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Subroutine DEMO producer risk</td>
<td>21A</td>
</tr>
<tr>
<td>ACMMH</td>
<td>Average corrective manhours per mission</td>
<td></td>
</tr>
<tr>
<td>ADT</td>
<td>Administrative delay time</td>
<td></td>
</tr>
<tr>
<td>AENDT1</td>
<td>Downtime in remainder of phase due to abort</td>
<td></td>
</tr>
<tr>
<td>AENDT2</td>
<td>Downtime in remainder of mission due to abort (up to current phase)</td>
<td></td>
</tr>
<tr>
<td>AFM</td>
<td>Average failures per mission</td>
<td></td>
</tr>
<tr>
<td>ALDONE</td>
<td>Sum of three DONE(I); if zero, skips spare printout</td>
<td></td>
</tr>
<tr>
<td>APPL</td>
<td>Bad apple unreliability and unavailability printout</td>
<td>21</td>
</tr>
<tr>
<td>AVA</td>
<td>Average availability or availability</td>
<td></td>
</tr>
<tr>
<td>AVAINS</td>
<td>Instant availability</td>
<td></td>
</tr>
<tr>
<td>AVAL</td>
<td>Average availability</td>
<td></td>
</tr>
<tr>
<td>AVAL</td>
<td>Average availability</td>
<td></td>
</tr>
<tr>
<td>AVGCST</td>
<td>Average cost per hour of repairman</td>
<td>7M</td>
</tr>
<tr>
<td>B</td>
<td>Subroutine DEMO consumer risk</td>
<td>21A</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>BAPRIN</td>
<td>Bad Apple printout indicator, when equals -1, print</td>
<td></td>
</tr>
<tr>
<td>BILL</td>
<td>Temporary variable used to integerize the number of spares</td>
<td></td>
</tr>
<tr>
<td>BLNK</td>
<td>Four character alphabetic blank</td>
<td></td>
</tr>
<tr>
<td>COUNTB(I)</td>
<td>Number of failures for equipment I</td>
<td></td>
</tr>
<tr>
<td>DAY(IX)</td>
<td>Occupation symbol</td>
<td></td>
</tr>
<tr>
<td>DELT</td>
<td>Time Difference</td>
<td></td>
</tr>
<tr>
<td>DEMO</td>
<td>Probability ratio test plan for system 21</td>
<td></td>
</tr>
<tr>
<td>DMNO</td>
<td>Same as DEMO</td>
<td></td>
</tr>
<tr>
<td>DNT1</td>
<td>Total system downtime in phase</td>
<td></td>
</tr>
<tr>
<td>DNT2</td>
<td>Total system downtime in mission</td>
<td></td>
</tr>
<tr>
<td>DONE(I)</td>
<td>Average number of spares used from ship, tender, depot(I=1,3)</td>
<td></td>
</tr>
<tr>
<td>DUM(J)</td>
<td>Dummy variable to read Fl</td>
<td></td>
</tr>
<tr>
<td>DUMMY</td>
<td>Skill types</td>
<td></td>
</tr>
<tr>
<td>ENDPHA</td>
<td>End of phase time</td>
<td></td>
</tr>
<tr>
<td>EQUIP(I)</td>
<td>Person type numbers of people who could be operating this type of equipment</td>
<td></td>
</tr>
<tr>
<td>ETIME</td>
<td>Event time</td>
<td></td>
</tr>
<tr>
<td>EX(I,J)</td>
<td>Administrative delay time (U,W)</td>
<td></td>
</tr>
<tr>
<td>F(I,J)</td>
<td>Same as Fl</td>
<td></td>
</tr>
<tr>
<td>FCOUNT</td>
<td>Real value of JCOUNT</td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>Alphabetic equipment description</td>
<td></td>
</tr>
<tr>
<td>GMMA</td>
<td>Alphabetic request for GAMMA subroutine</td>
<td></td>
</tr>
<tr>
<td>HAD</td>
<td>DEMO X-axis accept intercept</td>
<td></td>
</tr>
<tr>
<td>HRD</td>
<td>DEMO X-axis reject intercept</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Various indices; equipment type number</td>
<td></td>
</tr>
</tbody>
</table>

45
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IABC</td>
<td>Index</td>
</tr>
<tr>
<td>IAUP</td>
<td>Instant availability (up for entire simulation)</td>
</tr>
<tr>
<td>IAUP1(I)</td>
<td>Instant availability (up at beginning of sequence</td>
</tr>
<tr>
<td>IAUP2(I)</td>
<td>Instant availability (cumulative up at beginning of sequence</td>
</tr>
<tr>
<td>IB(I)</td>
<td>Group number and equipment and groups which make up the group</td>
</tr>
<tr>
<td>IBLANK</td>
<td>14 alphabetic blank spaces</td>
</tr>
<tr>
<td>IBM</td>
<td>Equipment type number</td>
</tr>
<tr>
<td>IBNUM(I,J)</td>
<td>Number of configuration matrix cards in phase</td>
</tr>
<tr>
<td>ICHLD</td>
<td>Child in reliability tree</td>
</tr>
<tr>
<td>ICRI</td>
<td>Subsystems exceeding mission allowable downtime (TAD2)</td>
</tr>
<tr>
<td>ID</td>
<td>Alphabetic system name</td>
</tr>
<tr>
<td>IDIFF</td>
<td>Total equipment failures (all types)</td>
</tr>
<tr>
<td>IDUM</td>
<td>Same as IUT</td>
</tr>
<tr>
<td>IEQ</td>
<td>Absolute value of IEQU(J)</td>
</tr>
<tr>
<td>IEQU(I)</td>
<td>Equipment type array</td>
</tr>
<tr>
<td>IFF</td>
<td>Number of failures</td>
</tr>
<tr>
<td>IFFEOP</td>
<td>Same as ISW</td>
</tr>
<tr>
<td>IFLAG</td>
<td>Repair option in each phase</td>
</tr>
<tr>
<td>IFR</td>
<td>Number of repairs</td>
</tr>
<tr>
<td>IGRP</td>
<td>Equipment group</td>
</tr>
<tr>
<td>II</td>
<td>Spare location (ship, tender, depot)</td>
</tr>
<tr>
<td>III</td>
<td>II-1</td>
</tr>
<tr>
<td>IIUSED(I,J)</td>
<td>Spares used per equipment type from each location</td>
</tr>
</tbody>
</table>
IK                Phase indicator
IK2               Phase indicator
IK3               Phase indicator
ILB               Counter for NEQ
ILL               Phase subscript for VDC(IU,ILL)
IND               Equipment type
INDEX              Index; equipment number
INEWA              Index used to rank equipment by number of failures
INMI(I)            Number of missions run
INOABT(I)          Number of aborts in the sequence
INREJ              Not used
INUM               Maximum number of mission repetitions (50)
IOR                Number of equipment operating rules
IPTR               Parent/Child index
IPRNT              Parent reliability tree
IRULE              Equipment operating rule card 19
ISeeder            Random number seed 2
ISO                +=string; -=standby
ISpare(I,J)        Quantity of spares at ship, tender, depot 15
ISS                System/subsystem identification number 16,17
ISSA(I)            Phase allowable downtime
ISTB(I)            Equipment operating rules 19
ISUM               Summation
ISW                Subsystem status (1=up, -1=down)
ISSC               Subsystems exceeding allowable downtime
ISYS(K)  System in phase K
ITEMP  System status indicator
ITEMP2 Subsystem status indicator
ITIME  Number of sets
ITER   Number of simulations per set
ITOTAL Integer value of total
IU     Variable duty cycle (IUI(I))
IUI(I)  Variable duty cycle indicator
IUNLIM Alphabetic 'unlimited spares'
IUT    Same as IDUM
IUSED(I,K) Spares used from ship, tender, depot
IV     Variable duty cycle indicator (IUI=IV)
IVALUE(I) Temporary variable for IB or ISTB
IX     NUM+1
IXX    Equipment type
IXXT   Phase type
J      Various indices; equipment type
JA     Index for IB
JB     Index for IB
JBB    Phase sequence number
JBB1   JBB-1
JC     Current timeline
JCC    Number of timelines
JCOUNT Number of failed equipments
JIND   Equipment type
JNUM   Integer of XNUM
K Various indices
KAA Mission number being simulated
KAB Mission number being simulated
KD Trucation line accept
KEQ Equipment number
KEQU(I) Number of failures for equipment type I
KID Dummy variable
KID1 Equipment group
KID2 Equipment group
KKK Phase in mission
KKK2 Same as KKK
KOPT Printout option switch 5
KS(I) Output options for KOPT 5
KSS Index
KT IB( , ,1), or number required up in group
K1 Equipment type; trail shape parameter
L Same as LL
LCL Lower confidence limit
LL Phase type number 16,17 
LLL Duration of phase sequence
LOAD(I) Equipment numbers assigned to equipment type 12
MAXIB Maximum number of configuration matrix cards (300)
MAXNEQ Maximum number of equipments (500)
MAXNPH Maximum number of phases (6)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAXRUN</td>
<td>Maximum number of mission (1000)</td>
</tr>
<tr>
<td>MAXSEQ</td>
<td>Total number of phases</td>
</tr>
<tr>
<td>MAXSS</td>
<td>Maximum number of subsystems (31)</td>
</tr>
<tr>
<td>MAXSTD</td>
<td>Maximum number of equipment operating rule cards (49)</td>
</tr>
<tr>
<td>MAXTYPE</td>
<td>Maximum number of equipment types (200)</td>
</tr>
<tr>
<td>MDT</td>
<td>Estimator of MTTR</td>
</tr>
<tr>
<td>MKBA</td>
<td>Bad Apple equipment vector</td>
</tr>
<tr>
<td>MM</td>
<td>0</td>
</tr>
<tr>
<td>MTBMF</td>
<td>Mean time between mission failures</td>
</tr>
<tr>
<td>MUT</td>
<td>Instantaneous MTBF parameter</td>
</tr>
<tr>
<td>M1</td>
<td>Trial scale parameter</td>
</tr>
<tr>
<td>N</td>
<td>Counter; NSS+1</td>
</tr>
<tr>
<td>NEQ</td>
<td>Equipment type counter</td>
</tr>
<tr>
<td>NLINE(I)</td>
<td>Number of configuration cards in phase</td>
</tr>
<tr>
<td>NL1</td>
<td>NLINE(LL)</td>
</tr>
<tr>
<td>NN</td>
<td>Index</td>
</tr>
<tr>
<td>NMAX</td>
<td>Maximum number of missions</td>
</tr>
<tr>
<td>NOPT</td>
<td>Optimal number of mission</td>
</tr>
<tr>
<td>NPH</td>
<td>Number of phases</td>
</tr>
<tr>
<td>NRO</td>
<td>Number required operating</td>
</tr>
<tr>
<td>NSS</td>
<td>Number of subsystems in phase</td>
</tr>
<tr>
<td>NTY</td>
<td>Last number of equipment types</td>
</tr>
<tr>
<td>NTYPE</td>
<td>Equipment type</td>
</tr>
<tr>
<td>NT1</td>
<td>Equipment type number</td>
</tr>
<tr>
<td>NUM</td>
<td>Mission number counter</td>
</tr>
<tr>
<td>Variable</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>PERC</td>
<td>Percent unreliable</td>
</tr>
<tr>
<td>PL</td>
<td>Reliability specification</td>
</tr>
<tr>
<td>R</td>
<td>Dummy variable used to find next event; temporary variable used to calculate VDC; discrimination ratio</td>
</tr>
<tr>
<td>RDT</td>
<td>Running down time</td>
</tr>
<tr>
<td>RED</td>
<td>Readiness</td>
</tr>
<tr>
<td>REDAD1(I)</td>
<td>Adjusted time for readiness calculation in phase</td>
</tr>
<tr>
<td>REDAD2</td>
<td>Adjusted time for readiness calculation in mission</td>
</tr>
<tr>
<td>RED1</td>
<td>Readiness</td>
</tr>
<tr>
<td>RED2</td>
<td>Readiness</td>
</tr>
<tr>
<td>REL</td>
<td>Reliability</td>
</tr>
<tr>
<td>RELGA(JBB)</td>
<td>Reliability (RELPY) for phase sequence</td>
</tr>
<tr>
<td>RELPY</td>
<td>Reliability up to and including phase just completed</td>
</tr>
<tr>
<td>REPOL</td>
<td>Percent of repairs performed aboard ship 7</td>
</tr>
<tr>
<td>RN</td>
<td>Random number</td>
</tr>
<tr>
<td>RN3</td>
<td>Random number</td>
</tr>
<tr>
<td>RUNID</td>
<td>Alphabetic program identification line</td>
</tr>
<tr>
<td>SLD</td>
<td>Slope</td>
</tr>
<tr>
<td>SPRS</td>
<td>Alphabetic request for SPARES output</td>
</tr>
<tr>
<td>SR</td>
<td>Intermediate value used to calculate ST</td>
</tr>
<tr>
<td>SSTIME(I,J)</td>
<td>System/subsystem allowable sustained downtime</td>
</tr>
<tr>
<td>ST</td>
<td>Intermediate time</td>
</tr>
<tr>
<td>STEPHAS</td>
<td>Accumulated phase time</td>
</tr>
<tr>
<td>SUMX</td>
<td>Total simulation time</td>
</tr>
</tbody>
</table>
SUMX2  Sum of SUMX squared (for variance calculation)
SX    Spares multiplier
T     Duration of phase
TABORT Time of abort
TACMMH Total average corrective maintenance manhours/mission
TAD1  Same as SSTIME
TAD2  Mission allowable downtime
TAFM  Total average failures per mission
TDEOP Time down at end of phase
TDOWN Time system went down
TIMA(I) Cumulative phase time
TIME Simulation clock time
TITLE(K,N) Alphabetic subsystem title
TNMI Real value of INMI(JBB)
TOTAL Number of failed missions
TR    Temporary variable used to find maximum unavailability/reliability
TRR   Same as TR
TP    Same as TIME
TTEMP Downtime
TTF   Time for failure
TTR   Time to repair
TT1   Phase length
TT2(JBB) Cumulative time of phase lengths
TT3   Cumulative phase times

