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Reliability and Maintainability Model (RAM) User and Maintenance Manual

Prepared for

National Aeronautics and Space Administration

Langley Research Center

under

Grant No. NAG1-1-1327

Entitled:

O&S Analysis of

Conceptual Space Vehicles

Annual Report, Part II
December 31, 1995

Prepared by

Charles E. Ebeling

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Engineering Management and Systems Department

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Preface

This document is the second version of the User and Maintenance Manual developed for the Reliability and Maintainability (RAM) Model under NASA (LRC) Grant No. NAG1-1-1327. The first version was completed in December 1994 as part of the same research grant. Numerous changes have been made to the model during the current research year making the previous manual obsolete. These changes are discussed in the annual report "O&S Analysis of Conceptual Space Vehicles," Part I, December 31, 1995. This document is designed to be self-contained and therefore repeats some information found in the previous manual and in previous reports. As further experience with the model is obtained, additional changes and enhancements are likely. Planned future research includes updating the underlying data base used to generate the estimating equations.

The principle researcher for this effort is Dr. Charles Ebeling, Department of Engineering Management and Systems, School of Engineering, University of Dayton, Dayton, Ohio 45469. Comments concerning this document and the accompanying software are welcome.

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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 references [11] through [15]. This Manual updates and supersedes the 1994 RAM User and Maintenance Manual [14]. Changes and enhancements from the 1994 version of the model are a result of prototype applications of the model during the 1995 research year.

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 (MH/MA). 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 34 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 manhours per maintenance action (MH/MA) data obtained from reference [29], or the user may specify a MTBM and MH/MA directly.

Table 1
Aircraft Design/Performance Variables[1]

VEHICLE DRY WEIGHT	VEHICLE LENGTH
WETTED AREA	VEHICLE WING SPAN
FUSELAGE VOLUME	SUBSYSTEM WEIGHTS
FUSELAGE SURFACE AREA	NUMBER OF PASSENGERS
CREW SIZE	NUMBER OXIDIZER TANKS
NUMBER ENGINES	NUMBER INTERNAL FUEL TANKS
MISSION LENGTH	NUMBER OF RCS/OMS ENGINES
NUMBER OF WHEELS	NUMBER ACTUATORS
NUMBER CONTROL SURFACES	MAXIMUM ELECTRICAL OUTPUT
NUMBER HYDRAULICS SYSTEMS	NUMBER AVIONICS SYSTEMS
BTU COOLING CAPACITY	

Table 2
AF/NAVY Aircraft

TACTICAL	BOMBER	CARGO/TANKER	COMMAND/CONTROL /TRAINER
A-7D/E	B-1B	C-2A	E-2C
A-10A	B-52G	C-5A	E-3A
F-4C/D/E	FB-111A	C-9A	EA-6B
F-5E		KC-10A	T-38
F-14A		C130B/E/H	
F-15A/C		KC-135A	
F-16A/B		C-140A	
F-18A		C-141B	
F-106			
F-111A/D/F			

[1] Variable definitions of those used in the models are found in Appendix D.

Table 3
WBS to WUC to STS Conversions

WBS		WUC		STS	
Wing	1.00	Airframe	11	STR (Structures)	8
Tail	2.00	Airframe	11	STR (Structures)	8
Body	3.00	Airframe Crew Compartment	11 12	STR (Structures)	8
Tanks, LOX Tanks, LH_2	3.10 3.20	Fuel Systems Fuel Systems	46 46	MPS (Main Propulsion System) MPS (Main Propulsion System)	41 41
HEP, Tiles HEP, TCS HEP, PVD	4.10 4.20 4.30			Tile TCS (thermal Control System) PVD (Purge, Vent & Drain)	9 6
Landing Gear	5.00	Landing Gear	13	MEQ (Mechanisms)	51
Propulsion, Main	6.00	Propulsion Systems	23	ME/SSME (Main Engines)	41
Propulsion, MPS	6.10	Propulsion Systems Fuel Systems	23 46	MPS (Main Propulsion System)	41
Propulsion, RCS	7.00	Propulsion Systems	23	FRC (Forward Reaction Control)	42
Propulsion, OMS	8.00	Propulsion Systems	23	OMS	43
Power, APU	9.10	APU Power	24	APU	46
Power, Battery	9.20	Battery	66C/E/G		
Power, Fuel Cell	9.30			FCP (Fuel Cell Power)	45
Electrical	10.00	Electrical Lighting System	42 44	EPD/OEL (Elect Power Dist)	76
Hydraulics/Pneu	11.00	Hydraulics/Pneu	45	HYD (Hydraulics)	58
Aero Surface Actuators	12.00	Flight Controls	14	MEQ (Mechanisms)	57
Avionics, GN&C	13.10	Autopilot Radio Navigation Radar Navigation	52 71 72	GNC	71
Avionics, Health Monitoring	13.20	Malfunc	55		
Avionics, Comm & Tracking	13.30	HF Comm VHF Comm UHF Comm Interphone Emergency Comm	61 62 63 64 66	COM (Communications)	74
Avionics, Display & Controls	13.40			DDC (Digital Display Control)	73
Avionics, Instrumentation System	13.50	Instruments	51	DIG (Digital Systems)	73
Avionics, Data Processing	13.60	Computers	51/52/55	Data Processing	72
Environmental Control, System	14.10	Environmental Control	41	ECL (Environmental Control)	60
Environmental Control, Life Support	14.20	Oxygen System	47	ECL (Environmental Control)	60
Personal Provisions	15.00	Misc. Utilities Personnel Provisions	49 96	FCS (Flight Crew Systems)	?
Recovery & Aux, Parachutes	16.10	Drag Chute Eqpt	93		
Recovery & Aux, Escape System	16.20	Explosive Devices Emergency Equipment	97 91		
Recovery & Aux, Separation System	16.30	Explosive Devices	97	PYR (Pyrotechnics) MEQ (Mechanisms)	55 56
Recovery & Aux, Cross Feed System	16.40				
Recovery & Aux, Docking System	16.50			MEQ (Mechanisms)	53
Recovery & Aux, Manipulator Systems	16.60				

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 presented 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 Regression Analysis

Regression (least-square) 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)

$$Y = B_0 + B_1 X_1 + B_2 X_2 + \dots + B_k X_k \tag{1}$$

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

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

and $B_0, B_1, \dots, B_k$ 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, RCS, and OMS 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]The exception is the landing gear subsystem in which the MTBM is measured in missions per maintenance action.

2.2.1 Technology and Reliability Growth Factor

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.[3] The year (yr) represents the technology development year of the vehicle.

$$\text{TECH MTBM} = \text{MTBM} \times (1+\text{ADJ FAC})^{(yr-1986)} \qquad (2)$$

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 continuous reliability improvements obtained over the operation (missions) of the vehicle.

$$\text{ADJ MTBM} = \text{TECH MTBM} \times (\text{MSN NBR})^{b} \qquad (3)$$

2.2.2 Inherent and External MTBMs

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 and external MTBM are computed in such a way that the total number of maintenance actions (MA) is consistent with the ADJ MTBM. Therefore, for shuttle type subsystems:

$$\text{MA} = (\text{GRND PROC HRS} + \text{MSN HRS}) \,/\, \text{ADJ MTBM}$$

$$\text{MTBM}_I = \text{MSN HRS} \,/\, (p \times \text{MA}). \qquad (4)$$

For aircraft type subsystems:

$$\text{MA} = \text{MSN HRS} \,/\, (p \times \text{SS MTBM})$$

where SS MTBM includes an environmental adjustment as discussed in the following sections. 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

$$\text{MTBM}_N = \text{GRND PROC HRS} \,/\, [(1-p) \times \text{MA}] \qquad (5)$$

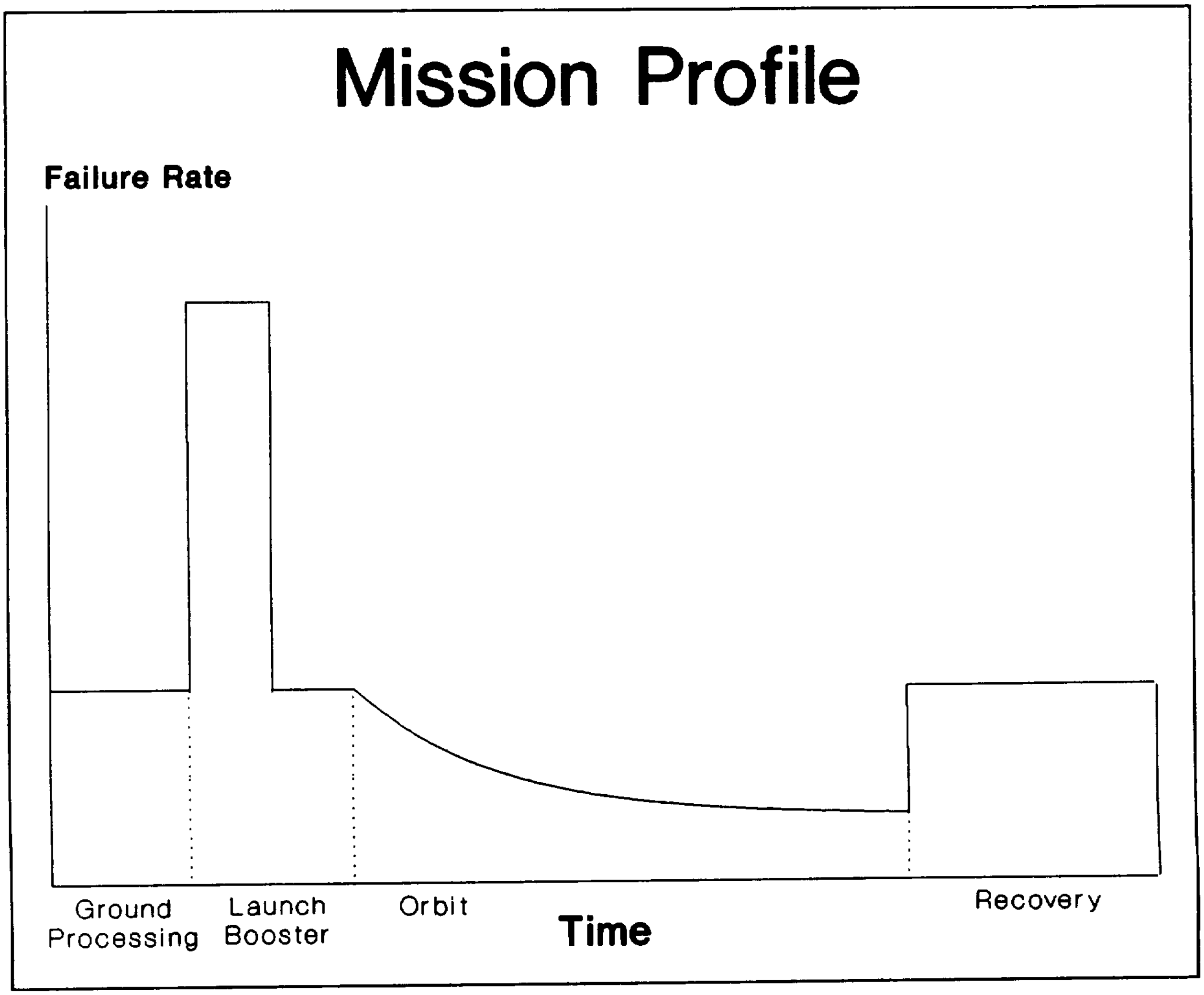
---

[3]If 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



A further adjustment to the $MTBM_I$ 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 $MTBM_I$ 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 (a .28 default value was based upon reference 3). 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:

$$\lambda(t) = \begin{cases} \lambda & for \quad 0 \le t < t_0 \\ \kappa \times \lambda & for \quad t_0 \le t < t_1 \\ \lambda & for \quad t_1 \le t < t_2 \\ \frac{b}{a}\left(\frac{t}{a}\right)^{b-1} & for \quad t_2 \le t < t_3 \\ \lambda & for \quad t_3 \le t < t_4 \end{cases} \tag{6}$$

where:

$$\lambda = \frac{1}{MTBM_I}$$

$\kappa = LAUNCH\ FACTOR$

and a, and b are the Weibull scale and shape parameters respectively

2.4 Reliability Calculations

In general, the reliability function is given by

$$R(t) = e^{-\int_0^t \lambda(t)\, dt} \tag{7}$$

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

$$R(t) = \begin{cases} e^{-\lambda t} & for \quad 0 \le t < t_0 \\ e^{-[\lambda t_0 - \kappa\lambda(t-t_0)]} & for \quad t_0 \le t < t_1 \\ e^{-\lambda[(t+t_0-t_1)-\kappa(t_1-t_0)]} & for \quad t_1 \le t < t_2 \\ e^{-\lambda(t_2+t_0-t_1)-\kappa\lambda(t_1-t_0)+\left(\frac{t}{a}\right)^b-\left(\frac{t_2}{a}\right)^b} & for \quad t_2 \le t < t_3 \\ e^{-\lambda(t_2+t_0-t_1)-\kappa\lambda(t_1-t_0)+\left(\frac{t_3}{a}\right)^b-\left(\frac{t_2}{a}\right)^b-\lambda(t-t_3)} & for \quad t_3 \le t < t_4 \end{cases} \tag{8}$$

Since the mission profile is repetitive over time, a steady-state MTBM may be computed from equation (9).

$$\text{SS MTBM} = \frac{\int_0^{t_4} R(t)\,dt}{1-R(t_4)} \tag{9}$$

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 is 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:

$$\text{CRIT MTBM} = \text{SS MTBM} / \text{AB} \tag{10}$$

With critical failure rates replacing $1/(MTBM_I)$, approximate mission reliabilities are found using Equation (8) for each subsystem. A vehicle reliability is computed by multiplying subsystem reliabilities (R_i)

$$R_{veh} = R_1 \text{ x } R_2 \text{ x } \ldots \text{ x } R_k \tag{11}$$

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

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

$$\text{VEH MTBM} = 1/[1/MTBM_1 + 1/MTBM_2 + \ldots + 1/MTBM_k] \tag{12}$$

where $1/MTBM_i$ is the failure rate of the ith subsystem[4].

2.4.2 Specified Subsystem Reliability

The user may specify a reliability, R_{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

$$R(t_4) = R_{spec}$$

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

$$\text{SS MTBM} = \text{CRIT MTBM x AB} \tag{13}$$

[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.

which will then be used in all subsequent calculations.[5] In order to establish a corresponding external MTBM for comparison purposes, the total number of maintenance actions is found from:

MA = MSN HRS / (p x SS MTBM), then

ADJ MTBM = (GRND PROC HRS + MSN HRS) / MA, and

$MTBM_n$ = GRND PROC HRS / [(1-p) x MA]

2.4.3 Redundant reliability

All reliability calculations are based upon the CRIT MTBM. Letting $\lambda = \frac{1}{CRIT\ MTBM}$ 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:

$$R_{s_i}(t) = 1-[1-R_i(t)]^{n_i} \tag{14}$$

where $R_i(t)$ is computed from Equation (8) for the ith 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:

$$R_{s_i}(t) = \sum_{x=k_i}^{n_i} \binom{n_i}{x} R_i(t)^x \, (1-R_i(t))^{n_i-x} \tag{15}$$

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

$$R_{veh}(t) = R_{s1}(t) \times R_{s2}(t) \times \ldots \times R_{sm}(t) \tag{16}$$

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

$$\text{TOT MA/MSN} = \text{NRD} \times (\text{GRND PROC HR} / MTBM_N + \text{MSN HRS} / \text{SS MTBM}) \tag{17}$$

---

[5]The calculations are performed numerically using the Newton-Raphson method for finding the solution of a nonlinear equation.

where NRD = the number of active redundant subsystems. Then total unscheduled manhours per mission for each subsystem is found from

$$\text{TOT UNSCH MANHRS} = \text{MHMA} \times \text{TOT MA/MSN} \tag{18}$$

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

$$\text{ON-VEH UNSCH MH} = (1\text{-POFF}) \times \text{TOT UNSCH MANHRS} \tag{19}$$

$$\text{OFF-VEH UNSCH MH} = \text{POFF} \times \text{TOT UNSCH MANHRS} \tag{20}$$

When using shuttle data, MHMA is an input value reflecting on-vehicle hours and is not computed from regression equations. A total (on plus off-vehicle) MHMA is then computed by:

$$TOT\,MHMA = MHMA + \frac{POFF \times MHMA}{1-POFF} \tag{21}$$

Default scheduled maintenance manhours is calculated by multiplying the total vehicle unscheduled manhours 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 manhours. The scheduled manhours are then allocated to the subsystems based upon the weight distribution. The analysts can replace individual subsystem values by directly specifying the scheduled maintenance hours.

$$SCHED\ MH = PCT \times (TOT\ UNSCH\ VEH\ MH) \tag{22}$$

Additional vehicle level scheduled maintenance manhours may be included through the use of a periodic (phase) inspection. Periodic maintenance hours per mission is computed by:

$$\text{PER HRS/MSN} = [\text{PER CREW SIZE} \times \text{HRS/INSP}] \,/\, \text{NBR MSNS} \tag{23}$$

where NBR MSNS = the number of missions between periodic inspections.

Total maintenance manhours is found from:

$$\text{TOT MANHRS} = \text{TOT UNSCH MANHRS} + \text{TOT SCHED MANHRS} \tag{24}$$

$$\text{TOT VEH MANHRS} = \text{TOT MANHRS} + \text{PER HRS/MSN} \tag{25}$$

2.6 Manpower

Maintenance manpower requirements are determined in three different ways. The first method is to take the total subsystem unscheduled and scheduled 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,

$$NBR\ PER = \frac{TOT\ MANHRS \times N}{(1 - IND)AV} \quad (rounded\ up) \tag{26}$$

The second approach uses the same methodology except it is applied by subsystem where total subsystem manpower is calculated and rounded up by subsystem. Because of the rounding this will always result in a manpower requirement equal to or greater than that given by Equation (26). However, it assumes that maintenance technicians are trained to work on a specific subsystem.

The third approach is based upon the number of assigned crews specified by the model or the user. Normally the number of assigned crews is established in order to support a desired vehicle turntime and fleet size for a given mission rate. From the number of assigned crews, by subsystem, the number of assigned positions is obtained:

$$\text{ASGN POSITIONS} = \text{ASGN CREWS} \times \text{CREW SIZE} \tag{27}$$

Then assigned manpower is found from:

$$\text{ASGN MANPWR} = \text{PMF} \times \text{ASGN POSITIONS (rounded up)} \tag{28}$$

where PMF is a position manning factor given by:

$$\text{PMF} = [21 \text{ days/mo} \times 8 \text{ hrs/day}] \ / \ [\ (1 - \text{indirect } \%) \times \text{avail hrs/mo}] \tag{29}$$

The PMF converts an 8 hour, 21 day a month position into the number of personnel necessary to fill the position. It accounts for sick time, vacation time, and other time away from the primary (direct) work requirement of the position and assumes that the position must be filled over the entire 8 hour shift. Since the manhour driven manpower by subsystem (NBR PER) is a minimum requirement to perform the identified work, the earned (maximum) manpower is the larger of the subsystem manhour driven manpower and the assigned manpower:

$$\text{EARNED MANPWR} = \text{MAX} \{ \text{NBR PER, ASGN MANPWR} \} \tag{30}$$

Periodic inspection manpower, if utilized, is computed separately from the above formulas and is added to the above in determining the total manpower requirement. This implies there is a dedicated crew which only performs vehicle level periodic maintenance. The computation is:

INSP MNPWR = [PER HRS/MSN x MSN/MO] / [(1- indirect %) x avail hrs/mo (31)

If INSP MNPWR < PHASE CREW SIZE then INSP MNPWR = PHASE CREW SIZE

Total manpower may then be obtained by adding:

TOT MANPWR = EARNED MANPWR + INSP MANPWR + PAD MANPWR (32)

where PAD MANPWR is a user specified input value. The TOT MANPWR is passed to the O&S costing model.

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) during the components repair or resupply time. That is,

MFAIL = RR x TOT MA/MSN x MSN/YR x RCT/365 (33)

where RCT = repair (or resupply) cycle time in days.

MFAIL is the mean number of components in repair at any one time and therefore is the average number of spares needed to meet demands. 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.[6]

[6] The logistics cost model refers to the fill rate as the Probability of Sufficiency (POS).

Let S = spare parts level to support a given mission and p = desired percent of time demands are satisfied (fill rate). Then S is defined as the smallest positive integer such that F(S) >= p where

$$F(S) = \sum_{i=0}^{S} Exp(-MFAIL) \times MFAIL^{i} / i! \qquad (34)$$

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

If MFAIL > 20, then a normal approximation to the Poisson distribution is used in order to avoid numerical problems resulting from large factorial values. This approximation takes the form:

$$S = [\ MFAIL + z\ SQRT(MFAIL)]\ \text{(rounded)} \qquad (35)$$

where z is the normal deviate, and is itself approximated by Strong's formula:

$$z = (.5\text{-}p) \times [(.14822401/(.29670919-(.5\text{-}p)^2)) + (.0014532591/(.2505217-(.5\text{-}p)^2))+2.0489]$$

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 maintenance time can be obtained from

$$MAINT.\ TIME = \frac{MTTR \times TOT\ MA/MSN + .98\, SCHED\ MH/CREW\ SIZE}{NBR\ CREWS} \qquad (36)$$

where NBR CREWS is the total number of crews available to perform parallel work on the subsystem.[7] The mean time to repair (MTTR) is found from:

$$MTTR = TOT\ ON\text{-}VEH\ MH\ /\ CREW\ SIZE \qquad (37)$$

Assuming tasks for each subsystem are performed sequentially (a worst case), then total vehicle maintenance time is the sum of the subsystem maintenance times:

$$VEH\ MAINT.\ TIME = \sum_{ALL\ SUBSYS} MAINT.\ TIME + PER\ HRS/MSN \qquad (38)$$

[7] Aircraft data has shown that 98 percent of the scheduled maintenance is on-aircraft work.

Mission time (in hours), pad time (in days), and integration time (in days) must be included in order to obtain a vehicle turn-around time. Therefore, vehicle turn-around time in working days is:

$$VEH\ TURNAROUND = \frac{MSN\ TIME}{24} + \frac{VEH\ MAINT.\ TIME}{sft \times 8} + PAD + INTG \tag{39}$$

The above equation, 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 a weighted average of working days (21 days/mo) and mission days (30.44 days/mo) gives an estimate of the number of missions per month per vehicle:

$$MSN/YR/VEH = \frac{12x[(VEH\ TURNAROUND - MSNTIME)\ 21 + (MSN\ TIME)\ 30.44]}{VEH\ TURNAROUND^2} \tag{40}$$

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:

$$FLEET\ SIZE = \frac{RQD\ MSN/YR}{MSN/YR/VEH}\ \ (rounded\ up) \tag{41}$$

Equation (38) implies that all subsystems will be repaired sequentially. Setting VEH MAINT. TIME equal to the maximum subsystem MAINT. TIME (or PER HRS/MSN if greater), a minimum vehicle turnaround time is obtained assuming all work may be accomplished in parallel. An average of the minimum and maximum turnaround times is then found from:

$$AVG\ VEH\ TURNAROUND = MAX\ PCT \times MAX\ VEH\ TURNAROUND + (1\text{-}MAXPCT) \times MIN\ VEH\ TURNAROUND \tag{42}$$

where MAXPCT is an input parameter representing the weight to be placed upon the maximum turnaround time. Both the number of missions per month per vehicle and the computed fleet size are found based upon the minimum, maximum and average vehicle turnaround times. A ground processing time which includes the maintenance, pad, and integration times but not mission time is also computed.

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:

$$R = e^{-\frac{OPER\ HRS}{MTBM/(CRIT\ FAIL\ RT)}} \tag{43}$$

and

$$UNSCH\ MH = \frac{OPER\ HRS}{MTBM} \times MTTR \times CREW\ SIZE \tag{44}$$

$$SCHD\ MH = PCT \times UNSCH\ MH \tag{45}$$

$$MAN\ PWR = \frac{(UNSCH\ MH + SCHD\ MH) \times N}{(1 - IND) \times AU} \quad (rounded\ up) \tag{46}$$

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 six 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

File	Module	Description
RAM.BAS		main file - initializes and displays main menu
	INIT	initializes variables and assigns values to arrays
	MAIN	displays main menu and provides name change logic
RAMI.BAS		input module file
	BOOSTER	computes reliability parameters for both a liquid rocket booster and an external tank.
	COMFAC	provides input menus for the computational factors
	DRIVER	controls computational sequencing
	INFILE	reads input data from a file
	INMENU	displays primary input menu and selected input screens
	LCCFILE	saves specified input/output to a file for use by costing model
	MSN	initializes mission profile
	OUTFILE	writes input data to a file
	PCTWGT	computes subsystem weights from weight distribution
	PRIVAR	contains primary variable selection menu
	REL	allows user to specify subsystem reliability
	SHUTTLE	displays/updates shuttle or user specified MTBM and MTTR values
	WEIGHT	displays/updates subsystem weights
RAM2.BAS		contains screen display reports
	AGRT	displays aggregated system R&M parameters
	DISPLAY	contains screen display (output) selection menu
	MAINTDIS	displays maintenance report
	MANDISPLAY	displays manpower report

Table 4 (continued)

File	Module	Description
	RAW	displays initial MTBM and MTTR values
	RELDISPLAY	displays reliability report
	SPAREDISPLAY	displays spare parts report
	SUMMARY	displays system summary report
	TURNTIME	displays/computes vehicle turntimes
RAM3.BAS (INACTIVE)		contains printer reports[8]
	ECHO	prints all input data
	ETSRB	prints LRB and ET reliability reports
	PRINTMAINT	prints maintenance report
	PRINTMAN	prints manpower report
	PRINTREL	prints reliability report
	PRINTSPR	prints spare parts report
	PRINTSUM	prints summary report
	PRINTTURN	prints turntime report
	REPORT	displays report selection menu
	SIMREP	prints computed values for use in simulation model
RAMC.BAS		contains computational modules
	ABORT	computes abort (critical failure) rates
	ACWGT	computes aircraft weight distribution
	COMPM	computes subsystem MTBM if reliability is given
	COMREL	computes non-redundant subsystem reliability
	COMTURN	computes average
	CREW	computes subsystem crew sizes
	CRIT	computes the critical MTBM
	EQS	computes initial MTBM and MHMA
	MANPWR	computes subsystem manpower requirements
	POFFEQS	computes percent off-vehicle values
	REDUNREL	computes redundant subsystem reliabilities
	REMEQS	computes removal rates
	SECONDARY	computes secondary variable values
	SIM	computes simulation model parameters
	SPACEMTBM	computes space adjusted MTBM
	SPARES	computes spare part requirements
	TECH	computes technology and reliability growth MTBM
RAMW.BAS		contains ASCII file output module
	PARA	provides the logic to write selected I/O to a file in support of parametric/sensitivity analysis studies
	WRFILE	writes most input/output reports to an ASCII file
	WARGT	contains the WBS aggregated system report and the initial MTBF/MTTR values

8 This file has been inactivated in order to free sufficient memory to allow for additional functionality. Quickbasic can only access conventional memory (640K).

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 the session.

3.2.2 Initialize Variables and Arrays (module INIT)

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 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 as the default 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

```
NBR                    SELECTION

1.....................READ INPUT FROM A FILE
2.....................INPUT PARAMETER MENU
3.....................COMPUTE R&M PARAMETERS
4.....................SCREEN DISPLAY (OUTPUT) MENU
5.....................SAVE INPUT PARAMETERS
6.....................SAVE DATA FOR COST MODEL
7.....................CHANGE VEHICLE/FILE NAME
8.....................WRITE RESULTS TO A FILE
9.....................TURN ON/OFF PARAMETRIC ANALYSIS
10....................TERMINATE SESSION
```

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.

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 Write results to a file

Provides an option for saving all input data and output reports in an ASCII file. This file may then be (1) printed directly on a parallel printer, (2) read by a wordprocessor, edited, and printed, or (3) sent over a LAN network for subsequent (direct) printing on a serial port printer. A special report for use in the maintenance simulation model (MSM) is also generated.

3.3.9 Turn on/off parametric analysis

This option allows the analyst to perform repeated runs of the model while writing selected input and output to an ASCII file for subsequent analysis. When first turned-on, the analyst is asked to select an input driver variable from the following list:

```
        PARAMETRIC ANALYSIS
SELECTION MENU FOR AN INPUT (DRIVER) VARIABLE
NBR                       SELECTION
1.....................VEH DRY WEIGHT
2.....................LENGTH+WING SPAN
3.....................CREW SIZE + PASSENGERS
4.....................TECHNOLOGY YR
5.....................WEIBULL SHAPE PARAMETER
6.....................MISSIONS PER YR
7.....................GROWTH CURVE SLOPE
8.....................MSN NBR FOR REL GROWTH
9.....................WETTED AREA
10....................MISSION LENGTH
11....................AVE TECHNOLOGY GROWTH
12....................AVG CRIT FAILURE RATE
13....................AVG REMOVAL RATE
14....................AVG PCT OFF-VEH WORK
15....................AVG CREW SIZE
16....................ASSIGNED MANPOWER
17....................AVG INHERENT FRACTION
return................exit to main menu
```

In addition, the analyst may specify one or two "wild card" values to be saved. The analyst will also be requested to enter the number of maintenance shifts per day (1-3) in order to compute the vehicle turntime. If the "wild card" option is selected, the analyst will be asked to input a numerical value to be saved each time the model is recomputed. The input variable, any "wild card" values, and the following output variables will be written to the file " .PAR" each time the model is recomputed:

ADJ MTBM, MSN RELIABILITY, TOT NBR MAs, UNSCHED MAINT HRS, TOT MAINT HRS, MANHR DRIVEN MANPWR, ASSIGNED MANPWR, VEH TURNTIME, NBR MSNS/YR/VEH, NBR VEHs, NBR SPARES.

The file which is created may be imported into a spreadsheet (such as EXCEL) where statistical analysis and graphing may be performed. Each time a record is written to the file, the entire file is displayed on the screen.

3.3.10 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 several temporary files created in the default (current) directory/subdirectory which permit a file display when saving, creating, 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:

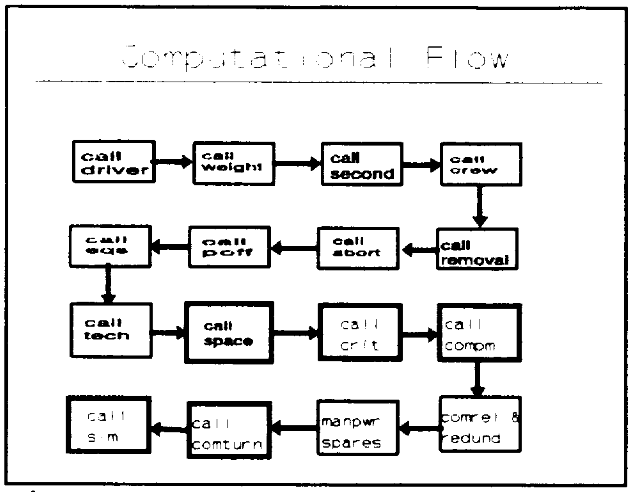


Figure 3

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
Record Parametric Output (if turned on)

The user may elect not to record the parametric output even though the option is on. This may be the case if it desired to view the output before saving the results to the parametric file.

3.4.2 **(CALL PCTWGT)** 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 or user specified values) 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. The inherent and induced MTBM's are also determined by splitting the technology and reliability adjusted MTBM.

3.4.10 **(CALL SPACEMTBM)** 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 then 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 subsystem maintenance manpower and periodic (vehicle) inspection manpower is included. (see section 2.6)

3.4.16 **(CALL SPARES)** A repairable subsystem spares requirement is found based upon the removal rate, total number of maintenance actions per mission, and the number of mission per year. (see section 2.7)

3.4.17 **(CALL COMTURN)** Maintenance tasktimes required to return a vehicle to mission status are computed by subsystem. Task times include both unscheduled and scheduled subsystem activities. (see section 2.8)

3.4.18 **(CALL PARA)** If the parametric analysis option is on, this module will initially request the user specify a driver variable, any wildcards, and the number of maintenance shifts to be used as a basis for the turntime statistics. Subsequent recomputations of the model will invoke this module in order which records the input and output values in the specified file. File contents are displayed on the screen.

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

3.4.20 Return to main menu. Certain additional calculations are computed on demand when an 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

```
NBR                      SELECTION

1.......................ADD/DELETE A SUBSYSTEM
2.......................SELECT SHUTTLE/AIRCRAFT
3.......................UPDATE/DISPLAY PRIMARY SYSTEM PARAMETERS
4.......................UPDATE/DISPLAY SUBSYSTEM WEIGHTS
5.......................UPDATE/DISPLAY SECONDARY VARIABLES
6.......................UPDATE/DISPLAY COMPUTATIONAL FACTORS
7.......................UPDATE/DISPLAY MISSION PROFILE
8.......................UPDATE/DISPLAY SYSTEM OPERATING HRS
9.......................UPDATE/DISPLAY REDUNDANCY CONFIGURATION
10......................UPDATE/DISPLAY LRB/ET RELIABILITY DATA
11......................UPDATE/DISPLAY SHUTTLE MTBM'S & MH/MA's
12......................CHANGE SCHEDULED MAINTENANCE
13......................ESTABLISH SUBSYSTEM RELIABILITIES
return......................exit to main menu
```

4.1.1 Add/Delete a Subsystem

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

4.1.2 Select Shuttle/Aircraft

The MTBM and MTTR for each subsystem will be based upon the parametric equations if **"AIRCRAFT"** is selected and will be based upon the shuttle displayed or user specified values (see 4.1.11) if **"SHUTTLE"** or **"ADJ-MTBM"** is selected. If the user desires to specify a MTBM or a MHMA, then **"SHUTTLE"** or **"ADJ-MTBM"** should be selected. If **"SHUTTLE"** is selected, then the space adjustment to the MTBM will not be applied unless the system parameter **ADJ SHUTTLE MTBM** is set to YES in which case it is applied to all "**SHUTTLE**" subsystems. iF "**ADJ-MTBM**" is selected, then the space adjustment is applied to the subsystem. In this manner, the user may apply the adjustment to only those subsystems in which the MTBM already accounts for the launch and space environments.

4.1.3 Update/Display Primary System Menu

The user must specify values for the primary driver and system parameter variables.

Table 5

Primary Driver Variables

VAR NBR	
1	DRY WEIGHT (lbs)
2	LENGTH (ft)
2	WING SPAN (ft)
3	CREW SIZE
4	NBR PASSENGERS
5	NBR MAIN ENGINES
21	NBR RCS ENGINES
22	NBR OMS ENGINES

Table 6

System Parameter Values

VAR NBR	PARAMETER	DEFAULT	DESCRIPTION
6	ADJ SHUTTLE MTBM	0-No	Determines if launch/space adjustment will be applied to shuttle selected MTBM's
7	TECHNOLOGY YR	1996	Year to be used in applying the technology growth factor
8	DEFAULT ABORT RATE	.001	Abort rate used for subsystems not having parametric equations
9	WEIBULL SHAPE PARAMETER	.28	Shape parameter for Weibull distribution used during orbit time when applying the launch/space adjustment
10	LAUNCH FACTOR	20	A multiplicative factor which increases the failure rate during launch when applying the launch/space adjustment
11	AVAIL MANHRS/MONTH	144	The average number of hours a month a single maintenance worker is available within the workplace
12	FRACTION INDIRECT WORK	.15	The fraction of the available time a worker spends performing indirect work (work not addressed by the model)
13	SPARE FILL RATE OBJ	.95	The fraction of time a spare is to be available when a failure (removal) occurs (sets fill rate goal for computing spares)
14	AVG CREW SIZE-SCHD MAINT	7	The average number of workers simultaneously performing scheduled maintenance - used in computing turntimes
15	PLANNED MISSIONS/YEAR	12	The number of missions per year to be flown
16	MODE INDICATOR	0	See para 4.2
17	VEHICLE INTEGRATION TIME	2	Number of days required to perform vehicle integration
18	LAUNCH PAD TIME (days)	1	Number of days vehicle is on launch pad for processing
19	AGGREGATE AVIONICS	0-NO	Roll-up the six avionics subsystems into a single subsystem
20	TURNTIME PRORAT-FRAC OF MAX	.2	The fraction of the max veh turnaround time used in computing a weighted average of the max and min turnaround times.
23	GROWTH SLOPE	.5	Exponent used in the reliability growth adjustment to the MTBM
24	MSN NBR FOR REL GROWTH	1	Mission number at which the reliability growth adjustment applies (no growth is realized at the default value)
25	AIR+GRND-0/AIR ABORTS-1	0	Bases critical failure rates on either air and ground aborts or air only aborts.
26	LRU TAT IN DAYS	97	Average LRU repair (or resupply) time.

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. For use in parametric analysis, a baseline weight and a current weight are displayed. Current weights may be adjusted by a common factor without affecting the baseline weight. Calculations are based upon the current weight. A any time, the user may restore the current weight to the baseline. The baseline weights can be changed by individual subsystem.

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

VAR NBR	
1	Fuselage area (sq ft)
2	Fuselage Volume (cu ft)
3	Wetted Area (sq ft)
4	Nbr wheels
5	Nbr Actuators
6	Nbr Control Surfaces
7	KVA MAX
8	Nbr Hydraulic Subsystems
9	Nbr Fuel Tanks (internal)
10	Total nbr Avionics Subsystems
11	Nbr Different Avionics Subsystems
12	BTU Cooling
13	Nbr Oxidizer Tanks

4.1.6 Update/Display Computational Factors

The following factors may be displayed and updated:

Table 8
Computational Factors[9]

TECHNOLOGY GROWTH FACTOR	CRITICAL FAILURE RATE*
REMOVAL RATES*	FRACTION OFF-VEHICLE*
CREW SIZE*	NBR CREWS ASSIGNED
FRACTION INHERENT FAILURES	

Each computational factor is discussed in paragraph 4.3. For each computational factor, a global value or individual subsystem values may be specified.

[9] 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.

4.1.7 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

NBR		TIME IN HOURS
1	GROUND POWER TIME	200
2	PAD TIME	10
LAUNCH TIME AT T=0		
3	POWERED PHASE COMPLETION TIME	.14
4	ORBIT INSERTION TIME	1
5	ORBIT COMPLETION TIME	71
6	REENTRY TIME	72

ENTER NUMBER TO BE CHANGED OR 0 IF NONE?

4.1.8 Update/Display System Operating Hours

Figure 6[10]

SUBSYSTEM OPERATING TIMES

TOTAL MISSION TIME 72 HRS MAX PAD TIME 10 HRS

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

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

[10] All subsystem displays show only 13 of the 33 subsystems as example input and output.

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.

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

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

ENTER NUMBER OF SUBSYSTEM TO BE CHANGED - 0 IF NONE?[11]

[11]Whenever 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

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

ENTER NUMBER FOR CHANGE?
ENTER SCHD MAINT AS A PCT OF UNSCH MAINT? .7

SUBSYSTEM	COMPUTED RELIABILITY	MISSION UNSCH MANHRS	SCH MANHRS	MANHR DRIVEN MANPWR
ELECTRICAL	.9964802	217.0578	151.9404	7
PROP-FLUIDS	.982161	1458	1020.6	44
RANGE SAFETY	.9983931	467.8713	327.5099	14
STRUCTURES	.9721467	868.2203	607.7542	26
THERMAL-TPS	.9553647	318.4931	222.9452	10
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

NBR	SUBSYSTEM	MTBM	OPER HRS	CRIT FAIL RT	MTTR	CREW SIZE
1	ELECTRICAL	35.21	669	.001	1	4.5
2	PROPULSION	70	677	.001	1	4.5
3	RANGE SAFETY	102	677	.001	1	4.5
4	STRUCTURES	75	667	.001	1	4.5

ENTER NUMBER FOR CHANGE?
ENTER SCHD MAINT AS A PCT OF UNSCH MAINT? .7

SUBSYSTEM	COMPUTED RELIABILITY	MISSION UNSCH MANHRS	SCHED MANHRS	MANHR DRIVEN MANPWR
ELECTRICAL	.9811791	85.50128	59.85089	3
PROPULSION	.9903752	43.52143	30.465	2
RANGE SAFETY	.9933847	29.86765	20.90735	1
STRUCTURES	.9911461	40.02	28.014	2
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 MHMA'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 MHMA to be used in the computation.

Figure 9
Shuttle MTBM/MHMA Update/Display Screen

Note: all MTBM's should be for a single subsystem.

