Integrating O&S Models During

Conceptual Design - PART II

Reliability and Maintainability Model (RAM)
User and Maintenance Manual

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Preface

This document is one of three prepared under NASA (Langley Research Center) grant number NAG1-1-1327. Collectively these documents form the technical report covering the research activities for the period of time from July 1, 1994 to December 31, 1994. The three documents consist of the following:

1. Integrating O&S Models During Conceptual Design - Part I
   Summarizes the overall study, objectives, and results. Discusses in detail enhancements made to the models developed under this grant.

2. Integrating O&S Models During Conceptual Design - Part II
   Reliability and Maintainability Model (RAM), User and Maintenance Manual
   Provides detailed documentation on the RAM model, its execution, and procedures for conducting a study using the model. A complete source listing is provided.

3. Integrating O&S Models During Conceptual Design - Part III
   Simulation of Maintenance and Logistics Support of Proposed Space Systems Using SLAM II.
   Documents the SLAM maintenance simulation model which provides for more accurate determination of maintenance manpower requirements. A complete example of its use is provided.
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Chapter 1

Introduction

1.1 Background

This report documents the procedures for utilizing and maintaining the Reliability &
Maintainability Model (RAM) developed by the University of Dayton for the National
Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) under NASA
research grant NAG-1-1327. The purpose of the grant is to provide support to NASA in
establishing operational and support parameters and costs of proposed space systems. As part
of this research objective, the model described here was developed. Additional documentation
concerning the development of this model may be found in Part I of this report and in references
[11] and [12].

1.2 Model Development

The RAM model predicts reliability and maintainability (R&M) parameters for conceptual
space vehicles using parametric relationships between vehicle design and performance
characteristics (Table 1) and subsystem mean time between maintenance actions (MTBM) and
manhours per maintenance action (MHMA). These parametric relationships were developed
using aircraft R&M data from over thirty different military aircraft of all types. The primary
source of R&M data was the Air Force AFM 66-1 Maintenance Data Collection (MDC) system
and the Navy 3-M data system. The data base consisted of AF MDC data as reported in Volume
V (October 1985 to September 1987) of AFALDP 800-4 and Navy data reported in the July
1987-September 1989) and the MODAS on-line system (January 1990-December 1991) were
secondary sources. AFALDP 800-4 summarizes R&M data at 6-month intervals. Four 6-month
periods were averaged together in order to provide more accurate measures. The Navy data is
presented by quarters. Four quarters were averaged together also to provide for more accurate
MTBM's and manhours. Table 2 lists the 37 Air Force and Navy aircraft used in the study and
Table 3 identifies by two-digit Work Unit Code (WUC) the 26 major aircraft subsystems which
were included and their correspondence to the 33 major subsystems comprising the NASA Work
Breakdown Structure (WBS). The NASA WBS defines the subsystems addressed in the model.
In addition, the user has the option of using shuttle MTBM and mean time to repair (MTTR)
data obtained from reference [27], or the user may specify a MTBM or MTTR directly.
Table 1
Aircraft Design/Performance Variables

<table>
<thead>
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<th>VEHICLE DRY WEIGHT</th>
<th>VEHICLE LENGTH</th>
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<td>FUSELAGE VOLUME</td>
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<td>FUSELAGE SURFACE AREA</td>
<td>NUMBER OF PASSENGERS</td>
</tr>
<tr>
<td>CREW SIZE</td>
<td>NUMBER OXIDIZER TANKS</td>
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<tr>
<td>NUMBER ENGINES</td>
<td>NUMBER INTERNAL FUEL TANKS</td>
</tr>
<tr>
<td>MISSION LENGTH</td>
<td>NUMBER OF RCS/OMS ENGINES</td>
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<td>NUMBER CONTROL SURFACES</td>
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<td>NUMBER HYDRAULICS SYSTEMS</td>
<td>NUMBER AVIONICS SYSTEMS</td>
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<td>BTU COOLING CAPACITY</td>
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Table 2
AF/NAVY Aircraft

<table>
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<th>TACTICAL</th>
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<td>C-2A</td>
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1 Variable definitions of those used in the models are found in Appendix D.
Table 3

WBS to WUC to STS Conversions

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1.3 Overview

Chapter 2 discusses the general methodology used within the model. Chapter 3 describes the execution and computational sequence. Chapter 4 addresses the input screens and data while Chapter 5 defines the output screens and reports. Study analysis and procedures are discussed in Chapter 6. Appendix A contains a glossary defining the terms found on the input/output screens and reports. Appendix B contains step by step procedures for implementing the model. A source listing of the program is included in Appendix C. Variable definitions are contained in Appendix D.
Chapter 2

Methodology

2.1 Parametric Analysis

Parametric equations of the form given by Eq (1) are used to estimate the following R&M parameters:

- MTBM - Mean Flying Hours between Maintenance Actions
- MH/MA - Maintenance Manhours per Maintenance Action
- RR - Subsystem removal rate
- POFF - Percent off-equipment (vehicle) manhours
- CREW - Average crew size per maintenance task
- AB - Abort Rates (Critical Failure Rate)

\[ Y = B_0 + B_1 X_1 + B_2 X_2 + \ldots + B_k X_k \]  

(1)

where \( Y \) = R&M parameter of interest (e.g. MTBF or MH/MA)

and \( X_j = j \)th design or performance specification (e.g. vehicle dry weight), \( j = 1, 2, \ldots k \),

and \( B_0, B_1, \ldots, B_k \) are the regression coefficients.

In addition to the above R&M parameters, regression equations are used to estimate subsystem weights and many of the design/performance variables (see Table 1) as functions of the vehicle dry weight, length + wing span, number of main engines, crew size, and number of passengers. These variables are classified as primary variables while the remaining variables are referred to as secondary variables.

2.2 Computation of MTBM

An initial MTBM is obtained by subsystem from the derived parametric estimating equations. The MTBM is in units of operating (flying) hours between maintenance actions and reflects a subsystem operating in an aircraft (air/ground) environment.²

2.2.1 Technology and Reliability Growth Factor

²The exception is the landing gear subsystem in which the MTBM is measured in missions per maintenance action.
In order to account for increased reliability as a result of technological change since the time the data was collected, a technology growth factor is applied. The baseline year of the data is 1986 and the MTBM reflects the baseline year. The year (yr) represents the technology development year of the vehicle.

\[ \text{TECH MTBM} = \text{MTBM} \times (1 + \text{ADJ FAC})^{\text{yr-1986}} \]  

A reliability growth factor may then be applied based upon a Duane growth curve having an exponent (slope on log scale), b, specified by the user. The reliability growth accounts for reliability improvements obtained over the operation (missions) of the vehicle.

\[ \text{ADJ MTBM} = \text{TECH MTBM} \times (\text{MSN NBR})^b \]  

2.2.2 Inherent MTBM

Using an estimate, p, obtained from aircraft data reflecting the fraction of maintenance actions which are a result of internal component failures (as opposed to externally induced or no defect found maintenance actions), an inherent MTBM is computed:

\[ \text{MTBM}_i = \frac{\text{ADJ MTBM}}{p} \]  

Inherent maintenance actions are assumed to occur during the vehicle mission time including PAD time while under power (or other stress) prior to launch. Non-inherent failures are assumed to occur during all other ground processing time. External maintenance actions are computed from

\[ \text{MTBM}_n = \frac{\text{ADJ MTBM}}{1-p} \]

\[ \text{3If shuttle data is being used, the baseline year is 1992.} \]
2.3 Mission Profile

For each subsystem, a mission profile curve is assumed having the following form:

A further adjustment to the MTBM<sub>f</sub> is then made to account for the change in failure rates (from those of the aircraft air/ground environment) during launch and orbit. During the air (non-booster launch and re-entry phase) and PAD phase, failure rates are assumed to be constant (exponential) with a MTBM based upon the MTBM<sub>f</sub> defined above. However, during launch under booster rockets, the failure rate is increased by a user specified factor although it is still assumed to be constant. On the other hand, while in orbit, the failure rate is assumed to decrease over time based upon a Weibull time to failure probability distribution with the shape
parameter specified by the user (.28 default value). The scale parameter is computed by the model to provide continuity in the failure rate from the nonpowered flight to orbit. The failure rate curve may be expressed mathematically as:

$$
\lambda(t) = \begin{cases} 
\lambda & \text{for } 0 \leq t < t_0 \\
\kappa \lambda & \text{for } t_0 \leq t < t_1 \\
\lambda & \text{for } t_1 \leq t < t_2 \\
\frac{b}{a} t^{b-1} & \text{for } t_2 \leq t < t_3 \\
\lambda & \text{for } t_3 \leq t < t_4 
\end{cases}
$$

(6)

where:

$$
\kappa = \text{LAUNCH FACTOR}
$$

and \( a, b \) are the Weibull scale and shape parameters respectively.

2.4 Reliability Calculations

In general, the reliability function is given by

$$
R(t) = e^{-\int_{t_0}^{t} \lambda(\xi) d\xi}
$$

(7)

For each epoch of the mission profile, the reliability function may be obtained from (6) using (7):

$$
R(t) = \begin{cases} 
e^{-\lambda t} & \text{for } 0 \leq t < t_0 \\
e^{-[\lambda t_0 - \kappa \lambda (t-t_0)]} & \text{for } t_0 \leq t < t_1 \\
e^{-[\lambda (t-t_0) - \kappa (t_1-t_0)]} & \text{for } t_1 \leq t < t_2 \\
e^{-\lambda [t_2-t_0-t_1] - \kappa \lambda (t_1-t_0) + \left(\frac{b}{a}\right)^b - \left(\frac{t_2}{a}\right)^b} & \text{for } t_2 \leq t < t_3 \\
e^{-\lambda [t_3-t_0-t_1] - \kappa \lambda (t_1-t_0) + \left(\frac{t_3}{a}\right)^b - \lambda (t-t_3)} & \text{for } t_3 \leq t < t_4 
\end{cases}
$$

(8)

Since the mission profile is repetitive over time, a steady-state MTBM may be computed from equation (9).
\[
\text{SS MTBM} = \frac{\int_{0}^{\tau} R(t) \, dt}{1 - R(\tau)}
\]  

(9)

The use of the Weibull failure distribution in defining \( R(t) \) requires a numerical integration to compute the MTBM from Equation (9). Simpson’s rule was used to perform the integration.

2.4.1 Critical MTBM

Using either air abort rates only or air and ground abort rates (AB) computed from regression equations (or user specified), a critical MTBM is computed:

\[
\text{CRIT MTBM} = \frac{\text{SS MTBM}}{\text{AB}}
\]  

(10)

With critical failure rates replacing \( 1/(\text{MTBM}_i) \), approximate mission reliabilities are found using Equation (8) for each subsystem. A Vehicle reliability is computed by multiplying subsystem reliabilities \( (R_i) \)

\[
R_{\text{veh}} = R_1 \times R_2 \times \ldots \times R_k
\]  

(11)

Equation (8) assumes no explicit redundancy at the subsystem level.

A vehicle MTBM is calculated from the subsystem MTBM’s using:

\[
\text{VEH MTBM} = \frac{1}{\left[1/\text{MTBM}_1 + 1/\text{MTBM}_2 + \ldots + 1/\text{MTBM}_k\right]}
\]  

(12)

where \( 1/\text{MTBM}_i \) is the failure rate of the \( i \)th subsystem4.

2.4.2 Specified Subsystem Reliability

The user may specify a reliability, \( R_{\text{spec}} \) for a subsystem rather than have the model compute this value using Equation (8). When this is the case, the model will compute the corresponding CRIT MTBM from Equation (8) by solving

\[
R(t) = R_{\text{spec}}
\]

numerically for the CRIT MTBM. Then an SS MTBM is found from Equation (10):

\[
\text{SS MTBM} = \text{CRIT MTBM} \times \text{AB}
\]  

(13)

4 Certain subsystems, such as landing gear, may have failure times based upon cycles (landings) rather than operating hours. When this is the case, the MTBM is converted to mean operating hours between maintenance in order to compute the vehicle MTBM.
which will then be used in all subsequent calculations.  

2.4.3 Redundant reliability

All reliability calculations are based upon the CRIT MTBM. Letting \( \lambda = \frac{1}{\text{MTBM}} \) for each subsystem, Equation (8) is used to compute a mission reliability at times \( t_0, t_1, t_2, t_3, t_4, \) and \( t_5. \) Subsystem redundancy is addressed in one of two ways. For most subsystems, reliability is obtained from:

\[
R_i(t) = 1 - [1 - R_i(t)]^n
\]

where \( R_i(t) \) is computed from Equation (8) for the \( i \)th subsystem and \( n \) is the number of redundant subsystems of type \( i. \) For selected subsystems (engines, power, and avionics), a \( k \)-out-of-\( n \) redundancy is computed, where \( k \) is the minimum number of redundant subsystems (of type \( i) \) which must be operational. This calculation makes use of the binomial probability distribution and is given by:

\[
R_{r}(t) = \sum_{x=0}^{n} \binom{n}{x} R_i(t)^x (1-R_i(t))^{n-x}
\]

A vehicle reliability is computed by multiplying the \( m \) subsystem redundant reliabilities:

\[
R_{\text{veh}}(t) = R_{s1}(t) \times R_{s2}(t) \times \ldots \times R_{sm}(t)
\]

2.5 Maintainability Estimates

The primary maintainability parameter is the maintenance manhours per maintenance action (MHMA). This parameter is estimated from the parametric equations for each subsystem. Then total subsystem maintenance actions per mission is found using

\[
\text{TOT MA} = \text{NRD} \times \left( \frac{\text{GRND PROC HR}}{\text{MTBM}_N} + \frac{\text{MSN HRS}}{\text{SS MTBM}} \right)
\]

where \( \text{NRD} \) = the number of redundant subsystems. Then total manhours per mission for each subsystem is found from

\[
\text{TOT MANHRS} = \text{MHMA} \times \text{TOT MA}
\]

Manhours are then split into on-vehicle and off-vehicle manhours using the percent off-equipment hours (POFF) obtained from regression equations:

\[
\text{TOT ON-VEH MH} = (1-\text{POFF}) \times \text{TOT MANHRS}
\]

3The calculations are performed numerically using the Newton-Raphson method for finding the solution of a nonlinear equation.
When using shuttle data, MHMA is not computed from the regression equations. Instead:

\[ MHMA = MTTR \times CREW \times \frac{POFF \times CREW \times MTTR}{1 - POFF} \]  

(21)

where MTTR is a direct input to the calculation and represents the mean time to repair on-vehicle work only.

Scheduled maintenance manhours is calculated by multiplying the total on-vehicle MH by a percentage. This percentage may be input directly or obtained from a regression equation which estimates the scheduled manhours as a percentage of the unscheduled on-vehicle manhours.

\[ SCHED\ MH = PCT \times (TOT\ ON-VEH\ MH) \]  

(22)

2.6 Manpower

Maintenance manpower requirements are determined in three different ways. The first method is to take the total unscheduled manhours of work per month and divide this total by the number of hours per month available per technician to do direct maintenance work. That is let \( N = \) number of missions per month,

\[ AV = \] available hours per month per individual

\[ IND = \] percent of indirect work (work not included in the MHMA)

then,

\[ NBR\ PER = \frac{TOT\ MANHRS \times N}{(1 - IND)AV} \ (rounded\ up) + \frac{SCHED\ MH \times N}{(1 - IND)AV} \ (rounded\ up) \]  

(23)

The second approach uses the same methodology except it is applied by subsystem. That is total manhours represents subsystem manhours and manpower is calculated and rounded up by subsystem. Since scheduled maintenance is computed only at the vehicle level and not by subsystem, it will not change.

The third approach identifies the average crew size by subsystem as a minimum requirement. If the manpower computed from subsystem manhours exceed the minimum crew size requirements, then the larger number should be used otherwise the minimum crew size rounded up becomes the manpower requirement. These three methods for determining manpower collectively provide lower and upper bounds on the total maintenance manpower requirement.
2.7 Spare Parts Requirements

In order to estimate spare parts requirements, it is necessary to distinguish between a failure resulting in a remove and replace action versus other maintenance actions such as on-vehicle troubleshoot and repair or no trouble found actions.

A removal rate (RR) per maintenance action obtained from regression equations or a user specified value, is used to obtain the mean number of demands (failures) for spares (MFAIL) per mission as follows:

\[ MFAIL = RR \times (TOT MA) \]  \hspace{1cm} (24)

Under the assumption that the number of failures in a given time period follows a Poisson process, a spare parts level is found which will satisfy demands a specified percent of the time (fill rate). Fill rate represents the percent of time a demand (failure) can be immediately satisfied from the on-hand stock.

Let \( S \) = spare parts level to support a given mission and \( p \) = desired percent of time demands are satisfied (fill rate), then find the smallest value for \( S \) such that 

\[ F(S) \geq p \]

where

\[ F(S) = \sum_{i=0}^{S} \frac{\text{Exp}(-MFAIL) \times MFAIL!}{i!} \]  \hspace{1cm} (25)

\( F(S) \) is the cumulative probability of demand not exceeding spares level, \( S \).

2.8 Vehicle Turn Times

In order to determine the time required to perform maintenance on the vehicle, estimates of the number of crews available by subsystem must first be obtained. Once the number of assigned crews has been determined, average on-vehicle repair time can be obtained from

\[ MSN REP TIME = \frac{MTTR \times TOT MA}{NBR CREWS} \]  \hspace{1cm} (26)

where \( NBR CREWS \) is the total number of crews available to perform parallel work on the subsystem. Assuming tasks for each subsystem are performed sequentially (a worst case), then total vehicle mission repair time is the sum of the subsystem repair times:

\[ VEH REP TIME = \sum_{\text{ALL SUBSYS}} MSN REP TIME \]  \hspace{1cm} (27)

Scheduled maintenance time may then be added to obtain a total vehicle maintenance task time:
Mission, pad, and integration time must be included in order to obtain a vehicle turn-around time. Therefore, vehicle turn-around time in working days is:

\[ VEH\ \text{TURNAROUND} = \frac{MSN\ \text{TIME} + PAD + INTG}{24}, \ \frac{TOT\ \text{VEH TASK TIME}}{sft \times 8} \]  

Equation (29), by including the number of shifts (sft) in the second term will provide a vehicle turnaround time based upon 1, 2, or 3 shift maintenance. Dividing the vehicle turnaround time into the number of working days per month gives an estimate of the number of missions per month per vehicle:

\[ MSN/\text{MO/VEH} = \frac{WORKING\ \text{DAYS/MO}}{VEH\ \text{TURNAROUND}} \]  

Dividing the required number of missions per month by the number of missions per month per vehicle provides an estimate of the required fleet size:

\[ FLEET\ \text{SIZE} = \frac{RQD\ MSN/\text{MO}}{MSN/\text{MO/VEH}} \quad \text{(rounded up)} \]  

Equation (27) implies that all subsystems will be repaired sequentially. Setting TOT VEH TASK TIME (Equation 28) equal to the maximum subsystem MSN REP TIME (or scheduled maintenance time, if larger), a minimum vehicle turnaround time assuming all work may be accomplished in parallel is obtained.

2.9 External Tank (ET) and Liquid Rocket Booster (LRB) Calculations

From input parameters consisting of subsystem MTBM, OPER HRS, CRIT FAIL RT, MTTR, and CREW SIZE, subsystem reliability, scheduled and unscheduled manhours and manpower are computed. Reliability is derived from:

\[ R = e^{-\frac{OPER\ HRS}{MTBM \times (CRIT\ FAIL\ RT)}} \]  

and

\[ UNSCH\ MH = \frac{OPER\ HRS}{MTBM} \times MTTR \times CREW\ SIZE \]  

---

\(^6\) Aircraft data has shown that 98 percent of the scheduled maintenance is on-aircraft maintenance.
$\text{SCHD MH} = \text{PCT} \times \text{UNSCH MH}$

(34)

$$\text{MAN PWR} = \frac{(\text{UNSCH MH} + \text{SCHD MH}) \times N}{(1 - \text{IND}) \times \text{AU}} \text{ (rounded up)}$$

(35)

ET/LRB system reliabilities are obtained by multiplying subsystem reliabilities while system manhours and manpower are obtained by summing corresponding subsystem values. Overall system reliabilities (VEH+ET+LRB) are computed by multiplying the results of Equation (16) by the ET reliability and the LRB reliability which are treated as launch reliabilities.
CHAPTER 3

Model Design and Execution

3.1 Model Design

The computer model is written in Microsoft QuickBasic Version 4.5 with a compiled version available for execution. It will run on any DOS system having a minimum of 640K memory. The source program consists of five files containing the modules shown in Table 4. In order to modify the software and recompile the executable program, version 4.5 (or higher) of Microsoft QuickBasic would be required. The source listing for each module is contained in Appendix C. To run the model when the executable file (RAM.EXE) is stored in the current directory, the user types RAM at the DOS prompt.

Table 4
Computer Files & Modules

<table>
<thead>
<tr>
<th>File</th>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAMX.BAS</td>
<td>BOOSTER</td>
<td>computes reliability parameters for both a liquid rocket booster and an external tank.</td>
</tr>
<tr>
<td></td>
<td>COMFAC</td>
<td>provides input menus for the computational factors</td>
</tr>
<tr>
<td></td>
<td>DRIVER</td>
<td>controls computational sequencing</td>
</tr>
<tr>
<td></td>
<td>INFIL</td>
<td>reads input data from a file</td>
</tr>
<tr>
<td></td>
<td>INIT</td>
<td>initializes variables and assigns values to arrays</td>
</tr>
<tr>
<td></td>
<td>INMEN</td>
<td>displays primary input menu and selected input screens</td>
</tr>
<tr>
<td></td>
<td>LCCFIL</td>
<td>saves specified input/output to a file for use by costing model</td>
</tr>
<tr>
<td></td>
<td>MAIN</td>
<td>displays main menu</td>
</tr>
<tr>
<td></td>
<td>MSN</td>
<td>initializes mission profile</td>
</tr>
<tr>
<td></td>
<td>OUTFIL</td>
<td>writes input data to a file</td>
</tr>
<tr>
<td></td>
<td>PCTWGT</td>
<td>computes subsystem weights from weight distribution</td>
</tr>
<tr>
<td></td>
<td>PRIVAR</td>
<td>contains primary variable selection menu</td>
</tr>
<tr>
<td></td>
<td>REL</td>
<td>allows user to specify subsystem reliability</td>
</tr>
<tr>
<td></td>
<td>SHUTTLE</td>
<td>displays/updates shuttle or user specified MTBF and MTTR values</td>
</tr>
<tr>
<td></td>
<td>WEIGHT</td>
<td>displays/updates subsystem weights</td>
</tr>
<tr>
<td>RAM2.BAS</td>
<td>AGR</td>
<td>contains screen display reports</td>
</tr>
<tr>
<td></td>
<td>DISPLAY</td>
<td>displays aggregated system R&amp;M parameters</td>
</tr>
<tr>
<td></td>
<td>MAINTDIS</td>
<td>contains screen display (output) selection menu</td>
</tr>
<tr>
<td></td>
<td>MANDISPLAY</td>
<td>displays maintenance report</td>
</tr>
<tr>
<td></td>
<td>RELDISPLAY</td>
<td>displays reliability report</td>
</tr>
<tr>
<td></td>
<td>SPAREDISPLAY</td>
<td>displays spare parts report</td>
</tr>
<tr>
<td></td>
<td>SUMMARY</td>
<td>displays system summary report</td>
</tr>
<tr>
<td></td>
<td>TURNTIME</td>
<td>displays/computes vehicle turntimes</td>
</tr>
</tbody>
</table>
### Table 4 (continued)
Computer Files & Modules

<table>
<thead>
<tr>
<th>File</th>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM3.BAS</td>
<td>ECHO</td>
<td>contains printer reports</td>
</tr>
<tr>
<td></td>
<td>ETSRB</td>
<td>prints LRB and ET reliability reports</td>
</tr>
<tr>
<td></td>
<td>PRINTMAINT</td>
<td>prints maintenance report</td>
</tr>
<tr>
<td></td>
<td>PRINTMAN</td>
<td>prints manpower report</td>
</tr>
<tr>
<td></td>
<td>PRINTREL</td>
<td>prints reliability report</td>
</tr>
<tr>
<td></td>
<td>PRINTSPR</td>
<td>prints spare parts report</td>
</tr>
<tr>
<td></td>
<td>PRINTSUM</td>
<td>prints summary report</td>
</tr>
<tr>
<td></td>
<td>PRINTTURN</td>
<td>prints turntime report</td>
</tr>
<tr>
<td></td>
<td>REPORT</td>
<td>displays report selection menu</td>
</tr>
<tr>
<td></td>
<td>SIMREP</td>
<td>prints computed values for use in simulation model</td>
</tr>
<tr>
<td>RAMC.BAS</td>
<td>ABORT</td>
<td>computes abort (critical failure) rates</td>
</tr>
<tr>
<td></td>
<td>ACWGT</td>
<td>computes aircraft weight distribution</td>
</tr>
<tr>
<td></td>
<td>COMPM</td>
<td>computes subsystem MTBM if reliability is given</td>
</tr>
<tr>
<td></td>
<td>COMREL</td>
<td>computes non-redundant subsystem reliability</td>
</tr>
<tr>
<td></td>
<td>CREW</td>
<td>computes subsystem crew sizes</td>
</tr>
<tr>
<td></td>
<td>CRIT</td>
<td>computes the critical MTBM</td>
</tr>
<tr>
<td></td>
<td>EOS</td>
<td>computes initial MTBM and MBMA</td>
</tr>
<tr>
<td></td>
<td>MANPWR</td>
<td>computes subsystem manpower requirements</td>
</tr>
<tr>
<td></td>
<td>POFFQS</td>
<td>computes percent off-vehicle values</td>
</tr>
<tr>
<td></td>
<td>REDONREL</td>
<td>computes redundant subsystem reliabilities</td>
</tr>
<tr>
<td></td>
<td>REMEOQS</td>
<td>computes removal rates</td>
</tr>
<tr>
<td></td>
<td>SECONDARY</td>
<td>computes secondary variable values</td>
</tr>
<tr>
<td></td>
<td>SIN</td>
<td>computes simulation model parameters</td>
</tr>
<tr>
<td></td>
<td>SPACEMTB</td>
<td>computes space adjusted MTBM</td>
</tr>
<tr>
<td></td>
<td>SPARES</td>
<td>computes spare part requirements</td>
</tr>
<tr>
<td></td>
<td>TECH</td>
<td>computes technology and reliability growth MTBM</td>
</tr>
<tr>
<td>RAMW.BAS</td>
<td>WRFILE</td>
<td>contains ASCII file output module</td>
</tr>
<tr>
<td></td>
<td></td>
<td>writes all input/output reports to an ASCII file except for the Summary Report</td>
</tr>
</tbody>
</table>
3.2 Initialization Sequence

Upon execution, the model will perform the following initialization activities in the order listed:

3.2.1 Display Opening Banner
The user will be requested to provide a file/project name. This name will be used for all files written to or read from during execution. If a name is not provided, the program will assign "NO_NAME." The user may change the name at any time during execution.

3.2.2 Initialize Variables and Arrays
Default values are assigned to all input variables. Arrays are assigned numeric or alphanumeric values from data statements contained in the main module (RAMX.BAS). Shuttle values are read in at this time from data statements.

3.2.3 Initialize mission profile
The mission profile (Figure 1) is assigned default values. All subsystems are then initialized to these same values.

3.2.4 Compute subsystem weights
A weight is assigned to each subsystem based upon the shuttle weight distribution and the default vehicle dry weight. Those subsystems having zero percent weight from the shuttle weight distribution will be set to "NO COMPUTE" and will not be displayed on any of the screens or output products. After initialization, the user may restore these subsystems provided they are assigned a nonzero weight (percent).

3.2.5 Perform Shuttle Clean-up
Converts shuttle MTBM and MTTR values to conform to the NASA WBS (Table 3) based upon the shuttle weight distribution. Weights are then recomputed to conform to the large aircraft distribution.

3.2.6 Compute R&M parameters
Calls the computation driver module (DRIVER) which computes reliability and maintainability values from the default input parameters. DRIVER sequencing is discussed later.
3.2.7 Display Main Menu

At this point all input and output variables have been assigned values. The program calls the main menu and waits for the user to select one of the options from the main menu:

Figure 2
Main Menu

<table>
<thead>
<tr>
<th>NBR</th>
<th>SELECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>READ INPUT FROM A FILE</td>
</tr>
<tr>
<td>2</td>
<td>INPUT PARAMETER MENU</td>
</tr>
<tr>
<td>3</td>
<td>COMPUTE R&amp;M PARAMETERS</td>
</tr>
<tr>
<td>4</td>
<td>SCREEN DISPLAY (OUTPUT) MENU</td>
</tr>
<tr>
<td>5</td>
<td>SAVE INPUT PARAMETERS</td>
</tr>
<tr>
<td>6</td>
<td>SAVE DATA FOR COST MODEL</td>
</tr>
<tr>
<td>7</td>
<td>CHANGE VEHICLE/FILE NAME</td>
</tr>
<tr>
<td>8</td>
<td>PRINT OUTPUT REPORT(S)</td>
</tr>
<tr>
<td>9</td>
<td>TERMINATE SESSION</td>
</tr>
</tbody>
</table>

3.3 Main Menu Options

3.3.1 Read Input From a File

This option allows the user to input a DOS file which has been previously saved under Main Menu NBR 5, Save Input Parameters. This file contains all input parameters necessary to execute the model. The file name is the name currently displayed by the program with a .DAT extension. If the file does not reside in the active directory/subdirectory, the vehicle/file name must include the applicable directory/subdirectory. For example: "A:\SHUTTLE". The extension is added automatically by the program. Upon successfully reading in the input file, the model automatically recomputes the output values.

3.3.2 Input Parameter Menu

Selection of this option will display the primary input menu (see Section 4.1). The user must select this menu to update any of the input parameters.

3.3.3 Compute R&M Parameters

This invokes the computation driver module which contains the overall sequence for recomputing the output. The computational sequence is discussed further in Section 3.4.
Reliability & Maintainability Menu Hierarchy

Main Menu

- Read input from File
- Compute R&M Parameters
- Save Input Parameters
- Screen Display (output) Menu
- Save Data for Cost Model
- Change vehicle/file name
- Print Output Reports

- select shuttle/aircraft
- add/delete subsystem
- update/display primary system parameters
- update/display weight distribution
- update/display secondary variables
- update/display mission profile
- update/display operating hrs
- update/display subsystem redundancy
- update/display ET/URB reliability data
- update/display shuttle MTBMW/FTTR
- change scheduled maintenance
- establish subsystem reliabilities
- computational factors

- reliability report
- maintainability report
- manpower requirements
- spares requirements
- vehicle turnaround report
- system performance summary

- print input data
- print summary report
- print reliability report
- print maintainability report
- print manpower report
- print spares report
- print turnaround report
- print ET/URB report
- print total output
- print total input/output
- simulation model input
- send report to a file
3.3.4 Screen Display (output) Menu

Displays the menu for selecting screen display of the various output reports. The output reports are discussed in Chapter 5.

3.3.5 Save Input Parameters

Stores all current input parameter values in a DOS file having a file name "name.DAT" where name is the current name given to the vehicle/file by the user. To store the data on a file in a different directory/subdirectory, the directory/subdirectory must be part of the vehicle/file name. For example: C:\STUDY\name". The file extension ".DAT" is automatically assigned by the program. The file may be read back in by selecting "Read Input from File" (Main menu NBR 1).

3.3.6 Save Data for Cost Model

Stores certain categories of input/output data in a DOS file for use in a corresponding costing model (LCC). The name given to the file is the same as the current vehicle/file name provided by the user. The program automatically assigns a file extension ".CST".

3.3.7 Change Vehicle/File Name

Allows the user to redefine the vehicle/file name. This is useful when the input parameters have been changed/updated to reflect a different scenario or a different vehicle. These new parameters can then be saved under a different file name. This option may also be used to read in a different input file or to save or read a file in a different directory/subdirectory (see 3.3.1 and 3.3.5).

3.3.8 Print Output Reports

Displays a report menu used to select any of the output reports as well as the input data for printing on a parallel port printer. The Report Menu also includes an option for saving all input/output in an ASCII file. This file may then be read by a wordprocessor or sent over a LAN network for subsequent printing on a serial port printer. A special report for use in the maintenance simulation model (MSM) may also be obtained from this menu.

3.3.9 Terminate Session

Returns control back to the DOS system. A final opportunity to save input data to a DOS file is available first. This option will also remove two temporary files created in the default (current) directory/subdirectory which permit a file display when saving a file or reading a file for the first time.
3.4 Computational Sequence

When the user selects the option to RECOMPUTE, a call is made to the DRIVER module which controls the sequencing of the calculations and executes the computational modules. The following sequence takes place:

![Computational Flow Diagram](image)

**Figure 3**

3.4.1 An input screen will request the user to identify those parameters which are not to be recomputed from the regression equations. "DO NOT RECOMPUTE" is automatically assigned to all the parameters listed when reading in an existing input file (".DAT"). Any parameter in which the user has specified one or more subsystem values, will be assigned a "DO NOT RECOMPUTE." The user may override this selection. The following parameters are affected:

- Critical Failure (abort) rates
- Fraction off-vehicle
- Removal rates
- Crew sizes
- Scheduled maintenance percent

3.4.2 (CALL WGT) If the user is in the PRECONCEPTUAL mode, the subsystem weights are recomputed using the current weight distribution.

3.4.3 (CALL SECONDARY) If the user is in the PRECONCEPTUAL or WEIGHT-DRIVEN modes, the secondary variables are recomputed from the regression equations.
3.4.4 (CALL CREW) Unless specified otherwise, the CREW SIZE is recomputed from the regression corresponding equations. For Shuttle subsystems, the default shuttle crew size (4.5 or 9) is assigned.

3.4.5 (CALL EQS) The primary parametric equations are evaluated to determine the MTBM and the MHMA values. For shuttle subsystems, the default (shuttle values) or user specified values are used. Single subsystem weights are used when called for in the equations. These are determined by dividing the total subsystem weight by the number of redundant subsystems. Calibration factors are applied to the MTBM and MHMA values (default is 1). Unless otherwise specified, a scheduled maintenance fraction is determined from a parametric equation. A vehicle MTBM is then computed.

3.4.6 (CALL POFF) Unless otherwise specified, the fraction of off-vehicle work is computed from parametric equations. A default value from the system parameter table is used for those subsystems in which parametric equations are not available. Single subsystem weights are used.

3.4.7 (CALL ABORT) Unless otherwise specified, critical failure rates are determined from parametric equations. A default value is used for those subsystems in which parametric equations are not available. Single subsystem weights are used. If air abort only is selected as from the primary system parameter table, then the air + ground abort rate is adjusted from fixed percentages (of air aborts of the total aborts). The default value is then assumed to be an air abort only value.

3.4.8 (CALL REMOVAL) Unless otherwise specified, removal rate fractions are determined from parametric equations. Single subsystem weights are used. If the subsystem is to be shuttle based, then shuttle removal rates are used in place of the parametric equations.

3.4.9 (CALL TECH) Technological and reliability growth adjustments are made to the MTBM.

3.4.10 (CALL SPACE) The technology and reliability adjusted MTBM is split into an inherent MTBM and a non-inherent (externally induced and no defect found) MTBM. The inherent MTBM is then modified to account for the launch and orbit environment (see paragraph 2.2.2 and 2.2.3).

3.4.11 (CALL CRIT) Critical failure MTBM's (CRIT MTBM) are computed by dividing the space adjusted MTBM by the abort rate. These are used in the reliability calculations.

3.4.12 (CALL COMPM) A check is made to see if any subsystems have a user specified reliability. If so, a corresponding critical MTBM and space adjusted (inherent) MTBM are found using numerical procedures. Inherent vehicle MTBM's are recomputed incorporating these values.
3.4.13 (CALL COMREL) A nonredundant subsystem reliability is computed using the CRIT MTBM.

3.4.14 (CALL REDUN) A redundant subsystem and vehicle reliability is computed for each epoch of the mission. These values are based upon the number of redundant subsystems specified by the user or the k out of n redundancy where applicable (i.e. engines, power subsystems and avionics subsystems).

3.4.15 (CALL MANPOWER) Subsystem manpower is computed based upon the total number of maintenance manhours generated per month. Scheduled maintenance manpower is also determined.

3.4.16 (CALL SPARES) Initial spares requirement is found based upon the removal rate and total number of maintenance actions.

3.4.17 (CALL SIM) Aggregated system R&M parameters are computed to support output screen display (AGRT) and printed (simulation input) report options.

3.4.18 Return to main menu. Turntime calculations are computed when a turntime output screen or report is requested.
Chapter 4

Model Input

4.1 Primary Input Menu

When the user selects INPUT PARAMETER MENU from the main menu, the menu shown in Figure 4 is displayed:

Figure 4
Input Parameter Menu

<table>
<thead>
<tr>
<th>NBR</th>
<th>SELECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ADD/DELETE A SUBSYSTEM</td>
</tr>
<tr>
<td>2</td>
<td>SELECT SHUTTLE/AIRCRAFT</td>
</tr>
<tr>
<td>3</td>
<td>UPDATE/DISPLAY PRIMARY SYSTEM PARAMETERS</td>
</tr>
<tr>
<td>4</td>
<td>UPDATE/DISPLAY SUBSYSTEM WEIGHTS</td>
</tr>
<tr>
<td>5</td>
<td>UPDATE/DISPLAY SECONDARY VARIABLES</td>
</tr>
<tr>
<td>6</td>
<td>UPDATE/DISPLAY COMPUTATIONAL FACTORS</td>
</tr>
<tr>
<td>7</td>
<td>UPDATE/DISPLAY MISSION PROFILE</td>
</tr>
<tr>
<td>8</td>
<td>UPDATE/DISPLAY SYSTEM OPERATING HRS</td>
</tr>
<tr>
<td>9</td>
<td>UPDATE/DISPLAY REDUNDANCY CONFIGURATION</td>
</tr>
<tr>
<td>10</td>
<td>UPDATE/DISPLAY LRB/ET RELIABILITY DATA</td>
</tr>
<tr>
<td>11</td>
<td>UPDATE/DISPLAY SHUTTLE MTBM'S &amp; MTTR'S</td>
</tr>
<tr>
<td>12</td>
<td>CHANGE SCHEDULED MAINTENANCE PERCENT</td>
</tr>
<tr>
<td>13</td>
<td>ESTABLISH SUBSYSTEM RELIABILITIES</td>
</tr>
</tbody>
</table>

return ..................................exit to main menu

4.1.1 Add/Delete a Subsystem

Permits the user to structure the WBS to a particular vehicle by deleting any of the 33 subsystems available. The user may also change the names given to any of the subsystems. However, if changing the name implies a different subsystem from the default subsystem, then the user should also identify that subsystem as "SHUTTLE" and specify appropriate MTBM and MTTR values (see 4.1.2). The parametric equations are valid only for the subsystems originally identified.

4.1.2 Select Shuttle/Aircraft

The MTBM and MTTR for each subsystem will be based upon the parametric equations if "AIRCRAFT" is selected and will be based upon the shuttle displayed values (see 4.1.11) if "SHUTTLE" is selected. If the user desires to specify a MTBM and MTTR, then "SHUTTLE" should be selected.
4.1.3 Update/Display Primary System Menu

The user must specify values for the primary driver variables.

Table 5
Primary Driver Variables

<table>
<thead>
<tr>
<th>VAR NBR</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DRY WEIGHT (lbs)</td>
</tr>
<tr>
<td>2</td>
<td>LENGTH (ft)</td>
</tr>
<tr>
<td>2</td>
<td>WING SPAN (ft)</td>
</tr>
<tr>
<td>3</td>
<td>CREW SIZE</td>
</tr>
<tr>
<td>4</td>
<td>NBR PASSENGERS</td>
</tr>
<tr>
<td>5</td>
<td>NBR MAIN ENGINES</td>
</tr>
<tr>
<td>21</td>
<td>NBR RCS ENGINES</td>
</tr>
<tr>
<td>22</td>
<td>NBR OMS ENGINES</td>
</tr>
</tbody>
</table>

The following parameter values must be specified:

Table 6
System Parameter Values

<table>
<thead>
<tr>
<th>VAR NBR</th>
<th>PARAMETER</th>
<th>DEFAULT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>ADJ SHUTTLE MTBM</td>
<td>0-No</td>
<td>Determines if launch/space adjustment will be applied to shuttle selected MTBW's.</td>
</tr>
<tr>
<td>7</td>
<td>TECHNOLOGY YR</td>
<td>1996</td>
<td>Year to be used in applying the technology growth factor.</td>
</tr>
<tr>
<td>8</td>
<td>DEFAULT ABORT RATE</td>
<td>.001</td>
<td>Abort rate used for subsystems not having parametric equations.</td>
</tr>
<tr>
<td>9</td>
<td>WEIBULL SHAPE PARAMETER</td>
<td>.28</td>
<td>Shape parameter for Weibull distribution used during orbit time when applying the launch/space adjustment.</td>
</tr>
<tr>
<td>10</td>
<td>LAUNCH FACTOR</td>
<td>20</td>
<td>A multiplicative factor which increases the failure rate during launch when applying the launch/space adjustment.</td>
</tr>
<tr>
<td>11</td>
<td>AVAL MAMRS/MONTH</td>
<td>144</td>
<td>The average number of hours a month a single maintenance worker is available within the workplace.</td>
</tr>
<tr>
<td>12</td>
<td>FRACTION INDIRECT WORK</td>
<td>.15</td>
<td>The fraction of the available time a worker spends performing indirect work (work not addressed by the model).</td>
</tr>
<tr>
<td>13</td>
<td>SPARE FILL RATE OBJ</td>
<td>.95</td>
<td>The fraction of time a spare is to be available when a failure (removal) occurs (sets fill rate goal for computing spares).</td>
</tr>
<tr>
<td>14</td>
<td>AVG CREW SIZE-SCHD MAINT</td>
<td>7</td>
<td>The average number of workers simultaneously performing scheduled maintenance - used in computing turntimes.</td>
</tr>
<tr>
<td>15</td>
<td>PLANNED MISSIONS/YEAR</td>
<td>12</td>
<td>The number of missions per year to be flown.</td>
</tr>
<tr>
<td>16</td>
<td>MODE INDICATOR</td>
<td>0</td>
<td>See para 4.2.</td>
</tr>
<tr>
<td>17</td>
<td>VEHICLE INTEGRATION TIME</td>
<td>2</td>
<td>Number of days required to perform vehicle integration.</td>
</tr>
<tr>
<td>18</td>
<td>LAUNCH PAD TIME (days)</td>
<td>1</td>
<td>Number of days vehicle is on launch pad for processing.</td>
</tr>
<tr>
<td>19</td>
<td>AGGREGATE AVIONICS</td>
<td>0-WO</td>
<td>Roll-up the six avionics subsystems into a single subsystem.</td>
</tr>
<tr>
<td>20</td>
<td>DEFAULT FRACTION OFF MAMRS</td>
<td>.2</td>
<td>The fraction of total maintenance manhours spent on off-vehicle work - used if no parametric equation is available.</td>
</tr>
<tr>
<td>23</td>
<td>REL GROWTH SLOPE</td>
<td>.5</td>
<td>Exponent used in the reliability growth adjustment to the MTBM.</td>
</tr>
<tr>
<td>24</td>
<td>REL GROWTH MSN NBR</td>
<td>1</td>
<td>Mission number at which the reliability growth adjustment applies (no growth is realized at the default value).</td>
</tr>
<tr>
<td>25</td>
<td>AIR&amp;GRND / AIR ABORTS</td>
<td>0-AIR+GRND</td>
<td>Bases critical failure rates on either air and ground aborts or air only aborts.</td>
</tr>
</tbody>
</table>
4.1.4 Update/Display Subsystem Weights

When in the preconceptual mode (see para 4.2.1), the user may select a weight distribution from either a large vehicle distribution, small vehicle distribution, shuttle weight distribution, or parametrically computed from aircraft weight distributions. The user may also input his own distribution. From the selected distribution, subsystem weights are computed based upon the vehicle DRY WEIGHT. When in the weight-driven or weight-variable driven modes, the user must specify the subsystem weights. The weights may be adjusted by a common factor when performing sensitivity or trade-off analysis.

4.1.5 Update/Display Secondary Variables

When in the preconceptual or weight-driven mode, this selection will only display the computed values of the secondary variables (obtained from a call to the module SECONDARY). In the variable driven mode, the user will update these values through an input screen. Complete definitions of these variables may be found in Appendix D.

Table 7

Secondary Variables

<table>
<thead>
<tr>
<th>VAR NBR</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuselage area (sq ft)</td>
</tr>
<tr>
<td>2</td>
<td>Fuselage Volume (cu ft)</td>
</tr>
<tr>
<td>3</td>
<td>Wetted Area (sq ft)</td>
</tr>
<tr>
<td>4</td>
<td>Nbr wheels</td>
</tr>
<tr>
<td>5</td>
<td>Nbr Actuators</td>
</tr>
<tr>
<td>6</td>
<td>Nbr Control Surfaces</td>
</tr>
<tr>
<td>7</td>
<td>KVA MAX</td>
</tr>
<tr>
<td>8</td>
<td>Nbr Hydraulic Subsystems</td>
</tr>
<tr>
<td>9</td>
<td>Nbr Fuel Tanks (internal)</td>
</tr>
<tr>
<td>10</td>
<td>Total nbr Avionics Subsystems</td>
</tr>
<tr>
<td>11</td>
<td>Nbr Different Avionics Subsystems</td>
</tr>
<tr>
<td>12</td>
<td>BTU Cooling</td>
</tr>
<tr>
<td>13</td>
<td>Nbr Oxidizer Tanks</td>
</tr>
</tbody>
</table>
4.1.6 Update/Display Computational Factors

The following factors may be displayed and updated:

<table>
<thead>
<tr>
<th>Technology Growth Factor</th>
<th>Critical Failure Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal Rate*</td>
<td>Fraction Off-Vehicle*</td>
</tr>
<tr>
<td>Crew Size*</td>
<td>NBR Crews Assigned</td>
</tr>
<tr>
<td>Fraction Inherent Failures</td>
<td></td>
</tr>
</tbody>
</table>

Each computational factor is discussed in paragraph 4.3.

4.1.7 Display and Update Mission Profile

Allows the user to specify the time in hours for each segment of the mission beginning with ground processing, then pad time, launch, non-powered flight to orbit, orbit, and return. Beginning at launch (T=0), times are cumulative. The user has the option of updating subsystem operating hours with the mission segment times.

Figure 5

Mission Profile

<table>
<thead>
<tr>
<th>NBR</th>
<th>Time in Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground Power Time</td>
</tr>
<tr>
<td></td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>Pad Time</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Powered Phase Completion Time</td>
</tr>
<tr>
<td></td>
<td>.14</td>
</tr>
<tr>
<td>4</td>
<td>Orbit Insertion Time</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Orbit Completion Time</td>
</tr>
<tr>
<td></td>
<td>71</td>
</tr>
<tr>
<td>6</td>
<td>Reentry Time</td>
</tr>
<tr>
<td></td>
<td>72</td>
</tr>
</tbody>
</table>

Enter number to be changed or 0 if none?

---

For those factors identified by a *, any changes to the displayed values will result in a NO COMPUTE assigned to that factor when a recomputation is requested. The user may override and request the factor be recomputed from the parametric equations.
4.1.8 Update/Display System Operating Hours

SUBSYSTEM OPERATING HOURS

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>PROCESS TIME</th>
<th>PAD TIME</th>
<th>BOOST RE TIME</th>
<th>ORBIT TIME</th>
<th>REENTRY TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>200</td>
<td>20</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>200</td>
<td>10</td>
<td>.14</td>
<td>.86</td>
<td>70</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?

Each subsystem’s operating hour profile defaults to the vehicle mission profile. The user may then adjust each subsystem based upon that subsystem mission profile and maintenance practices and procedures. In computing space adjusted MTBM’s, the ground segment, non-booster time to orbit, and recovery segments have constant failure rates based upon the calibrated MTBM as adjusted for technology and the steady-state ground/air/space environment. During the launch (booster) segment, the failure rate is increased by the launch factor (system parameter number 8). During the orbit segment, the failure rate is assumed to be decreasing based upon the Weibull shape parameter (system parameter number 7). The ground segment maintenance actions are based upon the external MTBM while all other segment maintenance actions are based upon the inherent MTBM. Input should be for an entire subsystem separated by commas. Current values will be retained by defaulting with a comma; e.g. 10,1,2,3 will result in the third and fifth entry defaulting to its present value and the first, second, fourth, and sixth values being 10, 1, 2, and 3 respectively.

---

8 All subsystem displays show only 13 of the 33 subsystems as example input and output.
4.1.9 Update/Display Redundancy Configuration

Except for engines, all subsystems are defaulted to one. This screen is used to identify multiple active redundant subsystems. For power (WBS 9.XX), propulsion (WBS 6.00, 7.00, 8.00), and avionics (WBS 13.XX) subsystems, a k out of n redundancy may be specified. Engines are defaulted to n out of n, where n is the number of main, RCS, and OMS engines specified on the system parameter table.

Figure 7

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>REDUNDANT SUBSYS</th>
<th>MIN NBR REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE

9Whenever a zero (0) response is appropriate, the user may select "enter" or "return" instead.
4.1.10 Update/Display LRB/ET Reliability Data

This selection will allow for the calculation of an LRB and/or ET reliability to be used in computing an overall system reliability. Unlike the other displays, the screens shown in Figure 8 contain both input parameters and R&M output values. The overall reliabilities are used in the System Performance Summary Report only.

Figure 8

EXTERNAL FUEL TANK INPUT DATA

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>MTBM</th>
<th>OPER HRS</th>
<th>CRIT FAIL RT</th>
<th>CRIT MTTR</th>
<th>CREW SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ELECTRICAL</td>
<td>20.42</td>
<td>72</td>
<td>.001</td>
<td>13.68</td>
<td>4.5</td>
</tr>
<tr>
<td>2</td>
<td>PROP-FLUIDS</td>
<td>4</td>
<td>72</td>
<td>.001</td>
<td>18</td>
<td>4.5</td>
</tr>
<tr>
<td>3</td>
<td>RANGE SAFETY</td>
<td>44.77</td>
<td>72</td>
<td>.001</td>
<td>64.65</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>STRUCTURES</td>
<td>.0354</td>
<td>1</td>
<td>.001</td>
<td>6.83</td>
<td>4.5</td>
</tr>
<tr>
<td>5</td>
<td>THERMAL-TPS</td>
<td>.0219</td>
<td>1</td>
<td>.001</td>
<td>1.55</td>
<td>4.5</td>
</tr>
</tbody>
</table>

ENTER NUMBER FOR CHANGE?