7
TYCOON(I)  Downtime for equipment
TYCUM    Unavailability
TYCUM2   Percent unavailability
T1       SSTIME( , ,1)
T3       Downtime
T3SUM    Cumulative downtime
U        Duty cycle utilization
UNAVA    Unavailability
UNREL    Unreliability
UP1      Time system up in phase
UP2(JBB) Cumulative system uptime
UP3      Cumulative system uptime
UP4      Cumulative system uptime
V        Administrative delay time (tender to ship)
VAR      MTBFM variance
VDC(I)   Duty cycle utilization during each phase
VMTTR(I,J) Variable mean time to repair
W        Administrative delay time (depot to ship)
X        Various; XMTBF; event indicator (+ fail; - repair)
XAV      Instant availability
XAVI     Instant availability
XCUM     Successful missions in last 50
XDWN     Number of mission failures (XNUM-XTCUM)
XIAUPP   Real of IAUP
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XIAUPI</td>
<td>Real of IAUPI</td>
</tr>
<tr>
<td>XID</td>
<td>Alphabetic ID</td>
</tr>
<tr>
<td>XIFF</td>
<td>Real of IFF</td>
</tr>
<tr>
<td>XIRR</td>
<td>Real of IRR</td>
</tr>
<tr>
<td>XK</td>
<td>Standard deviation for lower confidence limit 2</td>
</tr>
<tr>
<td>XKAA</td>
<td>Real of KAA</td>
</tr>
<tr>
<td>XLCLA</td>
<td>Lower confidence limit of 90 percent</td>
</tr>
<tr>
<td>XM</td>
<td>XMTBF Multiplier 7</td>
</tr>
<tr>
<td>XMDT</td>
<td>System man down time</td>
</tr>
<tr>
<td>XMTBA</td>
<td>Mean time between mission failures</td>
</tr>
<tr>
<td>XMTBF</td>
<td>Mean time between failures 8</td>
</tr>
<tr>
<td>XMTTR</td>
<td>Mean time to repair 8</td>
</tr>
<tr>
<td>XMUT</td>
<td>System mean up time</td>
</tr>
<tr>
<td>XM1</td>
<td>Same as XT</td>
</tr>
<tr>
<td>XNO</td>
<td>Number of non aborts</td>
</tr>
<tr>
<td>XNUM</td>
<td>Real of NUM (total missions run)</td>
</tr>
<tr>
<td>XPCAP</td>
<td>Reliability</td>
</tr>
<tr>
<td>XPLCL</td>
<td>Lower confidence limit</td>
</tr>
<tr>
<td>XT</td>
<td>XMTBF multiplier 7</td>
</tr>
<tr>
<td>XTABT(I)</td>
<td>Time of abort mission I</td>
</tr>
<tr>
<td>XTCUM</td>
<td>Cumulative successful missions</td>
</tr>
<tr>
<td>XXT(I)</td>
<td>Phase type (I odd); Duration (I even) 3</td>
</tr>
<tr>
<td>XXX</td>
<td>XMTBF or VMTTR</td>
</tr>
<tr>
<td>X2</td>
<td>X squared</td>
</tr>
<tr>
<td>Y</td>
<td>Same as XMTTR</td>
</tr>
<tr>
<td>YD</td>
<td>Truncation line accept 21A</td>
</tr>
</tbody>
</table>

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APPENDIX C

SPARES SUBROUTINE VARIABLE LIST

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUT</td>
<td>FLSIP cut point</td>
</tr>
<tr>
<td>DUM</td>
<td>Dummy variable</td>
</tr>
<tr>
<td>EX90DD</td>
<td>Expected 90 day demand</td>
</tr>
<tr>
<td>ITMPOP(I)</td>
<td>Number of equipment type I in reliability block diagram</td>
</tr>
<tr>
<td>K</td>
<td>Counter</td>
</tr>
<tr>
<td>KFACT</td>
<td>K factorial</td>
</tr>
<tr>
<td>PRBSUM</td>
<td>Poisson probability summation</td>
</tr>
<tr>
<td>SPR1-14</td>
<td>Various user defined input variables</td>
</tr>
</tbody>
</table>
MODIFICATIONS TO TIGER PROGRAM INPUT

To use the GAMMA and DEMO options, the end of the main section of the program must be changed to the following:

```
1210 IF (GMMA.EQ.BLNK) GO TO 1230
1220 CALL GAMMA
1230 CONTINUE
   IF (DMNO.EQ.BLNK) GO TO 1240
   CALL DEMO
1240 STOP
END
```

Subroutine GAMMA, function GAMF, subroutine DEMO, function CHISQ, subroutine TGEN, and subroutine CKTP must be added to the program deck (note: none of these have been utilized or verified for use on the NPS computer).

The following changes were made to the original input deck:
Card 2 - INREJ replaced by ISEED; the random number generator seed.
Card 14 - If spares subroutine is desired, enter 999. for SX. Fourteen variables (SPR1,SPR2,...,SPR14) may then be read into the spares subroutine in F4.0 format starting in column 25.
These changes are incorporated into the input requirements shown on the following pages. They should be used when preparing the TIGER data input deck.
All integer fields must be right justified

<table>
<thead>
<tr>
<th>Columns</th>
<th>Format</th>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>I4</td>
<td>JCC</td>
<td>No. of timeline variations to be run for the data deck. If JCC exceeds 1, only phase type and duration card(s) must be added in the back of the data deck, followed by a blank card.</td>
</tr>
<tr>
<td>5-80</td>
<td>19A4</td>
<td>RUNID</td>
<td>Alphanumeric run identifier.</td>
</tr>
</tbody>
</table>

(2) Statistical Parameter Card

<table>
<thead>
<tr>
<th>Columns</th>
<th>Format</th>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>I4</td>
<td>NMAX</td>
<td>Maximum number of missions to be run (should be in multiples of 50 and must not exceed 1000)</td>
</tr>
<tr>
<td>5-8</td>
<td>I4</td>
<td>NOPT</td>
<td>Optimal number of missions (not to exceed NMAX).</td>
</tr>
<tr>
<td>9-12</td>
<td>F4.0</td>
<td>PL</td>
<td>Specification requirement for reliability.</td>
</tr>
<tr>
<td>13-16</td>
<td>F4.0</td>
<td>XG</td>
<td>Standard deviation to be used in calculating lower control limit.</td>
</tr>
<tr>
<td>17-20</td>
<td>I4</td>
<td>ISEED</td>
<td>Random number seed.</td>
</tr>
<tr>
<td>21-24</td>
<td>I4</td>
<td>NPH</td>
<td>No. of phase types--not to exceed 6.</td>
</tr>
</tbody>
</table>

NOTE: - If a predefined fixed number of missions is to be run, set PL =1.0, and NOPT and NMAX to the desired number of missions.
<table>
<thead>
<tr>
<th>Columns</th>
<th>Format</th>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>F2.0</td>
<td>XXT(1)</td>
<td>Phase type number for first simulation sequence.</td>
</tr>
<tr>
<td>3-10</td>
<td>F8.0</td>
<td>XXT(2)</td>
<td>Duration of first sequence.</td>
</tr>
<tr>
<td>11-12</td>
<td>F2.0</td>
<td>XXT(3)</td>
<td>Phase type number for second simulation sequence (if any).</td>
</tr>
<tr>
<td>13-20</td>
<td>F8.0</td>
<td>XXT(4)</td>
<td>Duration of second sequence.</td>
</tr>
<tr>
<td>21-22</td>
<td>F2.0</td>
<td>XXT(5)</td>
<td>Phase type number for third simulation sequence (if any).</td>
</tr>
<tr>
<td>23-30</td>
<td>F8.0</td>
<td>XXT(6)</td>
<td>Duration of third sequence.</td>
</tr>
<tr>
<td>31-32</td>
<td>F2.0</td>
<td>XXT(7)</td>
<td>Phase type number for fourth sequence (if any).</td>
</tr>
<tr>
<td>33-40</td>
<td>F8.0</td>
<td>XXT(8)</td>
<td>Duration of fourth sequence.</td>
</tr>
<tr>
<td>41-42</td>
<td>F2.0</td>
<td>XXT(9)</td>
<td>Phase type no. for fifth sequence (if any).</td>
</tr>
<tr>
<td>43-50</td>
<td>F8.0</td>
<td>XXT(10)</td>
<td>Duration of fifth sequence.</td>
</tr>
</tbody>
</table>

Note: If more than 5 phase sequences are needed, continue on additional cards using the same fields. No more than 95 phase sequences are permitted.

(4) ******Blank Card******
<table>
<thead>
<tr>
<th>Columns</th>
<th>Format</th>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1-4     | I4     | KOPT          | Printout option switch  
          |         |               | = 1 for management summary printout.  
          |         |               | = 2 for engineering summary printout.  
          |         |               | = 3 for TIGER complete details printout.  
          |         |               | (For debugging only)  
| 5-8     | I4     | KS(1)         | = 1: Input Data  
| 9-12    | I4     | KS(2)         | = 1: equipment down at time of mission failure.  
| 13-16   | I4     | KS(3)         | = 1: down time at end of phase.  
| 17-20   | I4     | KS(4)         | = 1: abort messages.  
| 21-24   | I4     | KS(5)         | = 1: all events.  
| 25-28   | I4     | KS(6)         | = 1: ETIME Matrix. (For debugging only.)  
| 29-32   | I4     | KS(7)         | = 1: Not used.  
| 33-36   | I4     | KS(8)         | = 1: Not used.  
| 37-40   | I4     | KS(9)         | = 1: Not used.  
| 41-44   | I4     | KS(10)        | = 1: System & subsystem status.  
| 45-48   | I4     | KS(11)        | = 1: TIGER/MANNING debugging printout.  

If KOPT=5, select from the following output options as needed (otherwise leave the field(s) blank):
<table>
<thead>
<tr>
<th>Columns</th>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Format</td>
<td>Option Card (Cont.)</td>
<td></td>
</tr>
<tr>
<td>49-52</td>
<td>I4</td>
<td>KS(12)</td>
</tr>
<tr>
<td>53-56</td>
<td>I4</td>
<td>KS(13)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= 1: Status of all groups</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= 1: Downtime message</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Repair Card</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>I4</td>
<td>IFLAG(1)</td>
</tr>
<tr>
<td>5-8</td>
<td>I4</td>
<td>IFLAG(2)</td>
</tr>
<tr>
<td>9-12</td>
<td>I4</td>
<td>IFLAG(3)</td>
</tr>
<tr>
<td>13-16</td>
<td>I4</td>
<td>IFLAG(4)</td>
</tr>
<tr>
<td>17-20</td>
<td>I4</td>
<td>IFLAG(5)</td>
</tr>
<tr>
<td>21-24</td>
<td>I4</td>
<td>IFLAG(6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repair option for each phase type, up to 6:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 if on-board repair allowed in the phase.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 if no on-board repair allowed but failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>inhibited.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair Policy Card</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>F4.0</td>
<td>REPOL</td>
</tr>
<tr>
<td>5-12</td>
<td>F8.2</td>
<td>TAD2</td>
</tr>
<tr>
<td>13-16</td>
<td>F4.0</td>
<td>XM</td>
</tr>
<tr>
<td>17-20</td>
<td>F4.0</td>
<td>XT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decimal fraction of repairs to be performed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>aboard ship, i.e., organizational level.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mission allowable downtime. Default = 1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MTBF Multiplier. Default = 1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MTR Multiplier. Default = 1.0</td>
</tr>
<tr>
<td>Columns</td>
<td>Format</td>
<td>Variable</td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>1-4</td>
<td>I4</td>
<td>I</td>
</tr>
<tr>
<td>5-20</td>
<td>4A4</td>
<td>F1</td>
</tr>
<tr>
<td>21-28</td>
<td>F8.0</td>
<td>XMTBF</td>
</tr>
<tr>
<td>29-32</td>
<td>F4.0</td>
<td>XMTTR</td>
</tr>
<tr>
<td>33-36</td>
<td>F4.0</td>
<td>U</td>
</tr>
<tr>
<td>37-40</td>
<td>F4.0</td>
<td>V</td>
</tr>
<tr>
<td>41-44</td>
<td>F4.0</td>
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<td>45-48</td>
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<td>IUI</td>
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<tr>
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<tr>
<td>(9)</td>
<td>Variable Duty Cycle (VDC) Card</td>
<td>(Optional - If IUI on previous type card is non-zero, place this card immediately behind the type card to which it refers. A maximum of 50 VDC cards per deck are allowed.)</td>
</tr>
<tr>
<td>1-4</td>
<td>I4</td>
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<td>F4.0</td>
<td>VDC(2)</td>
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<td>F4.0</td>
<td>VDC(3)</td>
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<td>F4.0</td>
<td>VDC(4)</td>
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<td>F4.0</td>
<td>VDC(5)</td>
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<td>F4.0</td>
<td>VDC(6)</td>
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<tr>
<td>(10)</td>
<td>Variable Mean Time to Repair (MTTR) Card</td>
<td>(Optional - If XMTRR is negative on the Equipment Type Card place this card behind the VDC Card or, if there is no VDC Card, behind the Equipment Type Card.)</td>
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<tr>
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<td>F4.0</td>
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<td>Variable Name</td>
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<td>Variable Mean Time to Repair (MTTR) Card (Cont.)</td>
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<td>F4.0</td>
<td>VMTTR(2)</td>
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<tr>
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<td>F4.0</td>
<td>VMTTR(4)</td>
</tr>
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<td>F4.0</td>
<td>VMTTR(5)</td>
</tr>
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<td>F4.0</td>
<td>VMTTR(6)</td>
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<tr>
<td>(11) <strong>Blank Card</strong> (This indicates the end of the equipment type cards.)</td>
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<td>(12) Equipment Cards (One for each equipment type - Place sequentially by type number)</td>
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<td>I4</td>
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<td>I4</td>
<td>LOAD(2)</td>
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<td>LOAD(4)</td>
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<td>I4</td>
<td>LOAD(8)</td>
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<td>37-40</td>
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<td>LOAD(9)</td>
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<td>LOAD(18)</td>
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<td>77-80</td>
<td>I4</td>
<td>LOAD(19)</td>
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</table>