NBR	SUBSYSTEM	MTBM
1	1.00 WING GROUP	3.78
2	2.00 TAIL GROUP	22.2
3	3.00 BODY GROUP	1.36
7	4.20 IEP-TCS	5.0
9	5.00 LANDING GEAR	9999 msn/failure
10	6.00 PROPULSION-MAIN	21.06
16	10.00 ELECTRICAL	17.4
18	12.00 AERO SURF ACTUATORS	17.27
19	13.XX AGGREGATED AVIONICS	34.4
25	14.10 ENVIRONMENTAL CONTROL	24.47
26	14.20 ECS-LIFE SUPPORT	100
29	16.20 REC & AUX-ESCAPE SYS	200
32	16.50 REC & AUX DOCKING SYS	300

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

SHUTTLE MH/MA VALUES - Note: On veh MH/MA is the average number of manhours required per MA. It equals the on-veh MTTR x AvG Crew Size.

NBR	SUBSYSTEM	On-Veh MH/MA
1	1.00 WING GROUP	21.375
2	2.00 TAIL GROUP	21.375
3	3.00 BODY GROUP	21.375
7	4.20 IEP-TCS	29.7
9	5.00 LANDING GEAR	33.255
10	6.00 PROPULSION-MAIN	30.42
16	10.00 ELECTRICAL	22.41
18	12.00 AERO SURF ACTUATORS	33.255
19	13.XX AGGREGATED AVIONICS	40.0
25	14.10 ENVIRONMENTAL CONTROL	41.22
26	14.20 ECS-LIFE SUPPORT	41.22
29	16.20 REC & AUX-ESCAPE SYS	30.0
32	16.50 REC & AUX DOCKING SYS	36.0

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

4.1.12 Change Schedule Maintenance

As a default, 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 in place of the computed value. The user also specify individual subsystem scheduled maintenance hours replacing the current values. For informational purposes, the percent of the unscheduled maintenance is displayed.

Figure 10

SCHEDULED MAINTENANCE-INPUT/DISPLAY

note: Enter 99 for a global change.
Current schd maintenance percent of total unsch maint is 47.0
Parametric Equation scheduled maintenance pct of unsch is 37.83

NBR	SUBSYSTEM	PERCENT OF UNSCHD	SCHD MANHRS
1	1.00 WING GROUP	40	20.5
2	2.00 TAIL GROUP	40	30.6
3	3.00 BODY GROUP	50	50.1
7	4.20 IEP-TCS	40	78.0
9	5.00 LANDING GEAR	60	45.0
10	6.00 PROPULSION-MAIN	60	35.4
16	10.00 ELECTRICAL	50	71.9
18	12.00 AERO SURF ACTUATORS	40	34.3
19	13.XX AGGREGATED AVIONICS	40	82.5
25	14.10 ENVIRONMENTAL CONTROL	40	66.4
26	14.20 ECS-LIFE SUPPORT	50	53.2
29	16.20 REC & AUX-ESCAPE SYS	50	18.4
32	16.50 REC & AUX DOCKING SYS	30	29.7
TOTAL			616.0

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

A periodic (phase) inspection requirement may optionally be established as well by specifying the number of missions between inspections, length of inspection in hours, and crew size for phase inspection.

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 11

ESTABLISH SUBSYSTEM RELIABILITY

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

NBR	SUBSYSTEM	RELIABILITY
1	1.00 WING GROUP	COMPUTED
2	2.00 TAIL GROUP	COMPUTED
3	3.00 BODY GROUP	COMPUTED
7	4.20 IEP-TCS	.99889
9	5.00 LANDING GEAR	COMPUTED
10	6.00 PROPULSION-MAIN	COMPUTED
16	10.00 ELECTRICAL	COMPUTED
18	12.00 AERO SURF ACTUATORS	COMPUTED
19	13.XX AGGREGATED AVIONICS	COMPUTED
25	14.10 ENVIRONMENTAL CONTROL	COMPUTED
26	14.20 ECS-LIFE SUPPORT	COMPUTED
29	16.20 REC & AUX-ESCAPE SYS	COMPUTED
32	16.50 REC & AUX DOCKING SYS	COMPUTED

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 8 driver variables and the 19 system parameters (see para 4.1.3). 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 12

SUBSYSTEM WEIGHTS IN LBS   WEIGHT FACTOR IS 2

NBR	WBS	BASELINE WT	CURRENT WT
1	1.00 WING GROUP	1000	2000
2	2.00 TAIL GROUP	900	1800
3	3.00 BODY GROUP	6000	12000
7	4.20 IEP-TCS	1430	2860
9	5.00 LANDING GEAR	700	1400
10	6.00 PROPULSION-MAIN	3000	6000
16	10.00 ELECTRICAL	800	1600
18	12.00 AERO SURF ACTUATORS	500	1000
19	13.XX AGGREGATED AVIONICS	3000	6000
25	14.10 ENVIRONMENTAL CONTROL	900	1800
26	14.20 ECS-LIFE SUPPORT	700	1400
29	16.20 REC & AUX-ESCAPE SYS	500	1000
32	16.50 REC & AUX DOCKING SYS	1100	2200
	TOTAL WEIGHT	20530	41060

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 13

Secondary Variable Menu

NBR	VARIABLE	CURRENT VALUE
1	FUSELAGE AREA	875.9
2	FUSELAGE VOLUME	17567.8
3	WETTED AREA	14077.5
4	NBR WHEELS	3
5	NBR ACTUATORS	17
6	NBR CONTR SURFACES	6
7	KVA MAX	57.5
8	NBR HYDR SUBSYS	8
9	NBR FUEL TANKS (INTERNAL)	5
10	TOT NBR AVIONICS SUBSYS	21
11	NBR DIFF AVIONICS SUBSYS	21
12	BTU COOLING	125.4
13	NBR OXIDIZER TANKS	5

4.3. Computational Factors

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

Figure 14
Computational Factors Menu

```
NBR            SELECTION

1..............TECHNOLOGY GROWTH FACTOR
2..............CRITICAL FAILURE RATE
3..............SUBSYSTEM REMOVAL RATES
4..............MTBM/MTTR CALIBRATION
5..............CREW SIZES/CREWS ASSIGNED
6..............FRACTION OFF-EQUIP
7..............FRACTION INHERENT FAILURES

return............exit to input menu
```

4.3.1 Technology Factor

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

Figure 15

Annual Technology Factor

Enter 99 for a global change.

NBR	SUBSYSTEM	TECH GRWTH FACTOR
1	1.00 WING GROUP	.082
2	2.00 TAIL GROUP	.082
3	3.00 BODY GROUP	.082
7	4.20 IEP-TCS	.082
9	5.00 LANDING GEAR	.033
10	6.00 PROPULSION-MAIN	.011
16	10.00 ELECTRICAL	0
18	12.00 AERO SURF ACTUATORS	.056
19	13.XX AGGREGATED AVIONICS	.22
25	14.10 ENVIRONMENTAL CONTROL	.0062
26	14.20 ECS-LIFE SUPPORT	.0062
29	16.20 REC & AUX-ESCAPE SYS	.083
32	16.50 REC & AUX DOCKING SYS	.083
	Average	.0633

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

4.3.2 Subsystem Calibration

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

Figure 16

SUBSYSTEM MTBM CALIBRATION FACTOR
CAL MTBM = CAL FAC x computed MTBM

Enter 99 for a global change.

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

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

SUBSYSTEM MH/MA CALIBRATION FACTOR
CAL MH/MA = CAL FAC x computed MH/MA

Enter 99 for a global change.

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

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 17
Critical Failure Rate - Fraction of total MA resulting in a mission abort.
Enter 99 for a global change.

NBR	SUBSYSTEM	CRITICAL FAIL RATE
1	1.00 WING GROUP	1.308286E-02
2	2.00 TAIL GROUP	1.308286E-02
3	3.00 BODY GROUP	1.330428E-02
7	4.20 IEP-TCS	.001
9	5.00 LANDING GEAR	1.010141E-04
10	6.00 PROPULSION-MAIN	.010124
16	10.00 ELECTRICAL	8.578588E-02
18	12.00 AERO SURF ACTUATORS	2.376491E-03
19	13.XX AGGREGATED AVIONICS	2.283728E-02
25	14.10 ENVIRONMENTAL CONTROL	3.428872E-02
26	14.20 ECS-LIFE SUPPORT	3.428872E-02
29	16.20 REC & AUX-ESCAPE SYS	.001
32	16.50 REC & AUX DOCKING SYS	.001
	Average	.0178

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 18

REMOVAL RATE - probability of a removal per maintenance action
Enter 99 for a global change.

NBR	SUBSYSTEM	REMOVAL RATE
1	1.00 WING GROUP	.1896
2	2.00 TAIL GROUP	.1896
3	3.00 BODY GROUP	.233
7	4.20 IEP-TCS	.481
9	5.00 LANDING GEAR	.22
10	6.00 PROPULSION-MAIN	.5424
16	10.00 ELECTRICAL	.473
18	12.00 AERO SURF ACTUATORS	.252
19	13.XX AGGREGATED AVIONICS	.42
25	14.10 ENVIRONMENTAL CONTROL	.489
26	14.20 ECS-LIFE SUPPORT	.506
29	16.20 REC & AUX-ESCAPE SYS	.327
32	16.50 REC & AUX DOCKING SYS	.219
	Average	.349

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 19

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

Enter 99 for a global change.

NBR	SUBSYSTEM	FRACTION OFF - EQUIP
1	1.00 WING GROUP	.0835
2	2.00 TAIL GROUP	.0835
3	3.00 BODY GROUP	.08575
7	4.20 IEP-TCS	.2
9	5.00 LANDING GEAR	.134
10	6.00 PROPULSION-MAIN	.725
16	10.00 ELECTRICAL	.042
18	12.00 AERO SURF ACTUATORS	.2211
19	13.XX AGGREGATED AVIONICS	.532
25	14.10 ENVIRONMENTAL CONTROL	.0932
26	14.20 ECS-LIFE SUPPORT	.02
29	16.20 REC & AUX-ESCAPE SYS	.2356
32	16.50 REC & AUX DOCKING SYS	.2
	Average	.204

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.

Figure 20
CREW SIZE/NBR CREWS

Note: Nbr crews assigned affects turntime & assigned manpower.
Input mode is NBR ASGN. Enter 999 to toggle.
Enter 99 for a global change.

NBR	SUBSYSTEM	CREW SIZE	NBR CREWS ASGN
1	1.00 WING GROUP	2.137765	1
2	2.00 TAIL GROUP	2.137765	1
3	3.00 BODY GROUP	2.2	3
7	4.20 IEP-TCS	4.5	5
9	5.00 LANDING GEAR	2.137765	1
10	6.00 PROPULSION-MAIN	2.43	1
16	10.00 ELECTRICAL	2.316721	1
18	12.00 AERO SURF ACTUATORS	2.137765	1
19	13.XX AGGREGATED AVIONICS	2.2	2
25	14.10 ENVIRONMENTAL CONTROL	2.316721	1
26	14.20 ECS-LIFE SUPPORT	2.316721	1
29	16.20 REC & AUX-ESCAPE SYS	1.931436	1
32	16.50 REC & AUX DOCKING SYS	4.5	1
	Average	2.56	1.54

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.

Figure 21

Fraction Inherent Failure - fraction of total MA resulting from inherent failures; separates MTBM into ground and mission MTBM. Assign a zero value to freeze MSN(inherent) and GND (induced) MTBMs.
Enter 99 for a global change.

NBR	SUBSYSTEM	FRACTION INHERENT FAILURES
1	1.00 WING GROUP	.35
2	2.00 TAIL GROUP	.35
3	3.00 BODY GROUP	.36
7	4.20 IEP-TCS	.5
9	5.00 LANDING GEAR	.52
10	6.00 PROPULSION-MAIN	.46
16	10.00 ELECTRICAL	.57
18	12.00 AERO SURF ACTUATORS	.47
19	13.XX AGGREGATED AVIONICS	.49
25	14.10 ENVIRONMENTAL CONTROL	.41
26	14.20 ECS-LIFE SUPPORT	.46
29	16.20 REC & AUX-ESCAPE SYS	.43
32	16.50 REC & AUX DOCKING SYS	.5
	Average	.452

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 22
Screen Display (Output) Menu

```
NBR                     SELECTION

 1..................RELIABILITY REPORT
 2..................MAINTAINABILITY REPORT
 3..................MANPOWER REQUIREMENTS
 4..................SPARES REQUIREMENTS
 5..................VEHICLE TURNTIME REPORT
 6..................SYSTEM PERFORMANCE SUMMARY
 7..................AGGREGATED SYSTEM REPORT
 8..................INITIAL MTBMs AND MTTRs
 return......exit to main menu
```

5.1.1 Reliability Report[12]

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.

[12]The 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 23

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.

WBS	TECH/GROWTH MTBM (all)	GRND PROC MTBM (External)	MISSION MTBM (inherent)
1.00 WING GROUP	31.79182	48.9105	348.9151
2.00 TAIL GROUP	35.32425	54.34501	390.2049
3.00 BODY GROUP	3.986436	6.228806	26.61858
4.20 IEP-TCS	8.957087	17.91417	17.91417
5.00 LANDING GEAR MSN'S/FAILURE	29.90977	62.31203	57.51888
6.00 PROPULSION-MAIN	39.34385	72.85897	65.25906
10.00 ELECTRICAL	7.2832	16.93767	32.98675
12.00 AERO SURF ACTUATORS	141.0082	266.0532	922.6389
13.XX AGGREGATED AVIONICS	12.7012	24.90431	84.7984
14.10 ENVIRONMENTAL CONTROL	113.92	193.0847	1116.807
14.20 ECS-LIFE SUPPORT	20.63255	38.20843	161.3881
16.20 REC & AUX-ESCAPE SYS	47.61164	83.52919	430.3201
16.50 REC & AUX DOCKING SYS	538.9167	1077.833	1077.833
VEHICLE	1.274958	2.313801	5.403583

RELIABILITY REPORT - at mission nbr. 2 - page 2

all MTBM's are for a single subsystem.

WBS	CRITICAL FAILURE RATE-grnd+air	CRITICAL MTBM	SUBSYS NON-REDUNDANT MSN REL
1.00 WING GROUP	1.308286E-02	26669.64	.9992543
2.00 TAIL GROUP	1.308286E-02	29825.66	.9993332
3.00 BODY GROUP	1.330428E-02	2000.753	.9901056
4.20 IEP-TCS	.001	17914.17	.99889
5.00 LANDING GEAR	1.010141E-04	569414.1	.9999983
6.00 PROPULSION-MAIN	.010124	6445.978	.9978831
10.00 ELECTRICAL	8.578588E-02	384.5242	.9495768
12.00 AERO SURF ACTUATORS	2.376491E-03	388235.7	.9999256
13.XX AGGREGATED AVIONICS	2.283728E-02	3713.157	.9946564
14.10 ENVIRONMENTAL CONTROL	3.428872E-02	32570.68	.9993894
14.20 ECS-LIFE SUPPORT	3.428872E-02	4706.741	.995782
16.20 REC & AUX-ESCAPE SYS	.001	430320.1	.9999537
16.50 REC & AUX DOCKING SYS	.001	1077833	.9999815
VEHICLE		256.248	.9262028

RELIABILITY REPORT - at mission nbr. 2 - page 3

reliabilities based upon redundancy

WBS	LAUNCH TIME	END OF POWER FLT	ORBIT INSERTION
1.00 WING GROUP	.9996251	.9995202	.9994879
2.00 TAIL GROUP	.9996648	.9995709	.9995421
3.00 BODY GROUP	.9950144	.9936228	.9931958
4.20 IEP-TCS	.9994419	.9992858	.9992378
5.00 LANDING GEAR	1	1	1
6.00 PROPULSION-MAIN	.9953568	.9940605	.9936627
10.00 ELECTRICAL	.999341	.9989281	.9987819
12.00 AERO SURF ACTUATORS	.9999485	.9999413	.9999391
13.XX AGGREGATED AVIONICS	.9999928	.9999881	.9999865
14.10 ENVIRONMENTAL CONTROL	.9999999	.9999998	.9999998
14.20 ECS-LIFE SUPPORT	.9978777	.9972842	.997102
16.20 REC & AUX-ESCAPE SYS	.9999768	.9999703	.9999682
16.50 REC & AUX DOCKING SYS	.9999907	.9999881	.9999873
VEHICLE	.9862989	.9822762	.9810246

RELIABILITY REPORT - at mission nbr. 2 - page 4

reliabilities based upon redundancy

WBS	REENTRY COMPLETION	MISSION
1.00 WING GROUP	.9992918	.9992543
2.00 TAIL GROUP	.9993667	.9993332
3.00 BODY GROUP	.9906006	.9901056
4.20 IEP-TCS	.9989458	.99889
5.00 LANDING GEAR	1	.9999983
6.00 PROPULSION-MAIN	.9936627	.9936627
10.00 ELECTRICAL	.9977008	.9974575
12.00 AERO SURF ACTUATORS	.9999281	.9999256
13.XX AGGREGATED AVIONICS	.9999743	.9999714
14.10 ENVIRONMENTAL CONTROL	.9999996	.9999996
14.20 ECS-LIFE SUPPORT	.9959936	.995782
16.20 REC & AUX-ESCAPE SYS	.9999561	.9999537
16.50 REC & AUX DOCKING SYS	.9999825	.9999815
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 (MH/MA) is obtained parametrically or obtained directly from the user (or from Shuttle data). 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 from direct input or as a specified percent of the total unscheduled manhours allocated to the subsystems based upon their relative weights. Manhours are also displayed as on-vehicle and off-vehicle manhours.

Figure 24

MAINTAINABILITY REPORT - at mission nbr. 2 - page 1

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

WBS	UNSCHEDULED ON/OFF VEH	MAINT ACTIONS/MSN	AVG MANHR/MA	AVG MANHRS/MSN
1.00	WING GROUP	4.324116	9.050124	39.13379
2.00	TAIL GROUP	3.890337	9.050124	35.20803
3.00	BODY GROUP	35.18943	14.63651	515.0506
4.20	IEP-TCS	15.74173	84.375	1328.208
5.00	LANDING GEAR	3.343386E-02	8.062291	.2695535
6.00	PROPULSION-MAIN	8.403646	21.1	177.3169
10.00	ELECTRICAL	26.10184	4.1	107.0175
12.00	AERO SURF ACTUATORS	.8514433	2.1	1.788031
13.XX	AGGREGATED AVIONICS	17.02847	12.78584	217.7233
14.10	ENVIRONMENTAL CONTROL	2.145053	6.83832	14.66856
14.20	ECS-LIFE SUPPORT	5.742539	5.444892	31.26751
16.20	REC & AUX-ESCAPE SYS	2.584929	4.559166	11.78512
16.50	REC & AUX DOCKING SYS	.261636	68.175	17.83703
	TOTALS	126.162	20.03333 WT-AVG	2527.445

MAINTAINABILITY REPORT - at mission nbr. 2 - page 2

WBS UNSCHEDULED	ON-VEH MH	OFF-VEH MH	FRACTION ON-VEH
1.00 WING GROUP	35.86612	3.267671	.9165
2.00 TAIL GROUP	32.26817	2.939871	.9165
3.00 BODY GROUP	470.885	44.16559	.91425
4.20 IEP-TCS	1062.567	265.6416	.8
5.00 LANDING GEAR	.2334334	3.612018E-02	.866
6.00 PROPULSION-MAIN	50.71828	133.7118	.275
10.00 ELECTRICAL	112.2867	4.9228	.958
12.00 AERO SURF ACTUATORS	1.392702	.3953288	.7789026
13.XX AGGREGATED AVIONICS	107.6808	122.4064	.468
14.10 ENVIRONMENTAL CONTROL	13.75675	1.413905	.9068
14.20 ECS-LIFE SUPPORT	30.64215	.6253501	.98
16.20 REC & AUX-ESCAPE SYS	9.009071	2.776047	.7644447
16.50 REC & AUX DOCKING SYS	14.26963	3.567407	.8
UNSCHEDULED	1941.575	585.8699	.7957228 (AVG)
SCHEDULED	1427.058	29.12363	
PHASE INSPECTION	128.00		
TOTAL	3496.633	614.9936	

MAINTAINABILTY REPORT - at mission nbr. 1 - page 3[13]

WBS	SCHED MH	UNSCHED MH	TOTAL MH
1.00 WING GROUP	6.764172	16.91043	23.6746
2.00 TAIL GROUP	5.995502	14.98875	20.98425
3.00 BODY GROUP	197.5484	493.8711	691.4195
4.20 IEP-TCS	246.6439	616.6097	863.2535
5.00 LANDING GEAR	12.8657	32.16426	45.02996
6.00 PROPULSION-MAIN	13.71216	34.28039	47.99255
10.00 ELECTRICAL	3.132054	7.830134	10.96219
12.00 AERO SURF ACTUATORS	23.34639	58.36597	81.71236
13.XX AGGREGATED AVIONICS	18.40327	46.00818	64.41145
14.10 ENVIRONMENTAL CONTROL	3.193531	7.983827	11.17736
14.20 ECS-LIFE SUPPORT	.7646731	1.911683	2.676356
16.20 REC & AUX-ESCAPE SYS	.2507225	.6268061	.8775286
16.50 REC & AUX DOCKING SYS	.1178466	.2946164	.412463
TOTAL	434.85	1331.846	1766.696

[13] Screen generated from a different data set.

MAINTAINABILITY REPORT - at mission nbr. 2 - page 4

WBS	GRND PROC MA (external)	MSN MA (inherent)	TOTAL MA
1.00 WING GROUP	4.089102	.2350142	4.324116
2.00 TAIL GROUP	3.680191	.210146	3.890337
3.00 BODY GROUP	32.10888	3.080555	35.18943
4.20 IEP-TCS	11.16434	4.577381	15.74173
5.00 LANDING GEAR	1.604827E-02	.0173856	3.343386E-02
6.00 PROPULSION-MAIN	8.235087	.5056769	8.740765
10.00 ELECTRICAL	23.61599	4.971694	28.58769
12.00 AERO SURF ACTUATORS	.7517293	9.971399E-02	.8514433
13.XX AGGREGATED AVIONICS	16.06148	1.933999	17.99547
14.10 ENVIRONMENTAL CONTROL	2.07163	.1468472	2.218477
14.20 ECS-LIFE SUPPORT	5.234447	.508092	5.742539
16.20 REC & AUX-ESCAPE SYS	2.394373	.1905558	2.584929
16.50 REC & AUX DOCKING SYS	.1855574	7.607855E-02	.261636
TOTAL	109.6089	16.55314	126.162

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. A second manpower requirement (page 2) is based upon the assigned number of assigned crews. Assigned crews are specified by the user and are used in establishing turntime or fleet size objectives. Assigned positions are computed by multiplying subsystem average crew sizes by the number of assigned crews. Then assigned manpower is found by multiplying the assigned positions by the Position Manning Factor (PMF) and rounding up. The maximum manpower is the larger of the manhour driven manpower (page 1) and the assigned manpower. Total manpower is obtained by adding inspection and Pad manpower to the max manpower. This number is then used in the costing model (LCC) for establishing maintenance manpower costs.

Figure 25

MANPOWER REPORT - at mission nbr. 1

VEHICLE IS rpt96 DATE: 10-09-1995 TIME: 16:40:35

manpwr is computed from manhrs/mo divided by avail direct hrs per mo per person
available hrs per mo is 144 and the percent indirect is 15

WBS	MANHRS/MSN	MANHRS/MO	MANPWR
1.00 WING GROUP	23.10979	23.10979	1
2.00 TAIL GROUP	20.48363	20.48363	1
3.00 BODY GROUP	674.4797	674.4797	6
4.20 IEP-TCS	813.9248	813.9248	7
5.00 LANDING GEAR	42.21724	42.21724	1
6.00 PROPULSION-MAIN	38.05123	38.05123	1
10.00 ELECTRICAL	10.1734	10.1734	1
12.00 AERO SURF ACTUATORS	74.94191	74.94191	1
13.XX AGGREGATED AVIONICS	54.62091	54.62091	1
14.10 ENVIRONMENTAL CONTROL	10.87972	10.87972	1
14.20 ECS-LIFE SUPPORT	2.606109	2.606109	1
16.20 REC & AUX-ESCAPE SYS	.8184696	.8184696	1
16.50 REC & AUX DOCKING SYS	.3888937	.3888937	1
TOTAL	1766.696	1766.696	24
Pad Svc			7
Phase inspt	16	16	4

MANPOWER REPORT - at mission nbr. 1 page 2

Rqd crews is computed from manpwr divided by avg crew. Asgn manpwr is based on
a posn manning fac of 1.372549. Max mpwr is MAX {manpwr, asgn manpwr}

WBS	AVG CREW SIZE	RQD CREWS	CUR CREWS	ASGN POSNS	ASGN MNPWR	MAX MPWR
1.00 WING GROUP	2.137762	1	1	3	5	5
2.00 TAIL GROUP	2.137762	1	1	3	5	5
3.00 BODY GROUP	2.137762	3	1	3	5	6
4.20 IEP-TCS	4.5	2	1	5	7	7
5.00 LANDING GEAR	2.137762	1	1	3	5	5
6.00 PROPULSION-MAIN	2.43	1	1	3	5	5
10.00 ELECTRICAL	1.98833	1	1	2	3	3
12.00 AERO SURF ACTUATORS	2.137762	1	1	3	5	5
13.XX AGGREGATED AVIONICS	2.18	1	1	3	5	5
14.10 ENVIRONMENTAL CONTROL	1.98833	1	1	2	3	3
14.20 ECS-LIFE SUPPORT	1.98833	1	1	2	3	3
16.20 REC & AUX-ESCAPE SYS	1.930749	1	1	2	3	3
16.50 REC & AUX DOCKING SYS	4.5	1	1	5	7	7
TOTAL				9	61	62
Pad Svc					7	7
Phase Inspect				4	4	4
TOTAL RQMT						73

5.1.4 Spares Report

Spares requirements are based upon the mean number of removals of components per year times the mean repair or resupply time in years. The product is the average number of unserviceable components in repair at any given time (under steady-state conditions). Assuming a Poisson demand distribution with this mean, spares levels are then established to provide a specified fill rate (i.e. probability a spare is available on demand). An effective fill rate is displayed showing the achieved value which will always equal or exceed the stated fill rate goal.

Figure 26

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

WBS	REMOVAL RATE/MA	MEAN NUMBER IN REPAIR	SPARES RQMT	EFFECTIVE FILL RATE
1.00 WING GROUP	.1896146	.8199155	3	.9901355
2.00 TAIL GROUP	.1896146	.7376647	3	.99311
3.00 BODY GROUP	.2330179	8.199767	15	.9898019
4.20 IEP-TCS	.481	7.57177	14	.9889027
5.00 LANDING GEAR	.22	7.35545E-03	0	.9926715
6.00 PROPULSION-MAIN	.5424479	4.55854	9	.9815111
10.00 ELECTRICAL	.4729872	12.34584	20	.9846472
12.00 AERO SURF ACTUATORS	.25239	.2148958	2	.998591
13.XX AGGREGATED AVIONICS	.4195914	7.145002	13	.9850001
14.10 ENVIRONMENTAL CONTROL	.489287	1.049547	4	.9955227
14.20 ECS-LIFE SUPPORT	.5057694	2.9044	7	.9900324
16.20 REC & AUX-ESCAPE SYS	.3272568	.8459354	3	.9890459
16.50 REC & AUX DOCKING SYS	.219	5.729828E-02	1	.9984198
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 on-vehicle 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 maintained sequentially (serially). A weighted average of the maximum and minimum times are also computed. On-vehicle subsystem scheduled maintenance time is divided by the number of crews and added to the unscheduled maintenance time in arriving at an average on-vehicle maintenance time per mission. Integration time, pad time, and mission time are included in the total vehicle turn time. Maintenance times are converted from hours to days by dividing by 8, 16, or 24 hours to reflect one, two, or three shift maintenance. Mission time is converted to days by dividing by 24 hours. (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 27

VEHICLE TURN TIME REPORT - at mission nbr. 1 - page 1

VEHICLE IS rpt96 DATE: 10-09-1995 TIME: 16:40:35

WBS	ON-VEHICLE MTTR (HRS)	TOT MAIN ACT	NBR CREWS ASSIGNED	AVG ON-VEH MAINT. TIME PER MSN-hrs
1.00 WING GROUP	3.879964	1.86853	1	10.09176
2.00 TAIL GROUP	3.879964	1.656193	1	8.944948
3.00 BODY GROUP	4.569788	46.21927	1	294.0075
4.20 IEP-TCS	6.6	16.60901	1	152.5903
5.00 LANDING GEAR	1.691655	6.949658	1	16.36494
6.00 PROPULSION-MAIN	2.38786	1.624663	1	5.400218
10.00 ELECTRICAL	2.657209	1.108783	1	4.101205
12.00 AERO SURF ACTUATORS	.6974583	27.79332	1	26.98348
13.XX AGGREGATED AVIONICS	2.744849	3.598371	1	13.74876
14.10 ENVIRONMENTAL CONTROL	3.118692	1.167513	1	5.068429
14.20 ECS-LIFE SUPPORT	2.48686	.3510965	1	1.215394
16.20 REC & AUX-ESCAPE SYS	1.805118	.1374826	1	.345456
16.50 REC & AUX DOCKING SYS	2.666667	1.964109E-02	1	7.290775E-02
WAVG CREW SIZE 2.476504		WAVG TASK TIME 3.014314		542.9354 (TOTAL)

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

INTEGRATION TIME	0 DAYS
LAUNCH PAD TIME	1 DAYS
PHASE INSPECTION TIME (per msn)	4 hrs
MISSION TIME -INC GRND PWR TIME	74 HRS

CATEGORY	MIN TURN TIME (parallel tasks)	WT-AVG 20 % OF MAX	MAX TURN TIME (sequential tasks)
SCHED/UNSCHED MAINT TIME	294.0075	343.7931	542.9354 HRS
VEH GRN PROC TIME	320.0075 HRS	369.7931	568.9354 HRS
TOT VEH TURNAROUND TIME	392.0075 HRS	441.7931	640.9354 HRS
1 -SHIFT/DAY MAINTENANCE			
VEH GRND PROCESSING DAYS	37.75094	43.97414	68.86692
TOT VEH TURNAROUND DAYS	40.83427	47.05747	71.95026
AVG MISSIONS/YR/VEHICLE	6.448694	5.564041	3.591771
COMPUTED FLEET SIZE	2	3	4
2 -SHIFT/DAY MAINTENANCE			
VEH GRND PROCESSING DAYS	19.37547	22.48707	34.93346
TOT VEH TURNAROUND DAYS	22.45881	25.5704	38.01679
AVG MISSIONS/YR/VEHICLE	12.1376	10.56259	6.948699
COMPUTED FLEET SIZE	1	2	2
3 -SHIFT/DAY MAINTENANCE			
VEH GRND PROCESSING DAYS	13.25031	15.32471	23.62231
TOT VEH TURNAROUND DAYS	16.33365	18.40804	26.70564
AVG MISSIONS/YR/VEHICLE	17.16209	15.05473	10.08479
COMPUTED FLEET SIZE	1	1	2

NOTE: assumes 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 28

SYSTEM PERFORMANCE SUMMARY - at mission nbr. 1 - page 1

VEHICLE IS rpt96 DATE: 10-09-1995 TIME: 16:40:35

RELIABILITY REPORT

CATEGORY	LAUNCH TIME	END OF POWER FLT	ORBIT INSERTION
VEHICLE	.9728102	.9356906	.9245108

	REENTRY	MISSION COMPLETION
VEHICLE	.8907287	.8809927

MAINTAINABILITY REPORT

CATEGORY	MAINT ACTIONS/MSN	WT-AVG MANHR/MA	UNSCHED AVG MANHRS/MSN
VEHICLE	174.2482	10.09854	1759.653

	ON-VEH MH	OFF-VEH MH	TOTAL MH
VEHICLE			
UNSCHED	1391.956	367.6971	1759.653
SCHEDULED	12.936	.2639999	13.2
PERIODIC INSPECTION	15.68	.32	16
TOTAL	1420.572	368.2811	1788.853

MANPOWER/SPARES REPORT

Mission rate is 12 missions per year
Position manning factor is 1.372549
TOTAL SPARES REQUIRED = 163

	MANPOWER RQMTS		MISSION RQMTS	
CATEGORY	MANHR DRIVEN AGGREGATE	MANHR DRIVEN BY SUBSYS	ASGN POS BY SUBSYS	RQD MANPWR BY SUBSYS
VEHICLE				
VEH MANPWR	15	24	39	61
PAD	7	7	7	7
PHASE INSP	4	4	4	4
TOTAL	26	35	50	72
EXT TANK				
LRB				

Figure 28 (continued)

SYSTEM PERFORMANCE SUMMARY - at mission nbr. 1 - page 1

VEHICLE IS rpt96 DATE: 10-09-1995 TIME: 16:40:35

VEHICLE TURN TIMES

	MIN TURN TIME	WT-AVG	MAX TURN TIME
1 -SHIFT/DAY MAINTENANCE			
VEH GRND PROCESSING DAYS	41.75094	47.97414	72.86692
TOT VEH TURNAROUND DAYS	44.83427	51.05747	75.95026
AVG MISSIONS/YR/VEHICLE	5.850816	5.113054	3.398149
COMPUTED FLEET SIZE	3	3	4
2 -SHIFT/DAY MAINTENANCE			
VEH GRND PROCESSING DAYS	23.37547	26.48707	38.93346
TOT VEH TURNAROUND DAYS	26.45881	29.5704	42.01679
AVG MISSIONS/YR/VEHICLE	10.18497	9.051033	6.259615
COMPUTED FLEET SIZE	2	2	2
3 -SHIFT/DAY MAINTENANCE			
VEH GRND PROCESSING DAYS	17.25031	19.32471	27.62231
TOT VEH TURNAROUND DAYS	20.33365	22.40804	30.70564
AVG MISSIONS/YR/VEHICLE	13.51201	12.16717	8.697566
COMPUTED FLEET SIZE	1	1	2

5.1.7 Aggregated System report

The Aggregated System Report display the results of the subsystem to system roll-up. Specifically, the number of maintenance actions, mean time to repair, scheduled maintenance time, average crew size, and number of assigned crews is displayed. Maintenance times and average crew sizes are weighted averages of the subsystem values with the weights being the subsystem fraction of total maintenance actions.

Figure 29

Aggregated System Report - System Aggregation - page 1

VEHICLE IS RPT96 DATE: 10-10-1995 TIME: 12:21:53

SYSTEM	SYSTEM	SYSTEM
Structural	Fuel/Oxid Tanks	Auxiliary Systems
1.00 WING GROUP	3.10 TANKS-LOX	16.30 REC&AUX-SEPARATION
2.00 TAIL GROUP	3.20 TANKS-LH2	16.40 REC&AUX-CROSS FEED
3.00 BODY GROUP		16.50 REC & AUX DOCKING SYS
Thermal/Tiles	Propulsion	16.60 REC&AUX MANIPULATOR
4.10 IEP-TILES	6.00 PROPULSION-MAIN	
4.20 IEP-TCS	7.00 PROPULSION-RCS	
4.30 IEP-PVD	8.00 PROPULSION-OMS	
Power/Electrical	Mechanical Sys	
9.10 POWER-APU	11.00 HYDRAULICS/PNEUMATICS	
9.20 POWER-BATTERY	12.00 AERO SURF ACTUATORS	
9.30 POWER-FUEL CELL	5.00 LANDING GEAR	
10.00 ELECTRICAL		
Avionics	ECS/Life Support	
13.XX AGGREGATED AVIONICS	14.10 ENVIRONMENTAL CONTROL	
13.20 AV-HEALTH MONITOR	14.20 ECS-LIFE SUPPORT	
13.30 AVIONICS-COMM & TRACK	15.00 PERSONNEL PROVISIONS	
13.40 AV-DISPLAYS & CONTR	16.10 REC & AUX-PARACHUTES	
13.50 AVIONICS-INSTRUMENTS	16.20 REC & AUX-ESCAPE SYS	
13.60 AVIONICS-DATA PROC		

Aggregated System Report - page 2

Aggregated System	Nbr of Maint Actions	On-Veh MTTR per MA (hrs)	On-Veh Sched maint time(hrs)	Ave Crew Size
Structural	75.55466	4.398859	142.5926	2.195375
Thermal/Tiles	9.163376	6.6	8.436513	4.5
Propulsion	3.243359	2.38786	5.529791	2.43
Power/Electrical	39.09164	2.657209	81.45457	1.98833
Mechanical Sys	29.96566	.9583003	58.07438	2.137762
Avionics	12.77931	2.719896	24.06605	2.2
ECS/Life Support	4.384291	2.982055	9.148068	1.985667
Auxiliary Systems	6.593796E-02	2.666667	6.070759E-02	4.5
Total	174.2482	25.37084	329.3627	21.93713
Average	21.78103	3.171355	41.17033	2.742142

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.

Aggregated System Report - page 3

Aggregated System	Removal Rate	Off-Veh MTTR in hours	Off-Veh Sched maint time(hrs)	Nbr Crews Assigned
Structural	.2296812	.4118068	2.910053	5
Thermal/Tiles	.481	1.65	.1721737	5
Propulsion	.5424479	6.295268	.1128529	1
Power/Electrical	.5007281	.8944745	1.662338	1
Mechanical Sys	.3666887	.3474528	1.185191	2
Avionics	.4195914	3.091848	.4911438	2
ECS/Life Support	.4594413	.3231507	.1866953	3
Auxiliary Systems	.219	.6666667	1.23893E-03	1
Total		13.68067	6.721687	20
Average	.4023223	1.710083	.8402109	2.5

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.

5.1.8 Initial (raw) MTBM and MTTR values.

For comparison purposes, the initial or raw MTBM before any technology growth or reliability growth factors has been applied, may be displayed. The unadj MTBM for aircraft selected subsystems is the initial value computed by the parametric equations. For subsystems in which the reliability is specified as an input, the unadjusted MTBM is not computed. The adjusted MTBM is the same value displayed on the first page of the reliability report and is the MTBM after both the technology and reliability growth factors have been applied. This value is then subsequent split into the inherent and external MTBM. The MTTR includes both the on and off-vehicle unscheduled maintenance and is not displayed elsewhere.

Figure 30

Initial R&M Values

All MTBM's are for a single subsystem.

Adj MTBM includes technology and reliability growth. MTTR=MHMA/crew size

WBS	unadj - MTBM	adj - MTBM	MTTR
1.00 WING GROUP	11.06	24.32359	4.233458
2.00 TAIL GROUP	12.28889	27.02621	4.233458
3.00 BODY GROUP	1.386834	3.049981	4.856997
4.20 IEP-TCS	3.69	30.77468	8.25
5.00 LANDING GEAR MSN'S/FAILURE	.5534307	.5995499	3.77137
6.00 PROPULSION-MAIN	25.21166	28.12632	8.683127
10.00 ELECTRICAL	5.15	5.15	3.551684
12.00 AERO SURF ACTUATORS	2.8	4.828333	.9823356
13.XX AGGREGATED AVIONICS	1.5	10.95695	5.811744
14.10 ENVIRONMENTAL CONTROL	30.11609	32.03625	3.439228
14.20 ECS-LIFE SUPPORT	82.99512	88.28679	2.738425
16.20 REC & AUX-ESCAPE SYS	105.876	235.0077	2.361346
16.50 REC & AUX DOCKING SYS	3108.85	4276.748	3.333333
VEHICLE	.2009433	.3545437	3.859988

5.2 Report Generation

Hard copy output of the reports outlined in Paragraph 5.1 may be obtained by selecting number 8 on the main menu "WRITE RESULTS TO A FILE." This will create an ASCII file containing all of the input data and output reports. This file is identified by the **VEHICLE/FILE NAME** with an **.ASC** extension. This file may then be edited and printed or imported into a wordprocessing document as part of an overall report.

5.3 Parametric Analysis

When the parametric analysis option is exercised, the following screen is displayed which shows the current contents of the file "name".PAR. A new record is appended to this file each time the model is recomputed.