ENTER SCHD MAINT AS A PCT OF UNSCH MAINT? .7

COMPUTED MISSION

<table>
<thead>
<tr>
<th>SUBSYSTEM</th>
<th>RELIABILITY</th>
<th>UNSCH MANHRS</th>
<th>SCH MANHRS</th>
<th>MANHR DRIVEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRICAL</td>
<td>.9964802</td>
<td>217.0578</td>
<td>151.9404</td>
<td>7</td>
</tr>
<tr>
<td>PROP-FLUIDS</td>
<td>.982161</td>
<td>1458</td>
<td>1020.6</td>
<td>44</td>
</tr>
<tr>
<td>RANGE SAFETY</td>
<td>.9981931</td>
<td>467.8713</td>
<td>327.5099</td>
<td>14</td>
</tr>
<tr>
<td>STRUCTURES</td>
<td>.9721467</td>
<td>868.2203</td>
<td>607.7542</td>
<td>26</td>
</tr>
<tr>
<td>THERMAL-TPS</td>
<td>.9553647</td>
<td>310.4931</td>
<td>222.9452</td>
<td>10</td>
</tr>
</tbody>
</table>

OVERALL ET .9075152 3329.643 2330.75 101

note: set reliability=1 to eliminate subsystem

ENTER NEW RELIABILITY-OR RETURN TO USE COMPUTED?

LIQUID ROCKET BOOSTER INPUT DATA

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>MTBM</th>
<th>OPER HRS</th>
<th>CRIT FAIL RT</th>
<th>MTTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ELECTRICAL</td>
<td>35.21</td>
<td>669</td>
<td>.001</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>PROPULSION</td>
<td>70</td>
<td>677</td>
<td>.001</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>RANGE SAFETY</td>
<td>102</td>
<td>677</td>
<td>.001</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>STRUCTURES</td>
<td>75</td>
<td>667</td>
<td>.001</td>
<td>1</td>
</tr>
</tbody>
</table>

ENTER NUMBER FOR CHANGE?

ENTER SCHD MAINT AS A PCT OF UNSCH MAINT? .7

COMPUTED MISSION

<table>
<thead>
<tr>
<th>SUBSYSTEM</th>
<th>RELIABILITY</th>
<th>UNSCH MANHRS</th>
<th>SCH MANHRS</th>
<th>MANHR DRIVEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRICAL</td>
<td>.9811791</td>
<td>85.50128</td>
<td>59.85089</td>
<td>3</td>
</tr>
<tr>
<td>PROPULSION</td>
<td>.9903752</td>
<td>43.52143</td>
<td>30.465</td>
<td>2</td>
</tr>
<tr>
<td>RANGE SAFETY</td>
<td>.9933847</td>
<td>29.86765</td>
<td>20.90735</td>
<td>1</td>
</tr>
<tr>
<td>STRUCTURES</td>
<td>.9911461</td>
<td>40.02</td>
<td>28.014</td>
<td>2</td>
</tr>
</tbody>
</table>

OVERALL LRB .9567603 198.9104 139.2372 8

note: set reliability=1 to eliminate subsystem

ENTER NEW RELIABILITY-OR RETURN TO USE COMPUTED?
### 4.1.11 Update/Display Shuttle MTBM's and MTTR's

When "SHUTTLE" is selected the subsystem values displayed will be used in computing the R&M parameters. The default values were computed from shuttle data (see reference 12). The user may specify any MTBM and MTTR to be used in the computation.

#### Figure 9
Shuttle MTBM/MTTR Update/Display Screen

<table>
<thead>
<tr>
<th>MTBM (HRS/MAINT ACTION) VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Note:</strong> all MTBM's should be for a single subsystem</td>
</tr>
<tr>
<td>NBR</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>19</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>26</td>
</tr>
<tr>
<td>29</td>
</tr>
<tr>
<td>32</td>
</tr>
</tbody>
</table>

**NOTE:** indicates shuttle value currently in use

ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?

<table>
<thead>
<tr>
<th>MTTR VALUES - Note: MTTR is the average repair time in hours to complete a single maintenance action given the corresponding avg crew size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Note:</strong> indicates shuttle value currently in use</td>
</tr>
<tr>
<td>NBR</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>19</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>26</td>
</tr>
<tr>
<td>29</td>
</tr>
<tr>
<td>32</td>
</tr>
</tbody>
</table>

ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?
4.1.12 Change Schedule Maintenance

Scheduled maintenance is determined as a computed percent of the unscheduled maintenance. The percent used is determined from a parametric equation. The user may specify a percent to be used in the computation in place of the computed value.

4.1.13 Establish Subsystem Reliabilities

Each subsystem may have different reliabilities specified. By default, each subsystem will have its reliabilities determined based upon a computed or user specified MTBM, critical failure rate, and operating hour profile. However, the user may specify a desired reliability for a subsystem by assigning a value between zero and one. In order to reverse the process and have the model compute the reliability once a value has been specified, enter a zero (0) reliability value.

Figure 10

ESTABLISH SUBSYSTEM RELIABILITY

specify nonredundant subsystem reliability at the end of the mission
enter a zero reliability to have the system compute a value

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>RELIABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>0.99889</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>COMPUTED</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>COMPUTED</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?
4.2 Modes of Operation

4.2.1 The model operates in one of three modes: PRECONCEPTUAL, WEIGHT DRIVEN, & WEIGHT/VARIABLE DRIVEN. In mode 1, PRECONCEPTUAL, the user must specify the 6 driver variables and the 19 system parameters (see para 4.1.1). The driver variables are used to estimate subsystem weights and secondary variable values from the multiple regression models derived for this purpose. When operating in Mode 1, the user may display but not update the weight and secondary variable menus. However, changes to the primary variables will result in both weights and secondary variables being recomputed. The user has the option of having weights computed by the regression (aircraft based) equations or by one of the weight distributions available for small, large or shuttle vehicles. The user must specify the average crew size for scheduled maintenance activity. However, the model will compute crew sizes for unscheduled maintenance based upon the regression equations.

4.2.2 In Mode 2, WEIGHT DRIVEN, the user must input/change subsystem weights directly. Secondary variables may be recomputed from these weights, however, the secondary menu can be displayed but not updated. As subsystem weights are updated, the total vehicle dry weight is recomputed regardless of its initial value on the primary system parameter menu. The subsystem weight menu is shown below:

Figure 11

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM WEIGHTS</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>900</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>6000</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>1430</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>700</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>3000</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>800</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>500</td>
</tr>
<tr>
<td>19</td>
<td>13.10 AGGREGATED AVIONICS</td>
<td>3000</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>900</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>700</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>500</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>1100</td>
</tr>
<tr>
<td></td>
<td>TOTAL WEIGHT</td>
<td>20530</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?

4.2.3 Mode 3, WEIGHT/VARIABLE DRIVEN, allows the user to specify and change both subsystem weights and the 13 secondary variables. Since these secondary variables are used
in the MTBM and MHMA equations, this mode should result in the most accurate assessments. However, the vehicle must be sufficiently defined to enable the user to assign values to these variables. Default values are computed from the regression equations. These are the same values which would be used in Modes 1 and 2. The user may run the model in Mode 3, and by not changing the weight or secondary variable values, generate the same result as Mode 1.

Figure 12
Secondary Variable Menu

<table>
<thead>
<tr>
<th>NBR</th>
<th>VARIABLE</th>
<th>CURRENT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FUSELAGE AREA</td>
<td>875.9366</td>
</tr>
<tr>
<td>2</td>
<td>FUSELAGE VOLUME</td>
<td>17567.82</td>
</tr>
<tr>
<td>3</td>
<td>WETTED AREA</td>
<td>14077.51</td>
</tr>
<tr>
<td>4</td>
<td>NBR WHEELS</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>NBR ACTUATORS</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>NBR CONTR SURFACES</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>KVA MAX</td>
<td>57.53096</td>
</tr>
<tr>
<td>8</td>
<td>NBR HYDR SUBSYS</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>NBR FUEL TANKS (INTERNAL)</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>TOT NBR AVIONICS SUBSYS</td>
<td>21</td>
</tr>
<tr>
<td>11</td>
<td>NBR DIFF AVIONICS SUBSYS</td>
<td>21</td>
</tr>
<tr>
<td>12</td>
<td>BTU COOLING</td>
<td>125.4101</td>
</tr>
<tr>
<td>13</td>
<td>NBR OXIDIZER TANKS</td>
<td>5</td>
</tr>
</tbody>
</table>

ENTER NBR OF VARIABLE TO BE CHANGED - 0 IF NONE?

4.3. Computational Factors

By selecting Computational Factors from the Input Menu, the following menu appears:

Figure 13
Computational Factors Menu

<table>
<thead>
<tr>
<th>NBR</th>
<th>SELECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TECHNOLOGY GROWTH FACTOR</td>
</tr>
<tr>
<td>2</td>
<td>CRITICAL FAILURE RATE</td>
</tr>
<tr>
<td>3</td>
<td>SUBSYSTEM REMOVAL RATES</td>
</tr>
<tr>
<td>4</td>
<td>MTBM/MTTR CALIBRATION</td>
</tr>
<tr>
<td>5</td>
<td>CREW SIZES/CREWS ASSIGNED</td>
</tr>
<tr>
<td>6</td>
<td>PERCENT OFF-EQUIP</td>
</tr>
<tr>
<td>7</td>
<td>FRACTION INHERENT FAILURES</td>
</tr>
</tbody>
</table>

return..............exit to input menu
4.3.1 Technology Factor

The default technology factors used by the model are those displayed on the technology factors screen following initialization of the model.

![Technology Factor Display Menu](image)

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>TECH GROWTH FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>.082</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>.082</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>.082</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>.082</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>.033</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>.011</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>.056</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>.22</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>.0062</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>.0062</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>.083</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>.083</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?

4.3.2 Subsystem Calibration

To provide sufficient flexibility to transition from the aircraft system to the space vehicle system, a calibration factor is included. This factor is used in modifying the aircraft computed MTBM AND MH/MA where CALIBRATED MTBM = CAL FACTOR x AIRCRAFT MTBM and CALIBRATED MHMA = CAL FACTOR x MHMA. The default value is one. With these two factors, the R&M parameters may be calibrated by subsystem based upon non-aircraft data in order to account for those differences between aircraft and space vehicles which are not accounted for by the variables in the aircraft generated equations. These factors may also be used for sensitivity analysis. There are only applied to "AIRCRAFT" based MTBM's and MH/MA's.
### SUBSYSTEM MTBM CALIBRATION FACTOR

\[
\text{CAL MTBM} = \text{CAL FAC} \times \text{computed MTBM}
\]

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>CAL FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>1</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>1</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?

---

### SUBSYSTEM MH/MA CALIBRATION FACTOR

\[
\text{CAL MH/MA} = \text{CAL FAC} \times \text{computed MH/MA}
\]

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>CAL FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>1</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>1</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?
4.3.3 Critical Failure Rates

Critical failure rates (abort rates) are used to modify the MTBM in order to determine reliabilities based only on critical failures. Critical failures may include both prelaunch (PAD) and air maintenance actions or just air (launch and on-orbit) failures.

Figure 16
Critical Failure Rate Screen

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>CRITICAL FAIL RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>1.308286E-02</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>1.308286E-02</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>1.330428E-02</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>.001</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>1.010141E-04</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>.010124</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>8.578588E-02</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>2.376491E-03</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>2.283728E-02</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>3.428872E-02</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>3.428872E-02</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>.001</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>.001</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?
4.3.4 Removal Rates

Removal rates are used to convert from mean time between maintenance actions to mean time between removals. Removals are assumed to generate a demand for a spare component. The rate specified here will affect the calculation of the number of spare components needed.

Figure 17

REMOVAL RATE - probability of a removal per maintenance action

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>REMOVAL RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>.1896</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>.1896</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>.233</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>.481</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>.22</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>.5424</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>.473</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>.252</td>
</tr>
<tr>
<td>19</td>
<td>13.xx AGGREGATED AVIONICS</td>
<td>.42</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>.489</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>.506</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>.327</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>.219</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?
4.3.5 Fraction Off-Vehicle

This is the fraction of total maintenance manhours spent performing maintenance on components removed from the vehicle. Therefore, these hours do not enter into any of the vehicle turntime calculations. The shuttle "MTTR" input value is assumed to be all on-vehicle manhours. This fraction is then used to establish an off-vehicle manhour requirement.

Figure 18

FRACTION OFF EQUIP - fraction of total maintenance manhours performed off the vehicle - does not impact vehicle turntime

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>FRACTION OFF - EQUIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>.0835</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>.0835</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>.08575</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>.2</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>.134</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>.725</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>.042</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>.2211</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>.532</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>.0932</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>.02</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>.2356</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>.2</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?

4.3.6 Crew Size

Both average crew size and number of crews assigned are displayed and may be updated by the user. The crew size is used to convert the manhour per maintenance action into a mean time to repair (MTTR). The number of crews assigned is used only in the vehicle turntime calculations and represents the number of crews available by subsystem to perform work simultaneously (in parallel). It may also be used (optionally) in the costing model (LCC) as a basis for determining maintenance manpower requirements.
### CREW SIZE/NBR CREWS

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>CREW SIZE</th>
<th>NBR CREWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>2.137765</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>2.137765</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>2.2</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>2.137765</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>2.43</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>2.316721</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>2.137765</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>2.2</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>2.316721</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>2.316721</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>1.931436</td>
<td>1</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>4.5</td>
<td>1</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?

### 4.3.7 Fraction Inherent Failures

This is the fraction of the total maintenance actions which are inherent component failures. Other categories of maintenance actions include no trouble found actions and externally induced failures. This fraction is used to split the MTBM into an inherent (mission) MTBM and an induced (ground) MTBM.

### Fraction Inherent Failure Screen

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>FRACTION INHERENT FAILURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00 WING GROUP</td>
<td>.35</td>
</tr>
<tr>
<td>2</td>
<td>2.00 TAIL GROUP</td>
<td>.35</td>
</tr>
<tr>
<td>3</td>
<td>3.00 BODY GROUP</td>
<td>.36</td>
</tr>
<tr>
<td>7</td>
<td>4.20 IEP-TCS</td>
<td>.5</td>
</tr>
<tr>
<td>9</td>
<td>5.00 LANDING GEAR</td>
<td>.52</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>.46</td>
</tr>
<tr>
<td>16</td>
<td>10.00 ELECTRICAL</td>
<td>.57</td>
</tr>
<tr>
<td>18</td>
<td>12.00 AERO SURF ACTUATORS</td>
<td>.47</td>
</tr>
<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>.49</td>
</tr>
<tr>
<td>25</td>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>.41</td>
</tr>
<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>.46</td>
</tr>
<tr>
<td>29</td>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>.43</td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>.5</td>
</tr>
</tbody>
</table>

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?
Chapter 5

Output Displays & Reports

5.1 Screen Displays (Output)

By selecting the Screen Display (Output) Menu from the main menu, the following menu is obtained:

Figure 21
Screen Display (Output) Menu

<table>
<thead>
<tr>
<th>NBR</th>
<th>SELECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RELIABILITY REPORT</td>
</tr>
<tr>
<td>2</td>
<td>MAINTAINABILITY REPORT</td>
</tr>
<tr>
<td>3</td>
<td>MAUNPOWER REQUIREMENTS</td>
</tr>
<tr>
<td>4</td>
<td>SPARES REQUIREMENTS</td>
</tr>
<tr>
<td>5</td>
<td>VEHICLE TURNTIME REPORT</td>
</tr>
<tr>
<td>6</td>
<td>SYSTEM PERFORMANCE SUMMARY</td>
</tr>
<tr>
<td>7</td>
<td>AGGREGATED SYSTEM REPORT</td>
</tr>
<tr>
<td></td>
<td>return...exit to main menu</td>
</tr>
</tbody>
</table>

5.1.1 Reliability Report

This report shows the MTBM, computed from either the parametric equations or specified (i.e. SHUTTLE) by the user after applying the technology and reliability growth adjustment. This MTBM is then split into a ground processing MTBM and a mission MTBM using the fraction inherent failures. The mission MTBM includes the environmental adjustment (application of the launch factor and the on-orbit decreasing failure rate) if appropriate. The second page shows the critical failure MTBM which is used to compute the various reliabilities. Displayed is a nonredundant reliability followed by redundant based reliabilities at each of the mission epochs: launch, powered flight, orbit, reentry, and mission completion. The nonredundant reliability will match any user specified subsystem reliabilities (to at least 4 decimal places). In each case, subsystem values are rolled-up to display a vehicle value.

---

10The specific meaning of the various column headings in these and the other output reports may be found alphabetically in the glossary (Appendix A). Each output display requires two screens in order to accommodate all 33 subsystems.
Figure 22

RELIABILITY REPORT - at mission nbr. 2 - page 1

Vehicle is Example

DATE: 12-31-1994
TIME: 20:54:04

All MTBM's are for a single subsystem, e.g. one engine

<table>
<thead>
<tr>
<th>WBS</th>
<th>Tech/Growth MTBM (all MA's)</th>
<th>Ground Proc MTBM (External MA's)</th>
<th>Mission MTBM (inherent MA's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 Wing Group</td>
<td>31.79182</td>
<td>48.9105</td>
<td>348.9151</td>
</tr>
<tr>
<td>2.00 Tail Group</td>
<td>35.32425</td>
<td>54.34501</td>
<td>390.2049</td>
</tr>
<tr>
<td>3.00 Body Group</td>
<td>3.986436</td>
<td>6.228806</td>
<td>26.61858</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>8.957087</td>
<td>17.91417</td>
<td>17.91417</td>
</tr>
<tr>
<td>5.00 Landing Gear</td>
<td>29.90977</td>
<td>62.31203</td>
<td>57.51888</td>
</tr>
<tr>
<td>6.00 Propulsion-Main</td>
<td>39.34385</td>
<td>72.85897</td>
<td>65.25906</td>
</tr>
<tr>
<td>10.00 Electrical</td>
<td>7.2832</td>
<td>16.93767</td>
<td>32.98675</td>
</tr>
<tr>
<td>12.00 Aero Surf Actuators</td>
<td>141.0082</td>
<td>266.0532</td>
<td>922.6389</td>
</tr>
<tr>
<td>13.XX Aggregated Avionics</td>
<td>12.7012</td>
<td>24.90431</td>
<td>84.7984</td>
</tr>
<tr>
<td>14.10 Environmental Control</td>
<td>113.92</td>
<td>193.0847</td>
<td>111.6.807</td>
</tr>
<tr>
<td>14.20 ECS-Life Support</td>
<td>20.63255</td>
<td>38.20843</td>
<td>161.3881</td>
</tr>
<tr>
<td>16.20 Rec &amp; Aux-Escape Sys</td>
<td>47.61164</td>
<td>83.52919</td>
<td>430.3201</td>
</tr>
<tr>
<td>16.50 Rec &amp; Aux Docking Sys</td>
<td>538.9167</td>
<td>1077.833</td>
<td>1077.833</td>
</tr>
</tbody>
</table>

Vehicle

1.274958   2.313801   5.403583

RELIABILITY REPORT - at mission nbr. 2 - page 2

Critical MTBM's are for a single subsystem, e.g. one engine

<table>
<thead>
<tr>
<th>WBS</th>
<th>Critical Failure Rate-grnd+air</th>
<th>Critical Failure MTBM</th>
<th>Subsys Non-Redundant MSN Rel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 Wing Group</td>
<td>1.308286E-02</td>
<td>26669.64</td>
<td>.99992543</td>
</tr>
<tr>
<td>2.00 Tail Group</td>
<td>1.308286E-02</td>
<td>29825.66</td>
<td>.9999332</td>
</tr>
<tr>
<td>3.00 Body Group</td>
<td>1.330428E-02</td>
<td>2000.753</td>
<td>.9901056</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>.001</td>
<td>17914.17</td>
<td>.99889</td>
</tr>
<tr>
<td>5.00 Landing Gear</td>
<td>1.010141E-04</td>
<td>569414.1</td>
<td>.9999983</td>
</tr>
<tr>
<td>6.00 Propulsion-Main</td>
<td>.010124</td>
<td>6445.978</td>
<td>.9978831</td>
</tr>
<tr>
<td>10.00 Electrical</td>
<td>8.57858E-02</td>
<td>384.5242</td>
<td>.9498768</td>
</tr>
<tr>
<td>12.00 Aero Surf Actuators</td>
<td>2.376491E-03</td>
<td>388235.7</td>
<td>.9999256</td>
</tr>
<tr>
<td>13.XX Aggregated Avionics</td>
<td>2.283728E-02</td>
<td>3713.157</td>
<td>.9946564</td>
</tr>
<tr>
<td>14.10 Environmental Control</td>
<td>3.428872E-02</td>
<td>32570.68</td>
<td>.9993894</td>
</tr>
<tr>
<td>14.20 ECS-Life Support</td>
<td>3.428872E-02</td>
<td>4706.741</td>
<td>.995782</td>
</tr>
<tr>
<td>16.20 Rec &amp; Aux-Escape Sys</td>
<td>.001</td>
<td>430320.1</td>
<td>.9999537</td>
</tr>
<tr>
<td>16.50 Rec &amp; Aux Docking Sys</td>
<td>.001</td>
<td>1077833</td>
<td>.9999815</td>
</tr>
</tbody>
</table>

Vehicle

256.248   .9262028
### Reliability Report - at Mission nbr. 2 - Page 3

Reliabilities based upon redundancy

<table>
<thead>
<tr>
<th>WBS</th>
<th>LAUNCH TIME</th>
<th>END OF POWER FLT</th>
<th>ORBIT INSERTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 Wing Group</td>
<td>.9996251</td>
<td>.9995202</td>
<td>.9994879</td>
</tr>
<tr>
<td>2.00 Tail Group</td>
<td>.9996648</td>
<td>.9995709</td>
<td>.9995421</td>
</tr>
<tr>
<td>3.00 Body Group</td>
<td>.9950144</td>
<td>.9936228</td>
<td>.9931958</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>.9994419</td>
<td>.9992858</td>
<td>.9992378</td>
</tr>
<tr>
<td>5.00 Landing Gear</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6.00 Propulsion-Main</td>
<td>.9953568</td>
<td>.9940605</td>
<td>.9936627</td>
</tr>
<tr>
<td>10.00 Electrical</td>
<td>.999341</td>
<td>.9989281</td>
<td>.9987819</td>
</tr>
<tr>
<td>12.00 Aero Surf Actuators</td>
<td>.9999485</td>
<td>.9999413</td>
<td>.9999391</td>
</tr>
<tr>
<td>13.Xx Aggregated Avionics</td>
<td>.9999928</td>
<td>.9999881</td>
<td>.9999865</td>
</tr>
<tr>
<td>14.10 Environmental Control</td>
<td>.9999999</td>
<td>.9999999</td>
<td>.9999998</td>
</tr>
<tr>
<td>14.20 ECS-Life Support</td>
<td>.9978777</td>
<td>.9972842</td>
<td>.997102</td>
</tr>
<tr>
<td>16.20 REC &amp; AUX-Escape Sys</td>
<td>.9999768</td>
<td>.9999703</td>
<td>.9999682</td>
</tr>
<tr>
<td>16.50 REC &amp; AUX Docking Sys</td>
<td>.9999907</td>
<td>.9999881</td>
<td>.9999873</td>
</tr>
</tbody>
</table>

**Vehicle**        | .9862989    | .9822762         | .9810246        

### Reliability Report - at Mission nbr. 2 - Page 4

Reliabilities based upon redundancy

<table>
<thead>
<tr>
<th>WBS</th>
<th>REENTRY COMPLETION</th>
<th>MISSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 Wing Group</td>
<td>.9992918</td>
<td>.9992543</td>
</tr>
<tr>
<td>2.00 Tail Group</td>
<td>.9993667</td>
<td>.9993332</td>
</tr>
<tr>
<td>3.00 Body Group</td>
<td>.9906006</td>
<td>.9901056</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>.9989458</td>
<td>.99889</td>
</tr>
<tr>
<td>5.00 Landing Gear</td>
<td>1</td>
<td>.9999983</td>
</tr>
<tr>
<td>6.00 Propulsion-Main</td>
<td>.9936627</td>
<td>.9936627</td>
</tr>
<tr>
<td>10.00 Electrical</td>
<td>.9977008</td>
<td>.9974575</td>
</tr>
<tr>
<td>12.00 Aero Surf Actuators</td>
<td>.9999281</td>
<td>.9999256</td>
</tr>
<tr>
<td>13.Xx Aggregated Avionics</td>
<td>.9999743</td>
<td>.9999714</td>
</tr>
<tr>
<td>14.10 Environmental Control</td>
<td>.9999996</td>
<td>.9999996</td>
</tr>
<tr>
<td>14.20 ECS-Life Support</td>
<td>.9959936</td>
<td>.995782</td>
</tr>
<tr>
<td>16.20 REC &amp; AUX-Escape Sys</td>
<td>.9999561</td>
<td>.9999537</td>
</tr>
<tr>
<td>16.50 REC &amp; AUX Docking Sys</td>
<td>.9999825</td>
<td>.9999815</td>
</tr>
</tbody>
</table>

**Vehicle**        | .975628            | .9745619  |
5.1.2 Maintainability Report

The Maintainability Report provides a maintenance manhour summary by subsystem to support a typical mission. The average (mean) manhours per maintenance action is obtained parametrically or derived from a specified MTTR (i.e. SHUTTLE) and average crew size. Maintenance actions per mission is obtained by dividing subsystem operating hours (including redundant subsystems) by the MTBM. Maintenance actions are computed separately for mission (inherent failures) and ground processing (induced and no problem found). Scheduled manhours is determined as a specified percent of the total unscheduled manhours. Manhours are also displayed as on-vehicle and off-vehicle manhours.

Figure 23

MAINTAINABILITY REPORT - at mission nbr. 2 - page 1

<table>
<thead>
<tr>
<th>VEHICLE IS Example</th>
<th>DATE: 12-31-1994</th>
<th>TIME: 20:54:05</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBS</td>
<td>MAINT ACTIONS/MSN</td>
<td>AVG MANHR/MA</td>
</tr>
<tr>
<td>1.00 WING GROUP</td>
<td>4.324116</td>
<td>9.050124</td>
</tr>
<tr>
<td>2.00 TAIL GROUP</td>
<td>3.890337</td>
<td>9.050124</td>
</tr>
<tr>
<td>3.00 BODY GROUP</td>
<td>35.18943</td>
<td>14.63651</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>15.74173</td>
<td>84.375</td>
</tr>
<tr>
<td>5.00 LANDING GEAR</td>
<td>3.343386E-02</td>
<td>8.062291</td>
</tr>
<tr>
<td>6.00 PROPULSION-MAIN</td>
<td>8.403646</td>
<td>21.1</td>
</tr>
<tr>
<td>10.00 ELECTRICAL</td>
<td>26.10184</td>
<td>4.1</td>
</tr>
<tr>
<td>12.00 AERO SURF ACTUATORS</td>
<td>.8514433</td>
<td>2.1</td>
</tr>
<tr>
<td>13.10 AGGREGATED AVIONICS</td>
<td>17.02847</td>
<td>12.78584</td>
</tr>
<tr>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>2.145053</td>
<td>6.83832</td>
</tr>
<tr>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>5.742539</td>
<td>5.444892</td>
</tr>
<tr>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>2.584929</td>
<td>4.559166</td>
</tr>
<tr>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>.261636</td>
<td>68.175</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>126.162</strong></td>
<td><strong>20.03333</strong></td>
</tr>
</tbody>
</table>
## Maintainability Report - At Mission Nbr. 2 - Page 2

<table>
<thead>
<tr>
<th>WBS</th>
<th>On-Veh Hr</th>
<th>Off-Veh Hr</th>
<th>Fraction On-Veh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 Wing Group</td>
<td>35.86612</td>
<td>3.267671</td>
<td>.9165</td>
</tr>
<tr>
<td>2.00 Tail Group</td>
<td>32.26817</td>
<td>2.939871</td>
<td>.9165</td>
</tr>
<tr>
<td>3.00 Body Group</td>
<td>470.885</td>
<td>44.16559</td>
<td>.91425</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>1062.567</td>
<td>265.6416</td>
<td>.8</td>
</tr>
<tr>
<td>5.00 Landing Gear</td>
<td>.2334334</td>
<td>3.612018E-02</td>
<td>.866</td>
</tr>
<tr>
<td>6.00 Propulsion-Main</td>
<td>50.71828</td>
<td>133.7118</td>
<td>.275</td>
</tr>
<tr>
<td>10.00 Electrical</td>
<td>112.2867</td>
<td>4.9228</td>
<td>.958</td>
</tr>
<tr>
<td>12.00 Aero Surf Actuators</td>
<td>1.392702</td>
<td>.3953288</td>
<td>.7789026</td>
</tr>
<tr>
<td>13.XX Aggregated Avionics</td>
<td>107.6808</td>
<td>122.4064</td>
<td>.468</td>
</tr>
<tr>
<td>14.10 Environmental Control</td>
<td>13.75675</td>
<td>1.413905</td>
<td>.9068</td>
</tr>
<tr>
<td>14.20 ECS-Life Support</td>
<td>30.64215</td>
<td>.6253501</td>
<td>.98</td>
</tr>
<tr>
<td>16.20 Rec &amp; Aux-Escape Sys</td>
<td>9.009071</td>
<td>2.776047</td>
<td>.7644447</td>
</tr>
<tr>
<td>16.50 Rec &amp; Aux Docking Sys</td>
<td>14.26963</td>
<td>3.567407</td>
<td>.8</td>
</tr>
</tbody>
</table>

### Unscheduled

<table>
<thead>
<tr>
<th></th>
<th>On-Veh Hr</th>
<th>Off-Veh Hr</th>
<th>Fraction On-Veh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unscheduled</td>
<td>1941.575</td>
<td>585.8699</td>
<td>.7957228 (Avg)</td>
</tr>
</tbody>
</table>

### Scheduled

<table>
<thead>
<tr>
<th></th>
<th>On-Veh Hr</th>
<th>Off-Veh Hr</th>
<th>Fraction On-Veh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduled</td>
<td>1427.058</td>
<td>29.12363</td>
<td></td>
</tr>
</tbody>
</table>

### Total

<table>
<thead>
<tr>
<th></th>
<th>On-Veh Hr</th>
<th>Off-Veh Hr</th>
<th>Fraction On-Veh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3368.633</td>
<td>614.9936</td>
<td></td>
</tr>
</tbody>
</table>

## Maintainability Report - At Mission Nbr. 2 - Page 3

Note: Ground processing MA's consist of induced and no defect MA's. Mission MA's are inherent equipment failures.

<table>
<thead>
<tr>
<th>WBS</th>
<th>Grnd Proc MA</th>
<th>Msn MA</th>
<th>Total MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 Wing Group</td>
<td>4.089102</td>
<td>.2350142</td>
<td>4.324116</td>
</tr>
<tr>
<td>2.00 Tail Group</td>
<td>3.680191</td>
<td>.210146</td>
<td>3.890337</td>
</tr>
<tr>
<td>3.00 Body Group</td>
<td>32.10888</td>
<td>3.080555</td>
<td>35.18943</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>11.16434</td>
<td>4.577381</td>
<td>15.74173</td>
</tr>
<tr>
<td>5.00 Landing Gear</td>
<td>1.604827E-02</td>
<td>0.017385</td>
<td>3.343386E-02</td>
</tr>
<tr>
<td>6.00 Propulsion-Main</td>
<td>8.235087</td>
<td>.5056769</td>
<td>8.740765</td>
</tr>
<tr>
<td>10.00 Electrical</td>
<td>23.61599</td>
<td>4.971694</td>
<td>28.58769</td>
</tr>
<tr>
<td>12.00 Aero Surf Actuators</td>
<td>.7517293</td>
<td>9.971399E-02</td>
<td>.8514433</td>
</tr>
<tr>
<td>13.XX Aggregated Avionics</td>
<td>16.06148</td>
<td>1.933999</td>
<td>17.99547</td>
</tr>
<tr>
<td>14.10 Environmental Control</td>
<td>2.07163</td>
<td>.1468472</td>
<td>2.218477</td>
</tr>
<tr>
<td>14.20 ECS-Life Support</td>
<td>5.234447</td>
<td>.508092</td>
<td>5.742539</td>
</tr>
<tr>
<td>16.20 Rec &amp; Aux-Escape Sys</td>
<td>2.394373</td>
<td>.1905558</td>
<td>2.584929</td>
</tr>
<tr>
<td>16.50 Rec &amp; Aux Docking Sys</td>
<td>.1855574</td>
<td>7.607855E-02</td>
<td>.261636</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>On-Veh Hr</th>
<th>Off-Veh Hr</th>
<th>Fraction On-Veh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>109.6089</td>
<td>16.55314</td>
<td>126.162</td>
</tr>
</tbody>
</table>
5.1.3 Manpower Report

Manpower requirements by subsystem are computed by multiplying the maintenance manhours per mission by the number of missions per month and then dividing by the number of hours per month a technician is available to perform direct maintenance. This number is rounded up to a whole integer. Since the manhours of work may not provide sufficient manpower to meet an average crew size requirement, the average crew size is also displayed. Generally, required manpower would be the larger of these two values. Scheduled manpower is found by dividing the total scheduled manhours by the available hours per month per technician. Required crews are computed by dividing the manpower requirement by the average crew size and rounding up. Assigned crews are specified by the user and are used in establishing turntime or fleet size objectives. Total personnel assigned is computed by multiplying and summing subsystem average crew sizes by the number of assigned crews and adding scheduled maintenance manpower. This number may be used in the costing model (LCC) for establishing maintenance manpower costs.

Figure 24
MANPOWER REPORT - at mission nbr. 2

<table>
<thead>
<tr>
<th>VEHICLE IS</th>
<th>Example</th>
<th>DATE: 12-31-1994</th>
<th>TIME: 20:54:05</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVAIL HRS/MO= 144</td>
<td>INDIRECT WORK= 20 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Manpower is computed from manhrs/mo divided by avail direct hrs per mo per person
Rqd crews is computed from manpwr divided by avg crew

<table>
<thead>
<tr>
<th>WBS</th>
<th>MANHRS/MSN</th>
<th>MANHRS/MO</th>
<th>MANPWR</th>
<th>AVG CREW</th>
<th>CREWS</th>
<th>RQD</th>
<th>ASGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 WING GROUP</td>
<td>39.13379</td>
<td>78.26757</td>
<td>1</td>
<td>2.137765</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2.00 TAIL GROUP</td>
<td>35.20803</td>
<td>70.41607</td>
<td>1</td>
<td>2.137765</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3.00 BODY GROUP</td>
<td>515.0506</td>
<td>1030.101</td>
<td>9</td>
<td>2.2</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>1128.208</td>
<td>2656.416</td>
<td>24</td>
<td>4.5</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5.00 LANDING GEAR</td>
<td>.2695535</td>
<td>.5591071</td>
<td>1</td>
<td>2.137765</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6.00 PROPULSION-MAIN</td>
<td>184.4301</td>
<td>368.8602</td>
<td>4</td>
<td>2.43</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10.00 ELECTRICAL</td>
<td>117.2095</td>
<td>234.419</td>
<td>3</td>
<td>2.316721</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>12.00 AERO SURF ACTUATORS</td>
<td>1.788031</td>
<td>3.576062</td>
<td>1</td>
<td>2.137765</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>13.10 AGGREGATED AVIONICS</td>
<td>230.0872</td>
<td>460.1744</td>
<td>4</td>
<td>2.2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>15.17066</td>
<td>30.34131</td>
<td>1</td>
<td>2.316721</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>31.2675</td>
<td>62.53501</td>
<td>1</td>
<td>2.316721</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>11.78512</td>
<td>23.57024</td>
<td>1</td>
<td>1.931436</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>17.83703</td>
<td>35.67407</td>
<td>1</td>
<td>4.5</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

| | UNSCHEDULED | SCHEDULED | TOTAL |
| | 2527.445 | 1456.182 | 3983.627 |
| | 5054.891 | 2912.363 | 7967.253 |
| | 52 | 26 | 78 |
| | 34 | 4 | 38 |

Tot personnel assigned = SUM (avg crew size x asgd crews) + schd manpwr

83
5.1.4 Spares Report

Initial Spares requirements are based upon the mean number of removals of components per mission within each subsystem. Assuming a Poisson demand distribution having this mean, spares levels are established to provide a specified fill rate (i.e. probability a spare is available on demand). Recurring spares requirements must be added to these in order to account for condemnations. The assumption is that all non-condemned removals (unserviceables) will be repaired prior to the next scheduled mission. An effective fill rate is displayed showing the achieved value which will always equal or exceed the stated fill rate goal.

Figure 25

SUBSYSTEM SPARES REPORT - at mission nbr. 2

<table>
<thead>
<tr>
<th>VEHICLE IS Example</th>
<th>DATE: 12-31-1994</th>
<th>TIME: 20:54:05</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOTE: failures are assumed to be Poisson</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WBS</th>
<th>REMOVAL RATE/MA</th>
<th>MEAN DEMAND PER MISSION</th>
<th>SPARES RQMT</th>
<th>EFFECTIVE FILL RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 WING GROUP</td>
<td>.1896146</td>
<td>.8199155</td>
<td>3</td>
<td>.9901355</td>
</tr>
<tr>
<td>2.00 TAIL GROUP</td>
<td>.1896146</td>
<td>.7376647</td>
<td>3</td>
<td>.99311</td>
</tr>
<tr>
<td>3.00 BODY GROUP</td>
<td>.2330179</td>
<td>8.199767</td>
<td>15</td>
<td>.9898019</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>.481</td>
<td>7.57177</td>
<td>14</td>
<td>.9889027</td>
</tr>
<tr>
<td>5.00 LANDING GEAR</td>
<td>.22</td>
<td>7.35545E-03</td>
<td>0</td>
<td>.9926715</td>
</tr>
<tr>
<td>6.00 PROPULSION-MAIN</td>
<td>.5424479</td>
<td>4.55854</td>
<td>9</td>
<td>.9815111</td>
</tr>
<tr>
<td>10.00 ELECTRICAL</td>
<td>.4729872</td>
<td>12.34584</td>
<td>20</td>
<td>.9846472</td>
</tr>
<tr>
<td>12.00 AERO SURF ACTUATORS</td>
<td>.25239</td>
<td>.2148958</td>
<td>2</td>
<td>.998591</td>
</tr>
<tr>
<td>13.XX AGGREGATED AVIONICS</td>
<td>.4195914</td>
<td>7.145002</td>
<td>13</td>
<td>.9850001</td>
</tr>
<tr>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>.489287</td>
<td>1.049547</td>
<td>4</td>
<td>.9955227</td>
</tr>
<tr>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>.5057694</td>
<td>2.9044</td>
<td>7</td>
<td>.9900324</td>
</tr>
<tr>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>.3272568</td>
<td>.8459354</td>
<td>3</td>
<td>.9890459</td>
</tr>
<tr>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>.219</td>
<td>5.729828E-02</td>
<td>1</td>
<td>.9984198</td>
</tr>
</tbody>
</table>

TOTALS | .3493828 (AVG) | 46.45792 | 94 |
5.1.5 Vehicle Turn Time Report

In order to determine vehicle turn times, assumptions must be made concerning the order in which maintenance is to be performed. For each subsystem, an average repair time per mission is computed by multiplying the MTTR by the number of maintenance actions per mission and then dividing by the number of crews available (assigned) to work simultaneously. The number of crews assigned may be adjusted by the user (see paragraph 4.3.6). A minimum turn time is then found by assuming all subsystems may be repaired in parallel. A maximum turn time assumes each subsystem must be repaired sequentially (serially). Scheduled maintenance time, integration time, pad time, and mission time are included in total vehicle turn time. Times are converted from hours to days by dividing by 8, 16, or 24 hours to reflect one, two, or three shift maintenance. See paragraph 2.8 for the formulae used in computing total vehicle turnaround times, average missions per year per vehicle, and computed fleet size.

Figure 26

VEHICLE TURN TIME REPORT - at mission nбр. 2 - page 1

VEHICLE IS Example

<table>
<thead>
<tr>
<th>WBS</th>
<th>ON-VEH WTR (HRS)</th>
<th>TOT WTR (HRS)</th>
<th>MBR CREWS</th>
<th>AVG SUBSYS REPAIR TIME PER MSN (hrs)</th>
<th>AVG SUBSYS REPAIR TIME PER MSN (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 WING GROUP</td>
<td>3.879957</td>
<td>4.324116</td>
<td>1</td>
<td>16.77739</td>
<td></td>
</tr>
<tr>
<td>2.00 TAIL GROUP</td>
<td>3.879957</td>
<td>3.890337</td>
<td>1</td>
<td>15.09434</td>
<td></td>
</tr>
<tr>
<td>3.00 BODY GROUP</td>
<td>6.082469</td>
<td>35.18943</td>
<td>3</td>
<td>71.34621</td>
<td></td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>15</td>
<td>15.74173</td>
<td>5</td>
<td>47.22518</td>
<td></td>
</tr>
<tr>
<td>5.00 LANDING GEAR</td>
<td>3.266001</td>
<td>3.343386E-02</td>
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<td>.109195</td>
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</tr>
<tr>
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<td>2.38786</td>
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<td>1</td>
<td>20.06673</td>
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</tr>
<tr>
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<td>1.695414</td>
<td>26.10184</td>
<td>1</td>
<td>44.25341</td>
<td></td>
</tr>
<tr>
<td>12.00 AERO SURF ACTUATORS</td>
<td>.7651427</td>
<td>.8514433</td>
<td>1</td>
<td>.6514756</td>
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</tr>
<tr>
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<td>2.719896</td>
<td>17.02847</td>
<td>2</td>
<td>23.15784</td>
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</tr>
<tr>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>2.676623</td>
<td>2.145053</td>
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<td>5.7415</td>
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</tr>
<tr>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>2.303253</td>
<td>5.742539</td>
<td>1</td>
<td>13.22652</td>
<td></td>
</tr>
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<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
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<td>2.584929</td>
<td>1</td>
<td>4.664442</td>
<td></td>
</tr>
<tr>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>12.12</td>
<td>.261936</td>
<td>1</td>
<td>3.171028</td>
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</tr>
</tbody>
</table>

265.4852 (TOT)

AVG CREW SIZE 2.558666
AVG TASK TIME 4.506235
### VEHICLE TURN TIME REPORT - at mission nbr. 2 - page 2

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MIN TURN TIMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCHED MAINT MSN TASK TIME</td>
<td>356.7645 HRS</td>
</tr>
<tr>
<td>UNSCHEDULED MAINTENANCE TIME</td>
<td>71.34621 HRS</td>
</tr>
<tr>
<td>INTEGRATION TIME</td>
<td>1 DAYS</td>
</tr>
<tr>
<td>LAUNCH PAD TIME</td>
<td>1 DAYS</td>
</tr>
<tr>
<td>MISSION TIME - INC GRND PWR TIME</td>
<td>82 HRS</td>
</tr>
<tr>
<td>TOT VEHICLE TURNAROUND TIME</td>
<td>486.7645 TOT HR</td>
</tr>
</tbody>
</table>

#### ONE SHIFT/DAY MAINTENANCE

| TOT VEHICLE TURNAROUND TIME                                              | 50.01223 DAYS      |
| AVG MISSIONS/YR/VEHICLE                                                 | 5.038768           |
| COMPUTED FLEET SIZE                                                      | 5                  |

#### TWO SHIFTS/DAY MAINTENANCE

| TOT VEHICLE TURNAROUND TIME                                              | 27.71445 DAYS      |
| AVG MISSIONS/YR/VEHICLE                                                 | 9.092731           |
| COMPUTED FLEET SIZE                                                      | 3                  |

#### THREE SHIFTS/DAY MAINTENANCE

| TOT VEHICLE TURNAROUND TIME                                              | 20.28185 DAYS      |
| AVG MISSIONS/YR/VEHICLE                                                 | 12.4249            |
| COMPUTED FLEET SIZE                                                      | 2                  |

**NOTE:** assumes parallel unsch/sched maint tasks, 8 hr shifts, and 21 work days a month
CATEGORY MAX TURN TIMES

SCHED MAINT MSN TASK TIME 356.7645 HRS
UNSCHED MAINT TIME 265.4852 HRS
INTEGRATION TIME 1 DAYS
LAUNCH PAD TIME 1 DAYS
MISSION TIME - INC GRND TIME 82 HRS
TOT VEHICLE TURNAROUND TIME 752.2497 TOT HR

ONE SHIFT/DAY MAINTENANCE

TOT VEHICLE TURNAROUND TIME 83.19788 DAYS
AVG MISSIONS/YR/VEHICLE 3.028924
COMPUTED FLEET SIZE 8

TWO SHIFTS/DAY MAINTENANCE

TOT VEHICLE TURNAROUND TIME 44.30727 DAYS
AVG MISSIONS/YR/VEHICLE 5.687554
COMPUTED FLEET SIZE 5

THREE SHIFTS/DAY MAINTENANCE

TOT VEHICLE TURNAROUND TIME 31.34374 DAYS
AVG MISSIONS/YR/VEHICLE 8.039884
COMPUTED FLEET SIZE 3

NOTE: assumes sequential tasks, 8 hr shifts, and 21 work days a month
5.1.6 System Performance Summary

The System Performance Summary provides a concise report at the vehicle level only providing mission epoch reliabilities, total maintenance manhours, manpower and spares requirements, and a turntime comparison.

![Figure 27](SYSTEM PERFORMANCE SUMMARY - at mission nbr. 2 - page 1)

**DATE:** 01-01-1995  **TIME:** 02:10:54

### RELIABILITY REPORT

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LAUNCH TIME</th>
<th>END OF POWER FLT</th>
<th>ORBIT INSERTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLE</td>
<td>.9862989</td>
<td>.9822762</td>
<td>.9810246</td>
</tr>
<tr>
<td>VEHICLE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MISSION COMPLETION**

- .9745619

**REENTRY**

- .975628

### MAINTAINABILITY REPORT

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAINT ACTIONS/MSN</th>
<th>WT-AVG MANHR/MA</th>
<th>UNSCHED AVG MANHRS/MSN</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLE</td>
<td>126.162</td>
<td>20.03333</td>
<td>2527.445</td>
</tr>
</tbody>
</table>

**OFF-VEH MH**

- 1427.058

**ON-VEH MH**

- 1941.575

**TOTALS**

- 3368.633

**FRACTION ON-VEH**

- .7957228 (AVG)

### MANPOWER/SPARES REPORT

<table>
<thead>
<tr>
<th>SPARES-VEHICLE</th>
<th>MANHR DRIVEN AGGREGATE</th>
<th>MANHR DRIVEN BY SUBSYS</th>
<th>CREW SZ BY SUBSYS</th>
<th>TOT CREW BY SUBSYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNSCH MANPW</td>
<td>44</td>
<td>52</td>
<td>34</td>
<td>58</td>
</tr>
<tr>
<td>SCHED MANPW</td>
<td>26</td>
<td>26</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>70</td>
<td>78</td>
<td>38</td>
<td>62</td>
</tr>
</tbody>
</table>

### VEHICLE TURN TIMES

<table>
<thead>
<tr>
<th>ONE SHIFTS/DAY MAINTENANCE</th>
<th>MIN TURN TIME</th>
<th>MAX TURN TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOT VEHICLE TURNAROUND TIME</td>
<td>50.01223 DAYS</td>
<td>83.19788</td>
</tr>
<tr>
<td>AVG MISSIONS/YR/VEHICLE</td>
<td>5.038768</td>
<td>3.028923</td>
</tr>
<tr>
<td>COMPUTED FLEET SIZE</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TWO SHIFTS/DAY MAINTENANCE</th>
<th>MIN TURN TIME</th>
<th>MAX TURN TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOT VEHICLE TURNAROUND TIME</td>
<td>27.71445 DAYS</td>
<td>44.30727</td>
</tr>
<tr>
<td>AVG MISSIONS/YR/VEHICLE</td>
<td>9.092731</td>
<td>5.687554</td>
</tr>
<tr>
<td>COMPUTED FLEET SIZE</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THREE SHIFTS/DAY MAINTENANCE</th>
<th>MIN TURN TIME</th>
<th>MAX TURN TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOT VEHICLE TURNAROUND TIME</td>
<td>20.28185 DAYS</td>
<td>31.34374</td>
</tr>
<tr>
<td>AVG MISSIONS/YR/VEHICLE</td>
<td>12.4249</td>
<td>8.039884</td>
</tr>
<tr>
<td>COMPUTED FLEET SIZE</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
5.1.7 Aggregated System report

The Aggregated System Report display the results of the subsystem to system roll-up. Specifically, the number of maintenance actions, mean time to repair, scheduled maintenance time, average crew size, and number of assigned crews is displayed. Maintenance times and average crew sizes are weighted averages of the subsystem values with the weights being the subsystem fraction of total maintenance actions. This display is similar to a printed report which may be generated to provide input into the maintenance simulation model (MSM).