(13) ********Blank Card******** (This indicates end of equipment cards.)

(14) Blank Card or literal "UNLIMITED SPARES" starting in column 1. If Blank Card is used then the spares multiplier (SX) may be inserted in Col. 21-24. The format for SX is F4.0 and the default value is 1.0; Use 999. to call SPARES subroutine. Variables SPR1-SPR14 may be inserted in F4.0 format starting in Col. 25.
<table>
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<tr>
<th>Columns</th>
<th>Format</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(15) Spares Cards (Omit if unlimited spares specified above. One spares card for each equipment type-program assumes these cards are in sequential order starting with Type 1)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>I4</td>
<td>ISPARE(1)</td>
<td>Number of organizational level spares (on-board) for the equipment type.</td>
</tr>
<tr>
<td>5-8</td>
<td>I4</td>
<td>ISPARE(2)</td>
<td>Number of spares at the tender for the equipment type.</td>
</tr>
<tr>
<td>9-12</td>
<td>I4</td>
<td>ISPARE(3)</td>
<td>Number of spares at the base (depot) for the equipment type.</td>
</tr>
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</table>

NOTE: For each phase type, a set of the remaining cards (except the optional output and demo cards which appear once) must be placed consecutively in the data deck.

(16) System Card

<table>
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<th>Description</th>
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<tbody>
<tr>
<td>1-4</td>
<td>A4</td>
<td>ID</td>
<td>Any alphanumeric, e.g., the literal &quot;SYST&quot;</td>
</tr>
<tr>
<td>5-8</td>
<td>I4</td>
<td>LL</td>
<td>Phase type number (sequential) - Maximum value is 6.</td>
</tr>
<tr>
<td>9-12</td>
<td>I4</td>
<td>NSS</td>
<td>Number of subsystems in the phase (varies only from 1 to 31)</td>
</tr>
<tr>
<td>13-16</td>
<td>I4</td>
<td>ISS</td>
<td>System identification number (usually last group number on the configuration matrix cards).</td>
</tr>
<tr>
<td>Columns</td>
<td>Format</td>
<td>Variable Name</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
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<td>-------------</td>
</tr>
<tr>
<td>System Card (Cont.)</td>
<td>17-24</td>
<td>F8.0</td>
<td>SSTIME</td>
</tr>
<tr>
<td>(17) Subsystem Cards</td>
<td>(One for each subsystem - up to 31.) At least one subsystem is required.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>A4</td>
<td>ID</td>
<td>Any alphanumeric, e.g., the literal &quot;SS1&quot;, &quot;SS2&quot;, ... &quot;SS31&quot;.</td>
</tr>
<tr>
<td>5-8</td>
<td>I4</td>
<td>LL</td>
<td>Phase type number.</td>
</tr>
<tr>
<td>13-16</td>
<td>I4</td>
<td>ISS</td>
<td>Subsystem identification number. This is a group number for a group defined on a Configuration Matrix Card (see below). Each designated subsystem group must be a group that, upon its failure, causes the system to fail.</td>
</tr>
<tr>
<td>17-24</td>
<td>F8.0</td>
<td>SSTIME(2)</td>
<td>Subsystem allowable sustained down time (TAD1). This value should be less than or equal to SSTIME on the System Card. To inhibit aborts use a value of 100000.</td>
</tr>
<tr>
<td>Columns</td>
<td>Format</td>
<td>Variable Name</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td>(18) Configuration Matrix Cards</td>
<td>(One card for each group, up to 300 cards)</td>
<td></td>
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</tr>
<tr>
<td>1-4</td>
<td>I4</td>
<td>NRO</td>
<td>The number of members in the group defined on this card that are required to be operating and in an upstate.</td>
</tr>
<tr>
<td>5-8</td>
<td>I4</td>
<td>IB(1)</td>
<td>The group number assigned to the group of members defined on this card. It may vary from 501 to 1000 in any order.</td>
</tr>
<tr>
<td>9-12</td>
<td>I4</td>
<td>IB(2)</td>
<td>The numbers of the equipment and groups which make up the group defined on this card. The maximum number of members in a group is unlimited; however, if there are more than 7, a continuation card is required, which is of the same format.</td>
</tr>
<tr>
<td>13-16</td>
<td>I4</td>
<td>IB(3)</td>
<td>The number required and master group number must be identical on all continuation cards.</td>
</tr>
<tr>
<td>17-20</td>
<td>I4</td>
<td>IB(4)</td>
<td></td>
</tr>
<tr>
<td>21-24</td>
<td>I4</td>
<td>IB(5)</td>
<td></td>
</tr>
<tr>
<td>25-28</td>
<td>I4</td>
<td>IB(6)</td>
<td></td>
</tr>
<tr>
<td>29-32</td>
<td>I4</td>
<td>IB(7)</td>
<td></td>
</tr>
<tr>
<td>33-36</td>
<td>I4</td>
<td>IB(8)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>(19) Equipment Operating Rule Cards</th>
<th>(Optional - Usually this card is placed immediately behind the configuration matrix card which refers to the equipment and groups on this card.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>These cards indicate the equipment operating rules for string or standby equipment. The string equipment operating rule causes shutdown of a designated series equipment upon failure of any of the other equipment or equipment groups on the card. The standby</td>
<td></td>
</tr>
<tr>
<td>Columns</td>
<td>Format</td>
</tr>
<tr>
<td>---------</td>
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<td>I4</td>
</tr>
<tr>
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<td>I4</td>
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<tr>
<td>9-12</td>
<td>I4</td>
</tr>
<tr>
<td>13-16</td>
<td>I4</td>
</tr>
<tr>
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<td>I4</td>
</tr>
<tr>
<td>21-24</td>
<td>I4</td>
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</tr>
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<td>33-36</td>
<td>I4</td>
</tr>
<tr>
<td>37-40</td>
<td>I4</td>
</tr>
<tr>
<td>41-44</td>
<td>I4</td>
</tr>
<tr>
<td>Columns</td>
<td>Format</td>
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<tr>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td>(20) <strong><strong>Blank Card</strong></strong> (This indicates end of phase configuration and operating rules.)</td>
<td></td>
</tr>
<tr>
<td>(21) Optional Output Card (Optional - Appears once in computer job deck)</td>
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</tr>
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<td>1-4</td>
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<td>A4</td>
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<td>(22) DEMO Information Card (Optional - must be included if DEMO is specified on the Optional Output Card.)</td>
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<td>1-4</td>
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<td>F4.0</td>
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The following are optional inputs:

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<td>13-16</td>
<td>F4.0</td>
<td>HAD</td>
<td>X-Axis accept intercept (Delta).</td>
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<tr>
<td>17-20</td>
<td>F4.0</td>
<td>HRD</td>
<td>X-Axis reject intercept (Delta).</td>
</tr>
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<td>21-24</td>
<td>F4.0</td>
<td>YD</td>
<td>Trucation line accept (Delta).</td>
</tr>
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<td>F4.0</td>
<td>SLD</td>
<td>Slope (Delta).</td>
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<td>I4</td>
<td>KD</td>
<td>Truncation line reject (Delta).</td>
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<td>I4</td>
<td>ITIME</td>
<td>Number of sets (explained in Appendix C).</td>
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<td>I4</td>
<td>ITER</td>
<td>Number of simulations per set.</td>
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<td>Random number initializer.</td>
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<td>AVG. NO. FAILURES PER MISSION</td>
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<td>FUSE - E</td>
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<td>71777.3125</td>
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CRITICAL EQUIPMENTS

UNRELIABILITY AND
PERCENT OF MISSION FAILURES

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<th>DESCRIPTION</th>
<th>NO. FAILURES</th>
<th>UNREL</th>
<th>PERCENT</th>
<th>EQUIP TYPE</th>
<th>EQUIP NO.</th>
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<td>CIRCUIT BD - D</td>
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<td>0.0780</td>
<td>12.66</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>CIRCUIT BD - E</td>
<td>49.0</td>
<td>0.0490</td>
<td>7.95</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>COUPLER</td>
<td>48.0</td>
<td>0.0480</td>
<td>7.79</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>VIDEO SCREEN</td>
<td>34.0</td>
<td>0.0340</td>
<td>5.24</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>TRANSFORMER</td>
<td>30.0</td>
<td>0.0300</td>
<td>4.87</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>CIRCUIT BD - A</td>
<td>25.0</td>
<td>0.0250</td>
<td>4.06</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>CIRCUIT BD - A</td>
<td>24.0</td>
<td>0.0240</td>
<td>3.90</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>CIRCUIT BD - C</td>
<td>22.0</td>
<td>0.0220</td>
<td>3.57</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>RHIOSTAT</td>
<td>20.0</td>
<td>0.0200</td>
<td>3.25</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>SWITCH</td>
<td>15.0</td>
<td>0.0150</td>
<td>2.44</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>CIRCUIT BD - B</td>
<td>3.0</td>
<td>0.0030</td>
<td>0.49</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>CIRCUIT BD - B</td>
<td>2.5</td>
<td>0.0025</td>
<td>0.41</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>CIRCUIT BD - B</td>
<td>1.5</td>
<td>0.0015</td>
<td>0.24</td>
<td>6</td>
<td>11</td>
</tr>
</tbody>
</table>

TOTAL NO. MISSIONS=1000
TOTAL NO. MISSION FAILURES= 616
RELIABILITY PHASE 1, 1, IS 0.3840
READINESS IS 0.7229
AVERAGE AVAILABILITY IS 0.7229
INSTANT AVAILABILITY IS 1.0000
RELIABILITY UP TO PHASE 1 IS 0.3840
READINESS IS 0.7229
AVERAGE AVAILABILITY IS 0.7229
INSTANT AVAILABILITY IS 0.3840

A GRAND TOTAL OF 1000 MISSIONS HAVE BEEN RUN.

