Integrating O&S Models During
Conceptual Design - PART II

Reliability and Maintainability Model (RAM)
User and Maintenance Manual

Annual Report, Part II
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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 1990 - June 1991 R&M Summary Report. Volume VI of AFALDP 800-4 (October 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

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<thead>
<tr>
<th>VEHICLE DRY WEIGHT</th>
<th>VEHICLE LENGTH</th>
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<tr>
<td>WETTED AREA</td>
<td>VEHICLE WING SPAN</td>
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<tr>
<td>FUSELAGE VOLUME</td>
<td>SUBSYSTEM WEIGHTS</td>
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<tr>
<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>
</tr>
<tr>
<td>NUMBER OF WHEELS</td>
<td>NUMBER ACTUATORS</td>
</tr>
<tr>
<td>NUMBER CONTROL SURFACES</td>
<td>MAXIMUM ELECTRICAL OUTPUT</td>
</tr>
<tr>
<td>NUMBER HYDRAULICS SYSTEMS</td>
<td>NUMBER AVIONICS SYSTEMS</td>
</tr>
<tr>
<td>BTU COOLING CAPACITY</td>
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Table 2
AF/NAVY Aircraft

<table>
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<tr>
<th>TACTICAL</th>
<th>BOMBER</th>
<th>CARGO/TANKER</th>
<th>COMMAND/CONTROL/TRAINE</th>
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<tbody>
<tr>
<td>A-7D/E</td>
<td>B-1B</td>
<td>C-2A</td>
<td>E-2C</td>
</tr>
<tr>
<td>A-10A</td>
<td>B-52G</td>
<td>C-5A</td>
<td>E-3A</td>
</tr>
<tr>
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<td>FB-111A</td>
<td>C-9A</td>
<td>EA-6B</td>
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<td>F-5E</td>
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<td>KC-10A</td>
<td>T-38</td>
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<td>F-14A</td>
<td></td>
<td>C130B/E/H</td>
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<td>KC-135A</td>
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<td>F-16A/B</td>
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<td>C-140A</td>
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<td>C-141B</td>
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<td>F-111A/D/F</td>
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' Variable definitions of those used in the models are found in Appendix D.'
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<th>WUC</th>
<th>STS</th>
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<td>Airframe</td>
<td>STR (Structures)</td>
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<tr>
<td>Body</td>
<td>Airframe</td>
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<td>Tanks, Lox</td>
<td>Fuel Systems</td>
<td>MPS (Main Propulsion System)</td>
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<tr>
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<td>Fuel Systems</td>
<td>MPS (Main Propulsion System)</td>
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<tr>
<td>HEP, Trims</td>
<td>Fuel Systems</td>
<td>Tile</td>
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<td>HEP, TCS</td>
<td>Fuel Systems</td>
<td>FCS (thermal Control System)</td>
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<td>HEP, PVD</td>
<td>Fuel Systems</td>
<td>PVU (Purge, Vent &amp; Drain)</td>
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<td>Landing Gear</td>
<td>Landing Gear</td>
<td>MEQ (Mechanisms)</td>
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<td>Propulsion Systems</td>
<td>MRS (Main Engines)</td>
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<td>Propulsion Systems</td>
<td>FRC (Forward Reaction Control)</td>
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<td>OMS</td>
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<td>APU Power</td>
<td>FPC (Fuel Cell Power)</td>
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<td>Battery</td>
<td>66C/E/G</td>
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<td>Hydraulics/Pneu</td>
<td>HYD (Hydraulics)</td>
</tr>
<tr>
<td>Aero Surface Actuators</td>
<td>Flight Controls</td>
<td>MEQ (Mechanisms)</td>
</tr>
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<td>Avionics, GN&amp;C</td>
<td>Autopilots</td>
<td>GNC</td>
</tr>
<tr>
<td>Avionics, Health Monitoring</td>
<td>13.20</td>
<td>COM (Communications)</td>
</tr>
<tr>
<td>Avionics, Comm &amp; Tracking</td>
<td>HF Comm</td>
<td>DDC (Digital Display Control)</td>
</tr>
<tr>
<td>Avionics, Displays &amp; Controls</td>
<td>VHF Comm</td>
<td>DDC (Digital Display)</td>
</tr>
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<td>Avionics, Computers</td>
<td>UHF Comm</td>
<td>Data Processing</td>
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<td>14.10</td>
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<td>Environmental Control, Life Support</td>
<td>14.20</td>
<td>Environmental Control</td>
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<td>Environmental Control, UHF</td>
<td>14.30</td>
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<td>Environmental Control, Life Support</td>
<td>14.40</td>
<td>14.50</td>
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<td>Misc. Utilities</td>
<td>FCS (Flight Crew Systems)</td>
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<td>Emergency Equipment</td>
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<td>Recovery &amp; Aux. Manipulator Systems</td>
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Table 3: WBS to WUC to STS Conversions
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

\(^2\)The 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.

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

(2)

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.

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

(3)

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:

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

(4)

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

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

(5)

---

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:

Figure 1
Mission Profile

Mission Profile

Failure Rate

Time

Ground Processing  Launch Booster  Orbit  Recovery

A further adjustment to the MTBM_t 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_t 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:

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

(6)

\[
\lambda = \frac{1}{MTBM_f}
\]

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

\[
R(t) = e^{-\int_0^t \lambda(\xi) d\xi}
\]  

(7)

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

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

(8)

Since the mission profile is repetitive over time, a steady-state MTBM may be computed from equation (9).
SS MTBM = \frac{\int_0^\infty R(t) \, dt}{1 - R(t_0)} \tag{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:

\[
\text{CRIT MTBM} = \frac{\text{SS MTBM}}{\text{AB}} \tag{10}
\]

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 (\( R_s \))

\[
R_{\text{veh}} = R_1 \times R_2 \times \ldots \times R_k \tag{11}
\]

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

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

\[
\text{VEH MTBM} = \frac{1}{1/\text{MTBM}_1 + 1/\text{MTBM}_2 + \ldots + 1/\text{MTBM}_k} \tag{12}
\]

where \( 1/\text{MTBM}_i \) is the failure rate of the \( i \)th subsystem\(^4\).

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

\[
R(t_0) = R_{\text{spec}}
\]

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

\[
\text{SS MTBM} = \text{CRIT MTBM} \times \text{AB} \tag{13}
\]

\(^4\) 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.
2.4.3 Redundant reliability

All reliability calculations are based upon the CRIT MTBM. Letting \( \lambda = \frac{1}{\text{CRIT MTBM}} \) 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 \( n_i \) 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 \( k_i \) 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:

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

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

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

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:

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

\(^5\)The calculations are performed numerically using the Newton-Raphson method for finding the solution of a nonlinear equation.
TOT OFF-VEH MH = POFF x TOT MANHRS \hspace{1cm} (20)

When using shuttle data, MHMA is not computed from the regression equations. Instead:

\[
MHMA = MTTR \times CREW \times \frac{POFF - CREW \times MTTR}{1 - POFF}
\hspace{1cm} (21)
\]

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.

\[
SCHED\ MH = PCT \times (TOT\ ON-VEH\ MH)
\hspace{1cm} (22)
\]

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,

\[
NBR\ PER = \frac{TOT\ MANHRS \times N}{(1 - IND)AV} \hspace{0.5cm} (rounded\ up) + \frac{SCHD\ MH \times N}{(1 - IND)AV} \hspace{0.5cm} (rounded\ up)
\hspace{1cm} (23)
\]

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:

\[ MFAIL = RR \times (TOT\ MA) \]  

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

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

\( F(S) \) 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

\[ MSN\ REP\ TIME = \frac{MTTR \times TOT\ MA}{NBR\ CREWS} \]  

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:

\[ VEH\ REP\ TIME = \sum_{ALL\ SYS} MSN\ REP\ TIME \]  

Scheduled maintenance time may then be added to obtain a total vehicle maintenance task time:
\[ TOT\ VEH\ TASK\ TIME = VEH\ REP\ TIME + 0.98 \times SCHD\ MHRS \times \frac{6}{AVE\ CREW\ SIZE} \]  

(28)

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:

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

(29)

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:

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

(30)

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:

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

(31)

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:

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

(32)

and

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

(33)

\[^6\] Aircraft data has shown that 98 percent of the scheduled maintenance is on-aircraft maintenance.
\[ SCHD\ MH = PCT \times UNSCH\ MH \] (34)

\[ MAN\ PWR = \frac{(UNSch\ MH + SCHD\ MH) \times N}{(1 - IND) \times AU} \text{ (rounded up)} \] (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>INFILE</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>INMENU</td>
<td>displays primary input menu and selected input screens</td>
</tr>
<tr>
<td></td>
<td>LCCFILE</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>OUTFILE</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 MTTR and MTTR values</td>
</tr>
<tr>
<td></td>
<td>WEIGHT</td>
<td>displays/updates subsystem weights</td>
</tr>
<tr>
<td>RAM2.BAS</td>
<td>AGRT</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>displays maintenance report</td>
</tr>
<tr>
<td></td>
<td>MANDISPLAY</td>
<td>displays manpower 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>TURNNTIME</td>
<td>displays/computes vehicle turntimes</td>
</tr>
<tr>
<td>File</td>
<td>Module</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<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>PRINTSPPR</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>COMPN</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>EQS</td>
<td>computes initial MTBM and MEMA</td>
</tr>
<tr>
<td></td>
<td>MANWPR</td>
<td>computes subsystem manpower requirements</td>
</tr>
<tr>
<td></td>
<td>POFREQS</td>
<td>computes percent off-vehicle values</td>
</tr>
<tr>
<td></td>
<td>REDSUBREL</td>
<td>computes redundant subsystem reliabilities</td>
</tr>
<tr>
<td></td>
<td>REMREQS</td>
<td>computes removal rates</td>
</tr>
<tr>
<td></td>
<td>SECONDARY</td>
<td>computes secondary variable values</td>
</tr>
<tr>
<td></td>
<td>SIM</td>
<td>computes simulation model parameters</td>
</tr>
<tr>
<td></td>
<td>SPACEMTBM</td>
<td>computes space adjusted MTBM</td>
</tr>
<tr>
<td></td>
<td>SPARES</td>
<td>computes spare part requirements</td>
</tr>
<tr>
<td>RAMW.BAS</td>
<td>WRFILe</td>
<td>writes all input/output reports to an ASCII file except for the Summary Report</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></td>
<td>WRFILe</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  Input parameter menu  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/RLB reliability data
- update/display shuttle MTBM/FTR
- change scheduled maintenance
- establish subsystem reliabilities
- computational factors

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

- print input data
- print summary report
- print reliability report
- print maintainability report
- print manpower report
- print spares report
- print turntime report
- print ET/RLB 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]

**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>WBR</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>
<tr>
<td></td>
<td>return......................exit to main menu</td>
</tr>
</tbody>
</table>

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

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

the following parameter values must be specified:

Table 6

<table>
<thead>
<tr>
<th>System Parameter Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAR NBR PARAMETER</td>
</tr>
<tr>
<td>6 ADJ SHUTTLE MTBM</td>
</tr>
<tr>
<td>7 TECHNOLOGY YR</td>
</tr>
<tr>
<td>8 DEFAULT ABORT RATE</td>
</tr>
<tr>
<td>9 WEIBULL SHAPE PARAMETER</td>
</tr>
<tr>
<td>10 LAUNCH FACTOR</td>
</tr>
<tr>
<td>11 AVAL MANNERS/MONTH</td>
</tr>
<tr>
<td>12 FRACTION INDIRECT WORK</td>
</tr>
<tr>
<td>13 SPARE FILL RATE OBJ</td>
</tr>
<tr>
<td>14 AVG CREW SIZE-SCHD MAINT</td>
</tr>
<tr>
<td>15 PLANNED MISSIONS/YEAR</td>
</tr>
<tr>
<td>16 MODE INDICATOR</td>
</tr>
<tr>
<td>17 VEHICLE INTEGRATION TIME</td>
</tr>
<tr>
<td>18 LAUNCH PAD TIME (days)</td>
</tr>
<tr>
<td>19 AGGREGATE AVIONICS</td>
</tr>
<tr>
<td>20 DEFAULT FRACTION OFF MANHRS</td>
</tr>
<tr>
<td>23 REL GROWTH SLOPE</td>
</tr>
<tr>
<td>24 REL GROWTH MSN NBR</td>
</tr>
<tr>
<td>25 AIR&amp;GRND / AIR 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></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>Table 8</th>
<th>Computational Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECHNOLOGY GROWTH FACTOR</td>
<td>CRITICAL FAILURE RATE</td>
</tr>
<tr>
<td>REMOVAL RATES</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>2</td>
<td>PAD TIME</td>
</tr>
<tr>
<td>3</td>
<td>POWERED PHASE COMPLETION TIME</td>
</tr>
<tr>
<td>4</td>
<td>ORBIT INSERTION TIME</td>
</tr>
<tr>
<td>5</td>
<td>ORBIT COMPLETION TIME</td>
</tr>
<tr>
<td>6</td>
<td>REENTRY TIME</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

**Figure 6**

**SUBSYSTEM OPERATING HOURS**

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>PROCESS TIME</th>
<th>PAD TIME</th>
<th>BOOST TIME</th>
<th>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>
<td>1</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>
<td>1</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>
<td>1</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>
<td>1</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>
<td>1</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>
<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>
<td>1</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>
<td>1</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>
<td>1</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>
<td>1</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>
<td>1</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>
<td>1</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>
<td>1</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
SUBSYSTEM REDUNDANCY

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>REDUNDANT</th>
<th>MIN NBR</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>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>.9983931</td>
<td>467.8713</td>
<td>327.5099</td>
<td>14</td>
</tr>
<tr>
<td>STRUCTURES</td>
<td>.9553647</td>
<td>868.2203</td>
<td>607.7542</td>
<td>26</td>
</tr>
<tr>
<td>THERMAL-TPS</td>
<td>.9553647</td>
<td>318.4931</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>
<th>CREW SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ELECTRICAL</td>
<td>35.21</td>
<td>669</td>
<td>.001</td>
<td>1</td>
<td>4.5</td>
</tr>
<tr>
<td>2</td>
<td>PROPULSION</td>
<td>70</td>
<td>677</td>
<td>.001</td>
<td>1</td>
<td>4.5</td>
</tr>
<tr>
<td>3</td>
<td>RANGE SAFETY</td>
<td>102</td>
<td>677</td>
<td>.001</td>
<td>1</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>STRUCTURES</td>
<td>75</td>
<td>667</td>
<td>.001</td>
<td>1</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>.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>.9911146</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>SUBSYSTEM</th>
<th>MTBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>WING GROUP</td>
<td>3.7824</td>
</tr>
<tr>
<td>TAIL GROUP</td>
<td>22.24941</td>
</tr>
<tr>
<td>BODY GROUP</td>
<td>1.365487</td>
</tr>
<tr>
<td>IEP-TCS</td>
<td>5</td>
</tr>
<tr>
<td>LANDING GEAR</td>
<td>9999 MSN/FAILURE</td>
</tr>
<tr>
<td>PROPULSION-MAIN</td>
<td>21.06 (single engine)</td>
</tr>
<tr>
<td>ELECTRICAL</td>
<td>17.4</td>
</tr>
<tr>
<td>PROPULSION-MAIN</td>
<td>200</td>
</tr>
<tr>
<td>ELECTRICAL</td>
<td>6.41</td>
</tr>
<tr>
<td>AERO SURF ACTUATORS</td>
<td>12.12</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>SUBSYSTEM</th>
<th>MTTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>WING GROUP</td>
<td>14.5</td>
</tr>
<tr>
<td>TAIL GROUP</td>
<td>14.5</td>
</tr>
<tr>
<td>BODY GROUP</td>
<td>14.5</td>
</tr>
<tr>
<td>IEP-TCS</td>
<td>15</td>
</tr>
<tr>
<td>LANDING GEAR</td>
<td>12.12</td>
</tr>
<tr>
<td>PROPULSION-MAIN</td>
<td>4.02</td>
</tr>
<tr>
<td>ELECTRICAL</td>
<td>6.41</td>
</tr>
<tr>
<td>AERO SURF ACTUATORS</td>
<td>12.12</td>
</tr>
<tr>
<td>AGGREGATED AVIONICS</td>
<td>9.91</td>
</tr>
<tr>
<td>ENVIRONMENTAL CONTROL</td>
<td>9.9</td>
</tr>
<tr>
<td>ECS-LIFE SUPPORT</td>
<td>9.9</td>
</tr>
<tr>
<td>REC &amp; AUX-ESCAPE SYS</td>
<td>10</td>
</tr>
<tr>
<td>REC &amp; AUX DOCKING SYS</td>
<td>12.12</td>
</tr>
</tbody>
</table>

Note: indicates shuttle value currently in use
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>.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>13.00 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
SUBSYSTEM WEIGHTS       WEIGHT FACTOR IS 1

<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</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.XX 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>
</tbody>
</table>

TOTAL WEIGHT = 20530

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>5</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>9</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

34
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.

Figure 14
Technology Factor Display Menu

<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 MH/MA = CAL FACTOR x MH/MA. 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.
Figure 15

SUBSYSTEM MTBM CALIBRATION FACTOR
CAL MTBM = CAL FAC x 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
CAL MH/MA = CAL FAC x 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](image)

**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.
<table>
<thead>
<tr>
<th>NBR</th>
<th>SUBSYSTEM</th>
<th>CREW SIZE</th>
<th>CREW ASGN</th>
<th>NBR CREWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
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</tr>
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</tr>
<tr>
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<td>2.137765</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>6.00 PROPULSION-MAIN</td>
<td>2.43</td>
<td>1</td>
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<tr>
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<td>10.00 ELECTRICAL</td>
<td>2.316721</td>
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<td>1</td>
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<tr>
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<td>12.00 AERO SURF ACTUATORS</td>
<td>2.137765</td>
<td>1</td>
<td></td>
</tr>
<tr>
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<td>2.316721</td>
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<td></td>
</tr>
<tr>
<td>32</td>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>4.5</td>
<td>1</td>
<td></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.

<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>
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<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>
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<tr>
<td>19</td>
<td>13.XX AGGREGATED AVIONICS</td>
<td>.49</td>
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<td>14.10 ENVIRONMENTAL CONTROL</td>
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<tr>
<td>26</td>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>.46</td>
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<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>MANPOWER REQUIREMENTS</td>
</tr>
<tr>
<td>4</td>
<td>SPARES REQUIREMENTS</td>
</tr>
<tr>
<td>5</td>
<td>VEHICLE TURN TIME 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</th>
<th>GRND PROC MTBM</th>
<th>MISSION MTBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>(all MA’s)</td>
<td>(External MA’s)</td>
<td>(inherent MA’s)</td>
<td></td>
</tr>
<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>84.7994</td>
</tr>
<tr>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>113.92</td>
<td>193.0847</td>
<td>1116.807</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>
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<td>1077.833</td>
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</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 RATE-MTBM</th>
<th>CRITICAL NON-RENDANT MTBM</th>
<th>SUBSYS NON-RENDANT MSN REL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 WING GROUP</td>
<td>1.308286E-02</td>
<td>26669.64</td>
<td>.9992543</td>
<td>.9992543</td>
</tr>
<tr>
<td>2.00 TAIL GROUP</td>
<td>1.308286E-02</td>
<td>29825.66</td>
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<td>.9993332</td>
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<tr>
<td>3.00 BODY GROUP</td>
<td>1.330428E-02</td>
<td>2000.753</td>
<td>.9901056</td>
<td>.9901056</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>.001</td>
<td>17914.17</td>
<td>.99889</td>
<td>.99889</td>
</tr>
<tr>
<td>5.00 LANDING GEAR</td>
<td>1.010141E-04</td>
<td>569414.1</td>
<td>.9999983</td>
<td>.9999983</td>
</tr>
<tr>
<td>6.00 PROPULSION-MAIN</td>
<td>.010124</td>
<td>6445.978</td>
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<td>.9978831</td>
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<tr>
<td>10.00 ELECTRICAL</td>
<td>8.578588E-02</td>
<td>384.5242</td>
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<tr>
<td>12.00 AERO SURF ACTUATORS</td>
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<td>.9999256</td>
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<tr>
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<tr>
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VEHICLE 256.248 .9262028

42
reliabilities based upon redundancy

<table>
<thead>
<tr>
<th>WBS</th>
<th>LAUNCH TIME</th>
<th>END OF FLIGHT TIME</th>
<th>ORBIT INSERTION</th>
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VEHICLE | .9862989 | .9822762 | .9810246 |

reliabilities based upon redundancy

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</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

<table>
<thead>
<tr>
<th>WBS</th>
<th>MAINT ACTIONS/MSN</th>
<th>AVG MANHR/MA</th>
<th>AVG MANHRS/MSN</th>
</tr>
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<tr>
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</tr>
<tr>
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<td>3.3433862E-02</td>
<td>8.062291</td>
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</tr>
<tr>
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<td>8.403646</td>
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<td>177.3169</td>
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<tr>
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<td>2.145053</td>
<td>6.83832</td>
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<td>5.742539</td>
<td>5.444892</td>
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<tr>
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<td>4.559166</td>
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</tr>
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<td>16.50 REC &amp; AUX DOCKING SYS</td>
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<td>68.175</td>
<td>17.83703</td>
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<tr>
<td><strong>TOTALS</strong></td>
<td><strong>126.162</strong></td>
<td><strong>20.03333 Wt-AVG</strong></td>
<td><strong>2527.445</strong></td>
</tr>
</tbody>
</table>
### MAINTAINABILITY REPORT - at mission nbr. 2 - page 2

<table>
<thead>
<tr>
<th>WBS</th>
<th>ON-VEH MH</th>
<th>OFF-VEH MH</th>
<th>FRACTION ON-VEH</th>
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</thead>
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<td>1.00 WING GROUP</td>
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<td>2.00 TAIL GROUP</td>
<td>32.26817</td>
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<td>6.00 PROPULSION-MAIN</td>
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<td>30.64215</td>
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</tbody>
</table>

UNSCHEDULED: 1941.575 585.8699 .7957228 (AVG)

SCHEDULED: 1427.058 29.12363

TOTAL: 3368.633 614.9936

### 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>.0173856</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>.851443</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>

TOTAL: 109.6089 16.55314 126.162

45
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

VEHICLE IS Example

DATE: 12-31-1994
TIME: 20:54:05

AVAIL HRS/MO= 144    INDIRECT WORK= 20 %

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

WBS    MANHRS/MSN    MANHRS/MO    MANPWR AVG CREW CREWS    RQD CREWS    ASGD CREWS

1.00 WING GROUP
2.00 TAIL GROUP
3.00 BODY GROUP
4.20 IEP-TCS
5.00 LANDING GEAR
6.00 PROPULSION-MAIN
10.00 ELECTRICAL
12.00 AERO SURF ACTUATORS
13.10 AGGREGATED AVIONICS
14.10 ENVIRONMENTAL CONTROL
14.20 ECS-LIFE SUPPORT
16.20 RBC & AUX-ESCAPE SYS
16.50 RBC & AUX DOCKING SYS
UNSCHEDULED
SCHEDULED
TOTAL

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

46
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

VEHICLE IS Example DATE: 12-31-1994 TIME: 20:54:05

NOTE: failures are assumed to be Poisson

<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 nbr. 2 - page 1

VEHICLE IS Example                      DATE: 12-31-1994                      TIME: 20:54:05

<table>
<thead>
<tr>
<th>WBS</th>
<th>ON-VEH TOT MTTR (HRS)</th>
<th>NBR CREWS AVG SUBSYS REPAIR ACT</th>
<th>ASSIGNED TIME PER MSN (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 WING GROUP</td>
<td>3.879957</td>
<td>4.324116</td>
<td>16.77739</td>
</tr>
<tr>
<td>2.00 TAIL GROUP</td>
<td>3.879957</td>
<td>3.890337</td>
<td>15.09434</td>
</tr>
<tr>
<td>3.00 BODY GROUP</td>
<td>6.082469</td>
<td>35.18943</td>
<td>71.34621</td>
</tr>
<tr>
<td>4.20 IEP-TCS</td>
<td>15</td>
<td>15.74173</td>
<td>47.2518</td>
</tr>
<tr>
<td>5.00 LANDING GEAR</td>
<td>3.266001</td>
<td>3.343386E-02</td>
<td>.109195</td>
</tr>
<tr>
<td>6.00 PROPULSION-MAIN</td>
<td>2.38786</td>
<td>8.403646</td>
<td>20.06673</td>
</tr>
<tr>
<td>10.00 ELECTRICAL</td>
<td>1.695414</td>
<td>26.10184</td>
<td>44.25341</td>
</tr>
<tr>
<td>12.00 AERO SURF ACTUATORS</td>
<td>.7651427</td>
<td>.8514433</td>
<td>.6514756</td>
</tr>
<tr>
<td>13.XX AGGREGATED AVIONICS</td>
<td>2.719896</td>
<td>17.02847</td>
<td>23.15784</td>
</tr>
<tr>
<td>14.10 ENVIRONMENTAL CONTROL</td>
<td>2.676623</td>
<td>2.145053</td>
<td>5.7415</td>
</tr>
<tr>
<td>14.20 ECS-LIFE SUPPORT</td>
<td>2.303253</td>
<td>5.742539</td>
<td>13.22652</td>
</tr>
<tr>
<td>16.20 REC &amp; AUX-ESCAPE SYS</td>
<td>1.804476</td>
<td>2.584929</td>
<td>4.664442</td>
</tr>
<tr>
<td>16.50 REC &amp; AUX DOCKING SYS</td>
<td>12.12</td>
<td>.261636</td>
<td>3.171028</td>
</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
### VEHICLE TURN TIME REPORT - at mission nbr. 2 - page 3

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAX TURN TIMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCHD MAINT MSN TASK TIME</td>
<td>356.7645 HRS</td>
</tr>
<tr>
<td>UNSCHD MAINT TIME</td>
<td>265.4852 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 TIME</td>
<td>82 HRS</td>
</tr>
<tr>
<td>TOT VEHICLE TURNAROUND TIME</td>
<td>752.2497 TOT HR</td>
</tr>
</tbody>
</table>

**ONE SHIP/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**

VEHICLE IS Example

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>.975628</td>
<td>.9745619</td>
<td></td>
</tr>
</tbody>
</table>

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**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>
<tr>
<td>VEHICLE</td>
<td>1941.575</td>
<td>585.8699</td>
<td></td>
</tr>
<tr>
<td>VEHICLE</td>
<td>1427.058</td>
<td>29.12363</td>
<td>.7957228 (AVG)</td>
</tr>
<tr>
<td>SCHEDULED TOTALS</td>
<td>3368.633</td>
<td>614.9936</td>
<td></td>
</tr>
</tbody>
</table>

---

**MANPOWER/SPARES REPORT**

<table>
<thead>
<tr>
<th>SPARES-VEHICLE</th>
<th>94</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MANHR DRIVEN</th>
<th>MANHR DRIVEN</th>
<th>CREW SZ</th>
<th>TOT CREW</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNSCH MANPWR</td>
<td>44</td>
<td>52</td>
<td>34</td>
<td>58</td>
</tr>
<tr>
<td>SCHED MANPWR</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 SHIFT/DAY MAINTENANCE</th>
<th>TOT VEHICLE TURNAROUND TIME</th>
<th>MIN TURN TIME</th>
<th>MAX TURN TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50.01223 DAYS</td>
<td>50.01223</td>
<td>83.19788</td>
</tr>
<tr>
<td></td>
<td>5.038768</td>
<td>5.038768</td>
<td>3.028923</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TWOshiftS/DAY MAINTENANCE</th>
<th>TOT VEHICLE TURNAROUND TIME</th>
<th>MIN TURN TIME</th>
<th>MAX TURN TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27.71445 DAYS</td>
<td>27.71445</td>
<td>44.30727</td>
</tr>
<tr>
<td></td>
<td>9.092731</td>
<td>9.092731</td>
<td>5.687554</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THREE SHIFTS/DAY MAINTENANCE</th>
<th>TOT VEHICLE TURNAROUND TIME</th>
<th>MIN TURN TIME</th>
<th>MAX TURN TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.28185 DAYS</td>
<td>20.28185</td>
<td>31.34374</td>
</tr>
<tr>
<td></td>
<td>12.4249</td>
<td>12.4249</td>
<td>8.039884</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

51
5.1.7 Aggregated System report

The Aggregated System Report displays 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>Nbr of On-Veh MTTR</th>
<th>On-Veh Sched Maint time</th>
<th>Ave Crew Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>43.40389</td>
<td>5.66563</td>
<td>2.188222</td>
</tr>
<tr>
<td>Thermal/Tiles</td>
<td>15.74173</td>
<td>15</td>
<td>4.5</td>
</tr>
<tr>
<td>Propulsion</td>
<td>8.740764</td>
<td>2.38786</td>
<td>2.43</td>
</tr>
<tr>
<td>Power/Electrical</td>
<td>28.58769</td>
<td>0</td>
<td>2.137765</td>
</tr>
<tr>
<td>Mechanical Sys</td>
<td>.8848771</td>
<td>.736233</td>
<td>2.2</td>
</tr>
<tr>
<td>Avionics</td>
<td>17.99547</td>
<td>2.719896</td>
<td>2.222283</td>
</tr>
<tr>
<td>ECS/Life Support</td>
<td>10.54594</td>
<td>2.259541</td>
<td>2.137765</td>
</tr>
<tr>
<td>Auxiliary Systems</td>
<td>.261636</td>
<td>12.12</td>
<td>4.5</td>
</tr>
<tr>
<td>Total</td>
<td>126.162</td>
<td>40.88916</td>
<td>22.49499</td>
</tr>
<tr>
<td>Average</td>
<td>15.77025</td>
<td>5.111145</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  

<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>2.84854</td>
<td>1</td>
</tr>
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<td>3.091848</td>
<td>1.888242</td>
<td>2</td>
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<tr>
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<td>.2197556</td>
<td>1.102201</td>
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<td>1.342153E-02</td>
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<td>Total</td>
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<td>20</td>
</tr>
<tr>
<td>Average</td>
<td>.3836929</td>
<td>2.152338</td>
<td>1.520655</td>
<td>2.5</td>
</tr>
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</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 SEB REPORT</td>
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<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>
<tr>
<td></td>
<td>return................cancel request</td>
</tr>
</tbody>
</table>
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 turnover 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.