Figure 28

Aggregated System Report - System Aggregation - page 1

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>MAINT ACTIONS</th>
<th>ON-VEH MTTR</th>
<th>ON-VEH SCHED</th>
<th>AVE CREW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>43.40389</td>
<td>5.66563</td>
<td>224.3909</td>
<td>2.188222</td>
</tr>
<tr>
<td>1.00 WING GROUP</td>
<td>15.74173</td>
<td>15</td>
<td>39.5688</td>
<td>4.5</td>
</tr>
<tr>
<td>1.10 TANKS-LOX</td>
<td>8.740764</td>
<td>2.38786</td>
<td>40.68705</td>
<td>2.43</td>
</tr>
<tr>
<td>1.20 TANKS-LH2</td>
<td>28.58769</td>
<td>0</td>
<td>139.5784</td>
<td>2.316721</td>
</tr>
<tr>
<td>Mechanical Sys</td>
<td>17.99547</td>
<td>.736233</td>
<td>4.68205</td>
<td>2.137665</td>
</tr>
<tr>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>10.54594</td>
<td>2.259541</td>
<td>54.00785</td>
<td>2.222283</td>
</tr>
<tr>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>.261636</td>
<td>12.12</td>
<td>.6576549</td>
<td>4.5</td>
</tr>
<tr>
<td>Total</td>
<td>126.162</td>
<td>40.88916</td>
<td>596.0966</td>
<td>22.49499</td>
</tr>
<tr>
<td>Average</td>
<td>15.77025</td>
<td>5.111145</td>
<td>74.51208</td>
<td>2.811874</td>
</tr>
</tbody>
</table>

note: MTTR's & sched maint times assume the Avg Crew Size and are based upon a weighted avg (wts-fraction of total failures) of each subsystem.
VEHICLE IS Example

Aggregated System Report - page 3

DATE: 01-01-1995 TIME: 02:13:12

<table>
<thead>
<tr>
<th>Aggregated System</th>
<th>Removal Rate</th>
<th>Off-Veh MTTR in hours</th>
<th>Off-Veh Sched maint time(hrs)</th>
<th>Nbr Crews Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>.2248036</td>
<td>.5294231</td>
<td>4.579406</td>
<td>5</td>
</tr>
<tr>
<td>Thermal/Tiles</td>
<td>.481</td>
<td>3.75</td>
<td>.8075265</td>
<td>5</td>
</tr>
<tr>
<td>Propulsion</td>
<td>.5424479</td>
<td>6.295268</td>
<td>.8303479</td>
<td>1</td>
</tr>
<tr>
<td>Power/Electrical</td>
<td>.4729872</td>
<td>7.432919E-02</td>
<td>2.84654</td>
<td>1</td>
</tr>
<tr>
<td>Mechanical Sys</td>
<td>.2511662</td>
<td>.2280796</td>
<td>9.555205E-02</td>
<td>2</td>
</tr>
<tr>
<td>Avionics</td>
<td>.4195914</td>
<td>3.091848</td>
<td>1.888242</td>
<td>2</td>
</tr>
<tr>
<td>ECS/Life Support</td>
<td>.4585467</td>
<td>.2197556</td>
<td>1.102201</td>
<td>3</td>
</tr>
<tr>
<td>Auxiliary Systems</td>
<td>.219</td>
<td>3.03</td>
<td>1.342153E-02</td>
<td>1</td>
</tr>
<tr>
<td>Total Average</td>
<td>.3836929</td>
<td>17.2187</td>
<td>12.16524</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.152338</td>
<td>1.520655</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Note: MTTR's & sched maint times assume the Avg Crew Size and are based upon a weighted avg (wts- fraction of total failures) of each subsystem.

5.2 Report Generation

Hard copy output of the reports outlined in Paragraph 5.1 may be obtained from the PRINT options displayed in the menu below (Figure 29). These reports will be directed to the parallel printer port (normally LPT1:) and are generally compatible with either a dot matrix or ink jet printer (e.g. Epson LQ series or HP Deskjet 500 series). NBR's 9 and 10 on the Report Menu will generate the output reports obtained from NBR's 2-7. NBR 10 will also include the NBR 1 input data. NBR 11 generates a special report for use with the MSM simulation model. The user, by selecting NBR 12, SEND REPORT TO A FILE, will create an ASCII file of the entire input and output reports with the exception of the summary and simulation input report. This file will have the VEHICLE/FILE NAME with an .ASC extension. This file may then be imported into a wordprocessor and included as part of an overall report or sent over a LAN.

Figure 29
Report Menu

<table>
<thead>
<tr>
<th>NBR</th>
<th>SELECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRINT INPUT DATA</td>
</tr>
<tr>
<td>2</td>
<td>PRINT SUMMARY REPORT</td>
</tr>
<tr>
<td>3</td>
<td>PRINT RELIABILITY REPORT</td>
</tr>
<tr>
<td>4</td>
<td>PRINT MAINTAINABILITY REPORT</td>
</tr>
<tr>
<td>5</td>
<td>PRINT MANPOWER REPORT</td>
</tr>
<tr>
<td>6</td>
<td>PRINT SPARES REPORT</td>
</tr>
<tr>
<td>7</td>
<td>PRINT TURNTIME REPORT</td>
</tr>
<tr>
<td>8</td>
<td>PRINT EXT TANK &amp;/OR S.EB REPORT</td>
</tr>
<tr>
<td>9</td>
<td>PRINT TOTAL OUTPUT</td>
</tr>
<tr>
<td>10</td>
<td>PRINT TOTAL INPUT/OUTPUT</td>
</tr>
<tr>
<td>11</td>
<td>SIMULATION MODEL INPUT</td>
</tr>
<tr>
<td>12</td>
<td>SEND REPORT TO A FILE</td>
</tr>
</tbody>
</table>

return.................cancel request
Chapter 6

Study Analysis and Procedures

6.1 General

In using the R&M model as part of a space vehicle study, the analyst must obtain a minimum number of design specifications pertaining to the vehicle. Although the R&M model has default values for all input parameters, the analyst must replace, verify, or state as assumptions these default values when they are used. In most cases, the default values were obtained from analyses of large amounts of aircraft data or from shuttle data. When beginning a new study, all input menus should systematically be updated. Appendix B contains step-by-step guidelines for setting up the input data for each of the three modes: preconceptual, weight-driven, and weight/variable driven.

This model may be used in conjunction with other existing operational capability and support models such as NASA's (LRC) SLAM simulation model, the maintenance simulation model (MSM) discussed in Part III of this report, and the O&S costing model [13]. These models and their relationships among one another are discussed in Part I of this report.

6.2 Input Procedures

The following sequential set of tasks are provided as guidelines in completing a study using the R&M model. The order and nature of these tasks may change depending upon the study objectives and the availability of certain types of input data.

6.2.1 Obtain available vehicle design and performance parameters. These would include both primary driver variables and, to the extent possible, the secondary driver variables. Subsystem weights should be determined if possible. System parameter values should be determined (default values may be used but the analyst must consider these as part of the study assumptions).

6.2.2 Define the vehicle subsystems using the ADD/DELETE SUBSYSTEM screen. If one or more subsystems which are not part of the NASA WBS are to be included, rename a current subsystem and select shuttle from the SELECT SHUTTLE/AIRCRAFT screen. Also select shuttle for those subsystems in which the analyst can specify a MTBM and a MTTR.

6.2.3 Update primary system parameters and (mode 1) subsystem weights (or select an appropriate weight distribution if actual weights are unknown). Update secondary variables (mode 2) if known. If only some of the secondary variables are known, the model may be run in mode 0 (preconceptual) or mode 1 (weight-driven) to obtain parametric results for all the secondary variables. Then by switching to mode 2 (variable-driven), the analysts may replace particular values. However, both primary variables and weight variables should be established first.
6.2.4 Review and update the computational factors screens. Assumptions by subsystem must be made concerning technology and reliability growth, removal rates, fraction of off-vehicle work, critical failure rates, crew sizes, and inherent failure rates. Initially, it may be sufficient to use the default values. Number of crews assigned can be updated later once the initial turntime output has been observed. The calibration screens will default to one. Therefore, they also can be ignored initially. To negate the effect of reliability growth, the reliability growth mission number on the primary system parameter screen may be set to one (the default value). Critical failure rates may be either ground and airborne failures or just airborne failures including the default value specified on the primary system parameter screen. Removal rates are only important if the calculation of mission spares requirements is part of the study objective.

6.2.5 Update the mission profile and subsystem operating hours. The mission profile may be used to initialize the subsystem operating hours. However, it may then be necessary to adjust each subsystem to reflect their actual operating times. Maintenance actions are assumed to occur only during the hours specified. For many subsystems this will coincide with the power-on time. During ground processing time only the external failures will occur. All other times, only inherent failures are observed.

6.2.6 If active redundancy is present at the entire subsystem level, then update the redundancy screen accordingly. Many times, it may only be the engines (main, OMS or RCS) which need to be updated. In the case of engines (as well as power and avionics), a k out of n redundancy configuration may be specified. (Note: some lower level redundancy will be implied by the input data to the extent it was captured in the original aircraft and shuttle data bases.)

6.2.7 If it is desired to include an external tank (ET) and/or a solid rocket booster (SRB) in the overall reliability calculation, then the ET/LRB screen should be selected. Otherwise, this input screen may be ignored. When updating this screen, the analyst will need to specify the MTBM and MTTR of the four or five major subsystems. Default values were obtained from the shuttle system data. By assigning a reliability of one to either of these systems, the system will be ignored.

6.2.8 Scheduled maintenance is a large part of the total maintenance manhours needed to support a mission. An aircraft generated parametric equation will compute a percentage of the unscheduled maintenance to be used in determining the scheduled maintenance. This is a vehicle level number and not a subsystem number. The analyst should update this number based upon assumptions concerning the frequency and extent of scheduled or preventive maintenance. The average crew size for scheduled maintenance identified on the system parameter table will impact only on the vehicle turntime. The assumption is made that this is the number of individuals which can simultaneously perform scheduled maintenance on the vehicle.

6.2.9 Under certain study objectives, it may be desirable to specify the reliability (non-redundant) of specified subsystems. The normal situation is for the model to compute these
values from the variable and weight data provided. However, if a reliability is specified, then a corresponding MTBM is determined and all other values are computed from it.

6.2.10 Once all input screens have been reviewed and updated, the user should save the input values and then compute the R&M parameters.

6.3 Analyses Methods

6.3.1. Trade-off Studies and Sensitivity Analysis

The model is designed to be very flexible. Therefore, the analyst may systematically change one or more input parameters, recompute, and observe the effect on any number of output variables. For example, in the preconceptual mode, the vehicle dry weight may be gradually increased and vehicle R&M performance observed. In the weight driven or weight-variable driven modes, a weight factor is available to systematically increase or decrease subsystem weights by a common factor. The MTBM and MHMA calibration factors may be used to determine the effect of an increase in reliability and/or maintainability on the "AIRCRAFT" selected subsystems. When using an (unknown or estimated) system parameter value, such as the launch factor, it is recommended that a sensitivity analysis on this parameter be accomplished. If the observed output is highly sensitive to changes in this parameter, then an effort should be made to obtain a more accurate estimate of its value otherwise the analyst may be justified in using the current value.

6.3.2 Turntime, Fleetsize and Mission rates.

There is a mathematical relationship among average vehicle turntime, number of vehicles (fleet size), and the number of missions completed per year. The analyst can fix the desire number of missions per year on the system parameter table. By running the model with specified numbers of crews for each subsystem and for scheduled maintenance, vehicle minimum and maximum turntimes are determined for one, two, or three maintenance shifts per day. In each case a fleet size is computed based upon the given mission rate and the average turntime. By adjusting the number of crews assigned, both turntimes and fleet size will change. Therefore, the analyst through trial and error can assign crews to achieve either a desired turntime or fleet size.

6.3.3 Manpower Assessments

By its very nature, manpower is a highly flexible resource which makes its determination difficult. A minimum manpower requirement is computed by the model based upon the total maintenance manhours required per month and the average number of manhours per month an individual is available to do maintenance (direct labor) tasks. When manpower is to be determined by subsystem, this number should be compared to the average crew size for that subsystem and the larger of the two selected. If a single maintenance specialist can perform tasks on all the subsystems, then a smaller requirement may be computed. If the study objective is
to obtain a particular vehicle turntime or a specified fleet size, then the number of crews assigned times the average crew size should be the basis for establishing the manpower requirement. Both approaches are available to the costing model (LCC). The number of crews assigned is an input parameter to be used specifically for this purpose. It should also be noted that different aggregations of subsystems under a common maintenance specialty and different combinations of parallel and sequential maintenance will produce different manpower requirements. Therefore, more accurate manpower estimates may be obtained by using the maintenance simulation model (MSM) which was designed to provide for this flexibility.

6.3.4 Reliability Specification

With the feature which permits the analyst to specify by subsystem a nonredundant reliability, it is possible to generate (inherent) MTBM specifications by subsystem which will provide a given vehicle mission reliability. Through trial and error, adjustments can be made to each subsystem reliability until the desired vehicle reliability is obtained. At that point, the model computed inherent and critical MTBM's will provide the desired outcome.
Bibliography


APPENDIX A
GLOSSARY OF TERMS

Abort rates (AB): Same as Critical Failure Rate.

Add/Delete Subsystem: An option on the Input Parameter Menu for selecting the subsystems which define the vehicle. Enter the number corresponding to the subsystem to toggle from 'COMPUTE' to 'DELETE' or from 'DELETE' to 'COMPUTE' as needed. 'COMPUTE' means the subsystem is to be used. 'DELETE' means the vehicle does not require the subsystem.

Adj Shuttle MTBM-Space 0-No 1-Yes: A system parameter changed from the Update/Display Primary System Parameters Menu. If set to 1, this system parameter causes a space environment adjustment to be made to the shuttle values for MTBM. The environment adjustment decreases the MTBM because of the additional vibrations and stresses during launch (Launch Factor) and increases the MTBM during on-orbit time because of reduced stress (based upon a Weibull shape parameter less than one). Typically, the parameter should only be set to 1 if user input MTBM values are being used instead of regression calculated or shuttle values, and these values were input without consideration of operating in a space environment (see Update/Display Shuttle MTBM’s & MTTR’s). Otherwise, the value should be left defaulted at 0 because the program’s default shuttle values already account for launch and space operation.

Aggregate Avionics 0-No/1-Yes: If set to 1 (Yes), the six different avionics subsystems will be replaced by a single avionics subsystem. The default setting is 0 (No) so all six avionics subsystems are used. This parameter is set from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Aggregated System: A higher level assembly formed from logical groupings of the 33 subsystems comprising the NASA WBS. Several R&M parameters are computed for each of these aggregated systems by summing or weight averaging the corresponding subsystem values. Subsystem weights are the fraction of total failures within a grouping.

Air+Gnd Abort/ Air Abort: A toggle switch found on the Primary System Parameter menu to establish either ground plus air aborts or air aborts only as the basis for computing the critical MTBM. Ground aborts would consist of pre-launch (pad) aborts.

Asgd Crews (Manpower report): The number of crews assigned by the user for each subsystem. Each crew consists of the average crew size (see). It is the bases for controlling the vehicle turntime since this value represents the number of crews available to work simultaneously on the subsystem. This parameter is updated by calling the Computational Factors Menu and selecting CREW SIZES/CREWS ASSIGNED.

Avail Manhrs/Month: The total number of hours during a month an individual is available within the workplace to do both direct and indirect work. It is input from the Update/Display Primary
System Parameters option of the Input Parameter Menu. Used in computing manpower requirements from computed manhour totals.

Avg Crew (MANPOWER OUTPUT): The number of maintenance personnel required by subsystem equal to the Crew Size (see) calculated from the regression equations or updated directly by the user. It is considered to be the minimum requirement. See Manpwr for another method for computing monthly personnel requirements (the larger of the two values is passed to the O&S costing model (LCC)).

Avg Crew Size-Schd Maint: The average number of workers available to perform scheduled maintenance. It is input from the Update/Display Primary System Parameters option of the Input Parameter Menu. It is used only in determining the impact scheduled maintenance has on vehicle turntime.

Avg Manhrs/Msn (MAINTAINABILITY OUTPUT): The average number of unscheduled maintenance manhours expended per mission (by subsystem) calculated by multiplying the number of maintenance actions per mission (Maint Actions/Msn) by the average manhours per maintenance action (Tot Manhr/Ma).

Avg Subsys Repair Time Per Msn (VEHICLE TURN TIME OUTPUT): The average length of time to perform unscheduled on-vehicle maintenance per mission. It is computed by multiplying 'On-vehicle MTTR' by the average number of maintenance actions per mission (Maint Actions/Msn) and dividing by the number of crews assigned (Nbr Crews Assigned). It is assumed all assigned crews may work in parallel.

Calibrated MTBM: The basic mean time between maintenance actions computed from the aircraft derived regression equations, read in directly for subsystems set at 'SHUTTLE' (see Select Shuttle/Aircraft), or input by the user (see Update/Display Shuttle MTBM's & MTTR's). These values are then multiplied by the MTBM Calibration (default value = 1). Time is measured in operating (or power on) hours except for the landing gear subsystem which is measured in missions (or sorties). The MTBM represents a single subsystem value in the case where there are multiple redundant or k out of n redundant subsystems, and includes both inherent and external maintenance actions.

Change Scheduled Maintenance: The percent used to calculate scheduled maintenance as a percentage of unscheduled maintenance (see Scheduled Maintenance Manhours) can be input instead of calculated from regression equations with this option of the Input Parameter Menu. If the percent scheduled maintenance is changed, the model automatically changes the status of the percent scheduled maintenance parameter to 'DO NOT COMPUTE' as seen in the Compute R&M Parameters Menu selected from the Main Menu.

Computation Selection Menu: The menu entered when the Compute R&M Parameters option is selected from the Main Menu. From this menu, the Critical Failure Rate (see), Removal Rate (see), Crew Size (see), Percent Off-Equipment (see), and Scheduled Maintenance Percentage
(see) factors are set to be computed by the program or to be maintained at their current values. If set at 'RECOMPUTE', the program uses the derived regression equations to calculate new values. If set at 'DO NOT RECOMPUTE', the program maintains the current values. If any of these factor levels were changed within the Update/Display Computational Factors Menu (see), the program automatically sets the appropriate factor to 'DO NOT RECOMPUTE' in this menu. After reading in an input file, all factors are set to 'DO NOT RECOMPUTE.' Always recompute the R&M parameters after changing any input to ensure the output has been correctly updated.

Costing Model (OSC): A corresponding computer model which may be used in estimating vehicle operating and support costs (OSC). The model also allows for user input of various cost categories in order to produce a life cycle cost. Certain input/output parameters of the RAM may be saved in a file (".cst") which the cost model will read in and utilize in computing various costs.

Crew Size(s): The average number of maintenance personnel required to perform an unscheduled maintenance action calculated from the aircraft derived regression equations or mean values where data was limited. Equations were derived at the highest Work Unit Code (WUC) level. Each subsystem within a level is assigned that level's calculated crew size. Crew size can be input directly instead of calculated (see Update/Display Computational Factors).

Crew Sizes by Subsys (SYSTEM PERFORMANCE SUMMARY OUTPUT): The total manpower required to support the vehicle calculated by summing the subsystem 'Personnel Based Upon Min Crew Size' values and rounding up to the next larger integer.

Critical Fail Rate (RELIABILITY OUTPUT): The Critical Failure Rate (see) computed by the program or input by the user (see Update/Display Computational Factors and Default Abort Rate). The critical failure rate will be identified as ground plus air aborts or air aborts only.

Critical Failure Rate: The fraction of subsystem unscheduled maintenance actions which result in ground and/or air aborts. Critical Failure Rate is one of the R&M factors calculated by the program from aircraft derived regression equations. Data was not available to determine regression equations for the TANKS, xxIEP, xx REC, AUX SYS subsystems so default values were assigned (values can be changed, see Default Abort Rate). Also, a subsystem's value for Critical Failure Rate can be input, rather than calculated by the model, from the Update/Display Computational Factors Menu (see). The critical failure rates are used to compute the mission reliabilities only. The critical failure rate may be based upon air aborts only or air plus ground aborts.

Critical MTBM (RELIABILITY OUTPUT): The critical mean time between maintenance actions computed by dividing the space adjusted MTBM (Space Adj) by the Critical Fail Rate.

Default Abort Rate: The Default Abort Rate (Critical Failure Rate) is used for those subsystems not addressed by derived regression equations (TANKS, xxIEP, xx REC, AUX SYS) and is also
used for the ET/LRB system. The Default Abort Rate can be changed from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Default Percent Off Manhours: Regression equations were not obtained for the POWER, BATTERY/FUEL CELL, and REC AND AUX subsystems so the Default Percent Off Manhours is used for these subsystems. The percent is entered by selecting Update/Display Primary System Parameters from the Input Parameter Menu. Refer to Percent OFF Equipment for more information.

Direct Work: The maintenance work addressed by the program computed manhours. All other work is considered deferable and labeled as indirect work. This indirect work is accounted for as a percentage of the total available hours (see Avail Manhrs/Month). Therefore in computing manpower, the program computed maintenance manhours (direct work) is divided by one minus the percent indirect work times the available hours per month per person.

Effective Fill Rate (SYSTEM SPARES OUTPUT): The actual fill rate (percent of time a spare component is available when a failure has occurred) achieved as determined from the calculated Spares Requirement. It may differ from the user input fill rate (see Spare Fill Rate Obj) because the Spares Requirement is an integer value which assures that the level of spares meets or exceeds the fill rate goal based upon the Poisson probability distribution.

End of Power FIt (RELIABILITY OUTPUT): The probability that no critical failures have occurred up to the end of the main engine (and optionally LRB/ET) burn time. It is based upon the subsystem redundancy established by the user.

Environment Adjustment: See Adj Shuttle MTBM-Space 0-No 1-Yes.

Establish System Reliabilities: One of the options on the Input Parameter Menu. If nonredundant subsystem reliabilities are known, they can be input directly instead of the program calculating the reliabilities. This feature permits estimation of the effect of improving subsystem reliability on the vehicle’s reliability and maintainability. When this option is used, the program will compute corresponding space adjusted and critical MTBM’s for use in determining maintainability, manpower, spares, and turntimes.

File name: See Vehicle/File name.

Fraction inherent failures: The fraction of total maintenance actions resulting from inherent component failures rather than externally induced or no defect found actions. This fraction is used to modify the calibrated MTBM to obtain a mission and a ground processing MTBM.

Fraction OFF Equipment (POFF): The fraction of total unscheduled maintenance manhours performed on components removed from the vehicle. It is calculated from aircraft derived regression equations. Data was limited so regression equations for the POWER, BATTER/FUEL CELL, and REC AND AUX subsystems were not obtained so a default value was assigned to

A-4
those subsystems. The default value can be changed from the Update/Display Primary System Variables Menu (see Default Percent Off Manhours). In addition, a subsystem's value for Percent OFF Equipment can be input, rather than calculated by the model, from the Update/Display Computational Factors Menu. The hours spent working on off equipment do not delay processing of the vehicle. Therefore 1-POFF, or the percent of on-vehicle work, is used in determining vehicle turn time (see 'Max Turn Times' and 'Min Turn Times').

Fraction On-Veh (MAINTAINABILITY OUTPUT): One minus the fraction of off-vehicle work (1-POFF). The fraction of off-vehicle work is computed from regression equations or input directly by the user (See Fraction OFF Equipment).

Grnd Proc MA (Maintainability Report): The number of maintenance actions generated during the ground processing segment. Only externally induced and no defect found actions are considered. The number of maintenance actions is proportional to the length of time specified for ground processing, the effective failure rate (MTBM), and the number of redundant subsystems.

Grnd Proc MTBM (RELIABILITY OUTPUT): The 'Tech/Growth MTBM' value adjusted for external maintenance actions only by dividing this value by one minus the fraction of inherent failures. External maintenance actions are maintenance induced and no trouble found maintenance actions.

Growth Curve Slope: The value of the parameter b (default = .5) in the Duane reliability growth curve given by MTBM = MTBM x Mission Numberb. This curve may be used to account for reliability growth as a function of the number of missions completed. System R&M parameters will be computed for the specific mission number identified (default = 1).

Indirect Work: All other categories of work excluding the manhours of direct work accounted for by the model. This includes administrative time, training, clean-up, documentation, etc. This indirect work is accounted for as a percentage of the total available hours (see Avail Manhrs/Month). Therefore in computing manpower, the program computed maintenance manhours (direct work) is divided by one minus the percent indirect work times the available hours per month per person.

Input Parameter Menu: A second level menu entered from the Main Menu. All vehicle, system, and mission parameters are entered and updated from this menu. The options available from this menu are:
Add/Delete Subsystem (see)
Select Shuttle/Aircraft (see)
Update/Display Primary System Parameters (see)
Update/Display Subsystem Weights (see)
Update/Display Secondary Variables (see)
Update/Display Computational Factors (see)
Update/Display Mission Profile (see)

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Launch Factor: The launch factor is an adjustment to the MTBM (a constant failure rate is assumed) to account for increased vibration and stress during launch. This adjustment is applied to the MTBMs calculated from the aircraft derived regression equations automatically or to the user input MTBM values if Adj Shuttle MTBM-Space 0-No 1-Yes is set to "1". The Launch Factor can be changed from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Launch Pad Time: The number of days the vehicle is on the launch pad. This time includes the mission pad time (see Update/Display Mission Profile) which is the time the vehicle is actually operating while on the launch pad. Launch pad time is used to calculate vehicle turn time (see Max Turn Times and Min Turn Times). It is changed from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Launch Time (RELIABILITY OUTPUT): The reliability at launch time. The probability of no critical failures during prelaunch (pad time). It is based upon the subsystem redundancy established by the user. This reliability is one if ground aborts are not included.

Main Menu: The top level menu of the RAM program. The selections available from this menu are:
Read Input from a File (see Vehicle/File_name)
Input Parameter Menu (see)
Compute R&M Parameters (see Computation Selection Menu)
Output Report Menu (see)
Save Input Parameters (see Vehicle/File_name)
Save Output for Cost Model
Change Vehicle/File Name (see Vehicle/File_name)
Terminate Session

Maintainability Report (SYSTEM PERFORMANCE OUTPUT): One of the program’s output reports. It lists the vehicle maintainability parameters: maintenance actions per mission (sum of the subsystem Maint Actions/Msn), total maintenance hours per maintenance action (average of the subsystem Tot Manhr/Ma), average unscheduled maintenance manhours per mission (sum of the subsystem Avg Manhrs/Msn), on-vehicle maintenance manhours, off-vehicle maintenance manhours, and mission versus ground processing maintenance actions.

Maintenance Actions (MA): Unscheduled maintenance service initiated by inherent failures
(subsystem failures), induced failures (external failure causes), no defect found or cannot duplicate failures, and maintenance induced failures. Only inherent maintenance actions are assumed to occur as a result of the mission operating time. Induced and no defect found maintenance actions are assumed to occur during ground processing hours only.

Maint Actions/Msn (MAINTAINABILITY OUTPUT): The number of unscheduled maintenance actions per mission for each subsystem calculated by dividing a subsystem’s operating (mission) hours by its space adjusted inherent MTBM (Space Adj) and dividing its ground processing time by a non-inherent (external induced and no defect found) MTBM then multiplying by the number of redundant subsystems. Operating hours include pad time and the mission duration.

Manhhrs/Mo (MANPOWER OUTPUT): The average unscheduled maintenance manhours expended per month. It is calculated by multiplying the average maintenance manhours per mission (Avg Manhrs/Msn) by the required number of missions per month (Planned Missions/yr / 12).

Manhrs/Msn (MANPOWER OUTPUT): Same as Avg Manhrs/Msn.

Manhr Driven by Aggregate (MANPOWER/SPARES): The total maintenance manpower computed by dividing the total vehicle maintenance manhours per month by one minus the percent of indirect work times the available manhours per month per person rounded up to the next larger integer. That is

\[
\text{Manhr by Agr} = \frac{\text{Tot Manhrs/Mo}}{(1 - \% \text{ indirect}) \times (\text{Avail Manhrs/Mo/Person})}
\]

Manhr Driven by Subsystem (Manpower/Spares): The total maintenance manpower computed by dividing each subsystem’s maintenance manhours per month (Manhrs/Mo) by the percent of direct work (i.e. one minus % indirect) times the available manhours per month per person, rounding the subsystem values to the next larger integer, and then summing the values.

Manpower/Spares Report (SYSTEM PERFORMANCE OUTPUT): One of the program’s output reports. It shows the total number of spares computed to support all of the vehicle’s subsystems. It also shows the manpower requirements for the vehicle, and optionally ET/LRB, computed in three ways: Manhr Driven Aggregate (see), Manhr Driven by Subsystem (see), and Crew Size by Subsystem (see).

Manpwr (MANPOWER OUTPUT): The number of maintenance personnel earned by the subsystem average manhours per month requirement for unscheduled maintenance (Manhrs/Mo). It is computed by dividing the average manhours per month requirement by the number of direct labor hours a technician is available to work in a month. The larger of this value and the average crew size is passed to the O&S Costing Model (OSC) as the subsystem manpower requirement.
Max Turn Times (VEHICLE TURN TIME OUTPUT): The maximum vehicle turn time calculated under the assumption that all subsystem maintenance work is done sequentially. It is calculated (in hours) by summing the subsystem on-vehicle unscheduled maintenance times, scheduled maintenance time, integration time, launch pad time, and mission time. It is also computed in days for one, two, or three maintenance shifts per day.

Mean Demands per Mission (SYSTEM SPARES OUTPUT): The average number of removal and replacements of a component (demands for spares) per mission. It is computed by multiplying the average number of maintenance actions per mission (Maint Actions/Msn) by the Removal Rate. It becomes the mean of the Poisson distribution used to describe the number of failures requiring spares in a given period of time.

Mean Time Between Maintenance (MTBM): The average length of time in operating (and power on) hours between unscheduled maintenance actions on a particular subsystem. It is computed from aircraft derived regression equations, read in directly for subsystems set at 'SHUTTLE' (see Select Shuttle/Aircraft), or input by the user (see Update/Display Shuttle MTBM’s & MTTR’s). See Calibrated MTBM.

Mean Time to Repair (MTTR): The average length of time in hours to repair a subsystem. It is calculated by dividing the manhours per subsystem maintenance action (Tot Manhr/Ma) by the subsystem Crew Size. Shuttle values for MTTR can be used directly (see Select Shuttle/Aircraft) or values for MTTR can be input by the user directly (see Update/Display Shuttle MTBM’s & MTTR’s). See On-Vehicle MTTR.

Min Turn Times (VEHICLE TURN TIME OUTPUT): The minimum vehicle turn time calculated under the assumption that all subsystem maintenance work is done in parallel. It is calculated (in hours) by summing the maximum subsystem on-vehicle unscheduled maintenance time or scheduled maintenance time (whichever is larger), integration time, launch pad time, and mission time. Subsystem unscheduled maintenance times are computed by dividing the total subsystem maintenance manhours by the crew size times the number of assigned crews. It is also computed in days for one, two, or three maintenance shifts per day.

Mission Completion (RELIABILITY OUTPUT): The probability of no critical failures throughout the mission (the entire mission profile: pad time through landing). It is based upon the subsystem redundancy established by the user.

Mission MTBM (RELIABILITY OUTPUT): The 'Tech/Growth MTBM' value adjusted for both inherent maintenance actions only and for the high constant failure rate during launch and the decreasing failure rate while in orbit. (See 'Weibull Shape Parameter' and 'Launch Factor' if using MTBM values calculated from aircraft derived regression equations or 'Adj Shuttle MTBM 0-No 1-Yes' if using user input MTBM values.)

Msn MA (MAINTAINABILITY REPORT): The number of maintenance actions generated during the mission segment. Computed by taking the total mission time times the inherent
failure rate times the number of redundant subsystems. Excludes ground processing generated MA's.

Msn Nbr for Reliability Growth: The specific mission number at which the system reliabilities and maintainability parameters are to be computed based upon a Duane reliability growth curve (see Reliability Growth Curve Slope). The default value is one (1) which is equivalent to no reliability growth. All maintenance action numbers, manpower, spares, etc. will reflect the reliability growth achieved at this mission number. It assumes continuous reliability improvement at the rate given by the growth curve slope over the specified number of missions.

Mode or Mode Indicator: The RAM program operates in one of three modes: preconceptual, weight-driven, or weight/variable-driven. The mode is selected based on how much design data is available for the proposed vehicle at the time the program is to be run. It is changed from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Preconceptual mode: Only the six Primary Driver Variables (vehicle dry weight, vehicle length and wing span, crew size, number of passengers, and number of main engines) need to be input. The subsystem weights are calculated from the Weight Distribution selected by the user. The secondary variables are calculated from aircraft derived regression equations.

Weight-driven mode: The subsystem weights and the Primary Driver Variables, except vehicle dry weight, are input (see Update/Display Subsystem Weights). The vehicle dry weight is not input as it is calculated by the model as the sum of the entered subsystem weights. The secondary variables are calculated from aircraft derived regression equations.

Weight/variable-driven mode: The subsystem weights, secondary variables, and Primary Driver Variables, except vehicle dry weight, are input (see Update/Display Subsystem Weights and Update Display Secondary Variables). The vehicle dry weight is not input as it is calculated by the model as the sum of the entered subsystem weights.

MTBM & MTTR Calibration: MTBM & MTTR Calibration can be entered to make changes to the unadjusted (technology and reliability growth and environmental adjustments not yet applied) subsystem MTBM and MTTR values by multiplying the values by a common factor. When the program is run, the technology growth and environmental adjustments will then be made. This is particularly useful, for example, in performing sensitivity analyses where the MTBM and MTTR values are systematically changed. MTBM & MTTR Calibration is changed from the Update/Display Computational Factor Menu. The default value is 1.

Nbr Crews Assigned (VEHICLE TURN TIME OUTPUT): The number of crews assigned to work on each subsystem as input by the user (see Number of Crews). Used in computing vehicle turn times. Default is one crew per subsystem.
Number of Crews: The number of crews assigned to the unscheduled maintenance of a particular subsystem. It is used in calculation of the minimum vehicle turn time (Min Turn Time); the duration of total subsystem repair will decrease as Number of Crews is increased. Number of Crews is input from the Update/Display Computational Factor Menu (select CREW SIZE option). The number of individuals in a crew is the Crew Size (see).

Off-Veh Mh (MAINTAINABILITY OUTPUT): The average off-vehicle unscheduled maintenance manhours performed per mission computed by multiplying the average manhours per mission (Avg Manhrs/Msn) by the fraction off-vehicle work (POFF).

On-Veh Mh (MAINTAINABILITY OUTPUT): The average on-vehicle unscheduled maintenance manhours performed per mission computed by multiplying the average manhours per mission (Avg Manhrs/Msn) by one minus the fraction off-vehicle work (1-POFF).

On-Vehicle MTTR (VEHICLE TURN TIME OUTPUT): On-vehicle mean time to repair measured in hours by subsystem. It is the average on-vehicle repair time per unscheduled maintenance action for a subsystem. It is calculated by dividing the manhours per maintenance action (Tot Manhr/Ma) by Crew Size (Personnel Based on Min Crew) and multiplying by one minus the percent off-vehicle work (1-POFF), or input directly if shuttle values (see Select Shuttle/Aircraft) or user input values (see Update/Display Shuttle MTBM's & MTTR's) are used.

Orbit Insertion (RELIABILITY OUTPUT): The probability of no critical failures up to the time the vehicle has been inserted into orbit. It is based upon the subsystem redundancy established by the user.

Percent Indirect Work: The percent of time a worker will spend doing non-maintenance or Indirect Work. Percent Indirect Work is input from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Planned Missions/Year: The number of missions scheduled per year. It is input from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Primary Driver Variables: There are six primary driver variables: vehicle dry weight, vehicle length, wing span, crew size, number of passengers, and number of main engines. These variables are used in the aircraft derived regression equations to calculate the reliability and maintainability parameters. They are entered from the Input System Primary Parameters Menu.

R&M: Abbreviation for 'reliability and maintainability'.

Reentry (RELIABILITY OUTPUT): The probability of no critical failures up to the time at the end of the orbit phase of the mission just prior to reentry. It is based upon the subsystem redundancy established by the user.

Reliability and Maintainability Program (RAM): The computer program which estimates
reliability and maintainability parameters for proposed space vehicles. The R&M parameters are estimated from aircraft derived regression equations which are functions of the Primary Driver Variables, subsystem weights, and secondary variables. If the subsystem weights and/or secondary variables are not known, they are estimated from aircraft derived regression equations which are functions of the Primary Driver Variables. See 'Mode or Mode Indicator'.

Reliability Report (SYSTEM PERFORMANCE OUTPUT): One of the output reports. It provides subsystem and vehicle reliabilities assuming vehicle subsystem redundancies as set by the user (see Update/Display System Redundancy Configuration) at the mission's major milestone points: launch, end of power flight, orbit insertion, reentry, and mission completion. Reliabilities are based upon inherent failures only.

Rqd Crews (Manpower Report): The minimum number of crews required based upon the manpower requirements as determined by the maintenance manhours of work divided by the average crew size. Normally, assigned crews (see Asgd Crews) should be set to this value or a larger value.

Removal Rate (RR): The fraction of total maintenance actions which result in a removal and replacement of a component from the vehicle. Removal Rate is one of the R&M factors calculated by the RAM program. In some cases, regression equations for the removal rates could not be derived due to limited data, so the mean values of the available data were used instead. Subsystem values for removal rate can be entered from the Update/Display Computational Factors Menu replacing program values.

Removal Rate/MA (SYSTEM SPARES OUTPUT): The fraction of maintenance actions which result in a removal and replacement of a component from the vehicle as calculated by the program or input directly by the user (see Removal Rate). The assumption is made that a removed component will generate a demand for a replacement (spare) component.

Select Shuttle/Aircraft: An option on the Input Parameter Menu for selecting that the shuttle MTBM and MTTR values be used for a subsystem ('SHUTTLE') instead of the values calculated by aircraft derived regression equations ('AIRCRAFT') (see Shuttle MTBM, MTTR, and RR). Enter the number corresponding to a subsystem to toggle between 'AIRCRAFT' and 'SHUTTLE'. 'SHUTTLE' selected subsystems will be displayed in red. The 'SHUTTLE' values can be changed through the Update/Display Shuttle MTBM's & MTTR's option of the Input Parameter Menu.

Screen Display (Output) Menu: The output reports which display all of the reliability and maintainability parameters are available from this menu entered from the Main Menu. There are seven output reports: Reliability, Maintainability, Manpower, Spares, Vehicle Turn Time, System Performance Summary, and Aggregated System Report.

Shuttle MTBM, MTTR, and RR: A Martin Marietta database was analyzed to obtain mean values for MTBM, MTTR, and RR for the space shuttle's subsystems. The RAM program can be run
with these values instead of values calculated from the aircraft derived regression equations (see Select Shuttle/Aircraft).

Spare Fill Rate Obj: Fill rate is the fraction of time a spare component is available when a failure has occurred. This is a target fill rate used to establish the level of spares for each subsystem (see Effective Fill Rate). It is input from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Spare Fill Rate Obj: Fill rate is the fraction of time a spare component is available when a failure has occurred. This is a target fill rate used to establish the level of spares for each subsystem (see Effective Fill Rate). It is input from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Spares Requirement (SYSTEM SPARES OUTPUT): The computed number of spare components required per mission in order to achieve a user specified fill rate (see Spare Fill Rate Obj). It is computed based upon the Poisson probability distribution with a mean equal to the Mean Demands per Mission (see).

Subsys Non-Redundant Msn Rel (RELIABILITY OUTPUT): Subsystem non-redundant mission reliability. The probability that a subsystem will complete the mission without a critical failure assuming no system redundancy is present (primary system operates). It is this reliability which the user may specify (see Establish System Reliabilities).

Tech/Grwoth MTBM (RELIABILITY OUTPUT): The 'Calibrated MTBM' value (see) adjusted by the Technology Growth Factor to account for technology improvements occurring during the time period of the input data to the user specified Technology Yr (see and see Technology Growth Factor). This MTBM is further adjusted based upon the reliability growth curve slope (see) and mission number specified by the user.

Technology Growth Factor: The yearly rate at which technology will grow (improve). The regression equations were derived from 1986 aircraft data and the shuttle MTBM, MTTR, and RR values were obtained from 1992 data. Technology Growth Factor is used to increase the MTBM values to account for technological improvements since those baseline dates. Each subsystem has a default value for Technology Growth Factor which can be changed from the Update/Display Computational Factors option of the Input Parameter Menu.

Technology Yr: The year that reflects the technology level designed into the vehicle. The regression equations were derived from 1986 aircraft data and the shuttle MTBM, MTTR, and RR values were obtained from 1992 data. Technology is assumed to grow (improve) each year according to the Technology Growth Factor. Therefore, the RAM program uses Technology Yr to calculate the number of years over which technology would grow by the Technology Growth Factor and then adjusts the MTBM (Tech Adj). Technology Yr is changed from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Tot Maint Actions (VEHICLE TURN TIME OUTPUT): Same as Maint Actions/Msn.

Tot Manhr/Ma (MAINTAINABILITY OUTPUT): The average number of on and off vehicle manhours expended per unscheduled maintenance action computed from aircraft derived regression equations, from the shuttle MTTR and crew size values, or from user input MTTR
Update/Display Computational Factors: One of the options available from the Input Parameter Menu. The computational factors are: Technology Growth Factor (see), Critical Failure Rates (see), subsystem removal rates (see Removal Rates), MTBM & MTTR Calibration (see), Crew Sizes (see), Percent OFF-Equipment (see) and Fraction Inherent Failures (see). Subsystem values for these factors can be entered directly (instead of the program calculating the values or using default values) from the Update/Display Computational Factors Menu. If new values are entered, the program automatically changes the status of the corresponding parameter to 'DO NOT RECOMPUTE' as seen in the Compute R&M Parameters menu selected from the Main Menu. Note, if one subsystem's factor value is changed, the program will not compute any of the other subsystem values for that factor. Instead, the current values for that factor will be maintained.

Update/Display LRB/ET Reliability Data: If the vehicle has a liquid booster rocket or external fuel tank (LRB/ET), the reliability and maintainability parameters of these subsystems can be entered with this option of the Input Parameter Menu. If LRB/ET is required, either the subsystem reliabilities can be entered and the program calculates the system reliability or the LRB/ET system reliability can be entered directly. The default setting is no LRB/ET. If the menu is entered, set the system reliability to 1 to maintain the default setting of no LRB/ET.

Update/Display Mission Profile: The mission profile is entered from this option of the Input Parameter Menu. The mission profile is defined by the ground power time, pad time (while under power), powered phase completion, obit insertion, orbit completion, and reentry. The duration of ground power time and pad time are entered. However, the times are cumulative from launch time (time=0) to reentry time. For example, if the vehicle is inserted into orbit at time=1 and stays in orbit for time=70, the orbit completion time occurs at time =71. If the mission profile is changed, the subsystem operating hours will be updated if a Y (yes) is entered at the prompt within this menu so that the hours each subsystem operates will equate to the new mission profile. See Update/Display System Operating Hours. This option is generally used only to initialize the subsystem operating hours. Once the subsystem operating hours have been adjusted for each subsystem, this option should not be used.

Update/Display Primary System Parameters: One of the options available from the Input Parameter Menu. The six Primary Driver Variables and the 18 system parameters are input from this menu. They are listed below. (Each system parameter is defined individually in this glossary.)

Primary Driver Variables
Dry Wgt (weight in lbs)
Length (ft)
Wing Span (ft)
Crew Size
Nbr Passengers
Nbr Main Engines

System Parameters
Adj Shuttle MTBM-Space 0-No 1-Yes
Technology Yr
Default Abort Rate
Weibull Shape Parameter
Launch Factor
Avail Manhrs/Month
Percent Indirect Work
Spare Fill Rate Obj
Avg Crew Size-Schd Maint
Planned Missions/Year
Mode Indicator (see Mode)
Vehicle Integration Time (days)
Launch Pad Time (days)
Aggregate Avionics 0-No 1-Yes
Default Percent Off Manhours
NBR RCS Engines
NBR OMS Engines
Growth Curve Slope
Msn Nbr for Reliability Growth
Air+Gnd Aborts -0 / Air Aborts -1

Update/Display Redundancy Configuration: The number of duplicate subsystems (the redundancy configuration) can be entered from this option of the Input Parameter Menu. The number of subsystems entered must be at least as many as the minimum number required for that subsystem (specified within the menu). For the power, engine and avionics subsystems, a more general k-out-of-n redundancy can be entered. The number of main, RCS and OMS engines are automatically set to the value input from the Update/Display Primary System Parameters option of the Input Parameter Menu. The default settings for all other subsystems are 1 subsystem per vehicle (i.e., 1 primary with no backups).

Update/Display Secondary Variables: If the mode (see) has been set to Weight/Variable-Driven, the secondary variable values can be input (instead of calculated from regression equations) from this menu entered from the Input Parameter Menu. The secondary variables are:
Fuselage Area
Fuselage Volume
Wetted Area
Number of Wheels
Number of Actuators
Number of Control Surfaces
KVA Maximum

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Update/Display Shuttle MTBM’s & MTTR’s: The program has space shuttle subsystem MTBM and MTTR values obtained from a Martin Marietta database (see Shuttle MTBM, MTTR, and RR) that can be used instead of values calculated from the aircraft derived regression equations. If the shuttle values are being used (see Select Shuttle/Aircraft), they can be modified (user input) from this option of the Input Parameter Menu. The space adjustment factor must be changed from 0 to 1 (see Adj Shuttle MTBM-Space 0-No 1-Yes) if the new values do not account for the additional stresses and vibrations of operating in space.

Update/Display Subsystem Weights: One of the options available from the Input Parameter Menu. If operating in the Preconceptual Mode, the Weight Distribution for determining the subsystem weights from the vehicle dry weight is selected from this menu. If operating in either Weight-Driven or Variable/Weight-Driven Mode (see 'Mode or Mode Indicator'), the subsystem weights are input directly. A Weight Factor (see) can be used to increase or decrease each subsystem weight by a fixed percent. This may be useful for performing sensitivity analysis.

Update/Display System Operating Hrs: This option of the Input Parameter Menu provides a way to change the hours a particular subsystem operates (the vehicle’s operating hours are set through Update/Display Mission Profile). A subsystem’s hours may need to be changed so they more closely reflect the actual operating hours during a mission. For example, the main engines (propulsion-main subsystem) will not operate while the vehicle is in orbit so the orbit time is 0. The operating hours of the landing gear subsystem cannot be changed because the failure rate is measured as failures per mission on reentry not per operating time (see Calibrated MTBM). The ground operating hours are not used in computing the mission reliabilities but are used in calculating the turn times and the total maintenance actions per mission (Maint Actions/Msn).

Vehicle/File name: Each time the RAM program is started a vehicle_name or file_name must be entered. The vehicle_name will be displayed on screen and printed on the output reports. Also, the input parameters can be saved in a file called vehicle_name.dat (the program automatically attaches the .dat extension) by entering 5 from the Main Menu. The saved input parameters can then be loaded into the program during a later session by entering 2 from the Main Menu (enter the name without the .dat extension). Data can be saved in a file called vehicle_name.cst.dat (the program automatically attaches the .cst extension) to be used as input to the O&S Costing Model by entering 6. The vehicle_name may be changed at any time by entering 7 from the Main Menu. If a name is not specified when initializing the RAM program, the program will assign the name: "NO_NAME."

Vehicle Integration Time: The number of days allocated for integration of payloads and boosters
with the vehicle. It is changed from the Update/Display Primary System Parameters option of
the Input Parameter Menu.

Weight Factor: The weight factor changes the weights of the vehicle and each subsystem by the
amount entered. For example, if .95 is entered for the weight factor the current vehicle and
subsystem weights are reduced by 5% to 95% of their value. The weights are restored to their
previous value by entering the inverse of the weight factor (1/.95 = 1.0526316) as the new
weight factor. A cumulative weight factor is calculated by the program. If .9 is entered after
the .95, the cumulative weight factor is .9x.95 or .855. The weights are restored to their
previous value by entering the inverse of the last factor used (1/.9). The weights are restored to
their original values by entering the inverse of the (displayed) cumulative weight factor (1/.855).
The weight factor is changed from the Update/Display Subsystem Weights menu entered from
the Input Parameter menu.

Weight Distribution: If operating in the Preconceptual Mode, the weight distribution for
determining the subsystem weights from the vehicle dry weight must be selected within the
Update/Display Subsystem Weights Menu entered from the Input Parameter Menu.

1. Large Vehicle: subsystem weights are calculated by multiplying NASA estimated large
vehicle subsystem percentages by the total vehicle dry weight

2. Shuttle: subsystem weights are calculated by multiplying shuttle subsystem percentages
by the total vehicle dry weight

3. Small Vehicle: subsystem weights are calculated by multiplying NASA estimated small
vehicle subsystem percentages by the total vehicle dry weight

4. Aircraft: subsystem weights are calculated from the aircraft derived regression
equations

After the distribution selection, each subsystem’s weight percentage of the total vehicle dry
weight is displayed; the percentages can be modified as long as the total is 100%. The actual
subsystem weights are then displayed.

Weibull Shape Parameter: The subsystem failure rates while the vehicle is in orbit are assumed
to follow a Weibull distribution. An adjustment is made to the MTBM values obtained from
the aircraft derived regression equations or to the user input MTBM values if 'Adj Shuttle
MTBM-Space 0-No 1-Yes' is set to "1" to account for the decreased stresses during orbit. The
shape parameter (b) of the Weibull distribution can be entered from the Update/Display Primary
System Parameters option of the Input Parameter Menu. The default value of .28 was obtained
from a large database of satellite failures. The scale parameter (a) of the Weibull distribution
is computed automatically by the program to provide for a continuous failure rate in the
transition from launch to orbit.
APPENDIX B
SCENARIO 1:
PRECONCEPTUAL VEHICLE

To estimate reliability and maintainability (R&M) parameters for preconceptual space vehicles, i.e. for vehicles for which knowledge is very limited, use the RAM program as described below. The R&M parameters calculated by the program include MTBM, MTTR, reliability, maintenance manhours, critical failure rates, removal rates, maintenance crew sizes, percent off-equipment maintenance, and scheduled maintenance percentage. The primary input the program requires is vehicle dry weight, vehicle length and wing span, crew size, number of passengers, and number of main engines.

1. Enter RAM at the DOS prompt with the applicable path to the storage location of the program, at the DOS prompt to start up the program.

   **NOTE:** ALL USER RESPONSES SHOULD BE IN UPPER CASE!

2. Enter a vehicle name (file name).

3. The software initializes by default to the Preconceptual Mode. In this mode, there are two ways to estimate the R&M parameters by vehicle subsystem: 1) all parameters are calculated from the aircraft derived regression equations using the primary driver variables: vehicle dry weight, vehicle length and wing span, crew size, number of passengers, and number of main engines, or 2) shuttle (default) or user input values for MTBM and MTTR are used directly (they are not calculated) and all other R&M parameters are calculated. The necessary user input for each method is described separately below. Enter 2 from the Main Menu to bring up the Input Parameter Menu. Within this menu all vehicle, system, and mission parameters will be input.

1) ALL PARAMETERS TO BE CALCULATED...

   a) Enter 1 to select the subsystems which define your vehicle. For each subsystem that is not required, simply enter the number corresponding to the subsystem to toggle from 'COMPUTE' to 'DELETE'. If a subsystem has been erroneously deleted, enter the number of that subsystem to change 'DELETE' to 'COMPUTE'. This menu has two screens. Enter return when done with the first screen to bring up the second screen with the remaining subsystems. When done, enter return to go back to the Input Parameter Menu. Enter n (no) to the prompt to change a subsystem name. (The name of a subsystem can be changed as long as the total number of subsystems does not exceed 33. Please read section 2) on using shuttle MTBM and MTTR for

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1 unless a path is included as part of the name, all files saved will be in the current subdirectory/directory.