THE RELIABILITY IS 0.3840
THE LOWER CONF LIMIT IS 0.3646
THE SPEC REQUIREMENT IS 1.0000
THE READINESS IS 0.7229
THE AVERAGE AVAILABILITY IS 0.7229
THE INSTANT AVAILABILITY IS 0.3840

THE MEAN TIME BETWEEN MISSION FAILURES IS 2534.9
THE LCL 90% MTBF IS 1031.9
THE MTBF VARIANCE IS 1375166.0

THE SYSTEM MUT IS 2535.0
THE SYSTEM MDT IS 0.189
SIMULATION COMPLETE—OPTIMUM NUMBER MISSIONS WERE RUN.
C MAIN
C ******** TIGER ************
C ******** NAVSEC 6112 LUETJEN+MANDEL+VAIL+ALLEY+BROWN ********
C ****************** FEB 1979 ******************
C
C COMMON /ALPHA/DNT2,ENDPHA,ICR1,IFF,IFR,INUM,OPT,JB8,KEQ,KK,KZ
1, KK1,K51,LL,LLAST,NEQ,NPH,NTYPE,NUN,REDA2,REDA1(100),RELP,RED2
2,RELP,REPQ,STPHAS,TP,TX,CUN,TT3,UP3,IFFEGP,TT3,TIME,T3SUM
C COMMON/BETA/NQD(6,300),IB(6,300),BJ,NLINE(6)
C COMMON/EXTRA/ KS(201),ISW(31)
C COMMON /N/IEQ(500),KEQ(500),ETIME(1000),XMTBF(200),XMTTR(200)
C COMMON/NPH/N5S(6),FLAG(6),TITLE(6,31),5STIME(6,31,2),ISS(6,31)
C COMMON /SEQ/INOABY(100),IMLI(100),IAUP(100),TT2(100),UPZ(100)
1,IAUP(100)
C COMMON /TYP/EXIT(2,200),ISPAR(3,200),IUSED(3,200),IUUSED(3,200)
C COMMON /MAX/MAXNEXQ,MAXTP,MAXIB,MAXSTD
C COMMON /C/MAMMA/XTMA,VAR,RELGA(100),TMA(100),XTT(200),ITU,ISEED
C COMMON /TABORT/XTBAT(1000),RDT
C COMMON /TIGAP/UP4,NUM,DPAPRIN,AVA,XYPCAP,RUNID(19),TYCOON(500)
C COUNTB(500),XTUM
C COMMON /DNE/DONE(3)
C DATA BLNK/'4H'/
C MAXRUN=1000
C MAXNPH=6
C MAXSTD=50
C MAXNEX=500
C MAXTP=200
C MAXIB=300
C MAXSS=31
C MAXSEQ=100
C CALL OVFLOW
C READ (5,10) JCC,(RUNID(1),I=1,19)
C 10 FORMAT (14,19A4)
C WRITE (6,220) JCC
C DO 1230 JC=1,JCC
C 20 WRITE (6,30) (RUNID(I),I=1,19)
C 30 FORMAT (1H1,30X,'19A4/')
C WRITE (6,40)
C WRITE (6,50)
C WRITE (6,55)
C 40 FORMAT (1X,50H++++ NAVSEC 6112 LUETJEN+MANDEL+VAIL+ALLEY+BROWN +++)
C 50 FORMAT (1X,50H++++ NAVSEC 6112 LUETJEN+MANDEL+VAIL+ALLEY+BROWN +++)
C 55 FORMAT (1X,50H+++NPS IBM/360 VERSION LT. J. LEATHER THESIS 9/80++)
C BAPRIN=0.0
C DO TO 1=1,MAXNEQ
C COUNTB(I)=0.0
C TYCOON(I)=0.0
70 KEQU(I)=0
71 ETIME(I)=100000.
72 NUM=0
73 IFP=0
74 IFR=0
75 UP4=0.0
76 T3=0.0
77 T3SUM=0.0
78 SUMX=0.0
79 SUMX2=0.0
80 DO 80 I=1,100
81 TIMA(I)=0.
82 DO 90 I=1,3
83 DO 90 J=1,MAXTYP
84 DO 100 I=1,MAXSEQ
85 TI2(I)=0.0
86 UP2(I)=0.0
87 IAUP2(I)=0
88 READAD(I)=0.0
89 INMI(I)=0
90 INOABT(I)=0
91 IAUP=0
92 XTCUM=0
93 IF (JC-1) 110,110,140
94 110 READ (5,120) NMAX,NOPT,PL,XK,I SEED,NPH
95 120 FORMAT (14.2F4.0,2I4)
96 130 FORMAT (1X2I6,2XF4.2,2XF5.2,2XI6,2XI4)
97 140 CONTINUE
98 150 WRITE (6,170) I SEED
99 160 FORMAT (7/1X15HRANDOM SEED IS ,I4)
100 IF (NMAX-MAXRUN) 190,190,180
101 180 NMAX=1000
102 NOP T=1000
103 DO 200 I=1,NMAX
104 200 XTAB(I)=100000.
105 WRITE (6,130) NMAX,NOPT,PL,XK,I SEED,NPH
106 IF (MAXNPH-NPH) 1240,210,210
107 210 INUM=50
108 220 FORMAT (4l10)
109 230 DO 250 I=1,191,10
110 READ (5,240) XXT(I),{XXT(I+J),J=1,9}
111 IF (XXT(I)) 260,260,250
112 240 FORMAT (5(F2.0,F8.0))
113 250 CONTINUE
114 260 WRITE (6,270)
115 270 FORMAT (1H1,10X40PHASE SEQUENCE TYPE DURATION CUM TIME)
116 MAIN0480
117 MAIN0490
118 MAIN0500
119 MAIN0510
120 MAIN0520
121 MAIN0530
122 MAIN0540
123 MAIN0550
124 MAIN0560
125 MAIN0570
126 MAIN0580
127 MAIN0590
128 MAIN0600
129 MAIN0610
130 MAIN0620
131 MAIN0630
132 MAIN0640
133 MAIN0650
134 MAIN0660
135 MAIN0670
136 MAIN0680
137 MAIN0690
138 MAIN0700
139 MAIN0710
140 MAIN0720
141 MAIN0730
142 MAIN0740
143 MAIN0750
144 MAIN0760
145 MAIN0770
146 MAIN0780
147 MAIN0790
148 MAIN0800
149 MAIN0810
150 MAIN0820
151 MAIN0830
152 MAIN0840
153 MAIN0850
154 MAIN0860
155 MAIN0870
156 MAIN0880
157 MAIN0890
158 MAIN0900
159 MAIN0910
160 MAIN0920
161 MAIN0930
162 MAIN0940
163 MAIN0950
IK=1
IK2=2*IK
IK3=IK2-1
IXT=XT(IK3)
TIMA(IK)=XT(IK)
WRITE (6,280) IK,IXT,XT(IK2),TIMA(IK)
280 FORMAT (19X14,2X14,2X14F8.2,2X14F8.2)
DO 300 IK=2,100
IK2=2*IK
IK3=IK2-1
IF (IXT(IK2)) 290,310,290
290 TIMA(IK)=TIMA(IK-1)+XT(IK2)
IXT=XT(IK3)
WRITE (6,280) IK,IXT,XT(IK2),TIMA(IK)
300 CONTINUE
310 CONTINUE
IF (JDI=1) 320,320,330
320 CALL PACK

C
330 CONTINUE
JBB=1
RELPY=1.0
RELPL=1.0
UP3=0.0
TI3=0.0
TETAD2=0.0
DO 340 I=1,MAXSS
340 ISW[I]=1
ICK1=0
ONT2=0.0
350 STPHAS=0
T1=0.0

C
RDT IS RUNNING DOWNTIME
C
RDT=0.0
C
KKK = O INDICATES FIRST PHASE IN MISSION.
C
START OF MISSION INDICATION
C
IF (KSI(8)) 380,380,360
360 KAB=NUM+1
WRITE (6,370) KAB
370 FORMAT(IX,16HSTART OF MISSION,15,20H***************************************************************************)
380 KKK=0
390 I=1
400 LL=XXI(I)
   IF (LL) 450,450,410
410 ENDPHA=STPHAS*XXI(I+1)
   I=I+2
   CALL RUN
   IX=NUM+1
   IF (XTABT(IX)) 420,420,440
420 WRITE (6,430)
430 FORMAT (I44)THE ABORT TIME IS ZERO,CHECK THE INPUT DATA.
   GO TO 1240
440 STPHAS=ENDPHA
   N=NSL(LL)+1
   GO TO 400

C STATISTICAL SUMMARY BEGINS HERE
C
450 NUM=NUM+1
460 IFF=IFF+1
   IF (T3) 470,480,470
470 CONTINUE
   T3=SUM+T3
   T3=0.0
480 XTCUM=XTCUM+XNUM
   UP=UP4+ENPHIA-ONZ
C JBB IS THE PHASE SEQUENCE NUMBER
C   IF (XTABT(NUM)-100000.1) 500,490,500
490 X=ENDPHA
   GO TO 510
500 X=XTABT(NUM)
510 X2=X*X**2
   SUMX=SUMX+x
   SUMX2=SUMX2+x2
   IF (ISW(N)) 530,530,520
520 IAUP=IAUP+1
530 IF (NUM=INUM) 330,540,540
540 INUM=INUM+50
550 WRITE (6,560) NUM
560 FORMAT (I16)HA GRAND TOTAL OF,16,24H MISSIONS HAVE BEEN RUN.
570 XNUM=NUM
580 XPCAP=XTCUM/NXNUM
590 WRITE (6,600) XPCAP
600 FORMAT (I3X24H THE RELIABILITY IS ,F8.4)
610 XPLCL=XPCAP*XK*SORT(XPCAP*(1.-XPCAP)/XNUM)
   IF (XPLCL) 620,630,630
620 XPLCL=0.0
630 WRITE (6,640) XPLCL
640 FORMAT (I3X24H THE LOWER CUNF LIMIT IS ,F8.4)
WRITE (6,650) PL
650 FORMAT (1X24HTHE SPEC REQUIREMENT IS ,F8.4)   MAIN1920
WRITE (6,660) REDZ
660 FORMAT (1X17HTHE READINESS IS ,7XF8.4)   MAIN1930
AVA=UP4/T3   MAIN1940
WRITE (6,670) AVA
670 FORMAT (1X28HTHE AVERAGE AVAILABILITY IS ,F8.4)   MAIN1950
XIAUP=1AUP   MAIN1960
AVAINS=XIAUP/XNUM   MAIN1970
WRITE (6,680) AVAINS
680 FORMAT (1X28HTHE INSTANT AVAILABILITY IS ,F8.4)   MAIN1980
XDWN=XNUM-XTCUM   MAIN1990
IF (XDWN) 690,690,700   MAIN2000
690 XMTBA=2.0*SUMX   MAIN2010
XLCLA=0.434*SUMX   MAIN2020
VAR=(0.5*SUMX)**2   MAIN2030
GO TO 710   MAIN2040
700 XMTBA=SUMX/XDWN   MAIN2050
VAR=(SUMX2/XNUM)-(SUMX/XNUM)**2   MAIN2060
CORR=(SUMX*(1/XDWN-1/XNUM))**2   MAIN2070
VAR=VAR+CORR   MAIN2080
XLCLA=XMTBA-1.28*SQT(VAR)   MAIN2090
WRITE (6,720) XMTBA   MAIN2100
710 FORMAT (1X14HTHE MEAN TIME BETWEEN MISSION FAILURES IS,F20.1)   MAIN2110
WRITE (6,730) XLCLA   MAIN2120
720 FORMAT (1X21HTHE LCL,90, MTBMF IS ,F20.1)   MAIN2130
WRITE (6,740) VAR   MAIN2140
730 FORMAT (1X27HTHE MTBMF VARIANCE IS ,F20.1)   MAIN2150
XIFF=IFF   MAIN2160
XIFR=IFR   MAIN2170
IF (IFF) 740,760,770   MAIN2180
740 XNUT=2.0*UP4   MAIN2190
XMDT=0.0   MAIN2200
GO TO 790   MAIN2210
750 XNUT=UP4/XIFF   MAIN2220
IF (IFR) 780,770,780   MAIN2230
760 XMDT=(TT3-UP4-T3SUM)/XIFF   MAIN2240
GO TO 790   MAIN2250
770 XMDT=(TT3-UP4-T3SUM)/XIFR   MAIN2260
780 WRITE (6,810) XNUT   MAIN2270
790 WRITE (6,820) XMDT   MAIN2280
800 FORMAT (1X18HTHE SYSTEM MUT IS ,F20.1)   MAIN2290
810 FORMAT (1X18HTHE SYSTEM MDT IS ,F20.3)   MAIN2300
820 IF (XPCAP-PL) 840,840,320   MAIN2310
830 IF (NOPT-NUM) 870,870,850   MAIN2320
840 WRITE (6,860) 1BTAIN REQUIRED STATISTICAL CONFIDENCE.}   MAIN2330
850 WRITE (6,860)   MAIN2340
860 FORMAT (1X16HANOTHER SET OF 3H 50,20HMISSIONS WILL BE RUN,43H TO OMAIN2350
GO TO 330
870 WRITE (6,880)
880 FORMAT (1X52HSIMULATION COMPLETE-OPTIMUM NUMBER MISSIONS WERE RUN) MAIN2420
IF (PL.EQ.1.) GO TO 910
890 WRITE (6,900) MAIN2430
900 FORMAT (1X33HWEAPON SYSTEM FAILS REQUIREMENTS.) MAIN2440
910 GO TO 1010 MAIN2450
920 IF (NMAX-NU) 930,930,960 MAIN2460
930 WRITE (6,940) MAIN2470
940 FORMAT (1X52HSIM COMPLETE-PREDEFINED MAX NUMBER MISSIONS WERE RUN) MAIN2480
950 IF (XPLCL-PL) 890,990,990 MAIN2490
960 IF (XPLCL-PL) 850,970,970 MAIN2500
970 WRITE (6,980) MAIN2510
980 FORMAT (1X22HSIMULATION COMPLETE - ) MAIN2520
IF (PL.EQ.1.) GO TO 1010 MAIN2530
990 WRITE (6,1000) MAIN2540
1000 FORMAT (1X33HWEAPON SYSTEM MEETS REQUIREMENTS.) MAIN2550
1010 CONTINUE MAIN2560
C*****READ CARD CONTAINING PRINTOUT OPTIONS
C*****SPRS=SPARES GIVES PRINTOUT OF AVG. SPARES USED PER MISSION
C*****BY EQUIPMENT TYPE
C*****APPL=APPLE GIVES PRINTOUT OF CRITICAL EQUIPMENTS AND UNRELI.
C*****GMMA=GMMA GIVES PRINTOUT OF GAMMA FUNCTION WHICH REPRESENTS THE
C*****SYSTEM OR SUBSYSTEM CONFIGURATION AND VALUES AT TIME INTERVALS MAIN2620
C*****SPEFICED ON PHASE CARD
IF (JC-1) 1020,1020,1040 MAIN2630
1020 READ (5,1030) SPRS,APPL,GMMA MAIN2640
1020 READ (5,1030) SPRS,APPL,GMMA,DMNO MAIN2650
1030 FORMAT (3A4) MAIN2660
1030 FORMAT (4A4) MAIN2670
1040 IF (SPRS) 1050,1190,1050 MAIN2680
1040 IF (SPRS.EQ.BLNK) GO TO 1190 MAIN2690
C
C EQUIP FAILURE AND CORRECTIVE MAINTENANCE SUMMARY
C
1050 IDIFF=0 MAIN2700
1050 TAFM=0.0 MAIN2710
1050 TACHM=0.0 MAIN2720
1050 WRITE (6,1060) MAIN2730
1060 FORMAT (1H4X53HWEAPON FAILURES AND CORRECTIVE MAINTENANCE(CM) SUM) MAIN2740
1060 WRITE (6,1060) MAIN2750
1060 IF XMTTR(IACCESS).EQ.9999,1 GO TO 1090 MAIN2760
1060 IF (KEQUI(1)) 1090,1090,1070 MAIN2770
1060 IF (KEQ) 1090,1090,1070 MAIN2780
1070 AFM=KEQUI(1)/XNUM MAIN2790
1070 IEQ=IABS(KEQ(I)) MAIN2800
1070 ACMM=AFM=ABS(XMTTR(IEQ)) MAIN2810
WRITE(6, 1080) L, L1, EQ, KEUQ1(1); AFM, ACMM, 
1080 FORMAT (10XI4, 6X14, 6XI10, 6XFI0.3, 6XFI0.3) 
    IDIFF=IDIFF+KEUQ(1) 
    TAFM=TAFM+AFM 
    TCMMH=TCMMH+ACMMH 
1090 CONTINUE 
    WRITE (6, 1100) IDIFF, TAFM, TCMMH 
1100 FORMAT (3I10H, '---------', 6X10H, '----------', 6X10H, '----------') 
    1F10.3, 6XFI0.3) 
1110 CONTINUE 
    WRITE (6, 1120) 
1120 FORMAT (1H1, 3X41HAVERAGE NUMBER OF SPARES USED PER MISSION) 
    WRITE (6, 1130) 
1130 FORMAT (/4X6SPARES, 7X4HSHIP, 18X6HTENDER, 16X4HBASE) 
1140 FORMAT (8X4HYPER, 4X3I5HSTOCK, 3X4HUSED, 10X)) 
    DO 1170 J=1, NTYPE 
    ALDONE=0.0 
    DO 1150 I=1, J 
    DONE(I)=IJS(D1, J) / XNUM 
    ALDONE=ALDONE+DONE(I) 
1150 CONTINUE 
1155 IF (ALDONE) 555, 1170, 1155 
1150 WRITE(6, 1160) J, (ISPARE(I, J), DONE(I), I=1, 3) 
1160 FORMAT (8X14, 4X3(I5, F7.2, 10X)) 
1170 CONTINUE 
1180 CONTINUE 
1190 IF (APPL.EQ. BLNK) GO TO 1210 
1200 BAPRIN=.10 
    CALL APPLE 
C 
C    SEE APPENDIX TO THESIS ON PROCEDURE TO ADD GAMMA AND DEMO 
C 
1210 CONTINUE 
1220 CONTINUE 
1230 CONTINUE 
1240 STOP 
END
SUBROUTINE RUN
COMMON /MAX/MAXEQ,MAXTYP,MAXIB,MAXSTD
COMMON /ALPHA/DNT2,ENDPHA,ICRI,IFF,IFR,INUM,IOPT,JBQ,KEQ,KKK,KZI
1,KKK,KSI,L,LLLAST,NEQ,NPH,NPTYPE,NUM,REDAD1,REDAD2,REDAI(100),RELP,RED2
2,REPLY,REPLSTPHAS,IP,IT,XCUM,IT3,UP3,IFPEOP,ITM,IT3SUM
COMMON/BETA/NRO(16,300),IB1(16,300,8),NLIN(6)
COMMON/EXTRA/KS(20),ISW(31)
COMMON/N/IEQU(500),KEQU(500),ETIME(1000),XMTBF(200),XMTTR(200)
COMMON/NPH/NSS(61),IFLAG(6),TITLE(6,31),STIME(6,31,2),ISS(6,31)
COMMON/SEQ/INDAB(100),INM(100),IAUP(100),TT2(100),UP2(100)
1,IAUP2(100)
COMMON/TYP/EXIT(2,200),ISPARF(3,200),IUSED(3,200),IUSED(3,200)
COMMON/GAMMAA/XMTBA,VAR,RELG(100),TIMA(100),XXT(200),ITF,ISEED
COMMON/TABORT/XTAB(100),RDT
COMMON/Delta/KKK
COMMON/XXX
COMMON/VDC/VDC(50,6),IUI(200),VMTBF(200,6),TAO2
COMMON/STAN/ISTB(60,10,6)
COMMON/RUNAP/ITEMP2,DELT,ISSA(31),ISSC