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.

Aggregate 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 Aborts / Air Aborts: 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 Flt (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
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 Number^b. 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)
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.

Manhrs/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

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

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 results 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.

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.
values and Crew Size values.

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 (LBR/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

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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
Number of Hydraulic Subsystems
Number of Fuel Tanks (internal)
Total Number of Avionics Subsystems
Number of Different Avionics Subsystems (unique)
BTU Cooling
Number of Oxidizer Tanks

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

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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). ¹

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.² (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

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

²all negative responses may be accomplished by simply entering return.

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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

³several 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
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

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'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

DECLARE SUB SIM ()
DECLARE SUB DRIVER ()
DECLARE SUB OUTFILE ()
DECLARE SUB INFILE ()
DECLARE SUB PCTWGT ()
DECLARE SUB TECH ()
DECLARE SUB MAN ()
DECLARE SUB INMENU ()
DECLARE SUB PRIVAR ()
DECLARE SUB COMRES ()
DECLARE SUB WEIGHT ()
DECLARE SUB MANDISPLAY ()
DECLARE SUB SPARES ()
DECLARE SUB ABORT ()
DECLARE SUB SECONDARY ()
DECLARE SUB MANPWR ()
DECLARE SUB INIT ()
DECLARE SUB BROLL ()
DECLARE SUB SRBM ()
DECLARE SUB SPACE()()
DECLARE SUB SPOF()()
DECLARE SUB REMO()()
DECLARE SUB MAINTDIS ()
DECLARE SUB EQS ()
DECLARE SUB REDUNREL ()
DECLARE SUB RELDISP ()
DECLARE SUB ACWGT ()
DECLARE SUB MANDISPLAY ()
DECLARE SUB SPAREDISPLAY ()
DECLARE SUB ABO()()
DECLARE SUB IN()()
DECLARE SUB SPARES ()
DECLARE SUB BOOSTER ()
DECLARE SUB TURNTIME ()
DECLARE SUB SPACETIM()()
DECLARE SUB POPEFS ()
DECLARE SUB REMOQ ()
DECLARE SUB MAINTDIS ()
DECLARE SUB QXQ ()
DECLARE SUB REDUNKRE ()
DECLARE SUB RLDISP ()

C-1
COMMON SHARED G0H, L0H, TOH, O0H, R0H, R1, TS1K, P0H
COMMON SHARED V0, S0M0K, FMAT0, FMAC0, FMAS0, S0, SMA0, SMRO
COMMON SHARED M0W, C0, CM0, O0S0, TG0, PWT0
COMMON SHARED FA0, PA0, R00, W0, NR0, TRU
COMMON SHARED N0R0, K0, R1, R2, R3, R4, R5
COMMON SHARED PWT1, PW02, PWT3, PW04, SR0
COMMON SHARED FTM0S0, ETM0A0, ETR0, ETR0, ETM0R0, ETM0V0, ETR0, ETC0R0
COMMON SHARED SRT0B$, SRT0B0A0, SRT0B0, SRT0B0, SRT0B0, SRT0B0

ERRSUB: 'ERROR HANDLING ROUTINE
IF ERR = 53 OR ERR = 61 OR ERR = 71 THEN
  IF ERR = 53 THEN
    PRINT "FILE NOT FOUND"
    RESUME MAIN 'MAIN MENU
  IF ERR = 61 THEN PRINT "DISK FULL"
  IF ERR = 71 THEN PRINT "DISK NOT READY"
  INPUT 'ENTER RETURN'; RET
  RESUME MAIN 'MAIN MENU
ELSE
  PRINT "UNRECOVERABLE ERROR"
  ON ERROR GOTO ERRSUB
END IF
ON ERROR GOTO ERRSUB

83 GOSUB 1000 'OPENING BANNER
90 CALL INT 'INITIALIZATION
92 CALL MSN 'INITIALIZE MSN PROFILES
93 CALL PCTWGT 'INITIALIZE SUBSYS WEIGHTS
95 GOSUB 2000 'CLEAN-UP ADJUST SHUTTLE MTBM
97 CALL INIT 'INITIALIZE MSN PROFILES
98 CALL PC7WGT 'INITIALIZE SUBSYS WEIGHTS

ON ERROR GOTO ERRSUB

85 GOSUB 1000 'OPENING BANNER
90 CALL INT 'INITIALIZATION
92 CALL MSN 'INITIALIZE MSN PROFILES
93 CALL PCTWGT 'INITIALIZE SUBSYS WEIGHTS
95 GOSUB 2000 'CLEAN-UP ADJUST SHUTTLE MTBM
97 CALL INIT 'INITIALIZE MSN PROFILES
98 CALL PC7WGT 'INITIALIZE SUBSYS WEIGHTS

F2: FOR I = 1 TO 33:
  PW'I'S = PWTI
  NEXT I
  PRINT 'RETURN

1000 'OPENING BANNER
1010 KEY OFF: CLS: COLOR 11
1020 LOCATE 6, 15: PRINT 'VEHICLE RELIABILITY/MAINTAINABILITY MODEL'
1030 PRINT: PRINT 'NASA - LANGLEY RESEARCH CENTER': COLOR 14
1040 LOCATE 14, 20: INPUT 'ENTER VEHICLE/FIELD NAME'; VNAM$
1050 IF VNAM$ = "" THEN VNAM$ = "NO NAME"
1060 IF VNAM$ = "TEMP1" THEN PRINT 'INVALID NAME': GOTO 1040
1070 RETURN

2900 'CLEAN-UP DURING INITIALIZATION
2905 FOR I = 1 TO 24: WAV = WAV + W(I): NEXT I
2910 Y = SMA(1): TW = W(I) / (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
2930 TW = W(5) / (W(4) + W(5)): FR = (1 / Y) * TW: SMA(5) = 1 / FR
2940 Y = SMA(32)

FOR I = 1 TO 33: PW'I'S = PWTI
  NEXT I: PRINT 'RETURN

10000 'INPUT DATA
  WBS
10003 DATA '1.00 WING GROUP, 2.00 TAIL GROUP, 3.00 BODY GROUP
10007 DATA '3.10 TANKS-LOX, 3.20 TANKS-LH2, 4.10 IEP-TILES, 4.20 IEP-TCs
10008 DATA '4.30 IEP-PYD
10010 DATA '5.00 LANDING GEAR, 6.00 PROPULSION-MAIN, 7.00 PROPULSION-RCS
10020 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 11.00 HYDRAULICS/NEUMATICS,12.00 AUTO SURF ACTUATORS
10033 DATA 13.10 AVIONICS-GNC,13.20 AV-HEALTH MONITOR
10034 DATA 13.30 AVIONICS-COMM & TRACK,13.40 AV-Displays & CONTR
10035 DATA 13.50 AVIONICS-INSTRUMENTS,13.60 AVIONICS-DATA PROC
10040 DATA 14.10 ENVIRONMENTAL CONTROL,14.20 ECS-LIFE SUPPORT
10050 DATA 15.00 PERSONNEL PROVISIONS,16.10 REC & AUX-PARACHUTES
10055 DATA 16.20 REC & AUX-ESCAPE SYS,16.30 REC&AUX-SEPARATION
10056 DATA 16.40 REC&AUX-CROSS FIRE
10060 DATA 16.50 REC & AUX-DOCKING SYS,16.60 REC&AUX MANIPULATOR

' PRIMARY SYSTEM VARIABLES
10150 DATA DRY WGT (LB), LENGTH (FT), CREW SIZE, NBR PASSENGERS
10152 DATA NBR MAIN ENGINES, ADJ SHUTTLE MTBM-SPACE 0-NO 1-YES, TECHNOLOGY YR
10153 DATA DEFAULT ABORT RATE, W献BULL SHAP£ PARAMETER
10160 DATA LAUNCH FACTOR, AVAIL. MANHRS/MONTH, FRACTION INDIRECT WORK
10170 DATA SPARE FILL RATE ORL AVG CREW SIZE SCHD MAINT, PLANNED MISSIONS/YEAR
10180 DATA MODE INDICATOR, VEHICLE INTEGRATION TIME (DAYS), LAUNCH PAD TIME (DAYS)

DATA AGGREGATE AVIONICS 0-NO 1-YES, DEFAULT FRACTION OFF MANHRS
DATA NBR RCS ENGINES, NBR GMS ENGINES, GROWTH CURVE SLOPE, MIN NBR FOR REL GROWTH
DATA AIR-QND ABORTS 0 / AIR ABORTS 1

SECONDARY VARIABLES
11700 DATA FUSELAGE AREA, FUSELAGE VOLUME, WETTED AREA
11710 DATA NBR WHEELS, NBR ACTUATORS, NBR CONTR SURFACES, KVA MAX
11720 DATA NBR HYDR SUBSYS, NBR FUEL TANKS (INTERNAL)
11730 DATA TOT NBR AVIONICS SUBSYS
11740 DATA NBR DIFF AVIONICS SUBSYS, BTU COOLING, NBR OXIDIZER TANKS

11750 'TECH GROWTH RATES
11760 DATA 082, 082, 082, 0, 082, 082, 033, 011, 011, 011
11765 DATA 036, 056, 026, 0, 092, 0, 056
11770 DATA 22, 22, 22, 22, 22, 006, 006, 036, 083, 083, 083
11775 DATA 083

11780 'WGT DISTRIBUTION PERCENTAGES-LARGE VEHICLE
11790 DATA 081, 003, 174, 054, 114, 0, 143, 008, 043, 368, 018, 019
11791 DATA 0, 001, 007, 039
11792 DATA 0, 007, 003, 0, 004, 005, 003, 003, 016, 005, 008
11793 DATA 0, 014, 012, 0, 007, 0, 0

11794 'WGT DISTRIBUTION-SHUTTLE
11795 DATA 1, 017, 277, 015, 017, 133, 02, 011, 0, 04, 031, 0, 02, 019, 0, 006, 0
11796 DATA 007, 005, 012, 018, 006, 0, 01, 003, 004, 008, 013, 0, 07, 012, 0
11797 DATA 0, 006, 0, 0

' WGT DISTRIBUTION - SMALL VEHICLE
DATA 096, 004, 114, 018, 018, 0, 109, 0, 064, 0, 017, 017, 017, 016, 018, 014, 063
DATA 0, 009, 016, 008, 011, 007, 0, 021, 0, 018, 045, 0, 014, 0, 004, 001, 0, 01, 006, 0

11810 'SHUTTLE MTBM'S MAINT ACTIONS
11820 DATA 96, 96, 96, 96, 96, 96, 31, 31, 129, 3,999, 643, 3,9999, 21, 06, 13, 06, 40, 31
11821 DATA 7, 43, 9999, 30, 07, 17, 4, 52, 9999, 34, 41, 9999, 66, 22, 34, 52, 47, 2
11826 DATA 9999, 29, 47, 9999, 7, 2, 999999, 15, 6, 999999, 4, 85, 9999

11830 'SHUTTLE MTBM VALUES
DATA 14, 5, 14, 3, 14, 3, 14, 3, 14, 3, 14, 3, 14, 3, 14, 3, 7, 47, 11, 46, 20, 15, 63, 12, 14, 2, 10, 19, 8, 62, 4, 37
11850 DATA 0, 16, 3, 41, 3, 13, 12, 12, 91, 0, 10, 88, 13, 37, 4, 76, 0, 9, 9, 9, 8, 3, 0
11860 DATA 0, 7, 48, 0, 12, 0

'SHUTTLE REMOVAL RATES
DATA 143, 143, 143, 216, 216, 0073, 481, 391, 219, 0, 159, 0, 303, 443, 0, 561
DATA 088, 305, 219, 392, 0, 333, 466, 482, 0, 293, 293, 0, 174, 0, 0, 257, 0, 219, 0

'Fraction inherent failures
DATA 49, 38, 52, 5, 55, 5, 41, 46, 47, 49, 43, 09, 0, 5, 5, 5

'ET PARAMETERS
DATA ELECTRICAL, 20, 42, 72, 001, 13, 68, 4.5
DATA PROP-FLUIDS, 4, 72, 001, 18, 4.5
DATA RANGE SAFETY, 44, 77, 003, 64, 65, 4.5
DATA STRUCTURES, 0354, 1, 001, 6, 83, 4.5
DATA THERMAL-TPS, 0291, 1, 0.55, 4.5

'SRB PARAMETERS
DATA ELECTRICAL, 35, 21, 669, 001, 1, 4.5
DATA PROPULSION, 70, 677, 001, 1.4, 5
DATA RANGE SAFETY, 102, 677, 001, 1, 4.5

C-3
DATA STRUCTURES, 76, 667, 001.1.4.5

SUB BOOSTER
6000 GOTO BOOSTER ROCKET MODULE
6010 CLS
6020 PRINT TAB(20), "EXTERNAL FUEL TANK INPUT DATA"

6030 PRINT TAB(5), "SUBSYSTEM", TAB(10), "MTBM", TAB(20), "OPER HRS", TAB(30), "CRIT FAIL RT", TAB(50), "MTTR", TAB(59), "CREW SIZE"
6040 NEXT I
6050 PRINT FOR I = 1 TO 5
6060 NEXT I

6070 PRINT INPUT "ENTER NUMBER FOR CHANGE", NBR
6080 IF NBR > 5 THEN GOTO 6000
6090 IF NBR = 0 THEN GOTO COMP
6091 INPUT "ENTER NEW PARAMETERS SEPARATED BY COMMAS";
6100 GOTO 6010

COMP: INPUT "ENTER SCHD MAINT AS A PCT OF UNSCH MAINT";
6010 ETMBA(NBR), ETHRS(NBR), ETABR(NBR), ETMTR(NBR), ETCREW(NBR)
6100 GOTO 6040

BAK: CLS
6100 PRINT TAB(20), "LIQUID ROCKET BOOSTER INPUT DATA"

6110 PRINT TAB(5), "SUBSYSTEM", TAB(10), "MTBM", TAB(20), "OPER HRS", TAB(30), "CRIT FAIL RT", TAB(50), "MTTR", TAB(59), "CREW SIZE"
6120 PRINT FOR I = 1 TO 4
6130 PRINT FOR I = 1 TO 4
6140 NEXT I

6150 INPUT "ENTER NUMBER FOR CHANGE", NBR
6160 IF NBR > 4 THEN GOTO BAK
6170 IF NBR = 0 THEN GOTO COM2
6180 INPUT "ENTER NEW PARAMETERS SEPARATED BY COMMAS";
6190 GOTO 6040

COM2: INPUT "ENTER SCHD MAINT AS A PCT OF UNSCH MAINT";

PRINT TAB(20), "COMPUTED", TAB(40), "MISSION", TAB(61), "MANHR DRIVEN"

PRINT TAB(1), "SUBSYSTEM", TAB(10), "RELIABILITY", TAB(32), "UNSCH MANHRS", TAB(47), "SCH MANHRS", TAB(59), "MANPWR";

PRINT TAB(1); "STE = 0", TAB(30); "MTF = 0", TAB(36); "MTTR = 0"

FOR I = 1 TO 4

6200 PRINT TAB(20), "OVERALL ET";
6210 PRINT TAB(20), "OVERALL ET"

PRINT TAB(5); "SUBSYSTEM";
6220 PRINT TAB(18); "RELIABILITY";
6230 PRINT TAB(32); "UNSCH MANHRS";
6240 PRINT TAB(47); "SCH MANHRS";
6250 PRINT TAB(60); "MANPWR"

PRINT TAB(1); "STE";
6260 PRINT TAB(1); "STE"

FOR I = 1 TO 4

6270 PRINT TAB(20), "COMPUTED";
6280 PRINT TAB(20), "computed"

PRINT TAB(1), "SUBSYSTEM", TAB(10), "RELIABILITY", TAB(32), "UNSCH MANHRS", TAB(47), "SCH MANHRS", TAB(61), "MANPWR";

PRINT TAB(1); "STE = 0", TAB(30); "MTF = 0", TAB(36); "MTTR = 0"

FOR I = 1 TO 4

6290 PRINT TAB(20), "OVERALL ET";
6300 PRINT TAB(20), "OVERALL ET"

PRINT TAB(5); "SUBSYSTEM";
6310 PRINT TAB(18); "RELIABILITY";
6320 PRINT TAB(32); "UNSCH MANHRS";
6330 PRINT TAB(47); "SCH MANHRS";
6340 PRINT TAB(60); "MANPWR"

PRINT TAB(1); "STE";
6350 PRINT TAB(1); "STE"

FOR I = 1 TO 4

6360 PRINT TAB(20), "COMPUTED";
6370 PRINT TAB(20), "computed";

PRINT TAB(10), "SUBSYSTEM", TAB(18), "RELIABILITY", TAB(32), "UNSCH MANHRS", TAB(47), "SCH MANHRS", TAB(61), "MANPWR";

PRINT TAB(1); "STE = 0", TAB(30); "MTF = 0", TAB(36); "MTTR = 0"

FOR I = 1 TO 4

6380 PRINT TAB(20), "OVERALL ET";
6390 PRINT TAB(20), "OVERALL ET"

PRINT TAB(5); "SUBSYSTEM";
6400 PRINT TAB(18); "RELIABILITY";
6410 PRINT TAB(32); "UNSCH MANHRS";
6420 PRINT TAB(47); "SCH MANHRS";
6430 PRINT TAB(60); "MANPWR"

PRINT TAB(1); "STE";
6440 PRINT TAB(1); "STE"
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); VNAM$
12530 PRINT
12540 PRINT TAB(15); "NBR", TAB(35); "SELECTION";
12550 PRINT
12530 COLOR 3
12560 PRINT TAB(15); "1 TECHNOLOGY GROWTH FACTOR"
12570 PRINT TAB(15); "2 CRITICAL FAILURE RATES"
12580 PRINT TAB(15); "3 SUBSYSTEM REMOVAL RATES"
12590 PRINT TAB(15); "4 MTBF/MTTR CALIBRATION"
12590 PRINT TAB(15); "5 CREW SIZES"
12590 PRINT TAB(15); "6 FRACTION OFF-EQUIP"
12590 PRINT TAB(15); "7 FRACTION INHERENT FAILURES"
12590 PRINT COLOR 2
12590 PRINT TAB(15); "8 return ....... exit to input menu"
12590 PRINT TAB(15); "9 DO DEFAULT ON TECHNOLOGY GROWTH FACTOR"
12590 PRINT Tabs(10); "ANNUAL TECHNOLOGY GROWTH FACTOR": PRINT
12590 PRINT Tabs(3); "NBR SUBSYSTEM": TAB(45); "ANNUAL GROWTH RATE"
12590 FOR I = 1 TO 18
12590 IF OP$(D(I) = "DELETE" THEN G(O 12550
12590 IF SEL$(I) = "SHUFFLE" THEN COLOR 1 ELSE COLOR 11
12590 PRINT TAB(3); WBS$(I); TAB(45); PA(I)
12590 NEXT I
12590 COLOR 7
12590 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12590 IF NBR > 33 THEN GOTO 12405
12590 IF NBR = 0 THEN GOTO 12493
12590 GOTO 12705
12590 IF IO = 1 THEN IO = 19: IE = 19: GOTO 12405
12590 RETURN

12700 'CRITICAL FAILURE RATE DISPLAY/UPDATE
12701 IO = 1: IE = 18
12703 COLOR 7
12703 CLS PRINT TAB(15); "CRITICAL FAILURE RATE - fraction of total maintenance actions"
12703 PRINT TAB(29); "resulting in a mission abort"
12703 IF X(25) = 0 THEN PRINT TAB(3); "NBR SUBSYSTEM": TAB(35); "CRITICAL FAILURE RATE: ground & air shorts"
12703 IF X(25) = 1 THEN PRINT TAB(3); "NBR SUBSYSTEM": TAB(35); "CRITICAL FAILURE RATE: air shorts only"
12703 FOR I = 1 TO 18
12703 IF OP$(I) = "DELETE" THEN GOTO 12750
12703 IF SEL$(I) = "SHUFFLE" THEN COLOR 12 ELSE COLOR 11
12703 PRINT TAB(3); WBS$(I); TAB(45); PA(I)
12703 NEXT I
12703 COLOR 7
12703 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12703 IF NBR > 33 THEN GOTO 12750
12703 IF NBR = 0 THEN GOTO 12793
12703 GOTO 12750
12703 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12703
12703 RETURN

12750 'REMOVAL RATE DISPLAY/UPDATE
12750 IO = 1: IE = 18
12753 COLOR 7
12753 CLS PRINT TAB(15); "REMOVAL RATE - probability of a removal per maintenance action"
12753 PRINT TAB(29); "resulting in a mission abort"
12753 IF X(0) = 0 THEN PRINT TAB(3); "NBR SUBSYSTEM": TAB(35); "REMOVAL RATE: ground & air shorts"
12753 IF X(0) = 1 THEN PRINT TAB(3); "NBR SUBSYSTEM": TAB(35); "REMOVAL RATE: air shorts only"
12753 FOR I = 1 TO 18
12753 IF OP$(I) = "DELETE" THEN GOTO 12790
12753 IF SEL$(I) = "SHUFFLE" THEN COLOR 12 ELSE COLOR 11
12753 PRINT TAB(3); WBS$(I); TAB(45); PA(I)
12753 NEXT I
12753 COLOR 7
12753 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12753 IF NBR > 33 THEN GOTO 12790
12753 IF NBR = 0 THEN GOTO 12793
12753 GOTO 12790
12753 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12750
12753 RETURN

12790 'DO DEFAULT ON TECHNOLOGY GROWTH FACTOR
12790 Tab(10); "ANNUAL TECHNOLOGY GROWTH FACTOR": PRINT
12790 FOR I = 1 TO 18
12790 IF OP$(I) = "DELETE" THEN G(O 12750
12790 IF SEL$(I) = "SHUFFLE" THEN COLOR 1 ELSE COLOR 11
12790 NEXT I
12790 COLOR 7
12790 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
12790 IF NBR > 33 THEN GOTO 12790
12790 IF NBR = 0 THEN GOTO 12793
12790 GOTO 12790
12790 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12790
12790 RETURN

C-5
12830 FOR I = 10 TO IF.
12835 IF OP$(I) = "DELETE" THEN GOTO 12850
12840 IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
12845 PRINT TAB(3), 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)
12885 CP$(2) = "DO NOT RECOMPUTE"
12890 GOTO 12805
12893 IF IO = 1 THEN IO = 19: IE = 33: GOTO 12803
12897 RETURN

PC'TOFF: 'PERCENT OFF EQUIPMENT DISPLAY/UPDATE
12900 IO = 1: IE = 18 COLOR 7
BACK1: CLS
PRINT TAB(5), "PERCENT OFF EQUIPMENT CLEAR"
PRINT TAB(5), "CLEAR PERCENT OFF DISPLAY"
PRINT TAB(3); "NBR SUBSYSTEM"; TAB(45); PB(I)
12910 NEXT I
COLOR 7
PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
12920 IF NBR > 33 THEN GOTO 12900
12930 IF NBR = 0 THEN GOTO SKIP2
12940 INPUT "ENTER NEW PERCENT"; PB(NBR)
12950 CP$(4) = "DO NOT RECOMPUTE"
12960 GOTO BACK1
SKIP2: IF IO = 1 THEN IO = 19: IE = 33: GOTO BACK1
12970 RETURN

12980 'MODULE TO INPUT MOD FACTOR
12990 IO = 1: IE = 18 COLOR 7
13005 PRINT TAB(20), "SUBSYSTEM MTBM CALIBRATION FACTOR"
13010 PRINT TAB(20), "CAL VBEN-MTBM = CAL FAC x computed MTBM"
13015 PRINT TAB(3), "NBR SUBSYSTEM"; TAB(45), "CAL FACTOR"
13020 FOR I = 10 TO IE.
13025 IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
13030 IF OP$(I) = "DELETE" THEN GOTO 13050
13040 PRINT TAB(3), I, TAB(10), WBS$(I), TAB(45), PB(I)
13050 NEXT I
COLOR 7
13055 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
13060 IF NBR > 33 THEN GOTO 13005
13070 IF NBR = 0 THEN GOTO 13093
13080 INPUT "ENTER NEW FACTOR"; PB(NBR)
13090 GOTO 13005
13093 IF IO = 1 THEN IO = 19: IE = 33: GOTO 13050
13097 RETURN

13100 'DISPLAY/UPDATE SCREEN FOR CREW SIZES
13110 IO = 1: IE = 18
13120 'CLERS: CLOS
13125 PRINT TAB(20), "SUBSYSTEM MH/MA"; TAB(45), "CAL FAC x computed MH/MA"
13130 PRINT TAB(3), "NBR SUBSYSTEM"; TAB(45), "CAL FACTOR"
13135 PRINT TAB(3), I, TAB(10), WBS$(I), TAB(45), CM(I)
13140 NEXT I
COLOR 7
13150 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
13160 IF NBR > 33 THEN GOTO 13150
13170 IF NBR = 0 THEN GOTO 13193
13180 INPUT "ENTER NEW FACTOR"; CM(NBR)
13190 GOTO 13150
13193 IF IO = 1 THEN IO = 19: IE = 33: GOTO 13120
13197 RETURN

13200 'DISPLAY/UPDATE SCREEN FOR CREW SIZES
13210 IO = 1: IE = 18
13220 'CLERS: CLOS
13225 PRINT TAB(20), "SUBSYSTEM MH/MA CALIBRATION FACTOR"
13230 PRINT TAB(20), "CAL MH/MA = CAL FAC x computed MH/MA" COLOR 11
13235 PRINT TAB(3), "NBR SUBSYSTEM"; TAB(45), "CAL FACTOR"
13240 PRINT TAB(3), I, TAB(10), WBS$(I), TAB(45), CM(I)
13250 NEXT I
COLOR 7
13260 PRINT: INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
13270 IF NBR > 33 THEN GOTO 13250
13280 INPUT "ENTER NEW FACTOR"; CM(NBR)
13290 GOTO 13250
13293 IF IO = 1 THEN IO = 19: IE = 33: GOTO 13220
13297 RETURN

13300 'DISPLAY/UPDATE SCREEN FOR CREW SIZES
13310 IO = 1: IE = 18
13803 COLOR 7
13805 CLS : PRINT TAB(20); "CREW SIZES & ASSIGNED CREWS" : PRINT
COLOR 3 : PRINT "note: nbr crews assigned affects turn time only"
13810 PRINT TAB(3); "NBR subsystem", TAB(35), "AVG CREW SIZE", TAB(52); "NBR CREWS ASSIGNED"
13830 FOR I = 10 TO 10
13835 IF ORP(I) = "DELETE" THEN GOTO 13850
13840 IF ORP(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
13845 PRINT TAB(3), I, TAB(10), WBS$(I), TAB(40); C(I), TAB(55); CA(I)
13850 NEXT 1
COLOR 7
13860 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
13865 IF NBR > 33 THEN GOTO 13803
13870 IF NBR = 0 THEN GOTO 13893
13880 INPUT "ENTER NEW CREW SIZE & NBR CREWS ASSIGNED"; (NBR), CA(NBR)
13885 IF (NBR) < 1 THEN CNBR = 1
13890 IF CNBR < 1 THEN CA(NBR) = 1
13895 COLOR 11: "DO NOT RECOMPUTE"
13899 GOTO 13803
13903 IF IO = 1 THEN IO = 19: IE = 33: GOTO 13803
13907 RETURN

INFOAIL: dispL/ate/update fraction inherent failures
10 = 1: IE = 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(43), "FRACTION INHERENT FAILURES"
FOR I = IO TO IF
13900 IF ORP(I) = "DELETE" THEN GOTO SKIP3
IF ORP(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
PRINT TAB(3), 1, TAB(10), WBS$(I), TAB(45); P(I)
SKIP3: NEXT I
COLOR 7
PRINT : INPUT "ENTER NBR SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
IF NBR > 33 THEN GOTO INFOAIL
IF NBR = 0 THEN GOTO SKIP4
PRINT "ENTER NEW FRACTION"; P(NBR)
GOTO BACK2
SKIP4: IF IO = 1 THEN IO = 19: IE = 33: GOTO BACK2
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 8, 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
IF X(16) = THEN CALL PCWGT
1942 FOR 1 = 10 TO 24: WAV = WAV + W(I) : NEXT I
1943 IF X(16) = 0 OR X(16) = 1 THEN CALL SECONDARY
IF CP$(3) = "RECOMPUTE" THEN CALL CREW "COMPUTE CREW SIZES"
1950 CALL EQS: "REGRESSION MTBM/MTBM, UNADJUSTED"
IF CP$(4) = "RECOMPUTE" THEN CALL POFFEQS "COMPUTE POFF"
1952 IF CP$(1) = "RECOMPUTE" THEN CALL ABORT "CRITICAL FAILURE RATE"
1953 IF CPS(2) = "RECOMPUTE" THEN CALL REMDQS'REMOVAL, RATE
CALL TEC"TREACH:GROWTH ADJUSTMENT
1960 CALL SPACE'MTB'M SPACE: ADJUSTMENT
1965 CALL CRIT 'CRITICAL, FAILURE FMA
CALL COMP'M CHECK FOR SPECIFIED RELIABILITIES
1970 CALL COMRFL 'Determine RELIABILITY
1975 CALL REDUNREL 'REDUNDANT RELIABILITY
1980 CALL MANPW 'COMPUTE MANPOWER
1985 CALL SPARES 'COMPUTE SPARES
CALL SIM 'Aggregate parameters for simulation
END SUB