2 all negative responses may be accomplished by simply entering return.
more information before changing a subsystem name.)

NOTE: Most menus entered from the Input Parameter Menu are two screens. Entering return from the first screen will bring up the second screen. Also, you can return to the Input Parameter Menu by simply entering return when done inputting data.

b) Enter 3 to input the primary driver variables and other system parameters. Enter the values for vehicle dry weight, vehicle length and wing span, crew size, number of passengers, and number of main engines. The space adjustment to the MTBM calculation should be left defaulted at 0. The remaining parameters should be changed as needed. Refer to the Glossary of Terms in Appendix A or to Chapters 3 and 5 of "Enhanced Methods for Determining Operational Capabilities and Support Costs of Proposed Space Systems" for more information. Return to the Input Parameter Menu.

c) Enter 4 to select the method for determining the subsystem weights.

1. Large Vehicle: subsystem weights are calculated by multiplying NASA estimated large vehicle subsystem percentages by the total vehicle dry weight.
2. Shuttle: subsystem weights are calculated by multiplying shuttle subsystem percentages by the total vehicle dry weight.
3. Small Vehicle: subsystem weights are calculated by multiplying NASA estimated small vehicle subsystem percentages by the total vehicle dry weight.
4. Aircraft: subsystem weights are calculated from the aircraft derived regression equations.

After distribution selection, each subsystem's weight percentage of the total vehicle dry weight is displayed; the percentages can be modified as long as the total is 100%. Then the actual subsystem weights are displayed for each subsystem. Return to the Input Parameter Menu.

d) Selection number 5 is not applicable for the Preconceptual Mode as this input data is not known during this stage of vehicle development. However, the values of the secondary variables as calculated from the primary driver variables can be viewed if desired.

e) Enter 6 to modify the computational factors. Technology Growth Factor may be modified but the other factors probably are not known during this stage of vehicle development so they should remain as calculated by the program. Return to the Input Parameter Menu.

f) The mission profile can be input by entering 7. The times are cumulative from launch time (time = 0) to reentry time. For example, if the vehicle is inserted into orbit at time = 1 and stays in orbit for time = 70, the orbit completion time occurs at time = 71. After entering the mission profile, enter y (yes) at the prompt to update the subsystem operating hours; the hours each subsystem operates will equate to the new mission profile. When done, return to the Input Parameter Menu.

g) The subsystem operating hours updated above can be reviewed and also changed by entering
8. A subsystem’s hours may need to be changed so they more closely reflect the actual operating hours during a mission. For example, the main propulsion subsystem will not operate while the vehicle is in orbit so it may be necessary to reduce the orbit time hours to 0. Ground processing time must be positive if it is desired to account for maintenance induced and no problem found maintenance actions. Return to the Input Parameter Menu.

h) If the vehicle has duplicate subsystems, enter 9 to update the vehicle’s active redundancy configuration. The default settings are 1 subsystem per vehicle (i.e., 1 primary with no backups). Certain subsystems can have a k out of n redundancy specified. Return to the Input Parameter Menu.

i) Only select 10 if the vehicle has a liquid booster rocket or external fuel tank (LBR/ET). If 10 is not selected, the default setting is no LRB/ET. If 10 is selected, enter return twice and then enter 1 at the prompt to enter LRB/ET system reliability if LRB/ET is not required. Repeat entering return twice and entering 1 to leave this menu. If LRB/ET is required, either the subsystem reliabilities can be entered and the program calculates the system reliability or the LRB/ET system reliability can be entered directly. Output values are computed interactively and displayed as part of the input screen. Reliabilities are combined with the vehicle reliability only on the Summary (output) Report. Return to the Input Parameter Menu.

j) Percent scheduled maintenance (as a percent of the unscheduled maintenance) can be input instead of calculated from regression equations by entering 12. If the percent scheduled maintenance is changed, it will not be computed by the program. The program automatically changes the status of the percent scheduled maintenance parameter to ‘DO NOT RECOMPUTE’ as seen in the Compute R&M Parameters Menu selected from the Main Menu. When done, return to the Input Parameter Menu.

k) Enter 13 if nonredundant subsystem reliabilities are to be specified. The program will not calculate those nonredundant subsystem reliabilities entered, but will use them in other R&M parameter calculations. This feature allows estimation of the effect of improving subsystem reliability on the vehicle’s reliability and maintainability. Enter the subsystem number followed by 0 to toggle from using the entered value to having the program calculate the reliability. When done, return to the Input Parameter Menu.

l) Return to Main Menu when all inputs complete.

2) SHUTTLE OR USER INPUT VALUES FOR MTBM AND MTTR... ³

³ Several subsystems do not have aircraft derived parametric equations available and as a result SHUTTLE of user specified MTBM and MTTR values must be used. These appear as "SHUTTLE ONLY" on the 2nd input screen (SELECT SHUTTLE/AIRCRAFT).
The steps to run the RAM program as described above are repeated below. Steps which are different or new so that the shuttle or user input values are used for MTBM and MTTR directly instead of calculated are in SMALL CAPS.

a) Enter 1 to select the subsystems which define your vehicle. For each subsystem that is not required, simply enter the number corresponding to the subsystem to toggle from ‘COMPUTE’ to ‘DELETE’. If a subsystem has been erroneously deleted, enter the number of that subsystem to change ‘DELETE’ to ‘COMPUTE’. This menu has two screens. Enter return when done with the first screen to bring up the second screen with the remaining subsystems. When done, enter return to go back to the Input Parameter Menu. THE NAME OF A SUBSYSTEM CAN BE CHANGED (I.E., CREATE A DIFFERENT SUBSYSTEM) BY ENTERING Y (YES) FOLLOWED BY A NEW NAME AT THE PROMPTS. THE TOTAL NUMBER OF SUBSYSTEMS MUST NOT EXCEED 33. THE SHUTTLE VALUES FOR MTBM AND MTTR, AS DESCRIBED IN B), MUST BE USED FOR ALL RENAMED SUBSYSTEMS SINCE THE REGRESSION EQUATIONS WILL NOT BE VALID. IF NO SUBSYSTEM NAMES ARE TO BE CHANGED, ENTER N (NO) AND THEN RETURN TO GO BACK TO THE INPUT PARAMETER MENU.

NOTE: Most menus entered from the Input Parameter Menu are two screens. Entering return from the first screen will bring up the second screen. Also, you can return to the Input Parameter Menu by simply entering return when done inputting data.

b) ENTER 2. FOR ANY SUBSYSTEM, THE SHUTTLE VALUES FOR MTBM AND MTTR (OBTAINED FROM A MARTIN MARIETTA DATABASE) CAN BE USED INSTEAD OF THE CALCULATED VALUES BY ENTERING THE NUMBER CORRESPONDING TO THAT SUBSYSTEM (‘AIRCRAFT’ WILL CHANGE TO ‘SHUTTLE’). ‘SHUTTLE’ SELECTED SUBSYSTEMS WILL BE DISPLAYED IN RED. STEP K BELOW DESCRIBES HOW TO CHANGE THE SHUTTLE VALUES FOR MTBM AND MTTR TO USER INPUT VALUES. THE MTBM AND MTTR FOR SUBSYSTEMS NOT CHANGED AND ALL OTHER R&M PARAMETERS WILL BE CALCULATED BY THE REGRESSION EQUATIONS. WHEN DONE, RETURN TO THE INPUT PARAMETER MENU.

NOTE: IF THE NAME OF A SUBSYSTEM WAS CHANGED IN A), THAT SUBSYSTEM MUST USE SHUTTLE (OR USER SPECIFIED) DATA AS THE REGRESSION EQUATIONS ARE NO LONGER VALID.

c) Enter 3 to input the primary driver variables and other system parameters. Enter the values for vehicle dry weight, vehicle length and wing span, crew size, number of passengers, and number of main engines. THE SPACE ADJUSTMENT TO THE MTBM CALCULATION SHOULD BE CHANGED FROM 0 TO 1 (ENTER 6 FOLLOWED BY ENTERING A 1) IF THE PROGRAM VALUES FOR SHUTTLE MTBM AND MTTR ARE TO BE CHANGED AS DESCRIBED IN STEP K. The remaining parameters should be changed as needed. Refer to the Glossary of Terms at the end of this guide or to Chapters 3 and 5 of *Enhanced Methods for Determining Operational Capabilities and Support Costs of Proposed Space Systems* for more
information. Return to the Input Parameter Menu.

d) Enter 4 to select the method for determining the subsystem weights.

1. Large Vehicle: subsystem weights are calculated by multiplying NASA estimated large vehicle subsystem percentages by the total vehicle dry weight.
2. Shuttle: subsystem weights are calculated multiplying shuttle subsystem percentages by the total vehicle dry weight.
3. Small Vehicle: subsystem weights are calculated by multiplying NASA estimated small vehicle subsystem percentages by the total vehicle dry weight.
4. Aircraft: subsystem weights are calculated from the aircraft derived regression equations.

After distribution selection, the weight percentages are displayed for each subsystem; the percentages can be modified as long as the total is 100%. Then the calculated weights are also displayed for each subsystem. Return to the Input Parameter Menu.

e) Selection number 5 is not applicable for the Preconceptual Mode as this input data is not known during this stage of vehicle development. However, the values of the secondary variables as calculated from the previous set of inputs can be viewed if desired. These will be updated based upon current input values when the user selects "3" on the main menu (COMPUTE R&M PARAMETERS).

f) Enter 6 to modify the computational factors. Technology Growth Factor may be modified but the other factors probably are not known during this stage of vehicle development so they should remain as calculated by the program. Return to the Input Parameter Menu.

g) The mission profile can be input by entering 7. The times are cumulative from launch time (time = 0) to reentry time. For example, if the vehicle is inserted into orbit at time = 1 and stays in orbit for time = 70, the orbit completion time occurs at time = 71. After entering the mission profile, enter y (yes) at the prompt to update the subsystem operating hours; the hours each subsystem operates will equate to the new mission profile. When done, return to the Input Parameter Menu.

h) The subsystem operating hours updated above can be reviewed and also changed by entering 8. A subsystem’s hours may need to be changed so they more closely reflect the actual operating hours during a mission. For example, the main propulsion subsystem will not operate while the vehicle is in orbit so it may be necessary to reduce the orbit time hours to 0. Return to the Input Parameter Menu.

i) If the vehicle has duplicate subsystems, enter 9 to update the vehicle’s redundancy configuration. The default settings are 1 subsystem per vehicle (i.e., 1 primary with no backups). Return to the Input Parameter Menu.

j) Only select 10 if the vehicle has a liquid booster rocket or external fuel tank (LBR/ET). If
10 is not selected, the default setting is no LRB/ET. If 10 is selected, enter return twice and then enter 1 at the prompt to enter LRB/ET system reliability if LRB/ET is not required. Repeat entering return twice and entering 1 to leave this menu. If LRB/ET is required, either the subsystem reliabilities can be entered and the program calculates the system reliability or the LRB/ET system reliability can be entered directly. Return to the Input Parameter Menu.

k) FROM THE INPUT PARAMETER MENU, ENTER 11 IF THE VALUES FOR SHUTTLE MTBM AND MTTR NEED TO BE CHANGED FROM THE DEFAULT VALUES. IF THE SHUTTLE MTBM AND MTTR VALUES ARE CHANGED AND THE NEW VALUES DO NOT REFLECT OPERATING IN A SPACE ENVIRONMENT, THE SPACE ADJUSTMENT FACTOR MUST BE CHANGED FROM 0 TO 1. THE SPACE ADJUSTMENT FACTOR IS IN THE PRIMARY SYSTEM PARAMETERS MENU, SELECTION 3 OF THE INPUT PARAMETER MENU. SEE C) ABOVE. WHEN DONE, RETURN TO THE INPUT PARAMETER MENU.

l) Percent scheduled maintenance can be input instead of calculated from regression equations by entering 12. If the percent scheduled maintenance is changed, it will not be computed by the program. The program automatically changes the status of the percent scheduled maintenance parameter to ‘DO NOT RECOMPUTE’ as seen in the Compute R&M Parameters Menu selected from the Main Menu. When done, return to the Input Parameter Menu.

m) Enter 13 if nonredundant subsystem reliabilities are known. The program will not calculate those nonredundant subsystem reliabilities entered, but will use them in other R&M parameter calculations. This feature allows estimation of the effect of improving subsystem reliability on the vehicle’s reliability and maintainability. Enter the subsystem number followed by 0 to toggle from using the entered value to having the program calculate the reliability. When done, return to the Input Parameter Menu.

n) Return to the Main Menu when all inputs are complete.

4. Enter 3 to compute the R&M parameters with the new input values. The menu lists the status of the parameters (critical failure rates, removal rates, crew sizes, percent off-equipment, and scheduled maintenance percentage) to be calculated by the program. If any of the computational factors or the percent unscheduled maintenance were changed from the Input Parameter Menu, the corresponding parameter’s status will be ‘DO NOT RECOMPUTE’. A parameter’s status can be changed from ‘RECOMPUTE’ to ‘DO NOT RECOMPUTE’ by entering the number corresponding to the parameter so that the current value of that parameter is maintained. Enter return for the program to recompute the desired R&M parameters. Always recompute the R&M parameters after changing the inputs to update all parameter and output values.

5. The computed R&M parameters can be viewed on the screen by entering 4. Also, the calculated performance/specification variables and percentage of scheduled maintenance can be read from the Input Parameter Menu (enter 2). The inputs and various output reports can be printed by entering 8 from the Main Menu.
6. If it would be necessary to run the program again with these same input parameters, enter 5 from the Main Menu to store them in a file named vehicle_name.dat. (The .dat extension is appended to the vehicle_name automatically by the program.) The current input parameters can also be saved when the session is terminated (selection 9 on the Main Menu). The input parameter file can be loaded into the program at anytime by entering 1 from the Main Menu and then entering the vehicle_name (no extension).

7. Enter 6 if the Life Cycle Costing Model will be used. The required R&M data will be saved in a file called vehicle_name.cst (the .cst extension is appended to the vehicle_name automatically by the program) and used as input to the cost model.

8. Enter 9 from the Main Menu to terminate the current session. The input parameters can be saved in a file called vehicle_name.dat as described in step 6.
SCENARIO 2:

VEHICLE WITH KNOWN SUBSYSTEM WEIGHTS

To estimate reliability and maintainability (R&M) parameters for space vehicles when the subsystem weights are known (i.e., they will not be calculated from the subsystem weight percentages and total vehicle dry weight as for preconceptual vehicles in scenario 1), use the RAM program as described below. The primary input the program requires is vehicle subsystem weights, vehicle length and wing span, crew size, number of passengers, and number of engines.

All of the steps needed to run the RAM program for Scenario 2 are listed below. Those steps which are new or are different from Scenario 1 are in bold.

1. Enter RAM at the DOS prompt with the applicable path to the storage location of the program.

2. Enter a vehicle name (file name).

3. The software initializes by default to the Preconceptual Mode. The mode must be changed (step 1)b or 2)c ) to the Weight-Driven Mode since the subsystem weights will be input directly instead of being calculated by the program. The R&M parameters can be estimated by vehicle subsystem in two ways: 1) all R&M parameters are calculated from the aircraft derived regression equations using the subsystem weights and primary driver variables: vehicle length and wing span, crew size, number of passengers, and number of main engines, or 2) shuttle or user input values for MTBM and MTTR are used directly (they are not calculated) and all other R&M parameters are calculated. The necessary user input for each method is described separately below. Enter 2 from the Main Menu to bring up the Input Parameter Menu. Within this menu all vehicle, system, and mission parameters will be input.

1) ALL PARAMETERS TO BE CALCULATED...

a) Enter 1 to select the subsystems which define your vehicle. For each subsystem that is not required, simply enter the number corresponding to the subsystem to toggle from 'COMPUTE' to 'DELETE'. If a subsystem has been erroneously deleted, enter the number of that subsystem to change 'DELETE' to 'COMPUTE'. This menu has two screens. Enter return when done with the first screen to bring up the second screen with the remaining subsystems. When done, enter return to go back to the Input Parameter Menu. Enter n (no) to the prompt to change a subsystem name. (The name of a subsystem can be changed as long as the total number of subsystems does not exceed 33. Please read section 2) on using shuttle MTBM and MTTR for more information before changing a subsystem name.)

Note: Most menus entered from the Input Parameter Menu are two screens. Entering
return from the first screen will bring up the second screen. Also, you can return to the Input Parameter Menu by simply entering return when done inputting data.

b) Enter 3 to input the primary driver variables and other system parameters. Enter the values for vehicle length and wing span, crew size, number of passengers, and number of main engines. The total vehicle dry weight does not need to be input as the subsystem weights will be input directly (step c) and the program will automatically update the total vehicle dry weight as the sum of the subsystem weights. The space adjustment to the MTBM calculation should be left defaulted at 0. The mode is changed (Preconceptual to Weight-Driven) from the second screen of the Input Parameter Menu (enter return to bring up the second screen then enter 16 followed by entering 1). The remaining parameters should be changed as needed. Refer to the Glossary of Terms in Appendix A of this guide or to Chapters 3 and 5 of “Enhanced Methods for Determining Operational Capabilities and Support Costs of Proposed Space Systems” for more information. Return to the Input Parameter Menu.

c) Enter 4 to input the subsystem weights. The total vehicle dry weight will be automatically updated as the subsystem weights are changed. When done entering weights, the weight factor can be changed. The weight factor changes the weights of the vehicle and each subsystem by the amount entered. For example, if .95 is entered for the weight factor the current vehicle and subsystem weights are reduced by 5% to 95% of their value. The weights are restored to their previous value by entering the inverse of the weight factor (1/.95) as the new weight factor. The cumulative weight factor is displayed in the upper left portion of the screen. If .9 is entered after the .95, the cumulative weight factor is .9x.95 or .855. The weights are restored to their previous value by entering the inverse of the last weight factor (1/.9). The weights are restored to their original values by entering the inverse of the cumulative weight factor (1/.855).

d) Selection number 5 is not applicable for this mode as this input data is not known during this stage of vehicle development. However, the values of the secondary variables as calculated from the previous set of inputs can be viewed if desired. These will be updated based upon current input values when the user selects "3" on the main menu (COMPUTE R&M PARAMETERS).

e) Enter 6 to input or view the computational factors: technology growth factor, critical failure rates, subsystem removal rates, MTBM & MTTR calibration, crew sizes, percent off-equipment, and fraction inherent failures. A new technology growth factor value might need to be entered, but the other factors are probably not known during this stage of vehicle development so they should be calculated by the program. If a factor value is entered, the program automatically updates the status of several of the corresponding parameter to 'DO NOT RECOMPUTE' as seen in the compute R&M parameters menu selected from the Main Menu. If one subsystem's factor value is changed, the program will not compute any of the other subsystem values for that factor. Instead, the current
values for that factor will be maintained. Those factors not changed will be calculated by the program. The values of the computational factors as calculated from the previous set of inputs can be viewed within this menu by entering the number corresponding to the factor. Enter return to exit without entering factor values (they will be calculated). Return to the Input Parameter Menu.

f) The mission profile can be input by entering 7. The times are cumulative from launch time (time=0) to reentry time. For example, if the vehicle is inserted into orbit at time=1 and stays in orbit for time=70, the orbit completion time occurs at time =71. After entering the mission profile, enter Y (yes) at the prompt to update the subsystem operating hours; the hours each subsystem operates will equate to the new mission profile. When done, return to the Input Parameter Menu.

g) The subsystem operating hours updated above can be reviewed and also changed by entering 8. A subsystem's hours may need to be changed so they more closely reflect the actual operating hours during a mission. For example, the main propulsion subsystem will not operate while the vehicle is in orbit so it may be necessary to reduce the orbit time hours to 0. A positive ground processing time must be specified in order to account for any induced or no trouble found maintenance actions. It is assumed that mission failures are inherent equipment failures only. Return to the Input Parameter Menu.

h) If the vehicle has duplicate subsystems, enter 9 to update the vehicle's redundancy configuration. The default settings are 1 subsystem per vehicle (i.e., 1 primary with no backups). Certain subsystems can have a k out of n redundancy defined. Return to the Input Parameter Menu.

i) Only select 10 if the vehicle has a liquid booster rocket or external fuel tank (LBR/ET). If 10 is not selected, the default setting is no LRB/ET. If 10 is selected, enter return twice and then enter 1 at the prompt to enter LRB/ET system reliability if LRB/ET is not required. Repeat entering return twice and entering 1 to leave this menu. If LRB/ET is required, either the subsystem reliabilities can be entered and the program calculates the system reliability or the LRB/ET system reliability can be entered directly. Return to the Input Parameter Menu.

j) Percent scheduled maintenance can be input instead of calculated from regression equations by entering 12. If the percent scheduled maintenance is changed, it will not be computed by the program. The program automatically changes the status of the percent scheduled maintenance parameter to 'DO NOT RECOMPUTE' as seen in the Compute R&M Parameters Menu selected from the Main Menu. When done, return to the Input Parameter Menu.

k) Enter 13 if nonredundant subsystem reliabilities are to be specified. The program will not calculate those nonredundant subsystem reliabilities entered, but will use them in other R&M parameter calculations. This feature allows estimation of the effect of

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improving subsystem reliability on the vehicle's reliability and maintainability. Enter the subsystem number followed by 0 to toggle from using the entered value to having the program calculate the reliability. When done, return to the Input Parameter Menu.

1) Return to the Main Menu when all inputs are complete.

2) SHUTTLE OR USER INPUT VALUES FOR MTBM AND MTTR...

The above steps are repeated below with minor variation or additional steps so that the shuttle values or user input values for MTBM and MTTR are used directly instead of values calculated by the program. The new or modified steps are in SMALL CAPS.

a) Enter 1 to select the subsystems which define your vehicle. For each subsystem that is not required, simply enter the number corresponding to the subsystem to toggle from 'COMPUTE' to 'DELETE'. If a subsystem has been incorrectly deleted, enter the number of that subsystem to change 'DELETE' to 'COMPUTE'. This menu has two screens. Enter return when done with the first screen to bring up the second screen with the remaining subsystems. When done, enter return to go back to the Input Parameter Menu. THE NAME OF A SUBSYSTEM CAN BE CHANGED (I.E., CREATE A DIFFERENT SUBSYSTEM) BY ENTERING Y (YES) FOLLOWED BY A NEW NAME AT THE PROMPT. THE TOTAL NUMBER OF SUBSYSTEMS MUST NOT EXCEED 33. THE SHUTTLE VALUES FOR MTBM AND MTTR, AS DESCRIBED IN B), MUST BE USED FOR ALL RENAMED SUBSYSTEMS SINCE THE REGRESSION EQUATIONS WILL NOT BE VALID. IF NO SUBSYSTEM NAMES ARE TO BE CHANGED, ENTER N (NO) AND THEN RETURN TO GO BACK TO THE INPUT PARAMETER MENU.

Note: Most menus entered from the Input Parameter Menu are two screens. Entering return from the first screen will bring up the second screen. Also, you can return to the Input Parameter Menu by simply entering return when done inputting data.

b) ENTER 2. FOR ANY SUBSYSTEM, THE SHUTTLE VALUES FOR MTBM AND MTTR (OBTAINED FROM A MARTIN MARIETTA DATABASE) CAN BE USED INSTEAD OF THE CALCULATED VALUES BY ENTERING THE NUMBER CORRESPONDING TO THAT SUBSYSTEM ('AIRCRAFT' WILL CHANGE TO 'SHUTTLE'). 'SHUTTLE' SELECTED SUBSYSTEMS WILL BE DISPLAYED IN RED. STEP K BELOW DESCRIBES HOW TO CHANGE THE SHUTTLE VALUES FOR MTBM AND MTTR TO USER INPUT VALUES (VALUES CAN BE INPUT

' several subsystems do not have aircraft derived parametric equations available and as a result SHUTTLE of user specified MTBM and MTTR values must be used. These appear as "SHUTTLE ONLY" on the 2nd input screen (SELECT SHUTTLE/AIRCRAFT).
ONLY FOR SUBSYSTEMS SET AT 'SHUTTLE'). THE MTBM AND MTTR FOR
SUBSYSTEMS NOT CHANGED AND ALL OTHER R&M PARAMETERS WILL BE
CALCULATED BY THE REGRESSION EQUATIONS. WHEN DONE, RETURN TO
THE INPUT PARAMETER MENU.

NOTE: IF THE NAME OF A SUBSYSTEM WAS CHANGED IN A), THAT
SUBSYSTEM MUST USE SHUTTLE OR USER SPECIFIED DATA AS THE
REGRESSION EQUATIONS ARE NO LONGER VALID.

c) Enter 3 to input the primary driver variables and other system parameters. Enter the
values for vehicle length and wing span, crew size, number of passengers, and
number of main engines. The total vehicle dry weight does not need to be input
as the subsystem weights will be input directly (step d) and the program will
automatically update the total vehicle dry weight as the sum of the subsystem
weights. THE SPACE ADJUSTMENT TO THE MTBM CALCULATION SHOULD
BE CHANGED FROM 0 TO 1 (ENTER 6 FOLLOWED BY ENTERING A 1) IF THE
PROGRAM VALUES FOR SHUTTLE MTBM AND MTTR ARE TO BE CHANGED
AS DESCRIBED IN STEP K. The mode is changed (Preconceptual to Weight-
Driven) from the second screen of the Input Parameter Menu; enter return to bring
up the second screen then enter 16 followed by entering 1. The remaining
parameters should be changed as needed. Refer to the Glossary of Terms in Appendix
A of this guide or to Chapters 3 and 5 of "Enhanced Methods for Determining
Operational Capabilities and Support Costs of Proposed Space Systems" for more
information. Return to the Input Parameter Menu.

d) Enter 4 to input the subsystem weights. The total vehicle dry weight will be
automatically updated as the subsystem weights are changed. When done entering
weights, the weight factor can be changed. The weight factor changes the weights
of the vehicle and each subsystem by the amount entered. For example, if .95 is
entered for the weight factor the current vehicle and subsystem weights are reduced
by 5% to 95% of their value. The weights are restored to their previous value by
entering the inverse of the weight factor (1/.95) as the new weight factor. The
cumulative weight factor is displayed in the upper left portion of the screen. If .9
is entered after the .95, the cumulative weight factor is .9x.95 or .855. The
weights are restored to their previous value by entering the inverse of the last
weight factor (1/.9). The weights are restored to their original values by entering
the inverse of the cumulative weight factor (1/.855).

e) Selection number 5 is not applicable for this mode as this input data is not known
during this stage of vehicle development. However, the values of the secondary variables
as calculated from the previous set of inputs can be viewed if desired.

f) Enter 6 to input or view the computational factors: technology growth factor, critical
failure rates, subsystem removal rates, MTBM & MTTR calibration, crew sizes, percent
off-equipment, and fraction inherent failures. A new technology growth factor value might need to be entered, but the other factors are probably not known during this stage of vehicle development so they should be calculated by the program. If a factor value is entered, the program automatically updates the status of the corresponding parameter to ‘DO NOT RECOMPUTE’ as seen in the compute R&M parameters menu selected from the Main Menu. If one subsystem’s factor value is changed, the program will not compute any of the other subsystem values for that factor. Instead, the current values for that factor will be maintained. Those factors not changed will be calculated by the program. The values of the computational factors as calculated from the previous set of inputs can be viewed within this menu by entering the number corresponding to the factor. Enter return to exit without entering factor values (they will be calculated). Return to the Input Parameter Menu.

g) The mission profile can be input by entering 7. The times are cumulative from launch time (time=0) to reentry time. For example, if the vehicle is inserted into orbit at time=1 and stays in orbit for time=70, the orbit completion time occurs at time =71. After entering the mission profile, enter y (yes) at the prompt to update the subsystem operating hours; the hours each subsystem operates will equate to the new mission profile. When done, return to the Input Parameter Menu.

h) The subsystem operating hours updated above can be reviewed and also changed by entering 8. A subsystem’s hours may need to be changed so they more closely reflect the actual operating hours during a mission. For example, the main propulsion subsystem will not operate while the vehicle is in orbit so it may be necessary to reduce the orbit time hours to 0. Return to the Input Parameter Menu.

i) If the vehicle has duplicate subsystems, enter 9 to update the vehicle’s redundancy configuration. The default settings are 1 subsystem per vehicle (i.e., 1 primary with no backups). Return to the Input Parameter Menu.

j) Only select 10 if the vehicle has a liquid booster rocket or external fuel tank (LBR/ET). If 10 is not selected, the default setting is no LRB/ET. If 10 is selected, enter return twice and then enter 1 at the prompt to enter LRB/ET system reliability if LRB/ET is not required. Repeat entering return twice and entering 1 to leave this menu. If LRB/ET is required, either the subsystem reliabilities can be entered and the program calculates the system reliability or the LRB/ET system reliability can be entered directly. Return to the Input Parameter Menu.

k) FROM THE INPUT PARAMETER MENU, ENTER 11 IF THE VALUES FOR SHUTTLE MTBM AND MTTR NEED TO BE CHANGED FROM THE DEFAULT VALUES. IF THE SHUTTLE MTBM AND MTTR VALUES ARE CHANGED AND THE NEW VALUES DO NOT REFLECT OPERATING IN A SPACE ENVIRONMENT, THE SPACE ADJUSTMENT FACTOR MUST BE CHANGED FROM 0 TO 1. THE SPACE ADJUSTMENT FACTOR IS IN THE PRIMARY
SYSTEM PARAMETER MENU, SELECTION 3 OF THE INPUT PARAMETER MENU. SEE C) ABOVE. WHEN DONE, RETURN TO THE INPUT PARAMETER MENU.

1) Percent scheduled maintenance can be input instead of calculated from regression equations by entering 12. If the percent scheduled maintenance is changed, it will not be computed by the program. The program automatically changes the status of the percent scheduled maintenance parameter to 'DO NOT RECOMPUTE' as seen in the Compute R&M Parameters Menu selected from the Main Menu. When done, return to the Input Parameter Menu.

m) Enter 13 if nonredundant subsystem reliabilities are known. The program will not calculate those nonredundant subsystem reliabilities entered, but will use them in other R&M parameter calculations. This feature allows estimation of the effect of improving subsystem reliability on the vehicle's reliability and maintainability. Enter the subsystem number followed by 0 to toggle from using the entered value to having the program calculate the reliability. When done, return to the Input Parameter Menu.

n) Return to Main Menu when all inputs are complete.

4. Enter 3 to compute the R&M parameters with the new input values. The menu lists the status of the parameters (critical failure rates, removal rates, crew sizes, percent off-equipment, and scheduled maintenance percentage) to be calculated by the program. If certain of the computational factors or the percent unscheduled maintenance were changed from the Input Parameter Menu, the corresponding parameter's status will be 'DO NOT RECOMPUTE'. A parameter's status can be changed from 'RECOMPUTE' to 'DO NOT RECOMPUTE' by entering the number corresponding to the parameter so that the current value of that parameter is maintained. Enter return for the program to recompute the desired R&M parameters. Always recompute the R&M parameters after changing the inputs to update all parameter values.

5. The computed R&M parameters can be viewed on the screen by entering 4. Also, the calculated performance/specification variables and percentage of scheduled maintenance can be read from the Input Parameter Menu (enter 2). The inputs and various output reports can be printed by entering 8 from the Main Menu.

6. If it would be necessary to run the program again with these same input parameters, enter 5 from the Main Menu to store them in a file named vehicle_name.dat. (The .dat extension is appended to the vehicle_name automatically by the program.) The current input parameters can also be saved when the session is terminated (selection 9 on the Main Menu). The input parameter file can be loaded into the program at anytime by entering 1 from the Main Menu and then entering the vehicle_name (no extension).

7. Enter 6 if the Life Cycle Costing Model will be used. The required R&M data will be saved in a file called vehicle_name.cst (the .cst extension is appended to the vehicle_name
automatically by the program) and used as input to the cost model.

8. Enter 9 from the Main Menu to terminate the current session. The input parameters can be saved in a file called vehicle_name.dat as described in step 6 prior to returning to the DOS prompt.

SCENARIO 3:

VEHICLE WITH KNOWN SUBSYSTEM WEIGHTS AND SYSTEM VARIABLES

The RAM program can calculate reliability and maintainability (R&M) parameters for proposed space vehicles during advanced design stages when the subsystem weights and secondary variables (fuselage area, fuselage volume, wetted area, number of wheels, number of actuators, number of control surfaces, KVA maximum, number of hydraulic subsystems, number of internal fuel tanks, total number of avionics subsystems, number of different avionics subsystems, BTU cooling, and number of oxidizer tanks are known. The program requires vehicle subsystem weights, secondary variable values, vehicle length and wing span, crew size, number of passengers, and number of engines as input.

Only the steps which are different from those in Scenario 2 are listed below!

3. For both: ALL R&M PARAMETERS TO BE CALCULATED...and ... SHUTTLE OR USER INPUT VALUES FOR MTBM AND MTTR...

a) Change the mode (Preconceptual to Weight/Variable-Driven) from the second screen of the Input Parameter Menu.

b) Input the secondary variables by entering 5 from the Input Parameter Menu. None of the secondary variables will be calculated in the Weight/Variable-Driven mode so all of them must be input.

NOTE: If some of the secondary variables are not known, the program can be run in the weight-driven mode to initially calculate all of the secondary values. The known secondary variables can then be entered. The current values will be maintained for the variables not changed provided the mode is changed back to weight/variable driven.

c) Modify the computational factors: technology growth factor, critical failure rates, subsystem removal rates, MTBM & MTTR calibration, crew sizes, and percent off-equipment as needed. Recall that if certain factors are changed, they are not computed by the program.
APPENDIX C

RAM Model Source Listing

File: RAMX.BAS

**main module - input**

```plaintext
DECLARE SUB SIM
DECLARE SUB DRIVER
DECLARE SUB OUTFILE
DECLARE SUB INFIL
DECLARE SUB PCTWGT
DECLARE SUB TECH
DECLARE SUB MAIN
DECLARE SUB INMENU
DECLARE SUB PRIVAR
DECLARE SUB COMPAR
DECLARE SUB COMREL
DECLARE SUB SPARES
DECLARE SUB ABORT
DECLARE SUB SECONDARY
DECLARE SUB MANDIPS
DECLARE SUB MANPWR
DECLARE SUB INIT
DECLARE SUB SPARES
DECLARE SUB BOOSTER
DECLARE SUB TURNTIME
DECLARE SUB SPACEMTBM
DECLARE SUB POFFEQS
DECLARE SUB REMEQS
DECLARE SUB MAINTDIS
DECLARE SUB IQS
DECLARE SUB REDUNKREL
DECLARE SUB REDLDISPLAY

© NASA, LANGUAGE RESEARCH CENTER 20 'MTBM COMPUTATIONAL MODEL - NASA RESEARCH GRANT - DEVELOPED BY C. EBELING, UNIV OF DAYTON 9/10/94 (ulx fatcd)

33 ' ******** COMBINED PRE/CONCEPTUAL MODEL ******** 40

50 'SAVE AS "RAMX.BAS" Reliability & Maintainability Model - REVISED
60 COMMON SHARED YR, B, X1, X2, LF, VRI, V2, VR, VR5, VR, AREM
66 COMMON SHARED YFMA, SFTPMA, SAPMA, OPMHA, O PRHMA, TMA, OHRMA
67 COMMON SHARED SCHP, VMAH, TOMH, APP, PI, P2, P3, P4, WAV, TRH, EF
68 COMMON SHARED FMA11, FMA12, YAM AS, ARR, TNR, TS, SKIP
70 COMMON SHARED SMP, TMR, VMOH, WRT, WING, WP, WPW
72 COMMON SHARED STRE, SRBS, STRE, RYPS, ABTPS
73 COMMON SHARED STP, STE, MTE, TME, STF, MTF, TMF, CT
74 DIM SHARED WBS(35), X(30), NAM(50), THRS(35), MHMA(35), MHMA(35), MP(35), ORHMA(35), FMH(35)
75 DIM SHARED GSH(35), LOR(35), TSHR(35), OOR(35), ROR(35), R(35), TSHT(35), POH(35)
76 DIM SHARED V(35), SMAH(35), FMA(35), FM(35), SMA(35), STH(35)
77 DIM SHARED NWS(35), K(35), R1(35), R2(35), R3(35), R4(35), R5(35)
78 DIM SHARED WPS(35), PWS(35), PWS(35), SPS(35)
79 DIM SHARED ETS(35), ETM(35), ETB(35), ETM(35), ETB(35), ET(35), ET(35), ET(35), ET(35), ET(35)
80 DIM SHARED SWR(35), SWR(35), SWR(35), SWR(35), SWR(35), SWR(35), SWR(35)
81 DIM SHARED MW(35), C(35), C(35), C(35), C(35), C(35), C(35)
82 DIM SHARED V(35), V(35), V(35), V(35), V(35), V(35), V(35)
83 DIM SHARED NWS(35), K(35), R1(35), R2(35), R3(35), R4(35), R5(35)
84 DIM SHARED WPS(35), PWS(35), PWS(35), SPS(35)
85 DIM SHARED ETS(35), ETM(35), ETB(35), ETM(35), ETB(35), ET(35), ET(35), ET(35), ET(35)
86 DIM SHARED SWR(35), SWR(35), SWR(35), SWR(35), SWR(35), SWR(35), SWR(35)
87 DIM SHARED MW(35), C(35), C(35), C(35), C(35), C(35), C(35)
88 DIM SHARED V(35), V(35), V(35), V(35), V(35), V(35), V(35)
89 DIM SHARED NWS(35), K(35), R1(35), R2(35), R3(35), R4(35), R5(35)
90 DIM SHARED WPS(35), PWS(35), PWS(35), SPS(35)
91 COMMON SHARED P0, C0
92 COMMON SHARED SWR(35), MAS(9), MTR(9), MTR(9), MTR(9), MTR(9), MTR(9), MTR(9), MTR(9)
93 COMMON SHARED SWR(35), X1, NAM(4), TMR(9), MTR(9), MTR(9), MTR(9), MTR(9), MTR(9)
94 COMMON SHARED SEL(4), T(1), C(1), CA, RELF(), RF
```

C-1
COMMON SHARED GOH(), LOH(), TOH(), OOH(), ROH(), RI(), TSK(), PSH()
COMMON SHARED VO(), SMAS$, FMAS$, FMA(), FMS$, SMAs$, SMRR()
COMMON SHARED MW(), C(), CM(), OPS(), TG(), PWTS()
COMMON SHARED FMA(), PFA(), PAA(), W(), NRU(), TRU()
COMMON SHARED NRD(), K(), R1(), R2(), R3(), R4(), R5()
COMMON SHARED PWT1(), PWT2(), PWT3(), PWT4(), SR5()
COMMON SHARED FMS$, ETMBA$, ETMRS$, ETATR$, ETTR$, ET Crew()
COMMON SHARED SMAS$, SRMBA$, SRMBR$, SRMR$, SRBR$, SRBCR$()
ERRORSUB: 'ERROR HANDLING ROUTINE'
IF ERR = 53 OR ERR = 61 OR ERR = 71 THEN
IF ERR = 53 THEN PRINT "FILE NOT FOUND"; RET
IF ERR = 61 THEN PRINT "DISK FULL"; RET
IF ERR = 71 THEN PRINT "DISK NOT READY"; RET
RESUME MAIN 'MAIN MENU'
ELSE PRINT "UNRECOVERABLE ERROR"
ON ERROR GOTO ERRSUB
END

ON ERROR GOTO ERRSUB
83 GOSUB 1000 'OPENING BANNER
90 CALL INT 'INITIALIZE
92 CALL MSN 'INITIALIZE MSN PROFILES
93 CALL PCTWG 'INITIALIZE SUBSYS WEIGHTS
95 GOSUB 2000 'CLEAN-UP ADJUST SHUTTLE MTBM
97 CLS; COLOR 12; LOCATE 10, 20;
PRINT "VEHICLE RELIABILITY/MAINTAINABILITY MODEL"
PRINT: PRINT: PRINT 1020); "NASA - LANGLEY RESEARCH CENTER"
PRINT: PRINT: PRINT 1040); "ENTER VEHICLE/FILE NAME";
VNAM$ = ""; IF VNAM$ = "" THEN PRINT *INVALID NAME";
GOTO 1040
10,45 RETURN
2900 'CLEAN-UP DURING INITIALIZATION
2905 FOR I = 19 TO 24: WAV = WAV + W(I): NEXT I
2910 Y = SMA(1); TW = W(1) / (W(1) + W(2) + W(3)); FR = (1 / Y) * TW: SMA(1) = 1 / FR
2915 TW = W(2) / (W(1) + W(2) + W(3)); FR = (1 / Y) * TW: SMA(2) = 1 / FR
2920 TW = W(3) / (W(1) + W(2) + W(3)); FR = (1 / Y) * TW: SMA(3) = 1 / FR
2925 Y = SMA(4); TW = W(4) / (W(4) + W(5)); FR = (1 / Y) * TW: SMA(4) = 1 / FR
2930 TW = W(5) / (W(4) + W(5)); FR = (1 / Y) * TW: SMA(5) = 1 / FR
2945 Y = SMA(32)
FOR I = 1 TO 33: PWT(I) = PWT(I); NEXT I ' reset weights from shuttle
2955 RETURN

10000 'INPUT DATA
10000 'WBS
10003 DATA 1.00 WING GROUP, 2.00 TAIL GROUP, 3.00 BODY GROUP
10003 DATA 1.30 TANKS-LOX, 1.20 TANKS-LH2, 1.40 IEP-TILES, 1.20 IEP-TCS
10008 DATA 4.30 IEP-PYD
10010 DATA 5.00 LANDING GEAR, 6.00 PROPULSION-MAIN, 7.00 PROPULSION-RCS
10030 DATA 8.00 PROPULSION-OMS, 9.10 POWER-APU, 9.20 POWER-BATTERY
10022 DATA 9.30 POWER-FUEL CELL, 10.00 ELECTRICAL

C-2
10030 DATA HYDRAULICS/PNEUMATICS, 12.00 AERO SURF ACTUATORS
10033 DATA AVIONICS-GENAC, 13.20 AV HEALTH MONITOR
10034 DATA AVIONICS-SADRD & TRACK, 13.40 AV DISPLAYS & CONTR
10035 DATA AVIONICS-INSTRUMENTS, 13.60 AVIONICS-DATA PROC
10040 DATA ENVIRONMENTAL CONTROL, 14.20 ECS-LIFE SUPPORT
10050 DATA PERSONNEL PROVISIONS, 16.10 REC & AUX-PARACHUTES
10055 DATA REC & AUX-ESCAPE SYS, 16.30 REC & AUX-Separation
10056 DATA REC & AUX-CROSS FEED
10057 DATA RFC & AUX DOCKING SYS
10150 PRIMARY/SECONDARY VARIABLES
10152 DATA DRY WGT (LB), LENGTH (Ft), CREW SIZE, NBR PASSENGERS
10153 DATA NBR MAIN ENGINES, ADJ SHUTTL MTBM-SPACE NO/YES, TECHNOLOGY YR
10155 DATA DEFAULT ABORT RATE, WIEBULL SHAPE PARAMETER
10160 DATA LAUNCH FACTOR, AVAIL MANHRS/BLNTH, FRACT. INDIRECT WORK
10170 DATA SPARE FILL RATE, OBJ, AVG CREW SIZE-SCHD MAINT, PLANNED MISSIONS/YEAR
10180 DATA MODE INDICATOR, VEHICLE INTEGRATION TIME (DAYS), LAUNCH PAD TIME (DAYS)
10190 DATA AGGREGATE AVIONICS NO/YES, DEFAULT FRACTION OFF MANHRS
10191 DATA NBR RCS ENGINES, NBR OMS ENGINES, GROWTH CURVE SLOPE, MSN NBR FOR REL GROWTH
10192 DATA AIR GND ABORTS / # ABORTS-I
10200 SECONDARY VARIABLES
11700 DATA FUSELAGE AREA, FUSELAGE VOLUME, WEIGHTED AREA
11710 DATA NBR WHEELS, NBR ACTUATORS, NBR CONTR SURFACES, KVA MAX
11720 DATA NBR HYD SUBSYS, NBR FUEL TANKS (INTERNAL)
11730 DATA TOT NBR AVIONICS SUBSYS
11740 DATA NBR DFF AVIONICS SUBSYS, BTU COOLING, NBR OXIDIZER TANKS
11750 TECH GROWTH RATES
11760 DATA 0.82, 0.82, 0.08, 0.01, 0.01, 0.01, 0.01, 0.01
11770 DATA 0.056, 0.056, 0.056, 0.056, 0.056, 0.056, 0.056, 0.056
11780 DATA 0.22, 0.22, 0.22, 0.22, 0.22, 0.22, 0.22, 0.22
11790 DATA 0.006, 0.006, 0.006, 0.006, 0.006, 0.006, 0.006, 0.006
11800 WGT DISTRIBUTION PERCENTAGES-LARGE VEHICLE
11810 DATA 0.08, 0.08, 0.08, 0.08, 0.08, 0.08, 0.08, 0.08
11820 DATA 0.03, 0.03, 0.03, 0.03, 0.03, 0.03, 0.03, 0.03
11830 DATA 0.01, 0.01, 0.01, 0.01, 0.01, 0.01, 0.01, 0.01
11840 DATA 0.001, 0.001, 0.001, 0.001, 0.001, 0.001, 0.001, 0.001
11850 DATA 0.017, 0.017, 0.017, 0.017, 0.017, 0.017, 0.017, 0.017
11860 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11870 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11880 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11890 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11900 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11910 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11920 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11930 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11940 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11950 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11960 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11970 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11980 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
11990 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
12000 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
12010 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
12020 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
12030 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
12040 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
12050 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007
12060 DATA 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007, 0.007

C-3
DATA STRUCTURES, 75.667, 001.1.4.5

SUB BOOSTER
6000 'ET/ BOOSTER ROCKET MODULE
6010 CLS ' COLOR ?
6020 PRINT TAB(20), "EXTERNAL FUEL TANK INPUT DATA"
6030 PRINT ' COLOR 11
6050 PRINT TAB(1), "NBR", TAB(5), "MTBM", TAB(18), "MTDM", TAB(26), "CRIT FAIL RT", TAB(30), "MTTR", TAB(50), "CREW" 'PRINT
FOR I = 1 TO 1
PRINT TAB(1), I, TAB(5), ETSUB$(I), TAB(18), ETMBA(I), TAB(26), ETHRS(I), TAB(30), ETABR(I), TAB(50), ETMTR(I), ETCREW(I)
NEXT I
COLOR 2
INPUT "ENTER NUMBER FOR CHANGE", NBR
IF NBR > 5 THEN GOTO 6010
IF NBR = 0 THEN GOTO COMP
INPUT "ENTER NEW PARAMETERS SEPARATED BY COMMAS", ETMBA(NBR), ETHRS(NBR), ETABR(NBR), ETMTR(NBR), ETCREW(NBR)
GOTO 6010
COMP: INPUT "ENTER SCHD MAINT AS A PCT OF UNSCH MAINT"; ETS
COLOR 7: ETRL = 1
PRINT TAB(20), "COMPUTED", TAB(40), "MISSION", TAB(35), "MANJR DRIVEN"
PRINT TAB(1), "SUBSYSTEM", TAB(18), "RELIABILITY", TAB(32), "UNSCH MANHRS", TAB(47), "SCH MANHRS", TAB(59), "MANPWR" 'PRINT COLOR 11: STE = 0, MTE = 0, TME = 0
FOR I = 1 TO 5
ETR(I) = EXP(-ETHRS(I) / (ETMBA(I) / ETABR(I)))
ETREL = ETRL * ETR(I)
A3 = (TE + ETS * TE) * (X(1) / (12 * X(11) * (1 - X(12))))
A3 = INT(A3 + 999)
TME = TME + A3
MTE = MTE + ETHRS(I)
STF = STE + TE
PRINT TAB(20), ETSUB$(I), TAB(20), ETR(I), TAB(32), TE, TAB(47), ETS * STE, TAB(61), A3
NEXT I
6036 PRINT: COLOR 12
6050 PRINT TAB(20), "OVERALL ET"; TAB(20), ETREL; TAB(32), STE; TAB(47), ETS * STE; TAB(61), TME
PRINT: COLOR 3: PRINT TAB(2); "new reliability - 1 to eliminate subsystem"
COLOR 2
6070 INPUT "ENTER NEW RELIABILITY OR RETURN TO USE COMPUTED", NBR
6080 IF NBR > 0 THEN ETREL = NBR
BAK: CLS: COLOR 7
PRINT TAB(20), "LIQUID ROCKET BOOSTER INPUT DATA"
COLOR 11
PRINT TAB(1), "NBR", TAB(5), "SUBSYSTEM", TAB(18), "MTBM", TAB(26), "OPFR HRS", TAB(30), "CRIT FAIL RT", TAB(50), "MTTR", TAB(59), "CREW" 'PRINT
FOR I = 1 TO 4
PRINT TAB(1), I, TAB(5), SRBSUB$(I), TAB(18), SRBMB(A(I), TAB(26), SRBRHS(I), TAB(30), SSBABR(I), TAB(50), SSBMTR(I), TAB(59), SRBCREW(I)
NEXT I
PRINT: COLOR 2
INPUT "ENTER NUMBER FOR CHANGE", NBR
IF NBR > 4 THEN GOTO BAK
IF NBR = 0 THEN GOTO COM2
INPUT "ENTER NEW PARAMETERS SEPARATED BY COMMAS", SRBMB(A(NBR), SRBRHS(NBR), SSBABR(NBR), SSBMTR(NBR), SRBCREW(NBR)
GOTO BAK
COM2: INPUT "ENTER SCHD MAINT AS A PCT OF UNSCH MAINT"; SRS
COLOR 7: SRSREL = 1: TMF = 0, MTF = 0: STF = 0
PRINT TAB(20), "COMPUTED", TAB(40), "MISSION", TAB(61), "MANJR DRIVEN"
PRINT TAB(1), "SUBSYSTEM", TAB(18), "RELIABILITY", TAB(32), "UNSCH MANHRS", TAB(47), "SCH MANHRS", TAB(61), "MANPWR" 'PRINT COLOR 11
FOR I = 1 TO 4
SRBR(I) = EXP(SRBRHS(I) / (SRBMB(A(I) / SSBABR(I)))
SRBREL = SRBREL * SRBR(I)
TF = (SRBRHS(I) / SRBMB(A(I) * SSBMTR(I) * SRBCREW(I)
A4 = (TF + TP * SRS) * (X(15) / (12 * X(11) * (1 - X(13))))
A4 = INT(A4 + 999)
TME = TME + A4
MTE = MTE + SRBRHS(I) / SRBMB(A(I)
STF = STF + TP
PRINT TAB(20), SRBSUB$(I), TAB(20), SRBR(I), TAB(32, TF, TAB(47), SRS + TP, TAB(61, A4
NEXT I
PRINT: COLOR 12
PRINT TAB(1), "OVERALL LRB", TAB(20), SRSREL, TAB(32), TF, TAB(47), SRS + TP, TAB(61), TMF
PRINT: COLOR 3: PRINT TAB(2), "note: new reliability = 1 to eliminate subsystem"
PRINT: COLOR 2
PRINT "ENTER NEW RELIABILITY OR RETURN TO USE COMPUTED", NBR
C-4
IF NBR > 0 THEN SRBREL = NBR