Figure 31

```
        Parametric analysis results:

Driver     2005
VEH MTBM  .4180663 VEH REL   .995824    TOT MAs   88.84956    UNSCH MNHRS 1028.268
TOT MNHRS  2164.959  MNHR MANPWR 50     MAX MNPWR 148         TURNTIME 15.78243
MSN/YR/VEH 19.37801  NBR VEHs  2        NBR SPARES 144

Driver     2007
VEH MTBM  .4529217 VEH REL   .9960157   TOT MAs   77.28912    UNSCH MNHRS 1028.268
TOT MNHRS  1957.143  MNHR MANPWR 50     MAX MNPWR 148         TURNTIME 14.98112
MSN/YR/VEH 20.60669  NBR VEHs  2        NBR SPARES 130

Driver     2009
VEH MTBM  .4896447 VEH REL   .9961845   TOT MAs   67.59913    UNSCH MNHRS 1028.268
TOT MNHRS  1780.622  MNHR MANPWR 50     MAX MNPWR 148         TURNTIME 14.29932
MSN/YR/VEH 21.77834  NBR VEHs  2        NBR SPARES 123

Driver     2011
VEH MTBM  .5282707 VEH REL   .9963356   TOT MAs   59.42184    UNSCH MNHRS 1028.268
TOT MNHRS  1630.21   MNHR MANPWR 50     MAX MNPWR 148         TURNTIME 13.71768
MSN/YR/VEH 22.8854   NBR VEHs  2        NBR SPARES 117

Driver     2013
VEH MTBM  .5688354 VEH REL   .9964731   TOT MAs   52.48417    UNSCH MNHRS 614.5306
TOT MNHRS  1501.729  MNHR MANPWR 40     MAX MNPWR 148         TURNTIME 13.22047
MSN/YR/VEH 23.9223   NBR VEHs  2        NBR SPARES 109

Driver     2015
VEH MTBM  .6113746 VEH REL   .9965986   TOT MAs   46.57265    UNSCH MNHRS 614.5306
TOT MNHRS  1391.755  MNHR MANPWR 40     MAX MNPWR 148         TURNTIME 12.79469
MSN/YR/VEH 24.88552  NBR VEHs  2        NBR SPARES 103

Driver     2017
VEH MTBM  .6559246 VEH REL   .9967149   TOT MAs   41.51711    UNSCH MNHRS 614.5306
TOT MNHRS  1297.458  MNHR MANPWR 40     MAX MNPWR 148         TURNTIME 12.42955
MSN/YR/VEH 25.77352  NBR VEHs  2        NBR SPARES 98

Driver     2019
VEH MTBM  .7025217 VEH REL   .9968234   TOT MAs   37.17983    UNSCH MNHRS 614.5306
TOT MNHRS  1216.473  MNHR MANPWR 40     MAX MNPWR 148         TURNTIME 12.20994
MSN/YR/VEH 26.33778  NBR VEHs  2        NBR SPARES 94
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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.

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 reference [14], and the O&S costing model [13]. These models and their relationships among one another are discussed in Part I of reference [14].

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** or **ADJ-MTBM** for those subsystems in which the analyst can specify a MTBM and a MHMA.

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 should be updated to reflect at a minimum the required values computed by the model. Assigned crews can also be further updated if it is desired to modify the turntime or fleet size. 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 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).

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 total scheduled maintenance. This total is then allocated to the subsystems based upon the weight distribution. The user may then update the scheduled maintenance by individual subsystem. A vehicle level scheduled maintenance (phase or periodic inspection) may also be included by specifying the number of missions between inspections, inspection crew size, and length of time to perform the inspection.

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 recompute 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 selected subsystems. When using a (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 or default value. To support trade-off studies, the analysts may turn on the **Parametric Analysis** feature which will automatically record selected input and output values to an ASCII type file. This file may be imported to a spreadsheet, data base, or statistical package for further analysis and display.

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. In principle, any two can be controlled and the third is then predetermined. 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, maximum, and average 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 is compared to the assigned manpower (i.e. number of crews times crew size) with the larger of the two establishing the manpower requirement. If a single maintenance specialist can perform tasks on all the subsystems, then a smaller requirement may be computed. If the study objective is to obtain a particular vehicle turntime or a specified fleet size, then the number of crews assigned times the average crew size should be the basis for establishing the manpower requirement. 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.

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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-MTBM (INITIAL R&M VALUES): See Tech/Growth MTBM.

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 do not reflect operating in a space environment (see Update/Display Shuttle MTBM's & MTTR's). Otherwise, the value should be left defaulted at 0 because the program's default shuttle values already account for launch and space operation.

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

Aggregated System: A higher level assembly formed from logical groupings of the 34 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.

Asgn Mnpwr (Manpower report): The number of maintenance personnel required to fill the assigned manpower positions (see Asgn Posn) based upon a position manning factor computed from the Avail Manhrs/Month (see) and the Direct Work (see) and Indirect Work (see).

Asgn Posns (Manpower report): The number manpower positions assigned by subsystem. Determined by multiplying the number of Cur Asgd Crews (see) times the Avg Crew Size (see).

Avail hrs/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 Size (MANPOWER REPORT): The mean number of maintenance personnel required by subsystem to perform either a scheduled or unscheduled maintenance task on that subsystem. It is equal to the Crew Size (see) calculated from the regression equations or updated directly by the user. It is considered to be the minimum manpower requirement for that subsystem.

Avg Manhr/MA (MAINTAINABILITY OUTPUT): The average number of manhours of work generated by a single unscheduled maintenance action (MA). Determined either from a regression equation or specified by the user on the Shuttle Input screen. When divided by the Avg Crew Size provides the mean time to repair (MTTR).

Avg On-Veh Maint. Time Per Msn (VEHICLE TURN TIME OUTPUT): The average length of time in hours to perform scheduled and 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) and adding the scheduled maintenance hours divided by the average crew size times the current number of assigned crews. It is assumed all assigned crews may work in parallel.

Boost Time (SUBSYSTEM OPERATING HOURS): That portion of the mission during launch when the vehicle is powered by booster rockets. The launch factor applies to this time period.

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 & MH/MA'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: Option used to calculate scheduled maintenance as a percentage of unscheduled maintenance (see Scheduled Maintenance Manhours) or as specified subsystem values. As a percent, it can be specified instead of calculated from regression equations by selecting this option from the Input Parameter Menu. If the scheduled maintenance is changed, the model automatically changes the status of the 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.' When the parametric analysis is on, a 'RECORD - DO NOT RECORD' option is presented. 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 a scheduled or 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).

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.

Cur 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.

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 Reliablities: 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). Only on-vehicle work is used in the turntime calculations.

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)
Update/Display System Operating Hours (see)
Update/Display Redundancy Configuration (see)
Update/Display LRB/ET Reliability Data (see)
Update/Display Shuttle MTBM's & MTTR's (see)
Change Scheduled Maintenance (see)
Establish System Reliabilities (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)
Write Results to a File
Turn-on/off Parametric Analysis
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.

Maint Manhrs/Msn (MANPOWER OUTPUT): Total number of scheduled and unscheduled maintenance manhours generated by subsystem.

Manhrs/Mo (MANPOWER OUTPUT): The average number of scheduled and 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).

Manhr Driven Aggregate (SYSTEM PERFORMANCE SUMMARY-MANPOWER/SPARES REPORT): The 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

$$Manhr\,by Agr = \frac{Tot\ Manhrs/Mo}{(1 - \%\ indirect)\ x\ (Avail Manhrs/Mo\ /Person)}$$

Manhr Driven by Subsystem (SYSTEM PERFORMANCE SUMMARY-MANPOWER/SPARES REPORT): The 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 (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.

Max Mpwr (MANPOWER REPORT & SYSTEM PERFORMANCE SUMMARY): The larger of the assigned manpower (ASGN MNPWR) and the manhour earned manpower (MANPWR) by subsystem. Normally, this would be the required manpower.

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 maintenance time per mission integration time, launch pad time, and mission time. It is also computed in days for one, two, or three maintenance shifts per day.

Mean Number in Repair (SYSTEM SPARES OUTPUT): The average number of unservicebale components (demands for spares) in the (depot) repair pipeline. It becomes the mean of the Poisson distribution representing the number of unserviceables in the repair pipeline.

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' or 'ADJ-MTBM' (see Select Shuttle/Aircraft), or input by the user (see Update/Display Shuttle MTBM's & MH/MA'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 unscheduled manhours per subsystem by the subsystem Crew Size. MTTR values are computed by dividing the MH/MA by the Average Crew Size.

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 average on-vehicle maintenance time per mission, integration time, launch pad time, and mission time. Subsystem average 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 & MH/MA Calibration: MTBM & MH/MA Calibration can be entered to make changes to the unadjusted (technology and reliability growth and environmental adjustments not yet applied) subsystem MTBM and MH/MA 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 MH/MA 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 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 (MAINTAINABILITY & 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 (Avg Manhr/MA) by Avg Crew Size and multiplying by one minus the percent off-vehicle work (1-POFF).

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.

Orbit Time (SUBSYSTEM OPERATING HOURS): The main part of the mission in which the vehicle is in low earth orbit. The Weibull failure distribution applies to this time period.

Pad Time (SUBSYSTEM OPERATING HOURS): Total time on PAD in which the subsystem is susceptible to mission failures. Ground aborts occur during this time period.

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 for the entire fleet. It is input from the Update/Display Primary System Parameters option of the Input Parameter Menu.

Primary Driver Variables: There are eight primary driver variables: vehicle dry weight, vehicle length, wing span, crew size, number of passengers, number of main engines, number of OMS engines, and number of RCS 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.

Process Time (SUBSYSTEM OPERATING HOURS): Total ground maintenance time required to complete all scheduled and unscheduled tasks. For some subsystems, this time may reflect power on time only since this time is used to determine the number of external maintenance actions.

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.

Reentry Time (SUBSYSTEM OPERATING HOURS): The period of time from first leaving orbit until landing. Failure rates are assumed constant during this time period.

Re(maining) Time to-Orbit (SUBSYSTEM OPERATING HOURS): The time between cutoff of the booster rockets and time of entry into orbit.

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.

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.

Rqd Crews (MANPOWER REPORT): The estimated number of crews required based upon the manhour earned manpower divided by the average crew size and rounded up. It is the minimum number of whole crews necessary to cover the generated hours of maintenance by subsystem. It should be the starting point for adding additional crews to obtain a desired turntime or fleet size.

Scheduled Maint. Hours: Total number of hours required per subsystem to complete scheduled maintenance work. Default is based upon a parametrically estimated percent of unscheduled maintenance which is then allocated to each subsystem based upon the relative subsystem weights.

Sched MH/MSN (MAINTAINABILITY REPORT): The average number of scheduled maintenance hours per mission either specified directly by the user or computed as a percent of unscheduled maintenance hours allocated to the subsystems based upon their relative weights.

Select Shuttle/Aircraft: An option on the Input Parameter Menu for selecting that the shuttle MTBM and MH/MA values be used for a subsystem ('SHUTTLE' or 'ADJ-MTBM') instead of the values calculated by aircraft derived regression equations ('AIRCRAFT') (see Shuttle MTBM, MH/MA, and RR). Enter the number corresponding to a subsystem to toggle among 'AIRCRAFT', 'SHUTTLE' and 'ADJ-NMTBM'. 'SHUTTLE' and 'ADJ-MTBM' selected subsystems will be displayed in red. The 'SHUTTLE' and'ADJ-MTBM' values can be changed through the Update/Display Shuttle MTBM's & MH/MA'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, MH/MA, and RR: A Martin Marietta database was analyzed to obtain mean values for MTBM, MH/MA (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/Growth 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 (MA) (MAINTAINABILITY REPORT & VEHICLE TURN TIME OUTPUT): Same as Maint Actions/Msn.

Total MH/MSN (MAINTAINABILITY OUTPUT): The average number of scheduled and unscheduled manhours expended per mission.

Unsched MH/MSN (MAINTAINABILITY REPORT): Average unscheduled maintenance hours per mission determined by the number of maintenance actions per mission times the average manhours per maintenance action.

Unscheduled On-Veh MH (MAINTAINABILITY OUTPUT) : The average number of unscheduled on-vehicle maintenance manhours expended per mission (by subsystem) calculated by multiplying the number of maintenance actions per mission (see Maint Actions/Msn) by the average manhours per maintenance action (see Avg Manhr/MA) and by one minus the percent off-vehicle maintenance.

Unscheduled Off-Veh MH (MAINTAINABILITY OUTPUT) : The average number of unscheduled off-vehicle maintenance manhours expended per mission (by subsystem) calculated by multiplying the number of maintenance actions per mission (see Maint Actions/Msn) by the average manhours per maintenance action (see Avg Manhr/MA) and by the percent off-vehicle maintenance.

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 & MH/MA 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
Nbr Main Engines
NBR RCS Engines
NBR OMS 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
Growth Curve Slope
Msn Nbr for Reliability Growth
Air+Gnd Aborts -0 / Air Aborts -1
Depot turnaround time

Unadj-MTBM (INITIAL R&M VALUES): The raw MTBM computed from the regression equations (or user specified SHUTTLE MTBM) prior to the technological and reliability growth factors being applied and prior to the MTBM being split into external and inherent values.

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 & MH/MA's: The program has space shuttle subsystem MTBM and MH/MA values obtained from a Martin Marietta database (see Shuttle MTBM, MH/MA, 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) or the subsystem selected as "ADJ-MTBM' 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. Two sets of weights are displayed: a baseline weight and the current weight. All calculations are based upon the curent weight. The current weight may be reset to the baseline weight at any time.

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

Vehicle/File_name: Each time the RAM program is started a vehicle_name or file_name must be entered. The vehicle_name will be displayed on screen and printed on the output reports.

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

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

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

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

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

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

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

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

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

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

WT-AVG (VEHICLE TURNTIME REPORT): A weighted average of the maximum and minimum turntimes and vehicle ground processing times where the specified weight is multiplied by the maximum turntime and one minus the weight multiplied by the minimum turn time.

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 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 MH/MA 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

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

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

subsystems does not exceed 34. 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 updating the 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 and assigned crews 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) Scheduled maintenance as a percent of the unscheduled maintenance is determined by default and then allocated to the subsystems based upon the relative subsystem weights. A user specified percent or individual subsystem scheduled maintenance hours can be specified directly by entering a 12. If the percent scheduled maintenance is changed or any subsystem hours specified, scheduled maintenance will no longer be updated 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. Following subsystem scheduled maintenance options, the user may specify a vehicle level periodic (phase) inspection which may be performed every n missions. 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 MH/MA... [3]

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 MH/MA 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 MH/MA, 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 updating the data.

b) ENTER 2. FOR ANY SUBSYSTEM, THE SHUTTLE VALUES FOR MTBM AND MH/MA (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'AND THEN TO 'ADJ-MTBM'). 'SHUTTLE' AND 'ADJ-MTBM' SELECTED SUBSYSTEMS WILL BE DISPLAYED IN RED. STEP K BELOW DESCRIBES HOW TO CHANGE THE SHUTTLE VALUES FOR MTBM AND MH/MA TO USER INPUT VALUES. THE MTBM AND MH/MA 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 AND TYPE 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

[3]several subsystems do not have aircraft derived parametric equations available and as a result SHUTTLE or user specified MTBM and MH/MA values must be used. These appear as "SHUTTLE ONLY" on the 2nd input screen (**SELECT SHUTTLE/AIRCRAFT**).

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 MH/MA ARE GLOBALLY 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 and assigned crews 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 MH/MA NEED TO BE CHANGED FROM THE DEFAULT VALUES. IF THE SHUTTLE MTBM AND MH/MA 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 (GLOBALLY) OR INDIVIDUAL SUBSYSTEMS ARE IDENTIFIED AS 'ADJ-MTBM'. 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 specified instead of calculated from regression equations by entering 12. If the percent scheduled maintenance is changed or individual subsystem maintenance times specified, scheduled maintenance will not be recomputed 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. Periodic maintenance may also be specified at this time. 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 input data and all output reports can be written to an ASCII file 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 10 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 turn on the parametric analysis option. This option is useful if a series of output values are desired corresponding to a systematic change in one or input parameters ("driver" variables). This option will display on the screen and save in a file selected values from each recomputation of the model.

9. Enter 10 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 MH/MA 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 34. 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 updating the 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 (current) 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 .9 x .95 or .855. The weights are restored to their previous value by entering the inverse of the last weight factor (1/.9). The weights may be restored to their original values by entering the inverse of the cumulative weight factor (1/.855) or by reinstating the original weights which may be retained and are displayed along side the current weights. The current weights are always used in the calculations.**

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 & MH/MA calibration, crew sizes and assigned crews, percent off-equipment, and fraction inherent failures. A new technology growth factor value might need to be entered and assigned crews adjusted, 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 specified instead of calculated from regression equations by entering 12. If the percent scheduled maintenance is changed or individual subsystem maintenance times specified, scheduled maintenance will not be recomputed 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. Periodic maintenance may also be established at this time. 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 the Main Menu when all inputs are complete.

2) SHUTTLE OR USER INPUT VALUES FOR MTBM AND MH/MA... [4]

The above steps are repeated below with minor variation or additional steps so that the shuttle values or user input values for MTBM and MH/MA are used directly instead of values calculated by the program. The new or modified steps are in 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 34. THE SHUTTLE VALUES FOR MTBM AND MH/MA, 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 updating the data.

b) ENTER 2. FOR ANY SUBSYSTEM, THE SHUTTLE VALUES FOR MTBM AND MH/MA (OBTAINED FROM A MARTIN MARIETTA DATABASE) CAN BE USED INSTEAD OF THE

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[4]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**).

CALCULATED VALUES BY ENTERING THE NUMBER CORRESPONDING TO THAT SUBSYSTEM ('AIRCRAFT' WILL CHANGE TO 'SHUTTLE' THEN TO 'ADJ-MTBM'). 'SHUTTLE' AND 'ADJ-MTBM' SELECTED SUBSYSTEMS WILL BE DISPLAYED IN RED. STEP K BELOW DESCRIBES HOW TO CHANGE THE SHUTTLE VALUES FOR MTBM AND MH/MA TO USER INPUT VALUES (VALUES CAN BE INPUT ONLY FOR SUBSYSTEMS SET AT 'SHUTTLE' OR 'ADJ-MTBM'). THE MTBM AND MH/MA 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 AND TYPE 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 MH/MA 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 .9 x .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) or by reinstating the original weights which may be retained and are displayed along side the current weights. The current weights are always used in the calculations.

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 & MH/MA calibration, crew sizes and assigned crews, percent off-equipment, and fraction inherent failures. A new technology growth factor value might need to be entered and assigned crews adjusted, 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 MH/MA NEED TO BE CHANGED FROM THE DEFAULT VALUES. IF THE SHUTTLE MTBM AND MH/MA 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. SELECT 'ADJ-MTBM' RATHER THEN 'SHUTTLE' IN ORDER TO APPLY THE SPACE ADJUSTMENT TO INDIVIDUAL SUBSYSTEMS ONLY. WHEN DONE, RETURN TO THE INPUT PARAMETER MENU.

l) Scheduled maintenance can be input instead of calculated from a regression equation by entering 12. If the scheduled maintenance is changed, it will not be recomputed 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. <u>Always recompute the R&M parameters after changing the inputs to update all parameter values.</u>

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 input data and various output reports can be written to an ASCII file by entering 8 from the Main Menu.

6. If it would be necessary to run the program again with these same input parameters at a later time, 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 turn on the parametric analysis option. This option is useful if a series of output values are desired corresponding to a systematic change in one or input parameters ("driver" variables). This option will display on the screen and save in a file selected values from each recomputation of the model.

9. Enter 10 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 MH/MA...

   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 & MH/MA calibration, crew sizes and assigned crews, fraction inherent, 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

Main Module
File: RAMX.BAS

```
DECLARE SUB PARA ()
DECLARE SUB WRFILE ()
DECLARE SUB SIM ()
DECLARE SUB DRIVER ()
DECLARE SUB OUTFILE ()
DECLARE SUB INFILE ()
DECLARE SUB PCTWGT ()
DECLARE SUB TECH ()
DECLARE SUB MAIN ()
DECLARE SUB INMENU ()
DECLARE SUB PRIVAR ()
DECLARE SUB COMFAC ()
DECLARE SUB WEIGHT ()
DECLARE SUB MSN ()
DECLARE SUB CREW ()
DECLARE SUB CRIT ()
DECLARE SUB COMREL ()
DECLARE SUB SHUTTLE ()
DECLARE SUB DISPLAY ()
DECLARE SUB LCCFILE ()
DECLARE SUB REL ()
DECLARE SUB COMPM ()
DECLARE SUB REPORT ()
DECLARE SUB PRINTSUM ()
DECLARE SUB SUMMARY ()
DECLARE SUB ACWGT ()
DECLARE SUB MANDISPLAY ()
DECLARE SUB SPAREDISPLAY ()
DECLARE SUB ABORT ()
DECLARE SUB SECONDARY ()
DECLARE SUB MANPWR ()
DECLARE SUB INIT ()
DECLARE SUB SPARES ()
DECLARE SUB BOOSTER ()
DECLARE SUB TURNTIME ()
DECLARE SUB SPACEMTBM ()
DECLARE SUB POFFEQS ()
DECLARE SUB REMEQS ()
DECLARE SUB MAINTDIS ()
DECLARE SUB EQS ()
DECLARE SUB REDUNREL ()
DECLARE SUB RELDISPLAY ()


10 'NASA, LANGLEY RESEARCH CENTER
20 'MTBM COMPUTATIONAL MODEL - NASA RESEARCH GRANT -
30 'DEVELOPED BY C. EBELING, UNIV OF DAYTON 10/95 (updated)
35 '  ******** COMBINED PRE/CONCEPTUAL MODEL **********
40 '
50 'SAVE AS "RAMX.BAS"    Reliability & Maintainability Model -REVISED

  COMMON SHARED YR, B, X1, X2, LF, VR1, VR2, VR3, VR4, VR5, VR, AREM
  COMMON SHARED VFMA, TVFMA, SVFMA, CVFMA, OMHMA, OFMHMA, TMA, AMHMA
  COMMON SHARED SCHP, VMH, TOMH, TFMH, APF, P1, P2, P3, WAV, FH42, FH44
  COMMON SHARED FMA11, FMA12, VNAM$, ARR, TNR, TS, SKIP, TSCH, DTAT
  COMMON SHARED SMP, TMP, VMOH, WGTF, WING, WF, PWF, TMEN, NP, LE
  COMMON SHARED ETREL, SRBREL, ETS, SRBS, RTITLE$, ABTF$, PH, MPH, CSZ
  COMMON SHARED STP, STE, MTE, TME, STF, MTF, TMF, C1, PMF, SVADD, FZ
  COMMON SHARED AVCREW, GTT, ATSK, TTX, TTZ, TTW, TTYA, TJJ, TXY, TJX
  COMMON SHARED PARAF, PB17, ISJ, DSCH, WC
  DIM SHARED WBS$(35), X(50), NAM$(50), THRS(35), MHMA(35), MH(35), MP(35), OMH(35), FMH(35)
  DIM SHARED SEL$(35), T(10), CP$(9), CA(35), RELF(35), RF(35)
  DIM SHARED GOH(35), LOH(35), TOH(35), OOH(35), ROH(35), R(35), TSKT(35), POH(35)
  DIM SHARED V(15), SNAM$(15), FMAT(35), FMAC(35), FMAS(35), S(35), SMA(35), SMR(35)
  DIM SHARED MW(35), C(35), CM(35), OP$(35), TG(35), PWTS(35)
  DIM SHARED FMA(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
  DIM SHARED NRD(35), K(35), R1(35), R2(35), R3(35), R4(35), R5(35)
```

```
   DIM SHARED PWT1(35), PWT2(35), PWT3(35), PWT4(35), SRR(35)
   DIM SHARED ETSUB$(5), ETMBA(5), ETHRS(5), ETABR(5), ETMTR(5), ETR(5), ETCREW(5)
   DIM SHARED SRBSUB$(5), SRBMBA(5), SRBHRS(5), SRBABR(5), SRBMTR(5), SRBR(5), SRBCREW(5)
   DIM SHARED SWBS$(10), MAS(9), MTROS(9), MTRFS(9), REMS(9), SMT(9), SMTF(9), SC(9), FRS(9)
   DIM SHARED PI(35), CZ(9), SP(35), MA(35), TT(35), MPC(35), SW(35), IFMA(35)
   COMMON SHARED PI(), CZ(), SP(), MA(), TT(), MPC(), SW(), IFMA()
   COMMON SHARED SWBS$(), MAS(), MTROS(), MTRFS(), REMS(), SMT(), SMTF(), SC(), FRS()
   COMMON SHARED WBS$(), X(), NAM$(), THRS(), MHMA(), MH(), MP(), OMH(), FMH()
   COMMON SHARED SEL$(), T(), CP$(), CA(), RELF(), RF()
   COMMON SHARED GOH(), LOH(), TOH(), OOH(), ROH(), R(), TSKT(), POH()
   COMMON SHARED V(), SNAM$(), FMAT(), FMAC(), FMAS(), S(), SMA(), SMR()
   COMMON SHARED MW(), C(), CM(), OP$(), TG(), PWTS()
   COMMON SHARED FMA(), PF(), PA(), RR(), W(), NR(), FR()
   COMMON SHARED NRD(), K(), R1(), R2(), R3(), R4(), R5()
   COMMON SHARED PWT1(), PWT2(), PWT3(), PWT4(), SRR()
   COMMON SHARED ETSUB$(), ETMBA(), ETHRS(), ETABR(), ETMTR(), ETR(), ETCREW()
   COMMON SHARED SRBSUB$(), SRBMBA(), SRBHRS(), SRBABR(), SRBMTR(), SRBR(), SRBCREW()

ERRSUB: 'ERROR HANDLING ROUTINE
    IF ERR = 53 OR ERR = 61 OR ERR = 71 THEN
      IF ERR = 53 THEN PRINT "FILE NOT FOUND"
      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 0
    END IF

'  ON ERROR GOTO ERRSUB

85 GOSUB 1000 'OPENING BANNER
90 CALL INIT 'INITIALIZATION
92 CALL MSN  'INITIALIZE MSN PROFILES
93 CALL PCTWGT  'INITIALIZE SUBSYS WEIGHTS
95 GOSUB 2900 'CLEAN-UP ADJUST SHUTTLE MTBM
97 CLS : COLOR 12: LOCATE 10, 20: PRINT "STANDBY..... INITIALIZING ALL VALUES..."
98 SKIP = 1: CALL DRIVER: SKIP = 0     'INITIAL COMP

MAIN: CALL MAIN

OPEN "TEMP1.DAT" FOR OUTPUT AS #1
OPEN "TEMP1.CST" FOR OUTPUT AS #2
OPEN "TEMP1.ASC" FOR OUTPUT AS #3

WRITE #1, X(1)
WRITE #2, X(2)
WRITE #3, X(2)
CLOSE #1
CLOSE #2
CLOSE #3
OPEN "TEMP1.PAR" FOR OUTPUT AS #1
WRITE #1, X1
CLOSE #1


KILL "TEMP1.DAT"   'remove temp files -cleanup
KILL "TEMP1.CST"
KILL "TEMP1.ASC"
KILL "TEMP1.PAR"

END


1000 ' OPENING BANNER
1010 KEY OFF: CLS : COLOR 11
1020 LOCATE 6, 15: PRINT "VEHICLE RELIABILITY/MAINTAINABILITY MODEL"
1030 PRINT : PRINT TAB(20); "NASA - LANGLEY RESEARCH CENTER": COLOR 14
1040 LOCATE 14, 20: INPUT "ENTER VEHICLE/FILE NAME"; VNAM$
   IF VNAM$ = "" THEN VNAM$ = "NO_NAME"
   IF VNAM$ = "TEMP1" THEN PRINT "INVALID NAME": GOTO 1040
1045 RETURN
```

```
2900 'CLEAN UP DURING INITIALIZATION
2905 FOR I = 19 TO 24: WAV - WAV + W(I): NEXT I
2910 Y = SMA(1): TW = W(1) / (W(1) + W(2) + W(3)): FR = (1 / Y) * TW: SMA(1) = 1 / FR
2915 TW = W(2) / (W(1) + W(2) + W(3)): FR = (1 / Y) * TW: SMA(2) = 1 / FR
2920 TW = W(3) / (W(1) + W(2) + W(3)): FR = (1 / Y) * TW: SMA(3) - 1 / FR
2925 Y = SMA(4): TW - W(4) / (W(4) + W(5)): FR = (1 / Y) * TW: SMA(4) = 1 / FR
2930 TW = W(5) / (W(4) + W(5)): FR = (1 / Y) * TW: SMA(5) = 1 / FR
2940 'Y - SMA(9): TW = W(9) / (W(9) + W(18) + W(30) + W(32)): FR = (1 / Y) * TW: SMA(9) = 1 / FR
   Y = SMA(32)
2945 TW - W(18) / (W(9) + W(18) + W(30) + W(32)): FR = (1 / Y) * TW: SMA(18) = 1 / FR
2950 TW = W(30) / (W(9) + W(18) + W(30) + W(32)): FR = (1 / Y) * TW + 1 / SMA(30): SMA(30) = 1 / FR
2955 TW = W(32) / (W(9) + W(18) + W(30) + W(32)): FR = (1 / Y) * TW: SMA(32) = 1 / FR
   FOR I = 1 TO 34: PWTS(I) - PWT1(I): NEXT I ' reset weights from shuttle
2995 RETURN

10000 'INPUT DATA
    ' WBS
10005 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-PVD
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
10030 DATA 11.00 HYDRAULICS/PNEUMATICS,12.00 AERO SURF ACTUATORS
10033 DATA 13.10 AVIONICS-GN&C,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 FEED
10060 DATA 16.50 REC & AUX DOCKING SYS,16.60 REC&AUX MANIPULATOR
DATA 6.10 PROPULSION - MPS

' PRIMARY/SYSTEM VARIABLES
10150 DATA DRY WGT (LBS),LENGTH (FT),CREW SIZE,NBR PASSENGERS
10152 DATA NBR MAIN ENGINES, ADJ SHUTTLE MTBM-SPACE 0-NO 1-YES,TECHNOLOGY YR
10155 DATA DEFAULT ABORT RATE, WIEBULL SHAPE PARAMETER
10160 DATA LAUNCH FACTOR,AVAIL MANHRS/MONTH,FRACTION INDIRECT WORK
10170 DATA SPARE FILL RATE OBJ,MANPWR FOR PAD OPER,PLANNED MISSIONS/YEAR
10180 DATA MODE INDICATOR,VEHICLE INTEGRATION TIME (DAYS),LAUNCH PAD TIME (DAYS)
    DATA AGGREGATE AVIONICS 0-NO/1-YES,TURNTIME PRORATION-FRACTION OF MAX
    DATA NBR RCS ENGINES, NBR OMS ENGINES,GROWTH CURVE SLOPE,MSN NBR FOR REL GROWTH
    DATA AIR+GND 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,.082,0,0,.082,.082,.082,.033,.011,.011,.011
11765 DATA .056,.056,.056,0,.092,.056
11770 DATA .22,.22,.22,.22,.22,.22,.0062,.0062,.036,.083,.083,.083,.083,.083
11775 DATA .083,.011

11780 'WGT DISTRIBUTION PERCENTAGES-LARGE VEHICLE
11790 DATA .081,.003,.174,.054,.114,0,.143,.008,.043,.104,.018,.019
11791 DATA 0,.001,.007,.035
11792 DATA 0,.007,.003,0,.004,.005,.003,.003,.016,.005,.008
11793 DATA .014,.012,.005,.007,0,0,.104

11794 'WGT DISTR - SHUTTLE
11795 DATA .1,.017,.277,.015,.017,.133,.02,.011,.04,.066,.02,.019,.006,0
11796 DATA .007,.065,.012,.018,.006,0,.01,.013,.004,.008,.013,.02,.012,0
11797 DATA 0,.006,0,0,0,.065

' WGT DISTRIBUTION - SMALL VEHICLE
DATA .096,.004,.114,.018,.018,0,.109,0,.064,0,.017,.017,.116,.018,.014,.063
DATA 0,.009,.016,.008,.011,.007,0,.027,.038,.045,.074,.08,.001,.01,0,.006,0,0

11810 'SHUTTLE MTBM'S    MAINT ACTIONS
11820 DATA .96,.96,.96,8.31,8.31,.129,3.69,64.3,9999,42.12,13.06,40.31
11825 DATA 7.43,9999,30.07,17.4,5.62,9999,34.41,9999,66.22,34.52,47.2
11826 DATA 9999,24.47,9999,7.2,9999,9999,15.6,9999,4.85,9999,42.12
```

```
11830 ' SHUTTLE MHMA VALUES
    DATA 21.375,21.375,21.375,0,0,44.1,29.7,37.53,33.255,30.42,71.28,39.645
11850 DATA 56.34,0,64.8,22.41,33.21,33.255,151.695,0,94.995,210.015,40.14
11860 DATA 61.065,41.22,41.22,41.13,0,0,58.5,27.36,0,0,30.42

    ' SHUTTLE REMOVAL RATES
DATA .143,.143,.143,.216,.216,.0073,.481,.391,.219,0,.159,.303,.443,0,.261
DATA .088,.305,.219,.392,0,.333,.466,.482,0,.293,.293,.174,0,0,.257,0,.219,0,0

'Fraction inherent failures
DATA .35,.35,.36,.49,.49,.5,.5,.5,.52,.46,.46,.46,.46,.46,.46,.57,.49,.47
DATA .49,.38,.52,.5,.55,.5,.41,.46,.47,.49,.43,.09,.5,.5,.5,.46

 'ET PARAMETERS
   DATA ELECTRICAL,20.42,72,.001,13.68,4.5
   DATA PROP-FLUIDS,4,72,.001,18,4.5
   DATA RANGE SAFETY,44.77,72,.001,64.65,4.5
   DATA STRUCTURES,.0354,1,.001,6.83,4.5
   DATA THERMAL-TPS,.0219,1,.001,1.55,4.5

 '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
   DATA STRUCTURES,75,667,.001,1,4.5

SUB INIT
500 ' INITIALIZATION MODULE
520 FOR I = 1 TO 34
525 MW(I) = 1: NRD(I) = 1: K(I) = 1
526 CM(I) = 1: W(I) = 1: CA(I) = 1
527 OP$(I) = "COMPUTE"
528 SEL$(I) = "AIRCRAFT"
529 FMAS(I) = 1: RELF = 0
   PF(I) = .2: SP(I) = 1
530 READ WBS$(I)
540 NEXT I
550 SEL$(6) = "SHUTTLE": SEL$(7) = "SHUTTLE": SEL$(8) = "SHUTTLE"
555 SEL$(15) = "SHUTTLE"
560 SEL$(31) = "SHUTTLE": SEL$(32) = "SHUTTLE": SEL$(33) = "SHUTTLE"
580 FOR I = 1 TO 25
590 READ NAM$(I)
600 NEXT I
610 FOR I = 1 TO 13
620 READ SNAM$(I)
630 NEXT I

   FOR I = 1 TO 5: CP$(I) = "RECOMPUTE": NEXT I
   CP$(6) = "DO NOT RECORD"
640 FOR I = 1 TO 34: READ TG(I): NEXT I'TECH GROWTH RATES
650 FOR I = 1 TO 34: READ PWT1(I): NEXT I'WGT DISTR PERCENTS-AMLS (LARGE)
652 FOR I = 1 TO 34: READ PWT2(I): NEXT I    'WGT DISTR PERCENTS-SHUTTLE
653 FOR I = 1 TO 34: READ PWT3(I): NEXT I'WGT DISTR PERCENTS-PLSS (SMALL)
   FOR I = 1 TO 34: PWTS(I) = PWT2(I): NEXT I ' initialize wght distr
660 FOR I = 1 TO 34: READ SMA(I): NEXT I'  SHUTTLE MAINT ACTION MTBM
665 FOR I = 1 TO 34: READ SMR(I): NEXT I'  SHUTTLE MTTR
   FOR I = 1 TO 34: READ SRR(I): NEXT I' SHUTTLE REMOVAL RATES
   FOR I = 1 TO 34: READ PI(I): NEXT I'fraction inherent failures
680 FOR I = 1 TO 5  'READ IN ET PARAMETERS
   READ ETSUB$(I), ETMBA(I), ETHRS(I), ETABR(I), ETMTR(I), ETCREW(I)
   NEXT I
   FOR I = 1 TO 4  'READ IN LRB PARAMETERS
   READ SRBSUB$(I), SRBMBA(I), SRBHRS(I), SRBABR(I), SRBMTR(I), SRBCREW(I)
   NEXT I
```

```
690 '           **** DEFAULT VALUES ******
  WF = 1: PWF = 1' INITIAL WEIGHT FACTOR
700 X(1) = 10000! 'DRY WEIGHT - LBS
710 X(2) = 70  'LENGTH + WING SPAN - FT
  WING = 30  'TEMP WING SPAN
720 X(3) = 2'CREW SIZE
730 X(4) = 8'NBR PASSENGERS
740 X(5) = 3 ' NBR ENGINES
  NRD(10) = X(5)
  K(10) = X(5)
  X(21) = 2: X(22) = 2     'NBR OMS/RCS ENGINES
  NRD(11) = 2: K(11) = 2
  NRD(12) = 2: K(12) = 2
745 X(6) = 0 'FLAG FOR SPACE ADJ TO MTBM - SHUTTLE
750 X(7) = 1996 'TECHNOLOGY YR
760 X(8) = .001 'DEFAULT ABORT RATE
770 X(9) = .28 'WEIBULL SHAPE PARAMETER
780 X(10) = 20  'LAUNCH FAILURE RATE FACTOR
790 X(11) = 144  ' AVAIL HRS PER MONTH
800 X(12) = .15 'PERCENT INDIRECT WORK
810 X(13) = .95 'SPARES FILL RATE GOAL
815 X(14) = 7 ' AVG CREW SIZE-SCHEDULED
816 X(15) = 12'PLANNED MSN PER YEAR - CONVERTED TO MOS
817 X(16) = 0 'INITIALIZE IN PRECONCEPTUAL MODE
  X(17) = 0 'INTEGRATION TIME IN DAYS
  X(18) = 1 'LAUNCH PAD TIME IN DAYS
  X(19) = 0 'DO NOT AGGREGATE AVIONICS
  X(20) = .2  'TURN-TIME PRORATION
  X(23) = .5  'GROWTH CURVE SLOPE
  X(24) = 1  'MSN NBR
  X(25) = 0  'AIR+GRND ABORTS
  DTAT = 97  'Depot LRU repair turnaround time in days
818 WGTF = 1
  NP = 1 'Msns btwn phase inspt
  ETREL = 1: SRBREL = 1 'INITIAL ET/SRB RELIABILITIES
820 T(0) = 2: T(1) = .14: T(2) = 1: T(3) = 71: T(4) = 72: T(5) = 10
  YR = X(7): B = X(9): LF = X(10): X1 = X(1): X2 = X(2) + WING
  FZ = 1 'DO NOT FREEZE WEIGHTS
  PARAF = 0     'set parametric analysis to start
  ISJ = 1   'nbr shifts for parameteric anal

END SUB

SUB MAIN
100 'MAIN MENU
110 CLS : COLOR 10
120 PRINT TAB(15); "NASA LRC - RELIABILITY/MAINTAINABILITY MODEL"
130 PRINT : PRINT TAB(25); "MAIN MENU": PRINT
135 COLOR 11
140 PRINT TAB(15); "NBR"; TAB(35); "SELECTION": PRINT
150 PRINT TAB(15); "1........READ INPUT FROM A FILE"
155 PRINT TAB(15); "2........INPUT PARAMETER MENU"
159 COLOR 12
160 PRINT TAB(15); "3........COMPUTE R&M PARAMETERS"
161 COLOR 11
165 PRINT TAB(15); "4........SCREEN DISPLAY (OUTPUT) MENU"
170 PRINT TAB(15); "5........SAVE INPUT PARAMETERS"
172 PRINT TAB(15); "6........SAVE DATA FOR COST MODEL"
  PRINT TAB(15); "7........CHANGE VEHICLE/FILE NAME"
  PRINT TAB(15); "8........WRITE RESULTS TO A FILE"
  PRINT TAB(15); "9........TURN ON/OFF PARAMETRIC ANALYSIS"
175 PRINT TAB(15); "10........TERMINATE SESSION"
```

```
COLOR 9: LOCATE 21, 10
IF PARAF = 0 THEN
     PRINT ; "Parametric Analysis is OFF"
ELSE
     PRINT ; "Parametric Analysis is ON"
END IF
   IF X(16) = 0 THEN TNAM$ = "PRECONCEPTUAL MODE"
   IF X(16) = 1 THEN TNAM$ = "WEIGHT-DRIVEN MODE"
   IF X(16) = 2 THEN TNAM$ = "WEIGHT & VARIABLE DRIVEN MODE"
   COLOR 14: LOCATE 22, 10: PRINT "YOU ARE CURRENTLY IN THE "; TNAM$
177 LOCATE 20, 10: COLOR 13: PRINT "VEHICLE/FILE NAME IS  "; VNAM$
180 COLOR 10: LOCATE 18, 20: INPUT "ENTER SELECTION"; NBO
190 IF NBO = 1 THEN CALL INFILE
200 IF NBO = 2 THEN CALL INMENU
205 IF NBO = 3 THEN CALL DRIVER
210 IF NBO = 4 THEN CALL DISPLAY
215 IF NBO = 5 THEN CALL OUTFILE
217 IF NBO = 6 THEN CALL LCCFILE
   IF NBO = 7 THEN GOSUB CHG
   IF NBO = 8 THEN CALL WRFILE
   IF NBO = 9 THEN
     IF PARAF = 0 THEN CALL PARA ELSE PARAF = 0
   END IF
220 IF NBO = 10 THEN GOTO DONE
230 GOTO 110


CHG: CLS : COLOR 10
IF PARAF = 1 THEN
LOCATE 17, 5: PRINT "Please turn off parametric analysis before changing file name."
INPUT "Enter return..."; RET
RETURN