SUB INIT
1700 'MODULE TO READ FROM A FILE
OPEN "TEMPI.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" PRINT: COLOR 11
PRINT: TAB(10); "INPUT DATA WILL BE READ FROM \" VNAMS \" DAT" PRINT: INPUT "ENTER RETURN TO PROCEED OR A POSITIVE NBR TO ABORT"; RET
IF RET > - 1 THEN EXIT SUB
1710 OPEN VNAMS '\' DAT" FOR INPUT AS #3
INPUT #3, DUM, SCHP, WING
1720 FOR I = - 1 TO 33
1725 INPUT #3, WBS$(I), W(I), MW(I), CM(I), PWTS(I)
 INPUT #3, C(I), PC(I), PA(I), RR(I), CA(I), RELF(I), RF(I)
1730 INPUT #3, FORH(I), FORH(I), FORH(I), FORH(I), ROH(I)
1731 INPUT #3, OP$(I), TG(I), ETREL, STE, E'IS, TME, MTE
1733 NEXT I
1740 FOR I = - 1 TO 15
1745 INPUT #3, SNAM$(I), V(I)
1750 NEXT I
1755 FOR I = 1 TO 25: READ #3, DDM$(I), X(I): NEXT I
1760 FOR I = 1 TO 6: CPS(I) = "DO NOT RECOMPUTE"; NEXT I
YR = X(7); B = X(9); LF = X(10): X1 = X(1); X2 = X(2) + WING
WF = 1: PWFT = 1
PRINT: PRINT TAB(10); "UPDATING OUTPUT VALUES...STANDBY..." SKIP = 1: CALL DRIVER: SKIP = 0
PRINT: INPUT "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"; VNAMS
END SUB

SUB INIT
500 'INITIALIZATION MODULE
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
577 CPS(0) = "COMPUTE"
528 SEL$(0) = "AIRCRAFT"
579 FMA$(0) = 1: RFL = 0
530 READ WBS$(I)
540 NEXT I
550 SEL$(6) = "SHUTTLE": SEL$(7) = "SHUTTLE": SEL$(8) = "SHUTTLE"
555 SEL$(9) = "SHUTTLE"
560 SEL$(31) = "SHUTTLE": SEL$(32) = "SHUTTLE": SEL$(33) = "SHUTTLE"
580 FOR I = 1 TO 25
590 READ NAM$(I)
403 PRINT TAB(15); "2"
355 PRINT TAB(15); "COLOR"
SUB INMENU
END SUB
817 "PLANNED MSN PER YEAR - CONVERTED TO MOS"
790 "X(8) - .001 'DEFAULT ABORT RATE"
780 "X(7) - 0"
770 "X(6) - 0"
760 "X(5) - 3 'NBR ENGINES"
750 "NRD(10) - X(5)
740 "X(21) - 2: X(22) - 2 'NBR OMS/RCS ENGINES"
730 "NRD(11) - X(6)
720 "X(23) - 2: X(12) - 2"
710 "X(20) - 0 'FLAG FOR SPACE ADJ TO MTBM - SHUTTLE"
700 "X(7) - 1996 TECHNOLOGY YR"
690 ' **** DEFAULT VALUES *****
680 "WP - 1: PWF - 1 'INITIAL WEIGHT FACTOR"
670 "X(1) - 10000 'DRY WEIGHT - LBS"
660 "X(2) - 70 'LENGTH + WING SPAN - FT"
650 "WING - 30 'TEMP WING SPAN"
640 "X(3) - 2 'CREW SIZE"
630 "X(4) - 8 'NBR PASSENGERS"
620 "X(5) - 3 'NBR ENGINES"
510 NEXT I
410 READ SNAMS(I)
310 NEXT I
FOR I - 1 TO 6: CPS(I) = "RECOMPUTE": NEXT I
640 FOR I - 1 TO 33: READ TEG(I): NEXT I 'TECH GROWTH RATES
650 FOR I - 1 TO 33: READ PWT(I): NEXT I 'WGT DISTR PERCENTS-AMLS (LARGE)
660 FOR I - 1 TO 33: READ PWT2(I): NEXT I 'WGT DISTR PERCENTS-SMALL
670 FOR I - 1 TO 33: READ PWT3(I): NEXT I 'INITIAL wgt distr
660 FOR I - 1 TO 33: READ SRRI(I): NEXT I 'SHUTTLE MAINT ACTION MTBM
650 FOR I - 1 TO 33: READ SRMU(I): NEXT I 'SHUTTLE REMOVAL RATES
640 FOR I - 1 TO 33: READ PHF(I): NEXT I 'Fraction inherent failures
680 FOR I - 1 TO 5 'READ IN ET PARAMETERS
670 READ ETUSR(I), ETMBA(I), ETBMTR(I), ETMTR(I), ETCREW(I)
660 NEXT I
650 FOR I - 1 TO 4 'READ IN LRB PARAMETERS
640 READ SRBSUB(I), SRBMBAL(I), SRRHRS(I), SRBMTR(I), SRBMTR(I), SRBCREW(I)
630 NEXT I
620 NEXT I
610 NEXT I
600 NEXT I
590 NEXT I
580 NEXT I
490 NEXT I
480 NEXT I
470 NEXT I
460 NEXT I
450 NEXT I
440 NEXT I
430 NEXT I
420 NEXT I
410 NEXT I
400 NEXT I
390 NEXT I
380 NEXT I
370 NEXT I
360 NEXT I
350 NEXT I
340 NEXT I
330 NEXT I
320 NEXT I
310 NEXT I
300 NEXT I
290 NEXT I
280 NEXT I
270 NEXT I
260 NEXT I
250 NEXT I
240 NEXT I
230 NEXT I
220 NEXT I
210 NEXT I
200 NEXT I
190 NEXT I
180 NEXT I
170 NEXT I
160 NEXT I
150 NEXT I
140 NEXT I
130 NEXT I
120 NEXT I
110 NEXT I
100 NEXT I
90 NEXT I
80 NEXT I
70 NEXT I
60 NEXT I
50 NEXT I
40 NEXT I
30 NEXT I
20 NEXT I
10 NEXT I
FOR I - I TO 5 'WRITE OUT MAIN MENU
FOR I - 1 TO 6: TAB(I) - I2 "PROFILE"
FOR I - 1 TO 3: TAB(I) - I2 "UPDATE/DISPLAY PRIMARY SYSTEM PARAMETERS"
FOR I - 1 TO 2: TAB(I) - I2 "ADD/DELETE A SUBSYSTEM"
FOR I - 1 TO 2: TAB(I) - I2 "SELECT SHUTTLE/AIRCRAFT"
FOR I - 1 TO 2: TAB(I) - I2 "UPDATE/DISPLAY SECONDARY VARIABLES"
FOR I - 1 TO 2: TAB(I) - I2 "COMPUTATIONAL FACTORS MENU"
FOR I - 1 TO 2: TAB(I) - I2 "UPDATE/DISPLAY MISSION PROFILE"
FOR I - 1 TO 2: TAB(I) - I2 "UPDATE/DISPLAY SYSTEM OPERATING HRS"
FOR I - 1 TO 2: TAB(I) - I2 "UPDATE/DISPLAY REDUNDANCY CONFIGURATION"
FOR I - 1 TO 2: TAB(I) - I2 "UPDATE/DISPLAY LR/BET RELIABILITY DATA"
FOR I - 1 TO 2: TAB(I) - I2 "RESET"
405 PRINT TAB(15); "11 ...... UPDATE/DISPLAY SHUTTLE MTBM'S & MTTR'S"
406 PRINT TAB(15); "12 ...... CHANGE SCHEDULED MAINTENANCE"
407 PRINT TAB(15); "13 ...... ESTABLISH SUBSYSTEM RELIABILITIES"
408 PRINT TAB(15); "return ... exit to main menu"
410 LOCATE 22, 20 INPUT "ENTER SE(;CT'ON'; NB1
411 IF NBl - 1 THEN GOSUB 12300
412 IF NBl - 2 THEN GOSUB 14000
413 IF NBl - 3 THEN CALL PRIVAR
414 IF NBl - 4 THEN CALL WEIGHT
415 IF NBl - 5 THEN GOSUB 11300
416 IF NBl - 6 THEN CALL COMAC
417 IF NBl - 7 THEN GOSUB 1600
418 IF NBl - 8 THEN CALL SHUTTLE
419 IF NBl - 9 THEN GOSUB 1300
420 IF NBl - 10 THEN CALL BOOSTER
421 IF NBl - 11 THEN CALL SHUTTLE
422 IF NBl - 12 THEN GOSUB UNSCH
423 IF NBl - 13 THEN CALL REL
424 IF NBl - 14 THEN EXIT SUB
425 GOTO 310
12300 ' MENU TO DELETE A SUBSYSTEM
12301 IO - 1; IE - 18
12305 CLS : PRINT TAB(20): "OPTION TO DELETE/RESTORE A SUBSYSTEM': PRINT
12310 PRINT TAB(3); "NBR SUBSYSTEM'; TAB(45); "OPTION"
12320 FOR I - IO TO IE
12325 IF OP$(I) - "DELETE" THEN COLOR 4 ELSE COLOR 3
12330 NEXT I
12335 IF OP$(I) - "LET" THEN COLOR 4 ELSE COLOR 3
12340 FOR I - IO TO IE
12345 IF OP$(I) - "DELETE" THEN COLOR 4 ELSE COLOR 3
12350 FOR I - IO TO IE
12355 IF OP$(I) - "DELETE" THEN COLOR 4 ELSE COLOR 3
12360 PRINT "ENTER NBR OF SUBSYSTEM TO BE CHANGED: 0 IF NONE': NBR
12365 IF NBR > 33 THEN GOTO 12305
12370 IF NBR = 0 THEN GOTO 12393
12375 IF OP$(NBR) = "DELETE" THEN OP$(NBR) = "COMPUTE" : GOTO 12305
12380 IF OP$(NBR) = "DELETE" THEN OP$(NBR) = "COMPUTE"
12390 GOTO 12305
12393 IF IO = 1 THEN IO - 19: IE - 33: GOTO 12305
12394 INPUT "DO YOU WISH TO CHANGE A SUBSYSTEM NAME'; ANS$" 12395 IF ANS$ - "Y" OR ANS$ - "$" THEN GOTO 80
12396 RETURN
80: IO - 1; IE - 18
B: CLS : PRINT TAB(20): "OPTION TO CHANGE SUBSYSTEM NAME': PRINT
B: PRINT TAB(3); "NBR SUBSYSTEM'; TAB(45); "SELECTION"
B: PRINT FOR I - IO TO IE
B: IF OP$(I) - "DELETE" THEN COLOR 4 ELSE COLOR 3
B: PRINT TAB(18); I, TAB(IO); WBS$(I); TAB(45); OP$(I)
B: NEXT I
B: COLOR 7
B: PRINT "ENTER NBR OF SUBSYSTEM FOR NAME CHANGE: 0 IF NONE': NBR
B: IF NBR > 33 THEN GOTO 81
B: IF NBR = 0 THEN GOTO 82
B: INPUT "ENTER NEW WBS/NAME'; WBS$(NBR)
B: GOTO 80
B2: IO - 1 THEN IO - 19: IE - 33: GOTO 80
B: RETURN
14000 'SHUTTLE DATA MODULE
14005 IO - 1; IE - 18
14105 ' MENU TO SELECT MTBM OPTION
14106 CLS : COLOR 7: PRINT TAB(20): "OPTION TO SELECT AIRCRAFT VS SHUTTLE MTBM': PRINT
14110 PRINT TAB(3); "NBR SUBSYSTEM'; TAB(45); "OPTION"
14120 FOR I - IO TO IE
14130 IF OP$(I) - "DELETE" THEN GOTO 14150
14140 IF SEL$(I) - "SHUTTLE" THEN COLOR 4 ELSE COLOR 3
14150 NEXT I
14155 COLOR 7
14160 PRINT : PRINT "ENTER NBR OF SUBSYSTEM TO BE CHANGED: 0 IF NONE': NBR
14170 IF NBR = 33 THEN GOTO 14106
14180 IF NBR = 0 THEN GOTO 14106
14190 IF NBR = 6 OR NBR = 7 OR NBR = 8 OR NBR = 15 OR NBR = 31 OR NBR = 32 OR NBR = 33 THEN GOTO 14106
14200 IF NBR = 0 THEN GOTO 14192
14210 IF SEL$(NBR) = "SHUTTLE" THEN SEL$(NBR) = "AIRCRAFT": GOTO 14106
14220 IF SEL$(NBR) = "AIRCRAFT" THEN SEL$(NBR) = "SHUTTLE"
C-10
COLOR 14: PRINT TAB(1); "THREE SHIFTS/DAY MAINTENANCE": COLOR 15

DVT = (T(0) + T(4))/24 + TMAX / 24 + X(17) + X(18)
MDVTT = (T(0) + T(4))/24 + (T + SCHT) / 24 + X(17) + X(18)

PRINT TAB(3); "TOTAL VEHICLE TURNAROUND TIME": TAB(35); DVT; "DAYS": TAB(35); MDVTT
PRINT INPUT "ENTER VEHICLE TURNTIME FOR USE IN Q&S CUSTING MODEL": VTTIM

9530 OPEN VNAME$ = ".CST" FOR OUTPUT AS #1
9540 WRITE #1, VNAME$
9540 FOR I - 1 TO 33
9550 IF NB0
9560 OPEN #1, CT(I), XMP, ADI, CA(I)
9550 NEXT I
9560 WRITE #1, CT(I), XMP, 205 IF NB0
9570 IF NB0
9570 IF NB0
9580 WRITE #1, W(I), S(I), XMP, ADI, CA(I)
9580 IF NB0
9590 IF NB0
9590 IF NB0
9595 IF NB0
9600 WRITE #1, CMP, VNAME$, (T, H, TNR)
9600 FOR I - 1 TO 9
9610 WRITE #1, X(I)
9610 NEXT I
9620 IF NB0
9620 IF NB0
9620 IF NB0
9625 WRITE #1, T(1), C'IJ.2SE
9625 FOR I = 1 TO 9
9630 WRITE #1, T(I)
9630 NEXT I
9635 IF NB0
9635 IF NB0
9635 IF NB0
9640 IF NB0
9640 IF NB0
9645 IF NB0
9650 WRITE #1, "CURRENT NAME IS "; VNAM$; ".CST"
9650 IF NB0
9655 IF NB0
9660 CLOSE #1
9660 IF NB0
9660 IF NB0
9660 IF NB0
9665 PRINT PRINT TAB(10); "DATA WRITTEN TO "; VNAM$; ".CST"
9670 CLOSE #1
9670 IF NB0
9675 IF NB0
9680 LOCATE 24, 10; INPUT "ENTER RETURN... "; RET

END SUB

SUB MAIN

100 'MAIN MENU'
110 CLS: COLOR 10
120 PRINT TAB(1); "NASA LRC - RELIABILITY/MAINTAINABILITY MODEL":
130 PRINT PRINT TAB(15); "MAIN MENU": PRINT
135 COLOR 11
140 PRINT TAB(15); "INFILE", TAB(35); "SELECT": PRINT
150 PRINT TAB(15); "READ INPUT FROM A FILE": PRINT
155 PRINT TAB(15); "INPUT PARAMETER MENU":
160 PRINT TAB(15); "COMPUTE R&M PARAMETERS":
165 COLOR 11
170 PRINT TAB(15); "DISPLAY (OUTPUT) MENU":
175 PRINT TAB(15); "SAVE DATA FOR COST MODEL":
180 PRINT TAB(15); "CHANGE VEHICLE/FILE NAME":
185 PRINT TAB(15); "PRINT OUTPUT REPORT(S)"
190 IF X(16) = 0 THEN TNAMS = "PRECONCEPTUAL MODE"
195 IF X(16) = 1 THEN TNAMS = "WEIGHT-DRIVEN MODE"
200 IF X(16) = 2 THEN TNAMS = "WEIGHT & VARIABLE DRIVEN MODE"
205 COLOR 13
210 LOCATE 20, 10; COLOR 13; PRINT "VEHICLE/FILE NAME IS "; VNAMS
215 LOCATE 17, 20; INPUT "SELECT": NB0
220 IF NB0 = 1 THEN CALL INMENU
225 IF NB0 = 2 THEN CALL PDES
230 IF NB0 = 3 THEN CALL DRIVER
235 IF NB0 = 4 THEN CALL DISPLAY
240 IF NB0 = 5 THEN CALL OUTFILE
245 IF NB0 = 6 THEN CALL LCP
250 IF NB0 = 7 THEN GOSUB C'HG
255 IF NB0 = 8 THEN CALL REPORT
260 IF NB0 = 9 THEN GOTO DONE
265 GOTO 110

C'HG: 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
FILE$ "C.DAT"
COLOR 11; LOCATE 18, 12; PRINT "CURRENT NAME IS "; VNAMS
RT: COLOR 14; LOCATE 20, 12; PRINT "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) "; ANS$
IF ANS$ = "Y" OR ANS$ = "Y" THEN CALL OUTFILE
PRINT: COLOR 14; CLS; LOCATE 12, 28; PRINT "SESSION TERMINATED"
SUB MSN
900 'INITIALIZE SUBSYSTEM MSN PROFILES
910 FOR I = 1 TO 33
920 POH(I) = T0: GOH(I) = T1: TOH(I) = T2: ROH(I) = T3: POR(I) = T5
921 NEXT I
922 DMS(I) = 0: RHO(I) = 0: POH(I) = 1: GOH(I) = 0: TOH(I) = 0: OOH(I) = 0: ROH(I) = 1
END SUB

SUB OUTFILE
9600 '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)
WRITE #2, CI$: COLOR 3
PRINT: PRINT TAB(10); "CURRENT RAM INPUT FILES": PRINT FILES "* DAT"
PRINT: PRINT TAB(10); "DATA WILL BE WRITTEN TO " VNAME$ " DAT".
LOCATE 20, 10: INPUT "ENTER RETURN TO PROCEED OR A POSITIVE NBR TO ABORT "; RET
IF RET > -1 THEN EXIT SUB
9610 OPEN VNAME$ " DAT" FOR OUTPUT AS #2
WRITE #2, DUM, SCHP, WING
9615 FOR I = 1 TO 33
9620 WRITE #2, WBS(I), W(I), MW(I), CM(I), PWTS(I)
WRITE #2, C(I), PF(I), PA(I), RR(I), CA(I), RREF(I), RE(I)
9621 WRITE #2, POH(I), GOH(I), TOH(I), DUM, ROH(I)
9622 WRITE #2, OOH(I), RHO(I), OOH(I), ROH(I)
9625 NEXT I
V(14) = X(21): V(15) = X(22)
9630 FOR I = 1 TO 15
9635 WRITE #2, SNAM$(I), V(I)
9640 NEXT I
FOR I = 1 TO 25: WRITE #2, NAM$(I), X(I): NEXT I
9650 FOR I = 0 TO 5
9655 WRITE #2, T(I)
9660 NEXT I
WRITE #2, ETREL, STE, ETS, TME, MTE
FOR I = 1 TO 5
WRITE #2, ETSUB$(I), ETMBA(I), ETHRS(I), ETABR(I), ETMTR(I), ETCREW(I)
NEXT I
WRITE #2, SRBREL, STF, SRBS, TMF, MTF
FOR I = 1 TO 4
WRITE #2, SRBSUB$(I), SRBMBA(I), SRBHRS(I), SRBABR(I), SRBMTR(I), SRBCREW(I)
NEXT I
9690 CLOSE #2
END SUB

SUB PCTWGT
1500 'MODULE TO COMPUTE SUBSYSTEM WEIGHTS FROM PERCENTS
1520 TSM = 0
1530 FOR I = 1 TO 33
1540 IF OP$(I) = "DELETE" AND PWTS(I) > 0 THEN OP$(I) = "COMPUTE"
1545 IF PWTS(I) = 0 THEN OP$(I) = "DELETE"
1550 TSM = TSM + PWTS(I)
1560 NEXT I
SUM = 0
IF X(19) = 1 THEN FOR I = 20 TO 24: OP$(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
1588 NEXT I
END SUB

SUB PRIVAR
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 = I THEN PRINT TAB(I); "12 PRIMARY DRIVER VARIABLES": PRINT
COLOR 14
1040 FOR I = 1 TO 12
1075 IF I = 6 THEN PRINT TAB(I); "13.10 AVIONICS GND &" ELSE WBS$(I9) = "13.10 AGGREGATED AVIONICS"
NEXT I
COLOR 2
1100 PRINT": INPUT "ENTER NBR OF VARIABLE TO BE CHANGED: 0 IF NONE": NBR
IF NBR = 1 AND X(16) = 1 OR NBR = 1 AND X(16) = 2 THEN GOTO 1131
1110 IF NBR = 0 THEN GOTO 1131
1115 IF NBR > 25 OR NBR < 0 THEN GOTO 1050
IF NBR = 6 THEN X(8) = 1 - X(6): GOTO 1130
IF NBR = 19 THEN X(19) = 1 - X(19): GOTO 1130
IF NBR = 25 THEN X(25) = 1 - X(25): GOTO 1130
1120 IF NBR = 2 THEN PRINT "ENTER LENGTH, WING SPAN": X(2), WING ELSE INPUT "ENTER NEW VALUE": X(NBR)
IF NBR = 14 AND X(14) < 1 THEN X(14) = 1
IF NBR = 5 THEN NRD(10) = X(5)
IF NBR = 21 THEN NRD(11) = X(11) = X(21)
IF NBR = 22 THEN NRD(12) = X(22)
1130 CLS: GOTO 1050
1131 IF I = 1 THEN I = 12 = 25 CLS: GOTO 1050
1135 IF X(7) = 0 THEN CALL PCTWGT
1140 IF X(16) = 0 THEN CALL PCTWGT
1145 IF X(16) = 0 OR X(16) = 1 THEN CALL SECONDARY
IF X(19) = 1 THEN FOR I = 1 TO 24: OR(I) = "DELETE": NEXT I
IF X(9) = 0 THEN WBS$(9) = "13.10 AVIONICS GND &" ELSE WBS$(9) = "13.10 AGGREGATED AVIONICS"
END
SUB
REL
'MODULE TO ESTABLISH SUBSYSTEM RELIABILITIES'
IO = 1: IE = 18
TPREL: CLS: COLOR 7: PRINT TAB(10); "ESTABLISH SUBSYSTEM RELIABILITY" COLOR 3
PRINT TAB(10); "specify non-redundant subsystem reliability at the end of the mission": PRINT
TAB(10); "enter a zero reliability to have the system compute a value": PRINT
PRINT TAB(3), "NBR SUBSYSTEM": TAB(45); "RELIABILITY" PRINT
FOR I = IO TO IE
IF SEL(IO) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
IF OR(I) = "DELETE" THEN GOTO NK9
IF REL(I) = 0 THEN PRINT TAB(3), I, TAB(IO), WBS$(I), TAB(45); "TO BE COMPUTED" ELSE PRINT TAB(IO), WBS$(I), TAB(45); RF(IO)
NK9: NEXT I
COLOR 7
PRINT": INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED: 0 IF NONE": NBR
IF NBR > 3 THEN GOTO TPREL
IF NBR = 0 THEN GOTO BT10
INPUT "ENTER DESIRED RELIABILITY": RF(NBR)
IF RF(NBR) > 1 THEN RF(NBR) = 1
IF RF(NBR) < 0 THEN RELF(NBR) = 0 ELSE RELF(NBR) = 1
GOTO TPREL
BT10: IF IO = 1 THEN IO = 19: IE = 33: GOTO TPREL
END
SUB
SHUTTLE
1800 'UPDATE/DISPLAY SHUTTLE PARAMETERS'
1801 IO = 1: IE = 18
1805 COLOR 7: PRINT TAB(10); "SHUTTLE MTBM (HRS/MAINT ACTION) VALUES" PRINT TAB(5); "Note: all MTBM's should be for a single subsystem"
1810 PRINT TAB(3), "NBR SUBSYSTEM": TAB(45); "MTBM"
1820 FOR I = IO TO IE
1825 IF OR(I) = "DELETE" THEN GOTO 1825
1830 IF SEL(IO) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 11
IF I = 9 THEN PRINT TAB(3), I, TAB(IO), WBS$(I), TAB(45), SMA(0); "MSF/FA/FAILURE" IF I = 10 OR I = 11 OR I = 12 THEN PRINT TAB(3), I, TAB(IO), WBS$(I), TAB(45), SMA(0); "single engine"
1830 IF I < 9 OR I > 12 THEN PRINT TAB(3), I, TAB(10), WB$$(I), TAB(45), SMA(I)
1835 NEXT I
1840 COLOR 12: PRINT "NOTE: indicates shuttle value currently in use": COLOR 7
1845 INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
1850 IF NBR > 13 THEN GOTO 1805
1855 IF NBR = 0 THEN GOTO 1805
1860 INPUT "ENTER NEW MTBM": SMA(NBR)
1865 GOTO 1805
1870 IF IO - 1 THEN IO = 19: IF = 33: GOTO 1805
2000 "UPDATE/DISPLAY SHUTTLE PARAMETERS - MTTR
2001 IF I = 1 TO 8
2020 COLOR 7: CLS
PRINT TAB(1), "SHUTTLE MTTR VALUES - MTTR is the average repair time in hours"
PRINT TAB(1), "to complete a single maintenace action given the corresponding avg crew size"
2050 PRINT TAB(3); NBR; TAB(10); WBS(I); TAB(45); SMA(I)
2060 NEXT I
2070 "UPDATE/DISPLAY ShUTTLE PARAMETERS - MTTR
FOR I = 1 TO 8
COLOR 12: PRINT "NOTE: indicates shuttle value currently in use": COLOR 7
INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
IF NBR > 33 THEN GOTO 2605
IF NBR = 0 THEN GOTO 2665
INPUT "ENTER NEW MTTR": SMA(NBR)
GOTO 2605
IF IO - 1 THEN IO = 19: IF = 33: GOTO 2605
END SUB
SUB WEIGHT
1400 "SUBSYSTEM WEIGHT DISPLAY
1401 IF X(16) = 0 THEN GOSUB 14200
1403 IO - 1: IF = 18
1405 WAV = 0: COLOR 7: CLS: PRINT TAB(26), "SUBSYSTEM WEIGHTS"
1410 PRINT TAB(3), "NBR SUBSYSTEM", TAB(45), "WEIGHT IN LBS"
COLOR 5: PRINT TAB(26), "WEIGHT FACTOR IS CURRENTLY": PWF: PRINT
1411 IF X(16) - 0 THEN ADD = X(1): GOTO 1430
1412 ADD = 0: COLOR 11
1413 FOR I = 1 TO 33
1414 IF OP$(I) = "DELETE" THEN W(I) = I: GOTO 1416
W(I) = PWF * W(I)
1415 ADD = ADD + W(I)
1416 NEXT I
1417 X(1) = ADD: X(1) = ADD
1430 COLOR 11
FOR I = 1 TO 8
1455 IF OP$(I) = "DELETE" THEN GOTO 1450
1460 PRINT TAB(3); I, TAB(10), WB$$(I), TAB(45), W(I)
1450 NEXT I
1455 IF IO = 19 THEN COLOR 14: PRINT : PRINT TAB(3), "TOTAL WGT": TAB(45), ADD: PRINT
COLOR 7
1456 IF X(1) = 0 THEN PRINT : PRINT "ENTER RETURN": I, RET: GOTO 1493
1460 PRINT : PRINT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE": NBR
1465 IF NBR = 33 THEN GOTO 1405
1470 IF NBR = 0 THEN GOTO 1493
1480 INPUT "ENTER NEW WEIGHT": W(NBR)
1490 GOTO 1405
1493 IF IO = 1 THEN IO = 19: IE = 33: GOTO 1405
1495 FOR I = 19 TO 34: WAV = WAV + W(I): NEXT I
1496 IF X(16) = 1 THEN CALL SECONDARY
ANS$ = "N"
IF X(16) = 1 OR X(16) = 2 THEN PRINT "CHANGE WEIGHT FACTOR (Y/N)": ANS$ = INPUT "ENTER NEW FACTOR": W(F): PWF = PWF * W(F)
GOTO 1403
EXIT SUB
14300 "UPDATE DISPLAY WEIGHT PERCENTS
14302 GOSUB 14300
IF WGTF = 1 THEN FOR I = 1 TO 33: PWTS(I) = PWT(I): NEXT I
IF WGTF = 2 THEN FOR I = 1 TO 33: PWTS(I) = PWT(I): NEXT I
IF WGTF = 3 THEN FOR I = 1 TO 33: PWTS(I) = PWT(I): NEXT I
IF WGTF = 4 THEN CALL ACWGT
IF WGTF = 4 THEN FOR I = 1 TO 33: PWTS(I) = PWT(I): NEXT I
14304 IO = 1: IE = 18
14305 CLS: COLOR 7: PRINT TAB(26), "WEIGHT PERCENTAGES"
PRINT TAB(20); "PRECONCEPTUAL MODE ONLY"; PRINT; COLOR 11
IF WGTF = 0 THEN PRINT TAB(40); "CURRENT DISTRIBUTION"
IF WGTF = 1 THEN PRINT TAB(40); "DISTR BASED ON LARGE VEHICLE WGT"
IF WGTF = 2 THEN PRINT TAB(40); "DISTR BASED ON SHUTTLE WEIGHTS"
IF WGTF = 3 THEN PRINT TAB(40); "DISTR BASED ON SMALL VEHICLE WGT"
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
TPCT'I" = TPCT * PWTS(D)
NEXT I
FOR I = 10 TO 33
IF OP(I) = "DELETE" THEN GOTO 14250
IF X(I) = 1 AND I > 19 AND I < 25 THEN GOTO 14250
COLOR 3
TEMP = 1000 * PWTS(I): TEMP = TEMP / 10
PRINT TAB(3); I; TAB(10); WBS$(I), TAB(45); TEMP
GOTO 14250
NEXT I
IF IO = 19 THEN COLOR 14: PRINT: PRINT TAB(40); "TOT - TPCT COLOR 7"
COLOR 13
PRINT TAB(15); "RETURN - MAINTAIN CURRENT DISTRIBUTION"; PRINT
COLOR 7
PRINT: INPUT "SELECT DISTRIBUTION..."; WGTF
IF WGTF < 0 OR WGTF > 4 THEN GOTO 14310
END SUB