END SUB

SUB COMFAC
12500 'COMPUTATIONAL FACTORS MENU
12510 CLS COLOR 14
12520 PRINT TAB(15), "COMPUTATIONAL FACTORS MENU ", TAB(60), VNAMS
12530 PRINT
12540 PRINT TAB(15), "NBR", TAB(35), "SELECTION": PRINT
12550 PRINT TAB(15), "I", "TECHNOLOGY GROWTH FACTOR"
12560 PRINT TAB(15), "2", "CRITICAL FAILURE RATES"
12570 PRINT TAB(15), "3", "SUBSYSTEM REMOVAL RATES"
12580 PRINT TAB(15), "4", "MTBF/MTTR CALIBRATION"
12590 PRINT TAB(15), "5", "CREW SIZES"
12595 PRINT TAB(15), "6", "FRACTION OFF-EQUIP"
12600 PRINT TAB(15), "7", "FRACTION INHERENT FAILURES"
12605 PRINT TAB(15), "8", "RETURN TO INPUT MENU"

12600 LOCATE 22, 20: INPUT "ENTER SELECTION: NBR ": NBR
12610 IF NBR = 1 THEN GOSUB 124420
12620 IF NBR = 2 THEN GOSUB 12700
12630 IF NBR = 3 THEN GOSUB 12800
12640 IF NBR = 4 THEN GOSUB 12800
12650 IF NBR = 5 THEN GOSUB 13800
12660 IF NBR = 6 THEN GOSUB 13800
12670 IF NBR = 7 THEN GOSUB 13800
12680 IF NBR = 8 THEN EXIT SUB
12690 GOTO 12500

12400 'MENU TO DEFAULT ON TECHNOLOGY GROWTH FACTOR
12401 IO = 1: IE = 18
12402 COLOR 7
12403 CLS PRINT TAB(25), "ANNUAL TECHNOLOGY GROWTH FACTOR": PRINT
12404 PRINT TAB(3), "NBR SUBSYSTEM": TAB(45), "ANNUAL GROWTH RATE"
12405 FOR I = 1 TO IE
12406 IF OP$(I) = "DELETE" THEN GOSUB 12450
12407 IF SEL$(I) = "SHUFFLE" THEN COLOR 11 ELSE COLOR 14
12408 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); TG(I)
12409 NEXT I
12410 COLOR 7
12411 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12412 IF NBR > 33 THEN GOTO 12405
12413 IF NBR = 0 THEN GOTO 12493
12414 INPUT "ENTER NEW FACTOR": TG(NBR)
12415 GOTO 12405
12416 IF NBR = 0 THEN GOTO 12493
12417 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12403
12418 RETURN

12700 'CRITICAL FAILURE RATE DISPLAY/UPDATE
12701 IO = 1: IE = 18
12702 COLOR 7
12703 CLS PRINT TAB(35), "CRITICAL FAILURE RATE - fraction of total maintenance actions": PRINT
12704 PRINT TAB(29), "resulting in a mission abort"
12705 IF X(25) = 0 THEN PRINT TAB(3), "NBR SUBSYSTEM": TAB(35), "CRITICAL FAILURE RATE: ground & air shorts only"
12706 IF X(25) = 1 THEN PRINT TAB(3), "NBR SUBSYSTEM": TAB(35), "CRITICAL FAILURE RATE: air shorts only"
12707 FOR I = 1 TO IE
12708 IF OP$(I) = "DELETE" THEN GOSUB 12750
12709 IF SEL$(I) = "SHUFFLE" THEN COLOR 12 ELSE COLOR 11
12710 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); PA$(I)
12711 NEXT I
12712 COLOR 7
12713 PRINT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12714 IF NBR > 33 THEN GOTO 12705
12715 IF NBR = 0 THEN GOTO 12793
12716 INPUT "ENTER NEW FACTOR": PA(NBR)
12717 COLOR 1"DO NOT RECOMPUTE"
12718 GOTO 12705
12719 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12703
12720 RETURN

12800 'REMOVAL RATE DISPLAY/UPDATE
12801 IO = 1: IE = 18
12802 COLOR 7
12803 CLS PRINT TAB(35), "REMOVAL RATE - probability of a removal per maintenance action": PRINT
12804 PRINT TAB(35), "NBR SUBSYSTEM": TAB(45), "REMOVAL RATE"
12830 FOR I = IO TO IF.
12835 IF OP$(I) = "DELETE" THEN GOTO 12850
  IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
12840 PRINT TAB(I); I; TAB(10); WBS$(I); TAB(45); RR(I)
12850 NEXT I
COLOR 7
12860 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12865 IF NBR > 33 THEN GOTO 12805
12870 IF NBR = 0 THEN GOTO 12893
12880 INPUT "ENTER NEW RATE": RR(NBR)
  CP$(2) = "DO NOT RECOMPUTE"
12890 GOTO 12805
12893 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12803
12897 RETURN
PC'T'OFF: PERCENT OFF EQUIPMENT DISPLAY/UPDATE
IO = 1: IE = 18
COLOR 7
BACK: CLS
PRINT TAB(5); "FRACTION OFF EQUIP - fraction of total maintenance hours"
PRINT TAB(5); "performed off the vehicle - does not impact vehicle runtime"
PRINT TAB(5); "SUBSYSTEM": TAB(45); "FRACTION OFF-EQUIP"
FOR I = IO TO IE
  IF OP$(I) = "DELETE" THEN GOTO SKIP1
  IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
  PRINT TAB(I); I; TAB(10); WBS$(I); TAB(45); PF(I)
SKIP1: NEXT I
COLOR 7
PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12865 IF NBR > 33 THEN GOTO 1205
12880 INPUT "ENTER NEW PERCENT": PF(NBR)
  CP$(4) = "DO NOT RECOMPUTE"
GOTO BACK1
SKIP2: IF IO = 1 THEN IO = 19: IE = 33: GOTO BACK1
RETURN
1200 'MODULE TO INPUT MOD FACTOR
1201 IO = 1: IE = 18
1205 CLS: COLOR 7: PRINT TAB(20); "SUBSYSTEM MTBM CALIBRATION FACTOR"
1206 PRINT TAB(20); "VEH-MTBM = CAL FAC x computed MTBM"
1210 PRINT TAB(3); "SUBSYSTEM": TAB(45); "CAL FACTOR"
1220 FOR I = IO TO IE
  IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
  IF OP$(I) = "DELETE" THEN GOTO 12250
12200 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); MW(I)
12210 NEXT I
COLOR 7
12220 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12255 IF NBR > 33 THEN GOTO 1205
12270 IF NBR = 0 THEN GOTO 12291
12280 INPUT "ENTER NEW FACTOR": MW(NBR)
12290 GOTO 1205
12295 IF IO = 1 THEN IO = 19: IF = 33: GOTO 12205
12300 'MODULE TO INPUT MOD FACTOR FOR MAINTENANCE
12301 IO = 1: IE = 18
12305 CLS: PRINT TAB(20); "SUBSYSTEM MH/MA CALIBRATION FACTOR"
12310 PRINT TAB(20); "CAL MH/MA = CAL FAC x computed MH/MA"
12315 PRINT TAB(3); "SUBSYSTEM": TAB(45); "CAL FACTOR"
12320 PRINT
12330 FOR I = IO TO IE
  IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
  IF OP$(I) = "DELETE" THEN GOTO 12250
123200 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); CM(I)
12325 NEXT I
COLOR 7
12330 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12350 IF NBR = 0 THEN GOTO 12293
12360 INPUT "ENTER NEW FACTOR": CM(NBR)
12370 GOTO 12205
12380 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12202
RETURN
13800 'DISPLAY/UPDATE SCREEN FOR CREW SIZES
13801 IO = 1: IE = 18
C-6
1380 COLOR 7
1380 CLS: PRINT TAB(20); "CREW SIZES & ASSIGNED CREWS": PRINT
COLOR 3: PRINT "note: nbr crew sizes assigned affects run time only"
13810 PRINT TAB(3); "NBR SUBSYSTEM", TAB(35); "AVG CREW SIZE", TAB(35); "NBR CREWS ASSIGNED"
13820 FOR I = 1 TO II
13835 IF GPR(I) = "DELETE" THEN GOTO 13850
13840 IF SFI(I,4) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
13850 PRINT TAB(3), I, TAB(10), WBS$(I), TAB(40), G(I), TAB(55), CA(I)
13860 NEXT I
COLOR 7
13860 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
13865 IF NBR > 33 THEN GOTO 13805
13870 IF NBR = 0 THEN GOTO 13893
13880 INPUT "ENTER NEW CREW SIZE & NBR CREWS ASSIGNED": (NBR), CA(NBR)
13885 IF CA(NBR) < I THEN CA(NBR) = 1
13890 IF CA(NBR) < 1 THEN CA(NBR) = 1
13895 COLOR I2 ELSE COLOR I1
13897 RETURN

INFAIL: *display/update fraction inherent failures
10 = 1: II = 18
COLOR 7
BACK2: CLS: PRINT TAB(3): "FRACTION INHERENT FAILURES - fraction of total maintenance actions"
PRINT TAB(5): "resulting from inherent equip failures, used to modify MTBM’s to obtain"
PRINT TAB(5): "mission versus ground processing failure rates"
PRINT TAB(3), "NBR SUBSYSTEM", TAB(45), "FRACTION INHERENT FAILURES"
FOR I = 10 TO II
IF OPS(I) = "DELETE" THEN GOTO SKIP3
IF SEL(I,1) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
PRINT TAB(3), I, TAB(10), WBS$(I), TAB(45), P(NBR)
SKIP3: NEXT I
COLOR 7
PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
IF NBR > 33 THEN GOTO INFAIL
IF NBR = 0 THEN GOTO SKIP4
INPUT "ENTER NEW FRACTION": P(NBR)
GOTO BACK2
SKIP4: IF II = 1 THEN IO = 19: IE = 33: GOTO 13805
RETURN

END SUB

SUB DRIVER
1900 'COMPUTATIONAL SEQUENCING MODULE
IF SKIP = 1 THEN GOTO 1941
TOP: CLS: COLOR 11: PRINT TAB(20): "COMPUTATION SELECTION MENU"
LOCATE 3, 1
PRINT TAB(25), "FACTOR", TAB(50), "OPTION"
PRINT TAB(15), "1: CRITICAL FAILURE RATES", TAB(50), CP$(1)
PRINT TAB(15), "2: REMOVAL RATES", TAB(50), CP$(2)
PRINT TAB(15), "3: CREW SIZES", TAB(50), CP$(3)
PRINT TAB(15), "4: PERCENT OFF-EQUIP", TAB(50), CP$(4)
PRINT TAB(15), "5: SCH MAINT PERCENT", TAB(50), CP$(5)
COLOR 12
PRINT TAB(15), "6: CANCEL REQUEST"
PRINT: COLOR 2
PRINT TAB(15), "RETURN.....PROCEED WITH COMPUTATION..."
PRINT
IF NBR = 6 THEN NBR = 0: EXIT SUB
COLOR 11: INPUT "ENTER NUMBER TO CHANGE": NBR
IF NBR > 5 OR NBR < 0 THEN GOTO TOP
IF NBR = 0 THEN GOTO 1940
IF CP$(NBR) = "RECOMPUTE" THEN CP$(NBR) = "DO NOT RECOMPUTE" ELSE CP$(NBR) = "RECOMPUTE"
GOTO TOP
1940 CLS: COLOR 12: LOCATE 12, 22: PRINT "COMPUTING R&M PARAMETERS...
1941 WAV = 0
1942 FOR I = 10 TO 24: WAV = WAV + W(I): NEXT I
1943 IF X(16) = 0 THEN CALL PCTWGT
1944 FOR I = 10 TO 24: WAV = WAV + W(I): NEXT I
1945 IF X(16) = 0 THEN CALL SECONDARY
1946 IF CP$(1) = "RECOMPUTE" THEN CALL CREW "COMPUTE CREW SIZES"
1950 CALL EQS "REGRESSION MTBM/MTDA, UNADJUSTED"
1955 IF CP$(4) = "RECOMPUTE" THEN CALL POFF "COMPUTE POFF"
1957 IF CP$(1) = "RECOMPUTE" THEN CALL ABORT "CRITICAL FAILURE RATE"
1593 IF CP$(2) = "RECOMPUTE" THEN CALL REMFQS!'REMOVAL RATEallee.
CALL TECH 'TECHNICAL ADJUSTMENT.
1596 CALL SPACE!'SPACE ADJUSTMENT
1595 CALL CRIT 'CRITICAL FAILURE PMA
CALL COMP 'CHECK FOR SPECIFIED RELIABILITIES
1597 CALL COMRF 'Determine reliability
1597 CALL REDUNF 'REDUNDANT RELIABILITY
1598 CALL MANPWR 'COMPUTE MANPOWER
CALL SIM 'Aggregate parameters for simulation.
END SUB

SUB BUFLE
1700 'MODULE TO READ FROM A FILE.
OPEN "TEMP".DAT FOR OUTPUT AS #2 'create temp file.
WRITE #2, X$(1), X$(2), X$(3)
CLOSE #2
1701 'CLS : COLOR 10
PRINT : PRINT
TAB(10); "RAM INPUT FILES": PRINT
FILES * DAT".
COLOR I
PRINT: INPUT "ENTER DATA WILL BE READ FROM " ; VNAM$ ; " DAT":
PRINT : INPUT "ENTER RETURN TO PROCEED OR A POSITIVE NBR TO ABORT" ; RET
IF RET > - 1 THEN EXIT SUB
1710 OPEN VNAM$,' "DAT" FOR INPUT AS #3
INPUT #3, DUM, SCHP, WING
1720 FOR I = -1 TO 33
1725 INPUT #3, WBS$(I), W(I), MW(I), CM(I), PWS$(I)
INPUT #3, C(I), PF(I), PA(I), RR(I), CA(I), RELF(I), RF(I)
1730 INPUT #3, POLH(I), LORH(I), TORH(I), OORH(I), ROH(I)
1731 INPUT #3, CP$(I), TG(I), NRD(I), X(I), SEL$(I), SMA(I), SMR(I)
1733 NEXT I
1740 FOR I = -1 TO 15
1745 INPUT #3, SNAM$(I), V(I)
1750 NEXT I
FOR I = 1 TO 25: INPUT #3, DMS$(I), NEXT I
X(21) = V(4); X(22) = V(15)
1755 FOR I = 0 TO 5
1760 INPUT #3, ETREL, STE, TIM, MTF
FOR I = 1 TO 5
1765 INPUT #3, ETSUB$(I), ETMB$(I), ETBR$(I), ETMR$(I), ETCM$(I)
NEXT I
1770 FOR I = 1 TO 4
1775 INPUT #3, SRBREL, STF, SRS, TMS, MTF
FOR I = 1 TO 4
1780 READ NAM$(I)
1785 NEXT I
FOR I = 1 TO 6: CP$(I) = "DO NOT RECOMPUTE": NEXT I
1790 FOR I = 1 TO 33
1795 INPUT #3
1800 CALL DRIVER:
1810 PRINT : PRINT "DO YOU WISH TO CHANGE VEHICLE/FILE NAME? - Y/N": ANS$
IF ANS$ = "Y" OR ANS$ = "y" THEN LOCATE 13, 10: INPUT "ENTER NEW NAME" ; VNAM$
END SUB

SUB INFLE
520 FOR I = 1 TO 33
525 MW(I) = 1: NRD(I) = 1: K(I) = 1
530 CM(I) = 1: W(I) = 1: CA(I) = 1
535 CP$(I) = "COMPUTE"
540 SELL$(I) = "AIRCRAFT"
560 PMAS$(I) = 1: RELF = 0
570 READ WBS$(I)
580 NEXT I
590 FOR I = 1 TO 33
595 FOR I = 1 TO 25
596 READ NAM$(I)
C-8
660 NEXT I
610 FOR I = 1 TO 33
620 READ T_(I)
NEXT I
'TECH GROWTH RATES
6.50 FOR I = 1 TO 33:
READ PW_I(I):
NEXT I
WGT DISTR PERCENTS-AMLS (LARGE)
633 FOR I = 1 TO 33:
READ PW'I2(I):
NEXT I
WGT DISTR PERCENTS-SORTI'LZ.
636 FOR I = 1 TO 33:
READ PW'T3(I):
NEXT I
WGT DISTR PERCENTS-PLSS (SMALL)
660 FOR I = 1 TO 33: READ SMA(I):
NEXT I
SHUTTLE MAINT ACTION MTBM
665 FOR I = 1 TO 33: READ SMR(I):
NEXT I
SHUFFLE REMOVAL RATES
810 X(1) = 0.001 'DEFAULT ABORT RATE
817 X(16) = 0 'INITIALIZE IN PRECONCEPTUAL MODE
819 X(17) = 0 'INTEGRATION TIME IN DAYS
820 T(0) = 2: T(1) = .14: T(2) = 71: T(3) = 72: T(4) = 10
YR = X(7): B = X(9): LF = X(10): X1 = X(1): X2 = X(2) + WING
END SUB
SUB INMENU
300 ' INPUT PARAMETER MENU ******
310 CLS: COLOR 14
320 PRINT TAB(15): "NASA LRC - RELIABILITY/MAINTAINABILITY MODEL": TAB(60), VNAME$.
330 PRINT: PRINT TAB(25), "INPUT PARAMETER MENU": PRINT
340 PRINT TAB(15), "NBR": PRINT(35), "SELECTION": PRINT
345 COLOR 3
350 PRINT TAB(15), "1 ADD/DELETE A SUBSYSTEM": PRIN
355 PRINT TAB(15), "2 SELECT SHUTTLE/ AIRCRAFT": PRINT
360 PRINT TAB(15), "3 UPDATE/DISPLAY PRIMARY SYSTEM PARAMETERS": PRINT
365 PRINT TAB(15), "4 UPDATE/DISPLAY SUBSYSTEM WEIGHTS": PRINT
370 PRINT TAB(15), "5 UPDATE/DISPLAY SECONDARY VARIABLES": PRINT
385 PRINT TAB(15), "6 COMPUTATIONAL FACTORS MENU": PRINT
390 PRINT TAB(15), "7 UPDATE/DISPLAY MISSION PROFILE": PRINT
395 PRINT TAB(15), "8 UPDATE/DISPLAY SYSTEM OPERATING HOURS": PRINT
400 PRINT TAB(15), "9 UPDATE/DISPLAY REDUNDANCY CONFIGURATION": PRINT
405 PRINT TAB(15), "10 UPDATE/DISPLAY LRD/ET RELIABILITY DATA": PRINT
1200 'MENU TO DELETE A SUBSYSTEM
1201 IO = 1; IE = 18
1202 OLS: PRINT TAB(20); "OPTION TO DELETE/RESTORE A SUBSYSTEM": PRINT
1203 PRINT TAB(3); "NBR SUBSYSTEM": TAB(45); "OPTION"
1204 PRINT
1205 FOR I = IO TO IE
1206 IF OP$(I) = "DELETE" THEN COLOR 4 ELSE COLOR 3
1207 PRINT TAB(3); I; TAB(IO); WBS$(I); TAB(45); OP$(I)
1208 NEXT I
1209 COLOR 7
1210 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED: 0 IF NONE": NBR
1211 IF NBR > 33 THEN GOTO 12305
1212 IF NBR < 0 THEN GOTO 12393
1213 IF OP$(NBR) = "COMPUTE" THEN OP$(NBR) = "DELETE": GOTO 12305
1214 IF OP$(NBR) = "DELETE" THEN OP$(NBR) = "COMPUTE"
1215 GOTO 12305
1216 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12305
1217 IF ANS$ = "Y" OR ANS$ = "y" THEN GOTO B0
1218 RETURN
B0: IO = 1: IE = 18
B1: OLS: PRINT TAB(20); "OPTION TO CHANGE SUBSYSTEM NAME": PRINT
1220 PRINT TAB(3); "NBR SUBSYSTEM": TAB(45); "SELECTION"
1221 PRINT
1222 FOR I = IO TO IE
1223 IF SEL$(I) = "AIRCRAFT" THEN COLOR 4 ELSE COLOR 3
1224 IF I = 6 OR I = 7 OR I = 8 OR I = 15 OR I = 31 OR I = 32 OR I = 33 THEN TNMS = "SHUTTLE ONLY": ELSE TNMS = SEL$(I)
1225 PRINT TAB(3); I; TAB(IO); WBS$(I); TAB(45); TNMS
1226 NEXT I
1227 COLOR 7
1228 PRINT: INPUT "ENTER NBR OF SUBSYSTEM FOR NAME CHANGE: 0 IF NONE": NBR
1229 IF NBR > 33 THEN GOTO B1
1230 IF NBR = 0 THEN GOTO B2
1231 INPUT "ENTER NEW WBS/NAME": WBS$(NBR)
1232 GOTO B1
B2: IF IO = 1 THEN IO = 19: IE = 33: GOTO B1
RETURN
14000 'SHUTTLE DATA MODULE
14005 IO = 1: IE = 18
14010 'MENU TO SELECT MTBM OPTION
14015 OLS: PRINT TAB(20); "OPTION TO SELECT AIRCRAFT VS SHUTTLE MTBM": PRINT
14020 PRINT TAB(3); "NBR SUBSYSTEM": TAB(45); "OPTION"
14025 FOR I = IO TO IE
14030 IF OP$(I) = "DELETE" THEN GOTO 14150
14035 IF SEL$(I) = "SHUTTLE" THEN COLOR 4 ELSE COLOR 3
14040 IF I = 6 OR I = 7 OR I = 8 OR I = 15 OR I = 31 OR I = 32 OR I = 33 THEN TNMS = "SHUTTLE ONLY": ELSE TNMS = SEL$(I)
14045 PRINT TAB(3); I; TAB(IO); WBS$(I); TAB(45); TNMS
14050 NEXT I
14055 COLOR 7
14060 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED: 0 IF NONE": NBR
14065 IF NBR > 33 THEN GOTO 14106
14070 IF NBR = 0 THEN GOTO 14192
14075 IF SEL$(NBR) = "AIRCRAFT": GOTO 14075
14085 IF SEL$(NBR) = "SHUTTLE": GOTO 14075
RETURN
I1000 COLOR 7:CLS:PRINT:PRINTTAB(5);"SECONDARY INDEPEND VARIABLES":PRINT
I1010 PRINTTAB(10);"NBR",TAB(20);"VARIABLE",TAB(45);"CURRENT VALUE"
I1020 PRINT:PRINT:COLOR7
I1030 IFV(8)>1THENV(8)=0
I1040 FORI=1TO13
I1050 PRINTTab(10):1:Tab(20);SNAME(1):Tab(45):V(I)
I1200 NEXTI
I1601 PRINT:COLOR7
I1105 IFX(I)<0Orex(1)=1THNINPUT"ENTER RETURN...",RET:GOTO1100
I1107 PRINT:INPUT"ENTER NBR OF VARIABLE TO BE CHANGED:0IF NONE":NBR
I1108 IFNBR>16THENGOTO1100
I1109 IFNBR<0OTHENINPUT"ENTER NEW VALUE",V(NBR)
IFNBR<>0THENPRINT"ENTER NEW VALUE",V(NBR)
I1110 RETURN
I1600 MODUFI TO ESTABLISH MISSION PROFILE
I1615 CLS:COLOR7:KEY OFF
I1620 NBR=0
I1635 LOCATE3,25PRINT"MISSION PROFILE"
I1640 LOCATE7,10PRINT"NBR";TAB(50);"TIMEINHOURS":COLOR11
I1650 LOCATE9,10PRINT"1";TAB(20);"GROUNDPOWERTIME";TAB(55);T(3)
I1665 LOCATE11,10PRINT"2";TAB(20);"PADTIME";TAB(55);T(6)
I1680 LOCATE13,15PRINT"3";TAB(20);"POWERED PHASE COMPLETION TIME";TAB(55);T(1)
I1695 LOCATE14,10PRINT"4";TAB(20);"ORBIT INSERTION TIME";TAB(55);T(2)
I1705 LOCATE16,10PRINT"5";TAB(20);"ORBIT COMPLETION TIME";TAB(55);T(3)
I1715 LOCATE17,10PRINT"6";TAB(20);"REENTRY TIME";TAB(55);T(4)
I1725 PRINT:PRINT:COLOR2
I1760 INPUT"ENTER NUMBER TO BE CHANGED:0IF NONE":NBR
I1765 IFNBR>16THENGOTO1615
IFNBR=1THENPRINT"ENTER NEW GROUND TIME";T(3);GOTO1615
I1790 IFNBR>1THENNBR=NBR-2:INPUT"ENTER NEW TIME";T(NBR):GOTO1615
I1791 PRINT"DO YOU WISH TO UPDATE SUBSYS OPERATING TIMES-Y/N";and
I1793 if"y"o"n"="y"THENCALLMSH
I1797 RETURN
I1300 DISPLAY SUBSYSTEM OPERATING TIMES
I1310 \(X \leq 1 = X\)
I1320 CLS:PRINT:COLOR7:PRINTTAB(5);"SUBSYSTEM OPERATING TIMES"
I1330 PON(9)=1:GOH(9)=0:LOH(9)=0:TOM(9)=0:OON(9)=0:ROM(9)=1
I1350 PRINTTab(1);"TOTAL MISSION TIME";TAB(30);T(4);"HRS";TAB(30);"MAX PAD TIME";TAB(30);"HRS"
I1360 PRINTTab(1);"NBR SUBSYSTEM";Tab(27);"GROUND PROCESS";Tab(29);"PAD";Tab(30);"BOOST";Tab(32);"RE ENTRY";Tab(32);"TIME";Tab(61);"ORBIT";Tab(60);"RE ENTRY";Tab(65);"TIME"
I1370 FORI=1TO10:TE
IFSELECT(I)="SHUTTLE"THENCOLOR12ELSECOLOR11
IFI<>9ANDSELECT(I)<>"SHUTTLE"THENCOLOR13
I1335 IF"Y"=0)="DELETE"THENGOTO1350
I1340 PRINTTab(1);I:Tab(5):WBS(0):Tab(32):PON(0):Tab(39):GOH(0):Tab(46):LOH(0):Tab(53):TOM(0):Tab(60):OON(0):Tab(67):ROM(0)
I1350 NEXTI
I1370 COLOR7
I1360 PRINT:PRINT"ENTER NBR OF SUBSYSTEM TO BE CHANGED:0IF NONE":NBR
I1365 IFNBR>33THENGOTO1301
I1370 IFNBR=0THENGOTO1383
I1380 INPUT"ENTER NEW VALUES SEPARATED BY COMMAS";D6,D5,D4,D3,D2,D1
I1380 IFD6="0"THENPON(NBR)=0ELSEDD=VAL(D6)
I1380 IFD5="0"THENGOH(NBR)=0ELSEDD=VAL(D5)
I1380 IFD4="0"THENLOH(NBR)=0ELSEDD=VAL(D4)
I1380 IFD3="0"THENSHUTTLETIME=0ELSEDD=VAL(D3)
I1380 IFD2="0"THENREENTRYTIME=0ELSEDD=VAL(D2)
I1380 IFD1="0"THENRUN(NBR)=0ELSEDD=VAL(D1)
I1381 IFD1>0THENLOH(NBR)=D1
I1382 IFD2>0THENSHUTTLE TIME=D2
I1383 IFD3>0THENREENTRY TIME=D3
I1384 IFD4>0THENREENTRY TIME=D4
I1385 IFD5>0THENREENTRY TIME=D5
I1386 IFD6>0THENPON(NBR)=D6
I1390 GOTO1303
I1393 IFI0=1THENI0=18:IE=33:GOTO1303
I1397 RETURN
I1300 "RELIABILITY MODULE WITH REDUNDANCY"

C-11
13100 IF I = 1 THEN 19: IE - 18
13105 CLS: PRINT TAB(25), "SUBSYSTEM REDUNDANCY": PRINT
13110 PRINT TAB(1), "NBR", TAB(3), "WS", TAB(40), "NBR REDUNDANT SUBSYS", TAB(65), "MIN NBR RQD"
13120 FOR I = 1 TO 33
13130 IF (I > -10 AND I < -15) OR (I > -19 AND I < -24) THEN COLOR 14
13140 13150 IF (I > -10 AND I < -15) OR (I > -19 AND I < -24) THEN PRINT TAB(I), I, TAB(40), WBS(I), NRD(I), TAB(65), K(I): GOTO 13090
13160 IF (I > -10 AND I < -15) OR (I > -19 AND I < -24) THEN PRINT TAB(I), I: TAB(40), WBS(I), NRD(I)
13170 GOTO 13090
13180 NEXT I
13190 COLOR 7
13200 IF I = 0 THEN PRINT "ENTER NBR OF SUBSYS TO BE CHANGED - 0 IF NONE": NBR
13210 IF I = 0 THEN GOTO 13173
13220 IF NBR < 10 OR NBR > 12 THEN INPUT "ENTER NBR REDUNDANT SUBSYSTEMS- ": NRD(NBR)
13230 IF NRD(NBR) > 0 AND (NBR - 10 OR NBR - 11) OR NBR < -12 THEN INPUT "ENTER MIN NBR TO OPERATE": K(NBR)
13240 IF NRD(NBR) > 0 AND NBR > 19 AND NBR < -24 THEN INPUT "ENTER MIN NBR TO OPERATE": K(NBR)
13250 GOTO 13090
13260 SUB T.C'CFILE
13270 IF IO - 1 THEN 13005
13280 GOTO 13005
13290 IF NRD(NBR) > 0 AND (NBR - 10 OR NBR - 11) OR NBR < -12 THEN INPUT "ENTER NBR REDUNDANT SUBSYSTEMS- ": NRD(NBR)
13300 IF NRD(NBR) > 0 AND (NBR - 10 OR NBR - 11) OR NBR < -12 THEN INPUT "ENTER MIN NBR TO OPERATE": K(NBR)
13310 IF NRD(NBR) > 0 AND NBR > 19 AND NBR < -24 THEN INPUT "ENTER MIN NBR TO OPERATE": K(NBR)
13320 GOTO 13090
13330 IF IO - 1 THEN 13090: IE - 33: GOTO 13090
13340 RETURN

UNSC: CLS: COLOR 14
13350 LOCATE 5, 20: PRINT "SCHEDULED MAINTENANCE - OPTIONAL INPUT"
13360 PRINT: PRINT: COLOR 11
13370 PRINT TAB(5), "SCHEDULED MAINTENANCE IS": 100 * SCHP, ": % OF UNSCHEDULED ON VEHICLE MAINTENANCE"
13380 PRINT: PRINT TAB(5), "THIS HAS RESULTED IN": SCHP * TOSH, "HOURS OF SCHEDULED MAINTENANCE PER MSN"
13390 LOCATE 15, 20: PRINT "DO YOU WISH TO CHANGE THIS PERCENT?": ANSI, COLOR 15
13400 IF ANSI = "Y" OR ANSI = "Y" THEN LOCATE 17, 20: PRINT "ENTER NEW PERCENT": SCHP ELSE GOTO 2698
13410 SCHP = SCHP / 100: CP$(5) = "DO NOT RECOMPUTE"
13420 PRINT: PRINT TAB(5), "NEW VALUE IS": SCHP * TOSH, "HOURS OF SCHEDULED MAINTENANCE"
13430 PRINT: PRINT: COLOR 2: PRINT "ENTER NEW RETURN..": RET
13440 2698 RETURN

END SUB

SUB LCCFILE
13500 "MODULE TO WRITE DATA TO A FILE FOR LCC MODEL: - "name".CST"
13510 OPEN "TENPI.CST" FOR OUTPUT AS #2: "create temp file"
13520 WRITE #2, X(1), X(2), X(3)
13530 CLOSE #2

9510 CLS: COLOR 11
13540 PRINT: PRINT TAB(10), "CURRENT INPUT FILES FOR COST MODEL": PRINT
13550 PRINT: PRINT: COLOR 10
13560 PRINT: PRINT TAB(10), "DATA WILL BE SAVED IN FILE ": VNAM$: "CST"
13570 IF NUM > 0 THEN EXIT SUB
13580 VEHICLE TURN TIME CALCULATIONS
13590 TT = 0: Ti = 0: Tmax = 0
13600 SUM = 0: CT = 0: SUMC = 0
13610 FOR I = 1 TO 33
13620 IF OP$(I) = "DELET": THEN GOTO NZ21
13630 CT = CT + 1
13640 SUMC = SUMC + C(I)
13650 IF SEL$(I) = "SHUTTLE": THEN TSKT(I) = SMR(I) ELSE TSKT(I) = (1 - FPF(I) * MHMA(I) / C(I))
13660 Ti = NRD(I) * (1 - Pi(I)) * POH(I) / FMA(I) + THRS(I) / FMA(S)(I) * TSKT(I) / C(A(I))
13670 IF Ti > Tmax THEN Tmax = Ti: JJ = 1
13680 TT = TT + Ti
13690 SUM = SUM + TSKT(I)
13700 NZ21: NEXT I
13710 SCHT = RH * SCH * TOSH / X(I4)
13720 GTT = TT + SCH: ATSK = SUM / CT
13730 IF Tmax < SCHT THEN Tmax = SCHT
13740 PRINT: PRINT TAB(35), "VEHICLE TURN TIMES": PRINT
13750 PRINT COLOR 14: PRINT: PRINT TAB(35), "MIN TURN TIME": TAB(55), "MAX TURN TIME"
13760 PRINT TAB(1), "ONE SHIFT/DAY MAINTENANCE": COLOR 15
13770 DYTT - (T0) + T(4) / 24 + Tmax / 8 + X(17) + X(18)
13780 MDYTT = (T0) + T(4) / 24 + TT / SCMT / 8 + X(17) + X(18)
13790 PRINT TAB(5), "TOT VEHICLE TURNAROUND TIME": TAB(35), DVTT, "DAYS": TAB(35): MDYTT
13800 PRINT COLOR 14: PRINT TAB(1), "TWO SHIFTS/DAY MAINTENANCE": COLOR 15
13810 DYTT = (T0) + T(4) / 24 + (Tmax) / 16 + X(17) + X(18)
13820 MDYTT = (T0) + T(4) / 24 + (TT + SCHT) / 16 + X(17) + X(18)
13830 PRINT TAB(5), "TOT VEHICLE TURNAROUND TIME": TAB(35), DVTT, "DAYS": TAB(35): MDYTT
13840 PRINT COLOR 14: PRINT TAB(1), "THREE SHIFTS/DAY MAINTENANCE": COLOR 15
13850 DVTT = (T0) + T(4) / 24 + (Tmax) / 24 + X(17) + X(18)
13860 MDYTT = (T0) + T(4) / 24 + (TT + SCHT) / 24 + X(17) + X(18)
13870 PRINT TAB(5), "TOT VEHICLE TURNAROUND TIME": TAB(35), DVTT, "DAYS": TAB(35): MDYTT
13880 PRINT
COLOR 14: PRINT TAB(1); "THREE SHIFTS/DAY MAINTENANCE." COLOR 15

DVT - (T(0) + T(3)) / 24 + TMAX / 24 + X(17) + X(18)
MVTT - (T(0) + T(4)) / 24 + (T + SCHT) / 24 + X(17) + X(18)

PRINT TAB(3); "TJT VEHICLE TURNAROUND TIME": TAB(35); DVT, "DAYS": TAB(35), MVTT
PRINT "ENTER VEHICLE TURNAROUND TIME FOR USE IN QPSC CUSTING MODEL": VTTIM

9530 OPEN VNAMS 1 "* CST" FOR OUTPUT AS #1
WRITE #1, VNAMS
9540 FOR I = 1 TO 33
ADT = POM(I) + QOM(I) + LORR(I) + TOWR(I) + QNR(I) + RQR(I)
IF C(I) > MP(I) AND MP(I) > 0 THEN XMP = C(I) ELSE XMP = MP(I)
9550 WRITE #1, W(I), S(I), XMP(I), ADI, CAI
9555 IL = 1
9560 NEXT I
9560 WRITE #1, SM, VTTIM, T(4), TNR
FOR I = 1 TO 13 WRITE #1, V(I): NEXT I
FOR I = 1 TO 25 WRITE #1, X(3): NEXT I
FOR I = 0 TO 5 WRITE #1, T(9): NEXT I
WRITE #1, AREM, TMA
WRITE #1, TME, TMS ET AND LBR MANPOWER
FOR I = 1 TO 9 WRITE #1, C(2), SC(1): NEXT I
'nbr crews ago & avg crew size
9565 PRINT; PRINT TAB(10); "DATA WRITTEN TO": VNAMS, "CST"
9570 CLOSE #1
9580 LOCATE 24, 10: INPUT "ENTER RETURN.....": RET

END SUB

SUB MAIN
100 "MAIN MENU"
110 CLS: COLOR 10
120 PRINT TAB(15); "NASA LRC - RELIABILITY/MAINTAINABILITY MODEL."
130 PRINT TAB(15); "MAIN MENU": PRINT
135 COLOR 11
140 PRINT TAB(15); "NBR", TAB(35); "SELECTION": PRINT
150 PRINT TAB(15); "1......READ INPUT FROM A FILE"
155 PRINT TAB(15); "2......INPUT PARAMETER MENU"
159 COLOR 12
160 PRINT TAB(15); "3......COMPUTE R & M PARAMETERS."
160 COLOR 11
160 PRINT TAB(15); "4......SCREEN DISPLAY (OUTPUT) MENU"
170 PRINT TAB(15); "5......SAVE INPUT PARAMETERS"
172 PRINT TAB(15); "6......SAVE DATA FOR COST MODEL."
PRINT TAB(15); "7......CHANGE VEHICLE/FILE NAME"
PRINT TAB(15); "8......PRINT OUTPUT REPORT(S)"
175 PRINT TAB(15); "9......TERMINATE SESSION"
177 LOCATE 20, 10: COLOR 13: PRINT "VEHICLE/FILE NAME IS": VNAMS
180 COLOR 10: LOCATE 17, 20: INPUT "ENTER SELECTION": NBO
190 IF NBO = 1 THEN CALL .INI
200 IF NBO = 2 THEN CALL INMENU
205 IF NBO = 3 THEN CALL DRIVER
210 IF NBO = 4 THEN CALL DISPLAY
215 IF NBO = 5 THEN CALL OUTFILE
220 IF NBO = 6 THEN CALL COSTFILE
225 IF NBO = 7 THEN GOSUB CHG
225 IF NBO = 8 THEN GOSUB REPORT
225 IF NBO = 9 THEN GOTO DONE
230 GOTO 110

CHG: CLS: COLOR 10
OPEN "TEMP.DAT" FOR OUTPUT AS #2 "CREATE TEMP FILE"
WRITE #2, X(1), X(2), X(3)
CLOSE #2
PRINT; PRINT TAB(10); "CURRENT RAM INPUT FILES": PRINT
FILES "* DAT"
COLOR 11: LOCATE 18, 12: PRINT "CURRENT NAME IS": VNAMS
RT: COLOR 14: LOCATE 20, 12: INPUT "ENTER NEW NAME": VNAMS
IF VNAMS = "TEMP" THEN PRINT "INVALID NAME": GOTO RT
GOTO 110

DONE: CLS: COLOR 3
LOCATE 12, 20: INPUT "DO YOU WISH TO SAVE INPUT PARAMETERS? Y/N": ANSI
IF ANSI = "Y" OR ANSI = "N" THEN GOSUB OUTFILE
PRINT; COLOR 14: CLS; LOCATE 12, 28: PRINT "SESSION TERMINATED."

C-13
SUB MSN
900 "INITIALIZE SUBSYSTEM MSN PROFILES"
910 FOR I = 1 TO 33
920 POH(I) = T(2) - T(1); TOH(I) = T(2) - T(1); OOH(I) = T(3) - T(2); ROH(I) = T(4) - T(3); POR(I) = T(5)
921 NEXT I
922 DOH(I) = 0; ROH(I) = 0; POH(I) = T(0); TOH(I) = T(0); OOH(I) = T(0); ROH(I) = T(0)
END SUB

SUB OUTFILE
960 'MODULE TO WRITE INPUT DATA TO A FILE
OPEN "TEMP.DAT" FOR OUTPUT AS #2 'create temp file
WRITE #2, X(1), X(2), X(3)
OPEN VNAM$ "DAT" FOR OUTPUT AS #2
WRITE #2, DUM, SCHP, WING
FOR I = 1 TO 33
WRITE #2, WBS$(I), W(I), MW(I), CM(1), PWTS(I), C(I), PF(I), PA(I), RR(I), CA(I), RELF(I), RE(I)
WRITE #2, POH(I), GOH(I), LOH(I), TOH(I), OOH(I), ROH(I)
WRITE #2, DUM, SCHP, WING
FOR I = 1 TO 5
WRITE #2, T(I)
NEXT I
WRITE #2, ETREL, STE, ETS, TME, MTE
FOR I = 1 TO 5
WRITE #2, ETSUB$(I), ETMBA(I), ETHRS(I), ETABR(I), ETMTR(I), ETCREW(I)
NEXT I
WRITE #2, SRBSUB$(I), SRBMBA(I), SRBHRS(I), SRBABR(I), SRBMTR(I), SRBCREW(I)
NEXT I
WRITE #2, V(14), X(21), X(22)
FOR I = 1 TO 15
WRITE #2, SNAM$(I), V(I)
NEXT I
FOR I = 1 TO 25: WRITE #2, NAM$(I), X(I): NEXT I
FOR I = 0 TO 5
WRITE #2, T(I)
NEXT I
WRITE #2, ETREL, STE, ETS, TME, MTE
FOR I = 1 TO 5
WRITE #2, ETSUB$(I), ETMBA(I), ETHRS(I), ETABR(I), ETMTR(I), ETCREW(I)
NEXT I
WRITE #2, SRBSUB$(I), SRBMBA(I), SRBHRS(I), SRBABR(I), SRBMTR(I), SRBCREW(I)
NEXT I
WRITE #2, V(14), X(21), X(22)
END SUB

SUB PCTWGT
1500 'MODULE TO COMPUTE SUBSYSTEM WEIGHTS FROM PERCENTS
1520 TSM = 0
1530 FOR I = 1 TO 33
1540 IF UPS(I) = "DELETE" AND PWTS(I) > 0 THEN OP$(I) = "COMPUTE"
1545 IF PWTS(I) = 0 THEN OP$(I) = "DELETE"
1550 TSM = TSM + PWTS(I)
1560 NEXT I
1570 SUM = 0
1580 IF X(19) = 0 THEN FOR I = 20 TO 24: OP$(I) = "DELETE"; SUM = SUM + PWTS(I); PWTS(I) = 0: NEXT I: PWTS(19) = PWTS(19) + SUM
1570 FOR I = 1 TO 33
1575 PWTS(I) = PWTS(I) / TSM
1580 W(I) = PWTS(I) * X(I)
1585 IF W(I) < 0 THEN W(I) = 1
1590 NEXT I
END SUB

SUB PRVAR
1049 'PRIMARY VARIABLE MENU
11 = 1: 12 = 11
1050 COLOR 11: CLS: PRINT TAB(25); "INPUT MODULE: PRIMARY & SYSTEM VARIABLES"
PRINT

C-14
TPREL:

END

SUB

END

BTI0: IF I = 1 THEN PRINT TAB(10); "SYSTEM PARAMETER VALUES";

COLOR 14

1070 FOR I = 1 TO 12

1075 IF I = 6 THEN COLOR 7: PRINT TAB(10); "SYSTEM PARAMETER VALUES";

COLOR 14

1080 PRINT TAB(15); I, TAB(20); NAME$(15); X(I)

COLOR 13

1095 IF I = 16 THEN PRINT TAB(20); "O-PRECONCEPTUAL"

1090 IF I = 16 THEN PRINT TAB(20); "1-WEIGHT DRIVEN"

1097 IF I = 16 THEN PRINT TAB(20); "2-WEIGHT & VARIABLE DRIVEN"

NEXT I

COLOR 7

1100 PRINT: INPUT "ENTER NBR OF VARIABLE TO BE CHANGED - 0 IF NONE"; NBR

IF NBR = 1 AND X(16) = 1 OR NBR = 1 AND X(16) = 2 THEN GOTO 1131

1110 IF NBR = 0 THEN GOTO 1131

1115 IF NBR > 25 OR NBR < 0 THEN GOTO 1050

IF NBR = 6 THEN X(16) = 1 * X(6): GOTO 1130

IF NBR = 19 THEN X(19) = 1 * X(19): GOTO 1130

IF NBR = 25 THEN X(25) = 1 * X(25): GOTO 1130

1120 IF NBR = 2 THEN PRINT "ENTER LENGTH" WING SPAN": X(2), WING ELSE INPUT "ENTER NEW VALUE"; X(NBR)

IF NBR = 14 AND X(14) < 1 THEN X(14) = 1

IF NBR = 5 THEN NRD(10) = X(5)

IF NBR = 21 THEN NRD(11) = X(21)

IF NBR = 22 THEN NRD(12) = X(22)

1130 CLS: GOTO 1050

1135 YR = X(7) * B - X(9): LF = X(10): X1 = X(11) + X(2) = WING

1140 IF X(16) = 0 THEN CALL PCTWT

1145 IF X(16) = 0 OR X(16) = 1 THEN CALL SECONDARY

IF X(19) = 1 THEN FOR I = 20 TO 24: OPR(I) = "DELETE" NEXT I

IF X(19) = 0 THEN WBS$(19) = "13.10 AVIONICS-GN&C" ELSE WBS$(19) = "13.XX AGGREGATED AVIONICS"

END SUB

SUB REL

'MODULE TO ESTABLISH SUBSYSTEM RELIABILITIES'

IO = 1: IE = 18

TPREL: CLS: COLOR 7: PRINT TAB(20); "ESTABLISH SUBSYSTEM RELIABILITY"

COLOR 3

PRINT TAB(10); "specify nonredundant subsystem reliability at the end of the mission."

PRINT TAB(10); "enter a zero reliability to have the system compute a value."

PRINT

PRINT TAB(3); "NBR SUBSYSTEM"; TAB(45); "RELIABILITY"

PRINT FOR I = IO TO IE

IF SEL(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11

IF OPR(I) = "DELETE" THEN GOTO NX9

IF RELF(I) = 0 THEN PRINT TAB(3); I, TAB(10); WBS$(I); TAB(45); "TO BE COMPUTED" ELSE PRINT TAB(3); I, TAB(10); WBS$(I); TAB(45); RF(I)

NX9: NEXT I

COLOR 7

PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR

IF NBR > 33 THEN GOTO TPREL

IF NBR = 0 THEN GOTO BT10

INPUT "ENTER DESIRED RELIABILITY"; RF(NBR)

IF RF(NBR) = 1 THEN RF(NBR) = 1

IF RF(NBR) = 0 THEN RELF(NBR) = 0 ELSE RELF(NBR) = 1

GOTO TPREL

BT10: IF IO = 1 THEN IO = 19: IE = 33: GOTO TPREL

END SUB

SUB SHUTTLE

1800 'UPDATE/DISPLAY SHUTTLE PARAMETERS'

1801 IO = 1: IE = 18

1805 COLOR 7: CLS: PRINT TAB(20); "SHUTTLE MTBM (HRS/MAINT ACTION) VALUES"

PRINT TAB(5); "Note: all MTBM's should be for a single subsystem."