END IF

OPEN "TEMP1.DAT" FOR OUTPUT AS #2   'create temp file
WRITE #2, X(1), X(2), X(3)
CLOSE #2
PRINT : PRINT TAB(10); "CURRENT RAM INPUT FILES": PRINT
   FILES "*.DAT"
   COLOR 11: LOCATE 18, 12: PRINT "CURRENT NAME IS "; VNAM$
RT:  COLOR 14: LOCATE 20, 12: INPUT "ENTER NEW NAME"; VNAM$
   IF VNAM$ = "TEMP1" 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"

END SUB
```

Input Module
File: RAMI.BAS

```
DECLARE SUB PARA ()
DECLARE SUB COMTURN ()
DECLARE SUB SIM ()
DECLARE SUB TECH ()
DECLARE SUB CREW ()
DECLARE SUB CRIT ()
DECLARE SUB COMREL ()
DECLARE SUB COMPM ()
DECLARE SUB ACWGT ()
DECLARE SUB ABORT ()
DECLARE SUB SECONDARY ()
DECLARE SUB MANPWR ()
DECLARE SUB SPARES ()
DECLARE SUB SPACEMTBM ()
DECLARE SUB POFFEQS ()
DECLARE SUB REMEQS ()
DECLARE SUB EQS ()
DECLARE SUB REDUNREL ()
DECLARE SUB DRIVER ()
DECLARE SUB PCTWGT ()
DECLARE SUB PRIVAR ()
DECLARE SUB COMFAC ()
DECLARE SUB WEIGHT ()
DECLARE SUB MSN ()
DECLARE SUB SHUTTLE ()
DECLARE SUB REL ()
DECLARE SUB BOOSTER ()
  'NASA, LANGLEY RESEARCH CENTER
  'MTBM COMPUTATIONAL MODEL - NASA RESEARCH GRANT -
  'DEVELOPED BY C. EBELING, UNIV OF DAYTON  11/29/95 (UPDATED)
  '  ******** COMBINED PRE/CONCEPTUAL MODEL **********
  '
  'SAVE AS "RAMI.BAS"   input module
  '
  COMMON SHARED YR, B, X1, X2, LF, VR1, VR2, VR3, VR4, VR5, VR, AREM
  COMMON SHARED VFMA, TVFMA, SVFMA, CVFMA, OMHMA, OFMHMA, TMA, AMHMA
  COMMON SHARED SCHP, VMH, TOMH, TFMH, APF, P1, P2, P3, WAV, FH42, FH44
  COMMON SHARED FMA11, FMA12, VNAM$, ARR, TNR, TS, SKIP, TSCH, DTAT
  COMMON SHARED SMP, TMP, VMOH, WGTF, WING, WF, PWF, TMEN, NP, LE
  COMMON SHARED ETREL, SRBREL, ETS, SRBS, RTITLE$, ABTF$, PH, MPH, CSZ
  COMMON SHARED STP, STE, MTE, TME, STF, MTF, TMF, C1, PMF, SVADD, FZ
  COMMON SHARED AVCREW, GTT, ATSK, TTX, TTZ, TTW, TTYA, TJJ, TXY, TJX
  COMMON SHARED PARAF, PB17, ISJ, DSCH, WC
  DIM SHARED WBS$(35), X(50), NAM$(50), THRS(35), MHMA(35), MH(35), MP(35), OMH(35), FMH(35)
  DIM SHARED SEL$(35), T(10), CP$(9), CA(35), RELF(35), RF(35)
  DIM SHARED GOH(35), LOH(35), TOH(35), OOH(35), ROH(35), R(35), TSKT(35), POH(35)
  DIM SHARED V(15), SNAM$(15), FMAT(35), FMAC(35), FMAS(35), S(35), SMA(35), SMR(35)
  DIM SHARED MW(35), C(35), CM(35), OP$(35), TG(35), PWTS(35)
  DIM SHARED FMA(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
  DIM SHARED NRD(35), K(35), R1(35), R2(35), R3(35), R4(35), R5(35)
  DIM SHARED PWT1(35), PWT2(35), PWT3(35), PWT4(35), SRR(35)
  DIM SHARED ETSUB$(5), ETMBA(5), ETHRS(5), ETABR(5), ETMTR(5), ETR(5), ETCREW(5)
  DIM SHARED SRBSUB$(5), SRBMBA(5), SRBHRS(5), SRBABR(5), SRBMTR(5), SRBR(5), SRBCREW(5)
  DIM SHARED SWBS$(10), MAS(9), MTROS(9), MTRFS(9), REMS(9), SMT(9), SMTF(9), SC(9), FRS(9)
  DIM SHARED PI(35), CZ(9), SP(35), MA(35), TT(35), MPC(35), SW(35), IFMA(35)
  COMMON SHARED PI(), CZ(), SP(), MA(), TT(), MPC(), SW(), IFMA()
  COMMON SHARED SWBS$(), MAS(), MTROS(), MTRFS(), REMS(), SMT(), SMTF(), SC(), FRS()
  COMMON SHARED WBS$(), X(), NAM$(), THRS(), MHMA(), MH(), MP(), OMH(), FMH()
  COMMON SHARED SEL$(), T(), CP$(), CA(), RELF(), RF()
  COMMON SHARED GOH(), LOH(), TOH(), OOH(), ROH(), R(), TSKT(), POH()
  COMMON SHARED V(), SNAM$(), FMAT(), FMAC(), FMAS(), S(), SMA(), SMR()
  COMMON SHARED MW(), C(), CM(), OP$(), TG(), PWTS()
  COMMON SHARED FMA(), PF(), PA(), RR(), W(), NR(), FR()
  COMMON SHARED NRD(), K(), R1(), R2(), R3(), R4(), R5()
  COMMON SHARED PWT1(), PWT2(), PWT3(), PWT4(), SRR()
  COMMON SHARED ETSUB$(), ETMBA(), ETHRS(), ETABR(), ETMTR(), ETR(), ETCREW()
  COMMON SHARED SRBSUB$(), SRBMBA(), SRBHRS(), SRBABR(), SRBMTR(), SRBR(), SRBCREW()
```

```
SUB BOOSTER
6000 ' ET/ BOOSTER ROCKET MODULE
6010 CLS : COLOR 7
6020 PRINT TAB(20); "EXTERNAL FUEL TANK INPUT DATA"
6030 PRINT : COLOR 11
6035 PRINT TAB(1); "NBR"; TAB(5); "SUBSYSTEM"; TAB(18); "MTBM"; TAB(26); "OPER HRS"; TAB(36); "CRIT FAIL RT"; TAB(50); "MTTR"; TAB(59); "CREW SIZE"
    PRINT
    FOR I = 1 TO 5
    PRINT TAB(1); I; TAB(5); ETSUB$(I); TAB(18); ETMBA(I); TAB(26); ETHRS(I); TAB(36); ETABR(I); TAB(50); ETMTR(I); TAB(59); ETCREW(I)
    NEXT I
    COLOR 2
    INPUT "ENTER NUMBER FOR CHANGE"; NBR
    IF NBR > 5 THEN GOTO 6010
    IF NBR = 0 THEN GOTO COMP
    INPUT "ENTER NEW PARAMETERS SEPARATED BY COMMAS"; ETMBA(NBR), ETHRS(NBR), ETABR(NBR), ETMTR(NBR), ETCREW(NBR)
    GOTO 6010
COMP: INPUT "ENTER SCHD MAINT AS A PCT OF UNSCH MAINT"; ETS

    COLOR 7: ETREL = 1
    PRINT TAB(20); "COMPUTED"; TAB(40); "MISSION"; TAB(59); "MANHR DRIVEN"
    PRINT TAB(1); "SUBSYSTEM"; TAB(18); " RELIABILITY"; TAB(32); "UNSCH MANHRS"; TAB(47); "SCH MANHRS"; TAB(59); "MANPWR": PRINT
    COLOR 11: STE = 0: MTE = 0: TME = 0
    FOR I = 1 TO 5
    ETR(I) = EXP(-ETHRS(I) / (ETMBA(I) / ETABR(I)))
    ETREL = ETREL * ETR(I)
    TE = (ETHRS(I) / ETMBA(I)) * ETMTR(I) * ETCREW(I)
    A3 = (TE + ETS * TE) * X(15) / (12 * X(11) * (1 - X(12)))
    A3 = INT(A3 + .999)
    TME = TME + A3
    MTE = MTE + ETHRS(I) / ETMBA(I)
    STE = STE + TE
    PRINT TAB(5); ETSUB$(I); TAB(20); ETR(I); TAB(32); TE; TAB(47); ETS * TE; TAB(60); A3
    NEXT I
6036 PRINT : COLOR 12
6050 PRINT TAB(1); "OVERALL ET "; TAB(20); ETREL; TAB(32); STE; TAB(47); ETS * STE; TAB(60); TME
    PRINT : COLOR 3: PRINT TAB(2); "note:  set reliability=1 to eliminate subsystem"
    COLOR 2
6070 INPUT "ENTER NEW RELIABILITY-OR RETURN TO USE COMPUTED"; NBR
6080 IF NBR > 0 THEN ETREL = NBR

BAK: CLS : COLOR 7
    PRINT TAB(20); "LIQUID ROCKET BOOSTER INPUT DATA"
    COLOR 11
    PRINT TAB(1); "NBR"; TAB(5); "SUBSYSTEM"; TAB(18); "MTBM"; TAB(26); "OPER HRS"; TAB(36); "CRIT FAIL RT"; TAB(50); "MTTR"; TAB(59); "CREW SIZE"
    PRINT
    FOR I = 1 TO 4
    PRINT TAB(1); I; TAB(5); SRBSUB$(I); TAB(18); SRBMBA(I); TAB(26); SRBHRS(I); TAB(36); SRBABR(I); TAB(50); SRBMTR(I); TAB(59); SRBCREW(I)
    NEXT I
    PRINT : COLOR 2
    INPUT "ENTER NUMBER FOR CHANGE"; NBR
    IF NBR > 4 THEN GOTO BAK
    IF NBR = 0 THEN GOTO COM2
    INPUT "ENTER NEW PARAMETERS SEPARATED BY COMMAS"; SRBMBA(NBR), SRBHRS(NBR), SRBABR(NBR), SRBMTR(NBR), SRBCREW(NBR)
    GOTO BAK
COM2: INPUT "ENTER SCHD MAINT AS A PCT OF UNSCH MAINT"; SRBS
    COLOR 7: SRBREL = 1: TMF = 0: MTF = 0: STF = 0
    PRINT TAB(20); "COMPUTED"; TAB(40); "MISSION"; TAB(61); "MANHR DRIVEN"
    PRINT TAB(1); "SUBSYSTEM"; TAB(18); "RELIABILITY"; TAB(32); "UNSCH MANHRS"; TAB(47); "SCHED MANHRS"; TAB(61); "MANPWR": PRINT
    COLOR 11
    FOR I = 1 TO 4
    SRBR(I) = EXP(-SRBHRS(I) / (SRBMBA(I) / SRBABR(I)))
    SRBREL = SRBREL * SRBR(I)
    TF = (SRBHRS(I) / SRBMBA(I)) * SRBMTR(I) * SRBCREW(I)
    A4 = (TF + TF * SRBS) * X(15) / (12 * X(11) * (1 - X(12)))
    A4 = INT(A4 + .999)
    TMF = TMF + A4
    MTF = MTF + SRBHRS(I) / SRBMBA(I)
    STF = STF + TF
    PRINT TAB(5); SRBSUB$(I); TAB(20); SRBR(I); TAB(32); TF; TAB(47); SRBS * TF; TAB(61); A4
    NEXT I
    PRINT : COLOR 12
    PRINT TAB(1); "OVERALL LRB"; TAB(20); SRBREL; TAB(32); STF; TAB(47); SRBS * STF; TAB(61); TMF
    PRINT : COLOR 3: PRINT TAB(2); "note:  set reliability=1 to eliminate subsystem"
    PRINT : COLOR 2
    PRINT : INPUT "ENTER NEW RELIABILITY-OR RETURN TO USE COMPUTED"; NBR
```

```
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": PRINT
12550 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 "
12585 PRINT TAB(15); "4........MTBM/MTTR CALIBRATION  "
12590 PRINT TAB(15); "5........CREW SIZES & ASSIGNED CREWS"
    PRINT TAB(15); "6........FRACTION OFF-EQUIP"
    PRINT TAB(15); "7........FRACTION INHERENT FAILURES"
    PRINT : COLOR 2
12595 PRINT TAB(15); "return ....... exit to input menu"
12600 LOCATE 22, 20: INPUT "ENTER SELECTION"; NB7
12610 IF NB7 = 1 THEN GOSUB 12400
12620 IF NB7 = 2 THEN GOSUB 12700
12630 IF NB7 = 3 THEN GOSUB 12800
12640 IF NB7 = 4 THEN GOSUB 1200
12645 IF NB7 = 5 THEN GOSUB 13800
    IF NB7 = 6 THEN GOSUB PCTOFF
    IF NB7 = 7 THEN GOSUB INFAIL
12650 IF NB7 = 0 THEN EXIT SUB
12660 GOTO 12500

12400 ' MENU TO DEFAULT ON TECH GROWTH FACTOR
12401 IO = 1: IE = 18
12403 COLOR 7

12405 CLS : PRINT TAB(25); "ANNUAL TECHNOLOGY GROWTH FACTOR": PRINT
GAV = 0: KK = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO SK1
GAV = GAV + TG(I): KK = KK + 1
SK1: NEXT I

COLOR 9: PRINT TAB(3); "Enter 99 for a global change": PRINT : COLOR 11
12410 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "ANNUAL GROWTH RATE"
12430 FOR I = IO TO IE
12435 IF OP$(I) = "DELETE" THEN GOTO 12450
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
12440 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); TG(I)
12450 NEXT I
IF IO = 19 THEN COLOR 10: PRINT : PRINT TAB(5); "Average"; TAB(45); GAV / KK
    COLOR 7
12460 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC2
12465 IF NBR > 34 THEN GOTO 12405
12470 IF NBR = 0 THEN GOTO 12493
12480 INPUT "ENTER NEW FACTOR"; TG(NBR)
12490 GOTO 12405
12493 IF IO = 1 THEN IO = 19: IE = 34: GOTO 12403
12497 RETURN
SC2: INPUT "ENTER GLOBAL TECH GROWTH RATE"; XX
FOR I = 1 TO 34
TG(I) = XX
NEXT I
RETURN
```

```
12700 'CRITICAL FAILURE RATE DISPLAY/UPDATE
12701 IO = 1: IE = 18

12703 COLOR 7

12705 CLS : PRINT TAB(5); "CRITICAL FAILURE RATE - fraction of total maintenance actions"

GAV = 0: KK = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO SK2
GAV = GAV + PA(I): KK = KK + 1
SK2: NEXT I

    PRINT TAB(29); "resulting in a mission abort"
COLOR 9: PRINT TAB(3); "Enter 99 for a global change": PRINT : COLOR 11
12710 IF X(25) = 0 THEN PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(35); "CRITICAL FAILURE RATE-grnd & air aborts"
    IF X(25) = 1 THEN PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(35); "CRITICAL FAILURE RATE-air aborts only"
12730 FOR I = IO TO IE
12735 IF OP$(I) = "DELETE" THEN GOTO 12750
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
12740 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); PA(I)
12750 NEXT I
IF IO = 19 THEN COLOR 10: PRINT : PRINT TAB(5); "Average"; TAB(45); GAV / KK
    COLOR 7
12760 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC3
12765 IF NBR > 34 THEN GOTO 12705
12770 IF NBR = 0 THEN GOTO 12793
12780 INPUT "ENTER NEW RATE"; PA(NBR)
    CP$(1) = "DO NOT RECOMPUTE"
12790 GOTO 12705
12793 IF IO = 1 THEN IO = 19: IE = 34: GOTO 12703
12797 RETURN
SC3: INPUT "ENTER GLOBAL CRITICAL FAILURE RATE"; XX
FOR I = 1 TO 34
PA(I) = XX
NEXT I
CP$(1) = "DO NOT RECOMPUTE"
RETURN


12800 'REMOVAL RATE DISPLAY/UPDATE
12801 IO = 1: IE = 18
12803 COLOR 7
12805 CLS : PRINT TAB(5); "REMOVAL RATE - probability of a removal per maintenance action": PRINT

GAV = 0: KK = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO SK3
GAV = GAV + RR(I): KK = KK + 1
SK3: NEXT I

COLOR 9: PRINT TAB(3); "Enter 99 for a global change": PRINT : COLOR 11
12810 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "REMOVAL RATE"
12830 FOR I = IO TO IE
12835 IF OP$(I) = "DELETE" THEN GOTO 12850
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
12840 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); RR(I)
12850 NEXT I
IF IO = 19 THEN COLOR 10: PRINT : PRINT TAB(5); "Average"; TAB(45); GAV / KK
    COLOR 7
12860 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC4
12865 IF NBR > 34 THEN GOTO 12805
12870 IF NBR = 0 THEN GOTO 12893
12880 INPUT "ENTER NEW RATE"; RR(NBR)
    CP$(2) = "DO NOT RECOMPUTE"
12890 GOTO 12805
12893 IF IO = 1 THEN IO = 19: IE = 34: GOTO 12803
12897 RETURN
```

```
SC4: INPUT "ENTER GLOBAL REMOVAL RATE"; XX
FOR I = 1 TO 34
RR(I) = XX
NEXT I
CP$(2) = "DO NOT RECOMPUTE"
RETURN




PCTOFF: 'PERCENT OFF EQUIPMENT DISPLAY/UPDATE
    IO = 1: IE = 18: APF = 0: KK = 0
BACK1: COLOR 7: CLS
PRINT TAB(5); "FRACTION OFF VEHICLE - fraction of total maintenance manhours"
    PRINT TAB(5); "performed off the vehicle - does not impact vehicle turntime"
    COLOR 9: PRINT TAB(3); "Enter 99 for a global change": PRINT : COLOR 11
    PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "FRACTION OFF-VEH"
FOR I = IO TO IE
    IF OP$(I) = "DELETE" THEN GOTO SKIP1
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
    PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); PF(I)
     APF = APF + PF(I)
     KK = KK + 1
SKIP1: NEXT I
     PRINT
     IF IO = 19 THEN COLOR 10: PRINT TAB(5); "Average"; TAB(45); APF / KK
    COLOR 7
    PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC5
    IF NBR > 34 THEN APF = 0: KK = 0: GOTO BACK1
    IF NBR = 0 THEN GOTO SKIP2
    INPUT "ENTER NEW FRACTION"; PF(NBR)
    CP$(4) = "DO NOT RECOMPUTE"
    APF = 0: KK = 0: GOTO BACK1
SKIP2: IF IO = 1 THEN IO = 19: IE = 34: GOTO BACK1
    RETURN
SC5: INPUT "ENTER GLOBAL FRACTION OFF-VEH"; XX
FOR I = 1 TO 34
PF(I) = XX
NEXT I
CP$(4) = "DO NOT RECOMPUTE"
RETURN


1200 'MODULE TO INPUT MOD FACTOR
1201 IO = 1: IE = 18
1205 CLS : COLOR 7: PRINT TAB(20); "SUBSYSTEM MTBM CALIBRATION FACTOR"
GAV = 0: KK = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO SK4
GAV = GAV + MW(I): KK = KK + 1
SK4: NEXT I

1206 PRINT TAB(20); "Cal VEH-MTBM = CAL FAC x computed MTBM"
    COLOR 9: PRINT TAB(3); "Enter 99 for a global change": PRINT : COLOR 11
1210 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "CAL FACTOR"
1230 FOR I = IO TO IE
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
1235 IF OP$(I) = "DELETE" THEN GOTO 1250
1240 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); MW(I)
1250 NEXT I
IF IO = 19 THEN COLOR 10: PRINT : PRINT TAB(5); "Average"; TAB(45); GAV / KK
    COLOR 7
1260 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC6
1265 IF NBR > 34 THEN GOTO 1205
1270 IF NBR = 0 THEN GOTO 1291
1280 INPUT "ENTER NEW FACTOR"; MW(NBR)
1290 GOTO 1205
1291 IF IO = 1 THEN IO = 19: IE = 34: GOTO 1205

12200 'MODULE TO INPUT MOD FACTOR FOR MAINTENANCE
12201 IO = 1: IE = 18
12202 COLOR 7
12205 CLS : PRINT TAB(20); "SUBSYSTEM MH/MA CALIBRATION FACTOR"

GAV = 0: KK = 0
```

```
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO SK5
GAV = GAV + CM(I): KK = KK + 1
SK5: NEXT I

12206 PRINT TAB(20); "CAL MH/MA = CAL FAC x computed MH/MA": COLOR 11
    COLOR 9: PRINT TAB(3); "Enter 99 for a global change": PRINT : COLOR 11
12210 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "CAL FACTOR"
12220 PRINT
12230 FOR I = IO TO IE
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
12235 IF OP$(I) = "DELETE" THEN GOTO 12250
12240 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); CM(I)
12250 NEXT I
IF IO = 19 THEN COLOR 10: PRINT : PRINT TAB(5); "Average"; TAB(45); GAV / KK
    COLOR 7
12260 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC7
    IF NBR > 34 THEN GOTO 12205
12270 IF NBR = 0 THEN GOTO 12293
12280 INPUT "ENTER NEW FACTOR"; CM(NBR)
12290 GOTO 12205
12293 IF IO = 1 THEN IO = 19: IE = 34: GOTO 12202
    RETURN
SC6:  INPUT "ENTER GLOBAL MTBM FACTOR"; XX
FOR I = 1 TO 34
MW(I) = XX
NEXT I
RETURN
SC7:  INPUT "ENTER GLOBAL MHMA FACTOR"; XX
FOR I = 1 TO 34
CM(I) = XX
NEXT I
RETURN

13800 'DISPLAY/UPDATE SCREEN FOR CREW SIZES
13801 IO = 1: IE = 18: IFG = 0
13803 COLOR 7
13805 CLS : PRINT TAB(20); "CREW SIZES & ASSIGNED CREWS"

GAV = 0: KK = 0: GAV2 = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO SK6
GAV2 = GAV2 + CA(I)
GAV = GAV + C(I): KK = KK + 1
SK6: NEXT I

    COLOR 3: PRINT "note:  nbr crews assigned affects turntime & assigned manpower"
    IF IFG = 0 THEN PRINT TAB(1); "Input mode is set for NBR CREWS ASSIGNED"
    IF IFG = 1 THEN PRINT TAB(1); "Input mode is set for AVG CREW SIZE"
    COLOR 9: PRINT TAB(3); "Enter 99 for a global change; 999 TO TOGGLE INPUT MODE": PRINT : COLOR 11
13810 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(35); "AVG CREW SIZE"; TAB(52); "NBR CREWS ASSIGNED"
13830 FOR I = IO TO IE
13835 IF OP$(I) = "DELETE" THEN GOTO 13850
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
13840 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(40); C(I); TAB(55); CA(I)
13850 NEXT I
IF IO = 19 THEN COLOR 10: PRINT : PRINT TAB(5); "Average"; TAB(40); GAV / KK; TAB(55); GAV2 / KK
    COLOR 7
13860 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC8
    IF NBR = 999 THEN IFG = 1 - IFG
13865 IF NBR > 34 THEN GOTO 13805
13870 IF NBR = 0 THEN GOTO 13893
IF IFG = 1 THEN INPUT "ENTER NEW CREW SIZE "; C(NBR)
IF IFG = 0 THEN INPUT "ENTER NBR CREWS ASSIGNED"; CA(NBR)
    IF C(NBR) < 1 THEN C(NBR) = 1
    IF CA(NBR) < 1 THEN CA(NBR) = 1
    CP$(3) = "DO NOT RECOMPUTE"
13890 GOTO 13805
13893 IF IO = 1 THEN IO = 19: IE = 34: GOTO 13803
13897 RETURN
SC8: IF IFG = 1 THEN INPUT "ENTER GLOBAL CREW SIZE-0 to return "; XX
IF IFG = 0 THEN INPUT "ENTER GLOBAL NBR CREWS ASSIGNED-0 to return"; YY
IF IFG = 0 AND YY < = 0 THEN RETURN
IF IFG = 1 AND XX < = 0 THEN RETURN
FOR I = 1 TO 34
IF IFG = 1 THEN C(I) = XX
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IF IFG = 0 THEN CA(I) = YY
NEXT I
RETURN

INFAIL:  'display/update fraction inherent failures
    IO = 1: IE = 18
    COLOR 7
BACK2: CLS : PRINT TAB(3); "FRACTION INHERENT FAILURES - fraction of total maint. actions resulting"

GAV = 0: KK = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO SK7
GAV = GAV + PI(I): KK = KK + 1
SK7: NEXT I

    PRINT TAB(3); "from inherent failures; separates MTBM into a ground & mission MTBM"
    COLOR 9:  PRINT TAB(3); "ASSIGN A ZERO VALUE TO FREEZE MSN (inherent) & GRND (induced) MTBM'S"
    PRINT TAB(3); "Enter 99 for a global change": PRINT : COLOR 11
    PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "FRACTION INHERENT FAILURES"
FOR I = IO TO IE
    IF OP$(I) = "DELETE" THEN GOTO SKIP3
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
    IF PI(I) > O THEN PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); PI(I)
    IF PI(I) = O THEN PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); PI(I); "  MTBM'S FROZEN"
SKIP3: NEXT I
IF IO = 19 THEN COLOR 10: PRINT : PRINT TAB(5); "Average"; TAB(45); GAV / KK
    COLOR 7
    PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC9: COLOR 7: GOTO BACK2
    IF NBR > 34 THEN GOTO INFAIL
    IF NBR = 0 THEN GOTO SKIP4
    INPUT "ENTER NEW FRACTION"; TEMX
    IF TEMX = 0 AND RELF(NBR) = 1 THEN
      COLOR 9
      PRINT "Cannot freeze MTBM's since the reliability is specified at"; RF(NBR)
      INPUT "enter return"; RET
    ELSE
      PI(NBR) = TEMX
    END IF
    GOTO BACK2
SKIP4: IF IO = 1 THEN IO = 19: IE = 34: GOTO BACK2
    RETURN
SC9:  INPUT "ENTER GLOBAL FRACTION INHERENT MAINT ACTIONS"; XX
FOR I = 1 TO 34
PI(I) = XX
NEXT I
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
    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.....SCHD MAINTENANCE"; TAB(50); CP$(5)
 IF PARAF = 1 THEN PRINT TAB(15); "6.....PARAMETRIC OUTPUT"; TAB(50); CP$(6)
    COLOR 12
    PRINT TAB(15); "7.....CANCEL REQUEST"
    PRINT : COLOR 2
    PRINT TAB(15); "RETURN.....PROCEED WITH COMPUTATION..."
    PRINT
    IF PARAF = 1 THEN
      COLOR 9
      IF CP$(6) = "RECORD" THEN
          PRINT TAB(5); "Parametric analysis is on - results will be written to "; VNAM$ + ".PAR"
      ELSE
          PRINT TAB(5); "Parametric analysis is on - results will NOT be written to "; VNAM$ + ".PAR"
      END IF
```

```
    PRINT
   END IF
   IF NBR = 7 THEN NBR = 0: EXIT SUB
   COLOR 11: INPUT "ENTER NUMBER TO CHANGE"; NBR
   IF NBR > 6 OR NBR < 0 THEN GOTO TOP
   IF NBR = 0 THEN GOTO 1940
   IF NBR = 6 THEN
     IF CP$(6) = "RECORD" THEN CP$(6) = "DO NOT RECORD" ELSE CP$(6) = "RECORD"
     GOTO TOP
   END IF
   IF CP$(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) = 0 THEN CALL PCTWGT
1942 FOR I = 19 TO 24: WAV = WAV + W(I): NEXT I
   IF X(16) = 0 OR X(16) = 1 THEN CALL SECONDARY
   IF CP$(3) = "RECOMPUTE" THEN CALL CREW  'COMPUTE CREW SIZES
1950 CALL EQS     'REGRESSION MTBF/MHMA  UNADJUSTED
   IF CP$(4) = "RECOMPUTE" THEN CALL POFFEQS 'COMPUTE POFF
1952 IF CP$(1) = "RECOMPUTE" THEN CALL ABORT        'CRITICAL FAILURE RATE
1953 IF CP$(2) = "RECOMPUTE" THEN CALL REMEQS'REMOVAL RATE
   CALL TECH  'TECH/growth ADJUSTMENT
1960 CALL SPACEMTBM 'SPACE ADJUSTMENT
1965 CALL CRIT  'CRITICAL FAILURE FMA
   CALL COMPM  'CHECK FOR SPECIFIED RELIABILITIES
1970 CALL COMREL  'DETERMINE RELIABILITY
1975 CALL REDUNREL 'REDUNDANT RELIABILITY
1980 CALL MANPWR 'COMPUTE MANPOWER
1985 CALL SPARES 'COMPUTE SPARES
   CALL COMTURN  'COMPUTE TURNTIME PARAMETERS
   IF PARAF = 1 AND CP$(6) = "RECORD" THEN CALL PARA     'write results to file
   CALL SIM  ' Aggegrate parameters for simulation
END SUB

SUB INFILE
1700 'MODULE TO READ FROM A FILE
OPEN "TEMP1.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 "; VNAM$; ".DAT"
   PRINT : INPUT "ENTER RETURN TO PROCEED OR A POSITIVE NBR TO ABORT"; RET
   IF RET >= 1 THEN EXIT SUB
1710 OPEN VNAM$ + ".DAT" FOR INPUT AS #3
   INPUT #3, DTAT, CSZ, WING
   INPUT #3, NP, LE, D1, D2, D3
   TSCH = 0
1720 FOR I = 1 TO 34   'change to 34 after reading in and resaving all files
1725 INPUT #3, WBS$(I), W(I), MW(I), CM(I), PWTS(I), PI(I)
   INPUT #3, C(I), PF(I), PA(I), RR(I), CA(I), RELF(I), RF(I)
1730 INPUT #3, POH(I), GOH(I), LOH(I), TOH(I), OOH(I), ROH(I)
1731 INPUT #3, OP$(I), TG(I), NRD(I), K(I), SELS(I), SMA(I), SMR(I)
   INPUT #3, SP(I), D1, D2, D3, D4, D5
   TSCH = TSCH + SP(I)
1735 NEXT I
1740 FOR I = 1 TO 15
1745 INPUT #3, SNAM$(I), V(I)
1750 NEXT I
   FOR I = 1 TO 25: INPUT #3, DDM$, X(I): NEXT I
   X(21) = V(14): X(22) = V(15)
1755 FOR I = 0 TO 5
1760 INPUT #3, T(I)
1765 NEXT I
   INPUT #3, ETREL, STE, ETS, TME, MTE
   FOR I = 1 TO 5
   INPUT #3, ETSUB$(I), ETMBA(I), ETHRS(I), ETABR(I), ETMTR(I), ETCREW(I)
   NEXT I
```

```
   INPUT #3, SRBREL, STF, SRBS, TMF, MTF
   FOR I = 1 TO 4
   INPUT #3, SRBSUB$(I), SRBMBA(I), SRBHRS(I), SRBABR(I), SRBMTR(I), SRBCREW(I)
   NEXT I
1770 CLOSE #3
1780 PRINT : PRINT TAB(10); "DATA SUCCESSFULLY READ"

   FOR I = 1 TO 5: CP$(I) = "DO NOT RECOMPUTE": NEXT I
   CP$(6) = "DO NOT RECORD"
   YR = X(7): B = X(9): LF = X(10): X1 = X(1): X2 = X(2) + WING
   WF = 1: PWF = 1
   PRINT : PRINT TAB(10); "UPDATING OUTPUT VALUES....STANDBY..."
   SKIP = 1: CALL DRIVER: SKIP = 0
   SCHP = TSCH / TOMH
   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"; VNAM$

END SUB



SUB INMENU
300 ' INPUT PARAMETER MENU *******
310 CLS : COLOR 14
320 PRINT TAB(15); "NASA LRC - RELIABILITY/MAINTAINABILITY MODEL"; TAB(60); VNAM$
330 PRINT : PRINT TAB(25); "INPUT PARAMETER MENU": PRINT
340 PRINT TAB(15); "NBR"; TAB(35); "SELECTION": PRINT
345 COLOR 3
350 PRINT TAB(15); "1........ADD/DELETE A SUBSYSTEM"
355 PRINT TAB(15); "2........SELECT SHUTTLE/AIRCRAFT"
360 PRINT TAB(15); "3........UPDATE/DISPLAY PRIMARY SYSTEM PARAMETERS"
365 PRINT TAB(15); "4........UPDATE/DISPLAY SUBSYSTEM WEIGHTS"
370 PRINT TAB(15); "5........UPDATE/DISPLAY SECONDARY VARIABLES"
385 PRINT TAB(15); "6........COMPUTATIONAL FACTORS MENU"
390 PRINT TAB(15); "7........UPDATE/DISPLAY MISSION PROFILE"
395 PRINT TAB(15); "8........UPDATE/DISPLAY SYSTEM OPERATING HRS"
400 PRINT TAB(15); "9........UPDATE/DISPLAY REDUNDANCY CONFIGURATION"
403 PRINT TAB(15); "10.......UPDATE/DISPLAY LRB/ET RELIABILITY DATA"
405 PRINT TAB(15); "11.......UPDATE/DISPLAY SHUTTLE MTBM'S & MH/MA'S"
   PRINT TAB(15); "12.......CHANGE SCHEDULED MAINTENANCE"
   PRINT TAB(15); "13.......ESTABLISH SUBSYSTEM RELIABILITIES"
407 PRINT TAB(15); "return.....exit to main menu"
408 COLOR 14
410 LOCATE 22, 20: INPUT "ENTER SELECTION"; NB1
415 IF NB1 = 1 THEN GOSUB 12300
420 IF NB1 = 2 THEN GOSUB 14000
425 IF NB1 = 3 THEN CALL PRIVAR
430 IF NB1 = 4 THEN CALL WEIGHT
435 IF NB1 = 5 THEN GOSUB 11000
445 IF NB1 = 6 THEN CALL COMFAC
450 IF NB1 = 7 THEN GOSUB 1600
455 IF NB1 = 8 THEN GOSUB 1300
460 IF NB1 = 9 THEN GOSUB 13000
463 IF NB1 = 10 THEN CALL BOOSTER
465 IF NB1 = 11 THEN CALL SHUTTLE
   IF NB1 = 12 THEN GOSUB UNSCH
   IF NB1 = 13 THEN CALL REL
466 IF NB1 = 0 THEN EXIT SUB
495 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 PRINT
12330 FOR I = IO TO IE
12335 IF OP$(I) = "DELETE" THEN COLOR 4 ELSE COLOR 3
12340 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); OP$(I)
12350 NEXT I
   COLOR 7
12360 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
12365 IF NBR > 34 THEN GOTO 12305
12370 IF NBR <= 0 THEN GOTO 12393
12380 IF OP$(NBR) = "COMPUTE" THEN OP$(NBR) = "DELETE": GOTO 12305
12385 IF OP$(NBR) = "DELETE" THEN OP$(NBR) = "COMPUTE"
12390 GOTO 12305
```

```
12393 IF IO = 1 THEN IO = 19: IE = 34: GOTO 12305
    INPUT "DO YOU WISH TO CHANGE A SUBSYSTEM NAME"; ANS$
    IF ANS$ = "Y" OR ANS$ = "y" THEN GOTO B0
    RETURN
B0:  IO = 1: IE = 18
B1:  CLS : PRINT TAB(20); "OPTION TO CHANGE SUBSYSTEM NAME": PRINT
    PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "SELECTION"
    PRINT
    FOR I = IO TO IE
    IF OP$(I) = "DELETE" THEN COLOR 4 ELSE COLOR 3
    PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); OP$(I)
    NEXT I
    COLOR 7
    PRINT : INPUT "ENTER NBR OF SUBSYSTEM FOR NAME CHANGE-0 IF NONE"; NBR
    IF NBR > 34 THEN GOTO B1
    IF NBR = 0 THEN GOTO B2
    INPUT "ENTER NEW WBS/NAME"; WBS$(NBR)
    GOTO B1
B2:  IF IO = 1 THEN IO = 19: IE = 34: GOTO B1
    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"
14130 FOR I = IO TO IE
14135 IF OP$(I) = "DELETE" THEN GOTO 14150
14136 IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 4 ELSE COLOR 3
14140 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); SEL$(I)
14150 NEXT I
14155 COLOR 7
14160 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
14165 IF NBR > 34 THEN GOTO 14106
14166 IF NBR = 6 OR NBR = 7 OR NBR = 8 OR NBR = 15 OR NBR = 31 OR NBR = 32 OR NBR = 33 THEN GOSUB SHT: GOTO 14106
14170 IF NBR = 0 THEN GOTO 14192
14180 IF SEL$(NBR) = "SHUTTLE" THEN SEL$(NBR) = "ADJ-MTBM": GOTO 14106
14185 IF SEL$(NBR) = "AIRCRAFT" THEN SEL$(NBR) = "SHUTTLE": GOTO 14106
    IF SEL$(NBR) = "ADJ-MTBM" THEN SEL$(NBR) = "AIRCRAFT": GOTO 14106
14192 IF IO = 1 THEN IO = 19: IE = 34: GOTO 14106
14193 COLOR 7
14195 RETURN

SHT:  'module for non-aircrft subsys
    IF SEL$(NBR) = "SHUTTLE" THEN SEL$(NBR) = "ADJ-MTBM": RETURN
    IF SEL$(NBR) = "ADJ-MTBM" THEN SEL$(NBR) = "SHUTTLE"
RETURN

11000 COLOR 7: CLS : PRINT : PRINT TAB(5); "SECONDARY INDEP VARIABLES": PRINT
11010 PRINT TAB(10); "NBR"; TAB(20); "VARIABLE"; TAB(45); "CURRENT VALUE"
11020 PRINT : PRINT : COLOR 11
IF OP$(17) = "DELETE" THEN V(8) = 0
11040 FOR I = 1 TO 13
11050 PRINT TAB(10); I; TAB(20); SNAM$(I); TAB(45); V(I)
11060 NEXT I
11061 PRINT : COLOR 7
11065 IF X(16) = 0 OR X(16) = 1 THEN INPUT "ENTER RETURN..."; RET: GOTO 11110
11070 PRINT : INPUT "ENTER NBR OF VARIABLE TO BE CHANGED - 0 IF NONE"; NBR
11075 IF NBR > 16 THEN GOTO 11000
11080 IF NBR < > 0 THEN INPUT "ENTER NEW VALUE"; V(NBR)
    IF NBR < > 0 THEN GOTO 11000
11110 RETURN

1600 'MODULE TO ESTABLISH MISSION PROFILE
1615 CLS : COLOR 7: KEY OFF
1630 NBR = 0
1635 LOCATE 3, 25: PRINT "MISSION PROFILE"
1640 LOCATE 7, 10: PRINT "NBR"; TAB(50); "TIME IN HOURS": COLOR 11
   LOCATE 9, 10: PRINT "1"; TAB(20); "GROUND POWER TIME"; TAB(55); T(5)
1645 LOCATE 11, 10: PRINT "2"; TAB(20); "PAD TIME"; TAB(55); T(0): COLOR 7
1650 LOCATE 13, 5: PRINT "LAUNCH TIME AT T=0": COLOR 11
1655 LOCATE 14, 10: PRINT "3"; TAB(20); "POWERED PHASE COMPLETION TIME"; TAB(55); T(1)
1660 LOCATE 15, 10: PRINT "4"; TAB(20); "ORBIT INSERTION TIME"; TAB(55); T(2)
```

```
1665 LOCATE 16, 10: PRINT "5"; TAB(20); "ORBIT COMPLETION TIME"; TAB(55); T(3)
1670 LOCATE 17, 10: PRINT "6"; TAB(20); "REENTRY TIME"; TAB(55); T(4)
1675 PRINT : PRINT : COLOR 2
1680 INPUT "ENTER NUMBER TO BE CHANGED OR 0 IF NONE"; NBR
1685 IF NBR > 16 THEN GOTO 1615
   IF NBR = 1 THEN INPUT "ENTER NEW GROUND TIME"; T(5): GOTO 1615
1690 IF NBR > 1 THEN NBR = NBR - 2: INPUT "ENTER NEW TIME"; T(NBR): GOTO 1615
1692 INPUT "DO YOU WISH TO UPDATE SUBSYS OPERATING TIMES-Y/N"; an$
1693 IF an$ = "Y" OR an$ = "y" THEN CALL MSN
1697 RETURN