File: RAM2.BAS display module

DECLARE SUB AGRT() DECLARE SUB SIMTURNO
DECLARE SUB SUMMARY() DECLARE SUB MANDISPLAY() DECLARE SUB SPARE.DISPLAY() DECLARE SUB TURNTIME() DECLARE SUB MAINTDIS() DECLARE SUB REL.DISPLAY()

'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 "RAM2.BAS" Mean Time Between Maintenance -REVISED

COMMON SHARED YR, B, X1, X2, LF, VR1, VR2, VR3, VR4, VR5, YR, AREM
COMMON SHARED VPMA, TVFMA, SPVMA, CVFMA..., OMHMA, OPMHMA, TMA, AMHMA
COMMON SHARED SCHP, VGY, TGY, TFH, APF, P1, P2, P3, WAV, FH42, FH44
COMMON SHARED FMA11, FMA12, VNAAM, ARR, TNR, TS, SKP
COMMON SHARED SFMP, VMOH, WGT, WNG, WFX, WF
COMMON SHARED SRSC1, SRL4, SRL5, SRL6, SR7, ARS$,
COMMON SHARED SPW1, ST, MTE, MTE, STF, MTF, C1
DIM SHARED WBS$(35), X(50), Y(35), VMS$(35), TMS$(35), IBM(35), MP(35), OMH(35), FH4(35)
DIM SHARED TWL(35), T1(10), C1(35), B(35), R(35)
DIM SHARED H(35), O(35), U(35), R(35), T(35)
DIM SHARED V(15), SNAM$(15), FMAT(35), FMA(35), S(35), SMA(35), SMR(35)

--- End of file ---
CLS: COLOR 14
PRINT TAB(3), "Aggregated System Report - System Aggregation - page 1": COLOR 11
PRINT TAB(3), "VEHICLE IS ": VNAM, TAB(35), "DATE: ": DATES, TAB(60), "TIME: ": TIMES
PRINT TAB(3), "SYSTEM": TAB(30), "SYSTEM": TAB(30), "SYSTEM": COLOR 7
PRINT TAB(1), SWBS$(1), TAB(10), SWBS$(2), TAB(10), SWBS$(9), COLOR 13
FOR I = 1 TO 2: PRINT TAB(3), WBS$(I), TAB(31), WBS$(I + 3), TAB(32), WBS$(I + 29): NEXT I
PRINT TAB(3), WBS$(3), TAB(35), WBS$(3): COLOR 7
PRINT TAB(1), SWBS$(3), TAB(30), SWBS$(4), COLOR 13: PRINT TAB(52), WBS$(54): COLOR 14
FOR I = 1 TO 8: PRINT TAB(3), WBS$(I), TAB(31), WBS$(I + 4): NEXT I: COLOR 7
PRINT TAB(3), WBS$(5), TAB(35), WBS$(9)
PRINT TAB(3), WBS$(10): COLOR 7
PRINT TAB(1), SWBS$(7), TAB(30), SWBS$(8): COLOR 13: PRINT I = 19 TO 23: PRINT TAB(3), WBS$(I), TAB(33), WBS$(I + 6): NEXT I
PRINT TAB(3), WBS$(24)
COLOR 2: INPUT "ENTER RETURN ... "; RET
CLS: COLOR 14
PRINT TAB(25), "Aggregated System Report - page 2": PRINT
PRINT TAB(1), "VEHICLE IS ": VNAM, TAB(35), "DATE: ": DATES, TAB(60), "TIME: ": TIMES
PRINT TAB(2), "Aggregated": TAB(20), "Nbr of": TAB(35), "On-Veh MTTR": TAB(50), "Off-Veh School": TAB(65), "Ave Crew
PRINT TAB(3), "SYSTEM": TAB(20), "Maint Actions": TAB(35), "per MA (hr)": TAB(48), "maint time(hr)": TAB(65), "Size
PRINT COLOR 12
do = 0: Ti = 0: T2 = 0: T3 = 0
FOR I = 1 TO 9
Ti = Ti + MTRO(1): T2 = T2 + SMTO(1): T3 = T3 + SCI(1)
IF MASO > 0 THEN
NC = NC + 1
PRINT TAB(1), WBS$(1), TAB(20), MASO, TAB(35), MTROS(1), TAB(50), SMTO(1), TAB(65), SCI(1)
END IF
NEXT I
PRINT TAB(2), "Total": TAB(20), Ti, TAB(35), Ti, TAB(50), Ti, TAB(65): T3
PRINT TAB(2), "Average": TAB(20), Ti / NC, TAB(35), Ti / NC, TAB(50), Ti / NC, TAB(65), T3 / NC
PRINT COLOR 7: PRINT note: MTTR's & sched maint times assume the Ave Crew Size and are based
PRINT "upon a weighted avg (wt-fraction of total failures) of each subsystem.
COLOR 2: PRINT: INPUT "ENTER RETURN ...": RET
CLS: COLOR 14
PRINT TAB(25), "Aggregated System Report - page 3": PRINT
PRINT TAB(1), "VEHICLE IS ": VNAM, TAB(35), "DATE: ": DATES, TAB(60), "TIME: ": TIMES
PRINT TAB(2), "Aggregated": TAB(20), "Removal": TAB(35), "Off-Veh MTTR": TAB(50), "Off-Veh School": TAB(65), "Mor Crews
PRINT TAB(2), "System": TAB(20), "Rate": TAB(35), "in hours": TAB(48), "maint time(hr)": TAB(65), "Assigned
PRINT COLOR 12
T0 = 0: Ti = 0: T2 = 0: T3 = 0
C-18
FOR I = 1 TO 9
T0 = T0 + REMSI(1)
I1 = I1 + MTRFS(I) + MTROS(I) + SMT(I)
IF MAS(I) > 0 THEN PRINT TAB(1); SWBS$(I), TAB(20), REMSI(I), TAB(35), MTRFS(I), TAB(50), SMT(I), TAB(65), CZ(I)
NEXT I
PRINT
PRINT TAB(1); "Total", TAB(35), T1, TAB(50), T2, TAB(65); T3
PRINT TAB(1); "Average": TAB(20), T0 / NC, TAB(35), T1 / NC, TAB(50), T2 / NC, TAB(65); T3 / NC
PRINT COLOR 7; PRINT "MTRt's & sched maint times assume the Avg Crew Size and are based*"
PRINT "upon a weighted avg (w/fraction of total failures) of each subsystem.*"
COLOR 2; PRINT "INPUT 'ENTER RETURN ...', RET"
EXIT SUB
IF (MAS(8) * MTROS(8) + SMT(8)) / CZ(8) > (MAS(6) * MTRFS(8) + SMT(6)) / CZ(6) THEN Z = (MAS(8) * MTROS(8) + SMT(8)) / CZ(8) ELSE Z = (MAS(6) * MTRFS(8) + SMT(6)) / CZ(6)
IF Z < (MAS(4) * MTROS(4) + SMT(4)) / CZ(4) THEN Z = (MAS(4) * MTROS(4) + SMT(4)) / CZ(4)
IF (MAS(1) * MTRFS(1) + SMT(1)) / (Z1 + (MAS(3) * MTROS(3) + SMT(3)) / CZ(3)) > (MAS(5) * MTROS(5) + SMT(5)) / CZ(5) + (MAS(7) * MTROS(7) + SMT(7)) / CZ(7) THEN
Z = (MAS(1) * MTRFS(1) + SMT(1)) / (Z1 + (MAS(3) * MTROS(3) + SMT(3)) / CZ(3)) ELSE
Y = (MAS(2) * MTRFS(2) + SMT(2)) / CZ(2) + (MAS(9) * MTRFS(9) + SMT(9)) / CZ(9) THEN Y = (MAS(2) * MTRFS(2) + SMT(2)) / CZ(2) + (MAS(9) * MTRFS(9) + SMT(9)) / CZ(9)
CLS; COLOR 15
PRINT TAB(23); "Simulated system report - page 3"*
COLOR 7; PRINT "note: fleet sizes are based on an assumed series/parallel maintenance process"*
COLOR 13; PRINT TAB(5); "CATEGtory", TAB(53); "*TURN TIMES": COLOR 14
PRINT TAB(5); "UNSCH'TED/SCHED MAINT TIME", TAB(55), Y; "HRS"
PRINT TAB(5); "INTEGRATION TIME", TAB(55), X(17); "DAYS"
PRINT TAB(5); "LAUNCH PAD TIME", TAB(55), X(18); "DAYS"
PRINT TAB(5); "MISSION TIME: INC GRND TIME", TAB(55), T0 + T4; "HRS"
PRINT TAB(5); "T0 + (T4) + Y + X(17) * 24 + X(18) * 24": COLOR 12
PRINT TAB(5); "T0 + (T4) + Y + X(17) * 24 + X(18) * 24": COLOR 12
PRINT TAB(5); "RETURN.....exit to main menu"*
COLOR 2
INPUT "ENTER RETURN ...", RET
END SUB
SUB DISPLAY
5800 "DISPLAY MENU"
5810 CLS; COLOR 11
5815 PRINT TAB(15); "NASA LRC RELIABILITY/MAINTAINABILITY MODEL", TAB(60), VNAMS
5820 PRINT PRINT TAB(23); "SCREEN DISPLAY (OUTPUT) MENU": PRINT COLOR 15
5830 PRINT TAB(15); "NBR", TAB(33), "SELECTION": PRINT
5835 PRINT TAB(15); "1......RELIABILITY REPORT"
5840 PRINT TAB(15); "2......MAINTAINABILITY REPORT"
5850 PRINT TAB(15); "3......MANPOWER REQUIREMENTS"
5860 PRINT TAB(15); "4......SPARES REQUIREMENTS"
5870 PRINT TAB(15); "5......VEHICLE TURN TIME REPORT"
5875 PRINT TAB(15); "6......SYSTEM PERFORMANCE SUMMARY"
5880 PRINT TAB(15); "7......AGGREGATED SYSTEM REPORT"
5885 PRINT TAB(15); "RETURN......exit to main menu"*
COLOR 2
5890 LOCATT 20, 20; INPUT "ENTER SELECTION", NB3
5900 IF NB3 = 1 THEN CALL RDLDisp
5910 IF NB3 = 2 THEN CALL MAINTDIS
C-19
SUB MAINTDIS
7500 'DISPLAY MODULE FOR MAINTAINABILITY REPORT
    X = 0; Y = 0; Z = 0; K = 0 'AVIONICS ROLLUP
    FOR I = 19 TO 24
    IF OP$10 = 'DELETE' THEN GOTO Nx5
    K = K + 1
    X = X + NRD(I) * ((1 - PFI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I))
    Y = Y + MHMA(I)
    Z = Z + (NRD(I) * ((1 - PFI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) * MHMA(I)
Nx5: NEXT I
    YA = Y / K
    7505 IF I = 1: IF = 18
7510 CLS: COLOR 14
7520 PRINT TAB(5); 'MAINTAINABILITY REPORT - at mission nbr. ', X(24); ' - page 1'
7530 IF I = 1: THEN PRINT TAB(1); 'VEHICLE IS : ; VNAME, TAB(35); 'DATE : ; DATES, TAB(60); 'TIME : ; TIMES
7540 COLOR 7
7550 PRINT TAB(1), 'WBS', TAB(30), 'MAINT ACTIONS/MSN', TAB(50), 'AVG MANHRS/MA', TAB(65), 'AVG MANHRS/MSN'
7570 FOR I = 1 TO IO TO IE
    IF OP$10 = 'DELETE' THEN GOTO 7592
7590 IF SFIL(I) = 'SHUTTLE' THEN COLOR 12 FILSF COLOR 15
7595 PRINT TAB(1), 'WBS(I), TAB(32), NRD(I) * ((1 - PFI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)); TAB(50), MHMA(I), TAB(65); NRD(I) * ((1 - PFI(I)) * POH(I) / FMAT(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
7595 PRINT COLOR 2
7594 IF I = 1: THEN PRINT TAB(1); 'VEHICLE IS ; ; VNAME, TAB(35); 'DATE ; ; DATES, TAB(60); 'TIME ; ; TIMES
7600 PRINT TAB(5); 'TOTALS', TAB(32), TMA, TAB(47), AMHM; 'WT-AVG', TAB(65), VMH
7610 COLOR 2
7620 PRINT 'ENTER RETURN ...': RET: GOTO 7510
7630 IF I = 1: IF = 18
7640 CLS: COLOR 14
7650 PRINT TAB(5); 'MAINTAINABILITY REPORT - at mission nbr. ; ; X(24); ' - page 2'
7660 IF I = 19 TO 24
    IF OP$10 = 'DELETE' THEN GOTO Nx6
    K = K + 1
    X = X + 1 OMHR(I)
    Y = Y + FMHI(I)
    Z = Z + 1 PF(I)
Nx6: NEXT I
7660 PRINT TAB(1); 'VEHICLE IS ; ; VNAME, TAB(35); 'DATE ; ; DATES, TAB(60); 'TIME ; ; TIMES
7680 COLOR 7
7690 PRINT TAB(1), 'WBS', TAB(32), 'ON-VEH MH', TAB(47), 'OFF-VEH MH', TAB(60); 'FRACTION ON-VEH'
7710 FOR I = 1 TO IE
    IF OP$10 = 'DELETE' THEN GOTO 7740
7720 IF SFIL(I) = 'SHUTTLE' THEN COLOR 12 FILSF COLOR 15
7730 IF OP$10 = 'DELETE' THEN GOTO 7740
7740 NEXT I
7750 PRINT COLOR 2
7752 IF I = 19: IF = 33: PRINT 'ENTER RETURN ...': RET: GOTO 7760
7760 IF I = 1: THEN PRINT TAB(1); 'AVIONICS SCHEDULED', TAB(32), TMBH, TAB(50), TFMH, TAB(65), APF, 'AVG'
7770 PRINT TAB(5), 'TOTAL', TAB(32), TMBH + .98 * SCHP + TMBH, TAB(50), .02 * SCHP + TMBH
7780 COLOR 2
7790 INPUT 'ENTER RETURN ...'; RET
    X = 0; Y = 0 'AVIONICS ROLLUP
    FOR I = 19 TO 24
    IF OP$10 = 'DELETE' THEN GOTO NY8
    X = X + NRD(I) * ((1 - PFI(I)) * POH(I) / FMAT(I)
    Y = Y + NRD(I) * THRS(I) / FMAS(I)
NY8: NEXT I
10 = 1: IE = 18
SUB MANDISPLAY
7800 MANPOWER DISPLAY
X = 0: Y = 0: Z = 0: 'AVIONICS ROLLUP
FOR I = 19 TO 24
IF OPS(I) = 'DELETE' THEN GOTO NX8
X = X + MH(I)
Z = Z + MPI(I)
NX8 NEXT I
Y = (X(15) * X) / 12
MT = 0
7803 IO = 1: IE = 18: ASTP = 0
7805 CLR: COLOR 14
7810 PRINT TAB(25); "MANPOWER REPORT - at mission nbr. ", X(24)
7820 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS ", VNAME, TAB(35); "DATE: ", DATES; TAB(60); "TIME: ", TIMES
COLOR 3: PRINT 'mancap is computed from manhrs/no divided by avail direct hrs per man per person'
PRINT 'rpl crews is computed from manhrs divided by avg crew', COLOR 3: PRINT TAB(9); "RQD: ", TAB(75); "ASGD'
7830 PRINT TAB(1); "WRS", TAB(50); "MANHRS/MSN", TAB(38); "MANHRS/MO", TAB(50); "MANHRS/MO", TAB(50); "AVG CREW", TAB(69); "CREWS", TAB(75); "CREWS'
7840 FOR I = 10 TO IE
7850 IF OPS(I) = 'DELETE' THEN GOTO 7900
7860 IF SEL(I) = 'SHUTTLE' THEN COLOR 12 ELSE COLOR 15
IF I > 19 AND I < 24 THEN ASTP = ASTP + C(I)
NC = INT(MPI(I) / C(I) + 1)
MT = MT + NC * MPI(I) 'compute total pers
7890 PRINT TAB(1); "WRS", TAB(28); "MH(I); TAB(42); X(15) * MH(I) / 12; TAB(50); MPI(I); TAB(61); C(I); TAB(71); NC; TAB(75); C(I)
IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP", TAB(28); "AVIONICS ROLLUP", TAB(28); TAB(28), X; TAB(43); Y; TAB(58); Z; TAB(62); ASTP
7900 NEXT I
7910 COLOR 2
7920 IF IO = 1 THEN IO = 19: IE = 33: PRINT 'ENTER RETURN ...'; RET: GOTO 7805
COLOR 1: PRINT TAB(5); "UNSCHEDULED", TAB(28); VMH, TAB(42); VMH = X(15) / 12; TAB(50); TMP - SMP; TAB(61); STP
7915 PRINT TAB(5); "SCHEDULED", TAB(28); SCBP + TMH, TAB(42); VMH + SCBP + TMH, X(15) / 12; TAB(50); BMP, TAB(61); X(I4)
7920 COLOR 13
7930 PRINT TAB(5); "TOTAL", TAB(28); VMH + SCBP + TMH, TAB(42); VMH + SCBP + TMH, X(15) / 12; TAB(50); TMP, TAB(61); STP + X(14): COLOR 14
PRINT TAB(1); "Tot personal assigned - SUM (avg crew size x avg crews) + schd manpower", TAB(75); INT(MT) + SMP
7940 COLOR 2
7950 INPUT 'ENTER RETURN TO CONTINUE...'; RET
END SUB
SUB RELDISPLAY
9000 "DISPLAY MODULE FOR RELIABILITY REPORT "
X = 0: Y = 0: Z = 0: 'AVIONICS 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 = X / X
IF Y > 0 THEN YA = Y / Y
IF Z > 0 THEN ZA = Z / Z
MNFMA = 0
9003 IO = 1: IE = 18
9010 CLS: COLOR 14  
9020 PRINT TAB(15); "RELIABILITY REPORT - at mission nbr "; X(24); "; page 1"; COLOR 9  
9030 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE "; DATE$; TAB(60); "TIME "; TIME$  
9040 COLOR 4: PRINT " reliability specified "; COLOR 3: PRINT " all MTBM's are for a single subsystem"; COLOR 7  
9050 PRINT TAB(1); "WBS"; TAB(36); "TECH/GROWTH MTBM"; TAB(43); "GRND PROC MTBM"; TAB(61); "MISSION MTBM"  
9060 PRINT TAB(29); "(All MA's)", TAB(45); "(External MA's)", TAB(61); "(inherent MA's)"  
9070 FOR I = 1 TO TG IF  
9080 IF OP$(I) = "DELETE" THEN GOTO 9092  
9090 MNEMA = MNEMA + 1: PRU$ = FMAT(I)  
9100 IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 15  
9110 IF REL$(I) = 1 THEN COLOR 4  
9120 IF I = 9 THEN PRINT TAB(1); WBS$; " MSN'S/FAILURE "; TAB(35); FMAT(1); TAB(48); FMAT(1) / ( 1 - PRU$); TAB(61); FMAS(I)  
9130 IF I > 9 THEN PRINT TAB(1); WBS$; TAB(35); FMAT(1); TAB(48); FMAT(1) / ( 1 - PRU$); TAB(61); FMAS(I)  
9140 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 "ENTER RETURN ..."; RET: CLS: GOTO 9010  
9095 COLOR 13  
9100 PRINT TAB(5); "VEHICLE"; TAB(35); TFVMA; TAB(48); 1 / MNEMA; TAB(81); SYFMA  
9105 COLOR 2  
9110 INPUT "ENTER RETURN ... "; RET  
9120 CLS  
9130 X = 0: Y = 0: Z = 1: K = 0 "AVIONICS ROLLUP FOR I = 19 TO 24"  
9140 IF OP$(I) = "DELETE" THEN GOTO NX3  
9150 K = K + 1  
9160 X = X + P(A)  
9170 Y = Y + 1 / FMAC(I): YA = 1 / Y  
9180 Z = Z * R(I)  
NX2: NEXT I  
9190 IF K = 0 THEN K = 1  
9200 XA = X / K  
9125 IO = 1: IF = 18  
9130 CLS: COLOR 14  
9140 PRINT TAB(15); "RELIABILITY REPORT - at missionnbr "; X(24); "; page 2"; COLOR 9  
9150 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE "; DATE$; TAB(60); "TIME "; TIME$  
9160 COLOR 4: PRINT " reliabilityspecified "; COLOR 3: PRINT " all MTBM's are for a single subsystem"; COLOR 7  
9170 PRINT TAB(1); "WBS"; TAB(28); "CRITICAL FAILURE"; TAB(48); "CRITICAL"; TAB(60); "SUBSYS NON"  
9180 IF X(25) = 0 THEN PRINT TAB(28); "RATE: miss/air "; TAB(48); "MTBM"; TAB(60); "REDUNDANT MSN REL"  
9190 IF X(25) = 1 THEN PRINT TAB(28); "RATE: air-only": TAB(48); "MTBM"; TAB(60); "REDUNDANT MSN REL"  
9200 FOR I = 1 TO IO  
9210 PRINT TAB(1); WBS$(I); TAB(35); P(A); TAB(48); FMAC(I); TAB(65); R(I)  
9220 IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(27); XA; "AVG"; TAB(45); YA; TAB(62); ZA  
9230 NEXT I  
COLOR 2  
9235 IF IO = 1 THEN IO = 19: IF = 33 "ENTER RETURN ..."; RET: CLS: GOTO 9130  
9240 COLOR 13  
9250 PRINT TAB(5); "VEHICLE"; TAB(48); CVFMA; TAB(65); VR  
9260 COLOR 2  
9270 INPUT "ENTER RETURN ... "; RET  
9280 X = 1: Y = 1: Z = 1 "AVIONICS ROLLUP FOR I = 19 TO 24"  
9290 IF OP$(I) = "DELETE" THEN GOTO NX3  
9300 X = X * R(I)  
9310 Y = Y * R(I)  
9320 Z = Z * R3(I)  
NX3: NEXT I  
9285 IO = 1: IF = 18  
9300 CLS: COLOR 14  
9310 PRINT TAB(15); "RELIABILITY REPORT - at mission nbr "; X(24); "; page 3"; COLOR 9  
9320 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE "; DATE$; TAB(60); "TIME "; TIME$  
9330 COLOR 4: PRINT " reliability specified "; COLOR 3: PRINT " all MTBM's are for a single subsystem"; COLOR 7  
9340 PRINT TAB(1); "WBS"; TAB(33); "LAUNCH"; TAB(43); "END OF"; TAB(60); "ORBIT"  
9350 PRINT TAB(33); "TIMI"; TAB(43); "POWER FLT"; TAB(60); "INSERTION"  
9360 FOR I = 1 TO IO  
9370 IF OP$(I) = "DELETE" THEN GOTO 9345  
9380 IF SEL$(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 15  
9390 IF REL$(I) = 1 THEN COLOR 4  
9400 PRINT TAB(1); WBS$; TAB(33); R(I); TAB(45); R2(I); TAB(60); R3(I)  
9410 IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(30); XA; TAB(42); YA; TAB(57); ZA  
9345 NEXT I
9335 IF IO = 1 THEN IO = 19; IF = 33; INPUT "ENTER RETURN.", RET: GOTO 9500
COLOR 13
9360 PRINT TAB(5), "VEHICLE", TAB(33), VR1, TAB(43), VR2, TAB(60), VR3
9365 COLOR 2
9370 INPUT "ENTER RETURN...", RET
9375
X = 1; Y = 1; Z = 1 "AVIONICS ROLLUP
FOR I = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO NX4
X = X * R4(I)
Y = Y * R4(I)
NX4 NEXT I
9385 IO = 1; IE = 18
9400 CLS: COLOR 14
PRINT TAB(15); "RELIABILITY REPORT - at mission shr.", X(24), " - page 4", COLOR 9
IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS ", VNAMS, TAB(35); "DATE: ", DATES, TAB(60); "TIME: ", TIMES
COLOR 4 PRINT "reliability specified ". COLOR 3: PRINT "reliabilities based upon redundancy": COLOR 7
9415 PRINT TAB(1), "WBS", TAB(45), "REENTRY", TAB(60), "MISSION"
9420 PRINT TAB(60), "COMPLETION"
9430 FOR I = IO TO IE
9435 IF OP$(I) = "DELETE" THEN GOTO NX7
9440 PRINT TAB(1); WBS$(I), TAB(45), RR(I), TAB(60), R4(I), TAB(60), R5(I)
9450 NEXT I
COLOR 2
9455 IF IO = 1 THEN IO = 19; IF = 33; INPUT "ENTER RETURN. ", RET: CLS: GOTO 9400
COLOR 13
9460 PRINT TAB(5); "VEHICLE", TAB(45), VR1, TAB(60), VR3
9465 COLOR 2
9470 INPUT "ENTER RETURN...", RET
9475 END SUB

SUB SPAREDISPLAY
8500 "DISPLAY SPARES RESULTS
X = 0; Y = 0; Z = 0; \( K \) = 0 "AVIONICS ROLLUP
FOR I = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO NX7
K = K + 1
X = X + RR(I)
Y = Y + R4(I)
Z = Z + R5(I)
NX7 NEXT I
8510 XA = X / K
8520 ZX = ZX / K
8530 IO = 1; IE = 18
8550 COLOR 14
8560 PRINT TAB(20), "SUBSYSTEM SPARES REPORT - at mission shr.", X(24)
8570 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS ", VNAMS, TAB(35); "DATE: ", DATES, TAB(60); "TIME: ", TIMES
COLOR 3 PRINT TAB(3); "NOTE: failures are assumed to be Punish"
8580 COLOR 7 PRINT TAB(32), "REMOVAL", TAB(42), "MEAN DEMAND", TAB(56), "SPARES", TAB(65), "EFFECTIVE"
8590 PRINT TAB(1), "WBS", TAB(32), "RATE/MA", TAB(42), "PER MISSION", TAB(56), "RQMT", TAB(65), "FILL RATE"
8600 FOR I = IO TO IE
8610 IF OP$(I) = "DELETE" THEN GOTO 8650
8620 IF SFL(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 15
8630 PRINT TAB(1), WBS$(I), TAB(30), RR(I), TAB(41), R4(I), TAB(55), R5(I), TAB(60), FR0
8640 IF I = 24 THEN COLOR 14 PRINT TAB(30); "AVIONICS ROLLUP", TAB(25), XA, "(AVG)", TAB(40), Y, TAB(56), Z, TAB(62), ZX, "(AVG)
8660 NEXT I
COLOR 2
8670 IF IO = 1 THEN IO = 19; IE = 33; INPUT "ENTER RETURN. ", RET: GOTO 8510
8680 COLOR 13
8690 PRINT TAB(1), WBS$(I), TAB(30), RR(I), TAB(41), R4(I), TAB(55), TAB(60), FR0
8700 PRINT TAB(32), "TOTOALS", TAB(27), ARR, "(AVG)", TAB(43), TNR, TAB(53), TS
8710 PRINT TAB(5), "WGT AVG", TAB(27), AREM
8720 COLOR 2: INPUT "ENTER RETURN...", RET
9000 END SUB