1810 PRINT TAB(3); "NBR SUBSYSTEM"; TAB(45); "MTBM"

1820 FOR I = IO TO IE

1825 IF OPR(I) = "DELETE" THEN GOTO 1825

1830 IF SEL(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11

IF I = 9 THEN PRINT TAB(3); I, TAB(10); WBS$(I); TAB(45); SMA$(I); "MSN/FAILURE"

IF I = 10 OR I = 11 OR I = 12 THEN PRINT TAB(3); I, TAB(10); WBS$(I); TAB(45); SMA$(I); "(single engine)"
1830 IF I < 9 OR I > 12 THEN PRINT TAB(3), I, TAB(10), WB$(I), TAB(45), SMA(I)
1835 NEXT I
1840 COLOR 12: PRINT "NOTE: indicates shuttle value currently in use": COLOR 7
1843 INPUT "ENTER SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
1845 IF NBR > 13 THEN GOTO 1805
1850 IF NBR = 0 THEN GOTO 1805
1855 INPUT "ENTER NEW MTTR": SMA(NBR)
1860 GOTO 1805
1865 IF IO - 1 THEN IO = 19: IF = 33: GOTO 1805
1870 UPDATE/DISPLAY SHUTTLE PARAMETERS - MTTR
1871 IF I = 1 TO IF:
1872 IF OP$(I) = "DELETE" THEN GOTO 2635
1873 IF SM$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 1
1874 PRINT TAB(3), I; TAB(10); WBS$(I); TAB(45); SMA(I)
1875 NEXT I
1876 COLOR 12: PRINT "NOTE: indicates shuttle value currently in use": COLOR 7
1877 INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
1880 IF NBR > 33 THEN GOTO 2605
1885 IF NBR = 0 THEN GOTO 2605
1890 INPUT "ENTER NEW MTTR": SMA(NBR)
1895 GOTO 2605
1896 IF IO = 1 THEN IO = 19: IF = 33: GOTO 2605
END SUB

SUB WEIGHT
1400 ' SUBSYSTEM WEIGHT DISPLAY
1401 IF X(16) = 0 THEN GOSUB 14200
1403 IO = 1: IE = 18
1405 WAV = 0: COLOR 7: CLS: PRINT TAB(20); "SUBSYSTEM WEIGHTS"
1410 PRINT TAB(3), "NBR SUBSYSTEM"; TAB(45); "WEIGHT IN LBS"
1412 ADD = 0: COLOR 11
1413 FOR I = 1 TO 33
1414 IF OP$(I) = "DELETE" THEN W(I) = I: GOTO 1416
1415 ADD = ADD + W(I)
1416 NEXT I
1417 X1 = ADD: W(1) = ADD
1420 COLOR 11:
1421 FOR I = 1 TO IF:
1422 IF OP$(I) = "DELETE" THEN GOTO 1450
1423 PRINT TAB(3); I; TAB(10); WBS$(1); TAB(45); W(I)
1424 NEXT I
1425 IF IO = 19 THEN COLOR 14: PRINT TAB(3); "TOTAL WGT"; TAB(45); ADD; PRINT COLOR 1
1426 IF X(16) = 0 THEN PRINT; INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
1427 IF NBR > 33 THEN GOTO 1405
1430 INPUT "ENTER NEW WEIGHT": W(NBR)
1435 GOTO 1405
1436 IF IO = 1 THEN IO = 19: IE = 33: GOTO 1405
1437 FOR I = 1 TO 33: WAV = WAV + W(I): NEXT I
1438 IF X(16) = 0 THEN CALL ACWGT
1439 IF WGTF = 4 THEN FOR I = 1 TO 33: PWTS(I) = PWTS(I): NEXT I
1440 IF WGTF = 2 THEN FOR I = 1 TO 33: PWTS(I) = PWTS(I): NEXT I
1441 IF WGTF = 1 THEN FOR I = 1 TO 33: PWTS(I) = PWTS(I): PWTS(I) = PWTS(I): NEXT I
1442 IF WGTF = 3 THEN CALL ACWGT
1443 IF X(16) = 1 OR X(16) = 2 THEN PRINT "CHANGE WEIGHT FACTOR-(Y/N)": ANS$ = "Y" OR ANS$ = "y" THEN PRINT "ENTER NEW FACTOR": WF: PWF = WF * PWF * WF: GOTO 1403
1445 EXIT SUB
1450 ' UPDATE DISPLAY WEIGHT PERCENTS
1452 GOSUB 14300
1453 IF WGTF = 1 THEN FOR I = 1 TO 33: PWTS(I) = PWTS(I): NEXT I
1454 IF WGTF = 2 THEN FOR I = 1 TO 33: PWTS(I) = PWTS(I): NEXT I
1455 IF WGTF = 3 THEN FOR I = 1 TO 33: PWTS(I) = PWTS(I): NEXT I
1456 IF WGTF = 4 THEN CALL ACWGT
1457 IF WGTF = 3 THEN FOR I = 1 TO 33: PWTS(I) = PWTS(I): NEXT I
1458 FOR I = 1 TO 33: WAV = WAV + W(I): NEXT I
1459 IF X(16) = 0 THEN CALL SECONDARY
1460 ANS$ = "N"
1461 IF X(16) = 1 OR X(16) = 2 THEN PRINT "CHANGE WEIGHT FACTOR-(Y/N)": ANS$ = "Y" OR ANS$ = "y" THEN PRINT "ENTER NEW FACTOR": WF: PWF = WF * PWF * WF: GOTO 1403
1462 EXIT SUB
PRINT "PRECONCEPTUAL MODE ONLY": PRINT: COLOR 11
IF WGTF = 1 THEN PRINT TAB(40), "CURRENT DISTRIBUTION"
IF WGTF = 2 THEN PRINT TAB(40), "DISTR BASED ON LARGE VEHICLE WGT"
IF WGTF = 3 THEN PRINT TAB(40), "DISTR BASED ON SHUTTLE WEIGHTS"
IF WGTF = 4 THEN PRINT TAB(40), "DISTR BASED ON AIRCRAFT WGT"
PRINT TAB(3), "NBR SUBSYSTEM": TAB(45), "PCT OF TOT DRY WGT"
FOR I = 1 TO 33
TPC(I) = TPC(I) * PWTS(I)
NEXT I
FOR I = 10 TO 50
IF OPI(I) = "DELETE" THEN GOTO 14350
IF X(I) > 19 AND I < 33 THEN GOTO 14350
COLOR 3
TEMP = 1000 * PWTS(I): TEMP = TEMP / 10
PRINT TAB(3); I; TAB(5); WBS$(I); TAB(45); TEMP
NEXT I
IF I0 = 19 THEN PRINT TAB(40); "TOT": TPC(I) = TPC(I) / 10
COLOR 7
PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
IF NBR > 33 THEN GOTO 14205
IF NBR = 0 THEN GOTO 14205
INPUT "ENTER NEW PERCENT": PWTS(NBR)
PWTS(NBR) = PWTS(NBR) / 100: GOTO 14205
IF I0 = 19 AND TPC(I) < 99.9 THEN INPUT "PERCENTS MUST SUM TO 100": RET: GOTO 14300
IF I0 = 19 AND TPC(I) > 100.1 THEN INPUT "PERCENTS MUST SUM TO 100": RET: GOTO 14300
CALL PCTWGT
RETURN

File: RAM2.BAS display module

DECLARE SUB AGRT()
DECLARE SUB SIMTURN()
DECLARE SUB SUMMARY()
DECLARE SUB MANDISPLAY()
DECLARE SUB SPARE.DISPLAY()
DECLARE SUB TURNTIME()
DECLARE SUB MAINTDIS()
DECLARE SUB RELDisplay()

'NASA, Langley Research Center
'MBTM Computational Model - NASA Research Grant -
'Developed by C. Ebeling, Univ of Dayton 6/17/94 (updated)
'........ COMBINED PRE/CONCEPTUAL MODEL .........
'SAVE AS "RAM2.BAS"  Mean Time Between Maintenance -REVISED

COMMON SHARED YR, B, XI, X2, LF, VR1, VR2, VR3, VR4, VR5, VR, AREM
COMMON SHARED VPMA, TVFMA, SVFMA, CFMA, OPMMA, OPBMI, TMA, AMHMA
COMMON SHARED SCIP, YMS, TOMH, TFH, APP, P1, P2, P3, WAV, F142, F144
COMMON SHARED FMA11, FMA12, VNA, ARR, TNR, TS, SKIP
COMMON SHARED SMP, VMH, WGT, WING, WFF, FFF
COMMON SHARED STREL, SREL, ETS, SRR1, RITLE, ARLT
COMMON SHARED STP, STE, MTE, TME, STF, MTF, MTF, C1
DIM SHARED WBS$(35), X(50), NAMS$(50), TIRS$(35), MMMA$(35), MDH(35), MP(35), OMH(35), FMH(35)
DIM SHARED NAM$(35), TIR$(35), CA(35), REP$(35), RP$(35)
DIM SHARED V$(15), SNAMS$(15), FMAT$(35), FCAM$(35), FMAS$(35), SM(35), SMA(35), SMR(35)
IF Y < END IF
ELSE
IF (MAS(8) * MTROS(8) < 0) THEN EXIT
PRINT
"Total", "Vehicles Maintenance:"
COLOR 7
PRINT TAB(25); "Simulated system:
COLOR 15
PRINT TAB(2); "Mission:"
PRINT TAB(2); "Launch Pad:"
PRINT TAB(2); "3 SHIFTS/DAY MAINTENANCE:"
PRINT TAB(3); "TOTE
PRINT TAB(3); "AVG MISSIONS/YR/VEHICLE:"
PRINT TAB(50); "TAR(55):"
PRINT TAB(50); "DRT:"
COLOR 1
PRINT TAB(5); "TOTAL
PRINT TAB(5); "SHIFTS/DAY maINTENANCE:"
PRINT TAB(7); "TOTAL
PRINT TAB(7); "UNKED/SCHED MAINT TIME:"
PRINT TAB(10); "7
PRINT TAB(10); "LAUNCH PAD
PRINT TAB(10); "ENTER SELECTION:"
PRINT TAB(10); "NB3
RETURN..."
END
RETURN...
SUB MAINTDIS

7500 'DISPLAY MODULE FOR MAINTAINABILITY REPORT
X = 0: Y = 0: Z = 0: K = 0 'AVIONICS ROLLUP
FOR I = 1 TO 24
IF OP3(I) = 'DELETE' THEN GOTO NX5
K = K + 1
X = X + NRD(I) * ((1 + PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I))
Y = Y + MHMA(I)
Z = Z + NRD(I) * ((1 + PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) * MHMA(I)
NX5: NEXT I
YA = Y / K
7505 IF K = 1: IF = 18
7510 CLS: COLOR 14
7520 PRINT TAB(5), 'MAINTAINABILITY REPORT - at mission nbr., ', X(24): ' - page 1'
7530 IF IO = 1 THEN PRINT TAB(5), 'VEHICLE IS : ', VNAM$, TAB(35), 'DATE : ', DATES, TAB(60), 'TIME : ', TIMES$.
7540 COLOR 7
7550 PRINT TAB(5), 'WBS', TAB(30), 'MAINT ACTIONS/MSN', TAB(50), 'AVG MANHRS/MSN', TAB(65), 'AVG MANHRS/MSN'
7570 FOR I = 1 TO IO TO IE
7580 IF OP3(I) = 'DELETE' THEN GOTO 7592
7590 IF SFL(I) = 'SHUTTLE' THEN COLOR 12 FILSF COLOR 15
7590 PRINT TAB(1), 'WBS(I)', TAB(35), NRD(I) * ((1 + PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) + THRS(I) * (FMAS(I) * MHMA(I))
IF I = 24 THEN COLOR 14: PRINT TAB(5), 'AVIONICS ROLLUP', TAB(29), X, TAB(47), YA, 'AVG', TAB(63), Z
7592 NEXT I
7593 PRINT : COLOR 2
7594 IF IO = 1 THEN IO = 19: IF = 33: PRINT: INPUT 'ENTER RETURN ...';: RET: GOTO 7510
7595 COLOR 13
7600 PRINT TAB(5), 'TOTALS', TAB(35), TMA, TAB(47), AMRM$, 'AVG', TAB(65), VMH
7610 COLOR 2
7620 INPUT 'ENTER RETURN ...';: RET
7630 IO = 1: IF = 18
7640 CLS: COLOR 14
7650 PRINT TAB(5), 'MAINTAINABILITY REPORT - at mission nbr., ', X(24): ' - page 2'
X = 0: Y = 0: Z = 0: K = 0 'AVIONICS ROLLUP
FOR I = 1 TO 24
IF OP3(I) = 'DELETE' THEN GOTO NX6
K = K + 1
X = X + OMR(I)
Y = Y + FMH(I)
Z = Z + PI(I)
NX6: NEXT I
ZA = Z / K
7660 IF IO = 1 THEN PRINT TAB(1), 'VEHICLE IS : ', VNAM$, TAB(35), 'DATE : ', DATES, TAB(60), 'TIME : ', TIMES$.
7680 COLOR 7
7690 PRINT TAB(1), 'WBS', TAB(35), 'ON-VEH MH', TAB(47), 'OFF-VEH MH', TAB(60), 'FRACTION ON-VEH'
7710 FOR I = 1 TO IO TO IE
7720 IF OP3(I) = 'DELETE' THEN GOTO 7740
7730 IF SFL(I) = 'SHUTTLE' THEN COLOR 12 ELSE COLOR 15
7730 PRINT TAB(1), 'WBS(I)', TAB(35), OMR(I), TAB(50), FMH(I), TAB(65), 1: PI(I)
IF I = 24 THEN COLOR 14: PRINT TAB(5), 'AVIONICS ROLLUP', TAB(29), X, TAB(47), Y, TAB(62), ZA, 'AVG'
7740 NEXT I
7750 PRINT : COLOR 2
7752 IF IO = 1 THEN IO = 19: IF = 33: PRINT: INPUT 'ENTER RETURN ...';: RET: GOTO 7760
7760 COLOR 13
PRINT TAB(5), 'UNSCHEDULED', TAB(35), TOMH, TAB(50), TFMH, TAB(65), APF, 'AVG'
7770 PRINT TAB(5), 'SCHEDULED', TAB(35), 98 * SCHP * THRS(I) + THRS(I), TAB(50), 02 * SCHP * TOMH
7770 PRINT TAB(5), 'TOTAL', TAB(35), TOMH + 98 * SCHP * TOMH, TAB(50), TFMH + 02 * SCHP * TOMH
7780 COLOR 2
7790 INPUT 'ENTER RETURN ...';: RET
X = 0: Y = 0 'AVIONICS ROLLUP
FOR I = 19 TO 24
IF OP3(I) = 'DELETE' THEN GOTO NY8
X = X + NRD(I) * ((1 + PI(I)) * POH(I) / FMAT(I)
Y = Y + NRD(I) / THRS(I) / FMAS(I)
NY8: NEXT I
IO = 1: IF = 18
C-20
**MANPOWER DISPLAY**

X = 0: Y = 0: Z = 0: 'AVIIONS ROLLUP
FOR I = 19 TO 24
IF OPS(I) = 'DELETE' THEN GOTO NY9
X = X + MH(I)
Z = Z + MP(I)
NY9: NEXT I
Y = X(15) * X / 12
MT = 0
7803 IO = -1: IE = -18: ASPT = 0
7805 CLS: COLOR 14
7810 PRINT TAB(5); 'MANPOWER REPORT - at mission shr.'; X(24)
7870 PRINT TAB(5); 'MANPOWER REPORT - at mission shr.'; X(24)
7880 IF IF = 1 THEN PRINT TAB(1); 'SCHEDULED'; TAB(28); X; TAB(43); Y; TAB(51); X(14): COLOR 14
7840 PRINT TAB(5); 'MANPOWER DISPLAY
SUB
END SUB

SUB RELDISPLAY
9000: **** DISPLAY MODULE FOR RELIABILITY REPORT

X = 0: Y = 0: Z = 0: 'AVIIONS ROLLUP
FOR I = 19 TO 24
IF OPS(I) = 'DELETE' THEN GOTO NX1
IF REL(I) = 1 THEN GOTO NX1
X = X + 1: FMA(I)
Y = Y + 1: FMA(I)
Z = Z + 1: FMA(I)
NX1: NEXT I
IF X > 0 THEN XA = 1 / X
IF Y > 0 THEN YA = 1 / Y
IF Z > 0 THEN ZA = 1 / Z
MNFMA = 0
9005 IO = 1: IE = 18
9010 CLS : COLOR 14
9020 PRINT TAB(15); "RELIABILITY REPORT - at mission nbru ", X(24); " - page 2"; COLOR 9
9030 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS ", VNAMS(TAB(35)), "DATE "; DATE; TAB(60), "TIME "; TIMES
COLOR 4: PRINT "all MTBM's are for a subsystem"; COLOR 7
PRINT TAB(1); "(External MA)", TAB(45), "MISSION MTBM" PRINT TAB(2); "(inherent MA)", TAB(61), "AUTONOMY"
9040 FOR I = IO TO TG IF
9050 IF OP(S) = "DELETE" THEN GOTO 9092
MNEMA = MNEMA 1 + 1: PI(U) = FMAT(I)
9060 IF SEL(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 15
IF REL(F)(I) THEN COLOR 4
IF I < 9 THEN PRINT TAB(1), WSS(I), " MTBM ", TAB(48); FMAT(I); TAB(61); FMAS(I)
IF I < 9 THEN PRINT TAB(1), WSS(I), TAB(35), FMAT(I); TAB(48); FMAT(I); TAB(61); FMAS(I)
IF I = 24 THEN COLOR 14: PRINT TAB(5), "AVIONICS ROLLUP ", TAB(32), "XA ", TAB(45), "YA ", TAB(58), "ZA"
9092 NEXT I
COLOR 2
9094 IF IO = 1 THEN IO = 19: IF = 33: INPUT "ENTER RETURN ";: RET: CLS : GOTO 9010
9095 COLOR 13
9100 PRINT TAB(5), "VEHICLE IS ", TAB(35), TVFMA; TAB(48); 1 / MNEMA; TAB(61); SYFMA
9105 COLOR 2
9110 INPUT "ENTER RETURN ... ";: RET
9120 CLS
X - 0: Y = 0: Z = 1: K = 0: "AVIONICS ROLLUP"
FOR I = IO TO TG
IF OP(S) = "DELETE" THEN GOTO NX3
K = K + 1
X - X + PA(I)
Y = Y + 1 / FMAC(I): YA = 1 / Y
Z - Z * R(I)
NX2: NEXT I
IF K = 0 THEN K = 1
XA = X / K
9125 IO = 1: IF = 18
9130 CLS: COLOR 14
PRINT TAB(15), "RELIABILITY REPORT - at mission nbru ", X(24); " - page 2"; COLOR 9
IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS ", VNAMS(TAB(35)), "DATE "; DATE; TAB(60), "TIME "; TIMES
COLOR 4: PRINT "all MTBM's are for a subsystem"; COLOR 7
9170 PRINT TAB(1); "WSS ", TAB(28); "CRITICAL FAILURE ", TAB(48); "CRITICAL ", TAB(60); "SUBSYS NON-
IF X(25) = 0 THEN PRINT TAB(28), "RATE grd enr ", TAB(48), "MTBM ", TAB(60), "REDUNDANT MTBM" IF X(25) = 0 THEN PRINT TAB(28), "RATE enr ", TAB(48), "MTBM ", TAB(60), "REDUNDANT MTBM"
9190 FOR I = IO TO IE
9200 IF OP(S) = "DELETE" THEN GOTO 9220
9205 IF SEL(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 15
IF REL(F)(I) THEN COLOR 4
9210 PRINT TAB(1); WSS(I), TAB(35), PA(I), TAB(48); FMAC(I), TAB(65), R(I)
IF I = 24 THEN COLOR 14: PRINT TAB(5), "AVIONICS ROLLUP ", TAB(32), "XA ", TAB(45), "YA ", TAB(62), Z.
9220 NEXT I
COLOR 2
9235 IF IO = 1 THEN IO = 19: IF = 33: INPUT "ENTER RETURN ... ";: RET: CLS : GOTO 9130
9240 COLOR 13
9250 PRINT TAB(5), "VEHICLE IS ", TAB(48), CVFMA, TAB(65); VR
9260 COLOR 2
9270 INPUT "ENTER RETURN ... ";: RET
X = 1: Y = 1: Z = 1: "AVIONICS ROLLUP"
FOR I = IO TO TG
IF OP(S) = "DELETE" THEN GOTO NX3
X - X * RI(I)
Y = Y * R2(I)
Z - Z * R3(I)
NX3: NEXT I
9285 IO = 1: IE = 18
9300 CLS: COLOR 14
PRINT TAB(15); "RELIABILITY REPORT - at mission nbru ", X(24); " - page 3"; COLOR 9
IF IO = 1 THEN PRINT TAB(1), "VEHICLE IS ", VNAMS(TAB(35)), "DATE "; DATE; TAB(60), "TIME "; TIMES
COLOR 4: PRINT "reliability specified ", COLOR 3: PRINT "reliabilities based upon redundancy"; COLOR 7
9315 PRINT TAB(1); "WSS ", TAB(33), "LAUNCH ", TAB(45), "END OF ", TAB(60), "ORBIT"
9320 PRINT TAB(3); "TIME ", TAB(45), "POWER FT ", TAB(60), "INSERTION"
9330 FOR I = IO TO IE
9335 IF OP(S) = "DELETE" THEN GOTO 9345
9337 IF SEL(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 15
IF REL(F)(I) THEN COLOR 4
9340 PRINT TAB(1), WSS(I), TAB(33), R(I), TAB(45), R2(I), TAB(60), R3(I)
IF I = 24 THEN COLOR 14: PRINT TAB(5), "AVIONICS ROLLUP ", TAB(30), "X ", TAB(42), "Y ", TAB(57), Z
9345 NEXT I

C-22
IF IO = 1 THEN IO = 19: IF IE = 33: PRINT "ENTER RETURN...": RET: GOTO 9300
COLOR 3
9350 PRINT TAB(5), "VEHICLE IS "; TAB(33), VR1; TAB(45), VR2; TAB(60), VR3
9365 COLOR 2
9370 INPUT "ENTER RETURN...": RET: GOTO 9310

COLOR 13

PRINT TAB(5); "VEHICL.E IS "; VR1; TAB(35); "DATE "; DATES; TAB(60); "TIME "; TIMES
COLOR 4 PRINT "reliability specific ". COLOR 3: PRINT "relabilities based upon redundancy": COLOR 7

COLOR 9
PRINT TAB(5); "AVIONICS ROLLUP": TAB(42); X; TAB(57); Y
COLOR 14
PRINT TAB(5); "AVIONICS ROLLUP": TAB(25); XA; "AVG "; TAB(40); Y; TAB(56); Z; TAB(62); ZX; "AVG"
COLOR 14
PRINT TAB(5); "TOTALS": TAB(27); ARR; "AVG "; TAI_K43); TNR; TAB(55); "IS
PRINT TAB(5); "WGT AVG": TAB(27); AREM
COLOR 2: INPUT "ENTER RETURN...": RET
FIND SUB

SUB SPAREDISPLAY
8550 "DISPLAY SPARES RESULTS
X = 0: Y = 0: Z = 0: K = 0 "AVIONICS ROLLUP
FOR I = 19 TO 24
IF OP$(I) = "DELETE" THEN GOTO NX7
K = K + 1
X = X + RR(I)
Y = Y + NR(I)
Z = Z + S(I)
NX7: NEXT I
COLOR 2
8635 IF IO = 1 THEN IO = 19: IE = 33: INPUT "ENTER RETURN...": RET: GOTO 8510

COLOR 14
PRINT TAB(5); "SUBSYSTEM SPARES REPORT - at mission shr ": X(24)
8530 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAMS; TAB(35); "DATE "; DATES; TAB(60); "TIME "; TIMES
COLOR 3: PRINT TAB(5); "NOTE failures are assumed to be Poison
COLOR 7 PRINT TAB(32); "REMOVAL "; TAB(42); "MEAN DEMAND "; TAB(56); "SPARES "; TAB(65); "EFFECTIVE
PRINT TAB(32); "WBS "; TAB(32); "RATE/MA "; TAB(42); "PER MISSION "; TAB(56); "RQMT "; TAB(65); "FILL RATE
8570 FOR I = 1 TO IE
8580 IF OP$(I) = "DELETE" THEN GOTO 8600
IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 15
8590 PRINT TAB(1); WBS$(I); TAB(45); RR$(I); TAB(41); NR$(I); TAB(55); S(I); TAB(65); FR$(I)
8600 NEXT I
COLOR 2
8615 IF IO = 1 THEN IO = 19: IE = 33: INPUT "ENTER RETURN...": RET: GOTO 8510
8620 COLOR 13
8630 PRINT TAB(5); "TOTALS": TAB(27); ARR; "AVG "; TAB(43); "FILL RATE "; TAB(53), TS
PRINT TAB(5); "WGT AVG": TAB(27); AREM
8640 COLOR 2: INPUT "ENTER RETURN...": RET
FIND SUB

SUB SUMMARY
CLS : COLOR 10
PRINT TAB(5), "SYSTEM PERFORMANCE SUMMARY - at mission shr ": X(24)
PRINT TAB(1); "VEHICLE IS "; VNAMS; TAB(35); "DATE "; DATES; TAB(60); "TIME "; TIMES
COLOR 14: PRINT: PRINT TAB(5); "RELIABILITY REPORT"
PRINT
COLOR 7
PRINT TAB(1), "CATEGORY", TAB(33), "LAUNCH", TAB(45), "TND OF", TAB(60), "SRBREL"
PRINT TAB(33), "TIME", TAB(45), "POWER FLT", TAB(60), "INSERTION"
PRINT COLOR 12
PRINT TAB(3), "VEHICLE", TAB(33), VR1, TAB(45), VR2, TAB(60), VR3
IF SRBREL < 1 THEN PRINT TAB(5), "VEHICLE = [R1, TAB(33), SRBREL * VR1, TAB(45), SRBREL * VR2, TAB(60), SRBREL * VR3
IF ETREL < 1 THEN PRINT TAB(3), "VEHICLE = [R1; TAB(33), ETREL * SRBREL * VR1, TAB(45), ETREL * SRBREL * VR2, TAB(60), ETREL * SRBREL * VR3
PRINT COLOR 7
PRINT TAB(1), TAB(45), "REENTRY", TAB(60), "MISSION"
PRINT TAB(60), "COMPLETION" COLOR 12
PRINT TAB(3), "VEHICLE"; TAB(33), VR4, TAB(60), VR5
IF SRBREL < 1 THEN PRINT TAB(5), "VEHICLE = [R1, TAB(45), SRBREL * VR4, TAB(60), SRBREL * VR5
IF ETREL < 1 THEN PRINT TAB(3), "VEHICLE = [R1; TAB(45), ETREL * SRBREL * VR4, TAB(60), ETREL * SRBREL * VR5
PRINT
COLOR 2
IF MTE = 0 THEN MTE = 1
PRINT INPUT "ENTER RETURN.."; RET
CLS COLOR 10
PRINT TAB(15), "SYSTEM PERFORMANCE SUMMARY - at mission nbr.", X(24); "* page 2*
PRINT TAB(1), "VEHICLE IS"; VNAMS, TAB(33); "DATE"; dates, TAB(60); "TIME"; TIMES
PRINT COLOR 14 PRINT TAB(30), "MAINTAINABILITY REPORT"
COLOR 7 PRINT TAB(60), "UNSCHED"
PRINT TAB(1), "CATEGORY"; TAB(28), "MAINT ACTIONS/MSN"; TAB(48), "WT-AVG MANHR/MA"; TAB(60), "AVG MANHRS/MSN"
PRINT COLOR 12
PRINT TAB(5), "VEHICLE"; TAB(33), TMA, TAB(50), AMHA, TAB(65), VMH
IF ETREL < 1 THEN PRINT TAB(3), "EXTERNAL TANK"; TAB(32), MTE, TAB(50), STE / MTE, TAB(65), STE
IF SRBREL < 1 THEN PRINT TAB(3), "BOOSTER"; TAB(32), MTF, TAB(50), STE / MTN, TAB(65), STE
PRINT COLOR 7
PRINT TAB(32), "ON-VEH MH"; TAB(47), "OFF-VEH MH"; TAB(62), "FRACTION ON-VEH"
COLOR 12 PRINT TAB(5), "VEHICLE"
PRINT TAB(3), "UNSCHED"; TAB(22), TMHT, TAB(50), TMHT
PRINT TAB(3), "SCHEDULED"; TAB(32), 98 * SCHP * TMHT, TAB(50), 02 * SCHP * TMHT
PRINT TAB(3), "TOTALS"; TAB(32), TMHT + 98 * SCHP * TMHT, TAB(50), 02 * SCHP * TMHT
PRINT TAB(3), "FRACTIONS"; TAB(32), TMHT / 98 * SCHP * TMHT, TAB(50), 02 / SCHP * TMHT, TAB(65), APP; "AVG"
PRINT TAB(3), "FRACTION ON-VEH"
COLOR 12 PRINT INPUT "ENTER RETURN.."; RET
CLS COLOR 10
SCMP = X(4); B1 = 0; B4 = 0; A4 = 0; A1 = 0; A4 = 0
PRINT TAB(15), "SYSTEM PERFORMANCE SUMMARY - at mission nbr.", X(24); "* page 3"
PRINT TAB(1), "VEHICLE IS"; VNAMS, TAB(33); "DATE"; dates, TAB(60); "TIME"; TIMES
PRINT COLOR 14 PRINT TAB(30), "MAINTAINABILITY REPORT"
PRINT COLOR 13 PRINT TAB(35), "SPARES-VEHICLE"; TAB(50), TS
PRINT COLOR 7
PRINT TAB(1), "CATEGORY"; TAB(25), "MANHR DRIVEN"; TAB(40), "MANHR DRIVEN"; TAB(55), "CREW SZ"; TAB(65), "TOT CREW"
PRINT TAB(25), "AGGREGATE"; TAB(40), "BY SUBSYS"; TAB(55), "BY SUBSYS"; TAB(65), "BY SUBSYS"
PRINT COLOR 12
PRINT TAB(3), "VEHICLE" A2 = VMH + X(3) / (12 * X(11) * (1 - X(12))) A2 = INT(A2 + 999)
B2 = (SCHP * TMHT * X(15)) / (12 * X(11) * (1 - X(12))) B2 = INT(B2 + 999)
IF ETREL < 1 THEN MTE = 0
PRINT TAB(3), "UNSCH MANPWR"; TAB(25), A2, TAB(40), TMP - SMP, TAB(55), STP, TAB(65), CI
PRINT TAB(3), "SCHED MANPWR"; TAB(25), B2, TAB(40), SMP, TAB(55), SCMP, TAB(65), SCMP
PRINT TAB(3), "TOTALS"; TAB(25), A2 + B2, TAB(40), TMP, TAB(55), STP + SCMP, TAB(65), CI + SCMP
B1 = ETCREW(1) + ETCREW(2) + ETCREW(3) + ETCREW(4) + ETCREW(5)
B1 = INT(B1 + 999)
IF ETREL < 1 THEN A1 = 0; B1 = 0
IF ETREL < 1 THEN PRINT TAB(3), "SCHED/UNSCH MANPWR"; TAB(25), A1, TAB(40), TMP; TAB(55), B1; TAB(65), B1
PRINT TAB(3), "LRB" A4 = (BSRS * STF + STF) * X(15) / (12 * X(11) * (1 - X(12))) A4 = INT(A4 + 999)
B4 = SRBCREW(1) + SRBCREW(2) + SRBCREW(3) + SRBCREW(4)
B4 = INT(B4 + 999)
IF ETREL < 1 THEN B1 = 0
IF SRBREL < 1 THEN B4 = 0; MTE = 0; A4 = 0
PRINT TAB(3), "SCHED/UNSCH MANPWR"; TAB(25); A4, TAB(40), TMP; TAB(55), B4, TAB(65), B4
PRINT PRINT TAB(3), "TOTALS"; TAB(25); A2 + B2 + A4, TAB(40), TMP + MTE + TMP; TAB(55), STP + SCMP + B1 + B4; TAB(65), CI + SCMP + B1 + C-24
COLOR 2
PRINT: INPUT "ENTER RETURN ": RET
CLS
VEHICLE TURN TIME SUMMARY
TT = 0: TI = 0: TMAX = 0
SUM = 0: CT = 0: SUMC = 0
FOR I = 1 TO 33
IF OP$ = "DELETE" THEN GOTO:N:
CT = CT + 1
SUMC = SUMC + C(I)
IF SEL$ = "SHUTTLE" THEN TSKT(I) = SMR(I) ELSE TSKT(I) = (1 - PF(I)) * MHMA(I) / CIU
T1 = (NRD(I) * (1 - PI(I)) * POU(I) / TMAT(I) + THRS(I)) / (TMAS(I) * TSKT(I) / CIU)
IF T1 > TMAX THEN TMAX = T1: JJ = I
TT = TT + T1
SUM = SUM + TSKT(I)
NEXT I
SCHT = 98 * SCHP * TOMH / X(I4)
GTT = TT + SCHT: ATSK = SUM / CT
IF TMAX < SCHT THEN TMAX = SCHT
PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE": TAB(35); PMT; "TOT VEHICLE TURNAROUND TIME": TAB(35); "COMPUTED FLEET SIZE ": TAB(35); INT(X(I5) / 12) / (21 / DVTT) + 99; TAB(35); INT(X(I5) / 12) / (21 / DVTT) + 99
PRINT
CSHR = PRINT TAB(5); "TWO SHIFTS/DAY MAINTENANCE": COLOR 15
DVTT = (T0D + T4D) / 24 + (TMAX / 16 / X(I7) + X(I8)
MDVTT = (T0D + T4D) / 24 + (TT + SCHT) / 16 / X(I7) + X(I8)
PRINT TAB(5); "TOT VEHICLE TURNAROUND TIME": TAB(35); DVTT; "DAYS": TAB(55); MDVTT
PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE": TAB(35); (12 * 21 / DVTT; TAB(55); (12 * 21 / MDVTT)
PRINT TAB(5); "COMPUTED FLEET SIZE ": TAB(35); INT(X(I5) / 12) / (21 / DVTT) + 99; TAB(35); INT(X(I5) / 12) / (21 / MDVTT) + 99
PRINT
COLOR 14: PRINT TAB(5); "THREE SHIFTS/DAY MAINTENANCE": COLOR 15
DVTT = (T0D + T4D) / 24 + (TMAX / 16 / X(I7) + X(I8)
MDVTT = (T0D + T4D) / 24 + (TT + SCHT) / 16 / X(I7) + X(I8)
PRINT TAB(5); "TOT VEHICLE TURNAROUND TIME": TAB(35); DVTT; "DAYS": TAB(55); MDVTT
PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE": TAB(35); (12 * 21 / DVTT; TAB(55); (12 * 21 / MDVTT)
PRINT TAB(5); "COMPUTED FLEET SIZE ": TAB(35); INT(X(I5) / 12) / (21 / DVTT) + 99; TAB(35); INT(X(I5) / 12) / (21 / MDVTT) + 99
PRINT
COLOR 2: INPUT "ENTER RETURN ": RET
END SUB
SUB TURN
9700 MODULE TO DISPLAY VEHICLE TURN TIME
9705 TT = 0: TI = 0: TMAX = 0
9706 SUM = 0: CT = 0: SUMC = 0
9710 FOR I = 1 TO 33
9715 IF OP$ = "DELETE" THEN GOTO 9735
9716 CT = CT + 1
9720 IF SEL$ = "SHUTTLE" THEN TSKT(I) = SMR(I) ELSE TSKT(I) = (1 - PF(I)) * MHMA(I) / CIU
9725 T1 = (NRD(I) * (1 - PI(I)) * POU(I) / TMAT(I) + THRS(I)) / (TMAS(I) * TSKT(I) / CIU)
9730 IF T1 > TMAX THEN TMAX = T1: JJ = I
9735 TT = TT + T1
9738 SUM = SUM + TSKT(I)
9739 NEXT I
AVCREW = SUMC / CT
9740 SCHT = 98 * SCHP * TOMH / X(I4)
9750 GTT = TT + SCHT: ATSK = SUM / CT
9800 DISPLAY VEHICLE TURN TIME
9801 W = 0: X = 0: Y = 0: Z = 0: K = 0: O'AVIONICS ROLLUP
9802 FOR I = 19 TO 24
9805 IF OP$ = "DELETE" THEN GOTO 9810
9810 K = K + 1
9815 X = X + 1
9820 Y = Y + TSKT(I)
9825 Z = Z + (NRD(I) * (1 - PI(I)) * POU(I) / TMAT(I) + THRS(I)) / (TMAS(I) * TSKT(I) / CIU)
9830 W = W + NRD(I) * (1 - PI(I)) * POU(I) / TMAT(I) + THRS(I) / FMA(I)
9835 NEXT I
9840 YA = Y / K
C-25
DECLARE SUB PRINTSPR 0
DECLARE SUB A.RE
DECLARE SUB
File: RAM3.BAS print module
END

SUB ECHO
' DEVEI.OPED
COMMON ' SAVE
COMMON ' M'I_M
MODULE TO PRINT
COMMON
DIM SHARED PI(33), ETSUB$(5), ETMBA(5), ETI_5), ETABR(5), ETMTR(5), ETR(5), ETCREW(5)
DIM SHARED MW(35), V(15), SNAM$(IS), NASA, LANGLEY RESEARCH CENTER
COMMON SHARED YR, B, X1, X2, LF, VR1, VR2, VR3, VR4, VR5, VR, AREM
COMMON SHARED VFMA, TFVMA, SYVMA, CVFMA, OHRMA, OPRMBMA, TMA, AMRMA
COMMON SHARED SCRP, VMH, TOMP, APP, P1, P2, P3, WPF, FMA2, FMA4
COMMON SHARED FMA11, FMA12, VNAME, ARR, TNR, TS, T2P
COMMON SHARED SMP, TMP, VMOH, WOTT, WING, WF, WPF
COMMON SHARED ETR, EBELING, UNI'
COMMENT'S:
PRINT TAB[5]; 'AVG MISSIONS/YR/VEHFTED' TAB(55); 'COMPUTED MISSION TIMES': TAB(52); 'TOGRAPHY REPORT GENERATOR'
COMMON SHARED STP, STE, TME, TSP, TWP, TFP, C1
DIM SHARED WBSK(35), X(50), NAME(35), TIRS(35), MDAK(35), MH(35), MP(35), OMRH(35), FMH(35)
DIM SHARED SFEL(35), T169, CP69, CA35, RFLF(35), RFLK(35)
DIM SHARED GKH(35), LOH(35), TGH(35), OKH(35), ROH(35), TSX(35), PQRH(35)
DIM SHARED W(2), SNAM(15), FMAK(25), FMAC25, FMAC25, FMAK(35), S(35), SMAR(35), SMLR(35)
DIM SHARED MS(35), C35, CMS(35), CPZ(35), TQR(35), PWR(35)
DIM SHARED MK(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
DIM SHARED NRR(35), K(35), R(35), R(35), R(35), R(35), R(35)
DIM SHARED PWT(35), PWT(35), PWT(35), PWT(35), PWT(35), PWT(35), PWT(35), PWT(35)
DIM SHARED ETSUB(35), ETMBA(35), ETR(35), ETMTR(35), ETR(35), ETCREW(35)
DIM SHARED SRB(35), SRB(35), SRB(35), SRB(35), SRB(35), SRB(35)
DIM SHARED SW(35), MAS(35), MTR(35), MTS(35), MTS(35), MTS(35), MTS(35), MTS(35)
DIM SHARED P(33), C2(2)
COMMON SHARED P(2), C2(2)
COMMON SHARED SWSS(35), MAS(2), MTR(2), MTS(2), MTS(2), MTS(2), MTS(2), MTS(2)
COMMON SHARED WBSB(35), X(50), NAME(35), TIR(35), MDAK(35), MH(35), MP(35), OMRH(35), FMH(35)
COMMON SHARED SFEL(35), T169, CP69, CA35, RFLF(35), RFLK(35)
COMMON SHARED GKH(35), LOH(35), TGH(35), OKH(35), ROH(35), TSX(35), PQRH(35)
COMMON SHARED W(2), SNAM(15), FMAK(25), FMAC25, FMAC25, FMAK(35), S(35), SMAR(35), SMLR(35)
COMMON SHARED MS(35), C35, CMS(35), CPZ(35), TQR(35), PWR(35)
COMMON SHARED MK(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
COMMON SHARED NRR(35), K(35), R(35), R(35), R(35), R(35), R(35)
COMMON SHARED PWT(35), PWT(35), PWT(35), PWT(35), PWT(35), PWT(35), PWT(35), PWT(35)
COMMON SHARED ETSUB(35), ETMBA(35), ETR(35), ETMTR(35), ETR(35), ETCREW(35)
COMMON SHARED SRB(35), SRB(35), SRB(35), SRB(35), SRB(35), SRB(35)

SUB ECHO
* MODULE TO PRINT INPUT DATA
1.PRINT TAB(5), RITTI5
1.PRINT TAB(5), COMMENTS 1.PRINT : LPRINT

C-27
IF OP$(I) = "DELETE" THEN GOTO EX7
LPRINT
IF SEL(I) ≠ "SHUT" THEN GOTO EX7
FOR I = 1 TO 33
LPRINT
WBS$(I), TAB(40), V(I)
NEXT I
LPRINT
CHRS(12),
LPRINT
TAB(25), "INPUT PARAMETERS & DATA - page 1" : LPRINT
LPRINT
TAB(1), "VEHICLE IS": VNAMS, TAB(25), "DATE": DATE$, TAB(60), "TIME": TIMES : LPRINT
LPRINT : LPRINT
LPRINT TAB(5), "SYSTEM PARAMETER VALUES": LPRINT
LPRINT TAB(10), "PARAMETER", TAB(50), "VALUE": LPRINT
FOR I = 1 TO 33
LPRINT TAB(10), NAM$(I), TAB(50), X(I)
IF I = 2 THEN LPRINT TAB(10), "WING SPAN", TAB(50), "WING"
NEXT I
LPRINT : LPRINT
LPRINT TAB(10), SNAMS(I), TAB(40), V(I)
NEXT I
LPRINT : LPRINT
LPRINT CHR$(12),
LPRINT
TAB(25), "INPUT PARAMETERS & DATA - page 2" : LPRINT
LPRINT
TAB(3), "SUBSYSTEM WEIGHTS & CALIBRATION FACTORS"
IF X(16) = 0 THEN LPRINT : LPRINT TAB(1), "WBS", TAB(30), "WEIGHT", TAB(40), "PCT WGT", TAB(65), "MTBM FACTOR", TAB(65), "MTTR FACTOR": GOTO EX2
LPRINT
LPRINT:
LPRINT TAB(1), "WBS", TAB(30), "WEIGHT", TAB(40), "MTBM FACTOR", TAB(55), "MTTR FACTOR"
ADD = 0
EX2: FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO XE1
ADD = ADD + W(I)
IF X(16) = 0 THEN LPRINT TAB(1), "WBS$(I), TAB(30), W(I), TAB(40), PWTS(I), TAB(52), MW(I), TAB(65), CM(I): GOTO XE1
LPRINT TAB(1), WBS$(I), TAB(30), W(I), TAB(40), MW(I), CM(I)
XE1: NEXT I
LPRINT : LPRINT TAB(1), "TOTAL WEIGHT", TAB(30), ADD, TAB(50), "WEIGHT FACTOR IS", PWF
LPRINT : LPRINT
LPRINT TAB(10), "SCHEDULED MAINTENANCE PERCENT IS", TAB(45), 100 * SCHP
LPRINT
LPRINT CHR$(12),
LPRINT
TAB(25), "INPUT PARAMETERS & DATA - page 3" : LPRINT
LPRINT : LPRINT
LPRINT
LPRINT
LPRINT TAB(1), "SUBSYSTEM", TAB(30), "PROCESS", TAB(39), "PAD", TAB(46), "BOOST", TAB(52), "RE TIME", TAB(61), "ORBIT", TAB(64), "REENTRY"
LPRINT TAB(32), "TIME", TAB(39), "TIME", TAB(40), "ORBIT", TAB(51), "TO ORBIT", TAB(51), "TIME", TAB(40), "TIME"
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX4
LPRINT
LPRINT TAB(1), WBS$(I), TAB(32), PWS$(I), TAB(39), GOH(I), TAB(46), LQM(I), TAB(53), TOH(I), TAB(60), OOH(I), TAB(67), ROH(I)
EX4: NEXT I
LPRINT : LPRINT
LPRINT CHR$(12),
LPRINT
TAB(25), "INPUT PARAMETERS & DATA - page 4" : LPRINT
LPRINT : LPRINT
LPRINT
LPRINT
LPRINT TAB(1), "SUBSYSTEM", TAB(28), "TECH GROWTH", TAB(40), "CRITICAL", TAB(53), "REMOVAL", TAB(70), "PERCENT"
LPRINT TAB(28), "FACTOR", TAB(40), "FAIL RATE", TAB(55), "RATE", TAB(70), "OFF EQIP": LPRINT
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX5
LPRINT
LPRINT TAB(1), WBS$(I), TAB(28), TOH(I), TAB(40), PWS$(I), TAB(55), RR(I), TAB(70), PF(I)
EX5: NEXT I
LPRINT
LPRINT CHR$(12),
LPRINT
TAB(25), "INPUT PARAMETERS & DATA - page 5" : LPRINT
LPRINT : LPRINT
LPRINT : LPRINT
LPRINT TAB(1), "MORE SUBSYSTEM COMUTATION FACTORS": LPRINT
LPRINT
LPRINT
LPRINT
LPRINT TAB(1), "SUBSYS", TAB(28), "CREW", TAB(40), "MIN CREW", TAB(55), "FRACTION INHERENT"
LPRINT TAB(28), "SIZE", TAB(40), "ASCN", TAB(55), "FAILURES": LPRINT
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX6
LPRINT
LPRINT TAB(1), WBS$(I), TAB(29), C(I), TAB(40), CA(I), TAB(55), Pl(I)
EX6: NEXT I
LPRINT : LPRINT
LPRINT CHR$(12),
LPRINT
TAB(25), "INPUT PARAMETERS & DATA - page 6" : LPRINT
LPRINT : LPRINT
LPRINT
LPRINT
LPRINT TAB(1), "SUBSYSTEM REDUNDANCY": LPRINT
LPRINT
LPRINT
LPRINT
LPRINT TAB(1), "SUBSYS", TAB(28), "REDUNDANT", TAB(45), "MIN NBR"
LPRINT TAB(28), "SUBSYS", TAB(45), "REQUIRED": LPRINT
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX6
IF K(I) = 0 THEN K(I) = 1
LPRINT TAB(1), WBS$(I), TAB(29), NRR(I), TAB(45), K(I)
EX6: NEXT I
LPRINT : LPRINT
LPRINT CHR$(12),
LPRINT
TAB(25), "INPUT PARAMETERS & DATA - page 7" : LPRINT
LPRINT : LPRINT
LPRINT
LPRINT
LPRINT
LPRINT
LPRINT TAB(1), "SHUTTLE (FILE MAINTAINED) UTILIZED VALUES": LPRINT
LPRINT
LPRINT
LPRINT
LPRINT TAB(1), "SUBSYS", TAB(30), "MTBM", TAB(50), "MTTR"
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX7
IF SEL(I) < 2 "SHUTTLE" THEN GOTO EX7
I.PRINT TAB(1), WR$5(I), TAB(30), SMA(I), TAB(50), SMR(I);
FX$ NEXT I
I.PRINT CHR$(2);
END SUB

SUB ETSRB  ' EXTERNAL ROCKET BOOSTER INPUT DATA'
I.PRINT TAB(1), 'NBR'; TAB(5), 'SUBSYSTEM'; TAB(18), 'MTBM'; TAB(26), 'OPER HRS'; TAB(36), 'CRIT FAIL RT'; TAB(50), 'MTTR'; TAB(59), 'CREW SIZE'
I.PRINT FOR I - 1 TO 5
I.PRINT TAB(1); I; TAB(5); ETSUB$(I); TAB(18); ETMBA(I); TAB(26); ETHRS(I); TAB(50); ETMTR(I); TAB(59); ETCREW(I)
NEXT I
I.PRINT I.PRINT TAB(1), 'SCH D MAINT AS A PCT OF UNSCH MAINT'; ETS: I.PRINT I.PRINT TFREL = 1
I.PRINT TAB(1), 'COMPUTED'; TAB(40), 'MISSION'; TAB(59), 'MANH DRIVEN'
I.PRINT TAB(1), 'SUBSYSTEM'; TAB(18), 'RELIABILITY'; TAB(32), 'UNSCH MANSRS'; TAB(47), 'SCH MAINT'; TAB(59), 'MANPWR'
I.PRINT STF = 0; MTF = 0; TF = 0 FOR I = 1 TO 5 TFRI = TF * ETR(I) / ETMBA(I) / ETABR(I) TFRT = TF * ETR(I) / ETMTR(I) A3 = (TF + ETS * TE) * X(15) / (12 * X(11) * (1-X(12))) A3 = INT(A3 + 999) TME = TF + A3 MTE = MTF + A3 STE = STE + TE I.PRINT TAB(1), ETSUB$(I); TAB(20), ETR(I); TAB(32); TE; TAB(47); ETS * TE; TAB(60); A3 NEXT I
I.PRINT I.PRINT TAB(1), 'OVERALL ET '; TAB(20), TFREL; TAB(32); STE; TAB(47); ETS * STE; TAB(60); TME; I.PRINT IF SRBREL = 1
I.PRINT TAB(1), 'LIQUID ROCKET BOOSTER INPUT DATA'
I.PRINT TAB(1), 'NBR'; TAB(5), 'SUBSYSTEM'; TAB(18), 'MTBM'; TAB(26), 'OPER HRS'; TAB(36), 'CRIT FAIL RT'; TAB(50), 'MTTR'; TAB(59), 'CREW SIZE'
I.PRINT FOR I = 1 TO 4 SRBR(I) = ETR(SRBRHRS(I) / SRBMBA(I) / SRBABR(I)) SRBREL = SRBREL * SRBR(I) TF = (SRBRHRS(I) / SRBMBA(I) / SRBABR(I) * SRBREL) * ETCREW(I) A4 = (TF + ETS * SRBS) * X(15) / (12 * X(11) * (1-X(12))) A4 = INT(A4 + 999) TME = TF + A4 MTE = MTF + A4 STE = STE + TF I.PRINT TAB(5), SRSUB$(I); TAB(20); SRBR(I); TAB(32); TF; TAB(47); SRBS * TF; TAB(61); A4 NEXT I
I.PRINT I.PRINT TAB(1), 'OVERALL LRR'; TAB(20), SRBREL; TAB(32); STE; TAB(47); SRBS * STE; TAB(61); TME
I.PRINT CHR$(2);
END SUB

SUB PRNMAINT  'I,PRINT MODULE FOR MAINTAINABILITY REPORT'
X = 0; Y = 0; Z = 0; K = 0 'AVIONICS ROLLUP'
FOR I = 19 TO 24
SUB PRINTMAINT  'I,PRINT MODULE FOR MAINTAINABILITY REPORT'
X = 0; Y = 0; Z = 0; K = 0 'AVIONICS ROLLUP'
FOR I = 19 TO 24