START OF PHASE LL

C

TDEEP=0.0
TP=STPHAS
KAA=NUMA1
XKAA=KAA
NX=NSS(111)
N=NX+1
ITEMP=0
ITEMP2=0
IF (KKK) 40,10,40
10 DO 20 I=1,4,3
DO 20 J=1,NPTYPE
IUSED(I,J)=0
20 CONTINUE
DO 30 I=1,NEQ
100 ETIME(I)=100000.
30 CONTINUE
40 CONTINUE

KKK = 0 INDICATES FIRST PHASE IN MISSION.
IFLAG = 0 INDICATES REPAIR IS ALLOWED DURING PHASE.

DEFINE EVENT TIME VECTOR
1. IF REPAIR WAS PREVIOUSLY INHIBITED, GENERATE TTR.
2. DO 120 ILB=1,NEQ
   KEQ=ILB
IF(ETIME(KEQ)+100001.001)55,120,55
55 IF(ETIME(KEQ)+99999.)60,60,120
60 IF (IFLAG(LLL)) 120,70,120
C TO START REPAIR AT THE BEGINNING OF THE PHASE SO A POSITIVE ETIME MUST BE PASSED.
70 ETIME(KEQ)=STEMAS
120 XXX=VMTTR(IABC,LL)
80 IF (XXX=9999.) 120,90,120
90 ETIME(KEQ)=99999.
GO TO 120
100 XXX=VMTTR(IABC)
110 CALL TTE
120 CONTINUE
C II. TAG ALL EQUIPMENTS PREVIOUSLY FAILED OR OPERATING, NOT STANDBY.
C
DO 140 I1B=1,NEQ
KEQ=ILB
IEQ=ABS(IEQU(KEQ))
130 IF (ETIME(KEQ)+100000.) 130,140,130
140 IF (IEQ(KEQ)=ABS(IEQU(KEQ))
CONTINUE
150 CONTINUE
C III. FOR EQUIPMENTS USED IN CURRENT PHASE CONFIGURATION
C A. THAT WERE USED IN PRIOR PHASE
C
RUN 0770
1. IF EQUIPMENT IS UP, LEAVE AS IS
2. IF EQUIPMENT IS DOWN AND REPAIR IS ALLOWED, LEAVE AS IS
3. IF EQUIPMENT IS DOWN AND REPAIR IS DISALLOWED, ADD CURRENT PHASE DURATION
C
RUN 0820
B. THAT WERE NOT USED IN PRIOR PHASE
C
RUN 0830
1. IF EQUIPMENT IS DOWN AND REPAIR IS ALLOWED, LEAVE AS IS
2. IF EQUIPMENT IS DOWN AND REPAIR IS DISALLOWED, ADD CURRENT PHASE DURATION
C
RUN 0870
3. OTHERWISE, GENERATE TTF
C
KKK2=KKK
K=NLINE(LL)
DO 250 I=1,K
DO 250 JL=2,K+1
KEQ=ABS(IEQ(LL,I,J))
IF (KEQ-MAXNEQ) 151,151,250
151 IF(KEQ)250,250,155
155 IF(ETIME(KEQ)+100001.001)160,250,160
160 IEQUI(KEQ)=IABS(IEQUI(KEQ))
   IABC=IEQUI(KEQ)
170 IF (XMTTR(IABC)) 170,170,180
180 CONTINUE
190 IF (VMTR(IABC,LL)-9999.) 180,190,180
180 CONTINUE
190 IF (IFLAG(LL)-1) 210,190,210
200 IF (ETIME(KEQ)) 200,210,210
200 IF (ETIME(KEQ)-ETOIME(KEQ)-IGNPHA-STPHAS) 200,210,210
210 IF (ETIME(KEQ)-100000.) 220,240,220
220 IF (ABS(ETIME(KEQ))-STPHAS) 240,230,230
230 IF (STPHAS) 250,240,250
240 IF (STPHAS) 250,240,250
   IABC=IABS(IEQUI(KEQ))
   XXX=XMTBF(IABC)
   CALL IFE
250 CONTINUE
KKK=1

IV. FOR EQUIPMENTS NOT IN CURRENT PHASE CONFIGURATION
A: IF EQUIPMENT IS UP, PUT IN STANDBY.
B: IF EQUIPMENT IS DOWN
1. IF REPAIR IS ALLOWED, LEAVE AS IS.
2. IF REPAIR IS DISALLOWED, ADD DURATION OF CURRENT PHASE
   DO 330 ILB=1,NEQ
   KEQ=ILB
   IF(ETIME(KEQ)+100001.001)255,330,255
255 IF(IEQUI(KEQ))260,260,330
260 IEQUI(KEQ)=IABS(IEQUI(KEQ))
   IABC=IEQUI(KEQ)
270 IF (XMTTR(IABC)) 270,270,280
280 CONTINUE
   IF (IFLAG(LL)-1) 310,290,310
290 IF (ETIME(KEQ)) 300,320,320
300 IEQUI(KEQ)=ETIME(KEQ)-ENDOPA-STPHAS)
   GO TO 330
   EQUIPMENTS THAT WERE DOWN AT THE BEGINNING OF A PHASE IN WHICH
   THEY WERE NOT USED, WERE NOT PUT IN STANDBY AFTER REPAIR. INSTEAD
   THEY WERE ALLOWED TO FAIL AGAIN IN THAT PHASE.
310 IF(ETIME(KEQ)) 331,320,320
320 IEQUI(KEQ)=100000.
   IEQUI(KEQ)=IABS(IEQUI(KEQ))
   GO TO 330
331 IEQUI(KEQ)=IABS(IEQUI(KEQ))
330 CONTINUE

V. SET STANDBY EQUIPMENTS ETIME TO 100000.
CALL STATUS
CALL STNDBY

CALCULATIONS FOR INSTANT AWA AT START OF PHASE.
CALL STATUS
IF (ISWIN) 350, 350, 340
340 IAUI(JBB)=IAUI(JBB+1)
350 XIAUI=IAUI(JBB)
XAVI=XIAUI/XKAA

C ONTI IS TOTAL SYSTEM DOWNTIME IN PHASE.
TIME=STPHAS
ONTI=0.0
DO 360 KSS=1,N
360 SSSTIME(LL,KSS,1)=0.0

C THE ACTUAL MISSION SIMULATION BEGINS HERE
C
370 TP=TIME
    CALL STNDBY
380 IF (KS(6)) 390, 440, 390
390 WRITE (6,430) TP
    DO 410 J=1,NEQ
    IF (ETIME(J)>100000.) 410, 410, 410
410 IEQ=IABS(IEQUI(J))
    WRITE(6,420) J,IEQ,ETIME(J)
    420 CONTINUE
430 FORMAT (1X,I5,1X,I5,5XF22.4)
440 FORMAT (1XF12.4)
450 CALL EVENT
    TIME=ABS(ETIME(KEQ))
    IF (KS(9)) 450, 450, 450
    450 WRITE (6,460) KEQ,ETIME(KEQ),KAA
460 FORMAT (1X5HEQUIP,15,F12.4,5X7HMISSION,110)
470 DELT=TIME-TP
CALL STATUS
C
C SET TIME CLOCKS
480 DO 510 KSS=1,NX
    IF (ISWN(KSS)) 490, 490, 500
490 SSSTIME(LL,KSS,1)=SSSTIME(LL,KSS,1)+DELT
    GO TO 510
500 SSSTIME(LL,KSS,1)=0.0
510 CONTINUE
   IF (ISWN(N)) 520, 520, 530
520 SSSTIME(LL,N,1)=SSSTIME(LL,N,1)+DELT
T3=T3+DELT
IF (TIME-ENDPHA) 522,522,521
521 T3=T3+ENDPHA-TP-DELT
522 ROT=ROT+DELT
GO TO 550
530 T3=0.0
ROT=0.0
IF (SSTIME(LL,N,1)) 1140,550,540
540 TI=SSTIME(LL,N,1)
SSTIME(LL,N,1)=0.0
550 CONTINUE