SUB SUMMARY
CLS: COLOR 10
PRINT TAB(20), "SYSTEM PERFORMANCE SUMMARY - at mission shr.", X(24), " - page 1"
PRINT TAB(1); "VEHICLE IS ", VNAMS, TAB(35); "DATE: ", DATES, TAB(60); "TIME: ", TIMES
COLOR 14 PRINT TAB(30), "RELIABILITY REPORT -
PRINT
COLOR 7
PRINT TAB(1), "CATEGORY", TAB(33), "VEHICLE", TAB(45), "END OF", TAB(60), "PRINT"
PRINT TAB(3), "TIME", TAB(45), "POWER FLT", TAB(60), "INSERTION"
PRINT: COLOR 12
PRINT TAB(5), "VEHICLE", TAB(33), VR1, TAB(45), VR2, TAB(60), VR3
IF SRBREL < 1 THEN PRINT TAB(5), "VEHICLE = SRBREL", TAB(33), SRBREL * VR1, TAB(45), SRBREL * VR2, TAB(60), SRBREL * VR3
IF ETREL < 1 THEN PRINT TAB(3), "VEHICLE = ETREL", TAB(33), ETREL * SRBREL * VR1, TAB(45), ETREL * SRBREL * VR2, TAB(60), ETREL * SRBREL * VR3
PRINT: COLOR 7
PRINT TAB(1), TAB(45), "RETURN", TAB(60), "MISSION"
PRINT TAB(60), "COMPLETION", COLOR 12
PRINT TAB(5), "VEHICLE", TAB(45), VR4, TAB(60), VR5
IF SRBREL < 1 THEN PRINT TAB(5), "VEHICLE = SRBREL", TAB(45), SRBREL * VR4, TAB(60), SRBREL * VR5
IF ETREL < 1 THEN PRINT TAB(3), "VEHICLE = ETREL", 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 ", VNAM, TAB(33), "DATE ", DATE, TAB(60), "TIME ", TIME$;
PRINT COLOR 14: PRINT TAB(30), "MAINTAINABILITY REPORT"
COLOR 7: PRINT TAB(60), "UNSCHED"
PRINT TAB(1), "CATEGORY", TAB(28), "MAINT ACTIONS/MSN", TAB(48), "WT-AVG MANHRS/MSN", TAB(60), "AVG MANHRS/MSN"
PRINT COLOR 12
PRINT TAB(5), "VEHICLE", TAB(32), TMA, TAB(50), AMMA, TAB(65), VMH
IF ETREL < 1 THEN PRINT TAB(3), "EXTERN TANK", TAB(32), MTE, TAB(50), STE / MTE, TAB(65), STE
IF SRBREL < 1 THEN PRINT TAB(3), "BOOSTER", TAB(32), MTF, TAB(50), STE / MTF, TAB(65), STE
PRINT COLOR 7
PRINT TAB(32), "ON-VEH MH", TAB(47), "OFF-VEH MH", TAB(62), "FRACTION ON-VEH"
COLOR 12: PRINT TAB(5), "VEHICLE"
PRINT TAB(7), "UNSCHED", TAB(22), TMT, TAB(50), TMMH
PRINT TAB(7), "SCHEDULED", TAB(32), STF + SCMP * TMMH, TAB(50), 02 * SCHP * TMMH
PRINT TAB(7), "TOTALS", TAB(32), TMMH + 02 * SCHP * TMMH, TAB(50), 02 * SCHP * TMMH, TAB(65), APF, "(AVG)"
IF ETREL < 1 THEN PRINT TAB(5), "EXTERN TANK"
IF ETREL < 1 THEN PRINT TAB(5), "SCHEDULED", TAB(32), STE + ETS * STE
IF SRBREL < 1 THEN PRINT TAB(5), "BOOSTER"
IF SRBREL < 1 THEN PRINT TAB(5), "SCHEDULED/UNSCHED", TAB(32), STF + SRBS * STE
COLOR 2: PRINT "ENTER RETURN "; RET
CLS: COLOR 10
SCMP = X(4) - 1: B1 = 0: B4 = 0: A2 = 0: B2 = 0: A1 = 0: A4 = 0
PRINT TAB(15), "SYSTEM PERFORMANCE SUMMARY - at mission nbr.", X(24), " - page 3"
PRINT TAB(1), "VEHICLE IS ", VNAM, TAB(33), "DATE ", DATE, TAB(60), "TIME ", TIME$
PRINT COLOR 14: PRINT TAB(30), "MAINTAINABILITY REPORT"
PRINT COLOR 13 PRINT TAB(35), "SPARES-VEHICLE", TAB(60), TS
PRINT COLOR 7
PRINT TAB(1), "CATEGORY", TAB(25), "MANH IR DRIVEN", TAB(40), "MANH IR 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)))
B2 = INT(A2 + 999)
B2 = INT(B2 + 999)
IF ETREL < 1 THEN MTE = 0
PRINT TAB(3), "UNSCH MANPWR", TAB(25), A2, TAB(40), TEMP - SMP, TAB(55), STM, 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), TEMP, TAB(55), STM + SCMP, TAB(65), CI + SCMP
PRINT TAB(3), "EXT TANK"
A1 = INT((ETS * STE + STE) * X(15)) / (12 * X(11) * (1 - X(12)))
A1 = INT(A1 + 999)
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), TEMP, TAB(55), B1, TAB(65), B1
PRINT TAB(3), "LBB"
A4 = (SRBS + STE + STM) * 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: STE = 0: A4 = 0
IF SRBREL < 1 THEN PRINT TAB(3), "SCHED/UNSCH MANPWR", TAB(25), A4, TAB(40), TEMP, TAB(55), B4, TAB(65), B4
PRINT: PRINT TAB (10), "TOTALS", TAB(25), A2 + B2 + A1 + A4, TAB(40), TEMP + STE + STM, TAB(55), STM + SCMP + B1 + B4, TAB(65), CI + SCMP + B1 + C-24
COLOR 2
PRINT "ENTER RETURN "; RT
CLS
VEHICLE TURN TIME SUMMARY
TT = 0; TJ = 0; TMAX = 0
SUM = 0; CT = 0; SUMC = 0
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO N1
CT = CT + 1
SUMC = SUMC + C(I)
IF SEL$(I) = "SHUTTLE" THEN TSKT(I) = SMR(I) ELSE TSKT(I) = (1 - PFU(I)) * MHMA(I) / CI(I)
TI = (NRD(I) * (1 - PIU(I)) * POH(I)) / (FMA(T(I)) + THR(I)) / (FMAS(I) * TSKT(I) / CA(I))
IF TI > TMAX THEN TMAX = TI; JJ = 1
TT = TT + TI
SUM = SUM + TSKT(I)
N1: NEXT I
SCHT = .98 * SCHT * TOTM / X(14)
GTT = TT + SCHT; ATS: SUM / CT
IF TMAX < SCHT THEN TMAX = SCHT
PRINT TAB(5); "VEHICLE IS "; VNAM$; "SYSTEM PERFORMANCE SUMMARY - at million ubr. "; X(24)
PRINT TAB(5); "COMPUTED FLEET SIZE "; TAB(35); "AVG MISSIONS/YR/VEHICLE "; TAB(35); "TOT VEHICLE TURNAROUND TIME "; TAB(35); "MAX TIME ";
PRINT TAB(1); "ENTER RETURN "; RETURN
END
SUB
TURNTIME
9700  MODULE TO DISPLAY VEHICLE TURN TIME
9705 TL = 0; TJ = 0; TMAX = 0
9710 SUM = 0; CT = 0; SUMC = 0
9711 FOR I = 1 TO 33
9715 IF OP$(I) = "DELETE" THEN GOTO 9735
9716 CT = CT + 1
9720 IF SEL$(I) = "SHUTTLE" THEN TSKT(I) = SMR(I) ELSE TSKT(I) = (1 - PFU(I)) * MHMA(I) / CI(I)
9725 TI = (NRD(I) * (1 - PIU(I)) * POH(I)) / (FMA(T(I)) + THR(I)) / (FMAS(I) * TSKT(I) / CA(I))
9730 IF TI > TMAX THEN TMAX = TI; JJ = 1
9735 TT = TT + TI
9736 SUM = SUM + TSKT(I)
9737 NEXT I
AVCREW = SUMC / CT
9740 SCHT = .98 * SCHT * TOTM / X(14)
9750 GTT = TT + SCHT; ATS: SUM / CT
9800  "DISPLAY VEHICLE TURN TIME "; W = 0; X = 0; Y = 0; Z = 0; K = 0 "AVIONICS ROLLUP"
9805 FOR I = 19 TO 24
9810 IF OP$(I) = "DELETE" THEN GOTO NX10
9815 K = K + 1
9820 N = X + 1
9825 Y = Y + TSKT(I)
9830 Z = Z + (NRD(I) * (1 - PIU(I)) * POH(I)) / (FMA(T(I)) + THR(I)) / (FMAS(I) * TSKT(I) / CA(I))
9835 W = W + (NRD(I) * (1 - PIU(I)) * POH(I)) / (FMA(T(I)) + THR(I)) / (FMAS(I)
NX10: NEXT I
YA = Y + K
C-25
1985 IF IOD - 1: IF - 18
1980 COLOR 14
1985 PRINT TAB(20); "VEHICLE TURN TIME REPORT - at mission thr", "X(24)", " - page 1*"
1980 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS ", VNAMS, TAB(35); "DATE: ", DATES, TAB(60); "TIME: ", TIMES
1985 COLOR 2
1985 PRINT TAB(25); "ON-VEHICL", TAB(38); "E", "TOT", TAB(52), "NBR CREWS", TAB(63), "AVG SUBSYS REPAIR"
1985 PRINT TAB(1); "WTS", TAB(25); "MTTR (HRS)", TAB(38); "MAIN ACT", TAB(52); "ASSIGNED", TAB(62); "TIME PER MSN-hrs"
1980 FOR J = 1 TO IO
1985 PRINT IF UPS(I) = "DELETE" THEN GOTO 9900
1985 IF STR(I) = "SHUTTLE" THEN COLOR 12 ELSE COLOR 15
1985 IF J = JJ THEN COLOR (9
1985 TEMP = (NRD(I)) * (1. PUI) * PMAT(I) / THRS(I) / FMAS(I) * TSKR(I) / CA(I)
1985 IF J = JJ THEN TSAVE = TEMP
1985 IF J = 24 THEN COLOR 14 PRINT TAB(3); "AVIONICS ROLL UP", TAB(27); "AVG", YA, TAB(40); W, TAB(53); X, TAB(61); Z, "TOT"
1990 NEXT I
COLOR 2
1990 IF IO = 1 THEN IO = 19: IO = 33: PRINT: INPUT "ENTER RET", "RET": CLS GOTO 9810
1990 PRINT: COLOR 13
1990 PRINT TAB(1); "AVG CREW SIZE", AVGCREW, TAB(26); "AVG TASK TIME", ATSK, TAB(60); TT, "(TOTAL)"
1990 PRINT: COLOR 2: PRINT "INPUT "ENTER RETURN...", "RET": CLS GOTO 9810
1990 PRINT: COLOR 14
1990 PRINT TAB(20); "VEHICLE TURN TIME REPORT - at mission sbr", "X(24)", " - page 2*
1990 PRINT TAB(1); "VEHICLE IS ", VNAMS, TAB(35); "DATE: ", DATES, TAB(60); "TIME: ", TIMES
COLOR 15: PRINT PRINT TAB(5); "CATEGORY", TAB(32); "MIN TURN TIMES" PRINT
PRINT TAB(5); "SCHD MAINT MSN TASK TIME", TAB(55), SCHT, "HRS"
PRINT TAB(5); "UNSCHEDULED MAINTENANCE TIME", TAB(55), TSAVE, "HRS"
PRINT TAB(5); "INTEGRATION TIME", TAB(55), X(17), "DAYS"
PRINT TAB(1); "LAUNCH PAD TIME", TAB(55), X(18), "DAYS"
PRINT TAB(5); "MISSION TIME INC GRND PWR TIME", TAB(55), T(0) + T(4); "HRS"
IF TSAVE < SCHT THEN TSAVE = -SCHT
VTT = T(0) + T(4) + TSAVE * X(17) / X(18) * 24: COLOR 12
PRINT TAB(5); "TOT VEHICLE TURNAROUND TIME", TAB(55), VTT, "TOTAL HRS"
COLOR 14
PRINT TAB(1); "ONE SHIFT/DAY MAINTENANCE"
DVTT = (T(0) + T(4)) / 24 + (TT + SCHT) * X(17) / X(18)
PRINT TAB(5); "TOT VEHICLE TURNAROUND TIME", TAB(55), DVTT, "DAYS"
PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE", TAB(55), 12 + 24 / DVTT
PRINT TAB(5); "COMPUTED FLEET SIZE", TAB(55), INT((X(15) / 12) / 21 / DVTT) + 99
PRINT TAB(1); "TWO SHIFTS/DAY MAINTENANCE"
DVTT = (T(0) + T(4)) / 24 + (TT + SCHT) * X(17) / X(18)
PRINT TAB(5); "TOT VEHICLE TURNAROUND TIME", TAB(55), DVTT, "DAYS"
PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE", TAB(55), 12 + 21 / DVTT
PRINT TAB(5); "COMPUTED FLEET SIZE", TAB(55), INT((X(15) / 12) / 21 / DVTT) + 99
COLOR 3
PRINT TAB(5); "NOTE: assumes parallel unach/acted maint tasks, 8 hr shifts, and 21 work days a month"
COLOR 2
PRINT INPUT "ENTER RETURN...", "RET": CLS COLOR 14
PRINT TAB(20); "VEHICLE TURN TIME REPORT - at mission thr", "X(24)", " - page 3*
PRINT TAB(1); "VEHICLE IS ", VNAMS, TAB(35); "DATE: ", DATES, TAB(60); "TIME: ", TIMES
COLOR 15: PRINT PRINT TAB(5); "CATEGORY", TAB(32); "MAX TURN TIMES" PRINT
PRINT TAB(5); "SCHD MAINT MSN TASK TIME", TAB(55), SCHT, "HRS"
PRINT TAB(5); "UNSCHEDULED MAINTENANCE TIME", TAB(55), TSAVE, "HRS"
PRINT TAB(5); "INTEGRATION TIME", TAB(55), X(17), "DAYS"
PRINT TAB(1); "LAUNCH PAD TIME", TAB(55), X(18), "DAYS"
PRINT TAB(5); "MISSION TIME INC GRND PWR TIME", TAB(55), T(0) + T(4); "HRS"
VTT = (T(0) + T(4)) + TT + SCHT * X(17) / X(18) * 24: COLOR 12
PRINT TAB(5); "TOT VEHICLE TURNAROUND TIME", TAB(55), VTT, "TOTAL HRS"
COLOR 14: PRINT TAB(1); "ONE SHIFT/DAY MAINTENANCE"
DVTT = (T(0) + T(4)) / 24 + (TT + SCHT) * X(17) / X(18)
PRINT TAB(5); "TOT VEHICLE TURNAROUND TIME", TAB(55), DVTT, "DAYS"
PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE", TAB(55), 12 + 24 / DVTT
9960 PRINT TAB(5); "COMPUTED FLEET SIZE", TAB(55), INT((X(15) / 12) / 21 / DVTT) + 99
PRINT TAB(1); "TWO SHIFTS/DAY MAINTENANCE"
DVTT = (T(0) + T(4)) / 24 + (TT + SCHT) * X(17) / X(18)
PRINT TAB(5); "TOT VEHICLE TURNAROUND TIME", TAB(55), DVTT, "DAYS"
PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE", TAB(55), 12 + 21 / DVTT
PRINT TAB(5); "COMPUTED FLEET SIZE", TAB(55), INT((X(15) / 12) / 21 / DVTT) + 99
COLOR 3
PRINT TAB(5); "NOTE: assumes sequential tasks, 8 hr shifts, and 21 work days a month"
COLOR 2
9983 PRINT INPUT "ENTER RETURN...", "RET": CLS COLOR 14
PRINT TAB(20); "VEHICLE TURN TIME REPORT - at mission thr", "X(24)", " - page 4*
PRINT TAB(1); "VEHICLE IS ", VNAMS, TAB(35); "DATE: ", DATES, TAB(60); "TIME: ", TIMES
COLOR 15: PRINT TAB(5); "CATEGORY": PRINT
C-26
SUB PCHO
  "MODULE TO PRINT INPUT DATA"
LPRINT TAB(5), RITTL$ LPRINT LPRINT TAB(5), COMMENTS LPRINT LPRINT

File: RAM3.BAS  print module

DECLARE SUB WRFILE ()
DECLARE SUB SIMREP ()
DECLARE SUB SIM ()
DECLARE SUB ETSRB ()
DECLARE SUB PRINTSUM ()
DECLARE SUB PRINTREL ()
DECLARE SUB PRINTMAN ()
DECLARE SUB PRINTSPPR ()
DECLARE SUB PRINTTURN ()
DECLARE SUB ECHO ()
DECLARE SUB PRINTMAINT ()

'NASA, LANGLEY RESEARCH CENTER'
'MTBM COMPUTATIONAL MODEL - NASA RESEARCH GRANT'
'DEVELOPED BY C. BELEING, UNIV OF DAYTON 6/17/94 (updated)

'******* COMBINED PRE/CONCEPTUAL MODEL *******

'SAVE AS "RAM3.BAS"  OUTPUT REPORT GENERATOR'

COMMON SHARED YR, B, X1, X2, LF, VR1, VR2, VR3, VR4, VR5, VR, AREM
COMMON SHARED VFMA, TFVMA, SVFMA, CVFMA, OMFMA, FMMMA, TMA, AMHMA
COMMON SHARED SCRP, VMH, TOMH, TPMH, APP, P1, P2, P3, WAV, FH42, FH44
COMMON SHARED FMA11, FMA12, VNAME, TBR, TBR2, T5, TBPR
COMMON SHARED SMF, TMP, VMOH, WITT, WING, WIF, WFP
COMMON SHARED ETREL, ESRREL, ETS, SRBS, RITTL$, ABTFS
COMMON SHARED STT, MTE, TME, STM, WIF, TMP, C1
DIM SHARED WB5$(35), X$(50), NAM$(50), TIRS$(35), MDM$(35), MIP$(35), OMR$(35), FMM$(35)
DIM SHARED SFEL$(35), T1$(10), CP$(9), CA$(35), REFI$(35), RF$(35)
DIM SHARED GHR$(35), LHR$(35), JHR$(35), OHR$(35), RHR$(35), TSKT$(35), POR$(35)
DIM SHARED L$(15), SM$(15), FMA$(35), FMAC$(35), FMAC$(35), SX$(35), SMA$(35), SMR$(35)
DIM SHARED MW$(35), C$(35), CM$(35), OPM$(35), TB$(35), PWT$(35)
DIM SHARED FM$(35), PF$(35), PA$(35), JR$(35), WR$(35), NR$(35), FR$(35)
DIM SHARED NKR$(35), K$(35), R$(35), R$(35), R$(35), R$(35)
DIM SHARED PWT$(35), PWT$(35), PWT$(35), PWT$(35), PWT$(35), PWT$(35)
DIM SHARED ETSUB$(35), ETMBA$(35), ETHERS$(5), ETABR$(5), ETABR$(5), ETABR$(5), ETABR$(5), ETABR$(5)
DIM SHARED SRBSUB$(35), SBBMSB$(35), SBBMSB$(35), SBBMSB$(35), SBBMSB$(35), SBBMSB$(35)
DIM SHARED SWRSK$(35), MAS$(9), MTR$(35), MTR$(35), REM$(35), SMT$(35), SMT$(35), SC$(35)
DIM SHARED P1$(33), C$(35)
COMMON SHARED P1$(33), C$(35)
COMMON SHARED SWB$(35), MAS$(35), MTR$(35), MTR$(35), REM$(35), SMT$(35), SMT$(35), SC$(35)
COMMON SHARED SWB$(35), X$(35), NAM$(35), TIR$(35), MM$(35), MP$(35), OMR$(35), FMM$(35)
COMMON SHARED SHL$(35), C$(35), CP$(9), CA$(35), REFL$(35), RF$(35)
COMMON SHARED OH$(35), OOH$(35), OOH$(35), OOH$(35), OOH$(35), OOH$(35)
COMMON SHARED V$(35), SNAX$(35), FMAT$(35), FMAT$(35), FMAT$(35), SM$(35), SMR$(35)
COMMON SHARED MW$(35), C$(35), CM$(35), OPM$(35), TOL$(35), PWT$(35)
COMMON SHARED FM$(35), PF$(35), PA$(35), JR$(35), WR$(35), NR$(35), FR$(35)
COMMON SHARED NKR$(35), K$(35), R$(35), R$(35), R$(35), R$(35)
COMMON SHARED PWT$(35), PWT$(35), PWT$(35), PWT$(35), PWT$(35), PWT$(35)
COMMON SHARED ETSUB$(35), ETMBA$(35), ETHERS$(5), ETABR$(5), ETABR$(5), ETABR$(5), ETABR$(5), ETABR$(5)
COMMON SHARED SRBSUB$(35), SBBMSB$(35), SBBMSB$(35), SBBMSB$(35), SBBMSB$(35), SBBMSB$(35)
COMMON SHARED SWRSK$(35), MAS$(9), MTR$(35), MTR$(35), REM$(35), SMT$(35), SMT$(35), SC$(35)
COMMON SHARED P1$(33), C$(35)
IF OP$(I) = "DELETE" THEN GOTO EX7
LPRINT
IF SEL$(I) < "SHUT" THEN GOTO EX7
FOR I = 1 TO 33
LPRINT( I).PRINT TAB(25); "INPUT PARAMETERS & DATA - page 1": LPRINT
LPRINT(I).PRINT(I).PRINT(TAB(5)); "VEHICLE IS": VNAM$(I), TAB(25); "DATE": DATE$(I), TAB(60); "TIME": TIMES; LPRINT
LPRINT I).PRINT
LPRINT(I).PRINT(SYSTEM PARAMETER VALUES); LPRINT
LPRINT(I).PRINT(TAB(10); "PARAMETER", TAB(50); "VALUE": LPRINT
FOR I = 1 TO 33
LPRINT(I).PRINT(TAB(25); "INPUT PARAMETERS & DATA - page 2": LPRINT
LPRINT(I).PRINT(TAB(3)); "SUBSYSTEM WEIGHTS & CALIBRATION FACTORS"
IF X(6) = 0 THEN LPRINT(I).PRINT(TAB(1); "WBS": TAB(30), "WEIGHT": TAB(40), "PCIT WGT": TAB(52), "MTBM": TAB(65), "MTTR": TAB(55), "MTTR FACTOR": GOTO EX2
LPRINT(I).PRINT(TAB(1); "WBS": TAB(30), "WEIGHT": TAB(40), "MTBM": TAB(65), "MTTR": TAB(55), "MTTR FACTOR"
ADD = 0
EX2: FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX4
ADD = ADD + W(I)
IF X(6) = 0 THEN LPRINT(TAB(1); "WBS$(I), TAB(30), W(I), TAB(40), PWTS(I), TAB(52), MW(I), TAB(65), CM(I): GOTO XE!
LPRINT(I).PRINT(TAB(1); "WBS$(I), TAB(30), W(I), TAB(40), MW(I), CM(I)
XE: NEXT I
LPRINT(I).PRINT(TAB(1); "TOTAL WEIGHT": TAB(30), ADD, TAB(50), "WEIGHT FACTOR IS": PW
LPRINT I).PRINT(I).PRINT(TAB(10); "SCHEDULED MAINTENANCE PERCENT IS": TAB(45), 100 * SCHP
LPRINT(I).PRINT(SHUT$)
LPRINT I).PRINT(TAB(25); "INPUT PARAMETERS & DATA - page 3": LPRINT
LPRINT I).PRINT(I).PRINT(TAB(5)); "SUBSYSTEM OPERATING HOURS": LPRINT
LPRINT(I).PRINT(TAB(1); "SUBSYSTEM": TAB(30), "PROCESS": TAB(39), "PAD": TAB(46), "BOOST": TAB(52), "RE TIME": TAB(61), "ORBIT": TAB(64), "REENTRY": TAB(68), "TIME": TAB(32), "TIME": TAB(40), "TO ORBIT": TAB(51), "TIME": TAB(66), "TIME"
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX4
LPRINT(I).PRINT(TAB(1), "WBS$(I), TAB(32), POH(I), TAB(39), COH(I), TAB(46), LQH(I), TAB(53), TOH(I), TAB(60), OOH(I), TAB(67), ROH(I)
EX4: NEXT I
LPRINT(SHUT$)
LPRINT I).PRINT(TAB(25); "INPUT PARAMETERS & DATA - page 4": LPRINT
LPRINT(I).PRINT(I).PRINT(TAB(5)); "SUBSYSTEM COMPUTATION FACTORS": LPRINT
LPRINT(I).PRINT(TAB(1); "SUBSYSTEM": TAB(28), "TECH GROWTH": TAB(40), "CRITICAL": TAB(53), "REMOVAL": TAB(70), "PERCENT": LPRINT
LPRINT(TAB(28), "FACTOR": TAB(40), "FAIL RATE": TAB(55), "RATE": TAB(70), "OFF EQUIP": LPRINT
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX5
LPRINT(I).PRINT(TAB(1), "WBS$(I), TAB(28), TG(I), TAB(40), PA(I), TAB(55), RR(I), TAB(70), PF(I)
EX5: NEXT I
LPRINT(SHUT$)
LPRINT I).PRINT(TAB(25); "INPUT PARAMETERS & DATA - page 5": LPRINT
LPRINT(I).PRINT(I).PRINT(TAB(5)); "MORE SUBSYSTEM COMPUTATION FACTORS": LPRINT
LPRINT(I).PRINT(TAB(1); "SUBSYSTEM": TAB(28), "CREW": TAB(40), "NBR CROWS": TAB(55), "FRACTION INHERENT": LPRINT
LPRINT(TAB(28), "SIZE": TAB(40), "ASGN": TAB(55), "FAILURES": LPRINT
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX5
LPRINT(I).PRINT(TAB(1), "WBS$(I), TAB(29), C(I), TAB(40), CA(I), TAB(55), PI(I)
EX6: NEXT I
LPRINT(SHUT$)
LPRINT I).PRINT(TAB(25); "INPUT PARAMETERS & DATA - page 6": LPRINT
LPRINT(I).PRINT(I).PRINT(TAB(5)); "SUBSYSTEM REDUNDANCY": LPRINT
LPRINT(I).PRINT(TAB(1); "SUBSYSTEM": TAB(28), "REDUNDANT": TAB(45), "MIN NBR": LPRINT
LPRINT(TAB(28), "SUBSYS": TAB(45), "REQUIRED": LPRINT
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX6
IF K(I) = 0 THEN K(I) = 1
LPRINT(I).PRINT(TAB(1), "WBS$(I), TAB(29), NRD(I), TAB(45), K(I)
EX6: NEXT I
LPRINT(SHUT$)
LPRINT I).PRINT(TAB(25); "INPUT PARAMETERS & DATA - page 7": LPRINT
LPRINT(I).PRINT(I).PRINT(TAB(5)); "SHUTTLE FILE MAINTAINED UTILIZED VALUES": LPRINT
LPRINT(I).PRINT(TAB(1); "SUBSYSTEM": TAB(30), "MTBM": TAB(50), "MTTR", FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO EX7
IF SEL$(I) < "SHUT": THEN GOTO EX7
C-28
I PRINT TAB(1), "NBR", TAB(5), "SUBSYSTEM", TAB(18), "MTDM", TAB(26), "OPCM HRS", TAB(36), "CRIT FAL 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), ETABR(I), TAB(50), ETMTR(I), TAB(59), ETCRFW(1) NEXT I

I PRINT
I PRINT TAB(5), "SCHD MAINT AS A PCT OF UNSCH MAINT" ; ETS : I PRINT
I PRINT TAB(20), "SCHD MAINT AS A PCT OF UNSCH MAINT" ; ETS : I PRINT
I PRINT TAB(1), "NBR", TAB(5), "SUBSYSTEM", TAB(18), "MTDM", TAB(26), "OPCM HRS", TAB(36), "CRIT FAL 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), ETABR(I), TAB(50), ETMTR(I), TAB(59), ETCRFW(1) NEXT I

I PRINT
I PRINT TAB(1), "OVERALL ET" ; TAB(20), ETS ; TAB(32), STE ; TAB(47), ETS ; TAB(60) ; TIME.

I PRINT IF SRBR - 1 THEN GOTO ROT2
I PRINT I PRINT
I PRINT TAB(20), "LIQUID ROCKEHT BOOSTER INPUT DATA".
I PRINT TAB(1), "NBR", TAB(5), "SUBSYSTEM", TAB(18), "MTDM", TAB(26), "OPCM HRS", TAB(36), "CRIT FAL RT", TAB(50), "MTTR", TAB(59), "CREW SIZE".