IF OPS(I) = "DELETE" THEN GOTO SK7
K = K + 1
X = X + NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)
Y = Y + MHMA(I)
Z = Z + (NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) * MHMA(I)
SK7: NEXT I
YA = Y / K
IO = 1: IF IO = 13
LPRINT TAB(5), RTITLES, LPRINT
LPRINT TAB(5), "COMMENTS" LPRINT, LPRINT
LPRINT TAB(1), "PRINTS" LPRINT, LPRINT
LPRINT TAB(1), "Bill" LPRINT, LPRINT
LPRINT TAB(1), "VEHICLE IS" LPRINT, LPRINT
LPRINT TAB(1), "NAME$, TAB(35), "DATE: " LPRINT, LPRINT
LPRINT TAB(1), "VES" LPRINT, LPRINT, "PRINT MA$" LPRINT, LPRINT
LPRINT TAB(1), "PRINT MA$" LPRINT, LPRINT
LPRINT FOR I = 1 TO 3
IF OPS(I) = "DELETE" THEN GOTO SK6
LPRINT TAB(1), WBS(I), TAB(32), NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I), TAB(50), MHMA(I), TAB(65); (NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) * MHMA(I)
IF I = 24 THEN PRINT TAB(5), "AVIONICS ROLLUP", TAB(29), X, TAB(47), YA, "AVG" LPRINT, TAB(63), Z
SKM: NEXT I
LPRINT
LPRINT TAB(5), "TOTAL$", TAB(32), TMA, TAB(47), AMHMA, "WT.AVG", TAB(65), VMH
LPRINT CHR$(12);
IO = 1: IF IO = 33
LPRINT TAB(20), "MAINTAINABILITY REPORT" LPRINT, LPRINT
LPRINT TAB(20), "at mission nbr. ", X(24); " next page 2" LPRINT
X = 0 Y = 0 Z = 0 K = 0 AVIONICS ROLLUP
FOR I = 19 TO 24
IIF OPS(I) = "DELETE" THEN GOTO SK6
LPRINT FOR I = 1 TO IE
IF OPS(I) = "DELETE" THEN GOTO SK5
LPRINT TAB(1), WBS(I), TAB(32), OMRH(I), TAB(50), FMHR(I), TAB(65), 1 - PF(I)
IF I = 24 THEN PRINT TAB(5), "AVIONICS ROLLUP", TAB(29), X, TAB(47), Y, TAB(62), ZA, "AVG"
SK5: NEXT I
LPRINT LPRINT TAB(1), "UNCHANGED" LPRINT, LPRINT
LPRINT TAB(5), "SCHEDULED" LPRINT, LPRINT
LPRINT TAB(5), "SCHEDULED, TAB(32), TOMH, TAB(50), TFMH, TAB(65), APP, "AVG") LPRINT
LPRINT TAB(5), "TOTAL" LPRINT, LPRINT
LPRINT FOR I = 1 TO IE
IF OPS(I) = "DELETE" THEN GOTO PY8
X = X + NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I)
Y = Y + NRD(I) * THRS(I) / FMAS(I)
PY8: NEXT I
IO = 1: IF IO = 33
TXX = 0: TYY = 0
PY7: LPRINT TAB(20), "MAINTAINABILITY REPORT" LPRINT, LPRINT
LPRINT TAB(35), "Note: Ground processing MA's consist of reduced and no defect MA's." LPRINT
LPRINT TAB(5), "Mission MA's are inherent equipment failures" LPRINT
LPRINT LPRINT TAB(1), "WBS", TAB(32), "GRND PROC MA", TAB(50), "MSN MA", TAB(65), "TOTAL MA" LPRINT
LPRINT FOR I = 1 TO IO TO IE
IF OPS(I) = "DELETE" THEN GOTO PY9
XX = NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I)
TXX = TXX + XX
TY = TYY + YY
LPRINT TAB(1), WBS(I), TAB(32), XX, TAB(50); YY, TAB(65), XX + YY
IF I = 24 THEN PRINT TAB(5), "AVIONICS ROLLUP", TAB(29), X, TAB(47), Y, TAB(62), X + Y
PY9: NEXT I
LPRINT LPRINT TAB(5), "TOTAL", TAB(32), TXX, TAB(50), TYY, TAB(65), TXX + TYY
LPRINT CHR$(12);
END SUB
SUB PRINTMAN
   'PRINT MANPOWER MODULE
   X = 0: Y = 0: Z = 0: 'AVIONICS ROLLUP
   FOR I = 1 TO 24
   IF OP(I) = "DELETE" THEN GOTO SK5
   IF OP(I) = "DEFLECT:" THEN GOTO SK8
   X = X + MH(I)
   Z = Z + MP(I)
   NEXT I
   Y = X(5) * X / 12
   MT = 0
   IO = I: IF = 33: ASTP = 0
   I.PRINT TAB(5), RITITLES: I.PRINT
   I.PRINT TAB(5), COMMENTS: I.PRINT: I.PRINT
   I.PRINT TAB(20), "MANPOWER REPORT - at mission nbr "; X(24); "": I.PRINT
   I.PRINT TAB(1), "VEHICLE "; VNAME$, TAB(35); "DATE: "; DATES, TAB(60); "TIME: "; TIMES: I.PRINT
   I.PRINT TAB(3), "AVAIL HRS/MO "; X(11); TAB(40); "INDIRECT WORK "; , 100 * X(I2); "": I.PRINT
   "manpower is computed from manhr/mo divided by avail direct hrs per man per month": I.PRINT
   "avg crew": I.PRINT
   I.PRINT TAB(1), "WBS", TAB(27), "MANHRS/MSN "; TAB(42), "MANHRS/MO "; TAB(35), "MANPWR "; TAB(65), "AVG CREW"
   I.PRINT FOR I = IO TO IE
   IF OP(I) = "DELETE" THEN GOTO PMI
   I.PRINT TAB(5), WBS$(I), TAB(50); MH(I), TAB(45); X(15) * MH(I) / 12; TAB(59); MP(I), TAB(65), C(I)
   IF I = 24 THEN I.PRINT TAB(5), "AVIONICS ROLLUP", TAB(28), X; TAB(43), Y; TAB(58); Z; TAB(63); ASTP
   MT = MT + CA(I) * C(I)
   PMI: NEXT I
   I.PRINT
   I.PRINT I.PRINT TAB(5), "UNSCHEDULED "; TAB(30), VMH, TAB(45), VMH * X(I5) / 12, TAB(59), TMP, SMP, TAB(65), STP
   I.PRINT I.PRINT TAB(5), "SCHEDULED "; TAB(30), SCHP * TOMH, TAB(45), X(I5) * SCHP * TOMH / 12, TAB(59), SMP, TAB(65), X(I4)
   I.PRINT I.PRINT TAB(5), "TOTAL "; TAB(30), VMH + SCHP * TOMH, TAB(45), VMH + SCHP * TOMH * X(I3) / 12, TAB(59), TMP, TAB(65), STP + X(I4) * COLOR 14
   I.PRINT I.PRINT TAB(1), "Fac personnel assigned: SUM (avg crew size x assigned crew) / sched manpower", TAB(75); INT(MT): SMP
   I.PRINT CHR$(12)
END SUB

SUB PRINTREL
   "**** I.PRINT MODULE FOR RELIABILITY REPORT *******
   X = 0: Y = 0: Z = 0: 'AVIONICS ROLLUP
   FOR I = 1 TO 24
   IF OP(I) = "DELETE" THEN GOTO NX1
   IF REL(I) = 1 THEN GOTO NX1
   X = X + 1 / FMA(I)
   Y = Y + 1 / FMA(I)
   Z = Z + 1 / FMA(I)
   NEXT I
   IF X > 0 THEN XA = 1 / X
   IF Y > 0 THEN YA = 1 / Y
   IF Z > 0 THEN ZA = 1 / Z
   IO = I: IF = 33
   MNFMA = 0
   I.PRINT TAB(5), RITITLES: I.PRINT
   I.PRINT TAB(20), "RELIABILITY REPORT - at mission nbr "; X(24); "": page 1": I.PRINT
   I.PRINT TAB(1), "VEHICLE "; VNAME$, TAB(35); "DATE: "; DATES, TAB(60); "TIME: "; TIMES: I.PRINT
   I.PRINT TAB(3), "AVAIL HRS/MO "; X(11); TAB(40); "INDIRECT WORK "; , 100 * X(I2); "": I.PRINT
   "manpower is computed from manhr/mo divided by avail direct hrs per man per month": I.PRINT
   "avg crew": I.PRINT
   I.PRINT TAB(1), "WBS", TAB(27), "MANHRS/MSN "; TAB(42), "MANHRS/MO "; TAB(35), "MANPWR "; TAB(65), "AVG CREW"
   I.PRINT FOR I = IO TO IE
   IF OP(I) = "DELETE" THEN GOTO SK1
   MNFMA = MNFMA + (1 - P(I)) / FMA(I)
   IF X = 9 THEN I.PRINT TAB(1), WBS$(I), "MSN'S/FAILURE "; TAB(35), FMA(I), TAB(48), FMA(I) / (1 - P(I)), TAB(63), FMA(S)
   IF I < 0 THEN I.PRINT TAB(1), WBS$(I), TAB(35), FMA(I), TAB(48), FMA(I) / (1 - P(I)), TAB(61), FMA(S)
   IF I = 24 THEN I.PRINT TAB(5), "AVIONICS ROLLUP", TAB(32), XA, TAB(43), YA, TAB(58), ZA
   SK1: NEXT I
   I.PRINT: I.PRINT
   I.PRINT TAB(5), "VEHICLE "; TAB(35), TVFMA, TAB(48); 1 / MNFMA, TAB(61), SYFMA
   I.PRINT CHR$(12)
   X = 0: Y = 0: Z = 1: K = 0: 'AVIONICS ROLLUP
   FOR I = 1 TO 24
   IF OP(I) = "DELETE" THEN GOTO NY2
   K = K + 1
   X = X + PA(I)
   Y = Y + 1 / FMA(I)
   Z = Z * R(I)
NY2: NEXT I
  IF K = 0 THEN K - 1
  XA - X / K
I0 = 1: IE = 33
I.PRINT TAB(20); "RELIABILITY REPORT - at mission nbr ", X(24); " - page 2": I.PRINT
I.PRINT TAB(5); COMMENTS: I.PRINT: I.PRINT
I.PRINT TAB(1); "VEHICLE IS ", VNAM$: TAB(35); "DATE: ", DATE$: TAB(60); "TIME: ", TIME$: I.PRINT
I.PRINT "critical MTBM's are for a single subsystem, e.g. one engine": I.PRINT
I.PRINT TAB(1); "WBS ", TAB(28); "CRITICAL FAILURE ", TAB(48); "CRITICAL ", TAB(60); "SUBSYS NON -"
IF X(25) = 0 THEN I.PRINT TAB(28); "RATE ground ", TAB(48); "MTBM ", TAB(60); "REDUNDANT MSN REL ",
IF X(25) = 1 THEN I.PRINT TAB(28); "RATE air ", TAB(48); "MTBM ", TAB(60); "REDUNDANT MSN REL ",
FOR I = 10 TO IE
  IF OP$(I) = "DELETE" THEN GOTO SK2
I.PRINT TAB(1); WBS$(I); TAB(33); PA(I); TAB(48); FMAC(I); TAB(60); R(I)
  IF I = 24 THEN I.PRINT TAB(33); "AVIONICS ROLLUP ", TAB(27); XA ", " AVG ", TAB(45); YA; TAB(62); Z
SK2: NEXT I
I.PRINT : I.PRINT
I.PRINT TAB(5); "VEHICLE ", TAB(48); CVFMA; TAB(65); VR
I.PRINT CHR$(12);
IV - IIE - 33
I.PRINT TAB(20); "RELIABILITY REPORT - at mission nbr. ", X(24); ", - page 3": I.PRINT
X - 1; Y - 1; Z - 1; "AVIONICS ROLLUP 
FOR I = 19 TO 24
  IF OP$(I) = "DELETE" THEN GOTO NY3
X - X * R(I)
Y - Y * R2(I)
Z - Z * R3(I)
NY3: NEXT I
I.PRINT TAB(1); "VEHICLE IS ", VNAM$: TAB(35); "DATE: ", DATE$: TAB(60); "TIME: ", TIME$: I.PRINT
I.PRINT "reliabilities based upon redundancy": I.PRINT
I.PRINT TAB(1); "WBS ", TAB(33); "LAUNCH ", TAB(45); "END OF ", TAB(60); "ORBIT ",
I.PRINT TAB(33); "TIME ", TAB(45); "POWER FLT ", TAB(60); "INSERTION": I.PRINT
FOR I = 10 TO IE
  IF OP$(I) = "DELETE" THEN GOTO SK3
I.PRINT TAB(1); WBS$(I); TAB(33); R1(I); TAB(45); R2(I); TAB(60); R3(I)
  IF I = 24 THEN I.PRINT TAB(33); "AVIONICS ROLLUP ", TAB(27); X; TAB(42); Y; TAB(57); Z
SK3: NEXT I
I.PRINT : I.PRINT
I.PRINT TAB(5); "VEHICLE ", TAB(33); VR1; TAB(45); VR2; TAB(60); VR3
I.PRINT CHR$(12);
X - 1; Y - 1; Z - 1; "AVIONICS ROLLUP 
FOR I = 19 TO 24
  IF OP$(I) = "DELETE" THEN GOTO NY4
X - X * R4(I)
Y - Y * R3(I)
NY4: NEXT I
I - 1: IE = 33
I.PRINT TAB(20); "RELIABILITY REPORT - at mission nbr.", X(24); " - page 4": I.PRINT
I.PRINT TAB(1); "VEHICLE IS ", VNAM$: TAB(35); "DATE: ", DATE$: TAB(60); "TIME: ", TIME$: I.PRINT
I.PRINT "reliabilities based upon redundancy": I.PRINT
I.PRINT TAB(1); "WBS ", TAB(45); "REENTRY ", TAB(60); "MISSION ",
I.PRINT TAB(60); "COMPLETION": I.PRINT
FOR I = 10 TO IE
  IF OP$(I) = "DELETE" THEN GOTO SK4
I.PRINT TAB(1); WBS$(I); TAB(45); R4(I); TAB(60); R5(I)
  IF I = 24 THEN I.PRINT TAB(33); "AVIONICS ROLLUP ", TAB(42); X; TAB(57); Y
SK4: NEXT I
I.PRINT : I.PRINT
I.PRINT TAB(5); "VEHICLE ", TAB(45); VR4; TAB(60); VR3
I.PRINT CHR$(12);
END SUB
SUB PRINTSFR
  I.PRINT SPARES RESULTS
  X - 0; Y - 0; Z - 0; K = 0; "AVIONICS ROLLUP 
FOR I = 19 TO 24
  IF OP$(I) = "DELETE" THEN GOTO SK7
  K - 1
  X - X + R(I)
  Y - Y + R2(I)
  Z - Z + R3(I)
  ZX - ZX + R4(I)
SUB PRINTSUM
  I.PRINT TAB(3), "TOTALS": TAB(27), ARR:, "AVG(AVG)"
  I.PRINT CHR$(12)
END SUB

C-33
IF SUM-0:CT-0:SUMC-0
TT-0:TMAX-0
'MODULE, TO LPRINT
SUB
"I'T-TT — TI
IF SEL$(I) = "SHUTTLE"
END
NI: NEXTI
B4- SRBCREW(I) _ SRBCREW(2) ÷ SRBCREW(3) ÷ SRBCREW(4)
B4- INT(B4 _ 999)
BI- ETCREW(I) _ ETCREW(2) _ ETCREW(3) _ ETCREW(4) _ ETCREW(5)
AI- INT(AI + _)9)
AI
I,PRINT TAB(3); "EXT TANK"
I,PRINT TAB(5); "TOTAl,'; TAB(25); A2 _ B2; TAB(40); SMP; TAB(55); SCMP; TAB(65); CI _ SCMP
B2
I,PRINT TAB(5); "SCHED MANPWR'; TAB(25); B2: TAB(40); SMP; TAB(55); SCMP
I,PRINT
B2
I,PRINT TAB(5); "UNSCH MANPWR'; TAB(25); A1, B4, A4, B4; B4, TMAX
I,PRINT LPRINT TAB(0); "SCHD/UNSCH MANPWR'; TAB(25); A1, B4, A4, B4; B4, TMAX
I,PRINT
I,PRINT TAB(1); "TWO SHIFTS/DAY MAINTENANCE";
I,PRINT
I,PRINT TAB(3); "THREE SHIFTS/DAY MAINTENANCE";
I,PRINT
END SUB
SUB PRINTTURN
'MODULE TO LPRINT VEHICLE TURN TIME
TT-0: TI-0: TMAX-0
SUM-0: CT-0: SUMC-0
FOR I-1 TO 33
IF OP$(I) = "DELETE" THEN GOTO TN1
CT = CT + 1
SUMC = SUMC + 1
IF SEL$(I) = "SHUTTLE" THEN TSKT(I) = SMRID ELSE TSKT(I) = (1 - PF(I)) _ MIIMA(I) / C(I)
TT = TT + 1
IF TT > TMAX THEN TMAX = TT: JJ = 1
TT = TT + 1
SUM = SUM + TSKT(I)
N1: NEXT I
SCHT = 98 _ SCIP _ TOMH / X(14)
GTT = TT + SCCT: ASK = SUM / CT
IF TMAX < SCHT THEN TMAX = SCHT
I,PRINT
I,PRINT TAB(1); "TOTALS", TAB(23), A2 _ B2 _ AI _ A4 _ B4; B4, TMAX
I,PRINT
I,PRINT TAB(1); "DAYS'; I,PRINT
I,PRINT TAB(1); "TOTAL VEHICLE TURNAROUND TIME'; I,PRINT
I,PRINT TAB(1); "TOTAL MISSIONS/YR/VEHICLE'; I,PRINT
I,PRINT TAB(1); "COMPUTED FLEET SIZE '; I,PRINT
I,PRINT TAB(1); "AVG MISSIONS/YR/VEHICLE'; I,PRINT
I,PRINT TAB(1); "MIN TURN TIME'; I,PRINT
I,PRINT TAB(1); "MAX TURN TIME'
END SUB
C-34
I.PRINT: I.PRINT
I.PRINT TAB(1), "ONE SHIFT/DAY MAINTENANCE": I.PRINT
DVTT = (T(0) + T(4)) / 24 + (TT + SCHT) / 8 + (X(17) + X(18))
I.PRINT TAB(3), "TOT VEHICLE TURNAROUND TIME": TAB(35), DVTT, "DAYS"
I.PRINT TAB(3), "AVG MISSIONS/YR/VEHICLE": TAB(55), INT((X(15) / 12) / 21 / DVTT) + .99
I.PRINT: I.PRINT
I.PRINT TAB(1), "TWO SHIFTS/DAY MAINTENANCE": I.PRINT
DVTT = (T(0) + T(4)) / 24 + (TT + SCHT) / 8 + (X(17) + X(18))
I.PRINT TAB(3), "TOT VEHICLE TURNAROUND TIME": TAB(35), DVTT, "DAYS"
I.PRINT TAB(3), "AVG MISSIONS/YR/VEHICLE": TAB(55), INT((X(15) / 12) / 21 / DVTT) + .99
I.PRINT: I.PRINT
I.PRINT TAB(1), "THREE SHIFTS/DAY MAINTENANCE": I.PRINT
DVTT = (T(0) + T(4)) / 24 + (TT + SCHT) / 8 + (X(17) + X(18))
I.PRINT TAB(3), "TOT VEHICLE TURNAROUND TIME": TAB(35), DVTT, "DAYS"
I.PRINT TAB(3), "AVG MISSIONS/YR/VEHICLE": TAB(55), INT((X(15) / 12) / 21 / DVTT) + .99
I.PRINT: I.PRINT
I.PRINT TAB(3), "NOTE: assumes sequential tasks, 8 hr shifts, and 21 work days a month"
I.PRINT CHR$(12),
END SUB

SUB REPORT
CLS
PRINT: PRINT TAB(25), "REPORT MENU": PRINT
COLOR 11
PRINT TAB(5), "NBR": TAB(35), "SELECTION": PRINT
PRINT TAB(15), "1".... PRINT INPUT DATA*
PRINT TAB(15), "2".... PRINT SUMMARY REPORT*
PRINT TAB(15), "3".... PRINT RELIABILITY REPORT*
PRINT TAB(15), "4".... PRINT MAINTAINABILITY REPORT*
PRINT TAB(15), "5".... PRINT RELIABILITY REPORT*
PRINT TAB(15), "6".... PRINT SPARES REPORT*
PRINT TAB(15), "7".... PRINT TURN TIME REPORT*
PRINT TAB(15), "8".... PRINT EXT TANK AND/OR SRB REPORT*
PRINT TAB(15), "9".... PRINT REPORT TO A FILE*
COLOR 12
PRINT TAB(15), "RETURN...CANCEL REQUEST"
COLOR 11
LOCATE 23, 50: COLOR 12: PRINT "Is your printer ready???"
LOCATE 24, 5 COLOR 13: PRINT "VEHICLE/FLEET NAME IS : "; VNAM$ 
COLOR 10: LOCATE 18, 20: INPUT "ENTER SELECTION": NDO
IF NDO < - 0 OR NDO > 12 THEN GOTO BOTM
COLOR 3
LOCATE 20, 10: INPUT "ENTER TITLE OF REPORT": RTITL$ 
LOCATE 21, 10: INPUT "ENTER COMMENTS": CMNT$ 
IF NDO = 1 THEN CALL ECHO 
IF NDO = 2 THEN CALL PRINTSUM 
IF NDO = 3 THEN CALL PRINTREL 
IF NDO = 4 THEN CALL PRINTMAINT 
IF NDO = 5 THEN CALL PRINTMAN 
IF NDO = 6 THEN CALL PRINTSPR 
IF NDO = 7 THEN CALL PRINTTURN 
IF NDO = 8 THEN CALL ETSR$ 
IF NDO = 9 THEN GOSUB ALL 
IF NDO = 10 THEN GOSUB ALL 
IF NDO = 11 THEN CALL SIMREP 
IF NDO = 12 THEN CALL WRITE$ 
GOTO BOTM
ALL: CALL ALL PRINT MODULES 
IF NDO = 10 THEN CALL ECHO 
CALL PRINTSUM 
CALL PRINTREL 
CALL PRINTMAINT 
CALL PRINTMAN 
CALL PRINTSPR 
CALL PRINTTURN 
IF FILE$ < 1 OR SRBRE$ < 1 THEN CALL ETSR$ 
RETURN 
BOTM: 'RETURN TO MAIN MENU
END SUB

C-36
SUB SIMREP

"**** I.PRINT MODULE FOR SIMULATION INPUT ******

SWBS(1) - "Structural"; SWBS(2) - "Fuel/Oxid Tasks"; SWBS(3) - "Thermal/Tile"; SWBS(4) - "Propulsion"
SWBS(5) - "Power/Electrical"; SWBS(6) - "Mechanical Sys"; SWBS(7) - "Avionics"; SWBS(8) - "FCS/Life Support"
SWBS(9) - "Auxiliary Systems"

I.PRINT TAB(25); "SIMULATION INPUT REPORT"; I.PRINT
I.PRINT TAB(5); RTITLE I.PRINT
I.PRINT TAB(5); COMMENTS I.PRINT
I.PRINT TAB(1); "SYNOPSIS": VNAMS, TAB(35), "DATE": DATES, TAB(60), "TIME": TIMES; I.PRINT
I.PRINT I.PRINT TAB(1); "Subsys": TAB(25), "Maint Actions": TAB(40), "On-Veh MTTR": TAB(55), "Off-veh MTTR"
I.PRINT TAB(25); "Per Mission", TAB(40), "n hours", TAB(15), "in hours", TAB(60), "Prob-Rem": I.PRINT
FOR I = 1 TO 9
X = (FRS(I) - REMS(I)) / (1 - FRS(I) * REMS(I))
X(I) = (X(I) - X(13)) * REMS(I)
I.PRINT TAB(3), SWBS(I), TAB(25), MAS(I), TAB(40), MTRUS(I), TAB(55), MTRUS(I), TAB(60), X
NEXT I
I.PRINT
I.PRINT I.PRINT TAB(25); "Removal &": TAB(40), "On-Veh": TAB(55), "Off-Veh"
I.PRINT TAB(1); "Subsys": TAB(25), "No spare": TAB(40), "Sched MTTR": TAB(54), "Sched MTTR": TAB(60), "AVG CREW SIZE": I.PRINT
FOR I = 1 TO 9
I.PRINT TAB(3), SWBS(I), TAB(25), MAS(I), TAB(40), MTRUS(I), TAB(55), MTRUS(I), TAB(60), X
NEXT I
I.PRINT
I.PRINT TAB(10); "Launch Reliability", TAB(50), VR
I.PRINT TAB(10); "Mission Redundant Reliability", TAB(50), VR
I.PRINT TAB(10); "Integration Time - days", TAB(50), X(I)
I.PRINT TAB(10); "Fuel Time - days", TAB(50), X(I)
I.PRINT TAB(10); "Mission Time", TAB(50), X(I)
I.PRINT TAB(10); "Planned missions per Month", TAB(50), X(I)
I.PRINT TAB(10); "Fill rate objective", TAB(50), X(I)
I.PRINT CHR$(12)
END SUB

File: RAMC.BAS computational module

"NASA, LANGLEY RESEARCH CENTER"
"MTBM COMPUTATIONAL MODEL - NASA RESEARCH GRANT -
"DEVELOPED BY C. EBELING, UNIV. OF DAYTON 6/17/94 (updated)
" ****** COMBINED PRE/CONCEPTUAL MODEL *******
"SAVE AS "RAMC.BAS" computational module

COMMON SHARED YR, B, X, X2, LF, VR1, VR2, VR3, VR4, VR5, VR, AREW
COMMON SHARED VIMA, TVIMA, SVIMA, VIMA, OHIMA, OMFIMA, TMA, AMHIMA
COMMON SHARED SCHP, VMAI, VMAI2, VIMA$, ARR, TVIMA$, SKU
COMMON SHARED SEMP, TSEP, VM, VOM, WOF, WING, WF, PWF
COMMON SHARED ETREL, SRREL, ETS, SRBS, RTLILES, ASTOL
COMMON SHARED STP, STE, MTE, MME, MTF, TME, TFR, CF
DIM SHARED WBRS(35), X(50), NAM$(50), THR$(35), MMMA$(35), MH$(35), MPR$(35), OMID$(35), FM$(35)
DIM SHARED SEL$(35), T(10), CPP(9), CA(35), RELY(35), RF(35)
DIM SHARED GOH(35), LOG$(35), T Orb(35), DOrb(35), RHorb(35), RHorb(35), RHorb(35), RHorb(35), RHorb(35)
DIM SHARED V(15), SNAM$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35)
DIM SHARED MW(35), C(35), C(35), C(35), C(35), C(35), C(35), C(35)
DIM SHARED FMA$(35), PF$(35), PA$(35), PR$(35), P$(35), NR$(35), FR$(35)
DIM SHARED NDR$(35), K(35), R(35), R(35), R(35), R(35), R(35)
DIM SHARED P(35), P(35), P(35), P(35), P(35), P(35), P(35)
DIM SHARED ETS$(35), ETS$(35), ETS$(35), ETS$(35), ETS$(35), ETS$(35), ETS$(35)
DIM SHARED SBS$(35), SBS$(35), SBS$(35), SBS$(35), SBS$(35), SBS$(35), SBS$(35)
DIM SHARED SWBS$(35), SWBS$(35), SWBS$(35), SWBS$(35), SWBS$(35), SWBS$(35), SWBS$(35)
DIM SHARED FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35)
DIM SHARED HF$(35), HF$(35), HF$(35), HF$(35), HF$(35), HF$(35), HF$(35)
DIM SHARED PI$(35), C(35)
COMMON SHARED VIMA, TVIMA, SVIMA, VIMA, OHIMA, OMFIMA, TMA, AMHIMA
COMMON SHARED SCHP, VMAI, VMAI2, VIMA$, ARR, TVIMA$, SKU
COMMON SHARED SEMP, TSEP, VM, VOM, WOF, WING, WF, PWF
COMMON SHARED ETREL, SRREL, ETS, SRBS, RTLILES, ASTOL
COMMON SHARED STP, STE, MTE, MME, MTF, TME, TFR, CF
DIM SHARED WBRS(35), X(50), NAM$(50), THR$(35), MMMA$(35), MH$(35), MPR$(35), OMID$(35), FM$(35)
DIM SHARED SEL$(35), T(10), CPP(9), CA(35), RELY(35), RF(35)
DIM SHARED GOH(35), LOG$(35), T Orb(35), DOrb(35), RHorb(35), RHorb(35), RHorb(35), RHorb(35), RHorb(35)
DIM SHARED V(15), SNAM$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35)
DIM SHARED MW(35), C(35), C(35), C(35), C(35), C(35), C(35)
DIM SHARED FMA$(35), PF$(35), PA$(35), PR$(35), P$(35), NR$(35), FR$(35)
DIM SHARED NDR$(35), K(35), R(35), R(35), R(35), R(35), R(35)
DIM SHARED P(35), P(35), P(35), P(35), P(35), P(35), P(35)
DIM SHARED ETS$(35), ETS$(35), ETS$(35), ETS$(35), ETS$(35), ETS$(35), ETS$(35)
DIM SHARED SBS$(35), SBS$(35), SBS$(35), SBS$(35), SBS$(35), SBS$(35), SBS$(35)
DIM SHARED SWBS$(35), SWBS$(35), SWBS$(35), SWBS$(35), SWBS$(35), SWBS$(35), SWBS$(35)
DIM SHARED FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35), FMA$(35)
DIM SHARED HF$(35), HF$(35), HF$(35), HF$(35), HF$(35), HF$(35), HF$(35)
DIM SHARED PI$(35), C(35)

SUB ABORT
"ABORT RATE CALCULATIONS"

C-37
14505 FOR I = 1 TO 33: PA(I) = X(I): NEXT I: SET DEFAULT ABORT RATE

' WBS 1,2,3 STRUCTURES ****
' 14510 ABI1 = 031/2 - 1.5456F-07 * X*: 1.5456F-04 * SQR(X1)
14511 IF ABI1 < 0 THEN ABI1 = 00128
14512 IF ABI1 > 0 THEN ABI1 = 02065
14513 PA(I) = ABI1: PA(I) = ABI1
14520 IF ABI2 < 0 THEN ABI2 = 0
14521 IF ABI2 > 0 THEN ABI2 = 0.00128
14522 PA(3) = ABI2 / FMA11 - ABI2 / FMA12 / (1 / FMA11 + 1 / FMA12)

' WBS 5 LANDING GEAR ****
14530 ABI3 = 204327 _ 3.8175F-07 * X1 - 2.51883F-04 * SQR(X1)
14531 IF ABI3 < 0 THEN ABI3 = 0
14532 IF ABI3 > 0 THEN ABI3 = 0.00128

' WBS 9 10 APU ****
14540 ABI4 = 1_031213 + 1.956E+4 * XI
14541 IF ABI4 < 0 THEN ABI4 = 0
14542 IF ABI4 > 0 THEN ABI4 = 0.00128

' WBS 10.00 ELECTRICAL ****
14550 PA(16) = 39.958E - 10.00185 * X1
14551 IF PA(16) < 0 THEN PA(16) = 0.00128
14552 IF PA(16) > 0 THEN PA(16) = 0.00128

' WBS 11.00 HYDRAULICS ****
14560 PA(17) = 5000.2535 + 7578.183 * LOG(X1) + 24.6005 * LOG(X1) + 2 - .5276227 * I.0G(X1)
14561 IF PA(17) < 0 THEN PA(17) = 0.00128
14562 IF PA(17) > 0 THEN PA(17) = 0.00128

' WBS 12.00 ACTUATORS ****
14570 ABI5 = -71.953 + 18.81388 * LOG(X2) + 0209982 * SQR(X2)
14571 IF ABI5 < 0 THEN ABI5 = 0
14572 IF ABI5 > 0 THEN ABI5 = 0.00128

' AVIONICS GENERIC
14580 PA(18) = 502749 + 7.978183 * SQR(LOG(X1)) - 433.612 * LOG(X1) + 24.6005 * LOG(X1) + 2 - .5276227 * LOG(X1)
14581 IF PA(18) < 0 THEN PA(18) = 0.00128
14582 IF PA(18) > 0 THEN PA(18) = 0.00128

' WBS 14 XX ENVIRONMENTAL ****
14590 PA(20) = 0821999 + 5.002720-07 * X1 + 4.0617F-04 * SQR(X1)
14591 IF PA(20) < 0 THEN PA(20) = 0
14592 IF PA(20) > 0 THEN PA(20) = 0.00128

' WBS 15.00 PERSONNEL, PROVISIONS ****
14600 PA(27) = 0.0185

' WBS 16.00 ABRUT RATES
FOR I = 1 TO 5: ETABR(I) = X(8): SRBABR(I) = X(8): NEXT I

'compute air abort rates
IF X(25) = 1 THEN
FOR I = 1 TO 2: PA(I) = .25 * PA(I): NEXT I
PA(3) = .195 * PA(3)
FOR I = 4 TO 8: PA(I) = X(8): NEXT I
PA(9) = 22 * PA(9)
FOR I = 10 TO 12: PA(I) = .28 * PA(I): NEXT I
PA(13) = 0.2 * PA(13)
FOR I = 14 TO 16: PA(I) = .125 * PA(I): NEXT I
PA(17) = .08 * PA(17)
PA(18) = .14 * PA(18)
IF X(19) = 0 THEN PA(19) = .33 * PA(19) ELSE PA(19) = .16125 * PA(19)
PA(20) = X(8)
PA(21) = .1775 * PA(21)
PA(22) = X(8)
PA(23) = .16 * PA(23)
PA(24) = X(8)

C-38
END IF

END SUB

SUB ACWGT

* Module to compute subsystem weights - ACFT EQS

SUM = 0

FOR I = 1 TO 33: W(I) = 0: NEXT I

W(1) = -4485026.74 + 1331022.39 * LOG(X1) + 135432.1 * LOG(X1) + 2 * 4522.4 * LOG(X1) + 3

IF W(I) < 0 THEN W(I) = 795

W(2) = -299000.99 + 91929.4 * LOG(X1) - 91090.90 * LOG(X1) + 2 * 343.5 * LOG(X1) + 3

IF W(2) < 0 THEN W(2) = 302

W(3) = 39713145.29 + 1417950.84 * LOG(X1) - 40472209.7 / SQR(LOG(X1)) - 12991808.8 * SQR(LOG(X1))

IF W(3) < 0 THEN W(3) = 2140

FOR I = 28 TO 33: PA(I) = X(I): NEXT I

FOR I = 28 TO 33: PA(I) = X(I): NEXT I

W(18) = -9849.5 + 282563 * X2 + 6873.7 * LOG(X2) - 1601 * SQR(X2)

IF W(18) < 0 THEN W(18) = 2140

W(25) = -719.15 - 5.56265 * X2 + 56.882 * SQR(X2)

IF W(25) < 0 THEN W(25) = 63


W(16) = 1090.15 + 0.59666 * X1 + 1364.8 * LOG(X1) - 2648 * SQR(X1)

IF W(16) < 0 THEN W(16) = 1090.15

FOR I = 1 TO 33: SUM = SUM + W(I): NEXT I

FOR I = 1 TO 33

SUM = SUM + W(I)

NEXT I

FOR I = 1 TO 33

SUM = SUM + W(I)

NEXT I

FOR I = 1 TO 33

SUM = SUM + W(I)

NEXT I

END SUB

SUB COMPM

* Module to compute MTBM given a specified reliability

Y = 0: YY = 0: Y = 0: YY = 0

FOR I = 1 TO 33

IF OP$(I) = "DELETE" THEN GOT0 SKIP1

IF RELF(I) = 1 THEN GOSUB MTB

IF RELF(I) = 0 THEN YY = YY / FMA(I)

Y = 1 / FMAT(I)

EXIT SUB

FOR I = 1 TO 33

W(I) = W(I) / SUM

IF W(I) = 0 THEN OP$(I) = "DELETE" ELSE OP$(I) = "COMPUTE"

NEXT I

END SUB

MTB: 'Find FMAC

IF X(25) = THEN T0 = GOM(I) ELSE T0 = 0

T1 = T0 + LOG(I): T2 = T1 + TOR(I)

T3 = T2 + LOG(I): T4 = T3 + TOR(I)

L1 = 1 / FMAC(I)

IF I = 9 THEN L1 = LOG(RF(I)) / T4 GOTO END

RCP: L2 = LF * L1

A = (B * T2) * (B - 1) / L1 + (1 / B)

P = EXP(L1 * T2 + T0 - T1) / L2 * (T1 - T0) + (T3 / A) + (T2 / A) - B + L1 * (T4 - T5)

FP = F(RF(I))

C-39
DF = (- (T2 + T0 - T1) * T1 - T3 / (b * T2) * (b - 1) - 1 / (b * T2) * (b - 2)) - (T4 - T3) * F
IF DF < 0001 OR DF > 00001 THEN NEWL1 = 1 + FP / DF ELSE EXIT SUB

IF ABS(F - RE()) > 00001 THEN NEWL1 = - NEWL1 + GOTO RCP

RETURN

END SUB

SUB COMREI
2800 'MODUL TO DETERMINE nonredundant RELIABILITIES - CRITICAL FAILURES ONLY
2810 VR = 1
2820 FOR J = 1 TO 33
2830 IF X(25) = 0 THEN T0 = GOM(H) * T0
T1 = T0 + I0(H) T2 = T1 / T0(H)
2840 T3 = T2 + GOM(H) T4 = T3 / RO(H)
2850 IF OP$(J) = "DELETE" THEN R(J) = 1: GOTO 2890
2860 1,1 = I / FMAC(J): 1,2 = LF * 1,1
2870 A = (B * T(2) / (B - 1) / (B - 1)) (1 / B)
2880 R(J) = EXP(-1,1 * (T2 + T0 - T1 - 1,2 * (T1 + T0) - (T3 / A) - B + (T2 / A) - B - L1 * (T4 - T3))
2890 VR = VR * R(J)
2895 NEXT J
END SUB

SUB CREW
12000 'CREW SIZE CALCULATIONS
12100 C(I) = 1.5 - 000172 * V(3) + 000172 + SQR(V(3))
12140 C(19) = 2.43: C(20) = 2.18: C(21) = 2.18: C(22) = 2.18: C(23) = 2.18: C(24) - C(19)
12150 C(25) = 178.93 + 00009872 * SQR(S(1))
12155 C(26) = (C(16) + C(28)) / 2
TFC = 1
FOR I = 1 TO 33
IF I - 13 OR I = 23 OR I = 25 OR I = 26 OR I = 10 OR I = 11 OR I = 17 OR I = 4 OR I = 3 OR I = 30 THEN TFC = 2
IF SEL$(I) = "SHUTTLE" THEN C(I) = - TFC * 4.3
TFC = 1
NEXT I
END SUB

SUB CRIT
2700 'DETERMINE CRITICAL FMA
2710 YY = 0
2720 FOR I = 1 TO 33
2730 IF OP$(I) = "DELETE" THEN GOTO 2760
2740 FMAC(1) = FMAS(I) / PA(I)
2750 YY = YY + 1 / FMAC(I)
2760 NEXT I
2770 CVFMA = 1 / YY
END SUB

SUB EQS
FOR I = 1 TO 33
W(0) = W(I) / NRD(I)
NEXT I

' MTRM/MTTR CALCULATIONS BY WBS
' WBS 1,2 & 3 AIRFRAME
S1 = W(1) / W(2) + W(3)
P1 = W(1) / S1: P2 = W(2) / S1: P3 = 1 - P1 - P2
3020 FMA1 = 13.231 + 000657 * W(2) - 137573 * SQR(W(1) + W(2) + W(3)) - 000723 * V(3)
3022 IF FMA1 < 1.4 THEN FMA1 = 1.4
3025 FMA1 = FMA1 / P1: FMA(2) = FMA1 / P2
3030 MH(11) = 16.5732 : S515676 * W(3) / V(2) = 74556 * LOG(X1)

C-40
WUC12 AIRCRAFT COMPARTMENT

WUC46 FUEL SYS WBS 3 10/3 20

WUC13 LANDING GEAR SYSTEMS

WUC23 PROPULSION SYSTEM **** WBS 6, 7 & 8

WUC24 APU WBS 8 10

WUC 42/44 WBS 10 **** ELECTRICAL SYS

WUC45 WBS1 HYDRAULICS SYS
WUC14 WBS 12.00 AFRO SURFACE ACTUATORS ****************

WBS 12.00 AERO SURFACE ACTUATORS ****************

WUC14/47 WBS14.00 ENVIRONMENTAL CONTROL ****************

FMA(20) - 230.26 - 0.000821 * X1 - 45.134 * X2 + 137.3431 * X(5) - 1.129 * V(9) - 381.666 * SQRT(X(5))

FMA(23) - 330.26 - 0.000821 * X1 - 45.134 * X2 + 137.3431 * X(5) - 1.129 * V(9) - 381.666 * SQRT(X(5))

FMA(26) - 6663.12 - 1.442 * X2 - 133.83 * LOG(X(1)) + 73.58 * LOG(X(1)) - 2 - 725852 * X1 / X2

FMA(29) - FH41 - FMA(26) - FH47

FMA(29) - 7515 IF FMA(25) < 7.68 THEN FMA(25) = 7.68

FMA(29) - 7520 IF FMA(28) < 13.8 THEN FMA(28) = 13.8

FMA(29) - 6886774 * LOG(X1)

FMA(29) - 3521 IF MHMA(25) - 0.018535 * LOG(X1) - 3.36575E-03 * SQRT(X1)

FMA(29) - 3522 IF MHMA(25) - 0.018535 * LOG(X1) - 3.36575E-03 * SQRT(X1)

FMA(29) - 3523 IF MHMA(25) - 1! THEN MHMA(25) = 1!

WUC09/96 WBS15 PERSONNEL PROVISIONS ***********************

FMA(28) - 230.02 + 236.89 * X2 - 465.027 * SQRT(X2)

FMA(28) - 201.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 301.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 101.06 THEN FMA(28) = 101.1

FMA(28) - 201.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 301.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 101.06 THEN FMA(28) = 101.1

FMA(28) - 101.06 THEN FMA(28) = 101.1

FMA(28) - 230.02 + 236.89 * X2 - 465.027 * SQRT(X2)

FMA(28) - 201.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 301.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 101.06 THEN FMA(28) = 101.1

FMA(28) - 230.02 + 236.89 * X2 - 465.027 * SQRT(X2)

FMA(28) - 201.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 301.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 101.06 THEN FMA(28) = 101.1

FMA(28) - 230.02 + 236.89 * X2 - 465.027 * SQRT(X2)

FMA(28) - 201.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 301.06 + 10.54 * SQRT(X1) - 23.91 * X2 + 16346 * WAV - 20.27 * V(10) + 352.2 * SQRT(X2)

FMA(28) - 101.06 THEN FMA(28) = 101.1

FMA(28) - 230.02 + 236.89 * X2 - 465.027 * SQRT(X2)
IF SFL(I) = "SHUTTLE" THEN FMA(I) = SMA(I)
* COMPUTE SHUTTLE OFF MANHRS
IF SFL(I) = "SHUTTLE" THEN MHMA(I) = C(I) * SMRI(I) + PF(I) * C(I) * SMRI(I) / (1 - PF(I))
4930 NEXT I

5000 SCHUTTLE MAINTENANCE MODULE
IF CP$(5) = "DO NOT RECOMPUTE" THEN GOTO 5050
5010 SCHR = 2 + 5245 * X2 + 5362 * LOG(X2) + 3.039 * SQR(X2) + 0.215 * W(3) / W(2) + 0.0067 * V(3)
SCHR = 3.56 + 0.449 * X2 + 3.2794 * LOG(X2) + 0.2297 * SQR(X2) - 0.176 * (LOG(X1)) - 3.289 * LOG(X2) + 2.36793 * SQR(X2)
IF SCHR < 32 THEN SCHR = 32
IF SCHR > 794 THEN SCHR = 794
5050 NEXT I

5030 VEHICLE ROLL-UP - UNADJUSTED MTBM
5040 Y = 0
5050 FOR I = 1 TO 33
5060 IF OP$(I) = "DELETE" THEN GOTO 5110
5100 Y = Y + 1 / FMA(I)
5110 NEXT I
5220 VTMA = Y

FOR I = 1 TO 33
W(I) = W(I) * NRD(I)
NEXT I

END SUB

SUB MANPWR
7000 MANPOWER COMPUTATION MODULE ******
VMH = 0: OMHMA = 0: OFMHMA = 0
7020 FOR I = 1 TO 33
POFF = PF(I): MP(I) = 0
7030 IF OP$(I) = "DELETE" THEN GOTO 7140
7035 KK = KK + 1
7040 THRS(I) = ORS(I) + LDR(I) + TDR(I) + ORH(I) + ROH(I)
7045 MA = NRD(I) * (1 - PF(I)) * PDR(I) / FMA(I) + THRS(I) / FMA(S(I))
TOFR = TOFR + 1 / FMA(S(I))
7050 VMAH = VMH + MA
7070 MEN = (MII(I) * X(15)) / (12 * X(11) * (1 - X(12)))
7080 MPD = INT(MEN + .999)
7085 TMP = TMP + MP(D
7095 OMKH(I) = (1 - POFF) * MKH(I)
7100 FMH(I) = POFF * MKH(I)
7110 TOMH = TOMH + OMKH(I)
7120 TFMH = TFMH + FMH(I)
7130 APF = APF + 1 - PF(I)
7140 NEXT I
7150 APF = APF / KK
7155 OMKMA = OMKMA / KK: OFMKMA = OFMKMA / KK
7160 AMHMA = VMH / TMA
7170 SMP = (SCHR + TCMH * X(15)) / (12 * X(11) * (1 - X(12)))
7180 SMP = INT(SMP + .999)
7190 TMP = TMP + SMP
'MIN CREW SIZE
STP = 0: CI = 0
FOR I = 1 TO 33
IF CP$(I) = "DELETE" THEN GOTO N1
IF CP$(I) = "DELETE" THEN GOTO N1
IF CP$(I) > MP(I) THEN TP = C(I) ELSE TP = MP(I)
STP = STP + TP
CI = CI + CA(I) * CI)
N1 NEXT I
STP = INT(STP + .999)
CI = INT(CI + .999)
END SUB

SUB POFFEQS
3000 POFF EQUATIONS
FOR I = 1 TO 33
PF(I) = X(20): NEXT I
DEFAULT VALUE
FOR I = 1 TO 33
W(I) = W(I) / NRD(I)
NEXT I

C-43
4253 PF91 - 4.654 - 45718 * L(X3(X1) * .00242
4099'
4360
4057 PF(3) - (PF49 * .01)
4055 IF PF96 > 98 THEN PF96
4054 IF PF96 < 23 THEN PF96
4053 PF96 - -5.4686 - .16835 * X2 - .00448 * V(3) ÷ .36521 * X(4) - 4.1528 * $_tR(X(4))
4052
4010 'WUC23 PROPULSION SYSTEM **** WBS 6, 7 & 8 ********
4106 FOR I = 10 TO 12
4050 PF(I) = .1463 ÷ .572F95 * W(I) ÷ .01436 * SQR(W(I))
4106 IF PF(I) < 2 THEN PF(I) = .2
4107 IF PF(I) > 725 THEN PF(I) = 725
4108 NEXT I
3400 'WUC24 APU WBS 9.10
3450 IF PF(13) < .05 THEN PF(13) = .05
3452 IF PF(13) > .53 THEN PF(13) = .53
3463 IF PF(14) = 0
3499'
3600 'WUC42/44 WBS 10 *** ELECTRICAL SYS ******
3650 PF42 = -26.565 - 0.071 * V(7) - .007143 * W(16) - 7.4878 * SQR(W(16)) + 6.621 * LOG(W(16))
3651 IF PF42 < .04 THEN PF42 = .04
3652 IF PF42 > .53 THEN PF42 = .53
3653 PF44 = -3.661 + 1.78F95 * X1 - .000271 * V(3) - 4.2392 * LOG(X1) + 1.3468 * SQR(X2)
3654 IF PF44 < .03 THEN PF44 = .03
3655 IF PF44 > .47 THEN PF44 = .47
3656 PF(18) = (PF42 / FH42 ÷ PE44 + FH44) / (1 / FH42 + 1 / FH44)
3799'
3800 'WUC45 WBS11 HYDRAULICS SYS *******
3850 PF45(17) - 07614 - 00181 * X2 + .00543 * SQR(X1)
3851 IF PF45(17) < .04 THEN PF45(17) = .04
3852 IF PF45(17) > .33 THEN PF45(17) = .33
3899'
3900 'WUC14 WBS 12.DEO AFRO SURFACE ACTUATORS **********
3950 PF(8) = 5.5126 ÷ 002662 * V(5) - 000566 * W(18) - 1.93 * LOG(W(18)) + 10556 * SQR(W(18))
3951 IF PF(8) < .04 THEN PF(8) = .04
3952 IF PF(8) > .29 THEN PF(8) = .29
3999'
3950 'WBS 12 XX AVIONICS GENERAL ******
3990 IF PF(19) = 7.662 ÷ 00299 * V(11) - .00128 * WAV = 1774 * SQR(WAV) - 1.734 * LOG(WAV) + .0067 * WAV / V(10)
3991 IF PF(19) < .193 THEN PF(19) = .193
3992 IF PF(19) > .532 THEN PF(19) = .532
3993 PF(20) = PF(19) ÷ PF(21) - PF(9) ÷ PF(19) ÷ PF(23) ÷ PF(24) ÷ PF(24) ÷ PF(24)
3994 PF(23) - 8.734(1) ÷ 00001228 * X1 = 007198 * X2 + 80066 * LOG(X1) - .02 * SQR(X1) - 1.45834 * X(5) + .0254 * V(9) + 4.19664 * SQR(X(5))
3995 IF PF(23) < .05 THEN PF(23) = .05
3996 IF PF(23) > .44 THEN PF(23) = .44
3997
3990 'WUC41/47 WBS14 XX ENVIRONMENTAL CONTROL *******
3930 PF47 = 23.852 ÷ 00092 * X2 - 2.247 * LOG(X1) + 301 * LOG(W(18)) ÷ 20012 ÷ X1 / X2
3931 IF PF47 < .02 THEN PF47 = .02
3932 IF PF47 > .532 THEN PF47 = .532
3933 PF47 = 33 THEN PF47 = 33
3934 PF(35) = 0932 ÷ PF(26) ÷ PF47
4010 'WUC49/96 WBS15 PERSONNEL PROVISIONS **********
4050 PF49 = -19888 + 4.9318 * 006 * X1 - .00825 * SQR(X1) + 0008477 * V(7)
4051 IF PF49 < .002 THEN PF49 = .002
4052 IF PF49 > .45 THEN PF49 = .45
4053 PF46 - 5.4468 ÷ 16835 * X2 - 0.00448 * V(3) ÷ 30321 * X(4) - 4.1528 * SQR(X(4)) + .78 * SQR(W(27))
4054 IF PF46 < .23 THEN PF46 = .23
4055 IF PF46 > .98 THEN PF46 = .98
4057 PF27 = (PF49 + PF96) ÷ 2
4099
4200 'WUC9/13/97 WBS 16 ***** RECOVERY & AUX SYS ******
4230 FOR I = 28 TO 33: PF9(I) = .004678 NEXT I
4253 PF99 = 4.654 ÷ 45718 * LOG(X1) + 002342 * SQR(X1)
4254 IF PF99 < .01 THEN PF99 = .01
4255 IF PF99 > .84 THEN PF99 = .84
4297 PF(99) = (PF99 ÷ 01) ÷ 2: PF(28) - 287: PF(30) - .01 CHECK THIS
4270 FOR I = 1 TO 33: IF PF(I) > 1 THEN PF(I) = 1
4271 NEXT I
FOR I = 1 TO 33
W(I) = W(I) * NRD(I)
NEXT I
END SUB