1300 'DISPLAY SUBSYSTEM OPERATING TIMES
1301 IO = 1: IE = 17
1303 CLS : PRINT : COLOR 7: PRINT TAB(5); "SUBSYSTEM OPERATING TIMES"
   POH(9) = 1: GOH(9) = 0: LOH(9) = 0: TOH(9) = 0: OOH(9) = 0: ROH(9) = 1
1305 PRINT TAB(1); "TOTAL MISSION TIME"; TAB(20); T(4); " HRS"; TAB(30); "MAX PAD TIME"; T(0); " HRS"
1306 PRINT TAB(1); "NBR  SUBSYSTEM"; TAB(27); "GND PROCESS"; TAB(39); "PAD"; TAB(46); "BOOST"; TAB(52); "RE TIME"; TAB(61); "ORBIT"; TAB(68); "REENTRY"
1310 PRINT TAB(32); "TIME"; TAB(39); "TIME"; TAB(46); "TIME"; TAB(52); "TO-ORBIT"; TAB(61); "TIME"; TAB(68); "TIME"
1330 FOR I = IO TO IE
   IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
   IF I = 9 AND SEL$(I) < > "SHUTTLE" THEN COLOR 13
1335 IF OP$(I) = "DELETE" THEN GOTO 1350
1340 PRINT TAB(1); I; TAB(5); WBS$(I); TAB(32); POH(I); TAB(39); GOH(I); TAB(46); LOH(I); TAB(53); TOH(I); TAB(60); OOH(I); TAB(67); ROH(I)
1350 NEXT I
   COLOR 7
1360 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
1365 IF NBR > 34 THEN GOTO 1301
1370 IF NBR = 0 THEN GOTO 1393

1380 INPUT "ENTER NEW VALUES SEPARATED BY COMMAS"; D6$, D5$, D1$, D2$, D3$, D4$
   IF D6$ = "0" THEN POH(NBR) = 0 ELSE D6 = VAL(D6$)
   IF D5$ = "0" THEN GOH(NBR) = 0 ELSE D5 = VAL(D5$)
   IF D1$ = "0" THEN LOH(NBR) = 0 ELSE D1 = VAL(D1$)
   IF D2$ = "0" THEN TOH(NBR) = 0 ELSE D2 = VAL(D2$)
   IF D3$ = "0" THEN OOH(NBR) = 0 ELSE D3 = VAL(D3$)
   IF D4$ = "0" THEN ROH(NBR) = 0 ELSE D4 = VAL(D4$)
1381 IF D1 > 0 THEN LOH(NBR) = D1
1382 IF D2 > 0 THEN TOH(NBR) = D2
1383 IF D3 > 0 THEN OOH(NBR) = D3
1384 IF D4 > 0 THEN ROH(NBR) = D4
1385 IF D5 > 0 THEN GOH(NBR) = D5
   IF D6 > 0 THEN POH(NBR) = D6
1390 GOTO 1303
1393 IF IO = 1 THEN IO = 18: IE = 34: GOTO 1303
1397 RETURN

13000 'RELIABILITY MODULE WITH REDUNDANCY
13001 IO = 1: IE = 18
13005 COLOR 7: CLS : PRINT TAB(25); "SUBSYSTEM REDUNDANCY ": PRINT
13010 PRINT TAB(1); "NBR"; TAB(5); "WBS"; TAB(40); "NBR REDUNDANT SUBSYS"; TAB(65); "MIN NBR RQD"
13030 FOR I = IO TO IE
13040 IF OP$(I) = "DELETE" THEN GOTO 13090
13050 IF (I >= 10 AND I <= 15) OR (I >= 19 AND I <= 24) THEN COLOR 14
13060 IF (I >= 10 AND I <= 15) OR (I >= 19 AND I <= 24) THEN PRINT TAB(1); I; TAB(5); WBS$(I); TAB(40); NRD(I); TAB(65); K(I): GOTO 13090
13070 COLOR 11
13080 PRINT TAB(1); I; TAB(5); WBS$(I); TAB(40); NRD(I); TAB(65); K(I)
13090 NEXT I
   COLOR 7
13100 PRINT : INPUT "ENTER NBR OF SUBSYS TO BE CHANGED - 0 IF NONE"; NBR
13110 IF NBR = 0 THEN GOTO 13173
13120 IF NBR < 10 OR NBR > 12 THEN INPUT "ENTER NBR REDUNDANT SUBSYSTEMS- "; NRD(NBR)
13140 IF NRD(NBR) > 0 AND (NBR = 10 OR NBR = 11 OR NBR = 12) THEN INPUT "ENTER MIN NBR TO OPERATE"; K(NBR)
13150 IF NRD(NBR) > 0 AND (NBR = 13 OR NBR = 14 OR NBR = 15) THEN INPUT "ENTER MIN NBR TO OPERATE"; K(NBR)
13160 IF NRD(NBR) > 0 AND NBR >= 19 AND NBR <= 24 THEN INPUT "ENTER MIN NBR TO OPERATE"; K(NBR)
13170 GOTO 13005
13173 IF IO = 1 THEN IO = 19: IE = 34: GOTO 13005
13177 RETURN


UNSCH: 'scheduled Maintenance Input

SCH: IO = 1: IE = 18
SCH0: CLS : COLOR 7
   LOCATE 1, 20: PRINT "SCHEDULED MAINTENANCE - INPUT/DISPLAY"
   COLOR 11
   COLOR 9: PRINT TAB(3); "Enter 99 for a global change": COLOR 11
   PRINT TAB(3); "Current schd maintenance percent of total unsch maint is"; 100 * SCHP
   PRINT TAB(3); "Parametric Equation scheduled maintenance pct of unsch is "; 100 * DSCH
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    PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(30); " % of unsch mhrs"; TAB(58); "Current Schd mhrs"
  COLOR 15
    FOR I = IO TO IE
    IF OP$(I) = "DELETE" THEN GOTO SCH2
    PRINT TAB(3); I; TAB(10); WBS$(I); TAB(40); 100 * SP(I) / (OMH(I) + FMH(I)); TAB(60); SP(I)
  SCH2: NEXT I
IF IO = 19 THEN COLOR 14: PRINT : PRINT TAB(3); "Total"; TAB(60); TSCH: PRINT

  COLOR 7
    PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
    IF NBR = 99 THEN GOSUB SC1: GOTO SCH
    IF NBR > 34 THEN GOTO SCH0
    IF NBR = 0 THEN GOTO SCH3
    INPUT "ENTER Scheduled Manhours for selected subsystem"; SP(NBR)
    ADD = 0
    FOR I = 1 TO 34
    IF OP$(I) = "DELETE" THEN GOTO SCH1
    ADD = ADD + SP(I)
  SCH1: NEXT I
    CP$(5) = "DO NOT RECOMPUTE"
    TSCH = ADD: SCHP = TSCH / (TOMH + TFMH)
    GOTO SCH0
SCH3: IF IO = 1 THEN IO = 19: IE = 34: GOTO SCH0
2698 GOTO NX3
SC1: INPUT "ENTER New percent of unscheduled maintenance"; SCHP
SCHP = SCHP / 100
TSCH = SCHP * (TOMH + TFMH)
FOR I = 1 TO 34
SP(I) = W(I) * TSCH / X1
NEXT I
CP$(5) = "DO NOT RECOMPUTE"
RETURN

NX3: CLS : COLOR 10
PRINT TAB(10); "Periodic (phase) Maintenance Requirement"
PRINT : PRINT : COLOR 11
PRINT TAB(5); "1 - NBR missions btwn inspections"; TAB(50); NP
PRINT
PRINT TAB(5); "2 - Length of inspection in hours"; TAB(50); LE
PRINT
PRINT TAB(5); "3 - Crew size for phase inspection"; TAB(50); CSZ
COLOR 12: PRINT
PH = CSZ * LE / NP
MPH = INT((PH * X(15) / 12) / (X(11) * (1 - X(12))) + .999)
IF MPH < CSZ THEN MPH = CSZ
PRINT TAB(5); "Direct manhrs per man for phase"; TAB(50); PH
PRINT TAB(5); "Manpower reqd for phase"; TAB(50); MPH
PRINT : COLOR 2
INPUT "Enter selection for change else return"; NBR
PRINT : COLOR 7
IF NBR = 0 THEN GOTO BT4
IF NBR < 0 OR NBR > 4 THEN GOTO NX3
IF NBR = 1 THEN INPUT "enter nbr of MSNS between inspections"; NP
IF NP < 1 THEN NP = 1
IF NBR = 2 THEN INPUT "enter nbr hours to inspect a veh"; LE
IF NBR = 3 THEN INPUT "enter CREW SIZE for phase inspection"; CSZ
GOTO NX3

BT4: RETURN

END SUB

SUB LCCFILE
9500 'MODULE TO WRITE DATA TO A FILE FOR LCC MODEL - "name".CST
OPEN "TEMP1.CST" FOR OUTPUT AS #2  'create temp file
WRITE #2, X(1), X(2), X(3)
CLOSE #2

9510 CLS : COLOR 11
   PRINT : PRINT TAB(10); "CURRENT INPUT FILES FOR COST MODEL": PRINT
   FILES "*.CST"
   PRINT : COLOR 10
   PRINT : PRINT TAB(10); "DATA WILL BE SAVED IN FILE "; VNAM$; ".CST"
   PRINT : INPUT "ENTER RETURN TO PROCEED ELSE ENTER A POSITIVE NBR"; NUM
   IF NUM > 0 THEN EXIT SUB
  'VEHICLE TURN TIME CALCULATIONS
   COLOR 14: PRINT : PRINT TAB(35); "VEHICLE TURN TIMES": PRINT
   PRINT TAB(30); "MIN TURN TIME"; TAB(45); "WT-AVG"; TAB(60); "MAX TURN TIME"
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   FOR I = 1 TO 3
   COLOR 14: PRINT TAB(1); I; "-SHIFT/DAY MAINTENANCE": COLOR 15
   DVTT = (T(0) + T(4)) / 24 + TJJ / (8 * I) + X(17) + X(18)
   MDVTT = (T(0) + T(4)) / 24 + GTT / (8 * I) + X(17) + X(18)
   WDVTT = (T(0) + T(4)) / 24 + TXY / (8 * I) + X(17) + X(18)
   PRINT TAB(5); "TOT VEH TURNAROUND DAYS"; TAB(30); DVTT; TAB(45); WDVTT; TAB(60); MDVTT
   NEXT I
   PRINT : INPUT "ENTER VEHICLE TURNTIME FOR USE IN O&S COSTING MODEL"; VTTIM

9530 OPEN VNAM$ + ".CST" FOR OUTPUT AS #1
   WRITE #1, VNAM$
   ' TM = TMEN + X(14) + MPH
9540 FOR I = 1 TO 34
   AD1 = POH(I) + GOH(I) + LOH(I) + TOH(I) + OOH(I) + ROH(I)
   IF MPC(I) > MP(I) THEN XMP = MPC(I) ELSE XMP = MP(I)
9550 WRITE #1, W(I), S(I), XMP, AD1, CA(I)
9555 IL = I
9560 NEXT I
   X(2) = X2
9561 WRITE #1, SMP, VTTIM, T(4), TNR '.TM  make change to LCC
   FOR I = 1 TO 13: WRITE #1, V(I): NEXT I
   FOR I = 1 TO 25: WRITE #1, X(I): NEXT I
   FOR I = 0 TO 5: WRITE #1, T(I): NEXT I
   WRITE #1, AREM, TMA
   WRITE #1, TME, TMF 'ET AND LBR MANPOWER
   FOR I = 1 TO 9: WRITE #1, CZ(I), SC(I): NEXT I  'nbr crews asgn & avg crew size
9565 PRINT : PRINT TAB(10); "DATA WRITTEN TO "; VNAM$; ".CST"
   X(2) = X(2) - WING
9570 CLOSE #1
9580 LOCATE 24, 10: INPUT "ENTER RETURN...."; RET

END SUB



SUB MSN
900 'INITIALIZE SUBSYSTEM MSN PROFILES
910 FOR I = 1 TO 34
920 POH(I) = T(5): GOH(I) = T(0): LOH(I) = T(1): TOH(I) = T(2) - T(1): OOH(I) = T(3) - T(2): ROH(I) = T(4) - T(3): POH(I) = T(5)
921 NEXT I
922 OOH(10) = 0: ROH(10) = 0
   POH(9) = 1: GOH(9) = 0: LOH(9) = 0: TOH(9) = 0: OOH(9) = 0: ROH(9) = 1

END SUB

SUB OUTFILE
9600 'MODULE TO WRITE INPUT DATA TO A FILE
OPEN "TEMP1.DAT" FOR OUTPUT AS #2  'create temp file
WRITE #2, X(1), X(2), X(3)
CLOSE #2

9602 CLS : COLOR 3
PRINT : PRINT TAB(10); "CURRENT RAM INPUT FILES": PRINT
   FILES "*.DAT"
   PRINT : COLOR 11
   PRINT : PRINT TAB(10); "DATA WILL BE WRITTEN TO "; VNAM$; ".DAT"
   LOCATE 20, 10: INPUT "ENTER RETURN TO PROCEED OR A POSITIVE NBR TO ABORT"; RET
   IF RET >= 1 THEN EXIT SUB
9610 OPEN VNAM$ + ".DAT" FOR OUTPUT AS #2
   WRITE #2, DTAT, CSZ, WING
   WRITE #2, NP, LE, D1, D2, D3
9615 FOR I = 1 TO 34
9620 WRITE #2, WBS$(I), W(I), MW(I), CM(I), PWTS(I), PI(I)
   WRITE #2, C(I), PF(I), PA(I), RR(I), CA(I), RELF(I), RF(I)
9621 WRITE #2, POH(I), GOH(I), LOH(I), TOH(I), OOH(I), ROH(I)
9622 WRITE #2, OP$(I), TG(I), NRD(I), K(I), SEL$(I), SMA(I), SMR(I)
   WRITE #2, SP(I), D1, D2, D3, D4, D5
9625 NEXT I
   V(14) = X(21): V(15) = X(22)
9630 FOR I = 1 TO 15
9635 WRITE #2, SNAM$(I), V(I)
9640 NEXT I
'9642 FOR I = 1 TO 20: WRITE #2, NAM$(I), X(I): NEXT I
   FOR I = 1 TO 25: WRITE #2, NAM$(I), X(I): NEXT I
9645 FOR I = 0 TO 5
9650 WRITE #2, T(I)
9655 NEXT I
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    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 34
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 34
1575 'PWTS(I) = PWTS(I) / TSM
1580 W(I) = PWTS(I) * X1
1583 IF W(I) <= 0 THEN W(I) = 1
1585 NEXT I
END SUB

SUB PRIVAR

1049 'PRIMARY VARIABLE MENU
    I1 = 1: I2 = 11
1050 COLOR 11: CLS : PRINT TAB(25); "INPUT MODULE - PRIMARY & SYSTEM VARIABLES"
    PRINT
    IF I2 = 20 THEN COLOR 7: PRINT TAB(10); "SYSTEM PARAMETER VALUES (continued)": PRINT
1060 PRINT TAB(15); "NBR"; TAB(20); "VARIABLE"; TAB(55); "CURRENT VALUE"
1062 PRINT : COLOR 7
1065 IF I1 = 1 THEN PRINT TAB(10); "PRIMARY DRIVER VARIABLES": PRINT
    COLOR 14
1070 FOR I = I1 TO I2
1075 IF I = 6 THEN COLOR 7: PRINT : PRINT TAB(10); "SYSTEM PARAMETER VALUES": PRINT
    COLOR 14
1080 PRINT TAB(15); I; TAB(20); NAM$(I); TAB(55); X(I)
    IF I = 2 THEN PRINT TAB(15); I; TAB(20); "WING SPAN (FT)"; TAB(55); WING
    COLOR 13
1095 IF I = 16 THEN PRINT TAB(20); "0-PRECONCEPTUAL"
1096 IF I = 16 THEN PRINT TAB(20); "1-WEIGHT DRIVEN"
1097 IF I = 16 THEN PRINT TAB(20); "2-WEIGHT & VARIABLE DRIVEN"
    NEXT I
    COLOR 14
    IF I = 26 THEN PRINT TAB(15); " 26"; TAB(20); "Depot LRU TAT in days"; TAB(55); DTAT; ""
    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 1050
1110 IF NBR = 0 THEN GOTO 1131
1115 IF NBR > 26 OR NBR < 0 THEN GOTO 1050
    IF NBR = 6 THEN X(6) = 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
    IF NBR = 26 THEN INPUT "ENTER NEW VALUE"; DTAT: GOTO 1130
1120 IF NBR = 2 THEN INPUT "ENTER LENGTH, WING SPAN"; X(2), WING ELSE INPUT "ENTER NEW VALUE"; X(NBR)
    IF NBR = 14 AND X(14) < 0 THEN X(14) = 0
    IF NBR = 5 THEN NRD(10) = X(5): K(10) = X(5)
    IF NBR = 21 THEN NRD(11) = X(21): K(11) = X(21)
    IF NBR = 22 THEN NRD(12) = X(22): K(12) = X(22)

1130 CLS : GOTO 1050
1131 IF I1 = 1 THEN I1 = 12: I2 = 25: CLS : GOTO 1050
1135 YR = X(7): B = X(9): LF = X(10): X1 = X(1): X2 = X(2) + WING
```

```
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 = 20 TO 24: OP$(I) = "DELETE": NEXT I
   IF X(19) = O THEN WBS$(19) = "13.10 AVIONICS-GN&C" ELSE WBS$(19) = "13.XX AGGREGATED AVIONICS"

END SUB

SUB REL
'MODULE TO ESTABLISH SUBSYSTEM RELIABILITIES"
 IO = 1: IE = 18
TPREL: CLS : COLOR 7: PRINT TAB(20); "ESTABLISH SUBSYSTEM RELIABILITY"
COLOR 3
 PRINT TAB(10); "specify nonredundant subsystem reliability at the end of the mission"
 PRINT TAB(10); "enter a zero reliability to have the system compute a value"
 PRINT
 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "RELIABILITY"
 PRINT
 FOR I = IO TO IE
  IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
 IF OP$(I) = "DELETE" THEN GOTO NX9
IF RELF(I) = 0 THEN PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); "TO BE COMPUTED" ELSE PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); RF(I)
NX9: NEXT I
 COLOR 7
 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
 IF NBR > 34 THEN GOTO TPREL
 IF NBR = 0 THEN GOTO BT10
 INPUT "ENTER DESIRED RELIABILITY"; TEMX
 IF PI(NBR) = 0 THEN
   COLOR 9
   PRINT "Cannot specify reliability since MTBM's are frozen"
   INPUT "enter return"; RET
 ELSE
   RF(NBR) = TEMX
 END IF
 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 = 34: GOTO TPREL

 END SUB


 SUB SHUTTLE
 1800 'UPDATE/DISPLAY SHUTTLE PARAMETERS
 1801 IO = 1: IE = 18
 1805 COLOR 7: CLS : PRINT TAB(20); "SHUTTLE MTBM (HRS/MAINT ACTION) VALUES"
    PRINT TAB(5); "Note:  all MTBM's should be for a single subsystem"
 1810 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "MTBM"
 1820 FOR I = IO TO IE
 1825 IF OP$(I) = "DELETE" THEN GOTO 1835
 1826 IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
    IF I = 9 THEN PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); SMA(I); " MSN/FAILURE"
    IF I = 10 OR I = 11 OR I = 12 THEN PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); SMA(I); " (single engine)"
 1830 IF I < 9 OR I > 12 THEN PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); SMA(I)
 1835 NEXT I
 1840 COLOR 12: PRINT "NOTE: indicates shuttle value currently in use": COLOR 7
  INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
 1845 IF NBR > 34 THEN GOTO 1805
 1850 IF NBR = 0 THEN GOTO 1865
 1855 INPUT "ENTER NEW MTBM"; SMA(NBR)
 1860 GOTO 1805
 1865 IF IO = 1 THEN IO = 19: IE = 34: GOTO 1805

 2600 'UPDATE/DISPLAY SHUTTLE PARAMETERS - MH/MA
 2601 IO = 1: IE = 18
 2605 COLOR 7: CLS
 PRINT TAB(1); "SHUTTLE MH/MA VALUES - Note:  On-Veh MH/MA is the average number of manhours"
    PRINT TAB(1); "required per maintenance action.  It equals the On-Veh MTTR x average crew size"
 2610 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "On-Veh MH/MA"
 2620 FOR I = IO TO IE
 2625 IF OP$(I) = "DELETE" THEN GOTO 2635
 2626 IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 11
 2630 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); SMR(I)
 2635 NEXT I
 2640 COLOR 12: PRINT "NOTE: indicates shuttle value currently in use": COLOR 7
 2641 INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
 2645 IF NBR > 34 THEN GOTO 2605
 2650 IF NBR = 0 THEN GOTO 2665
```

```
2655 INPUT "ENTER NEW MH/MA"; SMR(NBR)
2660 GOTO 2605
2665 IF IO = 1 THEN IO = 19: IE = 34: GOTO 2605

END SUB

SUB WEIGHT
1400 ' SUBSYSTEM WEIGHT DISPLAY
1401 IF X(16) = 0 THEN GOSUB 14200
1403 IO = 1: IE = 18
1405 WAV = 0: COLOR 7: CLS : PRINT TAB(20); "SUBSYSTEM WEIGHTS IN LBS"
1410 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(40); "BASELINE WEIGHT"; TAB(60); "CURRENT WEIGHT"
   COLOR 5: PRINT TAB(10); "WEIGHT FACTOR IS CURRENTLY"; PWF: PRINT
1411 IF X(16) = 0 THEN ADD = X1: GOTO 1430
1412 ADD = 0: COLOR 11
1413 FOR I = 1 TO 34
1414 IF OP$(I) = "DELETE" THEN W(I) = 1: GOTO 1416
   W(I) = WF * W(I)
1415 ADD = ADD + W(I)
1416 NEXT I
   WF = 1
1417 X1 = ADD: X(1) = ADD
1430 COLOR 11
   IF FZ = 1 THEN SVADD = ADD
   FOR I = IO TO IE
   IF FZ = 1 THEN SW(I) = W(I)
1435 IF OP$(I) = "DELETE" THEN GOTO 1450
1440 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); SW(I); TAB(60); W(I)
1450 NEXT I
1455 IF IO = 19 THEN COLOR 14: PRINT : PRINT TAB(3); "TOTAL WGT"; TAB(45); SVADD; TAB(60); ADD
PRINT : COLOR 7
1456 IF X(16) = 0 THEN PRINT : INPUT "ENTER RETURN.."; RET: GOTO 1493
1460 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
1465 IF NBR > 34 THEN GOTO 1405
1470 IF NBR = 0 THEN GOTO 1493
1480 INPUT "ENTER NEW WEIGHT"; W(NBR)
1490 GOTO 1405
1493 IF IO = 1 THEN IO = 19: IE = 34: GOTO 1405
1495 FOR I = 19 TO 24: WAV = WAV + W(I): NEXT I
1496 IF X(16) = 1 THEN CALL SECONDARY
   ANS$ = "N"


IF X(16) = 1 OR X(16) = 2 THEN INPUT "CHANGE WEIGHT FACTOR-(Y/N)"; ANS$
   IF ANS$ = "Y" OR ANS$ = "y" THEN
     INPUT "ENTER NEW FACTOR"; WF
     PWF = PWF * WF
     IF FZ = 1 THEN INPUT "FREEZE BASELINE WGTS-(Y/N)"; AS2$
     IF AS2$ = "Y" OR AS2$ = "y" THEN FZ = 0
     GOTO 1403
   END IF
IF (X(16) = 1 OR X(16) = 2) AND FZ = 0 THEN INPUT "RESTORE BASELINE WGTS-(Y/N)"; AS3$
    IF AS3$ = "Y" OR AS3$ = "y" THEN
    FOR I = 1 TO 34: W(I) = SW(I): NEXT I
    FZ = 1: WF = 1: PWF = 1
    END IF
    IF AS3$ = "Y" OR AS3$ = "y" THEN AS3$ = "N": GOTO 1403
EXIT SUB

14200 ' UPDATE DISPLAY WEIGHT PERCENTS
14202 GOSUB 14300
IF WGTF = 1 THEN FOR I = 1 TO 34: PWTS(I) = PWT1(I): NEXT I
IF WGTF = 2 THEN FOR I = 1 TO 34: PWTS(I) = PWT2(I): NEXT I
IF WGTF = 3 THEN FOR I = 1 TO 34: PWTS(I) = PWT3(I): NEXT I
IF WGTF = 4 THEN CALL ACWGT
IF WGTF = 4 THEN FOR I = 1 TO 34: PWTS(I) = PWT4(I): NEXT I
14204 IO = 1: IE = 18
14205 CLS : COLOR 7: PRINT TAB(25); "WEIGHT PERCENTAGES "
14206 PRINT TAB(20); "PRECONCEPTUAL MODE ONLY": PRINT : COLOR 11
   IF WGTF = 0 THEN PRINT TAB(40); "CURRENT DISTRIBUTION"
14207 IF WGTF = 1 THEN PRINT TAB(40); "DISTR BASED ON LARGE VEHICLE WGTS"
14208 IF WGTF = 2 THEN PRINT TAB(40); "DISTR BASED ON SHUTTLE WEIGHTS"
14209 IF WGTF = 3 THEN PRINT TAB(40); "DISTR BASED ON SMALL VEHICLE WGTS"
   IF WGTF = 4 THEN PRINT TAB(40); "DISTR BASED ON AIRCRAFT WGTS"
14210 PRINT TAB(3); "NBR  SUBSYSTEM"; TAB(45); "PCT OF TOT DRY WGT"
14214 TPCT = 0
```

```
14215 FOR I = 1 TO 34
    TPCT = TPCT + 100 * PWTS(I)
    NEXT I
14230 FOR I = IO TO IE
14235 ' IF OP$(I) = "DELETE" THEN GOTO 14250
    IF X(19) = 1 AND I > 19 AND I < 25 THEN GOTO 14250
14236 COLOR 3
14237 TEMP = CINT(1000 * PWTS(I)): TEMP = TEMP / 10
14240 PRINT TAB(3); I; TAB(10); WBS$(I); TAB(45); TEMP
14250 NEXT I
14255 IF IO = 19 THEN COLOR 14: PRINT : PRINT TAB(40); "TOT="; TPCT
    COLOR 7
14260 PRINT : INPUT "ENTER NBR OF SUBSYSTEM TO BE CHANGED - 0 IF NONE"; NBR
14265 IF NBR > 34 THEN GOTO 14205
14270 IF NBR = 0 THEN GOTO 14290
14280 INPUT "ENTER NEW PERCENT"; PWTS(NBR)
14285 PWTS(NBR) = PWTS(NBR) / 100: GOTO 14205
14290 IF IO = 1 THEN IO = 19: IE = 34: GOTO 14205
    IF IO = 19 AND TPCT < 99.9 THEN COLOR 13: PRINT : INPUT "PERCENTS MUST SUM TO 100"; RET: GOTO 14204
    IF IO = 19 AND TPCT > 100.1 THEN COLOR 13: PRINT : INPUT "PERCENTS MUST SUM TO 100"; RET: GOTO 14204
14293 CALL PCTWGT
    RETURN

14300 'SELECT WEIGHT DISTRIBUTION
14310 CLS : COLOR 7
14320 LOCATE 5, 20: PRINT "SELECT WEIGHT DISTRIBUTION": PRINT : COLOR 11
14330 PRINT TAB(15); "1 - LARGE VEHICLE DISTR": PRINT
14350 PRINT TAB(15); "2 - SHUTTLE WGT DISTR": PRINT
14360 PRINT TAB(15); "3 - SMALL VEHICLE DISTR": PRINT
    PRINT TAB(15); "4-  AIRCRAFT WGT DISTR": PRINT
    COLOR 13
    PRINT TAB(15); "RETURN - MAINTAIN CURRENT DISTRIBUTION": PRINT
    COLOR 7
14370 PRINT : INPUT "SELECT DISTRIBUTION....": WGTF
14380 IF WGTF < 0 OR WGTF > 4 THEN GOTO 14310
14390 RETURN

END SUB
```

Computational Module
File: RAMI.BAS

```
'NASA, LANGLEY RESEARCH CENTER
'MTBM COMPUTATIONAL MODEL - NASA RESEARCH GRANT -
'DEVELOPED BY C. EBELING, UNIV OF DAYTON 11/29/95 (updated)
' ******** COMBINED PRE/CONCEPTUAL MODEL **********
'
'SAVE AS "RAMC.BAS" computational module
'
COMMON SHARED YR, B, X1, X2, LF, VR1, VR2, VR3, VR4, VR5, VR, AREM
COMMON SHARED VFMA, TVFMA, SVFMA, CVFMA, OMHMA, OFMHMA, TMA, AMHMA
COMMON SHARED SCHP, VMH, TOMH, TFMH, APF, P1, P2, P3, WAV, FH42, FH44
COMMON SHARED FMA11, FMA12, VNAM$, ARR, TNR, TS, SKIP, TSCH, DTAT
COMMON SHARED SMP, TMP, VMOH, WGTF, WING, WF, PWF, TMEN, NP, LE
COMMON SHARED ETREL, SRBREL, ETS, SRBS, RTITLE$, ABTF$, PH, MPH, CSZ
COMMON SHARED STP, STE, MTE, TME, STF, MTF, TMF, C1, PMF, SVADD, FZ
COMMON SHARED AVCREW, GTT, ATSK, TTX, TTZ, TTW, TTYA, TJJ, TXY, TJX
COMMON SHARED PARAF, PB17, ISJ, DSCH, WC
DIM SHARED WBS$(35), X(50), NAM$(50), THRS(35), MHMA(35), MH(35), MP(35), OMH(35), FMH(35)
DIM SHARED SEL$(35), T(10), CP$(9), CA(35), RELF(35), RF(35)
DIM SHARED GOH(35), LOH(35), TOH(35), OOH(35), ROH(35), R(35), TSKT(35), POH(35)
DIM SHARED V(15), SNAM$(15), FMAT(35), FMAC(35), FMAS(35), S(35), SMA(35), SMR(35)
DIM SHARED MW(35), C(35), CM(35), OP$(35), TG(35), PWTS(35)
DIM SHARED FMA(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
DIM SHARED NRD(35), K(35), R1(35), R2(35), R3(35), R4(35), R5(35)
DIM SHARED PWT1(35), PWT2(35), PWT3(35), PWT4(35), SRR(35)
DIM SHARED ETSUB$(5), ETMBA(5), ETHRS(5), ETABR(5), ETMTR(5), ETR(5), ETCREW(5)
DIM SHARED SRBSUB$(5), SRBMBA(5), SRBHRS(5), SRBABR(5), SRBMTR(5), SRBR(5), SRBCREW(5)
DIM SHARED SWBS$(10), MAS(9), MTROS(9), MTRFS(9), REMS(9), SMT(9), SMTF(9), SC(9), FRS(9)
DIM SHARED PI(35), CZ(9), SP(35), MA(35), TT(35), MPC(35), SW(35), IFMA(35)
COMMON SHARED PI(), CZ(), SP(), MA(), TT(), MPC(), SW(), IFMA()
COMMON SHARED SWBS$(), MAS(), MTROS(), MTRFS(), REMS(), SMT(), SMTF(), SC(), FRS()
COMMON SHARED WBS$(), X(), NAM$(), THRS(), MHMA(), MH(), MP(), OMH(), FMH()
COMMON SHARED SEL$(), T(), CP$(), CA(), RELF(), RF()
COMMON SHARED GOH(), LOH(), TOH(), OOH(), ROH(), R(), TSKT(), POH()
COMMON SHARED V(), SNAM$(), FMAT(), FMAC(), FMAS(), S(), SMA(), SMR()
COMMON SHARED MW(), C(), CM(), OP$(), TG(), PWTS()
COMMON SHARED FMA(), PF(), PA(), RR(), W(), NR(), FR()
COMMON SHARED NRD(), K(), R1(), R2(), R3(), R4(), R5()
COMMON SHARED PWT1(), PWT2(), PWT3(), PWT4(), SRR()
COMMON SHARED ETSUB$(), ETMBA(), ETHRS(), ETABR(), ETMTR(), ETR(), ETCREW()
COMMON SHARED SRBSUB$(), SRBMBA(), SRBHRS(), SRBABR(), SRBMTR(), SRBR(), SRBCREW()

SUB ABORT
14500 'ABORT RATE CALCULATIONS
14505 FOR I = 1 TO 34: PA(I) = X(8): NEXT I' SET DEFAULT ABORT RATE

' WBS 1,2,3 STRUCTURES ****
14510 AB11 = .031213 + 1.956E-07 * X1 - 1.5456E-04 * SQR(X1)
14511 IF AB11 <= 0 THEN AB11 = .00128
14512 IF AB11 > .02065 THEN AB11 = .02065
14513 PA(1) = AB11: PA(2) = AB11
14520 AB12 = .04232 + 3.8775E-07 * X1 - 2.51883E-04 * SQR(X1)
14521 IF AB12 > .02 THEN AB12 = .02
    IF AB12 < 0 THEN AB12 = 0
14522 PA(3) = (AB11 / FMA11 + AB12 / FMA12) / (1 / FMA11 + 1 / FMA12)

' WBS 5 LANDING GEAR ****
14530 AB13 = -2.4321 + .0059112 * X2 + 1.1457 * LOG(X2) - .33925 * SQR(X2)
14531 IF AB13 < 0 THEN PA(9) = .00185 ELSE PA(9) = AB13
14532 IF PA(9) > .08 THEN PA(9) = .08

' ENGINES****
14630 FOR I = 10 TO 12
14631 PA(I) = .048164 - .0001268 * X2
14632 IF PA(I) < .0013 THEN PA(I) = .0013
NEXT I
'PROP MPS
PA(34) = .048164 - .0001268 * X2
IF PA(34) < .0013 THEN PA(34) = .0013
PA(34) = (PA(34) + X(8)) / 2

' WBS 9.10 APU ****
    PA(13) = .064
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' WBS 10.00 ELECTRICAL ****
14580 PA(16) = -39.95984 + 11.09214 * LOG(X1) - 1.0178226# * LOG(X1) ^ 2 + .0309075 * LOG(X1) ^ 3
14581 IF PA(16) < = 0 THEN PA(16) = .00248
14582 IF PA(16) > .142 THEN PA(16) = .142
    PA(14) = PA(16)
    PA(15) = PA(16)

' WBS 11.00 HYDRAULICS ****
14600 PA(17) = 5000.2535# - 7578.183 / SQR(LOG(X1)) - 453.612 * LOG(X1) + 24.6005 * LOG(X1) ^ 2 - .5276227 * LOG(X1) ^ 3
14601 IF PA(17) < = 0 THEN PA(17) = .00084
14602 IF PA(17) > .1304 THEN PA(17) = .1304

' WBS 12.00 ACTUATORS ****
14540 AB14 = .711953 - .1881388 * LOG(X2) + .0209882 * SQR(X2)
14541 IF AB14 < 0 THEN PA(18) = 6.000001E-04 ELSE PA(18) = AB14
14542 IF PA(18) > .08128 THEN PA(18) = .08128

'  AVIONICS GENERIC
14610 PAG = .0502749 + 2.605132E-07 * X1 - 2.288197E-04 * SQR(X1)
14611 IF PAG < 0 THEN PAG = .00152
14612 IF PAG > .02376 THEN PAG = .02376
    FOR I = 19 TO 24: PA(I) = PAG: NEXT I
14615 IF X(19) = 0 THEN PA(19) = .01: PA(21) = .011: PA(23) = .015:

' WBS 14.XX ENVIRONMENTAL ****
14570 PA(25) = .082199 + 5.0072E-07 * X1 - 4.0612E-04 * SQR(X1)
14571 IF PA(25) < 0 THEN PA(25) = .00152
14572 IF PA(25) > .05222 THEN PA(25) = .05222
14573 PA(26) = PA(25)
' WBS 15.00 PERSONNEL PROVISIONS ****
14620 PA(27) = .0185
    ' ET/SRB ABORT RATES
     FOR I = 1 TO 5: ETABR(I) = X(8): SRBABR(I) = X(8): NEXT I

'compute air abort rates
 IF X(25) = 1 THEN
   FOR I = 1 TO 2: PA(I) = .25 * PA(I): NEXT I
   PA(3) = .195 * PA(3)
   FOR I = 4 TO 8: PA(I) = X(8): NEXT I
   PA(9) = .22 * PA(9)
   FOR I = 10 TO 12: PA(I) = .28 * PA(I): NEXT I
   PA(34) = (.28 * PA(34) + X(8)) / 2
   PA(13) = .02 * PA(13)
   FOR I = 14 TO 16: PA(I) = .125 * PA(I): NEXT I
   PA(17) = .08 * PA(17)
   PA(18) = .14 * PA(18)
   IF X(19) = O THEN PA(19) = .33 * PA(19) ELSE PA(19) = .16125 * PA(19)
   PA(20) = X(8)
   PA(21) = .1175 * PA(21)
   PA(22) = X(8)
   PA(23) = .16 * PA(23)
   PA(24) = X(8)
   PA(25) = .29 * PA(25)
   PA(26) = .16 * PA(26)
   PA(27) = .52 * PA(27)
   FOR I = 28 TO 33: PA(I) = X(8): NEXT I
 END IF

END SUB

SUB ACWGT
    ' MODULE TO COMPUTE SUBSYSTEM WEIGHTS - ACFT EQS
    SUM = 0
    FOR I = 1 TO 34: W(I) = 0: NEXT I
    W(1) = -4485026.7# + 1351022.5# * LOG(X1) - 135432! * (LOG(X1)) ^ 2 + 4522.4 * (LOG(X1)) ^ 3
    IF W(1) < = 0 THEN W(1) = 795
    W(2) = -290909.9 + 91929.4 * LOG(X1) - 9709.901 * (LOG(X1)) ^ 2 + 343.5 * (LOG(X1)) ^ 3
    IF W(2) < = 0 THEN W(2) = 302
    W(3) = 39713145.2# + 1417950.4# * LOG(X1) - 40472209# / SQR(LOG(X1)) - 12993808.8# * SQR(LOG(X1))
    IF W(3) < = 0 THEN W(3) = 2140
    W(9) = -49535! + .282563 * X1 + 6873.7 * LOG(X1) - 160.1 * SQR(X1)
    IF W(9) < = 0 THEN W(9) = 527
    W(18) = -9849.5 + .0459666 * X1 + 1364.8 * LOG(X1) - 26.248 * SQR(X1)
    IF W(18) < = 0 THEN W(18) = 100
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    W(13) = -910.4 + 100.22 * LOG(X1) + 1.3835 * SQR(X1)
    IF W(13) <= 0 THEN W(13) = 157
    W(25) = -719.15 + 5.56265 * X2 + 56.882 * SQR(X2)
    IF W(25) <= 0 THEN W(25) = 63
    W(26) = W(25) / 2: W(25) = W(25) / 2
    W(16) = -757.97 + 11.222 * SQR(X1)
    IF W(16) <= 0 THEN W(16) = 310
    W(17) = 575.27 + .022216 * X1 - 5.0608 * SQR(X1)
    IF W(17) <= 0 THEN W(17) = 147
    W(27) = 66255.6 - 14720.4 * LOG(X1) + 818.19 * (LOG(X1)) ^ 2
    IF W(27) <= 0 THEN W(27) = 284
    AV = -10901.5 + 1261.52 * LOG(X1)
    IF AV <= 0 THEN AV = 303
    FOR I = 19 TO 24: W(I) = AV / 6: NEXT I
    ' W(4) = .11 * X1: W(6) = .01 * X1: W(7) = .04 * X1: W(8) = .02 * X1: W(16) = .1 * X1
    W(10) = -7141.92 + 89.1053 * SQR(X1)
    FOR I = 1 TO 34
    SUM = SUM + W(I)
    NEXT I
    FOR I = 1 TO 34
    PWT4(I) = W(I) / SUM
    'IF W(I) = 0 THEN OP$(I) = "DELETE" ELSE OP$(I) = "COMPUTE"
    NEXT I

END SUB

SUB COMPM
'module to compute MTBM given a specified reliability
YZ = 0: YY = 0: Y = 0: YW = 0
FOR I = 1 TO 34
CK6 = 0
IF OP$(I) = "DELETE" THEN GOTO SKP1
IF RELF(I) = 1 THEN GOSUB MTB
   YW = YW + 1 / FMA(I)
   YZ = YZ + 1 / FMAS(I)
   YY = YY + 1 / FMAC(I)
   Y = Y + 1 / FMAT(I)
SKP1: NEXT I
   TVFMA = 1 / Y
   VFMA = 1 / YW
   SVFMA = 1 / YZ
   CVFMA = 1 / YY
EXIT SUB

MTB: 'find FMAC
  IF X(25) = 0 THEN T0 = GOH(I) ELSE T0 = 0
  T1 = T0 + LOH(I): T2 = T1 + TOH(I)
  T3 = T2 + OOH(I): T4 = T3 + ROH(I)
  L1 = 1 / FMAC(I)
  IF I = 9 THEN L1 = -LOG(RF(I)) / T4: GOTO ED1

RCP: L2 = LF * L1
  A = ((B * T(2) ^ (B - 1)) / L1) ^ (1 / B)
  F = EXP(-L1 * (T2 + T0 - T1) - L2 * (T1 - T0) - (T3 / A) ^ B + (T2 / A) ^ B - L1 * (T4 - T3))
  FP = F - RF(I)
  DF = (-(T2 + T0 - T1) - LF * (T1 - T0) - T3 / (B * T2 ^ (B - 1)) - 1 / (B * T2 ^ (B - 2)) - (T4 - T3)) * F
  IF DF < -.0001 OR DF > .0001 THEN NEWL1 = L1 - FP / DF ELSE GOTO ED1
  IF CK6 = 1 THEN GOTO ED1
  IF NEWL1 < .000001 THEN NEWL1 = .000001: CK6 = 1