C SYSTEM FAILURE AND REPAIR TALLY
C
IF (SSTIME(LL,N,1)) 570,560,570
560 IF (TI) 620,620,580
570 IF (TI) 620,610,620
580 IFF=IFF+1
590 IFR=IFR+1
600 TI=0.0
GO TO 620
610 TI=SSTIME(LL,N,1)
620 CONTINUE

C CHECK IF ANY DOWN TIMES HAVE EXCEEDED CRITERIA
C
IF (ICRI) 640,640,660
640 ISSC=1
ISSA(i)=N
IF (ROT-TAD2) 645,645,930
645 ICRI=0
IF (SSTIME(LL,N,1)-SSTIME(LL,N,2)) 650,650,960
650 ICRI=0
ISSC=0
DO 655 KSS=1,NX
IF (SSTIME(LL,KSS,1)-SSTIME(LL,KSS,2)) 655,655,652
652 ISSC=ISSC+1
ISSA(ISSC)=KSS
655 CONTINUE
IF (ISSC) 660,660,962
660 CONTINUE

C CHECK IF TIME GREATER THAN END OF PHASE
C
IF (TIME-ENDPHA) 670,670,1140

RUN 1930
RUN 1940
RUN 1950
RUN 1960
RUN 1970
RUN 1980
RUN 1990
RUN 2000
RUN 2010
RUN 2020
RUN 2030
RUN 2040
RUN 2050
RUN 2060
RUN 2070
RUN 2080
RUN 2090
RUN 2100
RUN 2110
RUN 2120
RUN 2130
RUN 2140
RUN 2150
RUN 2160
RUN 2170
RUN 2180
RUN 2190
RUN 2200
RUN 2210
RUN 2220
RUN 2230
RUN 2240
RUN 2250
RUN 2260
RUN 2270
RUN 2280
RUN 2290
RUN 2300
RUN 2310
RUN 2320
RUN 2330
RUN 2340
RUN 2350
RUN 2360
RUN 2370
RUN 2380
RUN 2390
RUN 2400
C
C IFLAG = 0 INDICATES REPAIR IS ALLOWED DURING PHASE.
C REPOL IS THE PROBABILITY THAT A REPAIR IS PERFORMED.
C
670 IF (ISW(N)) 680, 680, 730
680 CALL APPLE
730 IF (ETIME(KEQ)) 810, 810, 740
740 IF (ABC = IABS(IEQUI(KEQ))
750 IF (IFLAG(LLL) = 1) 750, 760, 750
750 CALL RANDOM (ISETED, RN, 1)
760 IF (RN-REPOL) 770, 770, 800
760 ETIME(KEQ) = -99999.
770 GO TO 830
780 IF (XTMTR(IAABC)) 780, 780, 790
780 XXX=XTMTR(IAABC, LL)
790 IF (XXX = 9999.) 820, 760, 820
790 XXX=XTMTR(IAABC)
800 ETIME(KEQ) = -100001.001
810 GO TO 830
810 IABC=IABS(IEQU(KEQ))
820 IF (IEQU(KEQ)) 811, 821, 821
811 IEQUI(KEQ) = IABS(IEQUI(KEQ))
811 ETIME(KEQ) = 100000.
821 GO TO 830
821 CALL ITE
830 IF (ETIME(KEQ)) 840, 1150, 870
C EVENT WAS FAILURE
C
840 KEQUI(KEQ) = KEQUI(KEQ)+1
850 IF (ISW(N)) 850, 850, 370
850 DNTI=DNTI+DELT
850 IF (ICRI) 860, 370, 860
860 READAD(IJB)=READAD(IJB)+DELT
860 GO TO 370
C EVENT WAS REPAIR
C
870 CONTINUE
880 IF (ISW(N)) 880, 880, 370
880 DNTI=DNTI+DELT
880 IF (ICRI) 890, 900, 890
890 READAD(IJB)=READAD(IJB)+DELT
900 TDOWN=TIME-SSTIME(LLL,N+1)
900 TTEMP=SSTIME(LLL,N+1)
900 IF (KS(I)) 370, 370, 910
910 WRITE (6,920) LL,TDOWN,TTMP,KAA
920 FORMAT (13H DURING PHASE,16,2OH) SYSTEM WENT DOWN AT ,F14.4,13H DOWNRUN 2900
1TIME IS ,F14.4,3X) HMISSION,16)
GO TO 370

C ABORT PROCEDURE
C
930 ICRI=5
940 IF (XTABT(KAA)-100000) 660,950,660
950 IF (TTMP=1)
960 IF (1009LL,JBK,KAAT,ABORT,TITLE(ILL,N),TAD2
970 GO TO 960
980 GO TO 964
990 GO TO 1000
1000 IF (XTABT(KAA)-100000) 660,1000,660
1005 WRITE(6,1005)LL,JBK,KAA,TABORT,TITLE(ILL,N)
1010 WRITE(6,1009)LL,JBK,KAA,TABORT,TITLE(ILL,N)
1015 WRITE(6,1009)LL,JBK,KAA,TABORT,TITLE(ILL,N)
1020 IF (TABORT) 1590,1590,1040
1040 DO 1110 I=1,NEQ
1050 IF (EQU(I)) 1080,1110,1110
1080 IF (KS(2)) 1090,1110,1090
1090 WRITE(6,1100)I,EQU(I)
1100 FORMAT (17X) EQUIPMENT,15,24H DOWN IT WILL COME UP AT,F16.4)
1110 CONTINUE
1120 CALL APPLE
ITEMP2=0
1130 GO TO 660
GO TO 1390
1380 RELY=0.0
1390 RELPY*RELY
TT1=ENDPH1-STPH1
TT2(JBB)=TT2(JBB)+TT1
UP1=TT1-DNT1
UP2(JBB)=UP2(JBB)+UP1
IF(ISW(N))=1410,1410,1400
1400 IAUP2(JBB)=IAUP2(JBB)+1
1410 XIAUPP=IAUP2(JBB)
XAV=XIAUPP/XKAA
IF (KAA-1NUH) =1570,1420,1570
1420 WRITE (6,1430) XAV
1430 FORMAT (/47X20HINSTANT AVAILABILITY,5X2X4H IS ,F6.4)
1440 WRITE (6,1450) LL,JBB,RELY,LL,RELY
1450 FORMAT (9X13HRELIABILITY PHASE,13,1H,,13,5H, IS ,F6.4,3X25HRELIABILITY)
1460 RELH(JBB)=RELY
AENOT1=0.0
AENOT2=0.0
DO 1520 I=1,KAA
1470 IF (XTAB(T)-100000.) =1470,1520,1520
1480 AENOT2=AENOT2+TIMAI(JBB)-XTAB(T)
1490 JBB=JBB+1
IF (JBB) =1500,1500,1490
1500 AENOT1=AENOT1+TIMAI(JBB)-XTAB(T)
GO TO 1520
1510 AENOT1=AENOT1+TIMAI(JBB)-TIMAI(JBB)
1520 CONTINUE
1530 TT3=TT3+TT2(JBB)
UP3=UP3+UP2(JBB)
REDAD2=REDAD2+REDAD1(JBB)
RED1=UP2(JBB)-AENOT1+REDAD1(JBB)/TT2(JBB)
RED2=(UP2-AENOT2+REDAD2)/TT3
1540 FORMAT (9X16HREADINESS ,9X4H IS ,F6.4,3X25HREADINESS)
1541 1
AVAL=UP2(JBB)/TT2(JBB)
AV2=UP3/TT3
WRITE (6,1550) AVAL,AVAL
1550 FORMAT (9X23HAVAGE AVAILABILITY ,2X4H IS ,F6.4,3X25HAVAGE AVAILABILITY)
LALABILITY=2X4H IS ,F6.4)
WRITE (6,1560) XAV
1560 FORMAT (47X20HINSTANT AVAILABILITY,5X2X4H IS ,F6.4)
1570 CONTINUE
1580 KKK=1
RUN 3850
RUN 3860
RUN 3870
RUN 3880
RUN 3900
RUN 3910
RUN 3920
RUN 3930
RUN 3940
RUN 3950
RUN 3960
RUN 3970
RUN 3980
RUN 3990
RUN 4000
RUN 4010
RUN 4020
RUN 4030
RUN 4040
RUN 4050
RUN 4060
RUN 4070
RUN 4080
RUN 4090
RUN 4100
RUN 4110
RUN 4120
RUN 4130
RUN 4140
RUN 4153
RUN 4160
RUN 4170
RUN 4180
RUN 4190
RUN 4200
RUN 4210
RUN 4220
RUN 4230
RUN 4240
RUN 4250
RUN 4260
RUN 4270
RUN 4280
RUN 4290
RUN 4300
RUN 4310
RUN 4320
SUBROUTINE PACK
COMMON /ALPHA/DN2, ENDPHA, ICRI, IFF, IFR, INUM, IGP, JBB, KEQ, KKK, KZZ

PACKO010
PACKO020
1.1K1, K8, L, LLLAST, NEQ, NPH, NTYPE, NUM, REXAD2, REXAD1(100), RFLP, RED2
PACKO030
2. RELB, REPOL, STAP, TIP, TL, XGUM, T13, UP3, IFEC, T3, TIME, SUM
PACKO040
PACKO050
COMMON /ALPHA/IR0(6, 300), IR(-6, 300, 8), NLINE(6)
PACKO060
COMMON /NTEQU(500), KEQU(500), ETIME(1000), XMTB(200), XMTT(200)
PACKO070
COMMON /NPH/ NS(6), IFLAG(4), T1(6, 31), SIT(6, 31); ISS(6, 31)
PACKO080
COMMON /NPH/ XTP(200), EX(320), ISUE(3, 200), ISUE(3, 200)
PACKO090
COMMON /NPH/ MAXQ, MAXTYP, MAXIQ, MAXSTD
PACKO100
COMMON /VDC/VDC(50, 6), UIUI(200), VMTR(200), TAD2
PACKO110
COMMON /PACKAP/ IBN(6500), IONS(61), F2(200, 4)
PACKO120
COMMON /TSTB/ I(60, 10, 6)
PACKO130
COMMON /TSTB/ I(60, 10, 6)
PACKO140
COMMON /TSTB/ I(60, 10, 6)
PACKO150
COMMON /TSTB/ I(60, 10, 6)
PACKO160
COMMON /TSTB/ I(60, 10, 6)
PACKO170
COMMON /TSTB/ I(60, 10, 6)
PACKO180
DATA IBLANK/4H/
PACKO190
PACKO200
PACKO210
PACKO220
PACKO230
PACKO240
PACKO250
PACKO260
PACKO270
PACKO280
PACKO290
PACKO300
PACKO310
PACKO320
PACKO330
PACKO340
PACKO350
PACKO360
PACKO370
PACKO380
PACKO390
PACKO400
PACKO410
PACKO420
PACKO430
PACKO440
PACKO450
PACKO460
PACKO470
PACKO480
AN EVALUATION OF THE EFFECT OF SPARES ALLOWANCE POLICY UPON SHIP COMMEND

FIG 15/5
60 FORMAT(1X,4F10.2)
GO TO (70,90,100,120,130),KOPT

KS SWITCHES ARE ON WHEN SET = 1
OFF = 0

70 KS(1)=1
 KS(3)=0
 KS(2)=0
 KS(5)=0
 KS(6)=0
 KS(7)=0
 KS(8)=0
 KS(9)=0
 KS(10)=0
GO TO 130

90 KS(1)=1
 KS(6)=0
 KS(10)=0
GO TO 110

100 KS(1)=1
 KS(6)=1
 KS(7)=1
 KS(10)=1
 KS(12)=1

110 KS(2)=1
 KS(3)=1
 KS(4)=1
 KS(5)=1
 KS(9)=1

120 KS(1)=0
 KS(4)=0
GO TO 80

FILL EQUIPMENT AND TYPE TABLES

130 NEQ=0
DO 140 I=1,MAXNEQ
ETIME(I)=100000.
IEQU(I)=0
CONTINUE
DO 150 J=1,6
DO 150 I=1,MAXTYP
440 FORMAT (9X39HEQUIP TYPES HAVE EXCEEDED MAX ALLOWABLE) PACK1450
450 FORMAT (14,1F4,01)) PACK1460
460 FORMAT (14XHEQUIP VARY DUTY CYCLE :4F10,3) PACK1470
470 FORMAT (14XHEQUIP VARYABLE MTR :4F10,3) PACK1480
480 FORMAT (1X4HEQUIP,15,1X13HEDEFINED TWICE) PACK1490
PACK1500

AFTER LAST TYPE CARD MUST BE A BLANK CARD, THEN FOLLOWS EQU CARDS.
PACK1510
PACK1520
PACK1530
PACK1540
PACK1550
PACK1560
PACK1570
PACK1580
PACK1590
PACK1600
PACK1610
PACK1620
PACK1630
PACK1640
PACK1650
PACK1660
PACK1670
PACK1680
PACK1690
PACK1700
PACK1710
PACK1720
PACK1730
PACK1740
PACK1750
PACK1760
PACK1770
PACK1780
PACK1790
PACK1800
PACK1810
PACK1820
PACK1830
PACK1840
PACK1850
PACK1860
PACK1870
PACK1880
PACK1890
PACK1900
PACK1910
PACK1920

490 WRITE (6,500) PACK1540
500 FORMAT (1X15HEQUIP EQUIPMENT) PACK1550
510 READ (5,10) NTYE,(LOAD1),I=1,19
PACK1560
520 DO 420 I=1,19
PACK1570
530 IF (LOAD1) 520,550,520
PACK1580
540 WRITE (6,550) PACK1590
550 FORMAT(15X HEQUIPMENT NUMBER GREATER THAN 500 **********************)
PACK1600
GO TO 1000
PACK1610
560 IF (IBM-EQ) 580,580,570
PACK1620
570 NEQ IBM
PACK1630
580 IF (IEQUIP) 590,610,590
PACK1640
590 WRITE (6,600) IBM
PACK1650
GO TO 1000
PACK1660
600 FORMAT (1X9HEQUIMENT,15,1X34HEDEFINED TWICE **********************)
PACK1670
610 CONTINUE
PACK1680
620 I=IEQUIP=NTYE
PACK1690
630 CONTINUE
PACK1700
640 IF (456111) 640,64G,630
PACK1710
650 WRITE (6,10) NTYE,(LOAD1),I=1,19
PACK1720
660 NTYE=NTYE
PACK1730
GO TO 510
PACK1740
PACK1750
PACK1760
PACK1770
PACK1780
PACK1790
PACK1800
PACK1810
PACK1820
PACK1830
PACK1840
PACK1850
PACK1860
PACK1870
PACK1880
PACK1890
PACK1900
PACK1910
PACK1920

ALL EQUIPMENT & TYPE CARDS HAVE BEEN READ IN.
THE LAST CARD AT THIS POINT MUST BE A BLANK CARD.