I PRINT
FOR I - 1 TO 4
I PRINT TAB(1), I, TAB(5), SRBSUB$(I), TAB(18), SRBMB$(I), TAB(26), SRBSRS$(I), TAB(36), SRBSBR$(I), TAB(50), SRBMTR$(I), TAB(59), SRBCREW$(I) NEXT I

I PRINT
I PRINT TAB(5), "SCHD MAINT AS A PCT OF UNSCH MAINT" ; SRBS : I PRINT
I PRINT SRBR - 1 ; TFME - 0 ; MTTR - 0 ; STE - 0
I PRINT TAB(20), "COMPUTED" , TAB(40), "MISSION" , TAB(61), "MANHR DRIVEN"
I PRINT TAB(1), "SUBSYSTEM", TAB(18), "RELIABILITY" , TAB(32), "UNSCH MANHRS" , TAB(47) , "SCH MANHRS" , TAB(59) , "MANPWR" . I PRINT
I PRINT IF SRBR - 1 THEN GOTO ROT2
I PRINT I PRINT
I PRINT TAB(20), "OVERALL LRB" ; TAB(20), SRBR - 1 , TAB(32) , STE , TAB(47) , SRBS * STE ; TAB(60) ; A4

NEXT I

I PRINT
I PRINT TAB(1), "OVERALL LRB" ; TAB(20), SRBR - 1 , TAB(32) , STE , TAB(47) , SRBS * STE ; TAB(60) ; TMFR

027 : I PRINT CHR$(12) ; END SUB

SUB PRINTMANT
I PRINT "MODULE FOR MAINTAINABILITY REPORT"
X - 0 ; Y - 0 ; Z - 0 ; K - 0 ; AVIONICS ROLLUP
FOR I - 19 TO 24

C - 29
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 1 TO 13
LPRINT TAB(3); RTITLES: LPRINT
LPRINT TAB(3); "COMMENTS": LPRINT; X(24); "; .PRINT: LPRINT
LPRINT TAB(3); "VEHICLE IS ": VNAME, TAB(33); "DATE ": DATE$, TAB(60); "TIME ": TIMES$; LPRINT
LPRINT TAB(3); "WBS ": TAB(32); "MAINT ACTIONS/MSN ": TAB(29), "AVG MANHR/MA" ": TAB(65), "AVG MANHRS/MSN"; LPRINT
SKM: NEXT I
LPRINT
LPRINT TAB(3); "TOTAL'S ": TAB(32), TMA, TAB(47), AMHMA, "WT.AVG ": TAB(65), VMH
LPRINT CHR$(12);
SK: NEXT I
LPRINT
LPRINT TAB(20); "MAINTAINABILITY REPORT - at mission nbr ": X(24); " .PRINT: LPRINT
X = 0: Y = 0: Z = 0: K = 0: NEXT I
LPRINT FOR 1 TO 24
IF OPS(I) = "DELETE" THEN GOTO SK6
K = K + 1
X = X + OMH(I)
Y = Y + FMH(I)
Z = Z + 1: PF(I)
SK6: NEXT I
ZA = Z / K
LPRINT : LPRINT
LPRINT TAB(3): "VEHICLE IS ": VNAM$, TAB(33); "DATE ": DATE$, TAB(60); "TIME ": TIMES$; LPRINT
LPRINT TAB(3); "WBS ": TAB(32); "ON-VEH MH ": TAB(29), "OFF-VEH MH ": TAB(62); "TRACTION ON-VEH ": LPRINT
SK5: NEXT I
LPRINT
LPRINT TAB(3): "TOTAL'S ": TAB(32), TMA, TAB(47), AMHMA, "WT.AVG ": TAB(65), VMH
LPRINT CHR$(12);
IO = 1: IF 1 TO 33
LPRINT TAB(20); "MAINTAINABILITY REPORT - at mission nbr ": X(24); " .PRINT: LPRINT
X = 0: Y = 0: Z = 0: K = 0: NEXT I
LPRINT FOR 1 TO 24
IF OPS(I) = "DELETE" THEN GOTO SK6
K = K + 1
X = X + OMH(I)
Y = Y + FMH(I)
Z = Z + 1: PF(I)
SK6: NEXT I
ZA = Z / K
LPRINT : LPRINT
LPRINT TAB(3): "VEHICLE IS ": VNAM$, TAB(33); "DATE ": DATE$, TAB(60); "TIME ": TIMES$; LPRINT
LPRINT TAB(3); "WBS ": TAB(32); "ON-VEH MH ": TAB(29), "OFF-VEH MH ": TAB(62); "TRACTION ON-VEH ": LPRINT
SK5: NEXT I
LPRINT
LPRINT TAB(3): "TOTAL'S ": TAB(32), TMA, TAB(47), AMHMA, "WT.AVG ": TAB(65), VMH
LPRINT CHR$(12);
IO = 1: IF 1 TO 33
LPRINT TAB(20); "MAINTAINABILITY REPORT - at missionnbr ": X(24); " .PRINT: LPRINT
X = 0: Y = 0: Z = 0: K = 0: NEXT I
LPRINT FOR 1 TO 24
IF OPS(I) = "DELETE" THEN GOTO SK6
K = K + 1
X = X + OMH(I)
Y = Y + FMH(I)
Z = Z + 1: PF(I)
SK6: NEXT I
ZA = Z / K
LPRINT : LPRINT
LPRINT TAB(3): "VEHICLE IS ": VNAM$, TAB(33); "DATE ": DATE$, TAB(60); "TIME ": TIMES$; LPRINT
LPRINT TAB(3); "WBS ": TAB(32); "ON-VEH MH ": TAB(29), "OFF-VEH MH ": TAB(62); "TRACTION ON-VEH ": LPRINT
SK5: NEXT I
LPRINT
LPRINT TAB(3): "TOTAL'S ": TAB(32), TMA, TAB(47), AMHMA, "WT.AVG ": TAB(65), VMH
LPRINT CHR$(12);
X = 0: Y = 0: Z = 0: K = 0: NEXT I
LPRINT FOR 1 TO 24
IF OPS(I) = "DELETE" THEN GOTO SK6
K = K + 1
X = X + OMH(I)
Y = Y + FMH(I)
Z = Z + 1: PF(I)
SK6: NEXT I
ZA = Z / K
LPRINT : LPRINT
LPRINT TAB(3): "VEHICLE IS ": VNAM$, TAB(33); "DATE ": DATE$, TAB(60); "TIME ": TIMES$; LPRINT
LPRINT TAB(3); "WBS ": TAB(32); "ON-VEH MH ": TAB(29), "OFF-VEH MH ": TAB(62); "TRACTION ON-VEH ": LPRINT
SK5: NEXT I
LPRINT
LPRINT TAB(3): "TOTAL'S ": TAB(32), TMA, TAB(47), AMHMA, "WT.AVG ": TAB(65), VMH
LPRINT CHR$(12);
SUB PRINTMAN
  "PRINT MANPOWER MODULE"
  X = 0; Y = 0; Z = 0; "AVIONICS ROLLOVER"
  FOR I = 1 TO 24
    IF OP$(I) = "DELETE" THEN GOTO SK8
    X = X + MH(I)
    Z = Z + MP(I)
  NEXT I
  Y = X I * X / 12
  MT = 0
  IO = 1; IF = 1; SST = 3; ASTP = 0
  LPRINT TAB(5); FLOATS; LPRINT; LPRINT
  LPRINT TAB(20); "MANPOWER REPORT - at mission str."); X(24); ""; LPRINT
  LPRINT TAB(1); "VEHICLE IS "; VNAMS; TAB(35); "DATE: "; DATES, TAB(60); "TIME: "; TIMES; LPRINT
  LPRINT TAB(3); "AVAIL HRS/MO "; X(11); TAB(40); "INDIRECT Wkkt. "; MT / X(12); "$".
  LPRINT "manpower is computed from manhrs/mo divided by avail direct hrs per mo per person";
  LPRINT
  LPRINT LPRINT TAB(1), "WRS, TAB(27), "MANHRS/MAN", TAB(42), "MANHRS/MO", TAB(35), "MANPWR", TAB(65), "AVG CREW"
  FOR I = 1 TO 10
    IF OP$(I) = "DELETE" THEN GOTO PM1
  NEXT I
  IF I > 19 AND I < 24 THEN ASTP = ASTP + C(I)
  IF I = 24 THEN LPRINT TAB(3); "AVIONICS ROLLOVER", TAB(28); X; TAB(43); Y; TAB(58); Z; TAB(63); ASTP
"MT = MT + C(I) * C(I)
  PM1: NEXT I
  LPRINT LPRINT TAB(5); "UNSCHEDULED", TAB(30); VMH; TAB(45); VMH * X(15) / 12; TAB(59); MP(I); TAB(65), C(I)
  IF I = 24 THEN LPRINT TAB(3); "AVIONICS ROLLOVER", TAB(28); X; TAB(43); Y; TAB(58); Z; TAB(63); ASTP
"MT = MT + C(I) * C(I)
  PRINT
  LPRINT LPRINT TAB(5); "SCHEDULED", TAB(30); SCHP * TOMH; TAB(45); X(15) * SCHP / 12; TAB(59); MP(I); TAB(65), C(I)
  LPRINT LPRINT TAB(5); "TOTAL", TAB(30); VMH; VMH * SCHP * TOMH; VMH * SCHP * TOMH; X(15) / 12; TAB(59); MP(I); TAB(65), C(I)
  LPRINT LPRINT TAB(5); "TOTAL", TAB(30); VMH; VMH; VMH; VMH; X(15) / 12; TOMH; MP(I); TAB(65), STP + X(14) COLOR 14
  LPRINT LPRINT TAB(1), "Tot personal assigned - SUM (avg crew size x avgl crews) schd manpower: TAB(75); INT(MT) / SMP
  LPRINT CHKRS(12);
END SUB
SUB PRINTREL
  "**** PRINT MODULE FOR RELIABILITY REPORT *******"
  X = 0; Y = 0; Z = 0; "AVIONICS ROLLOVER"
  FOR I = 1 TO 2
    IF OP$(I) = "DELETE" THEN GOTO NX1
    IF REL(I) = 1 THEN GOTO NX1
    X = X + FMA(I)
    Y = Y + FMA(I)
    Z = Z + FMA(I)
  NEXT I
  NX1: NEXT I
  IF X > 0 THEN XA = X / X
  IF Y > 0 THEN YA = Y / Y
  IF Z > 0 THEN ZA = Z / Z
  IO = 1; IF = 1; SST = 3
  MNFMA = 0
  LPRINT TAB(5), "RITELSS; LPRINT; LPRINT
  LPRINT TAB(20); "RELIABILITY REPORT - at mission str."); X(24); ""; page 1; "; LPRINT
  LPRINT TAB(1); "VEHICLE IS "; VNAMS; TAB(35); "DATE: "; DATES, TAB(60); "TIME: "; TIMES; LPRINT
  LPRINT TAB(3); "AVAIL HRS/MO "; X(11); TAB(40); "INDIRECT Wkkt. "; MT / X(12); "$"
  LPRINT "all MTBM's are for a single subsystem, e.g. one engine"; LPRINT
  LPRINT TAB(1); "WRS; TAB(27); "TECH/GROWTH MTBM", TAB(43); "GRND PROC MTBM", TAB(61); "MISSION MTBM"
  LPRINT TAB(29); "(all MA's)", TAB(43); "(external MA's)", TAB(61); "(abnormal MA's)
  FOR I = 1 TO 10
    IF OP$(I) = "DELETE" THEN GOTO SK1
    MNFMA = MNFMA + (1 - PI(I)) / FMA(I)
  NEXT I
  IF I = 9 THEN LPRINT TAB(1); WSSR(1); "", "", "", TAB(35); FMA(I); TAB(48); FMA(I) / (1 - PI(I)); TAB(61); FMA(I)
  IF I > 1 THEN LPRINT TAB(1), WSSR(1), "", "", TAB(35); FMA(I); TAB(48); FMA(I) / (1 - PI(I)); TAB(61); FMA(I)
  IF I = 24 THEN LPRINT TAB(5), "AVIONICS ROLLOVER", TAB(32); XA; TAB(43); YA; TAB(58); ZA
  SK1: NEXT I
  LPRINT LPRINT TAB(5), "AVIONICS ROLLOVER"
  FOR I = 1 TO 24
    IF OP$(I) = "DELETE" THEN GOTO NY2
    K = K + 1
    X = X / PA(I)
    Y = Y / FMA(I)
    Z = Z * R(I)
  NEXT I
C-31
NY2: NEXT I
  IF K = 0 THEN K = 1
  XA = X / K
  IQ = 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(3), "VEHICLE IS ", VNAMS; TAB(35), "DATE: ", DATES; TAB(60), "TIME: ", TIMES: I.PRINT
  I.PRINT "critical MTBM's are for a single subsystem e.g. one engine": I.PRINT
  I.PRINT TAB(2), "WBS "; TAB(14); "CRITICAL FAILURE "; TAB(48); "CRITICAL "; TAB(60); "SUBSYS NON":
  IF (X(2) = 0 THEN I.PRINT TAB(28); "RATE = grand total": TAB(48); "MTBM "; TAB(60); "REDUNDANT MSN REL":
  IF (K(2) = 1 THEN I.PRINT TAB(28); "RATE = rate": TAB(48); "MTBM "; TAB(60); "REDUNDANT MSN REL":
  FOR I = 10 TO 33
    IF OP(I) = "DELETE" THEN GOTO SK2
    I.PRINT TAB(5), "VEHICLE ", TAB(48); CVFMA; TAB(63); VR
    I.PRINT CHRK(12),
    IQ = I: IE = 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(1(I))
      Y = Y * R(2(I))
      Z = Z * R(3(I))
    NY3: NEXT I
    I.PRINT TAB(1), "VEHICLE IS ", VNAMS; TAB(35), "DATE: ", DATES; TAB(60), "TIME: ", TIMES: 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 33
      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(3), "AVIONICS ROLLUP ", TAB(30); X; TAB(42); Y; TAB(57); Z
    SK3: NEXT I
    I.PRINT I.PRINT
    I.PRINT TAB(5); "VEHICLE ", TAB(45); CVFMA; TAB(63); VR
    I.PRINT CHRK(12),
    IQ = I: IE = 33
    I.PRINT TAB(20); "RELIABILITY REPORT - at mission nbr "; X(24); " - page 4": I.PRINT
    I.PRINT TAB(1), "VEHICLE IS ", VNAMS; TAB(35), "DATE: ", DATES; TAB(60), "TIME: ", TIMES: 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 33
      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(3), "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); VR5
    I.PRINT CHRK(12),
    END SUB
    SUB PRINTSPR
      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
        X = X + R(I)
        Y = Y + R(I)
        Z = Z + R(I)
        ZX = ZX + R(I)
    C-32
FOR I = 1 TO 33
  IF SEI$(I) = "SHUTTLE" THEN GOTO NI
  IF OP$(I) = "DELETE" THEN GOTO N1
  CT = CT + 1
  SUMC = SUMC + C(I)
  IF SEL(I) = "SHUTTLE" THEN TSKT(I) = SMRID ELSE TSKT(I) = (1 - PF(I)) * MIMA(I) / C(I)
  T1 = (NRD(I) - (1 - PF(I)) * POH(I) / FMA(I) + THRS(I) / FMAS(I) * TSKT(I) / C(A(I))
  IF T1 > TMAX THEN TMAX = T1
  J = J + 1
  TT = TT + T1
  SUM = SUM + TSKT(I)
NEXT I

NI: NEXT I
  SC = 9.8 * SCF * (TMH / X(14)
  GTT = TT + SCF * AT5K = SUM / CT
  IF TMAX < SCF THEN TMAX = SCF
  PRINT
  PRINT 1: PRINT TAB(35), "VEHICLE TURN TIMES": PRINT
  PRINT TAB(35), "MIN TURN TIME": PRINT, T35(I), "MAX TURN TIME": PRINT
  PRINT TAB(35), "TOTALS": PRINT, T35(I)
  PRINT
  PRINT 1: PRINT TAB(35), "TOTALS": PRINT, T35(I)
  PRINT TMAX = TMAX
  PRINT SUM = SUM
  PRINT T1 = T1
  PRINT J = J
  PRINT TT = TT
  PRINT SC = SC
  PRINT GTT = GTT
  PRINT CT = CT
  PRINT SUMC = SUMC
  1 PRINT
  PRINT 1: PRINT TAB(35), "SHUTTLE": PRINT, T35(I)
  PRINT 1: PRINT TAB(35), "TOTALS": PRINT, T35(I)
  PRINT TMAX = TMAX
  PRINT SUM = SUM
  PRINT T1 = T1
  PRINT J = J
  PRINT TT = TT
  PRINT SC = SC
  PRINT GTT = GTT
  PRINT CT = CT
  PRINT SUMC = SUMC
END SUB

SUB PRINTTURN
  "MODULE TO PRINT VEHICLE TURN TIME
  TT = 0: T1 = 0: TMAX = 0
  SUM = 0: CT = 0: SUMC = 0
  FOR I = 1 TO 33
    IF OP$(I) = "DELETE" THEN GOTO N1
    CT = CT + 1
    SUMC = SUMC + C(I)
    IF SEL(I) = "SHUTTLE" THEN TSKT(I) = SMRID ELSE TSKT(I) = (1 - PF(I)) * MIMA(I) / C(I)
    T1 = (NRD(I) - (1 - PF(I)) * POH(I) / FMA(I) + THRS(I) / FMAS(I) * TSKT(I) / C(A(I))
    IF T1 > TMAX THEN TMAX = T1
    J = J + 1
    TT = TT + T1
  NEXT I
  PRINT SC = 9.8 * SCF * (TMH / X(14)
  GTT = TT + SCF * AT5K = SUM / CT
  IF TMAX < SCF THEN TMAX = SCF
  PRINT
  PRINT 1: PRINT TAB(35), "VEHICLE TURN TIMES": PRINT
  PRINT 1: PRINT TAB(35), "MIN TURN TIME": PRINT, T35(I), "MAX TURN TIME": PRINT
  PRINT 1: PRINT TAB(35), "TOTALS": PRINT, T35(I)
  PRINT
  PRINT 1: PRINT TAB(35), "TOTALS": PRINT, T35(I)
  PRINT TMAX = TMAX
  PRINT SUM = SUM
  PRINT T1 = T1
  PRINT J = J
  PRINT TT = TT
  PRINT SC = SC
  PRINT GTT = GTT
  PRINT CT = CT
  PRINT SUMC = SUMC
END SUB

C-34
LPRINT; TAB(5); "UNSCHEDULED MAINTENANCE TIME'; TAB(55); TSAVE; "HRS"

LPRINT; TAB(1); WBS$(I); TAB(28); TSKT(I); TAB(40); NRD(I) *

IF

[.PRINT TAB(25); "ON-VEHICLE'; TAB(38); "TOT

I,PRINT

W - W

GTT - 1"1"1

SCHT

LPRINT

I`PRINT TAB(5);

LPRINT TAB(20), "VEHICLE TURN TIME REPORT - at mission nbr. ", X(24), " - page 1"; LPRINT

LPRINT TAB(1); "VEHICLE IS "; VNAMS, TAB(35), "DATE: "; DATES, TAB(60), "TIME: "; TIMES; LPRINT

LPRINT TAB(25), "ON-VEHICLE'; TAB(38); "TOT "; TAB(52), "NBR CREWS'; TAB(62); "AVG SUBSYS REPAIR'

LPRINT TAB(1); "WBS'; TAB(25); "MTTR (HRS)'; TAB(38), "MAIN ACT', TAB(52), "ASSIGNED', TAB(62), "TIME PER MSN'

LPRINT

FOR I = 1 TO 10

IF OP5(I) = "DELETE" THEN GOTO TX3

IF I = JJ THEN TSAVE = TEMP

I,PRINT

WBS$(I); TSKT(I), NRD(I) * (1 - PI(I) * POH(I) / FMAT(I) + TSKT(I) / FMAS(I); CA(I), TAB(62), TEMP

IF I I = 24 THEN LPRINT TAB(1); "AVIONICS ROlL(UP)', TAB(27), "AVG'; YA; TAB(40); W, TAB(53); X, TAB(61); Z; :TOT"

TX3: NEXT I

LPRINT . I,PRINT

LPRINT TAB(1); "AVG CREW SIZE'; AVCREW, TAB(26); "AVG TASK TIME'; ATK, TAB(60); TT; "(TOTAL)'

LPRINT CHRS(12);

LPRINT TAB(20), "VEHICLE TURN TIME REPORT - at mission nbr. ", X(24), " - page 2"; LPRINT

LPRINT TAB(1); "VEHICLE IS "; VNAMS, TAB(35), "DATE: "; DATES, TAB(60), "TIME: "; TIMES; LPRINT

LPRINT TAB(3), "CATEGORY'; TAB(35), "MIN TURN TIMES'; LPRINT

LPRINT TAB(5), "SCHD MAINT MSN TASK TIME'; TAB(35), "SCHT'; "HRS'

LPRINT TAB(3), "UNSCHEDULED MAINTENANCE TIME'; TAB(35), "SCHT'; "HRS'

LPRINT TAB(5), "INTEGRATION TIME'; TAB(35), X(17), "DAYS'

LPRINT TAB(5), "LAUNCH PAD TIME'; TAB(35), X(18), "DAYS'

LPRINT TAB(5), "MISSION TIME: INC GRND PWR TIME'; TAB(35), T(0) + T(4), "HRS'

IF TSAVE < SCHT THEN TSAVE = SCHT

VTT - T(4) + T(4) + T(4) + X(17) = 24

LPRINT TAB(5), "TOT VEHICLE TURNAROUND TIME'; TAB(35), VTT, "TOTAL HRS'

LPRINT . I,PRINT

LPRINT TAB(1); "ONE SHIFTS/DAY MAINTENANCE'; LPRINT

DVT = (T(0) + T(0) / 24 + TSAVE) / 8 + X(17) + X(18)

LPRINT TAB(5), "TOT VEHICLE TURNAROUND TIME'; TAB(35), DVT, "DAYS'

LPRINT TAB(5), "AVG MISSIONS/YR/VEHICLE'; TAB(35), 12 * 21 / DVT

LPRINT TAB(5), "COMPUTED FLEET SIZE '; TAB(35), INT(X(15) / 12) / (21 / DVT) + .99

LPRINT . I,PRINT

LPRINT TAB(1); "TWO SHIFTS/DAY MAINTENANCE'; LPRINT

DVT = (T(0) + T(0) / 24 + TSAVE) / 16 + X(17) + X(18)

LPRINT TAB(5), "TOT VEHICLE TURNAROUND TIME'; TAB(35), DVT, "DAYS'

LPRINT TAB(5), "AVG MISSIONS/YR/VEHICLE'; TAB(35), 12 * 21 / DVT

LPRINT TAB(5), "COMPUTED FLEET SIZE '; TAB(35), INT(X(15) / 12) / (21 / DVT) + .99

LPRINT . I,PRINT

LPRINT TAB(1); "THREE SHIFTS/DAY MAINTENANCE'; LPRINT

DVT = (T(0) + T(0) / 24 + TSAVE) / 24 + X(17) + X(18)

LPRINT TAB(5), "TOT VEHICLE TURNAROUND TIME'; TAB(35), DVT, "DAYS'

LPRINT TAB(5), "AVG MISSIONS/YR/VEHICLE'; TAB(35), 12 * 21 / DVT

LPRINT TAB(5), "COMPUTED FLEET SIZE '; TAB(35), INT(X(15) / 12) / (21 / DVT) + .99

LPRINT . I,PRINT

LPRINT TAB(5), "NOTE: assumes parallel unsch/sched maint tasks, 8 hr shifts, and 21 work days a month'

LPRINT CHRS(12);

LPRINT TAB(20), "VEHICLE TURN TIME REPORT - at mission nbr. ", X(24), " - page 3"; LPRINT

LPRINT TAB(1), "VEHICLE IS "; VNAMS, TAB(35), "DATE: "; DATES, TAB(60), "TIME: "; TIMES; LPRINT

LPRINT TAB(5), "CATEGORY'; TAB(35), "MAX TURN TIMES'; LPRINT

LPRINT TAB(5), "SCHD MAINT MSN TASK TIME'; TAB(35), SCHT, "HRS'

LPRINT TAB(5), "UNSCHED MAINT TIME'; TAB(35), TT, "HRS'

LPRINT TAB(5), "INTEGRATION TIME'; TAB(35), X(17), "DAYS'

LPRINT TAB(5), "LAUNCH PAD TIME'; TAB(35), X(18), "DAYS'

LPRINT TAB(5), "MISSION TIME: INC GRND TIME'; TAB(35), T(0) + T(4), "HRS'

VTT - T(0) + T(4) + TT + SCHT + X(17) * 24 + X(18) * 24

LPRINT TAB(5), "TOT VEHICLE TURNAROUND TIME'; TAB(35), VTT, "TOTAL HRS'

C-35
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(35), (12 * 21) / DVTT
I.PRINT TAB(3), "COMPUTED FLEET SIZE"; TAB(35), 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) / 6 + 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(35), (12 * 21) / DVTT
I.PRINT TAB(3), "COMPUTED FLEET SIZE"; TAB(35), 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) / 24 + 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(35), (12 * 21) / DVTT
I.PRINT TAB(3), "COMPUTED FLEET SIZE"; TAB(35), INT((X(15) / 12) / (21 / DVTT) + 99)
I.PRINT: I.PRINT
I.PRINT CR$(12),
END SUB

SUB REPORT
COLOR 11
PRINT: PRINT TAB(25), "REPORT MENU" PRINT
PRINT TAB(15), "1........................ PRINT INPUT DATA" PRINT
PRINT TAB(15), "2........................ PRINT SUMMARY REPORT" PRINT
PRINT TAB(15), "3........................ PRINT RELIABILITY REPORT" PRINT
PRINT TAB(15), "4........................ PRINT MAINTAINABILITY REPORT" PRINT
PRINT TAB(15), "5........................ PRINT MANPOWER REPORT" PRINT
PRINT TAB(15), "6........................ PRINT SPARES REPORT" PRINT
PRINT TAB(15), "7........................ PRINT TURN TIME REPORT" PRINT
PRINT TAB(15), "8........................ PRINT EXTERNAL TANK/ENGINE REPORT" PRINT
PRINT TAB(15), "9........................ PRINT TOTAL OUTPUT" PRINT
PRINT TAB(15), "10........................ PRINT TOTAL INPUT/OUTPUT" PRINT
PRINT TAB(15), "11........................ SIMULATION MODEL INPUT" PRINT
PRINT TAB(15), "12........................ SEND REPORT TO A FILE" PRINT
COLOR 1
PRINT TAB(15), "RETURN...CANCEL REQUEST" PRINT
COLOR 11
LOCATE 23, 50: COLOR 12: PRINT "Is your printer ready???" PRINT
LOCATE 24, 5: COLOR 13: PRINT "VEHICLE/FILE NAME IS"; VNAM$ PRINT
COLOR 10: LOCATE 18, 20: INPUT "ENTER SELECTION"; NDO
IF NDO < 0 OR NDO > 12 THEN GOTO BOTM PRINT
COLOR 3
LOCATE 20, 10: INPUT "ENTER TITLE OF REPORT"; RTITL$ PRINT
LOCATE 21, 10: INPUT "ENTER COMMENTS"; COMMENTS$ PRINT
IF NDO = 1 THEN CALL ECHO PRINT
IF NDO = 2 THEN CALL PRINTSUM PRINT
IF NDO = 3 THEN CALL PRINTREL PRINT
IF NDO = 4 THEN CALL PRINTMAINT PRINT
IF NDO = 5 THEN CALL PRINTMAN PRINT
IF NDO = 6 THEN CALL PRINTSPR PRINT
IF NDO = 7 THEN CALL PRINTTURN PRINT
IF NDO = 8 THEN CALL ETSRB PRINT
IF NDO = 9 THEN GOSUB ALL PRINT
IF NDO = 10 THEN GOSUB ALL PRINT
IF NDO = 11 THEN CALL SIMREP PRINT
IF NDO = 12 THEN CALL WRFILE PRINT
GOTO BOTM PRINT
ALL: CALL ALL PRINT PRINT PRINT PRINT
IF NDO = 10 THEN CALL ECHO PRINT
CALL PRINTSUM PRINT
CALL PRINTREL PRINT
CALL PRINTMAINT PRINT
CALL PRINTMAN PRINT
CALL PRINTSPR PRINT
CALL PRINTTURN PRINT
IF FI.REL < 1 OR SRBREL < 1 THEN CALL ETSRB PRINT RETURN
GOTO BOTM: RETURN TO MAIN MENU PRINT
END SUB

C-36
SUB SIMREP

***** I PRINT MODULE FOR SIMULATION INPUT *****

SWBSK(1) - "Structural"; SWBSK(2) - "Fuel/Oxide Tanks"; SWBSK(3) - "Thermal/Protective"; SWBSK(4) - "Propulsion"

SWBSK(5) - "Power/Electrical"; SWBSK(6) - "Mechanical Systems"; SWBSK(7) - "Avionics"; SWBSK(8) - "FCS/life Support"

SWBSK(9) - "Auxiliary Systems"

I.PRINT TAB(25), "SIMULATION INPUT REPORT" : I.PRINT
I.PRINT TAB(5), RTITLE: I.PRINT
I.PRINT TAB(5), whose: I.PRINT
I.PRINT TAB(1), "VHICLE TYPE": VNAME, TAB(35), "DATE:" , DATES, TAB(60), "TIME:" , TIMES: I.PRINT
I.PRINT TAB(25), "Per Mission": TAB(40), "In hours": TAB(55), "In hours": TAB(60), "Prob-Rem": I.PRINT
FOR I - 1 TO 9
  X = (FRS(I)) * REMS(I) / (1 - FRS(I)) * REMS(I)
I.PRINT TAB(3), SWBSK(I), TAB(25), MAS(I), TAB(40), MTROS(I), TAB(55), MTRFS(I), TAB(60), X
NEXT I
I.PRINT
I.PRINT I.PRINT TAB(25), "Removal &": TAB(40), "On-Veh": TAB(55), "Off-Veh": TAB(55)
I.PRINT TAB(1), "Subsys": TAB(25), "No spare": TAB(40), "Sched MTTR": TAB(55), "Sched MTTR": TAB(60), "AVG CREW SIZE": I.PRINT
FOR I - 1 TO 9
I.PRINT TAB(3), SWBSK(I), TAB(23), REMS(I) * (1 - X(13)) * REMS(I)
NEXT I
I.PRINT
I.PRINT TAB(10), "Launch Reliability": TAB(50), VR1
I.PRINT TAB(10), "Mission Redundant Reliability": TAB(50), VR3
I.PRINT TAB(10), "Integration Time - days": TAB(50), X(17)
I.PRINT TAB(10), "Fuel Time - days": TAB(50), X(11)
I.PRINT TAB(10), "Miss Time": TAB(50), T(4)
I.PRINT TAB(10), "Flown missions per Year": TAB(50), X(15)
I.PRINT TAB(10), "Fill rate objective": TAB(50), X(13)
I.PRINT CHR$(12)
END SUB

File: RAMC.BAS computational module

' NASA, Langley Research Center
'MTBM computational module - NASA RESEARCH GRANT
'Developed by C. Efiling, Univ of Dayton 6/17/94 (updated)
' """""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""&
* WBS 1,2,3 STRUCTURES ****
14510 ABI1 - 0.031213 * X2 + 1.956E-07 * X1 - 1.546E-04 * SQ(X1)
14511 IF ABI1 < .0 THEN ABI1 = .00128
14512 IF ABI1 > 0.0065 THEN ABI1 = 0.0065
14513 PA(1) = ABI1 + 1.0
14520 ABI2 = 3.4732 + 3.8715E-07 * X1 + 2.5183E-04 * SQ(X1)
14521 IF ABI2 > 0.03 THEN ABI2 = 0.03
14522 PA(3) = (ABI1 / FMA11 _ ABI2 / FMA12) / (1 / FMA11 + 1 / FMA12)

* WBS 5 LANDING GEAR ****
14530 ABI3 = 2.4321 + 0.009112 * X2 + 1.1457 * LOG(X2) - 33925 * SQ(X2)
14531 IF ABI3 < 0 THEN ABI3 = 0015 . ELSE PA(9) = .0015 . ELSE PA(9) = .0015
14532 IF PA(9) > .0017 THEN PA(9) = .0017 ends

* WBS 9-10 APUs ****
14540 ABI4 = .711953 - .881388 * LOG(X2) + 0.209882 * SQR(X2)
14541 IF ABI4 < 0 THEN PA(18) = 0015 . ELSE PA(18) = ABI4
14542 IF PA(18) > 0.08 THEN PA(18) = 0.08

* WBS 11-00 ELECTRICAL ****
14550 PA(16) = 39.9988 + 1.09214 + LOG(X1) + 1.078226 + LOG(X1) + 3
14551 IF PA(16) < -0.00 THEN PA(16) = -0.00
14552 IF PA(16) > 0.142 THEN PA(16) = 0.142