IF ABS(F - RF(I)) > .000001 THEN L1 = NEWL1: GOTO RCP

ED1: FMAC(I) = 1 / L1
FMAS(I) = FMAC(I) * PA(I)
MA = THRS(I) / (FMAS(I) * PI(I))
IF PI(I) < 1 THEN FMA(I) = (POH(I) + THRS(I)) / MA ELSE FMA(I) = FMAS(I)
IF PI(I) < 1 AND POH(I) > 0 THEN FMAT(I) = POH(I) / ((1 - PI(I)) * MA) ELSE FMAT(I) = 10 ^ 6

RETURN

END SUB

SUB COMREL
2800 'MODULE TO DETERMINE nonredundant RELIABILITIES - CRITICAL FAILURES ONLY
2810 VR = 1
2820 FOR J = 1 TO 34
2830 IF X(25) = 0 THEN T0 = GOH(J) ELSE T0 = 0
```

```
   T1 = T0 + LOH(J): T2 = T1 + TOH(J)
2840 T3 = T2 + OOH(J): T4 = T3 + ROH(J)
2850 IF OP$(J) = "DELETE" THEN R(J) = 1: GOTO 2890
   IF FMAC(J) > 10 ^ 8 THEN R(J) = 1: GOTO 2890
2860 L1 = 1 / FMAC(J): L2 = LF * L1
2870 A = (B * T(2) ^ (B - 1) / L1) ^ (1 / B)
2880 R(J) = EXP(-L1 * (T2 + T0 - T1) - L2 * (T1 - T0) - (T3 / A) ^ B + (T2 / A) ^ B - L1 * (T4 - T3))
2890 VR = VR * R(J)
2895 NEXT J
END SUB

SUB COMTURN
9705 GTT = 0: TMAX = 0
9706 SUM = 0: CT = 0: SUMC = 0
9710 FOR I = 1 TO 34
9715 IF OP$(I) = "DELETE" THEN GOTO 9735
9716 CT = CT + 1 / FMA(I)
   SUMC = SUMC + C(I) * (1 / FMA(I))
9720 TSKT(I) = (1 - PF(I)) * MHMA(I) / C(I)
   TT(I) = (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) * TSKT(I) + .98 * SP(I) / C(I)) / CA(I)
   IF TT(I) > TMAX THEN TMAX = TT(I): TJ = I
9730 GTT = GTT + TT(I)
9733 SUM = SUM + TSKT(I) * (1 / FMA(I))
9735 NEXT I
   TJX = TJ
   GTT = GTT + LE / NP
   IF LE / NP > TT(TJ) THEN TJJ = LE / NP ELSE TJJ = TT(TJ)
   AVCREW = SUMC / CT
9750 ATSK = SUM / CT
TXY = (1 - X(20)) * TJJ + X(20) * GTT

   TTW = 0: TTX = 0: Y = 0: TTZ = 0: K = 0   'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NX10
   K = K + 1 / (FMA(I))
   TTX = TTX + CA(I)
   Y = Y + TSKT(I) / FMA(I)
   TTZ = TTZ + TT(I)
   TTW = TTW + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
NX10: NEXT I
   IF K > 0 THEN TTYA = Y / K ELSE TTYA = 0

END SUB

SUB CREW
12000 'CREW SIZE CALCULATIONS
12110 C(1) = 1.5 - .000032 * V(3) + .009172 * SQR(V(3))
12120 C(2) = C(1): C(3) = C(1): C(4) = C(1): C(5) = C(1): C(6) = C(1): C(7) = C(1): C(8) = C(1)
12130 C(18) = C(1): C(9) = C(1)
12140 C(10) = 2.43: C(11) = 2.43: C(12) = 2.43: C(34) = (2.43 + C(5)) / 2
12150 C(13) = 2.43: C(14) = 2.43: C(15) = 2.43
12160 C(16) = -1.48 - .002833 * X2 + .814656 * LOG(X2)
12170 C(17) = C(16): C(25) = C(16): C(26) = C(16)
12180 C(19) = 2.18: C(20) = C(19): C(21) = C(19): C(22) = C(19): C(23) = C(19): C(24) = C(19)
12190 C(28) = 1.7893 + .0009872 * SQR(X1)
12195 C(27) = (C(16) + C(28)) / 2
12196 C(29) = C(28): C(30) = C(28): C(31) = C(28): C(32) = C(28): C(33) = C(28)
    TFC = 1
    FOR I = 1 TO 34
    IF I = 13 OR I = 34 OR I = 23 OR I = 25 OR I = 26 OR I = 10 OR I = 11 OR I = 17 OR I = 4 OR I = 5 OR I = 30 THEN TFC = 2
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN C(I) = TFC * 4.5
    TFC = 1
    NEXT I

END SUB

SUB CRIT
2700 'DETERMINE CRITICAL FMA
2710 YY = 0
2720 FOR I = 1 TO 34
2730 IF OP$(I) = "DELETE" THEN GOTO 2760
2740 FMAC(I) = FMAS(I) / PA(I)
2750 YY = YY + 1 / FMAC(I)
2760 NEXT I
2770 CVFMA = 1 / YY

END SUB
```

```
SUB EQS

FOR I = 1 TO 34
W(I) = W(I) / NRD(I)
NEXT I

'MTBM/MTTR CALCULATIONS BY WBS
'WBS 1,2 & 3  AIRFRAME      ***********
   S1 = W(1) + W(2) + W(3)
   P1 = W(1) / S1: P2 = W(2) / S1: P3 = 1 - P1 - P2
3020 FMA11 = 15.231 + .006057 * W(2) - .137575 * SQR(W(1) + W(2) + W(3)) - .000723 * V(3)
3022 IF FMA11 < 1.4 THEN FMA11 = 1.4
3025 FMA(1) = FMA11 / P1: FMA(2) = FMA11 / P2
3030 MH11 = 16.5732 - .3511567 * W(3) / V(2) - .74556 * LOG(X1)
3031 IF MH11 < 3.9 THEN MH = 3.9
3032 MHMA(1) = MH11: MHMA(2) = MH11
'WUC12  AIRCREW COMPART      *************
3110 FMA12 = 3428.49 - .0142 * X1 - 423.96 * LOG(X1) + 11.05 * SQR(X1) + 111.567 * X(3) - 360.72 * SQR(X(3)) + .01865 * W(3) - 4.83566 * SQR(W(3)) - .25785 * (X(3)
+ X(4))
3112 IF FMA12 < 5.6 THEN FMA12 = 5.6' 25TH PERCENTILE RANGE
3115 TP = P3 / FMA11 + 1 / FMA12: FMA(3) = 1 / TP'CHECK LINE 3715 FOR FMA(3)
3120 IF X(3) + X(4) > 0 THEN MH12 = 7.0855 - 1.6667 / SQR(X(3) + X(4)) + .098778 * (X2 + X(4))
3121 IF MH12 < 3.2 THEN MH12 = 3.2
3123 MHMA(3) = ((1 / FMA11) * MH11 + (1 / FMA12) * MH12) / (1 / FMA11 + 1 / FMA12)

'WUC46  FUEL SYS  WBS 3.10/3.20  ********
'4710 BMA46 = 494.8 - 54.06 * X1 + .903 * SQR(V(3)) - 50.712 * X(5) + 16.39 * V(9) + 151.37 * SQR(X(5)) - 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
BMA46 = 19.4846 - .000194 * W(4) - .000118 * W(10)
IF BMA46 < .05 THEN BMA46 = .05
FMA(4) = BMA46

BMA46 = 19.4846 - .000194 * W(5) - .000118 * W(10)
IF BMA46 < .05 THEN BMA46 = .05
FMA(5) = BMA46

'4714 'Y = (W(4) / (W(4) + W(5))) * (1 / BMA46)
'4715 'Z = (W(5) / (W(4) + W(5))) * (1 / BMA46)
'4716 'FMA(4) = 1 / Y: FMA(5) = 1 / Z

'MH46 = -180.85 + .00126 * X1 + .6663 * X2 - .0121 * V(3) + 11.7288 * LOG(X1) - 1.635 * SQR(V(3)) - 20.309 * V(13) + 87.164 * SQR(V(13)) - .00131 * (W(10) + W(11)
+ W(12)) + .45 * SQR(W(4))
'IF MH46 < 7 THEN MH46 = 7
'IF MH46 > 21.34 THEN MH46 = 21.34
'MHMA(4) = MH46
'MH46 = -180.85 + .00126 * X1 + .6663 * X2 - .0121 * V(3) + 11.7288 * LOG(X1) - 1.635 * SQR(V(3)) - 20.309 * V(9) + 87.164 * SQR(V(9)) - .00131 * (W(10) + W(11) +
W(12)) + .45 * SQR(W(5))
'IF MH46 < 7 THEN MH46 = 7
'IF MH46 > 21.34 THEN MH46 = 21.34
'MHMA(5) = MH46
MHMA(4) = -4.6274 - .6504 * V(13) - .000386 * W(4) + 2.98686 * LOG(W(4))
MHMA(5) = -4.6274 - .6504 * V(9) - .000386 * W(5) + 2.98686 * LOG(W(5))
IF MHMA(4) < 2.1 THEN MHMA(4) = 2.1
IF MHMA(5) < 2.1 THEN MHMA(5) = 2.1

' WBS 4.XX  THERMAL PROTECTION SYSTEM ****************
' TILES,TCS, & PVD - NOT AVAILABLE FROM AIRCRAFT  - INDICES 6,7 & 8

'WUC13/WBS9   LANDING GEAR SYSTEMS     ****************
3210 SMA13 = 22.2723 - .00313 * V(3) + .19511 * X2 - 5.47476 * SQR(V(4)) + .003161 * W(9) - .5171441 * SQR(W(9))
3212 IF SMA13 < .4 THEN SMA13 = .4
   IF SMA13 > 19.1 THEN SMA13 = 19.1
3213 'FMA(9) = 72.4 + 14.568 * V(4) + .0994 * X2 - 12.41 * LOG(X1) - 65.6 * SQR(V(4)) - .00568 * W(9) + 18.598 * LOG(W(9))
3214 'IF FMA(9) < 1.4 THEN FMA(9) = 1.4
   FMA(9) = SMA13
3220 MHMA(9) = -156.95 + 55.984 * LOG(W(9)) - 6.095 * (LOG(W(9))) ^ 2 + .212817 * (LOG(W(9))) ^ 3
3221 IF MHMA(9) < 1.9 THEN MHMA(9) = 1.9
```

```
'******WUC23 PROPULSION SYSTEM **** WBS 6, 7 & 8 ********
FOR I = 10 TO 12
4170 FMA(I) = 34.1 + 9.853001E-04 * W(I) - .312232 * SQR(W(I))
4171 IF FMA(I) < 1.4 THEN FMA(I) = 1.4
4175 MHMA(I) = 52.6324 + .0009122 * W(I) - .3936 * SQR(W(I))
4176 IF MHMA(I) < 4.1 THEN MHMA(I) = 4.1
4177 IF MHMA(I) > 21.1 THEN MHMA(I) = 21.1
NEXT I
'MPS
F1 = 34.1 + 9.853001E-04 * W(34) - .312232 * SQR(W(34))
IF F1 < 1.4 THEN F1 = 1.4
F2 = 19.4846 - .000194 * W(34) - .000118 * W(10)
IF F2 < .05 THEN F2 = .05
M1 = 52.6324 + .0009122 * W(34) - .3936 * SQR(W(34))
IF M1 < 4.1 THEN M1 = 4.1
IF M1 > 21.1 THEN M1 = 21.1
M2 = -4.6274 - .6504 * V(9) - .000386 * W(34) + 2.98686 * LOG(W(34))
IF M2 < 2.1 THEN M2 = 2.1
FMA(34) = (F1 + F2) / 2
MHMA(34) = (M1 + M2) / 2

'WUC24    APU  WBS 9.10          ***************
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) = -451.4 + .09054 * V(7) - 2.9654 * SQR(V(7)) + .2657 * W(13) - 26.1 * SQR(W(13)) + 150.5 * LOG(W(13))
3421 IF MHMA(13) < 5.2 THEN MHMA(13) = 5.2
3422 IF MHMA(13) > 17.2 THEN MHMA(13) = 10!
'
' BATTERY WBS9.20 ************
   FMA(14) = 3570
   MHMA(14) = 1.907 + .000006975# * X1

'WBS 9.30  POWER, FUEL CELL ******************
' NOT AVAIL ON AIRCRAFT - INDEX 15

'WUC 42/44   WBS 10  *** ELECTRICAL SYS ******
3609 FMA(16) = 1193.13 - .0755 * W(16) + 6.758773 * SQR(W(16)) - .715596 * X2 - 167.24 * LOG(X1) + 2.2308 * SQR(X1) + 29.10236 * LOG(V(7)) - .00127 * V(7) ^ 2
3611 FH44 = 1
3613 FH42 = 1
3614 IF FMA(16) < 5.15 THEN FMA(16) = 5.15
3620 'MHMA(16)=-18392.3+1694.6*LOG(X1)-92.8412*(LOG(X1))^2+27629/SQR(LOG(X1))+2*LOG(X1)^3
3621 MH42 = -95.161 + 20.3158 * LOG(X1) - .98356 * (LOG(X1)) ^ 2
3622 MH44 = 2300.04 + 474.11 * LOG(X1) - 452.295 * LOG(X2) - .146285 * X1 / X2 - 2769.85 * SQR(LOG(X1)) + 1788.4 * SQR(LOG(X2))
3623 MHMA(16) = (MH42 + MH44) / 2
3624 IF MHMA(16) < 1! THEN MHMA(16) = 4.1

'WUC45 WBS11  HYDRAULICS SYS     ******************
'
IF V(8) > 0 THEN FMA(17) = 396.258 - .00622 * V(3) + 35.635 * V(8) - 779.83 * SQR(V(8)) + 975.56 * LOG(V(8)) + 8.812899 * SQR(W(17)) - 105.728 * LOG(W(17))
IF V(8) = 0 THEN FMA(17) = 10 ^ 6
3812 IF FMA(17) < 4.7 THEN FMA(17) = 4.7
3820 MH45 = 2.41235 * LOG(X1) - .16306 * LOG(X1) ^ 2
3821 MHMA(17) = MH45
3822 IF MHMA(17) < 2.4 THEN MHMA(17) = 2.4
'
'WUC14  WBS 12.00 AERO SURFACE ACTUATORS    ***************
3310 FMA(18) = 26.29 - 1.1136 * SQR(W(18)) + .9516 * V(5) - 1.9 * V(6) + .3505 * X2 - .00357 * V(3)
3312 IF FMA(18) < 2.8 THEN FMA(18) = 2.8
3320 MHMA(18) = 26.238 - 1.1067 * V(5) - 1.6658 * V(6) - .00328 * V(3) + .0006018 * X2 - 6.2827 * LOG(W(18)) + 14.289 * SQR(V(5))
3321 IF MHMA(18) < 2.1 THEN MHMA(18) = 2.1

' WBS 12.XX AVIONICS  GENERAL  *******
3910 FOR I = 19 TO 24
3911 MHMA(I) = 131.395 + 1.0394 * V(11) - 9.035 * SQR(V(10)) - .0154 * WAV + 2.864 * SQR(WAV) - 26.193 * LOG(WAV)
3912 IF MHMA(I) < 4.6 THEN MHMA(I) = 4.6
   FMA(I) = -36.92 - 4.496 * V(10) + 45.756 * SQR(V(10)) - .1231 * WAV / V(10) + .0236 * WAV - 2.453 * SQR(WAV)
   IF FMA(I) < 1.5 THEN FMA(I) = 1.5
   NEXT I
   IF X(19) = 1 THEN GOTO 3511  'USE AV GEN
   FMA(22) = 54.2
   MHMA(22) = 8.95
4350 FMA(23) = 330.26 + .0003821 * X1 - .451534 * X2 + 137.3431 * X(5) - 1.129 * V(9) - 381.666 * SQR(X(5))
4351 IF FMA(23) < 7 THEN FMA(23) = 7
4355 MHMA(23) = -229.62 + .0003 * X1 + .0985 * X2 + 23.4948 * LOG(X1) - .44697 * SQR(X1) - 25.3067 * X(5) + .17796 * V(9) + 74.155 * SQR(X(5))
4356 IF MHMA(23) < 3.5 THEN MHMA(23) = 3.5
4357 IF MHMA(23) > 12.6 THEN MHMA(23) = 12.6
4400 FMA(19) = -415.17 - .000317 * X1 + .2757 * X2 + .2242 * WAV - 26.744 * SQR(WAV) + 155.28 * LOG(WAV) - .3679 * WAV / V(10)
4405 IF FMA(19) <= 3.3 THEN FMA(19) = 3.3
4410 FMA(20) = 323.913 - 16.0757 * SQR(WAV) + 16.974 * X2 + .1735 * WAV + 23.82 * V(11) - 2.305 * WAV / V(10)
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4415 IF FMA(20) < 4.2 THEN FMA(20) = 4.2
4420 FMA(21) = 353.21 - .0338 * X2 + 10.74 * V(10) - 107.64 * SQR(V(10)) - 7.82 * LOG(WAV)
4425 IF FMA(21) < 7.9 THEN FMA(21) = 7.9
    FMA(24) = 29.13
    MHMA(24) = 4.75 + .2446 * LOG(X1)

'WUC41/47 WBS14.XX  ENVIRONMENTAL CONTROL **************
3511 FH41 = 454.387 - .000547 * X1 + .821 * X2 - 107.5185 * LOG(X2)
3512 FH47 = 6613.12 - 1.485 * X2 - 1358.3 * LOG(X1) + 73.58 * (LOG(X1)) ^ 2 - .725852 * X1 / X2
3513 FMA(25) = FH41: FMA(26) = FH47
3515 IF FMA(25) < 7.68 THEN FMA(25) = 7.68
   IF FMA(26) < 13.8 THEN FMA(26) = 13.8
3520 MH41 = .6886774 * LOG(X1)
3521 MH47 = 5.7432 + .018525 * LOG(X1) - 3.36575E-03 * SQR(X1)
3522 MHMA(25) = MH41: MHMA(26) = MH47
3523 IF MHMA(25) < 1! THEN MHMA(25) = 1!


 'WUC49  MISC UTILITIES      **********************
 ' WUC49/96  WBS15  PERSONNEL PROVISIONS ***************
4020 FMA(27) = 17952.8 + .00579 * X1 + 170 * X(3) - 10.136 * X2 + 21.15 * (X(3) + X(4)) - 461.34 * SQR(X(3) + X(4)) - 1.893 * W(27) + 421.8 * SQR(W(27)) - 4054 *
LOG(W(27))
4021 'FH49=58226.97+.0168*X1-42.358*X2-27480.6*LOG(X2)+79.598*LOG(X1)^2+3131.24*LOG(X2)^2-8.6965*X1/X2
4023 IF FMA(27) < 46.7 THEN FMA(27) = 46.7
4030 MHMA(27) = 9.51317 + .03508 * X2 - .000721 * W(27) - 4.52 * SQR(X(3))
4031 'MH49=.0831*LOG(X1)^2-.0116*X1/X2
4033 IF MHMA(27) < 2.2 THEN MHMA(27) = 2.2
'
'WUC91/93/97  WBS 16 ***** RECOVERY & AUX SYS ********
4205 FMA(28) = 23030.42 + 236.89 * X2 - 4657.052 * SQR(X2)
4206 IF FMA(28) < 101.1 THEN FMA(28) = 101.1
4208 MHMA(28) = 6.95
4210 FMA91 = -2032.57 + 10.54 * SQR(X1) - 23.91 * X2 + .16436 * WAV - 20.27 * V(10) + 352.2 * SQR(X2)
4211 IF FMA91 < 18.9 THEN FMA91 = 18.9
4212 FMA97 = 8962.941 + 22.477 * SQR(X1) - .0202 * X1 - 1172.605 * LOG(X1)
4213 IF FMA97 < 65.9 THEN FMA97 = 65.9
4214 Y = 1 / FMA97: TW = W(29) / (W(29) + W(30)): FMA(30) = 1 / ((1 - TW) * Y)
4215 Z = 1 / FMA91: FMA(29) = 1 / (Z + TW * Y)
4220 MHMA91 = -1368.29 + .000704 * X1 + 21064.55 / SQR(X1) + 138.37 * LOG(X1) - 1.131 * SQR(X1)
4221 IF MHMA91 < 1.4 THEN MHMA91 = 1.4':IF MHMA91>8.3 THEN MHMA91=8.3
4222 MHMA(29) = (MHMA91 + 4.03) / 2
4223 MHMA(30) = 4.03
'
4900 'APPLY MTBM & MHMA CALIBRATION FACTORS  'COMPUTE SHUTTLE MHMA
4910 FOR I = 1 TO 34

  IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN FMA(I) = SMA(I)
  IFMA(I) = FMA(I)
  FMA(I) = MW(I) * FMA(I)

' Add SHUTTLE OFF MANHRS
  IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN MHMA(I) = SMR(I) + PF(I) * SMR(I) / (1 - PF(I))

4925 MHMA(I) = CM(I) * MHMA(I)
4930 NEXT I

5000 'SCHEDULED MAINTENANCE MODULE 'as pct of total unsch

5010 'SCHP = 23.924 - .0545 * X2 - 10.563 * LOG(X2) + 3.039 * SQR(X2) + .0215 * W(3) / V(2) + .00067 * V(1)
DSCH = -3.861213 - .0449 * X2 + 3.2794 * LOG(X1) + .02297 * SQR(X1) - .0176 * (LOG(X1)) ^ 3 - 7.289 * LOG(X2) + 2.36973 * SQR(X2)
   IF DSCH < .132 THEN DSCH = .132
   IF DSCH > .794 THEN DSCH = .794
IF CP$(5) = "RECOMPUTE" THEN SCHP = DSCH

5050 'VEHICLE ROLL-UP  - UNADJUSTED MTBM
5060 Y = 0
5070 FOR I = 1 TO 34
5080 IF OP$(I) = "DELETE" THEN GOTO 5110
5100 Y = Y + 1 / FMA(I)
5110 NEXT I
5220 VFMA = 1 / Y

FOR I = 1 TO 34
W(I) = W(I) * NRD(I)
NEXT I

END SUB
```

```
SUB MANPWR
7000 'MANPOWER COMPUTATION MODULE ******
   PMF = 21 * 8 / (X(11) * (1 - X(12)))
   VMOH = 0: OMHMA = 0: OFMHMA = 0
TMA = 0: VMH = 0: AMHMA = 0: KK = 0: TOMH = 0: TFMH = 0: APF = 0: TMP = 0

7020 FOR I = 1 TO 34  'comp unsch manhrs
7030 IF OP$(I) = "DELETE" THEN GOTO 7121
7035 KK = KK + 1
7045 MA = NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
7046 TMA = TMA + MA
7050 MH(I) = MA * MHMA(I)
7055 OMHMA = OMHMA + MA * (1 - PF(I)) * MHMA(I)
   OFMHMA = OFMHMA + MA * PF(I) * MHMA(I)
7090 OMH(I) = (1 - PF(I)) * MH(I)
7100 FMH(I) = PF(I) * MH(I)
7110 TOMH = TOMH + OMH(I)
7120 TFMH = TFMH + FMH(I)
7121 NEXT I

AMHMA = (OMHMA + OFMHMA) / TMA

'SCHEDULED HRS
TSCH = 0
IF CP$(5) = "RECOMPUTE" THEN
      TSCH = SCHP * TOMH
      FOR I = 1 TO 34
      IF OP$(I) = "DELETE" THEN GOTO DN1
      SP(I) = W(I) * TSCH / X1
DN1:      NEXT I
ELSE
      FOR I = 1 TO 34
      IF OP$(I) = "DELETE" THEN GOTO DN2
      TSCH = TSCH + SP(I)
DN2:   NEXT I
END IF

FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO 7140
MH(I) = MH(I) + SP(I)    'unsch + schd
VMH = VMH + MH(I)
MEN = (MH(I) * X(15)) / (12 * X(11) * (1 - X(12)))
MP(I) = INT(MEN + .999)
TMP = TMP + MP(I)
7140 NEXT I

' ASSGN CREWS
   C1 = 0: STP = 0: TMEN = 0
   FOR I = 1 TO 34
    IF OP$(I) = "DELETE" THEN GOTO N1
    XM = INT(CA(I) * C(I) + .999)
    C1 = C1 + XM
    MPC(I) = INT(PMF * XM + .999)
    STP = STP + MPC(I)
    IF MPC(I) > MP(I) THEN XMP = MPC(I) ELSE XMP = MP(I)
    TMEN = TMEN + XMP
N1:  NEXT I
'phase insp
PH = CSZ * LE / NP   'mnhrs per msn
MPH = INT((PH * X(15) / 12) / (X(11) * (1 - X(12))) + .999)
IF PH > 0 AND MPH < CSZ THEN MPH = CSZ

END SUB

SUB POFFEQS
3000 'POFF EQUATIONS

FOR I = 1 TO 34
W(I) = W(I) / NRD(I)
NEXT I

3010 'WBS 1,2 & 3  AIRFRAME      ***********
3050 PF(1) = .0835: PF(2) = .0835: PF(3) = (.0835 + .088) / 2
3100 'WUC12  AIRCREW COMPARTMENT      *************
3200  'WUC13/WBS9  LANDING GEAR SYSTEMS     ****************
3250 PF(9) = .02774 - 4.07E-06 * X1 - .00194 * X2 + .19316 * SQR(V(4)) + .007156 * SQR(W(9))
3251 IF PF(9) < .134 THEN PF(9) = .134
3252 IF PF(9) > .54 THEN PF(9) = .54
```

```
3299 '
4100 '******WUC23 PROPULSION SYSTEM **** WBS 6, 7 & 8 ********
4160 FOR I = 10 TO 12
4165 PF(I) = 1.14633 + 4.572E-05 * W(I) - .011456 * SQR(W(I))
4166 IF PF(I) < .2 THEN PF(I) = .2
4167 IF PF(I) > .725 THEN PF(I) = .725
4180 NEXT I
'MPS
PF(34) = 1.14633 + 4.572E-05 * W(34) - .011456 * SQR(W(34))
IF PF(34) < .2 THEN PF(34) = .2
IF PF(34) > .725 THEN PF(34) = .725
PF(34) = (PF(34) + PF(5)) / 2

3400 'WUC24    APU  WBS 9.10          ***************
3450 PF(13) = -109.83 - .1645 * LOG(X1) + .1427 * V(7) - 6.1517 * SQR(V(7)) + 15.751 * LOG(V(7)) + .066 * W(13) - 5.6832 * SQR(W(13)) + 29.071 * LOG(W(13))
3451 IF PF(13) < .03 THEN PF(13) = .03
3452 IF PF(13) > .29 THEN PF(13) = .29
3465 PF(14) = 0

3600 'WUC 42/44  WBS 10  *** ELECTRICAL SYS ******
3650 PF42 = -26.565 - .00271 * V(7) + .005143 * W(16) - .74878 * SQR(W(16)) + 6.621 * LOG(W(16))
3651 IF PF42 < .054 THEN PF42 = .054
3652 IF PF42 > .53 THEN PF42 = .53
3653 PF44 = 3.061 + 1.178E-05 * X1 - .000127 * V(3) - .42392 * LOG(X1) + .13468 * SQR(X2)
3654 IF PF44 < .03 THEN PF44 = .03
3655 IF PF44 > .47 THEN PF44 = .47
3656 PF(16) = (PF42 / FH42 + PF44 / FH44) / (1 / FH42 + 1 / FH44)
3799 '
3800 'WUC45 WBS11  HYDRAULICS SYS    ******************
3850 PF(17) = .07614 - .00181 * X2 + .001543 * SQR(X1)
3851 IF PF(17) < .014 THEN PF(17) = .014
3852 IF PF(17) > .33 THEN PF(17) = .33
3899 '
3300 'WUC14  WBS 12.00 AERO SURFACE ACTUATORS   **************
3350 PF(18) = 5.51246 + .002663 * V(5) - .000566 * W(18) - 1.193 * LOG(W(18)) + .10556 * SQR(W(18))
3351 IF PF(18) < .04 THEN PF(18) = .04
3352 IF PF(18) > .29 THEN PF(18) = .29

3900 ' WBS 12.XX AVIONICS  GENERAL  *******
3950 PF(19) = 7.1662 + .0209 * V(11) - .00128 * WAV + .1774 * SQR(WAV) - 1.734 * LOG(WAV) + .0067 * WAV / V(10)
3951 IF PF(19) < .193 THEN PF(19) = .193
3952 IF PF(19) > .532 THEN PF(19) = .532
3955 PF(20) = PF(19): PF(21) = PF(19): PF(22) = PF(19): PF(23) = PF(19): PF(24) = PF(19)
4360 PF(23) = -8.734101 + .0000122 * X1 + .007198 * X2 + .80066 * LOG(X1) - .02 * SQR(X1) - 1.45834 * X(5) + .02554 * V(9) + 4.19646 * SQR(X(5))
4361 IF PF(23) < .05 THEN PF(23) = .05
4362 IF PF(23) > .44 THEN PF(23) = .44

3500 'WUC41/47 WBS14.XX  ENVIRONMENTAL CONTROL  **************
3550 PF47 = 23.852 - .00902 * X2 - 5.247 * LOG(X1) + .301 * LOG(X1) ^ 2 - .00212 * X1 / X2
3551 IF PF47 < .02 THEN PF47 = .02
3552 IF PF47 > .33 THEN PF47 = .33
3553 PF(25) = .0932: PF(26) = PF47

4010 ' WUC49/96  WBS15   PERSONNEL PROVISIONS  ****************
4050 PF49 = .19888 + 4.938E-06 * X1 - .00205 * SQR(X1) + .0004877 * V(7)
4051 IF PF49 < .002 THEN PF49 = .002
4052 IF PF49 > .45 THEN PF49 = .45
4053 PF96 = -5.4686 + .16835 * X2 - .00448 * V(3) + .36521 * X(4) - 4.1528 * SQR(X(4)) + .178 * SQR(W(27))
4054 IF PF96 < .23 THEN PF96 = .23
4055 IF PF96 > .98 THEN PF96 = .98
4057 PF(27) = (PF49 + PF96) / 2

4200 ' WUC91/93/97  WBS 16  ***** RECOVERY & AUX SYS ********
4230 FOR I = 28 TO 33: PA(I) = .004678: NEXT I
4253 PF91 = 4.654 - .45718 * LOG(X1) + .00242 * SQR(X1)
4254 IF PF91 < .011 THEN PF91 = .011
4255 IF PF91 > .84 THEN PF91 = .84
4257 PF(29) = (PF91 + .01) / 2: PF(28) = .287: PF(30) = .01' CHECK THIS
4270 FOR I = 1 TO 34: IF PF(I) > 1 THEN PF(I) = 1
4271 NEXT I