650 WRITE (6,660)
660 FORMAT(1X11HSPARES TYPE,6X4HSHIP,4X6HTENDER,6X4HBASE,12X6HEFACTON)
PACK1820
DO 670 J=1,13
PACK1830
NTYE=NTYE
PACK1840
DO 670 J=1,13
PACK1850
670 IUSEO(J)=J
PACK1860
READ(5,679)UMILN,SX,SPR1,SPR2,SPR3,SPR4,SPR5,SPR6,SPR7,SPR8,SPR9
PACK1870
1 SPR10,SPR11,SPR12,SPR13,SPR14
PACK1880
675 FORMAT(4,16X,15F5,2,0)
PACK1890
IF(SX-999.) 680,676,681
PACK1900
676 CALL SPARES
PACK1910
IF(SX(11)) 740,740,677
677 DO 678 I=1, NTYPE
678 WRITE (6, 750) I, (ISPARSE(J, 1), J=1, 3), SX
679 GO TO 740
680 IF (SK) 684, 682, 684
682 SX = 1.0
684 IF (IUNI.M = BLANK) 690, 720, 690
690 WRITE (6, 700)
700 FORMAT (1X, 'EQUIPMENT TYPES HAVE UNLIMITED SPARES')
710 DO 710 J=1, NTYPE
711 ISPARSE(J, 1) = 90000
720 DO 720 J=1, NTYPE
721 READ (5, 10) (ISPARSE(J, 1), J=1, 3)
722 BILL = FLOAT (ISPARSE(1, 1)) + SX
723 IF (INT(BILL) = BILL) 727, 725, 727
725 ISPARSE(1, 1) = BILL
726 GO TO 728
727 ISPARSE(1, 1) = INT(BILL) + 1
728 CONTINUE
730 WRITE (6, 750) I, (ISPARSE(J, 1), J=1, 3), SX
740 CONTINUE
750 FORMAT (5X, 14, 2X, 3110, 13X, 6.2)
760 WRITE (6, 770) NPH
770 FORMAT (1H1, 3X, 24H THE MISSION WILL BE RUN WITH, I4, 7H PHASE, 27HTYPE)
780 CONTINUE
C
790 FORMAT (6, 790) NPH
800 FORMAT (6, 790) NPH
810 FORMAT (6, 790) NPH
C
C PHASE CARDS APPEAR NEXT.
C
DO 777 I=1, 6
DO 776 J=1, 10
DO 775 K=1, 60
ISTB(K, 1, 1) = 0
775 CONTINUE
776 CONTINUE
777 CONTINUE
DO 990 K=1, NPH
READ (5, 780) XID, LL, NSS(K), ISS(K, NSS(K)+1), SSTIME(K, NSS(K)+1, 2)
780 CONTINUE
C
C ISSS(K) = ISS(K, NSS(K)+1)
N = NSS(K)
N =NX+1
IF (KS(1)) 820, 820, 790
800 WRITE (6, 800) XID, (LL, NSS(K), ISS(K, N), SSTIME(K, N, 2)
810 FORMAT (1X, 14, 314, F10.2)
820 FORMAT (1X, 14, 314, F10.2)
C
C SPARE CARDS APPEAR NEXT.
C
DO 990 K=1, NPH
READ (5, 790) XID, LL, NSS(K), ISS(K, N), SSTIME(K, N, 2)
900 CONTINUE
C
C NEXT PHASE CARDS APPEAR NEXT.
C
DO 990 K=1, NPH
WRITE (6, 900) XID, (LL, NSS(K), ISS(K, N), SSTIME(K, N, 2)
910 FORMAT (1X, 14, 314, F10.2)
920 FORMAT (1X, 14, 314, F10.2)
820 TITLE(K,N)=XI
     DO 840 IK=1,NX
     READ (5,780) TITLE(K,IK),KK,MM,ISS(K,IK),SSTIME(K,IK,2)
     IF (KS(1)) 840,840,830
830 WRITE (6,800) TITLE(K,IK),LL,MM,ISS(K,IK),SSTIME(K,IK,2)
840 CONTINUE

C EQUIPMENT & GROUP CONFIGURATION MATRIX

C     DO 850 JA=1,MAXIB
     DO 850 JB=1,8
     IB(K,JA,JB)=0
     NRO(K,JA)=0
     850 CONTINUE
     OR=0
     I=1
     IJ=5,10
     DVAL(J),J=1,10),IRULE
     IF(IJ,JA,JB)=0 GO TO 900
     IF(IRULE=NE.0)GOTO 930

C** GROUP CARD CHECK IF MORE THAN ALLOWED.
     IF(I.LE.MAXIB) GO TO 880
     WRITE(6,870) MAXIB
     WRITE(6,870) MAXIB
     870 FORMAT(1H1,10X,29H# OF GROUP CARDS GREATER THAN I4)
     STOP
     880 NRO(K,1)=IVAL(I)
     DO 890 J=1,8
     IB(K,1,J)=IVAL(J+1)
     890 CONTINUE
     IJ=K,IB(K,1,J)-500)=1
     NL1NE(K,1)=1
     900 IF(KS(1)) 860,860,910
     910 WRITE(6,920) NRO(K,1),IB(K,1,J),J=1,8
     920 FORMAT(1X,13,8I+)
     930 CONTINUE
     I=1,1
     OR=I+1

C** OPERATE RULE CARD CHECK IF MORE THAN ALLOWED.
     IF(IOR.LE.MAXSTD) GO TO 950
     WRITE(6,940) MAXSTD
     940 FORMAT(1H1,10X,26H# OF OPERATE RULE CARDS GREATER THAN I4)
     STOP
     950 CONTINUE
     DO 960 J=1,10
     960 CONTINUE
     IF(KS(1)) 860,860,970
SUBROUTINE TFE
COMMON/ALPHA/INT2, ENOPHA, ICRI, IFF, IFR, INUM, IOPT, JBB, KEQ, KKK, KZZ
COMMON/K1/K1, LL, LLAST, NEQ, NPH, NTYP, NUM, REDAD2, REDAD1(100), RELP, RED2
COMMON /N/IEQU(1500), KEQU(1500), ETIME(1000), XMTBF(200), XMTTR(200)
COMMON /EXTRA/ KS(120), ISW(311)
COMMON/NPH/ NS(61), IFLAG(6), TITLE(6, 311), SSTIME(6, 311), ISS(6, 311)
COMMON /TYP/EX1(2, 200), ISPARE(3, 200), I1USED(3, 200), I1USED(3, 200)
COMMON /DELTA/KKK2
COMMON /XXX/XXX
COMMON/VOC/VOC(50, 6), IUI(200), VMTTR(200, 6), TAO2
COMMON /GAMMA/XMTBA, VAR, RELGA(100), TIMA(100), XXT(200), ITT, ISEED

C 10 K = KEQ
20 J = IABS(IEQU(K))
30 IF (ETIME(K) - 100000.) 30, 120, 30
30 IF (ETIME(K)) 120, 120, 40
40 IF (INFINITE REPAIR TIME, NO SPARE IS USED
40 IF (ABS(XXX) - 9999.) 41, 120, 41
41 DO 60 I = 1, 2
42 IF (ISPAKE(I, J) - I1USED(I, J)) 60, 60, 50
50 I1USED(I, J) = I1USED(I, J) + 1
60 CONTINUE
70 IF (SPARE(3, J) - I1USED(3, J)) 70, 70, 110
70 IF (ETIME(K) - 1000000.) 80, 120, 80
80 IF (ETIME(K) - 5000000.) 80, 120, 80
90 WRITE (6, 100) J
100 FORMAT (1X, 5HEQUIPMENT TYPE 14, 25H HAS CONSUMED ALL SPARES.)
110 GO TO 340
110 I1USED(3, J) = I1USED(3, J) + 1
110 I1USED(3, J) = I1USED(3, J) + 1
110 I = 3
110 WRITE (6, 100) J
110 GO TO 340
110 IF (XXX = ABS(XXX)) 120, 400, 120
120 KKK = 0 INDICATES FIRST PHASE IN MISSION.
<table>
<thead>
<tr>
<th>Line</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>IF (KKK2) 140, 130, 140</td>
</tr>
<tr>
<td>140</td>
<td>IF (TIME(KI)=1000000) 160, 150, 160</td>
</tr>
<tr>
<td>150</td>
<td>GO TO 170</td>
</tr>
<tr>
<td>160</td>
<td>GO TO 170</td>
</tr>
<tr>
<td>170</td>
<td>CALL RANDOM (ISEED,RN)</td>
</tr>
<tr>
<td>180</td>
<td>GO TO 1220</td>
</tr>
<tr>
<td>190</td>
<td>GO TO 1220</td>
</tr>
<tr>
<td>200</td>
<td>GO TO 1220</td>
</tr>
<tr>
<td>210</td>
<td>IF (TIME(KI)=170) 10, 190</td>
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<tr>
<td>220</td>
<td>IF (TIME(KI)=170) 10, 190</td>
</tr>
<tr>
<td>230</td>
<td>IF (ABS(TIME(KI))=330) 330, 330</td>
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<tr>
<td>240</td>
<td>IF (ABS(TIME(KI))=330) 330, 330</td>
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<tr>
<td>250</td>
<td>IF (TIME(KI)=170) 10, 190</td>
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<tr>
<td>260</td>
<td>IF (TIME(KI)=170) 10, 190</td>
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<td>270</td>
<td>IF (TIME(KI)=170) 10, 190</td>
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<td>280</td>
<td>IF (TIME(KI)=170) 10, 190</td>
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<td>290</td>
<td>IF (TIME(KI)=170) 10, 190</td>
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<td>300</td>
<td>IF (TIME(KI)=170) 10, 190</td>
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<td>310</td>
<td>CONTINUE</td>
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<td>320</td>
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<td>370</td>
<td>CONTINUE</td>
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</tbody>
</table>
SUBROUTINE EVENT
COMMON /ALPHA/DNT2,ENDPHA,ICRI,IFF,IFR,INUM,OPT,J88,KEQ,KKK,KZZ
1,KK1,KS1,LL,LLAST,NEG,NPH,NTYPE,NUP,REDAD2,REDAD1(100),RELP,RED2
2,RELY,REP1,STPHAS,TP,T1,XCUN,T3,UP3,IPFEQ,T3,TIME,T3SUM
COMMON /NIEQU(500),KEQU(500),ETIME(1000),XMBF(200),XMTTR(200)
C DETERMINES SMALLEST VALUE IN ETIME VECTOR
C
R=ABS(ETIME(1))
KEQ=1
DO 20 I=2,NEQ
RR=ABS(ETIME(I))
IF (R-RR) 20,20,10
10 R=RR
KEQ=1
20 CONTINUE
RETURN
END
SUBROUTINE STNDBY
COMMON /ALPHA/ONT2, ENDPHA, ICRY, IFF, IFR, NUM, IOPT, JBB, KEQ, KKK, KZZ
 COMMON /K/ KK, K, L, LLAST, NEQ, NPH, NTYPE, NUM, REDD2, REDAD1(100), RELP, RED2
 COMMON /REL/ STOPAS, ET, T1, X, CM, V, UP3, IF, ECP, T3, TIME, T3SUM
 COMMON /N/ IEQUI(500), KEQUI(500), ETIME(1000), XMTBF(200), XMTTR(200)
 COMMON /XXX/XXX
 COMMON/STAN/STB(60, 10, 6)
 DO 170 I = 1, 50
 IF (STB(I, 1, LL)) 10, 180, 10
 C INDEX = 1 INDICATES ALL EQUIPMENTS IN STRING ARE UP.
 10 INDEX = 1
 DC 50 J = 2, 10
 KK = STB(I, J, LL)
 IF (KK) 30, 60, 20
 20 IF (ETIME(KK)) 40, 50, 50
 C INDEX = 0 INDICATES AT LEAST ONE OF THE EQUIPMENTS IN THE STRING IS DOWN.
 30 K = IABS(KK)
 IF (ETIME(KK)) 40, 40, 50
 40 INDEX = 0
 GO TO 60
 50 CONTINUE
 C K IS THE EQUIPMENT NUMBER WHICH WILL BE PUT UP OR STANDBY.
 60 K = IABS(STB(I, 1, LL))
 C ISO PLUS OR MINUS INDICATES STRING OR STANDBY LOGIC.
 70 ISO = STB(I, 1, LL)
 C IF EQUIPMENT DOWN (ETIME MINUS) LEAVE ALONE.
 80 IF (ETIME(K)) 170, 170, 80
 90 IF (ETIME(K) - 100000) 120, 90, 120
 100 IF (INDEX) 170, 170, 150
 110 IF (ISO) 150, 170, 170
 120 IF (INDEX) 170, 140, 130
 130 IF (ISO) 160, 170, 170
 140 IF (ISO) 170, 170, 160
 C CALL TTE TO PUT ON EQUIPMENT THAT WAS OFF (STANDBY).
 150 IABC = IABS(IEQUI(K))
 XXX = XMTBF(IABC)
 KEQ = K
 CALL TTE
 GO TO 170
 C TO PUT OFF (STANDBY) EQUIPMENT THAT WAS ON.
 160 ETIME(K) = 100000.
 170 CONTINUE
 180 RETURN
END
SUBROUTINE STATUS
COMMOM /ALPHA/DMT2,ENDPHA,ICRI,IFF,IFR,INUM,IOPT,JBB,KEQ,KKK,KZ3
1,KKI,KSL,LL,LLAST,NEQ,NPH,NTHPE,NUM,REDAD2,REDAD1(100),RELP,RED2
2,RELPA,RELPA,STPAS,TP,TI,ACOM,T3,UP3,IFSEOP,T3,TIME,T3SUM
COMMOM /BETA/NRO(6,300),IBL(6,300),8,NLINE(6)
COMMOM /EXTRA/ KS(20),ISW(31)
COMMOM /SEQU(500),KEQU(500),ETIME(1000),XMTBF(200),XMTTR(200)
COMMOM /NPH/ NSS(61),IFLAG(6),TITLE(6,31),STIME(6,31,2),ISS(6,31)