SUB RELUNDF

IF OP(s) = "DELETE" THEN GOTO 13260
IF X(25) = 0 THEN GH = GOSUB 13355 ELSE GH = 0
13220: L = 1: IF FAC(I) = T THEN GH = 0
13300: GOTO 13400
13305: GOTO 13400
13310: NN = NRD(I): GOSUB 13355: MFAC = FAC
13315: FOR J = 1 TO NRD(I)
13320: NN = J: GOSUB 13355: IFAC = FAC
13325: NN = NRD(I): J: GOSUB 13355
13330: C = MFAC / (IFAC * FAC)
13335: R(J) = R(J) + C * RT ' J * (1 - RT)' (NRD(I) - J)
13340: NEXT J
13345: RETURN
13350: }
13355: 'FACTORIZIAL SUBROUTINE
13360: IF NN = 0 THEN FAC = 1: RETURN
13365: FAC = 1
13370: FOR JK = 1 TO NN
13375: FAC = FAC * JK
13380: NEXT JK
13385: RETURN
13390: GOTO 13400
13395: GOTO 13400
13400: 'END OF POWERED PHASE
13405: VR2 = 1
13410: FOR I = 1 TO 33
13415: IF OP(s) = "DELETE" THEN GOTO 13440
13420: IF X(25) = 0 THEN GH = GOSUB 13355 ELSE GH = 0
13425: L = 1: IF FAC(I) = T THEN GH = 0
13430: IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13445 ELSE R2(I) = 1 - (1 - RT) ' NRD(I)
13435: VR2 = VR2 * R2(I)
13440: NEXT I
13445: GOTO 13500
13450: GOTO 13500
13455: NN = NRD(I): GOSUB 13355: MFAC = FAC
13460: FOR J = 1 TO NRD(I)
13465: NN = J: GOSUB 13355: IFAC = FAC
13470: NN = NRD(I): J: GOSUB 13355
13475: C = MFAC / (IFAC * FAC)
13480: R3(I) = R3(I) + C * RT ' J * (1 - RT)' (NRD(I) - J)
13485: NEXT J
13490: RETURN
13495: RETURN
13500: 'ORBIT INSERTION
13505: VR3 = 1
13510: FOR I = 1 TO 33
13515: IF OP(s) = "DELETE" THEN GOTO 13540
13520: IF X(25) = 0 THEN GH = GOSUB 13355 ELSE GH = 0
13525: L = 1: IF FAC(I) = T THEN GH = 0
13530: RT = EXP(L * (T + TXD - TX1) + LF * (TX1 - TXD))
13535: IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13545 ELSE R3(I) = 1 - (1 - RT) ' NRD(I)
13540: NEXT I
13545: GOTO 13600
13550: GOTO 13600
13555: NN = NRD(I): GOSUB 13355: MFAC = FAC
13560: FOR J = 1 TO NRD(I)
13565: NN = J: GOSUB 13355: IFAC = FAC
13570: NN = NRD(I): J: GOSUB 13355
13575: C = MFAC / (IFAC * FAC)
13580: R3(I) = R3(I) + C * RT ' J * (1 - RT)' (NRD(I) - J)
13585: NEXT J
13590: RETURN
13595: RETURN
13600: 'ENTRY

C-45
13605 VR4 = 1
13610 FOR I = 1 TO 33
13612 IF OP$(I) = "DELETE" THEN GOTO 13640
13615 IF X(25) = 0 THEN GH = GOH(I) ELSE GH = 0
13617 TX0 = GH, TX1 = TX0 + 1.OH(I), TX2 = TX1 + TOH(I)
13620 T = -1, FMAC(I) = T - GH + 1.OH(I) + TOH(I) + OOH(I)
13621 L2 = 1.2
13622 A = (B * T(2) - (B - 1) * L2) / (1 + B)
13624 RT = EXP(A) - B + (TX2 / A) * B
13625 IF I = 0 OR I = 11 OR I = 12 THEN GOSUB 13645
13628 TX0 = GH: TX1 = GH + 1.OH(I) + TOH(I) + OOH(I)
13630 NEXT I
13633 GOTO 13700
13640 NEXT I
13643 GOTO 13700
13645 'K OUT OF N SUBSYSTEM CALCULATION
13650 R4(I) = 0
13655 NN = NRD(I): GOSUB 13335: MFAC = FAC
13660 FOR J = K(I) TO NRD(I)
13665 NN = J: GOSUB 13335: JFAC = FAC
13670 NN = NRD(I): JFAC = FAC
13675 C = MFAC / JFAC
13680 RT(R4(I)) = R4(I) + C * RT(I) * (NRD(I) - J)
13685 NEXT J
13687 RETURN
13745 'K OUT OF N SUBSYSTEM CALCULATION
13750 RS(I) = 0
13755 NN = NRD(I): GOSUB 13355: MFAC = FAC
13760 FOR J = K(I) TO NRD(I)
13765 NN = J: GOSUB 13355: JFAC = FAC
13770 NN = NRD(I): JFAC = FAC
13775 C = MFAC / JFAC
13780 RT(RS(I)) = R5(I) + C * RT(I) * (NRD(I) - J)
13790 NEXT J
13791 RETURN
13795 'MISSION COMPLETION
13800 VR5 = 1
13810 FOR I = 1 TO 33
13815 IF OP$(I) = "DELETE" THEN GOTO 13740
13817 IF X(25) = 0 THEN GH = GOH(I) ELSE GH = 0
13820 TX0 = GH, TX1 = TX0 + 1.OH(I), TX2 = TX1 + TOH(I), TX3 = TX2 + OOH(I)
13825 T = -1, FMAC(I) = T - GH + 1.OH(I) + TOH(I) + OOH(I) + RSH(I)
13830 L1 = 2 * L1
13835 A = (B * T(2) - (B - 1) * L1) / (1 + B)
13838 RT = EXP(A) - B + (TX2 / A) * B
13840 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13745
13845 VR4 = VR4 * R4(I)
13850 NEXT I
13855 END SUB

SUB REMEQS
FOR I = 1 TO 33
W(I) = W(I) / NRD(I)
NEXT I

5500 'REMOVAL RATE EQUATIONS
5510 R11 = -1934.630978 * W(I)
5511 R12 = 20268 + 0.000888 * (Y(12)
5512 RR(1) = R11 * R12 = 0.11. RR(3) = (R11 + R12) / 2
5513 R46 = 5623 - 0.055 * X(I)
5517 IF RR(46 < 164 THEN R46 = 164
5518 IF RR(46 > 389 THEN R46 = 389
5519 RR(4) = R46 RR(5) = R46
5520 RR(9) = 8639 - 0.07903 * X2
5521 IF RR(9) < 22 THEN RR(9) = 22
5610 FOR I = 10 TO 12
5611 RR(I) = 6211 - 0.002472 * SQ(R(W(I)))
5612 IF RR(I) < 157 THEN RR(I) = 157
5613 IF RR(I) > 512000 THEN RR(I) = 512000
5614 NEXT I

C-46
5540 RR(13) = 579 * SQRT(X1)
5541 IF RR(13) < 0 THEN RR(13) = 0
5542 RR(15) = RR(15) * SHUTTLE BASED
RR(14) = 273
5560 RR(22) = 38533 * X2
5561 IF RR(22) < 23 THEN RR(22) = 23. IF RR(22) > 539 THEN RR(22) = 539
5562 RR(4) = 2 * SQRT(2) + 0.0201 * X2 * (1.052 * LOG(X2))
5563 IF RR(4) < 53 THEN RR(4) = 53. IF RR(4) > 872 THEN RR(4) = 872
5565 RR(16) = (RR(22) / RR(4) ÷ RR(22) / RR(4)) / (1 / RR(22) + 1 / RR(4))
5570 RR(17) = 368
5530 RR(18) = 4527 * X2
5531 IF RR(18) < 0 THEN RR(18) = 0
5550 RR(I) = 5194 - 8.914E-05 * W(I)
5590 IF RR(I) < 0 THEN RR(I) = 168
5551 RR(I) = 0.6026 - 0.0006758 * SQRT(XI)
5552 RR(I) = RR(I) - RR(I) / 2
5553 RR(I) = SRR(I)
FOR I = 1 TO 33
W(I) = W(I) * NR(I)
NEXT I

• BEGIN SHUTTLE VALUES
FOR I = 1 TO 33
IF SEL(I) = "SHUTTLE" THEN RR(I) = SRR(I)
NEXT I

• COMPUTE AVG REMOVAL RATE,
AREM = 0, SI = 0
FOR I = 1 TO 33
IF OPS(I) = "DELETE" THEN GOTO BTM
IF OPS(I) = "DELETE" THEN GOTO BTM
AREM = AREM + RR(I) / FMAS(I)
SI = SI + 1 / FMAS(I)
BTM: NEXT I
AREM = AREM / SI.

END SUB

SUB SECONDARY
1120 SUBROUTINE TO COMPUTE SECONDARY VARIABLES
1122 WETTED AREA
1123 V(3) = 486.026 + 1510165 * X2 * 2
1130 NBR WHEELS
1140 V(4) = 2.189572 + 6.66297E-05 * X1 + 1.38718E-10 * X1 + 2
1150 V(4) = CNT(V(4))
1160 IF V(4) < 3 THEN V(4) = 3
1170 NBR CONTROL SURFACES
1180 V(6) = 3.58837 + 0.0005281 * X1 + 0.9493 * X2 + 0.00517 * V(3)
1190 IF V(6) < 6 THEN V(6) = 6
1200 IF V(6) > 32 THEN V(6) = 32
1210 NBR ACTUATORS
1220 V(5) = 41 * 0.00425 * X1 + 2.0752E-09 * X1 + 2 + 0.007467 * V(3) + 0.0337 * SQRT(V(3)) + 0.4828 * SQRT(XI) + 14.97 * SQRT(V(6)) - 0.17811 * V(6) * 2

C-47
11230 IF V(5) < 5 THEN V(5) = 5
11240 IF V(5) > 42 THEN V(5) = 42
11250 XVA MAX
11270 V(I7) = -74.8 + 0.01098 * X(1) + 23.1571 * LOG(X(1))
11300 IF V(7) < 11 THEN V(7) = 11
11310 IF V(7) > 484 THEN V(7) = 484
11340 'NBR AVIONICS SYSTEMS (TOTSUBS)
11350 V(I0) = 40.3242 - 1.879605 * X(3) + 6.92823 * LOG(X(1))
11360 IF V(I0) < 9 THEN V(10) = 9
11370 V(I0) = CINT(V(I0))
11420 'NBR DIFFERENT AVIONICS SUBSYSTEMS
11430 V(I1) = 9.674 - 1.858 * LOG(X(I)) + 8.7648 * V(I0) + 1.45573 * LOG(WAV)
11440 IF V(I1) < 5 THEN V(I1) = 5: IF V(I1) > V(I0) THEN V(I1) = V(I0)
11450 V(I1) = CINT(V(I1))
11460 'RTU COOLING
11470 V(I2) = -0.11452 - 12(0.78 * X2 + 0.009405 * X2 * 2 + 230.872 * SQR(X2)
11480 IF V(I2) < 25 THEN V(I2) = 25
11490 IF V(I2) > 470.5 THEN V(I2) = 470.5
11510 'NBR HYDRAULICS SUBSYSTEMS
11520 V(I3) = -1.2326 + 1.817272 * LOG(X(I))
11530 IF V(I3) < 2 THEN V(I3) = 2
11540 IF V(I3) > 12 THEN V(I3) = 12
11550 V(I3) = CINT(V(I3))
11560 'FUSELAGE AREA
11570 V(I4) = 8832.74 + 1.02862 * X(1) + 1274.76 * LOG(X(I)) - 32.456 * SQR(X(I))
11580 IF V(I4) < 478 THEN V(I4) = 478
11590 IF V(I4) > 571 THEN V(I4) = 571
11600 'FUSELAGE VOLUME
11610 V(I5) = -4768.5 + 21243 * LOG(X2) - 5743.99 * SQR(X2) + 42623 * X2 * 2
11620 IF V(I5) < 571 THEN V(I5) = 571
11630 END SUB
SUB SIM
'X' = nbr maintenance actions
'Y' = on-veh task time
'Z' = off-veh task time
'XX' = removal rate
'YY' = sched maint on-veh task time
'ZZ' = sched maint off-veh task time
'XC' = avg crew size
'CH(I)' = nbr crews assigned
FOR I = 1 TO 9: CH(I) = 0: NEXT I
'STRUCTURAL
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 1 TO 3
IF OPP(I) = 'DELETE' THEN GOTO Q1
X = X + NRD(I) * (1 - PFI(I) * POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CH(I) = CH(I) + CA(I)
Q1: NEXT I
FOR I = 1 TO 3
IF OPP(I) = 'DELETE' THEN GOTO Q1
IF SELS(I) = 'SHUTTLE' THEN TSKT(I) - SMR(I) ELSE TSKT(I) = (1 - PFI(I) * MHMA(I) / CI)
Y = Y + TSKT(I) * (NRD(I) * (1 - PFI(I) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + TEMP * (NRD(I) * (1 - PFI(I) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (1 - PFI(I) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + 98 * TOWM * SCHR * (NRD(I) * (1 - PFI(I) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / (TMA * CI))
ZZ = ZZ + 0.2 * TCM(* SCH(R) * (NRD(I) * (1 - PFI(I) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / (TMA * CI))
XC1 = XC1 + CI) * (NRD(I) * (1 - PFI(I) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (1 - PFI(I) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q1: NEXT I
FRS(I) = XF
MAS(I) = X
MTROS(I) = Y
MTF(I) = Z
RTM(I) = XX
SMR(I) = YY
SMF(I) = ZZ
SC(I) = XC1
IF X = 0:
SC(6) SMT(6) - YY
MTRFS(6) - Z
MAS(6)
END 1F

Q66: NEXT
XCI - XC1
YY
Z - Z
IF SEL$(I) - FOR 1
CZ(6) - CZ(6) _
SMTF(5) - ZZ
REMS(5) XX
MTRFS(5) YY
MAS(5)
Q55: NEXT 1
XF - XF "FRO) * (NRD(I) * ((I
XC1 - ZZ - ZZ P D2 * TOMH * SCHP * (NRD(I) *
YY XX - XX 4 RR(I) " (NRD(I)
Z
Y
IF OP$(I) - "DELETE." THEN X - X
X9
Q5: NEXT I

POWER/FLIGHTIAL
X - 0 Y - 0 Z - 0 XX - 0 YY - 0 XC1 - 0 ZZ - 0 XF - 0
FOR I = 1 TO 5
IF OP(I) - "DELETE" THEN GOTO Q5
X - X + NRD(I) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I))
CZ5) + C5(I) + (A5)
Q5 NEXT I
FOR I = 1 TO 16
IF OP(I) - "DELETE" THEN GOTO Q55
Y - Y + TSKT(I) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I))
Z - Z + (PI(I) * MHMA(I) / C(I)) * (NRD(I) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
XX - XX + RR(I) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
YY - YY + 98 * TOMH * SCHP * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / (TMA * C(I)))
ZZ - ZZ + 02 * TOMH * SCHP * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / (TMA * C(I)))
XCI - XCI + C(I) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
XF - XF + FR(I) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
Q66 NEXT I

IF SEL$(9) < > "DELETE" THEN GOTO Q66
Y - Y + TSKT(I) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
Z - Z + (PI(I) * MHMA(I) / C(I)) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
XX - XX + RR(I) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
YY - YY + 98 * TOMH * SCHP * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / (TMA * C(I)))
ZZ - ZZ + 02 * TOMH * SCHP * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / (TMA * C(I)))
XCI - XCI + C(I) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
XF - XF + FR(I) * (NRD(I)) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)) / X)
Q66 NEXT I

IF SEL$(9) < > "DELETE" THEN
Y - Y + TSKT(I) * X Y / X
Z - Z + (PI(I) * MHMA(I) / C(I)) * (X9 / X
XX - XX + RR(I) * X9 / X
YY - YY + 98 * TOMH * SCHP * X9 / (TMA * C9)
ZZ - ZZ + 02 * TOMH * SCHP * X9 / (TMA * C9)
XCI - XCI + C9 / X9 / X
XF - XF + FR(I) * X9 / X9 / X
C7(I) - C7(I) + CA9(I)
END IF

AVIONICS
X - 0 Y - 0 Z - 0 XX - 0 YY - 0 XC1 - 0 ZZ - 0 XF - 0
FOR I = 19 TO 24
IF OP(I) - "DELETE" THEN GOTO Q7
X - X + NRD(I) * ((I - PI(I)) * POH(I) / FMA(T(I) + THRS(I) / FMA(S(I)))
C-50
C7(7) - C7(7) + CA(I)
Q7 NEXT I
FOR I = 1 TO 24
IF OPS(I) = "DELETE" THEN GOTO Q7
IF SF1S(I) = "SHUTTLE" THEN GOTO Q8
ELSE TSKT(I) = SMR(I) ELSE TSKT(I) = (1 - PF(I)) * MIMA(I) / C(I)
Y = Y + 1 TSKT(I) * (NRD(I) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / X
Z = Z - 1 (PF(I) * MIMA(I) / C(I)) * (NRD(I) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / X
XX = XX + 1 RR(0) * (RR(0) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / X
YY = YY + 98 * TOMH * SCBP * (RRD(I) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / (TMA * C(I))
ZZ = ZZ - 0 * TOMH * SCBP * (RRD(I) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / (TMA * C(I))
XX = XX + 1 RR(0) * (RR(0) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / X
YY = YY + 98 * TOMH * SCBP * (RR(0) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / X
Z = Z - 1 (PF(I) * MIMA(I) / C(I)) * (RRD(I) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / X
X = X + 1 RR(I) * (RRD(I) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / X
Y = Y + 1 RR(I) * (RRD(I) * (1 - PI(I) * POH(I)) / FMAT(I) + THRS(I) / FMAS(I)) / X
Q7 NEXT I
MTRFS(8) = Y
MTRFS(8) = Z
REMS8 = XX
SMTF(8) = YY
SMF(8) = ZZ
SC(8) = XCI

END SUB

Q99 NEXT I
MTRFS(9) = Y
MTRFS(9) = Z
REMS9 = XX
SMTF(9) = YY
SMF(9) = ZZ
SC(9) = XCI

END SUB
SUB SPACEMTB
2000 'MODULE TO DETERMINE SPACE ADJUSTED MTBM
2010 YZ - 0: YX - 1
2020 FOR J = 1 TO 33
2030 T0 - GOH(J): T1 - T0 + 1: GOH(J): T2 - T1 + TOH(J)
2040 IF OP(J) = "DELETE" THEN GOTO 2100
2050 IF SF1(J) = "SHUTTLE" AND X(J) = 0 THEN MEAN - FMAT(J)/PI(J) GOTO 2080
2060 IF UPS(J) = "DELETE" THEN GOTO 2100
2065 IF SFL$O(J) = "SHUTTLE" AND X(J) = 0 THEN MEAN - FMAT(J)/PI(J) GOTO 2080
2070 IF SFL$O(J) = "SHUTTLE" AND X(J) = 0 THEN MEAN - FMAT(J)/PI(J) GOTO 2080
2080 FMAT(J) - MEAN
2090 YZ - YZ / MEAN
2095 YX - YX * RT4
2100 NEXT J
2101 SVFMAT - I/YZ: VR - YX
2102 EXIT SUB
2200 'MODULE TO COMPUTE SPACE ADJUSTED MTBM
2210 A - (B * T2) / (B - 1)
2215 A1 - (I / B)
2220 A2 - EXP(I * T2) / (1 - EXP(I * T2)) / L2
2225 A3 - EXP((I * T2 + T0) / L2) / (1 - EXP((I * T2 + T0) / L2))
2230 A4 - EXP((I * T2 + T0) / L2) / (1 - EXP((I * T2 + T0) / L2)) * (1 / L2)
2235 A5 - EXP((I * T2 + T0) / L2) / (1 - EXP((I * T2 + T0) / L2)) * (1 / L2) * (1 / L2)
2240 A6 - EXP((I * T2 + T0) / L2) / (1 - EXP((I * T2 + T0) / L2)) * (1 / L2) * (1 / L2)
2250 MEAN - MEAN / (1 - RT4)
2255 RETURN
2260 N - INT((T3 - T2) / 5)
2265 IF N = 0 THEN AREA - 0: RETURN
2270 DX - (T3 - T2) / N
2275 FX - 4
2280 Z1 - T2: SUM - EXP(-Z1 / A) / B
2290 FOR I = 1 TO N
2295 Z1 - Z1 + DX
2300 Y1 - EXP(-Z1 / A) / B
2305 IF I = N THEN FX - I
2310 SUM - SUM + FX * Y1
2315 IF FX > 4 THEN FX = 4 ELSE FX = 4
2320 NEXT I
2325 AREA - DX * SUM / 3
2330 RETURN
END SUB

SUB SPARES
8000 'SPARES CALCULATIONS
8010 ARR - 0: TRS - 0: KK - 0: TNR - 0
8020 FOR J = 1 TO 33
8030 IF UPS(J) = "DELETE" THEN GOTO 8100
8040 NR(J) - RR(J) * (NRD(J) * (I - PI(J)) * POH(J) / FMAT(J) + THRS(J) / FMAS(J)) MEAN NBR REMOVALS
8045 MN - NR(J)
8050 IF MN < 20 THEN GOSUB 8300 ELSE GOSUB NORM ' COMPUTE FILL RATE REQMT - POISSON/NORM
8055 S(I) - STK: FRO - I
8060 TNR - TNR + NR(J)
8150 ARR - ARR + RR(J)
8160 TS - TS + S(I)
8170 KK - KK + 1
8180 NEXT I
8190 ARR - ARR / KK
8200 GOTO IOUT
8300 'COMPUTE SPARES USING POISSON DIST
8310 P - EXP(MN): P = P
8320 IF P > X(13) THEN JD = 1: GOTO 8370
8330 JD - 1: P = P
8340 P = P * MN / JD
8350 JD - JD + 1: F = F + P
8360 IF F < X(13) THEN GOTO 8340
8370 STK - JD - 1
8380 RETURN

'NORMAL (STRONG'S) APPROXIMATION
NORM: FC - I - X(13)
SD - SQRT(MN)
Z = (X - FC) / (SQRT(MN) * 2.0489)
STK - CINT(MN + Z * SD)
C-52
RETURN

RETURN TO MAIN

END SUB

SUB TECH

2500 TECHNOLOGY ADJUSTMENT MODULE

2510 Y = 0

2520 FOR I = 1 TO 33

2530 IF OP$(I) = "DEI.ETE" THEN GOTO 2560

2540 IF OP$(I) = "SHU_'I.E" THEN XYZ = 1992 ELSE XYZ = 1986

2550 FMAT(I) = FMA(I) * (YR - XYZ)

2560 NEXT I

2570 TVFMA = 1 / Y

EXIT SUB

END

SUB WRFILE

' module to write to a file arg1 output

C0 : COLOR 11

PRINT TAB(10); "RAM-ASCII OUTPUT FILES": PRINT

FILES ASC

PRINT COLOR 11

PRINT TAB(12); "OUTPUT WILL BE SAVED IN FILE": VNAMES ASC

LOCATE 20, 12: INPUT "ENTER RETURN TO PROCEED OR A POSITIVE NBR TO ABORT"; RET

IF RET > 0 THEN EXIT SUB

OPEN VNAMES ASC FOR OUTPUT AS #1

SUB WRFILE

' module to write to a file arg2 output

C53
PRINT #1, TAB(5), RTITLE$ PRINT #1, TAB(5), COMMENTS PRINT #1. PRINT #1, TAB(25), "INPUT PARAMETERS & DATA - page 1" PRINT #1, PRINT #1, TAB(1), "VHICLTE IS ", VNAM$, TAB(35), "DATE ", DATES, TAB(40), "TIME ", TIMES PRINT #1, PRINT #1, : PRINT #1, PRINT #1, "SYSTEM PARAMETER VALUES" PRINT #1, PRINT #1, TAB(10), "PARAMETER", TAB(50), "VALUE" PRINT #1, FOR I = 1 TO 25 PRINT #1, TAB(I), NAM$(1), TAB(50), X(I)
IF I = 2 THEN PRINT #1, TAB(I), "WING SPAN", TAB(50), WING NEXT I
PRINT #1, PRINT #1. PRINT #1, TAB(5), "SECONDARY VARIABLE VALUES" PRINT #1, PRINT #1, PRINT #1, TAB(10), "VARIABLE", TAB(40), "VALUE" PRINT #1, FOR I = 1 TO 13 PRINT #1, TAB(I), SNAM$(1), TAB(40), VI
NEXT I
PRINT #1, CHR$(12), PRINT #1, TAB(25), "INPUT PARAMETERS & DATA - page 2" PRINT #1, PRINT #1, TAB(1), "SUBSYSTEM WEIGHTS & CALIBRATION FACTORS" IF X(I6) = 0 THEN PRINT #1, PRINT #1, TAB(1), "WBS", TAB(30), "WEIGHT", TAB(40), "PCT WGT", TAB(52), "MTBM FACTOR", TAB(65), " MTTR FACTOR" : GOTO FEX2 PRINT #1, PRINT #1, TAB(1), "WBS", TAB(30), "WEIGHT", TAB(40), "MTBM FACTOR", TAB(50), "MTTR FACTOR" ADD = 0 FEX2: FOR I = 1 TO 33 IF OPS$(I) = 'DELETE' THEN GOTO FEX4 ADD = ADD + 1
IF X(I6) = 0 THEN PRINT #1, TAB(1), WBS$(I), TAB(30), W(I), TAB(40), PWTS(I), TAB(52), MW0(I), TAB(65), CM0(I) : GOTO FEX1 PRINT #1, TAB(1), WBS$(I), TAB(30), W0(I), TAB(40), MW0(I), TAB(65), CM0(I) : GOTO FEX1 : NEXT I PRINT #1, PRINT #1, TAB(1), TOTAL WEIGHT, TAB(30), ADD, TAB(50), "WEIGHT FACTOR IS ", PWF PRINT #1, PRINT #1, PRINT #1, TAB(1), TAB(10), "SCHEDULED MAINTENANCE PERCENT IS ", TAB(45), 100 * SCHP PRINT #1, CHR$(12),
PRINT #1, TAB(25), "INPUT PARAMETERS & DATA - page 3" PRINT #1, PRINT #1, PRINT #1, PRINT #1, PRINT #1, "SUBSYSTEM OPERATING HOURS" PRINT #1, PRINT #1, TAB(1), "SUBSYSTEM", TAB(30), "PROCESS", TAB(19), "PAD", TAB(40), "BOOST", TAB(52), "RE TIME", TAB(61), "ORBIT", TAB(68), " REENTRY" PRINT #1, TAB(1), "TIME", TAB(30), "TIME", TAB(40), "TIME", TAB(52), "TO-ORBIT", TAB(61), "TIME", TAB(68), " TIME" FOR I = 1 TO 33 IF OPS$(I) = 'DELETE' THEN GOTO FEX4 PRINT #1, TAB(1), WBS$(I), TAB(32), PISH$(I), TAB(39), OISH$(I), TAB(46), LOH(I), TAB(63), TOH(I), TAB(66), OOH$(I), TAB(67), ROH(I) FEX4: NEXT I
PRINT #1, CHR$(12),
PRINT #1, TAB(25), "INPUT PARAMETERS & DATA - page 4" PRINT #1, PRINT #1, PRINT #1, PRINT #1, PRINT #1, "SUBSYSTEM COMPUTATION FACTORS" PRINT #1, PRINT #1, TAB(1), "SUBSYSTEM", TAB(28), "TECH GROWTH", TAB(40), "CRITICAL", TAB(55), "REMOVAL", TAB(70), "PERCENT" PRINT #1, TAB(28), "FACTOR", TAB(40), "FAIL RATE", TAB(55), "RATE", TAB(70), "OFF EQUIP" : PRINT #1, FOR I = 1 TO 33 IF OPS$(I) = 'DELETE' THEN GOTO FEX5 PRINT #1, TAB(1), WBS$(I), TAB(28), TG$(I), TAB(40), PA$(I), TAB(55), RR$(I), TAB(70), PF$(I) FEX5: NEXT I
PRINT #1, CHR$(12),
PRINT TAB(25), "INPUT PARAMETERS & DATA - page 5" PRINT #1, PRINT #1, PRINT #1, PRINT #1, PRINT #1, "MORE SUBSYSTEM COMPUTATION FACTORS" PRINT #1, PRINT #1, TAB(1), "SUBSYSTEM", TAB(28), "CREW", TAB(40), "NBR CREWS", TAB(55), "FRACTION INHERENT" PRINT #1, TAB(28), "SIZE", TAB(40), "ASGN", TAB(55), "FAILURES": PRINT #1, FOR I = 1 TO 33 IF OPS$(I) = 'DELETE' THEN GOTO FEX6 PRINT #1, TAB(1), WBS$(I), TAB(39), CI$(I), TAB(40), CA$(I), TAB(55), PI$(I) FEX6: NEXT I
PRINT #1, CHR$(12),
PRINT #1, TAB(25), "INPUT PARAMETERS & DATA - page 6" PRINT #1, PRINT #1, PRINT #1, PRINT #1, PRINT #1, "SUBSYSTEM REDUNDANCY": PRINT #1, PRINT #1, TAB(1), "SUBSYSTEM", TAB(28), "REDUNDANT", TAB(45), "MIN NBR" PRINT #1, TAB(28), "SUBSYS", TAB(45), "REQUIRED": PRINT #1, FOR I = 1 TO 33 IF OPS$(I) = 'DELETE' THEN GOTO FEX7 PRINT #1, TAB(1), WBS$(I), TAB(29), NR$(I), TAB(45), K$(I) FEX7: NEXT I
PRINT #1, CHR$(12),
PRINT #1, TAB(25), "INPUT PARAMETERS & DATA - page 7" PRINT #1, PRINT #1, PRINT #1, PRINT #1, PRINT #1, "SHUTTLE (FILE MAINTAINED) UTILIZED VALUES": PRINT #1,

C-54
PRINT #1, TAB(1), "SUBSYSTEM", TAB(30), "MTBM", TAB(50), "MTTR".
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO FEX7;
IF $I$(1) > "SHUTTLE" THEN GOTO FEX7
PRINT #1, TAB(1), WBS$(I), TAB(30), SMA$(I), TAB(50), SMR$(I).
FEX7: NEXT I
PRINT #1, CHR$(12),

**** PRINT #1, MODULE FOR RELIABILITY REPORT ****

X = 0: Y = 0: Z = 0: 'AVIONICS ROLLUP
FOR I = 19 TO 24
IF OP$(I) = "DELETE" THEN GOTO NA2
IF RELF$(I) = 1 THEN GOTO NA1
X = X + 1: FMA$(I)
Y = Y + 1: FMAT$(I)
Z = Z + 1: FMAS$(I)
NA1: NEXT I
IF X > 0 THEN XA = 1 / X
IF Y > 0 THEN YA = 1 / Y
IF Z > 0 THEN ZA = 1 / Z
MNFMA = 0
I0 = 1: IF = 15
PRINT #1, TAB(1), WBS$(I), TAB(30), "DATE", TAB(60), "TIME": TIMES PRINT #1,
PRINT #1, "MTBM's are for a single subsystem, e.g. one engine"
PRINT #1, TAB(1), "WBS", TAB(26), "TECH/GROWTH MTBM", TAB(45), "GRND PROC MTBM", TAB(51), "MISSION MTBM"
PRINT #1, TAB(29), "(all MA's)", TAB(45), "(Critical MA's)", TAB(61), "(inherent MA's)"
FOR I = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO SA1
MNFMA = MNFMA + (1 - PI(I) / FMAT$(I))
IF I = 9 THEN PRINT #1, TAB(1), WBS$(I), "MTBM's/Failure", TAB(35), FMAT$(I), TAB(48), FMAT$(I) / (1 - PI(I)), TAB(61), FMAS$(I)
IF I = 10 THEN PRINT #1, TAB(1), WBS$(I), TAB(35), FMAT$(I), TAB(48), FMAT$(I) / (1 - PI(I)), TAB(61), FMAS$(I)
IF I = 24 THEN PRINT #1, TAB(5), "AVIONICS ROLLUP", TAB(32), XA, TAB(45), YA, TAB(58), ZA
SA1: NEXT I
PRINT #1, PRINT #1,
PRINT #1, TAB(5), "VEHICLE", TAB(35), TVFMA, TAB(48), Y / MNFMA, TAB(51), SVFMA
PRINT #1, CHR$(12),
X = 0: Y = 0: Z = 0: 'AVIONICS ROLLUP
FOR I = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO NA2
K = K + 1
X = X + PI(I)
Y = Y + 1: FMAC$(I) : YA = 1 / Y
Z = Z * R(I)
NA2: NEXT I
IF K = 0 THEN K = 1
XA = X / K
I0 = 1: IF = 15
PRINT #1, TAB(20), "RELIABILITY REPORT - at mission shr.", X(24), " - page 2": PRINT #1,
PRINT #1, TAB(1), "COMMENTS": PRINT #1,
PRINT #1, TAB(1), "Critical MTBM's are for a single subsystem, e.g. one engine": PRINT #1,
PRINT #1, TAB(1), "WBS", TAB(28), "CRITICAL FAILURE", TAB(48), "CRITICAL", TAB(60), "SUBSYS NON"
IF X(25) = 0 THEN PRINT #1, TAB(28), "RATE: grade az", TAB(48), "MTBM", TAB(60), "REDUNDANT MTBM REEL"
IF X(25) = 1 THEN PRINT #1, TAB(28), "RATE: air only", TAB(48), "MTBM", TAB(60), "REDUNDANT MTBM REL"
PRINT #1, TAB(1), "WBS", TAB(33), "CRITICAL", TAB(48), "CRITICAL", TAB(60), "SUBSYS NON"
PRINT #1, TAB(33), "FAIL RATE": TAB(48), "MTBM": TAB(60), "REDUNDANT MTBM REL": PRINT #1,
FOR I = 10 TO 33
IF OP$(I) = "DELETE" THEN GOTO SA2
PRINT #1, TAB(1), WBS$(I), TAB(33), PA$(I), TAB(48), FMAC$(I), TAB(65), R(I)
IF I = 24 THEN PRINT #1, TAB(5), "AVIONICS ROLLUP", TAB(27), XA, "AVG": TAB(45), YA, TAB(62), Z
SA2: NEXT I
PRINT #1, PRINT #1,
PRINT #1, TAB(5), "VEHICLE", TAB(48), CVFMA, TAB(65), VR
PRINT #1, CHR$(12),
I0 = 1: IF = 15
PRINT #1, TAB(20), "RELIABILITY REPORT - at mission shr.", X(24), " - page 3": PRINT #1,
X = 1: Y = 1: Z = 1: 'AVIONICS ROLLUP
FOR I = 19 TO 24
IF OP$(I) = "DELETE" THEN GOTO NA3
X = X * R(I)
Y = Y * R(I)
Z = Z * R(I)

C-55
PRINT #1, "reliabilities based upon redundancy"

FOR I = 10 TO IE
  IF OP$(I) = "DELETE" THEN GOTO SA3

  PRINT #1, WBS$(I), TAB(32), NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)
  Y = Y + FMH(I)
Z = Z + 1 - PF(I)

SA6: NEXT I

IF OP$(I) = "DELETE" THEN GOTO SA5
PRINT #1, "ON-VEH MH", TAB(32), AMMMA, "WT-AVG", TAB(65), VMH
PRINT #1, CHR$(12)

SA5: NEXT I

PRINT #1, TAB(20), "MAINTAINABILITY REPORT - at mission nbr ", X(24), ": page 2": PRINT #1,
PRINT #1, "reliabilities based upon redundancy"
PRINT #1, TAB(1), "WBS", TAB(32), "ON-VEH MH", TAB(47), "OFF-VEH MH", TAB(62), "FRACTION ON VEH": PRINT #1,
FOR I = 10 TO IE
  IF OP$(I) = "DELETE" THEN GOTO SA5

  PRINT #1, WBS$(I), TAB(32), OMR(H(I)
Y = Y + FMH(I)
Z = Z + 1 - PF(I)
SA5: NEXT I

PRINT #1, TAB(1), TAB(1), "WBS", TAB(32), "ON-VEH MH", TAB(47), "OFF-VEH MH", TAB(62), "FRACTION ON VEH": PRINT #1,
FOR I = 10 TO IE
  IF OP$(I) = "DELETE" THEN GOTO SA5
PRINT #1, TAB(1), WBS$(I), TAB(32), OMR(H(I), TAB(50), FMH(I), TAB(65), 1 - PF(I)
IF I = 24 THEN PRINT #1, TAB(5), "AVIONICS ROLLUP"; TAB(29), X, TAB(47), Y, TAB(62), ZA, "(AVG)"
SA$: NEXT I
PRINT #1: PRINT #1,
PRINT #1, TAB(5), "UNSCHEDULED", TAB(32), TOMH, TAB(50), TMFH, TAB(5), APF, "(AVG)"; PRINT #1,
PRINT #1, TAB(5), "SCHEDULED", TAB(32), 98 * SCHP * TOMH, TAB(50), 02 * SCHP * TOMH, PRINT #1,
PRINT #1, TAB(5), "TOTAL", TAB(32), TOMH + 98 * SCHP * TOMH, TAB(50), TMFH + 02 * SCHP * TOMH,
PRINT #1, CHR(12),

X = Y = Z = 0 "AVIONICS ROLLUP"
FOR I = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO MY8
X = X + NRD(I) * (1 - P0H(I) * P0R(I) / FMAT(I))
Y = Y + NRD(I) / THSR(I) / FMAS(I)
MY8: NEXT I
IF I = 10 THEN I = 33
TXX = 0; TYY = 0
MY?): PRINT #1, TAB(10), "MAINTENABILITY REPORT - at mission nber ", X(24), ": page 3"; PRINT #1,
PRINT #1, TAB(5), "Note: Ground processing MA's consist of induced and no defect MA's";
PRINT #1, TAB(5), "Mission MA's are inherent equipment failures"; PRINT #1,
PRINT #1, TAB(1), "WBS", TAB(32), "GRND PROC MA", TAB(50), "MSN MA", TAB(65), "TOTAL MA"; PRINT #1,
FOR I = 1 TO 10
IF OP$(I) = "DELETE" THEN GOTO MY9
X = X + MH(I)
Z = Z + MP(I)
SA$: NEXT I
Y = X(15) * X / 12
MT = 0
IO = I; IT = 33; ASTP = 0
PRINT #1, TAB(5), RITLES: PRINT #1,
PRINT #1, TAB(5), COMMENTS: PRINT #1, : PRINT #1,
PRINT #1, TAB(25), "MAINTENABILITY REPORT - at mission nber ", X(24), ": "; PRINT #1,
PRINT #1, TAB(1), "VEHICLE IS ", VNAME, TAB(35), "DATE ", DATE$, TAB(60), "DTE ", TIME$: PRINT #1,
PRINT #1, TAB(5), "AVAIL HRS/MO ", X(11), TAB(40), "INDIRECT WORK ": IOD * X(12), "%"
PRINT #1, TAB(5), "SCHEDULED MA's computed from manpower divided by email direct hrs per ma per person"
PRINT #1, "sbe crews is computed from manpower divided by avg crew"
PRINT #1, TAB(1), "WBS", TAB(27), "MANHRS/MSN", TAB(42), "MANHRS/MO", TAB(38), "MANPWR", TAB(65), "AVG CREW"
PRINT #1,
FOR I = 10 TO 1
IF OP$(I) = "DELETE" THEN GOTO PA1
IF I > 19 AND I < 24 THEN ASTP = ASTP + 1
PRINT #1, TAB(1), WBS$(I), TAB(30), MH(I), TAB(45), (X(15) * MH(I) / 12; TAB(59), MP(I), TAB(65), CD)
IF I = 24 THEN PRINT #1, TAB(5), "AVIONICS ROLLUP"; TAB(28), X, TAB(43), Y, TAB(58), Z, TAB(63), ASTP
PA$: NEXT I
PRINT #1,
PRINT #1, PRINT #1, TAB(5), "UNSCHEDULED", TAB(30), VMH, TAB(45), VMH * X(15) / 12, TAB(39), TMH - SMP, TAB(65), STP
PRINT #1, PRINT #1, TAB(5), "SCHEDULED", TAB(30), SCHP * TMH, TAB(45), X(15) * SCHP * TMH / 12, TAB(39), SMP, TAB(63), X(14)
PRINT #1, PRINT #1, TAB(5), "TOTAL", TAB(30), VMH + SCHP * TMH, TAB(43), VMH + SCHP * TMH + X(15) / 12, TAB(39), TMH, TAB(63), STP + X(14) COLOR
PRINT #1, PRINT #1, TAB(1), "Actual personel assigned - SUM (avg crew size * sbe crews) / sbe manpower", TAB(75), INT(MT / SMP
PRINT #1, CHR(12),

PRINT #1, SPARES RESULTS
X = 0; Y = 0; Z = 0; K = 0 "AVIONICS ROLLUP"
FOR I = 19 TO 24
IF OP$(I) = "DELETE" THEN GOTO SB7
K = K + 1
X = X + RR(I)
Y = Y + NR(I)
Z = Z + S(I)
SX = SX + FR(I)
SB7: NEXT I
KX = X / K
JX = SX / K
C-57
PRINT #1, TAB(5); RTITLE$; PRINT #1,
PRINT #1, TAB(5); COMMENTS PRINT #1, PRINT #1,
PRINT #1, TAB(20); "SUBSYSTEM SPARES REPORT" AT mission nbr ", X(24), " - PRINT #1,
PRINT #1, TAB(1); "VEHICLE IS ", VNAME, TAB(15), "DATE: ", DATES, TAB(60), "TIME ", TIMES: PRINT #1,
PRINT #1, TAB(5), "NOTE: failures as assumed to be Poisson" PRINT #1,
PRINT #1, TAB(32); "REMOVAL", TAB(42), "MEAN DEMAND", TAB(56), "SPARES", TAB(65), "EFFECTIVE" PRINT #1,
PRINT #1, TAB(1); "WS", TAB(32), TAB(31), "RAT-MA", TAB(42), "PRM MISSION", TAB(56), "RQMT", TAB(63), "FILL RATE" PRINT #1,
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO SA5
PRINT #1, TAB(1), PRINT #1, TAB(5), "TOTALS", TAB(27), ARR, "(AVG)", TAB(45), TNR, TAB(55), TS
PRINT #1, CHR$(12); PRINT #1, TAB(1), PRINT
PRINT #1, TAB(20); "VEHICLE TURN TIME"
TT = 0: TI = 0: TMAX = 0
SUM = 0: CT = 0: SUMC = 0
END IF
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO TA1
CT = CT + 1
SUM = SUM + TSKT(I)
END IF
IF I > TMAX THEN TMAX = I: JJ = I
TT = TT + TI
END IF
SA5: NEXT I
PRINT #1, TAB(1), PRINT #1, TAB(5), "NOTE: failures as assumed to be Poisson" PRINT #1,
PRINT #1, TAB(32); "REMOVAL", TAB(42), "MEAN DEMAND", TAB(56), "SPARES", TAB(65), "EFFECTIVE" PRINT #1,
PRINT #1, TAB(1); "WS", TAB(32), "RAT-MA", TAB(42), "PRM MISSION", TAB(56), "RQMT", TAB(63), "FILL RATE" PRINT #1,
DVTT - (T(0) + T(4)) / 24 + (TSAVE) / 16 + X(17) + X(18)
PRINT #1, TAB(5), "TOTAL VEHICLE TURNAROUND TIME": TAB(55), DVTT, "DAYS"
PRINT #1, TAB(5), "AVG MISSIONS/YR/VEHICLE": TAB(55), 12 * 21 / DVTT
PRINT #1, TAB(5), "COMPUTED FLEET SIZE": TAB(55), INT(X(15) / 12) / (21 / DVTT) + .99
PRINT #1, PRINT #1,
PRINT #1, TAB(1), "TWO SHIFTS/DAY MAINTENANCE": PRINT #1,
DVTT - (T(0) + T(4)) / 24 + (TSAVE) / 16 + X(17) + X(18)
PRINT #1, TAB(5), "TOTAL VEHICLE TURNAROUND TIME": TAB(55), DVTT, "DAYS"
PRINT #1, TAB(5), "AVG MISSIONS/YR/VEHICLE": TAB(55), 12 * 21 / DVTT
PRINT #1, TAB(5), "COMPUTED FLEET SIZE": TAB(55), INT(X(15) / 12) / (21 / DVTT) + .99
PRINT #1, PRINT #1,
PRINT #1, TAB(5), "NOTE: Assumes sequential tasks, 8 hr shifts, and 21 work days a month"
PRINT #1, CHR$(12),
PRINT #1, TAB(20), "VEHICLE TURNAROUND REPORT at mission nbr": X(24); " page 3": PRINT #1,
PRINT #1, TAB(1), "VEHICLE IS": VNAMS, TAB(55); "DATE": TXT, "DATE": TAB(60), "TIME": TIME
PRINT #1,
PRINT #1, PRINT #1, TAB(5), "CATEGORY": TAB(52), "MAX TURN TIMES": PRINT #1,
PRINT #1, TAB(5), "SCID MAINT MEN TASK TIME": TAB(55), SCMT, "HRS"
PRINT #1, TAB(5), "UNSCHD MAINT TIME": TAB(55), TT, "HRS"
PRINT #1, TAB(5), "INTEGRATION TIME": TAB(55), X(17), "DAYS"
PRINT #1, TAB(5), "LAUNCH PAD TIME": TAB(55), X(18), "DAYS"
PRINT #1, TAB(5), "MISSION TIME: INC GRND TIME": TAB(55), T(0) + T(4), "HRS"
VTT - T(0) + T(4) / TT + SCMT + X(17) * 24 + X(18) * 24
PRINT #1, TAB(5), "TOTAL VEHICLE TURNAROUND TIME": TAB(55), VTT, "TOTAL HRS"
PRINT #1, PRINT #1,
PRINT #1, TAB(1), "ONE SHIFTS/DAY MAINTENANCE": PRINT #1,
DVTT - (T(0) + T(4)) / 24 + (TT + SCMT) / 16 + X(17) + X(18)
PRINT #1, TAB(5), "TOTAL VEHICLE TURNAROUND TIME": TAB(55), DVTT, "DAYS"
PRINT #1, TAB(5), "AVG MISSIONS/YR/VEHICLE": TAB(55), 12 * 21 / DVTT
PRINT #1, TAB(5), "COMPUTED FLEET SIZE": TAB(55), INT(X(15) / 12) / (21 / DVTT) + .99
PRINT #1, PRINT #1,
PRINT #1, TAB(1), "TWO SHIFTS/DAY MAINTENANCE": PRINT #1,
DVTT - (T(0) + T(4)) / 24 + (TT + SCMT) / 16 + X(17) + X(18)
PRINT #1, TAB(5), "TOTAL VEHICLE TURNAROUND TIME": TAB(55), DVTT, "DAYS"
PRINT #1, TAB(5), "AVG MISSIONS/YR/VEHICLE": TAB(55), 12 * 21 / DVTT
PRINT #1, TAB(5), "COMPUTED FLEET SIZE": TAB(55), INT(X(15) / 12) / (21 / DVTT) + .99
PRINT #1, PRINT #1,
PRINT #1, TAB(5), "NOTE: Assumes sequential tasks, 8 hr shifts, and 21 work days a month"
PRINT #1, CHR$(12),
CLOSE #1
END SUB
## APPENDIX D
### VARIABLE DEFINITIONS

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Basic Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRY WGT</td>
<td>$X(1), X_1$</td>
<td>Empty weight (without fuel, oil, crew, or cargo) of vehicle in pounds.</td>
</tr>
<tr>
<td>LEN+WING</td>
<td>$X_2$</td>
<td>Aircraft length plus wing span in feet.</td>
</tr>
<tr>
<td>WETTED AREA</td>
<td>$V(3)$</td>
<td>Total external surface area of vehicle in square feet (includes canopy). External skin laid flat.</td>
</tr>
<tr>
<td>FUSELAGE VOL</td>
<td>$V(2)$</td>
<td>Total volume of fuselage in cubic feet excluding any engine inlet duct volume.</td>
</tr>
<tr>
<td>FUSELAGE AREA</td>
<td>$V(1)$</td>
<td>External area of fuselage in square feet including canopy.</td>
</tr>
<tr>
<td>CREW SIZE</td>
<td>$X(3)$</td>
<td>Total number of crew members in a normal flight crew for the vehicle.</td>
</tr>
<tr>
<td>NBR PASSENGERS</td>
<td>$X(4)$</td>
<td>Maximum number of passengers.</td>
</tr>
<tr>
<td>NBR MAIN ENGINES</td>
<td>$X(5)$</td>
<td>Number of primary engines.</td>
</tr>
<tr>
<td>NBR WHEELS</td>
<td>$V(4)$</td>
<td>Total number of primary landing gear wheels normally used during taxi, take-off or landing.</td>
</tr>
<tr>
<td>NBR ACTUATORS</td>
<td>$V(5)$</td>
<td>Total number of actuators to operate all vehicle moveable flight surfaces. May be hydraulic or electro-mechanical.</td>
</tr>
<tr>
<td>NBR CONT SUR</td>
<td>$V(6)$</td>
<td>Total number of control surfaces - ailerons, rudders, elevator tabs, flaps, spoilers and slats both primary and secondary.</td>
</tr>
<tr>
<td>Description</td>
<td>Equation</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>KVA MAX</td>
<td>V(7)</td>
<td>Total normal electrical power output capacity of engines, motors and APU driven generators/alternators in KVA.</td>
</tr>
<tr>
<td>NBR HYDR. SUBSYS</td>
<td>V(8)</td>
<td>Total number of subsystems requiring use of hydraulic or pneumatic power in their normal and/or auxiliary operating role.</td>
</tr>
<tr>
<td>NBR FUEL TK</td>
<td>V(9)</td>
<td>Number of separate internal fuel cells, bladders and tanks.</td>
</tr>
<tr>
<td>NBR OXIDIZER TK</td>
<td>V(13)</td>
<td>NBR of separate, internal oxidizer tanks.</td>
</tr>
<tr>
<td>NBR TOT AVIONICS SUBS</td>
<td>V(10)</td>
<td>Total number of avionics (AN nomenclature) subsystems.</td>
</tr>
<tr>
<td>NBR DIF AVIONICS SUBS</td>
<td>V(11)</td>
<td>Total number of different avionics subsystems (two or more identical units count as one).</td>
</tr>
<tr>
<td>BTU COOLING</td>
<td>V(12)</td>
<td>Total cooling capacity of air-conditioning equipment used for personnel and equipment cooling. Measured in BTU/HR/1000.</td>
</tr>
</tbody>
</table>