* WBS 12-00 HYDRAULICS ****
14560 PA(17) = 5000.2535 - 7578.183 * SQR(IZG(X1)) - 453.612 * LOG(X1) + 2.65005 * LOG(X1)^2 - 0.787751 * LOG(X1)^3
14561 IF PA(17) < -0 THEN PA(17) = -0.00
14562 IF PA(17) > 0.13 THEN PA(17) = 0.13

* WBS 13-00 ACTUATORS ****
14570 PA(18) = -71953.1881388 * LOG(X2) + 0.099882 * SQR(X2)
14571 IF PA(18) < 0 THEN PA(18) = 0015 . ELSE PA(18) = ABI4
14572 IF PA(18) > 0.08 THEN PA(18) = 0.08

* WBS 14-XX ENVIRONMENTAL ****
14570 PA(25) = -0.062749 + 2.605132E-07 * X1 + 2.288897E-04 * SQ(X1)
14571 IF PA(25) < 0 THEN PA(25) = -00152 . ELSE PA(25) = 00152
14572 IF PA(25) > 0.0222 THEN PA(25) = 0.0222
14573 PA(26) = PA(25)

* WBS 15-00 PERSONNEL, PROVISIONS ****
14580 PA(27) = 0.0185 .
14581 IF X(27) = 0 THEN PA(27) = 0.0185

* COMPUTE ABR RATES
FOR I = 1 TO 5: ETABR(I) = X(8): SRBABR(I) = X(8): NEXT I

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) = .02 * PA(13)
FOR I = 14 TO 16: PA(I) = .125 * PA(I): NEXT I
PA(17) = 0.08 * PA(17)
PA(18) = .14 * PA(18)
IF X(19) = 0 THEN PA(19) = 0.33 * PA(19) ELSE PA(19) = .10125 * PA(19)
PA(20) = X(8)
PA(21) = .175 * PA(21)
PA(22) = X(8)
PA(23) = .16 * PA(23)
PA(24) = X(8)

C-38
FOR I = 28 TO 33: PA(I) = X(I): NEXT I
END IF

END SUB

SUB ACWGT
* MODUL TO COMPUTE SUBSYSTEM WIGHTS - ACFT EQS
SUM = 0
FOR I = 1 TO 33: W(I) = 0: NEXT I
W(1) = -4485026 * (LOG(X1)) - 135432 * (LOG(X1)) * 2 + 452.4 * (LOG(X1)) + 3
W(2) = -3999029 * (LOG(X1)) - 9709.90 * (LOG(X1)) * 2 + 343.5 * (LOG(X1)) + 3
W(3) = -3971315.2 + 1417950.8 * (LOG(X1)) - 12993808.8 * (LOG(X1))
W(9) = -495.35 * 282563 * XI + 6873.7 * (LOG(X1)) + 1601 * SQR(X1)
W(18) = -719.15 * 5.56265 * X2 + 56.882 * SQR(X2)
W(16) = -75797 * 11.222 * SQR(X1)
W(17) = -575.27 * 0.22216 * XI + 5.0608 * SQR(X1)
W(27) = -662556 - 14720.4 * (LOG(X1)) + 818.19 * (LOG(X1)) + 2
AV = -10901.5 + 1261.52 * LOG(X1)
IF W(I) < 0 THEN W(I) = 522
W(1) = -5849.5 + 0.459666 * XI + 1364.8 * LOG(X1) - 26.248 * SQR(X1)
W(18) = 9.104 + 100.22 * LOG(X1) + 1 + 3835 * SQR(X1)
W(25) = -719.15 + 5.56265 * X2 + 56.882 * SQR(X2)
W(22) = W(22) / 2
W(6) = -157.97 + 11.222 * SQR(X1)
W(16) = W(16) - 2140
W(27) = W(27) - 284
AV = -10901.5 + 1261.52 * LOG(X1)
IF AV < 0 THEN AV = 303
FOR 1 = 1 TO 24: W(I) = AV: NEXT I
W(1) = 11 * XI: W(6) = -0.1 * XI: W(7) = -0.4 * XI: W(8) = -0.2 * XI: W(16) = 1 * XI
W(0) = 7141.92 + 89103 * SQR(X1)
FOR 1 = 1 TO 33: SUM = SUM + W(I):
NEXT I
FOR 1 = 1 TO 33: PA(I) = W(I) / SUM:
NEXT I
IF W(I) < 0 THEN OP$(I) = "DELETE" ELSE OP$(I) = "COMPUTE"
NEXT I

END SUB

SUB COMPMT
* module to compute MTBM given a specified reliability
Y1 = 0: Y1 = 0: Y1 = 0: Y1 = 0
FOR 1 = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO SKP1
IF RELF(I) = 1 THEN GOSUB MTB
IF RELF(I) = 0 THEN YW = YW + I / FMAS(I)
YZ = YZ + 1 / FMAC(I)
YY = YY + 1 / FMAT(I)
Y = Y + 1 / FMAT(I)
SKP1: NEXT I
TVMFA = 1 / Y
IF YW > 0 THEN VFMA = 1 / YW
SVFMA = 1 / Y
CVFMA = 1 / YY
EXIT SUB

MTB: 'find FMAC
IF X(25) = 0 THEN TO = -GOM(I) ELSE TO = 0
T1 = TO + LOG(I): T2 = T1 + MOD(I)
T3 = T2 + OOM(I): T4 = T3 + MOK(I)
L1 = 1 / FMAC(I)
IF I = 9 THEN L1 = LOGREL(I) + T4 GOTO ED1
RCF: L2 = LE - L1
A = (8 * T2) + (B - 1) / (8 * T1) + (1 / B)
B = EXP(L1 * (T2 + T1)): L2 * (T1 - T0) = (T3 / A) + (T2 / A) + B - L1 * (T4 - T3)
FP = F - RFI1

C-39
IF DF < 0.0001 OR DF > 0.0001 THEN NEWI1 = 1.0 \ FP / DF ELSE EXIT SUB

IF ABS(F - RF(i)) > 0.00001 THEN NEWI1 = NEWI1 GOTO RCP

RETURN

END SUB

SUB COMREI
2800 'MODUI,E TO DETERMINE nonredundant REI. I.ABI.EITIES - CRITICAl. FAILURES ONLY
2810 VR = I
2820 FOR J = 1 TO 33
2830 IF X(25) = 0 THEN TO = GOSH(J) ELSE TO = 0
2840 T3 = T2 - 2 * GOSH(J). T4 = T3 - ROH(J)
2850 IF OP$(J) = "DELETE" THEN R(J) = 1: GOTO 2890
2860 1,1 = I / FMAC(J); 1,2 = LF * 1,1
2870 IF B = (T2 * (T2 * B - 1)) / (T4 - T3)) THEN NEWI1 = 1.1 \ FP * 1,1; FMAC(I) = 1.2 * (1 / B)
2880 R(J) = EXP(-1.1 * (T2 - TO - TI) - 1.2 * (TI - TO) - (T3 / B' - T2 / B) + (T2 / B'))
2890 VR = VR * R(J)
2895 NEXT J
END SUB

SUB CREW
1200 'CREW SIZE CALCULATIONS
12100 FC(1) = 1.5 \ 0.000012 * V(3) - 0.00172 * SQR(V(3))
12140 C(9) = C(1): C(10) = C(1): C(11) = C(1): C(12) = 2.43: C(13) = 2.43: C(14) = 2.43: C(15) = 2.43
12160 C(16) = 1.14: .003733 * V2 + .814656 * LOG(X2)
12190 C(28) = 1.7893: .0009872 * SQR(X1)
12195 C(27) = (C(16) + C(28)) / 2
12200 C(35) = 1.9: TFC = 1.0 FOR I = 1 TO 33
12220 IF SEI$(I) = "SHUTTLE" THEN C(I) = TFC * 4.5
12250 TFC = 1.0 NEXT I
END SUB

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

'MTRBM/MTTR CALCULATIONS BY WBS
'WBS 1,2 & 3 AIRFRAME

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 = 15.231 + 200000 * W(2) - 137575 * SQR(W(1) + W(2) + W(3)) - 0.00023 * V(3)
3021 IF FMA1 < 1.0 THEN FMA1 = 1.4
3025 FMA(1) = FMA1: P1 = FMA(2) - FMA1: P2 = FMA(3)
3030 MHI1 = 16.5732: 351567 * W(3) / V(2) - 74556 * LOG(X1)

C-40
3031 IF MH11 < 1.0 THEN MH1 - 3.9
3032 MHMA(1) - MH11: MHMA(2) - MH11

WUC12 AIRCRAFT COMPARTMENT

3110 FMA12 - 3428.40 * X1 + 423.96 * LOG(X1) + 11.65 * SQR(X1) + 11.567 * X3 - 360.72 * SQR(X3) + .01865 * W(3) - 4.83566 * SQR(W(3)) - 23785 * (X3) + X1
3112 IF FMA12 < 5.6 THEN BMA12 - 5.6. 23rd PERCENTILE RANGE
3115 T - P3 / FMA(1) - 1 / FMA12: FMA(3) - 1 / TP CHECK LINE 3715 FOR FMA(3)
3120 IF X1) > X4) > 0 THEN MH12 - 1.0855 * 1.6667 * SQR(X3) + X4 + 088778 * (X2 + X4)
3121 IF MH12 < 3.2 THEN MH12 - 3.2
3123 MHMA(3) - 1 / (FMA(1) - MH11: (1 / FMA12) * MHMA(2)) / (1 / FMA11 + 1 / FMA12)

WUC46 FUEL SYS WBS 3 10/3 20

4710 BMA46 - 494.8 - 54.06 * X1 - .906 * SQR(V(3)) - 50.712 * X5 + 16.39 * V(9) + 151.37 * SQR(V(3)) - 83.12 * SQR(V(9)) - 0004 * (W(4)) + 2756 * SQR(W(4))
4711 IF BMA46 < 8.37 THEN BMA46 - 8.37
4712 IF BMA46 > 84 THEN BMA46 - 84
FMA(4) - BMA46
4714 V - (W(4) - W(4)) * (1 / BMA46)
4715 - 7 - (W(5) - W(4)) / (1 / BMA46)
4716 BMA46 - 494.8 - 54.06 * X1 - .906 * SQR(V(3)) - 50.712 * X5 + 16.39 * V(9) + 151.37 * SQR(V(3)) - 83.12 * SQR(V(9)) - 0004 * (W(5)) + 2756 * SQR(W(5))
IF BMA46 < 8.37 THEN BMA46 - 8.37
IF BMA46 > 84 THEN BMA46 - 84
FMA(5) - BMA46
4716 FMA(4) - 1 / V: FMA(5) - 1 / Z
4720 MH46 - (160.85 + X3 + 6663 * X2 - .0121 + V(3) + 11.7288 * LOG(X1) - 1.655 * SQR(V(3)) - 20.309 * W(9) + 87.164 * SQR(V(9)) - 000131 * W(10) + W(11) + W(12) + 45 * SQR(W(4) + W(5))
4721 IF MH46 < 7 THEN MH46 - 7
4722 IF MH46 > 21.3 THEN MH46 - 21.34
4723 MHMA(4) - MH46. MHMA(5) - MH46

WBS 4 XX THERMAL PROTECTION SYSTEM

1. TILES, TCS, PVD - NOT AVAILABLE FROM AIRCRAFT - INDICES 6, 7 & 8

WUC13 WBS9 LANDING GEAR SYSTEMS

3210 SMA13 - 22.2723 - 00313 * V(3) + .9511 + X2 - 5.47476 * SQR(V(3)) + .00361 * W(9) - .5171441 * SQR(W(9))
3212 IF SMA13 < 4 THEN SMA13 - 4
IF SMA13 > 19 THEN SMA13 - 19.1
3213 FMAA(1) - 72.4 + 14.568 * X4 + .9994 * X2 - 12.41 * LOG(X1) - 65.6 * SQR(V(3)) - 000568 * W(9) + 18.598 * LOG(W(9))
3214 IF FMA(9) < 1 THEN FMA(9) - 1.4
FMA(9) - SMA13
3220 MHMA(9) - -156.95 + 55.984 * LOG(W(9)) - 6.095 * (LOG(W(9))) * 2 + 2128127 * (LOG(W(9))) * 3
3221 IF MHMA(9) < 1.9 THEN MHMA(9) - 1.9

WUC23 PROPULSION SYSTEM WBS 6, 7 & 8

FOR 1 - 10 FROM 12
4170 FMA(11) - .341 + 9.8530010E-04 * W(1) - 312232 * SQR(W(1))
4171 IF FMA(11) < 1.4 THEN FMA(11) - 1.4
4175 MHMA(11) - 52.6324 + 0000922 * W(1) - 9396 * SQR(W(1))
4176 IF MHMA(11) < 4 THEN MHMA(11) - 4.1
4177 IF MHMA(11) - 21.1 THEN MHMA(11) - 21.1
NEXT 1

WUC24 APU WBS 8.10

3410 FMA(13) - 4996.525 - 1.906 * V(7) + 46.35 * SQR(V(7)) - 2.735 * W(13) + 284.549 * SQR(W(13)) - 1642.99 * LOG(W(13))
3411 IF FMA(13) < 14.5 THEN FMA(13) - 14.5
3420 MHMA(13) - 5114 + .09254 * V(7) - 2.9624 * SQR(V(7)) + 2657 * W(13) - 26.1 * SQR(W(13)) + 150.5 * LOG(W(13))
3421 IF MHMA(13) < 5 THEN MHMA(13) - 5.2
3422 IF MHMA(13) > 17.2 THEN MHMA(13) = 17.2

WBS 9 30 POWER, FUEL CELL

1. NOT AVAILABLE ON AIRCRAFT - INDEX 15

WUC 42/44 WBS 10 ELECTRICAL SYS

3609 FMA(6) - 1193.3 - 0755 - W(16) + 6.758773 * SQR(W(16)) - .715996 * X2 - 167.24 * LOG(X1) + 2.2308 * SQR(X1) + 29.0236 * LOG(V(7)) - .00127 * V(7) + 2
3611 FHAA - 1
3612 FHAA - 1
3614 IF FMA(6) < 5.15 THEN FHAA(6) - 5.15
3620 MHMA(16) - -18392.1 + 1664.6 * LOG(X1) + 92.8412 * LOG(X1)) + 27628 * SQR(LOG(X1)) + 2 * LOG(X1)) + 3
3621 MHMA(16) - -95.161 + 20.3158 * LOG(X1) - .98356 * LOG(X1)) + 2
3622 MHAA = 2300.04 + 474.11 * LOG(X1) - 457.295 * LOG(X2) - 1465885 * X1 + X2 - 2769.85 * SQR(LOG(X1)) + 1788.4 * SQR(LOG(X2))
3623 MHMA(6) = (MHAA + MHMA(6)) / 2
3624 IF MHAA(6) < 1 THEN MHAA(6) - 1.4

WUC45 WBS11 HYDRAULICS SYS
**MISC UTILITIES ****************************

C-2
IF SEI(I) = "SHUTTLE" THEN FMA(I) = SMA(I)
  COMPUTE SHUTTLE OFF MANHRS
IF SEI(I) = "SHUTTLE" THEN MHMA(I) = C(I) * SMR(I) * PF(I) * C(I) * SMR(I) / (1 - PF(I))
4930 NEXT I

5000 SCHYLLOED MAINTENANCE MODULE
  IF CPS(I) = "DO NOT RECOMPUTE" THEN GOTO 5050
5010 SCYP = 23 924 + 0.645 * X2 + 10 062 * LOG(X2) + 3 039 * SQR(X2) + 0.235 * W(3) / V(2) + 0.0067 * V(1)
SCYP = 3.69 * 2313 + 0.645 * X2 + 3 2794 * LOG(X2) + 02297 * SQR(X2) + 0176 * (LOG(X1)) - 3 789 * LOG(X2) + 2.36973 * SQR(X2)
  IF SCYP < 32 THEN SCYP = 32
  IF SCYP > 794 THEN SCYP = 794

5040 'VEHICLE ROLL UP - UNADJUSTED MTBM
5050 Y = 0
5060 FOR I = 1 TO 33
5070 IF OP$(I) = "DELETE" THEN GOTO 5110
5080 Y = Y + 1 / FMA(I)
5110 NEXT I
5220 VFMA = Y / Y
FOR I = 1 TO 33
W(I) = W(I) * NRD(I)
NEXT I
END SUB

SUB MANPWR
7000 MANPOWER COMPUTATION MODULE
  VMOH = 0: OMHMA = 0: OFMHMA = 0
7005 TMA = 0: VMH = 0: AMHMA = 0: KK = 0: TOMH = 0: TFMH = 0: APF = 0: TMP = 0
7010 FOR I = 1 TO 33
POFF = PF(I): MP(I) = 0
7010 IF OP$(I) = "DELETE" THEN GOTO 7140
7045 THRS(I) = GEI(I) + I.OH(I) + OOH(I) + ROH(I)
7045 MA = NRD(I) * (1 - PF(I)) * PRG(I) / FMAT(I) + THRS(I) / FMAS(I)
7045 TOFR = TOFR + 1 / FMAS(I)
7045 VMH = VMH + THRS(I)
7045 TMH = TMH + MA
7045 TFMH = TFMH + FMH(I)
7045 TMP = TMP + MP(I)
7045 OFMH(I) = (1 - POFF) * MA
7045 TOMH = TOMH + OFMH(I)
7140 NEXT I
7160 APF = APF + 1 - PF(I)
7140 NEXT I
7160 APF = APF / KK
7160 OFMHMA = OFMHMA / KK
7160 AMHMA = AMHMA / TMA
7170 SMP = (SCYP * TOMH * X(I(3))) / (12 * X(I(1)) * (1 - X(I(2))))
7170 SMP = IN(SMP) + .999
7170 MPV = INT(MPV) + .999
7170 TMP = TMP + SMP
  'MIN CREW SIZE
  STP = 0: CI = 0
  FOR I = 1 TO 33
  IF POFF(I) = "DELETE" THEN GOTO N1
  IF CI > MPV THEN TP = CI ELSE TP = MPV
  STP = STP + CI
  CI = CI + CI + CA(I) * C(I)
N1 NEXT I
  STP = INT(STP) + .999
  CI = INT(CI) + .999
END SUB

SUB POFFQS
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
END SUB

SUB REFDUNRFL
13180 ' RELIABILITY SUBROUTINE
13185 ' LAUNCH RELIABILITY
13190 VR1 = 1
13200 FOR I = 1 TO 33
13210 IF OP0(I) = "DELETE" THEN GOTO 13260
13220 L = FMAC(I): T = GH
13230 RT = EXP(L * T)
13240 IF (I > -10 AND I < -15) OR (I > -19 AND I < -24) THEN GOSUB 13300 ELSE R0(I) = 1 - (1 - RT) * NRD(I)
13250 VR1 = VR1 * R0(I)
13260 NEXT I
13270 GOTO 13400
13300 ' K OUT OF N SUBSYSTEM CALCULATION
13305 R(I) = 0
13310 NN = NRD(I): GOSUB 13355: MFAC = FAC
13315 FOR J = K(I) TO NRD(I)
13320 NN = J: GOSUB 13355: IFAC = FAC
13325 NN = NRD(I): J: GOSUB 13355
13330 C = MFAC / IFAC
13335 R(J) = X(J) * C * RT * (1 - RT) * (NRD(I) - J)
13340 NEXT J
13345 RETURN
13350 ' FACTORIAL SUBROUTINE
13360 IF NN = 0 THEN FAC = 1: RETURN
13365 FOR JK = I TO NN
13370 FAC = JK * FAC
13380 NEXT JK
13385 RETURN
13390 ' END OF POWERED PHASE
13400 VR2 = 1
13410 FOR I = 1 TO 33
13415 IF OP0(I) = "DELETE" THEN GOTO 13440
13420 L = FMAC(I): T = GH + LOH(I)
13425 RT = EXP(L * (GH + LF * (T - GH)))
13430 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13445 ELSE R0(I) = 1 - (1 - RT) * NRD(I)
13435 VR2 = VR2 * R0(I)
13440 NEXT I
13445 GOTO 13500
13445 ' K OUT OF N SUBSYSTEM CALCULATION
13450 R(I) = 0
13455 NN = NRD(I): GOSUB 13355: MFAC = FAC
13460 FOR J = K(I) TO NRD(I)
13465 NN = J: GOSUB 13355: IFAC = FAC
13470 NN = NRD(I): J: GOSUB 13355
13475 C = MFAC / IFAC
13480 R(J) = R0(I) + C * RT * (1 - RT) * (NRD(I) - J)
13485 NEXT J
13485 RETURN
13490 ' ORBIT INSERTION
13500 VR3 = 1
13510 FOR I = 1 TO 33
13515 IF OP0(I) = "DELETE" THEN GOTO 13540
13520 L = FMAC(I): T = GH + LOH(I)
13525 RT = EXP(L * (T + TD0 - TX1) + LF * (TX1 - TX0))
13530 IF I = 1 OR I = 11 OR I = 12 THEN GOSUB 13545 ELSE R0(I) = 1 - (1 - RT) * NRD(I)
13535 VR3 = VR3 * R0(I)
13540 NEXT I
13545 GOTO 13600
13550 ' K OUT OF N SUBSYSTEM CALCULATION
13550 R(I) = 0
13555 NN = NRD(I): GOSUB 13355: MFAC = FAC
13560 FOR J = K(I) TO NRD(I)
13565 NN = J: GOSUB 13355: IFAC = FAC
13570 NN = NRD(I): J: GOSUB 13355
13575 C = MFAC / IFAC
13580 R(J) = R0(I) + C * RT * (1 - RT) * (NRD(I) - J)
13585 NEXT J
13585 RETURN
13600 ' RENTRY
13605 VR4 = 1
13610 FOR I = 1 TO 33
13612 IF OP$(I) = "DELETE" THEN GOTO 13640

13615 IF X(I:2) = 0 THEN GH = GOH(I) ELSE GH = 0
13617 TX0 = GH * TX1 - TXD + 1.0GH(I) * TX2 - TX1 + TOH(I)
13620 L1 = 1 / FMAC(I) T = GH + 1.0GH(I) + TOH(I) + OOH(I)

13621 12.1 = L1 * TL
13622 A = (B * T(I)) / (L1 + 1.1 / L1)
13623 RT = EXP(L1 * (TX2 - TXD) - (T / A) - B + (TX2 / A) * B)
13625 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13645 ELSE R4(I) = I - (1 - RT) * NRD(I)
13630 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13645 ELSE R4(I) = I - (1 - RT) * NRD(I)
13635 FOR I = 1 TO 33
13640 FOR I = 1 TO 33
13645 'K OUT OF N SUBSYSTEM CALCULATION
13650 R4(I) = 0
13655 IF X(I:2) = 0 THEN GH = GOH(I) ELSE GH = 0
13660 TX0 = GH: TX1 - TXI - TXD: TX2 - TXI - TOH(I): TX3 - TXI - TOH(I)
13665 NN = J: GOH(I) = J: GOH(I) = J
13670 NN = J: GOH(I) = J: GOH(I) = J
13675 C = MFAC / (JFAC * FAC)

13680 R4(I) = R4(I) + C * RT * J * (1 - RT) * (NRD(I) - J)
13685 NEXT J
13690 RETURN
13700 'MISSION COMPLETIONS
13705 VR5 = 1
13710 FOR I = 1 TO 33
13712 IF OP$(I) = "DELETE" THEN GOTO 13740

13715 TX0 = GH * TX1 - TXD + 1.0GH(I) * TX2 - TX1 + TOH(I)
13720 L1 = 1 / FMAC(I) T = GH + 1.0GH(I) + TOH(I) + OOH(I)
13721 L2 = L1 * L1
13722 A = (B * T(I)) / (L1 + 1.1 / L1)
13723 RT = EXP(L1 * (TX2 - TXD) - (T / A) - B + (TX2 / A) * B)
13725 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13745 ELSE R5(I) = I - (1 - RT) * NRD(I)
13730 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13745 ELSE R5(I) = I - (1 - RT) * NRD(I)
13735 FOR I = 1 TO 33
13740 FOR I = 1 TO 33
13745 'K OUT OF N SUBSYSTEM CALCULATION
13750 R5(I) = 0
13755 IF X(I:2) = 0 THEN GH = GOH(I) ELSE GH = 0
13760 TX0 = GH: TX1 - TXI - TXD: TX2 - TXI - TOH(I): TX3 - TXI - TOH(I)
13765 NN = J: GOH(I) = J: GOH(I) = J
13770 NN = J: GOH(I) = J: GOH(I) = J
13775 C = MFAC / (JFAC * FAC)

13780 R5(I) = R5(I) + C * RT * J * (1 - RT) * (NRD(I) - J)
13785 NEXT J
13790 RETURN
13800 'REMOVAL RATE EQUATIONS
13805 FOR I = 1 TO 33
13810 W(I) = W(I) / NRD(I)
13820 NEXT I

SUB REMEOUS

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

5500 'REMOVAL RATE EQUATIONS
5510 R11 = -1394 - 6.30917 * W(I)
5511 R12 = 202058 + 0.000188 * W(I)
5512 RR(1) = R11: RR(2) = R11: RR(3) = (R11 + R12) / 2
5513 R46 = -5623 - 0.955 * X(I)
5514 R11 IF R46 > 164 THEN R46 = 164
5515 IF R46 > 389 THEN R46 = 389
5516 RR(5) = R46: RR(5) = R46

THERMAL SYSTEMS - SHUTTLE BASED
FOR I = 1 TO 33, RR(I) = RR(I): NEXT I

5520 RR(9) = 8639 - 0.07903 * X2
5521 IF RR(9) < 22 THEN RR(9) = 22
5610 FOR I = 1 TO 12
5611 RR(I) = 6211 - 0.0024872 * SQRT(W(I))
5612 IF RR(I) < 157 THEN RR(I) = 157
5613 IF RR(I) > 51300 THEN RR(I) = 5130000
5614 NEXT I

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5540 RR(13) = 579 - .0007512 * SQR(X1)
5541 IF RR(13) < 0 THEN RR(13) = 0.1
5542 RR(15) = SRR(15) * SHUTTLE BASED
   RR(4) = 273
5560 RR(2) = 38533 - 001 * X2 + .17715 * LOG(X2)
5561 IF RR(2) < 3 THEN RR(2) = 3. IF RR(2) > 539 THEN RR(2) = 539
5562 RR(4) = .0001 X2 + .452 * LOG(X2)
5563 IF RR(4) < 1. THEN RR(4) = 1.3. IF RR(4) > 872 THEN RR(4) = 872
5564 IF RR(6) = (.RR(4) / RR(4) ÷ RR(6)) / (.1 / RR(4) + 1 / RR(4))
5570 RR(17) = 368

IF RR(18) < 0 THEN RR(18) = 0.7

RRG = 3.9735 - .42659E-07 * XI
   _2 1635E-04 * SQR(XI)

IF RRG < 0 THEN RRG = -23.5
IF RRG > .726 THEN RRG = .726
FOR I = 19 TO 24: RR(I) = RRG: NEXT
IF X(19) = 0 THEN RR(19) = .4: RR(21) = .4; RR(23) = .51
RR(24) = -1.3 + 16458 * LOG(X1) / A/C COMPUTER SYSTEMS
IF RR(24) < 0 THEN RR(24) = RRG
IF RR(24) > 5.3 THEN RR(24) = RRG

RRt = 5291 - 8.914E-05 * W(25)
IF RRt < 0 THEN RRt = 165
RR7 = .6026 - 0006758 * SQR(X1)

RR(25) = RRt:
RR(26) = RR7

RR(27) = .274

RR(29) = (RRt - RRt) / 2
RR(30) = RR7
RR(32) = SRR(32)
FOR I = 1 TO 33
   W(I) = W(I) * NRD(I)
NEXT I

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

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

END SUB

SUB SECONDARY
11120 SUBROUTINE TO COMPUTE SECONDARY VARIABLES
11122 'WETTED AREA
11123 V(3) = .486.026 + 1510165 * X2 " 2
11130 'NBR WHEELS
11140 V(4) = 2.189572 + 6.66297E-05 * X1 - 1.3871610 * X1 " 2
11150 V(4) = CINT(V(4))
11160 IF V(4) < 3 THEN V(4) = 3
11170 'NBR CONTROL SURFACES
11180 V(6) = 3.58837 + .0005281 * X1 - 0.9493 * X2 + .00517 * V(3)
11190 IF V(6) < 6 THEN V(6) = 6
   IF V(6) > 32 THEN V(6) = 32
11200 V(6) = INT(V(6))
11210 'NBR ACTUATORS
11220 V(5) = .41 - .000425 * X1 + 2.07352E-09 * X1 " 2 + .007467 * V(3) - 1.0377 * SQR(V(3)) + .4828 * SQR(X1) + 14.97 * SQR(V(6)) - .017811 * V(6) " 2

C-47
11230 IF V(5) < 5 THEN V(5) = 5
11240 IF V(5) > 42 THEN V(5) = 42
11250 IF V(7) > 25.1571 * LOG(X(1)) THEN V(7) = 25.1571 * LOG(X(1))
11300 IF V(7) < 5 THEN V(7) = 11
11340 IF V(10) < 9 THEN V(10) = 9
11350 'NBR AVIONICS SYSTEMS (TOTSUBS)
11360 IF V(7) < 11 THEN V(7) = 11
11370 IF V(7) > 484 THEN V(7) = 484
11400 IF V(11) > V(10) THEN V(11) = V(10)
11410 V(12) = -111452 - 120178 * X2 + .009405 * X2 - 230.872 * SQR(X2)
11440 IF V(12) < 25 THEN V(12) = 25
11510 'NBR HYDRAULICS SUBSYSTEMS
11520 IF V(8) < 8 THEN V(8) = 8
11540 IF V(8) > 76 THEN V(8) = 76
11550 V(9) = 13.2236 + 1.851772 * LOG(X(I))
11600 'FUSELAGE AREA
11610 X = -883274 + .082862 * X(1) + 1274.76 * LOG(X(I)) + 32.456 * SQR(X(1))
11640 IF V(1) < 478 THEN V(1) = 478
11650 'FUSELAGE VOLUME
11660 V(2) = -47618.5 * 22143 + 5743.09 * SQR(X2) * .42623 * X2 - 2
11670 IF V(2) < 571 THEN V(2) = 571
11680 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
'CZ(I) - avg crew size
'CZ(I) = 0: NEXT I
FOR I = 1 TO 9: CZ(I) = 0: NEXT I