FOR I = 1 TO 34
```

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W(I) = W(I) * NRD(I)
NEXT I
END SUB

SUB REDUNREL
13180 ' RELIABILITY SUBROUTINE
13185 ' LAUNCH RELIABILITY
13190 VR1 = 1
13200 FOR I = 1 TO 34
13210 IF OP$(I) = "DELETE" THEN GOTO 13260
    IF X(25) = 0 THEN GH = GOH(I) ELSE GH = 0
    IF FMAC(I) > 10 ^ 8 THEN R1(I) = 1: GOTO 13250
13220 L1 = 1 / FMAC(I): T = GH
13230 RT = EXP(-L1 * T)
13240 IF (I >= 10 AND I <= 15) OR (I >= 19 AND I <= 24) THEN GOSUB 13300 ELSE R1(I) = 1 - (1 - RT) ^ NRD(I)
13250 VR1 = VR1 * R1(I)
13260 NEXT I
13270 GOTO 13400
13300 'K OUT OF N SUBSYSTEM CALCULATION
13305 R1(I) = 0
13310 NN = NRD(I): GOSUB 13355: MFAC = FAC
13315 FOR J = K(I) TO NRD(I)
13320 NN = J: GOSUB 13355: JFAC = FAC
13325 NN = NRD(I) - J: GOSUB 13355
13330 C = MFAC / (JFAC * FAC)
13335 R1(I) = R1(I) + C * RT ^ J * (1 - RT) ^ (NRD(I) - J)
13340 NEXT J
13345 RETURN

13355 'FACTORIAL SUBROUTINE
13360 IF NN = 0 THEN FAC = 1: RETURN
13365 FAC = 1
13370 FOR JK = 1 TO NN
13375 FAC = FAC * JK
13380 NEXT JK
13385 RETURN
13400 'END OF POWERED PHASE
13405 VR2 = 1
13410 FOR I = 1 TO 34
13415 IF OP$(I) = "DELETE" THEN GOTO 13440
    IF X(25) = 0 THEN GH = GOH(I) ELSE GH = 0
    IF FMAC(I) > 10 ^ 8 THEN R2(I) = 1: GOTO 13435
13420 L = 1 / FMAC(I): T = GH + LOH(I)
13425 RT = EXP(-L * (GH + LF * (T - GH)))
13430 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13445 ELSE R2(I) = 1 - (1 - RT) ^ NRD(I)
13435 VR2 = VR2 * R2(I)
13440 NEXT I
13443 GOTO 13500
13445 'K OUT OF N SUBSYSTEM CALCULATION
13450 R2(I) = 0
13455 NN = NRD(I): GOSUB 13355: MFAC = FAC
13460 FOR J = K(I) TO NRD(I)
13465 NN = J: GOSUB 13355: JFAC = FAC
13470 NN = NRD(I) - J: GOSUB 13355
13475 C = MFAC / (JFAC * FAC)
13480 R2(I) = R2(I) + C * RT ^ J * (1 - RT) ^ (NRD(I) - J)
13485 NEXT J
13487 RETURN
13500 'ORBIT INSERTION
13505 VR3 = 1
13510 FOR I = 1 TO 34
13515 IF OP$(I) = "DELETE" THEN GOTO 13540
    IF X(25) = 0 THEN GH = GOH(I) ELSE GH = 0
13517 TX0 = GH: TX1 = TX0 + LOH(I)
    IF FMAC(I) > 10 ^ 8 THEN R3(I) = 1: GOTO 13535
13520 L = 1 / FMAC(I): T = GH + LOH(I) + TOH(I)
13525 RT = EXP(-L * ((T + TX0 - TX1) + LF * (TX1 - TX0)))
13530 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13545 ELSE R3(I) = 1 - (1 - RT) ^ NRD(I)
13535 VR3 = VR3 * R3(I)
13540 NEXT I
13543 GOTO 13600
13545 'K OUT OF N SUBSYSTEM CALCULATION
13550 R3(I) = 0
13555 NN = NRD(I): GOSUB 13355: MFAC = FAC
13560 FOR J = K(I) TO NRD(I)
13565 NN = J: GOSUB 13355: JFAC = FAC
13570 NN = NRD(I) - J: GOSUB 13355
13575 C = MFAC / (JFAC * FAC)
```

```
13580 R3(I) = R3(I) + C * RT ^ J * (1 - RT) ^ (NRD(I) - J)
13585 NEXT J
13587 RETURN
13600 'RENTRY
13605 VR4 = 1
13610 FOR I = 1 TO 34
13612 IF OP$(I) = "DELETE" THEN GOTO 13640
    IF X(25) = 0 THEN GH = GOH(I) ELSE GH = 0
    IF FMAC(I) > 10 ^ 8 THEN R4(I) = 1: GOTO 13635
13615 TX0 = GH: TX1 = TX0 + LOH(I): TX2 = TX1 + TOH(I)
13620 L1 = 1 / FMAC(I): T = GH + LOH(I) + TOH(I) + OOH(I)
13621 L2 = LF * L1
13622 A = (B * T(2) ^ (B - 1) / L1) ^ (1 / B)
13625 RT = EXP(-L1 * (TX2 + TX0 - TX1) - L2 * (TX1 - TX0) - (T / A) ^ B + (TX2 / A) ^ B)
13630 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13645 ELSE R4(I) = 1 - (1 - RT) ^ NRD(I)
13635 VR4 = VR4 * R4(I)
13640 NEXT I
13643 GOTO 13700
13645 'K OUT OF N SUBSYSTEM CALCULATION
13650 R4(I) = 0
13655 NN = NRD(I): GOSUB 13355: MFAC = FAC
13660 FOR J = K(I) TO NRD(I)
13665 NN = J: GOSUB 13355: JFAC = FAC
13670 NN = NRD(I) - J: GOSUB 13355
13675 C = MFAC / (JFAC * FAC)
13680 R4(I) = R4(I) + C * RT ^ J * (1 - RT) ^ (NRD(I) - J)
13685 NEXT J
13687 RETURN



13745 'K OUT OF N SUBSYSTEM CALCULATION
13750 R5(I) = 0
13755 NN = NRD(I): GOSUB 13355: MFAC = FAC
13760 FOR J = K(I) TO NRD(I)
13765 NN = J: GOSUB 13355: JFAC = FAC
13770 NN = NRD(I) - J: GOSUB 13355
13775 C = MFAC / (JFAC * FAC)
13780 R5(I) = R5(I) + C * RT ^ J * (1 - RT) ^ (NRD(I) - J)
13785 NEXT J
13790 RETURN

13700 'MISSION COMPLETION
13705 VR5 = 1
13710 FOR I = 1 TO 34
13712 IF OP$(I) = "DELETE" THEN GOTO 13740
    IF X(25) = 0 THEN GH = GOH(I) ELSE GH = 0
    IF FMAC(I) > 10 ^ 8 THEN R5(I) = 1: GOTO 13735
13715 TX0 = GH: TX1 = TX0 + LOH(I): TX2 = TX1 + TOH(I): TX3 = TX2 + OOH(I)
13720 L1 = 1 / FMAC(I): T = GH + LOH(I) + TOH(I) + OOH(I) + ROH(I)
13721 L2 = LF * L1
13722 A = (B * T(2) ^ (B - 1) / L1) ^ (1 / B)
13725 RT = EXP(-L1 * (TX2 + TX0 - TX1) - L2 * (TX1 - TX0) - (TX3 / A) ^ B + (TX2 / A) ^ B - L1 * (T - TX3))
13730 IF I = 10 OR I = 11 OR I = 12 THEN GOSUB 13745 ELSE R5(I) = 1 - (1 - RT) ^ NRD(I)
13735 VR5 = VR5 * R5(I)
13740 NEXT I
END SUB

SUB REMEQS

FOR I = 1 TO 34
W(I) = W(I) / NRD(I)
NEXT I

5500 'REMOVAL RATE EQUATIONS
5510 R11 = .1934 - 6.309E-07 * W(3)
5511 R12 = .20268 + .000588 * V(12)
5512 RR(1) = R11: RR(2) = R11: RR(3) = (R11 + R12) / 2

5580 R46 = .5623 - .0955 * X(5)
5581 IF R46 < .164 THEN R46 = .164
5582 IF R46 > .389 THEN R46 = .389
5583 RR(4) = R46: RR(5) = R46

' THERMAL SYSTEMS - SHUTTLE BASED
  FOR I = 6 TO 8: RR(I) = SRR(I): NEXT I
```

```
5520 RR(9) = .8639 - .02963 * X2
5521 IF RR(9) < .22 THEN RR(9) = .22

5610 FOR I = 10 TO 12
5611 RR(I) = .6211 - .0024872 * SQR(W(I))
5612 IF RR(I) < .157 THEN RR(I) = .157
5613 'IF RR(I) > .5120001 THEN RR(I) = .5120001
5614 NEXT I
'MPS
RR(34) = .6211 - .0024872 * SQR(W(34))
IF RR(34) < .157 THEN RR(34) = .157
RR(34) = (RR(34) + R(5)) / 2

5540 RR(13) = .579 - .0007512 * SQR(X1)
5541 IF RR(13) < 0 THEN RR(13) = .01
5542 RR(15) = SRR(15) 'SHUTTLE BASED
   RR(14) = .273

5560 RR42 = -.38533 - .001 * X2 + .17715 * LOG(X2)
5561 IF RR42 < .23 THEN RR42 = .23: IF RR42 > .539 THEN RR42 = .539
5562 RR44 = 2.3651 + .00201 * X2 - .41152 * LOG(X2)
5563 IF RR44 < .53 THEN RR44 = .53: IF RR44 > .872 THEN RR44 = .872
5565 RR(16) = (RR42 / FH42 + RR44 / FH44) / (1 / FH42 + 1 / FH44)
5570 RR(17) = .368
5530 RR(18) = .4527 - .0006677 * X2
5531 IF RR(18) < 0 THEN RR(18) = .07

5590 RRG = .39735 - 4.2659E-07 * X1 + 2.1635E-04 * SQR(X1)
5591 IF RRG < 0 THEN RRG = .235
5592 IF RRG > .726 THEN RRG = .726
   FOR I = 19 TO 24: RR(I) = RRG: NEXT I
5595 IF X(19) = 0 THEN RR(19) = .4: RR(21) = .4: RR(23) = .51
   RR(24) = -1.3 + .14458 * LOG(X1)  'A/C COMPUTER SYSTEMS
   IF RR(24) <= .235 THEN RR(24) = RRG
   IF RR(24) >= .726 THEN RR(24) = RRG

5550 R41 = .5294 - 8.914E-05 * W(25)
5551 IF R41 < 0 THEN R41 = .168
5552 R47 = .6026 - .0006758 * SQR(X1)
5553 RR(25) = R41: RR(26) = R47

5600 RR(27) = .274

5620 R97 = 2.532 - .22837 * LOG(V(3))
5621 IF R97 < 0 THEN R97 = .128
5622 R91 = 2.3489 - .35852 * LOG(X2)
5623 IF R91 < 0 THEN R91 = .461'SET EQUAL TO MEAN VALUE
5624 IF R91 > 1 THEN R91 = .461
5625 IF R97 > 1 THEN R97 = .968
'   RR(28) = ??? DRAG CHUTE
5626 RR(29) = (R91 + R97) / 2
    RR(30) = R97
    RR(32) = SRR(32)

FOR I = 1 TO 34
W(I) = W(I) * NRD(I)
NEXT I

' BEGAN SHUTTLE VALUES
   FOR I = 1 TO 34
   IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN RR(I) = SRR(I)
   NEXT I
'COMPUTE AVG REMOVAL RATE
  AREM = 0: SL = 0
FOR I = 1 TO 34
  IF OP$ = "DELETE" THEN GOTO BTM
  AREM = AREM + RR(I) / FMAS(I)
  SL = SL + 1 / FMAS(I)
BTM: NEXT I
AREM = AREM / SL
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 * X(1) - 1.38718E-10 * X(1) ^ 2
```

```
11150 V(4) = CINT(V(4))
11160 IF V(4) < 3 THEN V(4) = 3
11170 'NBR CONTROL SURFACES
11180 V(6) = 3.588737 + .0005281 * X(1) + .09493 * 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 - .001425 * X1 + 2.0752E-09 * X1 ^ 2 + .007467 * V(3) - 1.0377 * SQR(V(3)) + .4828 * SQR(X1) + 14.97 * SQR(V(6)) - .017811 * V(6) ^ 2
11230 IF V(5) < 5 THEN V(5) = 5
   IF V(5) > 42 THEN V(5) = 42
11240 V(5) = INT(V(5))
11280 'KVA MAX
11290 V(7) = -214.812 + .001098 * X(1) + 25.1571 * LOG(X(1))
11300 IF V(7) < 11 THEN V(7) = 11
   IF V(7) > 484 THEN V(7) = 484
11340 'NBR AVIONICS SYSTEMS  (TOTSUBS)
11350 V(10) = -40.4242 - 1.879E-05 * X(1) + 6.192823 * LOG(X(1))
11360 IF V(10) < 9 THEN V(10) = 9
11370 V(10) = CINT(V(10))
11420 'NBR DIFFERENT AVIONICS SUBSYSTEMS
11430 V(11) = 9.674 - 1.858 * LOG(X(1)) + .87684 * V(10) + 1.4557 * LOG(WAV)
11440 IF V(11) < 5 THEN V(11) = 5: IF V(11) > V(10) THEN V(11) = V(10)
11450 V(11) = CINT(V(11))
11460 'BTU COOLING
11470 V(12) = -1114.52 - 12.0178 * X2 + .009405 * X2 ^ 2 + 230.872 * SQR(X2)
11480 IF V(12) < 25 THEN V(12) = 25
   IF V(12) > 470.5 THEN V(12) = 470.5
11510 'NBR HYDRAULICS SUBSYSTEMS
11520 V(8) = 13.48 - .56854 * X2 + .002409 * V(3) + .433276 * SQR(X1)
11530 IF V(8) < 8 THEN V(8) = 8
   IF V(8) > 76 THEN V(8) = 76
11540 V(8) = CINT(V(8))
11550 'NBR INTERNAL FUEL TANKS
11560 V(9) = -13.2236 + 1.851772 * LOG(X(1))
11570 IF V(9) < 2 THEN V(9) = 2
11580 IF V(9) > 12 THEN V(9) = 12
11590 V(9) = CINT(V(9))
   V(13) = V(9)
11620 'FUSELAGE AREA
11630 V(1) = -8832.74 + .082862 * X(1) + 1274.76 * LOG(X(1)) - 32.456 * SQR(X(1))
11640 IF V(1) < 478 THEN V(1) = 478
11650 'FUSELAGE VOLUME
11660 V(2) = -47618.5 + 22143 * LOG(X2) - 5743.09 * SQR(X2) + .42623 * X2 ^ 2
11670 IF V(2) < 571 THEN V(2) = 571

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
'XC1 = avg crew size
'CZ(I) = nbr crews assigned
FOR I = 1 TO 9: CZ(I) = 0: NEXT I

'STRUCTURAL
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 1 TO 3
IF OP$(I) = "DELETE" THEN GOTO Q1
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(1) = CZ(1) + CA(I)
Q1: NEXT I
FOR I = 1 TO 3
IF OP$(I) = "DELETE" THEN GOTO Q11
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
TEMP = PF(I) * MHMA(I) / C(I)
Z = Z + TEMP * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q11: NEXT I
FRS(1) = XF
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MAS(1) = X
MTROS(1) = Y
MTRFS(1) = Z
REMS(1) = XX
SMT(1) = YY
SMTF(1) = ZZ
SC(1) = XC1

'TANKS
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 4 TO 5
IF OP$(I) = "DELETE" THEN GOTO Q2
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(2) = CZ(2) + CA(I)
Q2: NEXT I
FOR I = 4 TO 5
IF OP$(I) = "DELETE" THEN GOTO Q22
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * MHMA(I) / C(I)) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)

Q22: NEXT I
FRS(2) = XF
MAS(2) = X
MTROS(2) = Y
MTRFS(2) = Z
REMS(2) = XX
SMT(2) = YY
SMTF(2) = ZZ
SC(2) = XC1

'THERMAL PROTECTION
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 6 TO 8
IF OP$(I) = "DELETE" THEN GOTO Q3
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(3) = CZ(3) + CA(I)
Q3: NEXT I
FOR I = 6 TO 8
IF OP$(I) = "DELETE" THEN GOTO Q33
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * MHMA(I) / C(I)) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q33: NEXT I
FRS(3) = XF

MAS(3) = X
MTROS(3) = Y
MTRFS(3) = Z
REMS(3) = XX
SMT(3) = YY
SMTF(3) = ZZ
SC(3) = XC1

' PROPULSION
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 10 TO 12
IF OP$(I) = "DELETE" THEN GOTO Q4
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(4) = CZ(4) + CA(I)
Q4: NEXT I
IF OP$(34) = "DELETE" THEN GOTO SKQ
X = X + NRD(34) * (POH(34) / FMAT(34) + THRS(34) / FMAS(34))
CZ(4) = CZ(4) + CA(34)
SKQ: FOR I = 10 TO 12
IF OP$(I) = "DELETE" THEN GOTO Q44
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * MHMA(I) / C(I)) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
```

```
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q44: NEXT I
IF OP$(34) = "DELETE" THEN GOTO QA4
Y = Y + TSKT(34) * (NRD(34) * (POH(34) / FMAT(34) + THRS(34) / FMAS(34)) / X)
Z = Z + (PF(34) * MHMA(34) / C(34)) * (NRD(34) * (POH(34) / FMAT(34) + THRS(34) / FMAS(34)) / X)
XX = XX + RR(34) * (NRD(34) * (POH(34) / FMAT(34) + THRS(34) / FMAS(34)) / X)
YY = YY + .98 * SP(34) / C(34)
ZZ = ZZ + .02 * SP(34) / C(34)
XC1 = XC1 + C(34) * (NRD(34) * (POH(34) / FMAT(34) + THRS(34) / FMAS(34)) / X)
XF = XF + FR(34) * (NRD(34) * (POH(34) / FMAT(34) + THRS(34) / FMAS(34)) / X)

QA4: FRS(4) = XF
MAS(4) = X
MTROS(4) = Y
MTRFS(4) = Z
REMS(4) = XX
SMT(4) = YY
SMTF(4) = ZZ
SC(4) = XC1

'POWER/ELECTRICAL
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 13 TO 16
IF OP$(I) = "DELETE" THEN GOTO Q5
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(5) = CZ(5) + CA(I)
Q5: NEXT I
FOR I = 13 TO 16
IF OP$(I) = "DELETE" THEN GOTO Q55
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * MHMA(I) / C(I)) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q55: NEXT I
FRS(5) = XF
MAS(5) = X
MTROS(5) = Y
MTRFS(5) = Z
REMS(5) = XX
SMT(5) = YY
SMTF(5) = ZZ
SC(5) = XC1

' MECHANICAL SYSTEMS
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 17 TO 18
IF OP$(I) = "DELETE" THEN GOTO Q6
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(6) = CZ(6) + CA(I)
Q6: NEXT I
X9 = NRD(9) * (POH(9) / FMAT(9) + THRS(9) / FMAS(9))
IF OP$(9) < > "DELETE" THEN X = X + X9
FOR I = 17 TO 18
IF OP$(I) = "DELETE" THEN GOTO Q66
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * MHMA(I) / C(I)) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q66: NEXT I

IF SEL$(9) < > "DELETE" AND X > 0 THEN
      Y = Y + TSKT(9) * X9 / X
      Z = Z + (PF(9) * MHMA(9) / C(9)) * (X9) / X
      XX = XX + RR(9) * X9 / X
      YY = YY + .98 * SP(9) / C(9)
      ZZ = ZZ + .02 * SP(9) / C(9)
      XC1 = XC1 + C(9) * X9 / X
      XF = XF + FR(9) * X9 / X
      CZ(6) = CZ(6) + CA(9)
END IF
```

```
FRS(6) = XF
MAS(6) = X
MTROS(6) = Y
MTRFS(6) = Z
REMS(6) = XX
SMT(6) = YY
SMTF(6) = ZZ
SC(6) = XC1

'AVIONICS
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 19 TO 24
IF OP$(I) = "DELETE" THEN GOTO Q7
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(7) = CZ(7) + CA(I)
Q7: NEXT I
FOR I = 19 TO 24
IF OP$(I) = "DELETE" THEN GOTO Q77
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * MHMA(I) / C(I)) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q77: NEXT I
FRS(7) = XF
MAS(7) = X
MTROS(7) = Y
MTRFS(7) = Z
REMS(7) = XX
SMT(7) = YY
SMTF(7) = ZZ
SC(7) = XC1

'ECS/LIFE SUPPORT
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 25 TO 29
IF OP$(I) = "DELETE" THEN GOTO Q8
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(8) = CZ(8) + CA(I)
Q8: NEXT I
FOR I = 25 TO 29
IF OP$(I) = "DELETE" THEN GOTO Q88
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * MHMA(I) / C(I)) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q88: NEXT I
FRS(8) = XF
MAS(8) = X
MTROS(8) = Y
MTRFS(8) = Z
REMS(8) = XX
SMT(8) = YY
SMTF(8) = ZZ
SC(8) = XC1
'AUXILIARY SYSTEMS
X = 0: Y = 0: Z = 0: XX = 0: YY = 0: XC1 = 0: ZZ = 0: XF = 0
FOR I = 30 TO 33
IF OP$(I) = "DELETE" THEN GOTO Q9
X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
CZ(9) = CZ(9) + CA(I)
Q9: NEXT I
FOR I = 30 TO 33
IF OP$(I) = "DELETE" THEN GOTO Q99
Y = Y + TSKT(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Z = Z + (PF(I) * MHMA(I) / C(I)) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XX = XX + RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
YY = YY + .98 * SP(I) / C(I)
ZZ = ZZ + .02 * SP(I) / C(I)
XC1 = XC1 + C(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
XF = XF + FR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)) / X)
Q99: NEXT I
FRS(9) = XF
```

```
MAS(9) = X
MTROS(9) = Y
MTRFS(9) = Z
REMS(9) = XX
SMT(9) = YY
SMTF(9) = ZZ
SC(9) = XC1
END SUB

SUB SPACEMTBM
 'MODULE TO DETERMINE SPACE ADJ MTBM
2020 FOR J = 1 TO 34
IF (SEL$(J) = "SHUTTLE" AND X(6) = 0) OR PI(J) = 0 OR OP$(J) = "DELETE" THEN GOTO 2100
2030 T0 = GOH(J): T1 = T0 + LOH(J): T2 = T1 + TOH(J)
2040 T3 = T2 + OOH(J): T4 = T3 + ROH(J)
L1 = 1 / FMA(J): L2 = LF * L1
2070 GOSUB 2200
2080 FMAS(J) = MEAN

 MA = THRS(J) / (FMAS(J) * PI(J))
 IF POH(J) > 0 AND PI(J) < 1 THEN FMAT(J) = POH(J) / ((1 - PI(J)) * MA) ELSE FMAT(J) = 10 ^ 6
2100 NEXT J
EXIT SUB

2200 'MODULE TO COMPUTE SPACE ADJUSTED MTBM
2210 A = (B * T(2) ^ (B - 1) / L1) ^ (1 / B)
2220 A1 = (1 - EXP(-L1 * T0)) / L1
2230 A2 = EXP(-L1 * T0) * (1 - EXP(-L2 * (T1 - T0))) / L2
2240 A3 = EXP(-L2 * (T1 - T0)) * (EXP(-L2 * T0) / L2 - EXP(-L2 * (T2 + T0 - T1)) / L2)
2255 GOSUB 2320 'FIND A4 USING SIMPSON'S RULE
2260 A4 = EXP(-L1 * (T2 + T0 - T1) - L2 * (T1 - T0) + (T2 / A) ^ B) * AREA
2270 A5 = EXP(-L1 * (T2 + T0 - T1) - L2 * (T1 - T0) - (T3 / A) ^ B + (T2 / A) ^ B) * (1 - EXP(-L1 * (T4 - T3))) / L1
2280 MEAN = A1 + A2 + A3 + A4 + A5
2290 RT4 = EXP(-L1 * (T2 + T0 - T1) - L2 * (T1 - T0) - (T3 / A) ^ B + (T2 / A) ^ B - L1 * (T4 - T3))
2300 MEAN = MEAN / (1 - RT4)
2310 RETURN
2320 N = INT((T3 - T2) / .5)
2330 IF N = 0 THEN AREA = 0: RETURN
2340 DX = (T3 - T2) / N
2350 FX = 4
2360 Z1 = T2: SUM = EXP(-(Z1 / A) ^ B)
2370 FOR I = 1 TO N
2380 Z1 = Z1 + DX
2390 Y1 = EXP(-(Z1 / A) ^ B)
2400 IF I = N THEN FX = 1
2410 SUM = SUM + FX * Y1
2420 IF FX = 4 THEN FX = 2 ELSE FX = 4
2430 NEXT I
2440 AREA = DX * SUM / 3
2450 RETURN
END SUB

SUB SPARES
8000 'SPARES CALCULATIONS
8010 ARR = 0: TS = 0: KK = 0: TNR = 0
8020 FOR I = 1 TO 34
8030 IF OP$(I) = "DELETE" THEN GOTO 8180
8040 NR(I) = RR(I) * (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)))   ' MEAN NBR REMOVALS
8045 MN = X(15) * NR(I)   'mean nbr removals per yr
   MN = DTAT * MN / 365      'mean nbr in pipeline  DTAT =depot turnaround time
8050 IF MN <= 20 THEN GOSUB 8300 ELSE GOSUB NORM'COMPUTE FILL RATE RQMT - POISSON/NORM
8055 S(I) = STK: FR(I) = F
8060 TNR = TNR + NR(I)
8150 ARR = ARR + RR(I)
8160 TS = TS + S(I)
8170 KK = KK + 1
8180 NEXT I
8190 ARR = ARR / KK
8200 GOTO BOT
8300 ' COMPUTE SPARES USING POISSON DIST
8310 P = EXP(-MN): F = P
8320 IF P >= X(13) THEN JD = 1: GOTO 8370
8330 JD = 1: F = P
8340 P = P * MN / JD
8350 JD = JD + 1: F = F + P
8360 IF F < X(13) THEN GOTO 8340
8370 STK = JD - 1
8380 RETURN
```

```
'NORMAL (STRONG'S) APPROXIMATION
NORM: FC = 1 - X(13)
SD = SQR(MN)
Z = (.5 - FC) * ((.14822401# / (.29670919# - (.5 - FC) ^ 2)) + (.0014532591# / (.2505217 - (.5 - FC) ^ 2)) + 2.0489)
STK = CINT(MN + Z * SD)
F = 1 - FC
RETURN

BOT: 'RETURN TO MAIN

END SUB

SUB TECH
2500 'TECHNOLOGY ADJUSTMENT MODULE
2510 Y = 0
2520 FOR I = 1 TO 34
2530 IF OP$(I) = "DELETE" THEN GOTO 2560
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN XYZ = 1992 ELSE XYZ = 1986
2540 FMA(I) = FMA(I) * (1 + TG(I)) ^ (YR - XYZ)
    FMA(I) = FMA(I) * X(24) ^ X(23)     'rel growth
2550 Y = Y + 1 / FMA(I)

'compute inherent and induced MTBM's
THRS(I) = GOH(I) + LOH(I) + TOH(I) + OOH(I) + ROH(I)
IF SEL$(I) = "SHUTTLE" AND X(6) = 0 AND PI(I) > 0 THEN
 MA = (POH(I) + THRS(I)) / FMA(I)
 MMA = PI(I) * MA: GMA = MA - MMA
 IF POH(I) > 0 AND GMA > 0 THEN FMAT(I) = POH(I) / GMA ELSE FMAT(I) = 10 ^ 6
 IF MMA > 0 THEN FMAS(I) = THRS(I) / MMA ELSE FMAS(I) = 10 ^ 6
END IF
2560 NEXT I
2570 TVFMA = 1 / Y
EXIT SUB


END SUB
```