C

C KID=0
NLI=NLINE(LL)
10 DO 130 K=1,NLI
12 KT=IB(L,L,K,1)
14 IF(KID-KT)16,18,16
16 ISUN=0

C NRO IS NUMBER OF EQUIPMENTS REQUIRED UP

C 18 IF(NRO(LLL,K))130,130,20
20 DO 60 J=1,8
30 KJ=IABS(IB(LLL,K,J))
30 IF (KK) 70,70,40
40 IF (ETIME(KK)) 60,60,50
50 ISUM=ISUN+1
60 CONTINUE
70 CONTINUE
80 IF ((SUM-NRO(LLL,K))) 80,90,90
80 ETIME(KT)=1.
90 GO TO 100
90 ETIME(KT)=1.
100 IF(KS(12))125,125,110
110 WRITE(6,120)K,ETIME(KT)
120 FORMAT(IX3KK,15,7HETIME,F10.5)
125 KID=KT
130 CONTINUE
N=NSS(LL)+1
130 DO 160 I=1,N
140 J=NSS(LL)+1
150 IF (ETIME(I)) 140,140,150
150 ISW(I)=1
GO TO 160
160 CONTINUE
KZ3=0
RETURN
END
SUBROUTINE APPLE
Call MKBA(100)
DIMENSION IPRNT(50),ICHLO(50),MKBA(100)
COMMON /ALPHA/DTZ,ENDPHA,ICRI,IFF,IFR,INUM,IOPT,IBB,KEQ,KKK,KZI
1,KKL,KSL,KLLAST,KEQ,NHP,NYPE,NUM,REDAD(100),REL,RID
2,RELP,REPO,STPHAS,IP,T,Xcum,T3,UP3,IFFEOP,T3,TIME,T3SUM
COMMON/BEQ/IB3(6,300),IB6(6,300),BNL(6)
COMMON/N/ERQ(500),KEQ(500),ETIME(1000),XMTBF(200),XMTTR(200)
COMMON /IGAP/UP4,XNUM,BAPRIN,AVA,FCAP,AUNID(19),TYCOCQ(500)
+COUNTB(500),XTCM
COMMON/RUNAP/ITEMP2,DELT,ISSA(31),ISSC
COMMON/NPH/NSI(6),IFLAG(6),TITLE(6,31),STIME(6,31,2),ISS(6,31)
COMMON /PACKAP/ IBDUM(6,500),[SYS(6),F[200,4]

C
90 IF(BAPRIN1790,90,90
C
90 JCOUNT=0
C
C************ INITIALIZE
100 IF(IPRNT)240,105,107
105 K=IBNUM(L,ISYS[L]-500)
GOTO 108
107 KSS=ISSA(ISSC)
108 K=IBNUM(L,ISS[L,KSS]-500)
110 K=LB(L,K)
110 NN=2
C
C************ LOOK AT CHILDREN OF PARENT
C
C LOOK FROM (NN-1)TH CHILD,
C
210 DO 210 NNN=8
215 IF(IGRP=IB(L,K,N)
220 IF(IPMP1240,212,140
140 IF [ETIME[IGRP]] 150,150,210
150 IF [ETIME[IGRP]] 170,190,190
160 CONTINUE
210 CONTINUE
170 IF (JCOUNT) 240,200,180
180 DO 190 L=1,JCOUNT
190 IF [MKBA(L)=IGRP 190,210,190
190 CONTINUE
200 CONTINUE
C
C *** ADD TO LIST OF FAILED PRIORITY EQ.
C
190 JCOUNT=JCOUNT+1
MKBA(JCOUNT)=IGRP
210 CONTINUE
C
C 212 IF Ji=220,220,214
214 KID=N(L,220,216,220
216 K=K-1
**GOTO 108**

**220 IF (I PTR) 240,260,230**

**C*********** GO BACK TO LAST PARENT**

**230 K=IPRT(IPTR)**

**KID=IB(L,K,1)**

**NN=CHILD(IPTR)**

**IPTR=IPTR-1**

**GOTO 120**

**C*********** LOOK AT CHILDREN OF FAILED CHILD**

**160 IF (N-8) 165,167,240**

**C**** PUT PARENT INTO STACK AND MAKE CHILD NEXT PARENT**

**165 IPTR=IPTR+1**

**IFRT(IPTR)=K**

**CHILD(IPTR)=N+1**

**167 K=INUM(L,IGRP=500)**

**GOTO 108**

**240 WRITE (6,250)**

**250 FORMAT (LH APPLE ERROR)**

**GO TO 300**

**C*********** BOOKKEEPING**

**260 IF (ITEMP2) 240,265,262**

**262 I SSC=ISSC-1**

**IF (ISSC) 240,265,100**

**265 FCOUNT=FLOAT(JCOUNT)**

**IF (ITEMP2) 270,270,280**

**C*** SUMMING DOWNTIME BY EQ**

**270 DO 275 I=1,JCOUNT**

**275 TYCOON(MKBA(I))=TYCOON(MKBA(I))+DELT/FCOUNT**

**GOTO 300**

**C*** SUMMING ABORTS BY EQ.**

**280 DO 290 I=1,JCOUNT**

**290 COUNTB(MKBA(I))=COUNTB(MKBA(I))+1/FCOUNT**

**300 CONTINUE**

**RETURN**

**C BEGINNING OF FINAL PRINTOUT**

**790 CONTINUE**

**WRITE (6,800) (RUNID(I),I=1,19)**

**800 FORMAT (IHL,3X,19A4//)**

**WRITE (6,810)**

**810 FORMAT (3X,19HCRTICAL EQUIPMENTS//32X,18HUNAVAILABILITY AND/ 27APPL0900**

**1X25PERCENT OF UNAVALIABILITY//)**

**WRITE (6,820)**

**820 FORMAT (24XHNAME,17X7HNUM HRS,11X5HUNAVA,2X7PERCENT,6X8HEQU TYPEAPPL0930**

**1,5X7HEQU NUM/)**

**C SKIPS BAD APPLE PRINTOUT WHEN AVA OR REL = 1.0**

**APPL0960**
C IF (AVA=1.) 830,880,830 830 TR=TYCOON(1) INDEX=1 DO 850 I=2,NEQ TRR=TYCOON(1) IF (TR-TRR) 840,850,850 840 TR=TRR INDEX=1 850 CONTINUE TYCUM=TYCOON(INDEX)/TT3 860 IXX=LABS(I'EQUIINDEX) WRITE (6,870) (F(IXX,J),J=1,4),TYCOON(INDEX),TYCUM,TYCUM2,IXX INDEX 870 FORMAT (20X4A4,F20.4,4XF8.4,F8.2,8XI4,10XI4) TYCOON(INDEX)=0.0 GO TO 830 880 WRITE (6,880) (RUNID(I),I=1,19) WRITE (6,910) 910 FORMAT(32X,19HCritical Equipments//32X,17hUnreliability And// 127Percent Of Mission Failures//) WRITE (6,920) 920 FORMAT (12X11HDescription,8X3HNo.,6X6HUnrel,3X7HPercent,2X13HEquipment) IF (XPCAP-1.) 930,1090,930 IF (XPCAP-1.) 930,1090,930 C*******THROW OUT EQUIPMENTS WITH ZERO FAILURES C 930 INEWA=0 DO 950 I=1,NEQ IF (COUNT(I)) 950,950,940 940 INEWA=INEWA+1 MKBA(INEWA)=I 950 CONTINUE C*******RANK LIST BY NO. FAILURES C 950 CONTINUE TOTAL=XNUM-XTUCUM 955 IF (INEWA-1) 1010,975,952 952 INDEX=MKBA(1) NN=1 TR=COUNT(IXDEX) DO 970 I=2,INEWA IF (TR-COUNT(MKBA(I))) 960,970,970 960 INDEX=MKBA(I) NN=1
TR=COUNTB(INDEX)
970 CONTINUE
977 UNREL=TR/XNUM
PERC=TR/TOTAL*100.
IND=ABS(IABS(IINDEX))
WRITE(6,990) (F(IND),J=1,4),TR,UNREL,PERC,IND,INDEX
990 FORMAT (9X4A4,3XF6.1,5XF6.4,3XF6.2,4XI4,3XI4)
MKBA(NN)=MKBA(INEWA)
INEWA=INEWA-1
GOTO 955
975 INDEX=MKBA(1)
TR=COUNTB(INDEX)
GOTO 977
1010 JNUM=FIX(XNUM)
WRITE(6,1020) JNUM
1020 FORMAT ('/79X19HTOTAL NO. MISSIONS=,I4)
ITOTAL=TOTAL
WRITE(6,1030) ITOTAL
1030 FORMAT (9X27HTOTAL NO. MISSION FAILURES=,I4)
1090 RETURN
END
SUBROUTINE SPARES

FLSIP COSAL MODEL WITH INSURANCE CUT POINT READ IN WITH DATA

COMMON /ALPHA/DNT2,ENDPHA,ICRI,IFF,IFR,INUM,1OPT,JBQ,KEQ,KK,ZZ
1.KKI,KSL,LLLAST,NEQ,MP,NTYPE,NUM,REDAD2,REDAD1100,HELP,RED1
2.REPLY,REPOL,STPHS,TP,T1,KCUM,TT3,UP3,IFFEDO,T3,TIME,T3SUM
COMMON /N/EQ11000,KEQ11000,TIME11000,XTM11000,XTMTR11000
COMMON /CSPARE/SPR1,SPR2,SPR3,SPR4,SPR5,SPR6,SPR7,SPR8,SPR9
CUT-SPAR
DO 10 I=1,NTYPE
ITMPOP(I)=0
10 CONTINUE
DO 20 I=1,NEQ
ITMPOP(EQU(I))=ITMPOP(EQU(I))+1
20 CONTINUE
DO 90 I=1,NTYPE
IF(9000D-1.1) 60,30,30
90 ITMPOP(I)=0
DEMAND BASED ITEM
30 PRBSUM=EXP(-EX900D)
DUM=PRBSUM
KFACT=1
K=0
DO 40 K=1,KFACT
PRBSUM=PRBSUM+DUM*(EX900D+K)/KFACT
K=K+1
40 CONTINUE
GO TO 90
60 IF(I14,900D-CUT) 80,80,70
INSURANCE ITEM
70 ISPARE(I,1)=1
GO TO 90
80 ISPARE(I,1)=0
CONTINUE
DO 100 I=1,NTYPE
DO 100 J=2,3
ISPARE(I,J)=0
100 CONTINUE
RETURN
END
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