'STRUCTURAL
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: ZZ = 0: XF = 0
FOR I = 1 TO 3
IF OP(I) = "DELETE" THEN GOTO Q1
X = X + NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) + (C(I) * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X))
Y = Y + TSKT(I) * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X))
Z = Z + TEMP * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X))
XX = XX + RR(I) * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X))
YY = YY + .98 * TOMH * SCHP * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / (TMA * C(I))))
ZX = ZX + 0.2 * TMH * SCHP * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / (TMA * C(I))))
XX = XX + RR(I) * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X))

Q1: NEXT I
FOR I = 1 TO 3
IF OP(I) = "DELETE" THEN GOTO Q1
IF SELL$(I) = "SHUTTLE" THEN TSKT(I) = SMR(I) ELSE TSKT(I) = (1 - PF(I)) * MHMA(I) / C(I)
Y = Y + TSKT(I) * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X))
Z = Z + TEMP * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X))
XX = XX + RR(I) * (NRD(I) * ((1 - Pl(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X))

Q1: NEXT I

END SUB
MTFS(4) = Z
REM(4) = XX
SMT(4) = YY
SMT(4) = ZZ
XCI(4) = XC1

*POWER/FI. ELECTRIAL*
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XCI = 0: ZZ = 0: XF = 0
FOR I = 1 TO 6
IF OP$(I) = "DELETE" THEN GOTO Q5
X = X + NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I))
C76) = CA(6) + (AI)
Q5 NEXT I
FOR I = 1 TO 16
IF OP$(I) = "DELETE" THEN GOTO Q5
Y = Y + TSHT(I) * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * HMMA(I) / CI) + ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
XX = XX + RR(I) * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
YY = YY + 98 * TOSH * SCHP * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / ( TMA * CI(I)))
ZZ = ZZ + 02 * TOSH * SCHP * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / (TMA * CI(I)))
XCI = XCI + ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
X = X + FMAS(I) * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
XQ5 NEXT I

*MECHANICAL SYSTEMS*
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XCI = 0: ZZ = 0: XF = 0
FOR I = 17 TO 18
IF OP$(I) = "DELETE" THEN GOTO Q6
X = X + NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I))
C76) = CA(6) + CA(I)
Q6 NEXT I
IF OP$(I) = "DELETE" THEN GOTO Q6
X9 = X9 + NRD(9) * ((1 - PI(9)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I))
IF OP$(I) = "DELETE" THEN GOTO Q6
FOR I = 17 TO 18
IF OP$(I) = "DELETE" THEN GOTO Q6
Y = Y + TSHT(I) * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * HMMA(I) / CI) + ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
XX = XX + RR(I) * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
YY = YY + 98 * TOSH * SCHP * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / ( TMA * CI(I)))
ZZ = ZZ + 02 * TOSH * SCHP * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / (TMA * CI(I)))
XCI = XCI + ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
X = X + FMAS(I) * ( NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I)) / X)
Q66 NEXT I

IF OP$(I) = "DELETE" THEN GOTO Q7
X = X + NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I))

*AVIONICS*
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XCI = 0: ZZ = 0: XF = 0
FOR I = 19 TO 24
IF OP$(I) = "DELETE" THEN GOTO Q7
X = X + NRD(I) * ((1 - PI(I)) * POH(I) / FMAT(I) + TSHS(I) / FMAS(I))
C(7) - C(7) + CA(I)
Q7 NEXT I
FOR I = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO Q97
IF SEL(I) = "DELETE" THEN GOTO Q8
ELSE
TSM(I) = TSM(I) + TSM(I) - TSM(I)
ELSE TSM(I) = TSM(I) + TSM(I)
END IF
Y = Y - 1
TSM(T) = TSM(T) + TSM(T) - TSM(T)
ELSE TSM(T) = TSM(T) + TSM(T)
END IF
Z = Z + 1
TSM(R) = TSM(R) + TSM(R) - TSM(R)
ELSE TSM(R) = TSM(R) + TSM(R)
END IF
X = X - 1
TSM(S) = TSM(S) + TSM(S) - TSM(S)
ELSE TSM(S) = TSM(S) + TSM(S)
END IF

FOR I = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO Q8
IF SEL(I) = "DELETE" THEN GOTO Q8
ELSE
MAS(I) = MAS(I) + MAS(I) - MAS(I)
ELSE MAS(I) = MAS(I) + MAS(I)
END IF
MTR(S) = MTR(S) + MTR(S) - MTR(S)
ELSE MTR(S) = MTR(S) + MTR(S)
END IF
SMT(7) = SMT(7) + SMT(7) - SMT(7)
ELSE SMT(7) = SMT(7) + SMT(7)
END IF

NEXT I

END SUB
SUB SPACMTBM
2000 ' MODULE TO DETERMINE SPACE ADJUSTED MTBM
2010 YZ = 0: VX = 1
2020 FOR J = 1 TO 33
2030 TO = GOH(J): T1 = T0 + GOH(J): T2 = T1 + TOH(J)
2040 IF OP(J) = "DELETE" THEN GOTO 2000
2050 IF FMAS(J) = "SHUTTLE" AND X(J) = 0 THEN MEAN = FMAT(J) / PI(J)
2060 FOR I = 1 TO 33
2070 TOIl(J): T2 - T1: P TOIl(J)
2080 T3 - T2: OOH(J): T4 - T3: RHH(J)
2090 IF UPS(J) = "DELETE" THEN GOTO 2100
2100 IF SFL$O(J) = "SHUTTLE" AND X(J) = 0 THEN MEAN = FMAT(J) / PI(J)
2110 MEAN = PI(J) / FMAT(J): 1,2 = MEAN / MEAN
2120 FMAS(J) = MEAN
2130 YZ - YZ / MEAN
2140 YX - YX * RT4
2150 NEXT J
2160 SVFMA = YZ / YX: EXIT
SUB
2200 ' MODULE TO COMPUTE SPACE ADJUSTED MTBM
2210 A = (B * T2 - (B - 1) / L1) / (I / B)
2220 A1 = (1 - EXP(-LI * 10)) / LI
2230 A2 = EXP(-LI * T2 / (T2 + T0 - T1)) / L2
2240 A3 = EXP(-LI * (T1 - T0)) * (EXP(-LI * T2) / L2 - EXP(-LI * T2 + T0 - T1)) / L2
2250 GOSUB 2230 ' FIND A4 USING SIMPSON'S RULE
2260 A4 = EXP(-LI * T2 / (T2 + T1 - T2)) * B / AREA
2270 A5 = EXP(-LI * (T2 + T0 - T1) * L2 - (T2 / A) * B) / (1 - EXP(-LI * (T4 - T3))) / L1
2280 MEAN = A1 + A2 + A3 + A4 + A5
2290 RT4 = EXP(-LI * (T2 / T0 - T1) * L2 - (T1 / T0) * L2 - (T2 / A) * B) / L2
2300 MEAN = MEAN / (1 - RT4)
2310 RETURN
SUB SPARES
8000 ' SPARES CALCULATIONS
8010 ARR = 0: TS = 0: KK = 0: TNR = 0
8020 FOR I = 1 TO 33
8030 IF UPS(I) = "DELETE" THEN GOTO 8100
8040 NR(I) = RR(I) * (NRD(I) * (1 - PI(I)) * PONR(I) / FMAT(I) + THRS(I) / FMAS(I)) / MEAN NBR REMOVALS
8050 MN = NR(I)
8060 IF MN < 20 THEN GOSUB 8300 ELSE GOSUB 8090 ' COMPUTE FILL RATE QMT - POISSON/NORM
8070 S(I) - STK: FRO = 0
8080 TNR = TNR + NR(I)
8090 IF TNR < 130 ARR = ARR + RR(I)
8100 TS = TS + S(I)
8110 KK = KK + 1
8120 NEXT I
8130 ARR = ARR / KK
8140 GOTO 8300
8300 ' COMPUTE SPARES USING POISSON DIST
8310 P = EXP(-MN): P = P
8320 IF P < 13 THEN JD = 1: GOTO 8370
8330 JD = 1: P = P
8340 P = P * MN / JD
8350 JD = JD + 1: F = P
8360 IF F < 13 THEN GOTO 8340
8370 STK = JD - 1
8380 RETURN
'NORMAL (STRONG'S) APPROXIMATION
NORM: FC = I - X(13)
SD = SQR(MN)
Z = (FC - 5) * (((14822401# / (256706919# - (3 - FC) * 2)) + (0014532591# / (2505217 - (5 - FC) * 2)) + 2.0489)
STK = CINT(MN + Z * SD)
C-52
RETURN

BGT 'RETURN TO MAIN

END SUB

SUB TEC
2500 TECHNOLOGY ADJUSTMENT MODULE
2510 Y = 0
2520 FOR I = 1 TO 33
2530 IF OP$(I) = "DATA" THEN GOTO 2560
2540 FMAT(I) = FMAT(I) * (1 + TG(I)) * (YR - XYZ)
FMAT(I) = FMAT(I) * X(24) * X(23)
2550 NEXT I
2560
EXIT SUB

END SUB

File: RAMW.BAS create ASCII file

10 'NASA, Langley Research Center
20 'MTBM Computational Model - NASA Research Grant
30 'Developed by C. Ebeling, University of Dayton
35 '9/10/94
40 '******** Combined PreConceptual Model ********
45 'Save As "RAMX.BAS"
50 'Reliability & Maintainability Module for writing to a file
60 COMMON SHARED YR, XI, X2, LF, VR1, VR2, VR3, VR4, VR, AREM
66 COMMON SHARED VFMA, TVFMA, SVFMA, FMA, FMHMA, FMAHMA, TM, AMHMA
67 COMMON SHARED SCHP, VMH, TMH, FMH, APP, P1, P2, P3, WAY, FH42, FH44
68 COMMON SHARED FMA1, FMA12, VNAM, ARR, TNR, TS, SKD
COMMON SHARED SMP, TNP, WGT, WING, WF, WPF
COMMON SHARED ENREL, ETREL, ETS, SRS, LTS, ATBF
COMMON SHARED SP, STE, TM, SF, TFP, C1
70 DIM SHARED WBS$(35), X(50), NAM$(50), THRS(35), MHMA(35), MH(35), MP(35), OMH(35), FMH(35)
71 DIM SHARED SEL(35), T(10), CP5(5), CA(35), REL(35), RF(35)
72 DIM SHARED GON(35), LON(35), TON(35), OON(35), RON(35), R(35), TSKR(35), PGR(35)
73 DIM SHARED V(35), SNAMR(35), FMAT(35), FMAC(35), FMAS(35), S(35), SMAR(35), SMR(35)
74 DIM SHARED WRN(35), C(35), CM(35), S(35), SMR(35)
75 DIM SHARED FMH(35), FMA(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
76 DIM SHARED NRN(35), K(3), R(35), R(35), R(35), R(35)
77 DIM SHARED PWT(35), PWTS(35), PWTA(35), SRR(35)
DIM SHARED ETSM(35), ETSM(35), ETSM(35), ETSM(35), ETSM(35), ETSM(35)
DIM SHARED SRSB(35), SRSB(35), SRSB(35), SRSB(35), SRSB(35), SRSB(35)
DIM SHARED SWBS(35), M2(35), MTWFS(35), REMS(35), SMT(35), SMT(35), SMT(35)
DIM SHARED P1(33), C2(33)
COMMON SHARED P1, C2
COMMON SHARED SWBS(35), S2(35), MTRO(35), REMS(35), SMT(35), SMT(35), SMT(35)
COMMON SHARED WRN(35), V(35), NAM$(35), THRS(35), MHMA(35), MH(35), MP(35), OMH(35), FMH(35)
COMMON SHARED WBS(35), X(35), CP5(5), CA(35), REL(35), RF(35)
COMMON SHARED GON(35), LON(35), TON(35), OON(35), RON(35), R(35), TSKR(35), PGR(35)
COMMON SHARED V(35), SNAMR(35), FMAT(35), FMAC(35), FMAS(35), S(35), SMAR(35), SMR(35)
COMMON SHARED WRN(35), C(35), CM(35), S(35), SMR(35)
COMMON SHARED FMH(35), FMA(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
COMMON SHARED NRN(35), K(3), R(35), R(35), R(35)
COMMON SHARED PWT(35), PWTS(35), PWTA(35), SRR(35)
COMMON SHARED ETSM(35), ETSM(35), ETSM(35), ETSM(35), ETSM(35), ETSM(35)
DIM SHARED SRSB(35), SRSB(35), SRSB(35), SRSB(35), SRSB(35), SRSB(35)
DIM SHARED SWBS(35), M2(35), MTWFS(35), REMS(35), SMT(35), SMT(35), SMT(35)
DIM SHARED P1(33), C2(33)
COMMON SHARED P1, C2
COMMON SHARED SWBS(35), S2(35), MTRO(35), REMS(35), SMT(35), SMT(35), SMT(35)
COMMON SHARED WRN(35), V(35), NAM$(35), THRS(35), MHMA(35), MH(35), MP(35), OMH(35), FMH(35)
COMMON SHARED WBS(35), X(35), CP5(5), CA(35), REL(35), RF(35)
COMMON SHARED GON(35), LON(35), TON(35), OON(35), RON(35), R(35), TSKR(35), PGR(35)
COMMON SHARED V(35), SNAMR(35), FMAT(35), FMAC(35), FMAS(35), S(35), SMAR(35), SMR(35)
COMMON SHARED WRN(35), C(35), CM(35), S(35), SMR(35)
COMMON SHARED FMH(35), FMA(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
COMMON SHARED NRN(35), K(3), R(35), R(35), R(35)
COMMON SHARED PWT(35), PWTS(35), PWTA(35), SRR(35)
COMMON SHARED ETSM(35), ETSM(35), ETSM(35), ETSM(35), ETSM(35), ETSM(35)
DIM SHARED SRSB(35), SRSB(35), SRSB(35), SRSB(35), SRSB(35), SRSB(35)
DIM SHARED SWBS(35), M2(35), MTWFS(35), REMS(35), SMT(35), SMT(35), SMT(35)
DIM SHARED P1(33), C2(33)
PRINT #1, TAB(1), "SUBSYSTEM", TAB(30), "MTBM", TAB(50), "MTTR".
FOR I = 1 TO 33
IF OP$(I) = "DELETE" THEN GOTO FEX7.
IF SFI$(S) > "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 = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO NA4.
IF RELF$(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: IE = 33
PRINT #1, TAB(5), RTITLE$: PRINT #1, PRINT #1.
PRINT #1, TAB(20), "RELIABILITY REPORT - at mission shr.", X(24): " - page 1": PRINT #1,
PRINT #1, TAB(1), "VEHICLE IS ", VNAME, TAB(35), "DATE: ", DATES, TAB(60), "TIME: ", TIMES, PRINT #1.
PRINT #1, "all MTBM's are for a single subsystem, e.g. one engine".
PRINT #1, TAB(1), "WBS", TAB(26), "TECH/GROWTH MTBM", TAB(45), "GRND PROC MTBM", TAB(51), "MISSION MTBM".
PRINT #1, TAB(29), "(all MA's)", TAB(45), "(Critical MA's)", TAB(61), "(inherent MA's)"
FOR I = 1 TO IO TO IE.
IF OP$(I) = "DELETE" THEN GOTO SA2.
MNFMA = MNFMA + 1 / FMAT(I).
IF I = 1 THEN PRINT #1, TAB(1), WBS$(I), " MTBM FAILURE", TAB(35), FMAT(I), TAB(48), FMAT(I) / (1 - PI(I)), TAB(61), FMAS(I).
IF I < IE THEN PRINT #1, TAB(I), WBS$(I), TAB(35), FMAT(I), TAB(48), FMAT(I) / (1 - PI(I)), TAB(61), FMAS(I).
IF I = 12 THEN PRINT #1, TAB(35), "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), I / MNFMA, TAB(61), 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 + PA(I).
Y - Y + 1 / FMAC0: YA - 1 / Y.
Z = Z * R(I).
NA2: NEXT I.
IF K = 0 THEN K = 1.
XA - X / K.
IO - 1 IF - 33.
PRINT #1, TAB(20), "RELIABILITY REPORT - at mission shr.", X(24): " - page 2": PRINT #1.
PRINT #1, TAB(8), "COMMENTS": PRINT #1, 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-GRND+AIR", TAB(48), "MTBM", TAB(60), "REDUNDANT MTBM REL.
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 = 1 TO IO TO IE.
IF OP$(I) = "DELETE" THEN GOTO SA2.
PRINT #1, TAB(1), WBS$(I), TAB(33), PA(I), TAB(48), FMAC0, TAB(65), R(I).
IF I = 24 THEN PRINT #1, TAB(35), "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$(12).
IO - 1 IF - 33.
PRINT #1, TAB(20), "RELIABILITY REPORT - at mission shr.", X(24): " - page 3": PRINT #1.
X - 1: Y - 1: Z - 1: 'AVIONICS ROLLUP
FOR I = 1 TO 19 TO 24
IF OP$(I) = "DELETE" THEN GOTO NA3.
X - X * R(I).
Y - Y * R(I).
Z - Z * R(I).
PRINT #1, **"RELIABILITY REPORT - at mission nbr "; X(24), "; - page 1"** PRINT #1,
PRINT #1, **"RELIABILITY REPORT - at mission nbr "; X(24), "; - page 2"** PRINT #1,
PRINT #1, **"RELIABILITY REPORT - at mission nbr "; X(24), "; - page 3"** PRINT #1,
PRINT #1, **"RELIABILITY REPORT - at mission nbr "; X(24), "; - page 4"** PRINT #1,
PRINT #1, **"RELIABILITY REPORT - at mission nbr "; X(24), "; - page 5"** PRINT #1,
PRINT #1, **"RELIABILITY REPORT - at mission nbr "; X(24), "; - page 6"** PRINT #1,
PRINT #1, **"RELIABILITY REPORT - at mission nbr "; X(24), "; - page 7"** PRINT #1,
IF I = 1 - 24 THEN PRINT #1, TAB(5), "AVIONICS ROLLUP", TAB(29), X, TAB(47), Y, TAB(62), ZA, "(AVG)"
SA5 NEXT I
PRINT #1 PRINT #1:
PRINT #1, TAB(3), "UNSCHEDULED", TAB(32), TOMH, TAB(50); TMH; TAB(65), AFT, "(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), TMH + 02 * SCHP * TOMH
PRINT #1, CHR$(12),
X = 0 Y = 0 "AVIONICS ROLLUP"
FOR I = 1 TO 24
IF OP$(I) = "DELETE" THEN GOTO MY9
X = X + NRD(I) + 1 - P0(I) * P0H(I) / FMAT(I)
Y = Y + NRD(I) * THR$(I) / FMAS(I)
MY9 NEXT I
IO = I - II = 33
TXX = 0: TYY = 0
MY? PRINT #1, TAB(10), "MAINTAINABILITY REPORT - at mission nhr ", X(24); " - page 3" PRINT #1,
PRINT #1, TAB(5), "Note: Ground processing MA's consist of induced and no defect MA's"
PRINT #1, TAB(5), "Mission MA's are inherent equipment failures" PRINT #1,
PRINT #1, TAB(1), "WBS", TAB(32), "GRND PROC MA", TAB(50), "MSN MA", TAB(65), "TOTAL MA" PRINT #1,
FOR I = 1 TO II
IF OP$(I) = "DELETE" THEN GOTO S8
X = X + MHI(I)
Z = Z + MP(I)
S8: NEXT I
Y = X(15) * X / 12
MT = 0
IO = I - II = 33 ASTP = 0
PRINT #1, TAB(5), RITLES; PRINT #1,
PRINT #1, TAB(5), COMMENTS; PRINT #1, PRINT #1,
PRINT #1, TAB(25), "MANPOWER REPORT - at mission nhr ", X(24); " - page 1" PRINT #1,
PRINT #1, TAB(1), "VEHICLE IS ", VNAME; TAB(35), "DATE: ", DATE$; TAB(60), "TIME: ", TIME$ PRINT #1,
PRINT #1, TAB(5), "AVAILABLE HRS/MA = ", X(11), TAB(40), "INDIRECT WORK = ", 100 * X(12), " %"
PRINT #1, "manpower is computed from maashrmd by email direct hrs per per person"
PRINT #1, "ncrew 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, PRINT #1, FOR I = 1 TO II
IF OP$(I) = "DELETE" THEN GOTO PA1
IF I > 19 AND I < 24 THEN ASTP = ASTP + C(I)
PRINT #1, TAB(1), WBS$(I), TAB(30), MHI(I), TAB(45), X(15) * MHI(I) / 12, TAB(59), MP(I), TAB(65), C(I)
IF I = 24 THEN PRINT #1, TAB(5), "AVIONICS ROLLUP"; TAB(28), X, TAB(43), Y, TAB(58), Z, TAB(63), ASTP
MT = MT + C(I) * CA(I)
PA1 NEXT I
PRINT #1,
PRINT #1, PRINT #1, TAB(5), "UNSCHEDULED", TAB(30), VMH, TAB(45), VMH * X(15) / 12, TAB(39), TMP - SMP, TAB(65), STP
PRINT #1, PRINT #1, "SCHEDULED", TAB(30), SCHP * TOMH, TAB(45), X(15) * SCHP * TOMH / 12, TAB(39), SMP, TAB(63), X(14)
PRINT #1, PRINT #1, TAB(5), "TOTAL", TAB(30), VMH + SCHP * TOMH, TAB(43), VMH + SCHP * TOMH * X(15) / 12, TAB(39), JMP, TAB(63), STP + X(14) * COLOR
PRINT #1, PRINT #1, TAB(1), "Total personnel assigned = SUM (avg crew size x ncrews) + schd 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 + SD(I)
Z = Z + FR(I)
SB7 NEXT I
KX = X / K
ZX = Z / 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(35); "DATE: "; DATES$; TAB(60); "TIME: "; TIMES$; PRINT #1;
PRINT #1, TAB(5); "NOTE: failures are assumed to be Poisson": PRINT #1;
PRINT #1, TAB(32); "REMOVAL", TAB(42); "MEAN DEMAND", TAB(50); "SPARES", TAB(60); "EFFEETIVE";
PRINT #1, TAB(1); "WBS", TAB(32); "DATE/MIA", TAB(42); "PUR MISSION", TAB(50); "RQMT", TAB(63); "FILL RATE";
PRINT #1;
FOR I = 1 TO 33
IF OP$(I) - "DELETE" THEN GOTO SA9
PRINT #1, PRINT #1,
PRINT #1, TAB(5); "TOTALS", TAB(27); ARR, "(AVG)", TAB(43); TNR, TAB(55); TS;
PRINT #1, CHKR$(2);
'MODULE TO PRINT #1, VEHICLE TURN TIME
TT = 0; TI = 0; TMAX = 0
SUM = 0; CT = 0; SUMC = 0
FOR I = 0 TO 33
IF OP$(I) - "DELETE" THEN GOTO TA1
CT = CT + 1
SUMC = SUMC + C(I)
IF SELK(I) - "SHUTTLE" THEN TSKT(I) - SMT(I); ELSE TSKT(I) - (1 - PM(I)) * MIMA(I) / C(I)
THI = (NRD(I) * (1 - PI(I)) / FMAT(I)) + THRS(I) / FMAS(I) * TSKT(I) / CA(I)
IF THI > TMAX THEN TMAX = THI; JJ = I
TT = TT + THI
SUM = SUM + TSKT(I)
TA1: NEXT I
AVCREW = SUMC / CT
SCRT = 98 * SCHP $TOMH / X(14)
GTT = TT + SCRT; ATSK = SUM / CT
W = 0; X = 0; Y = 0; Z = 0; K = 0; AVIONICS ROLLUP
FOR I = 19 TO 24
IF OP$(I) - "DELETE" THEN GOTO TA2
K = K + 1
X = X + CA(I)
Y = Y + TSKT(I)
Z = Z + (NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I) * TSKT(I) / CA(I)
W = W + NRD(I) * (1 - PI(I)) * POH(I) / FMAT(I) + THRS(I) / FMAS(I)
TA2: NEXT I
VA = Y / X
IO = IO - 1; IF = 33
PRINT #1, PRINT #1, TAB(5); RTITLE$; PRINT #1;
PRINT #1, TAB(5); COMMENTS PRINT #1: : PRINT #1;
PRINT #1, TAB(20); "VEHICLE TURN TIME REPORT: at mission nbr "; X(24); " " PRINT #1;
PRINT #1, TAB(1); "VEHICLE IS "; VNAME$; TAB(35); "DATE: "; DATES$; TAB(60); "TIME: "; TIMES$; PRINT #1;
PRINT #1, PRINT #1, TAB(23); "ON VEHICLE", TAB(38); "TOT "; TAB(52); "NBR CREWS", TAB(62); "AVG SUBSYS REPAIR";
PRINT #1, TAB(1); "WBS", TAB(25); "MTTR (HRS)", TAB(38); "MAIN ACT", TAB(52); "ASSIGNED", TAB(62); "TIME PER MSN";
PRINT #1,
FOR I = 1 TO 33
IF OP$(I) - "DELETE" THEN GOTO TA2
NHRS = TBL(I); X(48)
TMAX = TBL(I); X(47)
X = X + NHRS
TBL(I); X(49);  "TOT"
TA2: NEXT I
PRINT #1, PRINT #1,
PRINT #1, TAB(1); "AVG CREW SIZE", AVCREW, TAB(26); "AVG TASK TIME", ATSK, TAB(60); TT, "(TOTAL)"
PRINT #1, CHKR$(2);
PRINT #1, TAB(20); "VEHICLE TURN TIME REPORT: at mission nbr "; X(24); " " PRINT #1,
PRINT #1, TAB(1); "VEHICLE IS "; VNAME$; TAB(35); "DATE: "; DATES$; TAB(60); "TIME: "; TIMES$; PRINT #1;
PRINT #1, PRINT #1, TAB(5); "CATEGORY": TAB(32); "MIN TURN TIMES": PRINT #1;
PRINT #1, TAB(5); "SCHD MAINT MSN TASK TIME", TAB(55); SCRT; "HRS";
PRINT #1, TAB(5); "UNSCHEDULED MAINTENANCE TIME", TAB(55); TSAVE; "HRS"
PRINT #1, PRINT #1, TAB(5); "INITIATION 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 PWR TIME", TAB(55); T(0); T(4); "HRS"
IF TSAVE < SCRT THEN TTSAVE = SCRT
VTT = T(0) + T(4); TSAVE = X(17) * 24 + X(18) * 24
PRINT #1, TAB(5); "TOT VEHICLE TURNAROUND TIME", TAB(55); VTT; "TOTAL HRS"
PRINT #1, PRINT #1,
PRINT #1, TAB(1); "ONE SHIF/DAI MAINTENANCE": PRINT #1,
ROUTE = (T(0) + T(4)) / 24 + (TSAVE) / 8 + X(17) + X(18)
PRINT 1, TAB(5), "TOT 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), "TOT 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 parallel unach/sched maint tasks, 8 hr shifts, and 21 work days a month"
PRINT 1, CHR(2).
PRINT 1, TAB(20), "VEHICLE TURN TIME REPORT at mission nbr "; X(24); " page 3": PRINT #1,
PRINT 1, TAB(1), "VEHICLE IS ", VNAMS, TAB(55), "DATE ", DATES, TAB(60), "TIME ", TIMES
PRINT 1, PRINT #1.
PRINT 1, PRINT #1, TAB(5), "CATEGORY", TAB(52), "MAX TURN TIMES": PRINT #1,
PRINT 1, TAB(5), "SCHD MAINTENANCE 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), "TOT VEHICLE TURNAROUND TIME", TAB(55), VTT, "TOTAL HRS"
PRINT 1, PRINT #1.
PRINT 1, TAB(1), "ONE SHIFT/DAY MAINTENANCE": PRINT #1,
DVTT = (T(0) + T(4)) / 24 + (TT + SCMT) / 8 + X(17) + X(18)
PRINT 1, TAB(5), "TOT 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), "TOT 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.
CLOSE #1.
FND 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), X1</td>
<td>Empty weight (without fuel, oil, crew, or cargo) of vehicle in pounds.</td>
</tr>
<tr>
<td>LEN+WING</td>
<td>X2</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><strong>KVA MAX</strong></td>
<td><strong>V(7)</strong></td>
<td>Total normal electrical power output capacity of engines, motors and APU driven generators/alternators in KVA.</td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>NBR HYDR. SUBSYS</strong></td>
<td><strong>V(8)</strong></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><strong>NBR FUEL TK</strong></td>
<td><strong>V(9)</strong></td>
<td>Number of separate internal fuel cells, bladders and tanks.</td>
</tr>
<tr>
<td><strong>NBR OXIDIZER TK</strong></td>
<td><strong>V(13)</strong></td>
<td>NBR of separate, internal oxidizer tanks.</td>
</tr>
<tr>
<td><strong>NBR TOT AVIONICS SUBS</strong></td>
<td><strong>V(10)</strong></td>
<td>Total number of avionics (AN nomenclature) subsystems.</td>
</tr>
<tr>
<td><strong>NBR DIF AVIONICS SUBS</strong></td>
<td><strong>V(11)</strong></td>
<td>Total number of different avionics subsystems (two or more identical units count as one).</td>
</tr>
<tr>
<td><strong>BTU COOLING</strong></td>
<td><strong>V(12)</strong></td>
<td>Total cooling capacity of air-conditioning equipment used for personnel and equipment cooling. Measured in BTU/HR/1000.</td>
</tr>
</tbody>
</table>