Display Module
File: RAM2.BAS

```
DECLARE SUB RAW ()
DECLARE SUB TURNDIS ()
DECLARE SUB AGRT ()
DECLARE SUB SIMTURN ()
DECLARE SUB SUMMARY ()
DECLARE SUB MANDISPLAY ()
DECLARE SUB SPAREDISPLAY ()
DECLARE SUB TURNTIME ()
DECLARE SUB MAINTDIS ()
DECLARE SUB RELDISPLAY ()
  'NASA, LANGLEY RESEARCH CENTER
  'MTBM COMPUTATIONAL MODEL - NASA RESEARCH GRANT -
  'DEVELOPED BY C. EBELING, UNIV OF DAYTON  11/29/95 (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, VR, AREM
  COMMON SHARED VFMA, TVFMA, SVFMA, CVFMA, OMHMA, OFMHMA, TMA, AMHMA
  COMMON SHARED SCHP, VMH, TOMH, TFMH, APF, P1, P2, P3, WAV, FH42, FH44
  COMMON SHARED FMA11, FMA12, VNAM$, ARR, TNR, TS, SKIP, TSCH, DTAT
  COMMON SHARED SMP, TMP, VMOH, WGTF, WING, WF, PWF, TMEN, NP, LE
  COMMON SHARED ETREL, SRBREL, ETS, SRBS, RTITLE$, ABTF$, PH, MPH, CSZ
  COMMON SHARED STP, STE, MTE, TME, STF, MTF, TMF, C1, PMF, SVADD, FZ
  COMMON SHARED AVCREW, GTT, ATSK, TTX, TTZ, TTW, TTYA, TJJ, TXY, TJX
  COMMON SHARED PARAF, PB17, ISJ, DSCH, WC
  DIM SHARED WBS$(35), X(50), NAM$(50), THRS(35), MHMA(35), MH(35), MP(35), OMH(35), FMH(35)
  DIM SHARED SEL$(35), T(10), CP$(9), CA(35), RELF(35), RF(35)
  DIM SHARED GOH(35), LOH(35), TOH(35), OOH(35), ROH(35), R(35), TSKT(35), POH(35)
  DIM SHARED V(15), SNAM$(15), FMAT(35), FMAC(35), FMAS(35), S(35), SMA(35), SMR(35)
  DIM SHARED MW(35), C(35), CM(35), OP$(35), TG(35), PWTS(35)
  DIM SHARED FMA(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
  DIM SHARED NRD(35), K(35), R1(35), R2(35), R3(35), R4(35), R5(35)
  DIM SHARED PWT1(35), PWT2(35), PWT3(35), PWT4(35), SRR(35)
  DIM SHARED ETSUB$(5), ETMBA(5), ETHRS(5), ETABR(5), ETMTR(5), ETR(5), ETCREW(5)
  DIM SHARED SRBSUB$(5), SRBMBA(5), SRBHRS(5), SRBABR(5), SRBMTR(5), SRBR(5), SRBCREW(5)
  DIM SHARED SWBS$(10), MAS(9), MTROS(9), MTRFS(9), REMS(9), SMT(9), SMTF(9), SC(9), FRS(9)
  DIM SHARED PI(35), CZ(9), SP(35), MA(35), TT(35), MPC(35), SW(35), IFMA(35)
  COMMON SHARED PI(), CZ(), SP(), MA(), TT(), MPC(), SW(), IFMA()
  COMMON SHARED SWBS$(), MAS(), MTROS(), MTRFS(), REMS(), SMT(), SMTF(), SC(), FRS()
  COMMON SHARED WBS$(), X(), NAM$(), THRS(), MHMA(), MH(), MP(), OMH(), FMH()
  COMMON SHARED SEL$(), T(), CP$(), CA(), RELF(), RF()
  COMMON SHARED GOH(), LOH(), TOH(), OOH(), ROH(), R(), TSKT(), POH()
  COMMON SHARED V(), SNAM$(), FMAT(), FMAC(), FMAS(), S(), SMA(), SMR()
  COMMON SHARED MW(), C(), CM(), OP$(), TG(), PWTS()
  COMMON SHARED FMA(), PF(), PA(), RR(), W(), NR(), FR()
  COMMON SHARED NRD(), K(), R1(), R2(), R3(), R4(), R5()
  COMMON SHARED PWT1(), PWT2(), PWT3(), PWT4(), SRR()
  COMMON SHARED ETSUB$(), ETMBA(), ETHRS(), ETABR(), ETMTR(), ETR(), ETCREW()
  COMMON SHARED SRBSUB$(), SRBMBA(), SRBHRS(), SRBABR(), SRBMTR(), SRBR(), SRBCREW()

SUB AGRT
'***** MODULE FOR AGGREGATED RESULTS ******
SWBS$(1) = "Structural": SWBS$(2) = "Fuel/Oxid Tanks": SWBS$(3) = "Thermal/Tiles": SWBS$(4) = "Propulsion"
SWBS$(5) = "Power/Electrical": SWBS$(6) = "Mechanical Sys": SWBS$(7) = "Avionics": SWBS$(8) = "ECS/Life Support"
SWBS$(9) = "Auxiliary Systems"

CLS : COLOR 14
PRINT TAB(5); "Aggregated System Report - System Aggregation - page 1": COLOR 11
PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
COLOR 7
PRINT TAB(1); SWBS$(1); TAB(30); SWBS$(2); TAB(50); SWBS$(9): COLOR 13
FOR I = 1 TO 2: PRINT TAB(3); WBS$(I); TAB(31); WBS$(I + 3); TAB(52); WBS$(I + 29): NEXT I
PRINT TAB(3); WBS$(3); TAB(52); WBS$(32): COLOR 7
PRINT TAB(1); SWBS$(3); TAB(30); SWBS$(4), : COLOR 13: PRINT TAB(52); WBS$(33)
FOR I = 6 TO 8
IF I = 6 OR I = 8 THEN PRINT TAB(3); WBS$(I); TAB(31); WBS$(I + 4)
IF I = 7 THEN PRINT TAB(3); WBS$(I); TAB(31); WBS$(I + 4); TAB(53); WBS$(34)
NEXT I
COLOR 7
PRINT TAB(1); SWBS$(5); TAB(30); SWBS$(6): COLOR 13
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FOR I = 13 TO 14: PRINT TAB(3); WBS$(I); TAB(31); WBS$(I + 4): NEXT I
PRINT TAB(3); WBS$(15); TAB(31); WBS$(9)
PRINT TAB(3); WBS$(16): COLOR 7
PRINT TAB(1); SWBS$(7); TAB(30); SWBS$(8): COLOR 13
FOR I = 19 TO 23: PRINT TAB(3); WBS$(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$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
COLOR 2
PRINT : PRINT TAB(2); "Aggregated"; TAB(20); "Nbr of"; TAB(35); "On-Veh MTTR"; TAB(50); "On-Veh Sched"; TAB(65); "Ave Crew"
PRINT TAB(2); "System"; TAB(20); "Maint Actions"; TAB(35); "per MA (hrs)"; TAB(48); "maint time(hrs)"; TAB(65); "Size"
PRINT : COLOR 12
T0 = 0: T1 = 0: T2 = 0
FOR I = 1 TO 9
T0 = T0 + MAS(I)
T1 = T1 + MTROS(I): T2 = T2 + SMT(I): T3 = T3 + SC(I)
IF MAS(I) > 0 THEN
  NC = NC + 1
  PRINT TAB(1); SWBS$(I); TAB(20); MAS(I); TAB(35); MTROS(I); TAB(50); SMT(I); TAB(65); SC(I)
END IF
NEXT I
PRINT
PRINT TAB(2); "Total"; TAB(20); T0; TAB(35); T1; TAB(50); T2; TAB(65); T3
PRINT TAB(2); "Average"; TAB(20); T0 / NC; TAB(35); T1 / NC; TAB(50); T2 / NC; TAB(65); T3 / NC
PRINT : COLOR 7: PRINT "note:  MTTR's assume the Avg Crew Size and are based"
PRINT "upon a weighted avg (wts-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$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
COLOR 2
PRINT : PRINT TAB(2); "Aggregated"; TAB(20); "Removal"; TAB(35); "Off-Veh MTTR"; TAB(50); "Off-Veh Sched"; TAB(65); "Nbr Crews"
PRINT TAB(2); "System"; TAB(20); "Rate"; TAB(35); "in hours"; TAB(48); "maint time(hrs)"; TAB(65); "Assigned"
PRINT : COLOR 12
T0 = 0: T1 = 0: T2 = 0: T3 = 0
FOR I = 1 TO 9
T0 = T0 + REMS(I)
T1 = T1 + MTRFS(I): T2 = T2 + SMTF(I): T3 = T3 + CZ(I)
IF MAS(I) > 0 THEN PRINT TAB(1); SWBS$(I); TAB(20); REMS(I); TAB(35); MTRFS(I); TAB(50); SMTF(I); TAB(65); CZ(I)
NEXT I
PRINT
PRINT TAB(2); "Total"; TAB(35); T1; TAB(50); T2; TAB(65); T3
PRINT TAB(2); "Average"; TAB(20); T0 / NC; TAB(35); T1 / NC; TAB(50); T2 / NC; TAB(65); T3 / NC
PRINT : COLOR 7: PRINT "note:  MTTR's assume the Avg Crew Size and are based"
PRINT "upon a weighted avg (wts- fraction of total failures) of each subsystem."

COLOR 2: PRINT : INPUT "ENTER RETURN ..."; RET
EXIT SUB

END SUB

SUB DISPLAY
5800 'DISPLAY MENU
5810 CLS : COLOR 11
5815 PRINT TAB(15); "NASA LRC - RELIABILITY/MAINTAINABILITY MODEL"; TAB(60); VNAM$
5820 PRINT : PRINT TAB(22); "SCREEN DISPLAY (OUTPUT) MENU": PRINT : COLOR 15
5830 PRINT TAB(15); "NBR"; TAB(35); "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"
    PRINT TAB(15); "6........SYSTEM PERFORMANCE SUMMARY"
    PRINT TAB(15); "7........AGGREGATED SYSTEM REPORT"
    PRINT TAB(15); "8........INITIAL MTBMs and MTTRs"
5880 PRINT TAB(15); "return.....exit to main menu"
    COLOR 2
5890 LOCATE 20, 20: INPUT "ENTER SELECTION"; NB3
5900 IF NB3 = 1 THEN CALL RELDISPLAY
5910 IF NB3 = 2 THEN CALL MAINTDIS
5920 IF NB3 = 3 THEN CALL MANDISPLAY
5930 IF NB3 = 4 THEN CALL SPAREDISPLAY
5940 IF NB3 = 5 THEN CALL TURNDIS
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    IF NB3 = 6 THEN CALL SUMMARY
    IF NB3 = 7 THEN CALL AGRT
    IF NB3 = 8 THEN CALL RAW
5950 IF NB3 = 0 THEN EXIT SUB
5960 GOTO 5810
END SUB

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$(I) = "DELETE" THEN GOTO NX5
    K = K + 1
    X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
    Y = Y + MHMA(I)
    Z = Z + (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))) * MHMA(I)
NX5: NEXT I
    YA = Y / K
7505 IO = 1: IE = 18
7510 CLS : COLOR 14
7520 PRINT TAB(15); "MAINTAINABILTY REPORT - at mission nbr."; X(24); " - page 1"
7530 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
7548 COLOR 7
7550 PRINT TAB(1); "WBS"; TAB(10); "UNSCHEDULED ON/OFF"; TAB(30); "MAINT ACTIONS/MSN"; TAB(50); "AVG MANHR/MA"; TAB(65); "AVG MANHRS/MSN"
7570 FOR I = IO TO IE
7580 IF OP$(I) = "DELETE" THEN GOTO 7592
    IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
7590 PRINT TAB(1); WBS$(I); TAB(32); NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)); TAB(50); MHMA(I); TAB(65); (NRD(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
7593 PRINT : COLOR 2
7594 IF IO = 1 THEN IO = 19: IE = 34: PRINT : INPUT "ENTER RETURN..."; RET: GOTO 7510
7595 COLOR 13
7600 PRINT TAB(3); "TOTALS-UNSCHED ON+OFF VEH"; TAB(32); TMA; TAB(47); AMHMA; "WT-AVG"; TAB(65); OMHMA + OFMHMA
7610 COLOR 2
7620 INPUT "ENTER RETURN ..."; RET
    KA = 0: AV = 0
    X = 0: Y = 0: Z = 0: K = 0: ZB = 0'AVIONICS ROLLUP
    FOR I = 19 TO 24
    IF OP$(I) = "DELETE" THEN GOTO NX6
    K = K + 1
    X = X + OMH(I)
    Y = Y + FMH(I)
    ZB = ZB + (1 / FMA(I))
    Z = Z + ((1 - PF(I)) * MHMA(I) / C(I)) * (1 / FMA(I))
NX6: NEXT I
    ZA = Z / ZB

FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO NZZ
   AV = AV + ((1 - PF(I)) * MHMA(I) / C(I)) * (1 / FMA(I))
   KA = KA + (1 / FMA(I))
NZZ: NEXT I

7630 IO = 1: IE = 18
7640 CLS : COLOR 14
7650 PRINT TAB(15); "MAINTAINABILTY REPORT - at mission nbr."; X(24); " - page 2"
COLOR 9: PRINT "note:  MTTR is for a single maintenance action"
7680 COLOR 7
7690 PRINT TAB(1); "WBS"; TAB(16); "UNSCHEDULED"; TAB(32); "ON-VEH MH"; TAB(47); "OFF-VEH MH"; TAB(60); "ON-VEH MTTR"
7710 FOR I = IO TO IE
7720 IF OP$(I) = "DELETE" THEN GOTO 7740
IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
PRINT TAB(1); WBS$(I); TAB(32); OMH(I); TAB(50); FMH(I); TAB(65); ((1 - PF(I)) * MHMA(I) / C(I))
    IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(29); X; TAB(47); Y; TAB(62); ZA; "(WAVG)"
7740 NEXT I
7750 PRINT : COLOR 2
7752 IF IO = 1 THEN IO = 19: IE = 34: PRINT : INPUT "ENTER RETURN.."; RET: GOTO 7640
    COLOR 13
    PRINT TAB(3); "UNSCHEDULED"; TAB(32); TOMH; TAB(50); TFMH; TAB(63); AV / KA; "(WAVG)"
7755 PRINT TAB(5); "SCHEDULED"; TAB(32); TSCH
    PRINT TAB(5); "PHASE INSPECTION"; TAB(32); PH
7770 PRINT TAB(5); "TOTAL"; TAB(32); TOMH + TSCH + PH
7780 COLOR 2
7790 INPUT "ENTER RETURN ..."; RET
```

```
IO = 1: IE = 18
NW6: CLS : COLOR 14
PRINT TAB(15); "MAINTAINABILTY REPORT - at mission nbr."; X(24); " - page 3"
   X = 0: Y = 0    'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NY6
   X = X + OMH(I) + FMH(I)
   Y = Y + SP(I)
NY6: NEXT I
   COLOR 7
PRINT TAB(1); "WBS"; TAB(32); "SCHED MH"; TAB(47); "UNSCHED MH"; TAB(65); "TOTAL MH"
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO NZ7
IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
PRINT TAB(1); WBS$(I); TAB(32); SP(I); TAB(50); OMH(I) + FMH(I); TAB(65); SP(I) + OMH(I) + FMH(I)
IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(29); Y; TAB(47); X; TAB(62); X + Y
NZ7: NEXT I
PRINT : COLOR 2
IF IO = 1 THEN IO = 19: IE = 34: PRINT : INPUT "ENTER RETURN.."; RET: GOTO NW6
COLOR 13
PRINT TAB(5); "TOTAL-ON+OFF VEH"; TAB(32); TSCH; TAB(50); TOMH + TFMH; TAB(65); TSCH + TOMH + TFMH
COLOR 2
INPUT "ENTER RETURN ..."; RET

   X = 0: Y = 0: 'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NY8
   X = X + NRD(I) * POH(I) / FMAT(I)
   Y = Y + NRD(I) * THRS(I) / FMAS(I)
NY8: NEXT I
IO = 1: IE = 18
TXX = 0: TYY = 0
NY7: CLS : COLOR 14
   PRINT TAB(10); "MAINTAINABILTY REPORT - at mission nbr."; X(24); " - page 4"
   COLOR 7
   PRINT TAB(1); "WBS"; TAB(32); "GRND PROC MA"; TAB(50); "MSN MA"; TAB(65); "TOTAL MA"
   PRINT TAB(32); "(external)"; TAB(50); "(inherent)"
   FOR I = IO TO IE
   IF OP$(I) = "DELETE" THEN GOTO NY9
   IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
   XX = NRD(I) * POH(I) / FMAT(I): YY = NRD(I) * THRS(I) / FMAS(I)
   TXX = TXX + XX: TYY = TYY + YY
   PRINT TAB(1); WBS$(I); TAB(32); XX; TAB(50); YY; TAB(65); XX + YY
   IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(29); X; TAB(47); Y; TAB(62); X + Y
NY9: NEXT I
   IF IO = 1 THEN IO = 19: IE = 34: PRINT : INPUT "ENTER RETURN.."; RET: GOTO NY7
   COLOR 13
   PRINT TAB(5); "TOTAL"; TAB(32); TXX; TAB(50); TYY; TAB(65); TXX + TYY
   COLOR 2
   INPUT "ENTER RETURN ..."; RET

END SUB

SUB MANDISPLAY
7800 'MANPOWER DISPLAY
   X = 0: Y = 0: Z = 0: ASTP = 0      'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NX8
   X = X + MH(I)
   Z = Z + MP(I)
   ASTP = ASTP + C(I)
NX8: NEXT I
   Y = X(15) * X / 12
7803 IO = 1: IE = 18
7805 CLS : COLOR 14
7810 PRINT TAB(25); "MANPOWER REPORT - at mission nbr."; X(24); " page 1"
7820 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
   COLOR 3: PRINT "manpwr is computed from manhrs/mo divided by avail direct hrs per mo per person"
   PRINT "available hrs per mo is"; X(11); "and the percent indirect is"; 100 * X(12)
7850 PRINT TAB(1); "WBS"; TAB(25); "MAINT. MANHRS/MSN"; TAB(45); "MANHRS/MO"; TAB(60); "MANPWR"
7870 FOR I = IO TO IE
7880 IF OP$(I) = "DELETE" THEN GOTO 7900
   IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
7890 PRINT TAB(1); WBS$(I); TAB(30); MH(I); TAB(45); X(15) * MH(I) / 12; TAB(60); MP(I)
   IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(28); X; TAB(43); Y; TAB(58); Z
7900 NEXT I
7910 COLOR 2
7912 IF IO = 1 THEN IO = 19: IE = 34: INPUT "ENTER RETURN ..."; RET: GOTO 7805
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7920 COLOR 13
7930 PRINT TAB(5); "TOTAL"; TAB(30); VMH; TAB(45); VMH * X(15) / 12; TAB(60); TMP
    PRINT TAB(5); "Pad Svc"; TAB(60); X(14)
   PRINT TAB(5); "Phase inspt"; TAB(30); PH; TAB(45); PH * X(15) / 12; TAB(60); MPH
7940 COLOR 2
7950 INPUT "ENTER RETURN TO CONTINUE..."; RET
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```
IO = 1: IE = 18
MX1: CLS : COLOR 14
PRINT TAB(25); "MANPOWER REPORT - at mission nbr."; X(24); " page 2"
COLOR 3: PRINT "Rqd crews is computed from manpwr divided by avg crew.  Asgn manpwr is based on"
PRINT "a posn manning fac of"; PMF; ".  Max mpwr is MAX {manpwr, asgn manpwr}"
COLOR 7: PRINT TAB(28); "AVG"; TAB(38); "RQD"; TAB(47); "CUR ASGD"; TAB(56); "ASGN"; TAB(65); "ASGN"; TAB(72); "MAX"
PRINT TAB(1); "WBS"; TAB(28); "CREW SIZE"; TAB(38); "CREWS"; TAB(47); "CREWS"; TAB(56); "POSNS"; TAB(65); "MNPWR"; TAB(72); "MPWR"
FOR I = IO TO IE
 IF OP$(I) = "DELETE" THEN GOTO MX2
 IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
 IF MPC(I) > MP(I) THEN XM = MPC(I) ELSE XM = MP(I)
 NC = INT(MP(I) / C(I) + 1)
PRINT TAB(1); WBS$(I); TAB(28); C(I); TAB(38); NC; TAB(47); CA(I); TAB(56); INT(CA(I) * C(I) + .999); TAB(65); MPC(I); TAB(72); XM
 IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(28); ASTP
MX2: NEXT I
COLOR 2
IF IO = 1 THEN IO = 19: IE = 34: INPUT "ENTER RETURN ..."; RET: GOTO MX1
COLOR 13
PRINT TAB(5); "TOTAL"; TAB(56); C1; TAB(65); STP; TAB(72); TMEN
PRINT TAB(5); "Pad Svc"; TAB(65); X(14); TAB(72); X(14)
PRINT TAB(5); "Phase Inspect"; TAB(56); CSZ; TAB(65); MPH; TAB(72); MPH
COLOR 2
INPUT "ENTER RETURN TO CONTINUE..."; RET

END SUB

SUB RAW
'***** DISPLAY INITIAL MTBM AND MTTR VALUES******
    X = 0: Y = 0: Z = 0   'AVIONICS ROLLUP
    FOR I = 19 TO 24
    IF OP$(I) = "DELETE" THEN GOTO NZ1
    IF RELF(I) = 1 THEN GOTO NZ1
     X = X + 1 / FMA(I)
     Y = Y + 1 / IFMA(I)
     Z = Z + (MHMA(I) / C(I)) / FMA(I)
NZ1: NEXT I
    IF X > 0 THEN XA = 1 / X
    IF Y > 0 THEN YA = 1 / Y
    ZA = Z / X

YZ = 0: XZ = 0: ZZ = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO N93
ZZ = ZZ + 1 / IFMA(I)
YZ = YZ + 1 / FMA(I)
XZ = XZ + (MHMA(I) / C(I)) / FMA(I)
N93: NEXT I
IF YZ > 0 THEN XZ = XZ / YZ
IF ZZ > 0 THEN IFMA = 1 / ZZ

IO = 1: IE = 18
N10: CLS : COLOR 14
PRINT TAB(15); "Initial R&M Values": COLOR 9
IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
COLOR 4: PRINT "Reliability specified.  "; : COLOR 3: PRINT "All MTBM's are for a single subsystem."
PRINT "Adj MTBM includes technology and reliability growth. MTTR=MHMA/Crew size": COLOR 7
PRINT TAB(1); "WBS"; TAB(26); "unadj - MTBM"; TAB(45); "adj - MTBM"; TAB(61); "MTTR (on+off-veh)"
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO N92
IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
IF RELF(I) = 1 THEN COLOR 4: PRINT TAB(1); WBS$(I); TAB(48); FMA(I); TAB(61); MHMA(I) / C(I)
    IF I = 9 THEN PRINT TAB(1); WBS$(I); "  MSN'S/FAILURE "; TAB(35); FMA(I); TAB(48); FMAT(I); TAB(61); MHMA(I) / C(I)
    IF I < > 9 AND RELF(I) = 0 THEN PRINT TAB(1); WBS$(I); TAB(35); IFMA(I); TAB(48); FMA(I); TAB(61); MHMA(I) / C(I)
    IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(32); YA; TAB(45); XA; TAB(58); ZA
N92: NEXT I
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    COLOR 2
IF IO = 1 THEN IO = 19: IE = 34: INPUT "ENTER RETURN..": RET: CLS : GOTO N10
COLOR 13
PRINT TAB(5); "VEHICLE"; TAB(35); IFMA; TAB(48); VFMA; TAB(61); XZ
COLOR 2
INPUT "ENTER RETURN ..."; 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 OP$(I) = "DELETE" THEN GOTO NX1
    IF RELF(I) = 1 THEN GOTO NX1
     X = X + 1 / FMA(I)
     Y = Y + 1 / FMAT(I)
     Z = Z + 1 / FMAS(I)
NX1: NEXT I
    IF X > 0 THEN XA = 1 / X
    IF Y > 0 THEN YA = 1 / Y
    IF Z > 0 THEN ZA = 1 / Z
9005 IO = 1: IE = 18
9010 CLS : COLOR 14
9020 PRINT TAB(15); "RELIABILITY REPORT - at mission nbr."; X(24); " - page 1": COLOR 9
9030 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
    COLOR 4: PRINT "reliability specified ", : COLOR 3: PRINT "all MTBM's are for a single subsystem": COLOR 7
    PRINT TAB(1); "WBS"; TAB(26); "TECH/GROWTH MTBM"; TAB(45); "GRND PROC MTBM"; TAB(61); "MISSION MTBM"
    PRINT TAB(29); "(all)"; TAB(45); "(External)"; TAB(61); "(inherent)"
9070 FOR I = IO TO IE
9080 IF OP$(I) = "DELETE" THEN GOTO 9092
9085 IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
    IF RELF(I) = 1 THEN COLOR 4
    IF I = 9 THEN PRINT TAB(1); WBS$(I); "  MSN'S/FAILURE "; TAB(35); FMA(I); TAB(48); FMAT(I); TAB(61); FMAS(I)
    IF I < > 9 THEN PRINT TAB(1); WBS$(I); TAB(35); FMA(I); TAB(48); FMAT(I); TAB(61); FMAS(I)
    IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(32); XA; TAB(45); YA; TAB(58); ZA
9092 NEXT I
    COLOR 2
9094 IF IO = 1 THEN IO = 19: IE = 34: INPUT "ENTER RETURN..": RET: CLS : GOTO 9010
9095 COLOR 13
9100 PRINT TAB(5); "VEHICLE"; TAB(35); VFMA; TAB(48); TVFMA; TAB(61); SVFMA
9105 COLOR 2
9110 INPUT "ENTER RETURN ..."; RET
9120 CLS
    X = 0: Y = 0: Z = 1: K = 0 'AVIONICS ROLLUP
    FOR I = 19 TO 24
    IF OP$(I) = "DELETE" THEN GOTO NX2
    K = K + 1
    X = X + PA(I)
    Y = Y + 1 / FMAC(I): YA = 1 / Y
    Z = Z * R(I)
NX2: NEXT I
    IF K = 0 THEN K = 1
    XA = X / K
9125 IO = 1: IE = 18
9130 CLS : COLOR 14
    PRINT TAB(15); "RELIABILITY REPORT - at mission nbr."; X(24); " - page 2": COLOR 9
    COLOR 4: PRINT "reliability specified ", : 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-"
    IF X(25) = 0 THEN PRINT TAB(28); "RATE-grnd+air"; TAB(48); "MTBM"; TAB(60); "REDUNDANT MSN REL"
    IF X(25) = 1 THEN PRINT TAB(28); "RATE-air only"; TAB(48); "MTBM"; TAB(60); "REDUNDANT MSN REL"
9190 FOR I = IO TO IE
9200 IF OP$(I) = "DELETE" THEN GOTO 9220
9205 IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
    IF RELF(I) = 1 THEN COLOR 4
9210 PRINT TAB(1); WBS$(I); TAB(33); PA(I); TAB(48); FMAC(I); TAB(65); R(I)
    IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(27); XA; "AVG"; TAB(45); YA; TAB(62); Z
9220 NEXT I
    COLOR 2
9235 IF IO = 1 THEN IO = 19: IE = 34: INPUT "ENTER RETURN..": RET: CLS : GOTO 9130
9240 COLOR 13
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9250 PRINT TAB(5); "VEHICLE"; TAB(48); CVFMA; TAB(65); VR
9260 COLOR 2
9270 INPUT "ENTER RETURN ..."; RET

   X = 1: Y = 1: Z = 1    'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NX3
   X = X * R1(I)
   Y = Y * R2(I)
   Z = Z * R3(I)
NX3: NEXT I

9285 IO = 1: IE = 18
9300 CLS : COLOR 14
   PRINT TAB(15); "RELIABILITY REPORT - at mission nbr."; X(24); " - page 3": COLOR 9
   COLOR 4: PRINT "reliability specified ", : COLOR 3: PRINT "reliabilities based upon redundancy": COLOR 7
9315 PRINT TAB(1); "WBS"; TAB(33); "LAUNCH"; TAB(45); "END OF"; TAB(60); "ORBIT"
9320 PRINT TAB(33); "TIME"; TAB(45); "POWER FLT"; TAB(60); "INSERTION"
9330 FOR I = IO TO IE
9335 IF OP$(I) = "DELETE" THEN GOTO 9345
9337 IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
   IF RELF(I) = 1 THEN COLOR 4
9340 PRINT TAB(1); WBS$(I); TAB(33); R1(I); TAB(45); R2(I); TAB(60); R3(I)
  IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(30); X; TAB(42); Y; TAB(57); Z
9345 NEXT I
9355 IF IO = 1 THEN IO = 19: IE = 34: COLOR 3: INPUT "ENTER RETURN.."; RET:  GOTO 9300
   COLOR 13
9360 PRINT TAB(5); "VEHICLE"; TAB(33); VR1; TAB(45); VR2; TAB(60); VR3
9365 COLOR 2
9370 INPUT "ENTER RETURN ..."; RET

   X = 1: Y = 1: Z = 1    'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NX4
   X = X * R4(I)
   Y = Y * R5(I)
NX4: NEXT I

9385 IO = 1: IE = 18
9400 CLS : COLOR 14
   PRINT TAB(15); "RELIABILITY REPORT - at mission nbr."; X(24); " - page 4": COLOR 9
   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$(I) = "DELETE" THEN GOTO 9445
9437 IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
   IF RELF(I) = 1 THEN COLOR 4
9440 PRINT TAB(1); WBS$(I); TAB(45); R4(I); TAB(60); R5(I)
   IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(42); X; TAB(57); Y
9445 NEXT I
   COLOR 2
9455 IF IO = 1 THEN IO = 19: IE = 34: INPUT "ENTER RETURN.."; RET: CLS : GOTO 9400
   COLOR 13
9460 PRINT TAB(5); "VEHICLE"; TAB(45); VR4; TAB(60); VR5
9465 COLOR 2
9470 INPUT "ENTER RETURN ..."; RET
END SUB

SUB SPAREDISPLAY
8500 ' DISPLAY SPARES RESULTS
   X = 0: Y = 0: Z = 0: K = 0 'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NX7
   K = K + 1
   X = X + RR(I)
   Y = Y + NR(I)
   Z = Z + S(I)
   ZX = ZX + FR(I)
NX7: NEXT I
   XA = X / K
```

```
   ZX = ZX / K
8505 IO = 1: IE = 18
8510 CLS : COLOR 14
8520 PRINT TAB(20); "SUBSYSTEM SPARES REPORT - at mission nbr."; X(24)
8530 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
   COLOR 3: PRINT TAB(5); "NOTE: failures are assumed to be Poisson"
8545 COLOR 7
   PRINT TAB(32); "REMOVAL"; TAB(42); "MEAN NBR"; TAB(56); "SPARES"; TAB(65); "EFFECTIVE"
8550 PRINT TAB(1); "WBS"; TAB(32); "RATE/MA"; TAB(42); "IN REPAIR"; TAB(56); " RQMT"; TAB(65); " FILL RATE; "
8570 FOR I = IO TO IE
8580 IF OP$(I) = "DELETE" THEN GOTO 8600
   IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
8590 PRINT TAB(1); WBS$(I); TAB(30); RR(I); TAB(41); NR(I); TAB(55); S(I); TAB(65); FR(I)
   IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(25); XA; "(AVG)"; TAB(40); Y; TAB(56); Z; TAB(62); ZX; "(AVG)"
8600 NEXT I
   COLOR 2
8615 IF IO = 1 THEN IO = 19: IE = 34: INPUT "ENTER RETURN.."; RET: GOTO 8510
8620 COLOR 13
8630 PRINT TAB(5); "TOTALS"; TAB(27); ARR; "(AVG)"; TAB(43); TNR; TAB(55); TS
   PRINT TAB(5); "WGT AVG"; TAB(27); AREM
8640 COLOR 2: INPUT "ENTER RETURN ..."; RET
END SUB

SUB SUMMARY
 CLS : COLOR 10
 PRINT TAB(20); "SYSTEM PERFORMANCE SUMMARY - at mission nbr."; X(24); " - page 1"
 PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
 COLOR 14: PRINT : PRINT TAB(30); "RELIABILITY REPORT "
 PRINT : COLOR 7
 PRINT TAB(1); "CATEGORY"; TAB(33); "LAUNCH"; TAB(45); "END OF"; TAB(60); "ORBIT"
 PRINT TAB(33); "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+LRB"; TAB(33); SRBREL * VR1; TAB(45); SRBREL * VR2; TAB(60); SRBREL * VR3
 IF ETREL < 1 THEN PRINT TAB(5); "VEHICLE+LRB+ET"; TAB(33); ETREL * SRBREL * VR1; TAB(45); ETREL * SRBREL * VR2; TAB(60); ETREL * SRBREL * VR3
 PRINT : COLOR 7
 PRINT TAB(1); TAB(45); "REENTRY"; TAB(60); "MISSION"
 PRINT TAB(60); "COMPLETION": COLOR 12
 PRINT TAB(5); "VEHICLE"; TAB(45); VR4; TAB(60); VR5
 IF SRBREL < 1 THEN PRINT TAB(5); "VEHICLE+LRB"; TAB(45); SRBREL * VR4; TAB(60); SRBREL * VR5
 IF ETREL < 1 THEN PRINT TAB(5); "VEHICLE+LRB+ET"; 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$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
   PRINT : COLOR 14: PRINT TAB(30); "MAINTAINABILITY REPORT"
   COLOR 7: PRINT TAB(66); "UNSCHED"
   PRINT TAB(1); "CATEGORY"; TAB(28); "MAINT ACTIONS/MSN"; TAB(48); "WT-AVG MANHR/MA"; TAB(66); "AVG MANHRS/MSN"
   PRINT : COLOR 12
   PRINT TAB(5); "VEHICLE"; TAB(32); TMA; TAB(50); AMHMA; TAB(65); TOMH + TFMH
   IF ETREL < 1 THEN PRINT TAB(5); "EXTERNAL TANK"; TAB(32); MTE; TAB(50); STE / MTE; TAB(65); STE
   IF SRBREL < 1 THEN PRINT TAB(5); "BOOSTER"; TAB(32); MTF; TAB(50); STF / MTF; TAB(65); STF
   PRINT : COLOR 7
   PRINT TAB(32); "ON-VEH MH"; TAB(47); "OFF-VEH MH"; TAB(62); "TOTAL MH"
   COLOR 12: PRINT TAB(5); "VEHICLE"
   PRINT TAB(7); "UNSCHED"; TAB(32); TOMH; TAB(50); TFMH; TAB(65); TOMH + TFMH
   PRINT TAB(7); "SCHEDULED"; TAB(32); .98 * TSCH; TAB(50); .02 * TSCH; TAB(65); TSCH
   PRINT TAB(7); "PERIODIC INSPECTION"; TAB(32); .98 * PH; TAB(50); .02 * PH; TAB(65); PH
   PRINT TAB(7); "TOTAL"; TAB(32); .98 * TSCH + TOMH + .98 * PH; TAB(50); .02 * (PH + TSCH) + TFMH; TAB(65); TOMH + TFMH + PH + TSCH
   IF ETREL < 1 THEN PRINT TAB(5); "EXTERNAL TANK"
   IF ETREL < 1 THEN PRINT TAB(7); "SCHED/UNSCHED"; TAB(32); STE + ETS * STE
   IF SRBREL < 1 THEN PRINT TAB(5); "BOOSTER"
   IF SRBREL < 1 THEN PRINT TAB(7); "SCHED/UNSCHED"; TAB(32); STF + SRBS * STF
   COLOR 2: PRINT : INPUT "ENTER RETURN.."; RET

   CLS : COLOR 10
   B1 = 0: B4 = 0: A1 = 0: A4 = 0
   PRINT TAB(15); "SYSTEM PERFORMANCE SUMMARY - at mission nbr."; X(24); " - page 3"
   COLOR 14: PRINT TAB(30); "MANPOWER/SPARES REPORT"
   COLOR 7: PRINT TAB(5); "Mission rate is"; X(15); "missions per year"
   PRINT TAB(5); "Position manning factor is"; PMF
   PRINT : COLOR 13: PRINT TAB(5); "TOTAL SPARES REQUIRED ="; TS: COLOR 14
   PRINT : PRINT TAB(31); "MANPOWER RQMTS"; TAB(53); "MISSION RQMTS"
   PRINT TAB(1); "CATEGORY"; TAB(20); "MANHR DRIVEN"; TAB(35); "MANHR DRIVEN"; TAB(49); "ASGN POS"; TAB(60); "ASGN MANPWR"; TAB(72); "MAX"
```

```
    PRINT TAB(20); "AGGREGATE"; TAB(35); "BY SUBSYS"; TAB(49); "BY SUBSYS"; TAB(60); "BY SUBSYS"; TAB(72); "MANPWR"
    PRINT : COLOR 15
    PRINT TAB(3); "VEHICLE"
    A2 = (VMH * X(15)) / (12 * X(11) * (1 - X(12)))
    A2 = INT(A2 + .999)
    IF ETREL = 1 THEN TME = 0
    PRINT TAB(5); "VEH MANPWR"; TAB(20); A2; TAB(35); TMP; TAB(50); C1; TAB(60); STP; TAB(72); TMEN
    PRINT TAB(5); "PAD"; TAB(20); X(14); TAB(35); X(14); TAB(60); X(14); TAB(72); X(14)
    PRINT TAB(5); "PHASE INSP"; TAB(20); MPH; TAB(35); MPH; TAB(50); CSZ; TAB(60); MPH; TAB(72); MPH
    PRINT TAB(5); "TOTAL"; TAB(20); A2 + X(14) + MPH; TAB(35); TMP + X(14) + MPH; TAB(50); C1 + CSZ; TAB(60); STP + X(14) + MPH; TAB(72); TMEN + X(14)
+ MPH
    PRINT TAB(3); "EXT TANK"
    A1 = ((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(5); "SCHD/UNSCH MANPWR"; TAB(20); A1; TAB(35); TME; TAB(50); B1; TAB(60); B1
    PRINT TAB(3); "LRB"
    A4 = ((SRBS * STF + STF) * X(15)) / (12 * X(11) * (1 - X(12)))
    A4 = INT(A4 + .999)
    B4 = SRBCREW(1) + SRBCREW(2) + SRBCREW(3) + SRBCREW(4)
    B4 = INT(B4 + .999)
    IF ETREL = 1 THEN B1 = 0
    IF SRBREL = 1 THEN B4 = 0: TMF = 0: A4 = 0
    IF SRBREL < 1 THEN PRINT TAB(5); "SCHD/UNSCH MANPWR"; TAB(20); A4; TAB(35); TMF; TAB(50); B4; TAB(60); B4
    COLOR 2
  PRINT : INPUT "ENTER RETURN.."; RET

    CLS
  ' VEHICLE TURN TIME SUMMARY

    PRINT TAB(15); "SYSTEM PERFORMANCE SUMMARY - at mission nbr."; X(24); " - page 4"
    COLOR 14: PRINT : PRINT TAB(35); "VEHICLE TURN TIMES"
    PRINT TAB(30); "MIN TURN TIME"; TAB(45); "WT-AVG"; TAB(60); "MAX TURN TIME"
    FOR I = 1 TO 3
    COLOR 14: PRINT TAB(1); I; "-SHIFT/DAY MAINTENANCE": COLOR 15
    DVTT = (T(4)) / 24 + TJJ / (8 * I) + X(17) + X(18)
    MDVTT = (T(4)) / 24 + GTT / (8 * I) + X(17) + X(18)
    WDVTT = (T(4)) / 24 + TXY / (8 * I) + X(17) + X(18)
    MDA = (T(4)) / 24
    PRINT TAB(5); "VEH GRND PROCESSING DAYS"; TAB(30); DVTT - MDA; TAB(45); WDVTT - MDA; TAB(60); MDVTT - MDA
    PRINT TAB(5); "TOT VEH TURNAROUND DAYS"; TAB(30); DVTT; TAB(45); WDVTT; TAB(60); MDVTT
    TP = MDA + X(17) + X(18)
    DAD = ((DVTT - TP) * 21 + TP * 30.44) / DVTT
    DAMD = ((MDVTT - TP) * 21 + TP * 30.44) / MDVTT
    DAWD = ((WDVTT - TP) * 21 + TP * 30.44) / WDVTT
    PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE"; TAB(30); 12 * DAD / DVTT; TAB(45); 12 * DAWD / WDVTT; TAB(60); 12 * DAMD / MDVTT
    PRINT TAB(5); "COMPUTED FLEET SIZE "; TAB(30); INT((X(15) / 12) / (DAD / DVTT) + .99); TAB(45); INT((X(15) / 12) / (DAWD / WDVTT) + .99); TAB(60); INT((X(15)
/ 12) / (DAMD / MDVTT) + .99)
    NEXT I
    PRINT : COLOR 2: INPUT "ENTER RETURN..."; RET

END SUB

SUB TURNDIS
9700 'MODULE TO DISPLAY VEHICLE TURN TIME
9800 ' DISPLAY VEHICLE TURN TIME
9805 IO = 1: IE = 18
9810 CLS : COLOR 14
9820 PRINT TAB(20); "VEHICLE TURN TIME REPORT - at mission nbr."; X(24); " - page 1"
9830 IF IO = 1 THEN PRINT TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
9845 COLOR 7
   PRINT TAB(25); "ON-VEHICLE"; TAB(38); " TOT "; TAB(52); "NBR CREWS"; TAB(62); "AVG ON-VEH MAINT."
9850 PRINT TAB(1); "WBS"; TAB(25); "MTTR (HRS)"; TAB(38); "MAIN ACT"; TAB(52); "ASSIGNED"; TAB(62); "TIME PER MSN-hrs"
9870 FOR I = IO TO IE
9880 IF OP$(I) = "DELETE" THEN GOTO 9900
   IF SEL$(I) = "SHUTTLE" OR SEL$(I) = "ADJ-MTBM" THEN COLOR 12 ELSE COLOR 15
   IF I = TJX THEN COLOR 19
9890 PRINT TAB(1); WBS$(I); TAB(28); TSKT(I); TAB(40); NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)); TAB(54); CA(I); TAB(62); TT(I)
  IF I = 24 THEN COLOR 14: PRINT TAB(5); "AVIONICS ROLLUP"; TAB(27); "WAVG"; TTYA; TAB(40); TTW; TAB(53); TTX; TAB(61); TTZ; "TOT"
 9900 NEXT I
   COLOR 2
9905 IF IO = 1 THEN IO = 19: IE = 34: PRINT : INPUT "ENTER RET"; RET: CLS : GOTO 9810
   PRINT : COLOR 13
   PRINT TAB(1); "WAVG CREW SIZE"; AVCREW; TAB(26); "WAVG TASK TIME"; ATSK; TAB(60); GTT; "(TOTAL)"
9910 PRINT : COLOR 2: INPUT "ENTER RETURN....."; RET
9920 CLS : COLOR 14
```

```
9921 PRINT TAB(15); "VEHICLE TURN TIME REPORT - at mission nbr."; X(24); " - page 2"
   PRINT : COLOR 12
   PRINT TAB(5); "INTEGRATION TIME"; TAB(48); X(17); "DAYS"
   PRINT TAB(5); "LAUNCH PAD TIME"; TAB(48); X(18); "DAYS"
   PRINT TAB(5); "PHASE INSPECTION TIME (per msn)"; TAB(48); LE / NP; "hrs"
   PRINT TAB(5); "MISSION TIME -INC GRND PWR TIME"; TAB(48); T(0) + T(4); "hrs"
   VTT = T(4) + TJJ + X(17) * 24 + X(18) * 24
   MVTT = T(4) + GTT + X(17) * 24 + X(18) * 24: COLOR 12
   WVTT = T(4) + TXY + X(17) * 24 + X(18) * 24
   PRINT : COLOR 15
   PRINT TAB(5); "CATEGORY"; TAB(30); "MIN TURN TIME"; TAB(45); "WT-AVG"; TAB(60); "MAX TURN TIME"
   PRINT TAB(26); "(parallel tasks)"; TAB(45); 100 * X(20); "% OF MAX"; TAB(60); "(sequential tasks)"
COLOR 12: PRINT
     PRINT TAB(1); "SCHED/UNSCHED MAINT TIME"; TAB(30); TJJ; "hrs"; TAB(45); TXY; "hrs"; TAB(60); GTT; "hrs"
   PRINT TAB(1); "VEH GRN PROC TIME"; TAB(30); VTT - T(4); "hrs"; TAB(45); WVTT - T(4); "hrs"; TAB(60); MVTT - T(4); "hrs"
   PRINT TAB(1); "TOT VEH TURNAROUND TIME"; TAB(30); VTT; "hrs"; TAB(45); WVTT; "hrs"; TAB(60); MVTT; "hrs"
PRINT : COLOR 2: INPUT "ENTER RETURN..."; RET




   CLS : COLOR 14: PRINT
   PRINT TAB(15); "VEHICLE TURN TIME REPORT - at mission nbr."; X(24); " - page 3"
   PRINT : COLOR 12
   COLOR 15: PRINT TAB(5); "CATEGORY"; TAB(30); "MIN TURN TIME"; TAB(45); "WT-AVG"; TAB(60); "MAX TURN TIME"
   PRINT TAB(26); "(parallel tasks)"; TAB(45); 100 * X(20); "% OF MAX"; TAB(60); "(sequential tasks)"
   FOR I = 1 TO 3
   COLOR 14: PRINT TAB(1); I; "-SHIFT/DAY MAINTENANCE": COLOR 15
   DVTT = (T(4)) / 24 + TJJ / (8 * I) + X(17) + X(18)
   MDVTT = (T(4)) / 24 + GTT / (8 * I) + X(17) + X(18)
   WDVTT = (T(4)) / 24 + TXY / (8 * I) + X(17) + X(18)
   MDA = T(4) / 24
   PRINT TAB(5); "VEH GRND PROCESSING DAYS"; TAB(30); DVTT - MDA; TAB(45); WDVTT - MDA; TAB(60); MDVTT - MDA
   PRINT TAB(5); "TOT VEH TURNAROUND DAYS"; TAB(30); DVTT; TAB(45); WDVTT; TAB(60); MDVTT
   TP = MDA + X(17) + X(18)
   DAD = ((DVTT - TP) * 21 + TP * 30.44) / DVTT
   DAMD = ((MDVTT - TP) * 21 + TP * 30.44) / MDVTT
   DAWD = ((WDVTT - TP) * 21 + TP * 30.44) / WDVTT
   PRINT TAB(5); "AVG MISSIONS/YR/VEHICLE"; TAB(30); 12 * DAD / DVTT; TAB(45); 12 * DAWD / WDVTT; TAB(60); 12 * DAMD / MDVTT
   PRINT TAB(5); "COMPUTED FLEET SIZE "; TAB(30); INT((X(15) / 12) / (DAD / DVTT) + .99); TAB(45); INT((X(15) / 12) / (DAWD / WDVTT) + .99); TAB(60); INT((X(15)
/ 12) / (DAMD / MDVTT) + .99)
   NEXT I
   PRINT TAB(5); "NOTE:  assumes 8 hr shifts, and 21 work days a month"
   COLOR 2: INPUT "ENTER RETURN..."; RET

END SUB
```

Output Module
File: RAMW.BAS

```
DECLARE SUB WARGT ()
10 'NASA, LANGLEY RESEARCH CENTER
20 'MTBM COMPUTATIONAL MODEL - NASA RESEARCH GRANT -
30 'DEVELOPED BY C. EBELING, UNIV OF DAYTON 11/29/95 (updated)
35 ' ******** COMBINED PRE/CONCEPTUAL MODEL **********
40 '
50 'SAVE AS "RAMX.BAS"   Reliability & Maintainability Model -REVISED
' module for writing to a file input/output
  COMMON SHARED YR, B, X1, X2, LF, VR1, VR2, VR3, VR4, VR5, VR, AREM
  COMMON SHARED VFMA, TVFMA, SVFMA, CVFMA, OMHMA, OFMHMA, TMA, AMHMA
  COMMON SHARED SCHP, VMH, TOMH, TFMH, APF, P1, P2, P3, WAV, FH42, FH44
  COMMON SHARED FMA11, FMA12, VNAM$, ARR, TNR, TS, SKIP, TSCH, DTAT
  COMMON SHARED SMP, TMP, VMOH, WGTF, WING, WF, PWF, TMEN, NP, LE
  COMMON SHARED ETREL, SRBREL, ETS, SRBS, RTITLE$, ABTF$, PH, MPH, CSZ
  COMMON SHARED STP, STE, MTE, TME, STF, MTF, TMF, C1, PMF, SVADD, FZ
  COMMON SHARED AVCREW, GTT, ATSK, TTX, TTZ, TTW, TTYA, TJJ, TXY, TJX
  COMMON SHARED PARAF, PB17, ISJ, DSCH, WC
  DIM SHARED WBS$(35), X(50), NAM$(50), THRS(35), MHMA(35), MH(35), MP(35), OMH(35), FMH(35)
  DIM SHARED SEL$(35), T(10), CP$(9), CA(35), RELF(35), RF(35)
  DIM SHARED GOH(35), LOH(35), TOH(35), OOH(35), ROH(35), R(35), TSKT(35), POH(35)
  DIM SHARED V(15), SNAM$(15), FMAT(35), FMAC(35), FMAS(35), S(35), SMA(35), SMR(35)
  DIM SHARED MW(35), C(35), CM(35), OP$(35), TG(35), PWTS(35)
  DIM SHARED FMA(35), PF(35), PA(35), RR(35), W(35), NR(35), FR(35)
  DIM SHARED NRD(35), K(35), R1(35), R2(35), R3(35), R4(35), R5(35)
  DIM SHARED PWT1(35), PWT2(35), PWT3(35), PWT4(35), SRR(35)
  DIM SHARED ETSUB$(5), ETMBA(5), ETHRS(5), ETABR(5), ETMTR(5), ETR(5), ETCREW(5)
  DIM SHARED SRBSUB$(5), SRBMBA(5), SRBHRS(5), SRBABR(5), SRBMTR(5), SRBR(5), SRBCREW(5)
  DIM SHARED SWBS$(10), MAx(9), MTROS(9), MTRFS(9), REMS(9), SMT(9), SMTF(9), SC(9), FRS(9)
  DIM SHARED PI(35), CZ(9), SP(35), MA(35), TT(35), MPC(35), SW(35), IFMA(35)
  COMMON SHARED PI(), CZ(), SP(), MA(), TT(), MPC(), SW(), IFMA()
  COMMON SHARED SWBS$(), MAx(), MTROS(), MTRFS(), REMS(), SMT(), SMTF(), SC(), FRS()
  COMMON SHARED WBS$(), X(), NAM$(), THRS(), MHMA(), MH(), MP(), OMH(), FMH()
  COMMON SHARED SEL$(), T(), CP$(), CA(), RELF(), RF()
  COMMON SHARED GOH(), LOH(), TOH(), OOH(), ROH(), R(), TSKT(), POH()
  COMMON SHARED V(), SNAM$(), FMAT(), FMAC(), FMAS(), S(), SMA(), SMR()
  COMMON SHARED MW(), C(), CM(), OP$(), TG(), PWTS()
  COMMON SHARED FMA(), PF(), PA(), RR(), W(), NR(), FR()
  COMMON SHARED NRD(), K(), R1(), R2(), R3(), R4(), R5()
  COMMON SHARED PWT1(), PWT2(), PWT3(), PWT4(), SRR()
  COMMON SHARED ETSUB$(), ETMBA(), ETHRS(), ETABR(), ETMTR(), ETR(), ETCREW()
  COMMON SHARED SRBSUB$(), SRBMBA(), SRBHRS(), SRBABR(), SRBMTR(), SRBR(), SRBCREW()

SUB PARA
' append veh lvl results to file for parametric analysis
' file is "name$.par"
'select input var

IF PARAF = 1 THEN GOTO MD1
CP$(6) = "RECORD"
OPEN "TEMP1.PAR" FOR OUTPUT AS #3  'create temp file
WRITE #3, X(1)
CLOSE #3

CLS : COLOR 11
PRINT : PRINT TAB(10); "RAM-PARAMETRIC DATA FILE": PRINT
   FILES "*.PAR "
   PRINT : COLOR 11

   PRINT TAB(12); "SELECTED OUTPUT WILL BE WRITTEN TO FILE "; VNAM$; ".PAR"
LOCATE 20, 12: INPUT "ENTER RETURN TO PROCEED OR A POSITIVE NBR TO ABORT"; RET
IF RET > 0 THEN EXIT SUB
```

```
'PRINT #4, "TOTAL MAINT HRS, MANPWR (MH DRIVEN), REQD (max) MANPWR, VEH TURNTIME-days, VEH GRND PROC TIME-days, MSN PER YR PER VEH, AVG NBR
OF VEHS"
CLS : COLOR 14
PRINT TAB(25); "PARAMETRIC ANALYSIS"
PRINT TAB(15); "SELECTION MENU FOR AN INPUT (DRIVER) VARIABLE"
PRINT TAB(15); "NBR"; TAB(35); "SELECTION"
COLOR 3
PRINT TAB(15); "1........VEH DRY WEIGHT"
PRINT TAB(15); "2........LENGTH + WING SPAN"
PRINT TAB(15); "3........CREW SIZE + PASSENGERS"
PRINT TAB(15); "4........TECHNOLOGY YR"
PRINT TAB(15); "5........WEIBULL SHAPE PARAMETER"
PRINT TAB(15); "6........MISSIONS PER YR"
PRINT TAB(15); "7........GROWTH CURVE SLOPE"
PRINT TAB(15); "8........MSN NBR FOR REL GROWTH"
PRINT TAB(15); "9........WETTED AREA"
PRINT TAB(15); "10.......MISSION LENGTH"
PRINT TAB(15); "11.......AVG TECHNOLOGY GROWTH"
PRINT TAB(15); "12.......AVG CRIT FAILURE RATE"
PRINT TAB(15); "13.......AVG REMOVAL RATE"
PRINT TAB(15); "14.......AVG PCT OFF-VEH WORK"
PRINT TAB(15); "15.......AVG CREW SIZE"
PRINT TAB(15); "16.......ASSIGNED MANPOWER"
PRINT TAB(15); "17.......AVG INHERENT FRACTION"
COLOR 2
PRINT TAB(15); "return ....... exit to main menu"
LOCATE 24, 20: INPUT "ENTER SELECTION"; PB17
IF PB17 = 0 THEN EXIT SUB
CLS : COLOR 10: LOCATE 10, 1
PRINT TAB(10); "Dependent variable values saved are:": PRINT : COLOR 13
PRINT TAB(5); "wild card1, wild card2, adjusted MTBM, mission reliability, tot nbr of MAs"
PRINT TAB(5); "Unsch maint. hrs, total maint. hrs, manhr driven manpower, assigned manpwr"
PRINT TAB(5); "turntime, nbr missions per veh per yr, nbr of vehicles, nbr of spares"
PRINT : COLOR 11
GB: INPUT "Enter number of shifts for turntime"; ISJ
IF ISJ < 1 OR ISJ > 3 THEN GOTO GB
GB1: PRINT : INPUT "Enter the number of wild cards - 0,1,2"; WC
IF CW < 0 OR CW > 2 THEN GOTO GB1

OPEN VNAM$ + ".PAR" FOR OUTPUT AS #4
WRITE #4, "Driver,WC1,WC2,Adj MTBM,Msn Rel, Tot Nbr MAs, Unsch Maint Hrs, Tot Maint Hrs,MH Manpwr,Asgn Manpwr,turntime,Msn/veh/yr,nbr veh,spares"
CLOSE #4
PARAF = 1
EXIT SUB

MD1: P1 = 0: CT = 0: WC1 = 0: WC2 = 0
IF PB17 = 1 THEN P1 = X1
IF PB17 = 2 THEN P1 = X(2)
IF PB17 = 3 THEN P1 = X(3) + X(4)
IF PB17 = 4 THEN P1 = X(7)
IF PB17 = 5 THEN P1 = X(9)
IF PB17 = 6 THEN P1 = X(15)
IF PB17 = 7 THEN P1 = X(23)
IF PB17 = 8 THEN P1 = X(24)
IF PB17 = 9 THEN P1 = V(3)
IF PB17 = 10 THEN P1 = T(4)
IF PB17 = 11 THEN
     FOR I = 1 TO 34
     IF OP$(I) = "DELETE" THEN GOTO SL1
     P1 = P1 + TG(I)
     CT = CT + 1
SL1:   NEXT I
     P1 = P1 / CT
END IF
IF PB17 = 12 THEN
     FOR I = 1 TO 34
     IF OP$(I) = "DELETE" THEN GOTO SL2
     P1 = P1 + PA(I)
     CT = CT + 1
SL2:   NEXT I
     P1 = P1 / CT
END IF
IF PB17 = 13 THEN
     FOR I = 1 TO 34
     IF OP$(I) = "DELETE" THEN GOTO SL3
     P1 = P1 + RR(I)
```

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    CT = CT + 1
SL3:  NEXT I
    P1 = P1 / CT
END IF

IF PB17 = 14 THEN
    FOR I = 1 TO 34
    IF OP$(I) = "DELETE" THEN GOTO SL4
    P1 = P1 + PF(I)
    CT = CT + 1
SL4:  NEXT I
    P1 = P1 / CT
END IF
IF PB17 = 15 THEN
    FOR I = 1 TO 34
    IF OP$(I) = "DELETE" THEN GOTO SL5
    P1 = P1 + C(I)
    CT = CT + 1
SL5:  NEXT I
    P1 = P1 / CT
END IF
IF PB17 = 16 THEN P1 = TMEN
IF PB17 = 17 THEN
    FOR I = 1 TO 34
    IF OP$(I) = "DELETE" THEN GOTO SL6
    P1 = P1 + PI(I)
    CT = CT + 1
SL6:  NEXT I
    P1 = P1 / CT
END IF
IF WC >= 1 THEN PRINT : INPUT "ENTER A WILD CARD VALUE"; WC1
IF WC = 2 THEN INPUT "ENTER SECOND WILD CARD VALUE"; WC2

OPEN VNAM$ + ".PAR" FOR APPEND AS #4

WDVTT = (T(4)) / 24 + TXY / (8 * ISJ) + X(17) + X(18)
MDA = (T(4)) / 24
TP = MDA + X(17) + X(18)
DAWD = ((WDVTT - TP) * 21 + TP * 30.44) / WDVTT
XY = 12 * DAWD / WDVTT
XZ = INT((X(15) / 12) / (DAWD / WDVTT) + .99)
WRITE #4, P1, WC1, WC2, VFMA, VR5, TMA, TOMH + TFMH, VMH, TMP + MPH, TMEN + MPH, WDVTT, XY, XZ, TS
CLOSE #4

CLS : COLOR 7: CTR = 0
PRINT TAB(10); "Parametric analysis results:": PRINT
OPEN VNAM$ + ".PAR" FOR INPUT AS #5
INPUT #5, DUM$
DO UNTIL EOF(5)
INPUT #5, P1, WC1, WC2, VFMA, VR5, TMA, X1, VMH, X2, X3, WDVTT, XY, XZ, TS
X1 = TOMH + TFMH
X2 = TMP + MPH
X3 = TMEN + MPH
COLOR 10
IF WC1 > 0 OR WC2 + 0 THEN
PRINT TAB(1); "Driver "; P1; TAB(20); "Wild Card 1 "; WC1; TAB(40); "Wild Card 2 "; WC2
ELSE
PRINT TAB(1); "Driver"; TAB(10); P1
END IF
COLOR 14
PRINT TAB(1); "VEH MTBM "; VFMA; TAB(20); "VEH REL "; VR5; TAB(40); "TOT MAs "; TMA; TAB(60); "UNSCH MNHRS"; X1
PRINT TAB(1); "TOT MNHRS "; VMH; TAB(22); "MNHR MANPWR"; X2; TAB(40); "MAX MNPWR"; X3; TAB(60); "TURNTIME"; WDVTT
PRINT TAB(1); "MSN/YR/VEH"; XY; TAB(22); "NBR VEHs "; XZ; TAB(40); "NBR SPARES"; TS
PRINT : CTR = CTR + 1
IF CTR = 4 THEN PRINT : COLOR 2: INPUT "Enter return..."; RET: COLOR 10: CTR = 0
LOOP
CLOSE #5
COLOR 2
PRINT : INPUT "Enter return..."; RET

END SUB
```

```
SUB WARGT
'***** DISPLAY INITIAL MTBM AND MTTR VALUES******
    X = 0: Y = 0: Z = 0    'AVIONICS ROLLUP
    FOR I = 19 TO 24
    IF OP$(I) = "DELETE" THEN GOTO NZ2
    IF RELF(I) = 1 THEN GOTO NZ2
     X = X + 1 / FMA(I)
     Y = Y + 1 / IFMA(I)
     Z = Z + (MHMA(I) / C(I)) / FMA(I)
NZ2: NEXT I
    IF X > 0 THEN XA = 1 / X
    IF Y > 0 THEN YA = 1 / Y
    ZA = Z / X

YZ = 0: XZ = 0: ZZ = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO N93
ZZ = ZZ + 1 / IFMA(I)
YZ = YZ + 1 / FMA(I)
XZ = XZ + (MHMA(I) / C(I)) / FMA(I)
N93: NEXT I
IF YZ > 0 THEN XZ = XZ / YZ
IF ZZ > 0 THEN IFMA = 1 / ZZ

IO = 1: IE = 34
N11: PRINT #1, TAB(25); "Initial R&M Values"
PRINT #1, "All MTBM's are for a single subsystem."
PRINT #1, "Adj MTBM includes technology and reliability growth. MTTR=MHMA/crew size"
PRINT #1, TAB(1); "WBS"; TAB(26); "unadj - MTBM"; TAB(45); "adj - MTBM"; TAB(61); "MTTR"
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO N95
    IF I = 9 THEN PRINT #1, TAB(1); WBS$(I); "  MSN'S/FAILURE "; TAB(35); FMA(I); TAB(48); FMAT(I); TAB(61); MHMA(I) / C(I)
    IF I <> 9 THEN PRINT #1, TAB(1); WBS$(I); TAB(35); IFMA(I); TAB(48); FMA(I); TAB(61); MHMA(I) / C(I)
    IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(32); YA; TAB(45); XA; TAB(58); ZA
N95: NEXT I
PRINT #1,
PRINT #1, TAB(5); "VEHICLE"; TAB(35); IFMA; TAB(48); VFMA; TAB(61); XZ
PRINT #1,
PRINT #1, CHR$(12);

SWBS$(1) = "Structural": SWBS$(2) = "Fuel/Oxid Tanks": SWBS$(3) = "Thermal/Tiles": SWBS$(4) = "Propulsion"
SWBS$(5) = "Power/Electrical": SWBS$(6) = "Mechanical Sys": SWBS$(7) = "Avionics": SWBS$(8) = "ECS/Life Support"
SWBS$(9) = "Auxiliary Systems"

PRINT #1, TAB(5); "Aggregated System Report - System Aggregation - page 1"
PRINT #1, TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
PRINT #1, TAB(1); SWBS$(1); TAB(30); SWBS$(2); TAB(50); SWBS$(9)
FOR I = 1 TO 2: PRINT #1, TAB(3); WBS$(I); TAB(31); WBS$(I + 3); TAB(52); WBS$(I + 29): NEXT I
PRINT #1, TAB(3); WBS$(3); TAB(52); WBS$(32)
PRINT #1, TAB(1); SWBS$(3); TAB(30); SWBS$(4): PRINT #1, TAB(52); WBS$(33)
FOR I = 6 TO 8: PRINT #1, TAB(3); WBS$(I); TAB(31); WBS$(I + 4): NEXT I
PRINT #1, TAB(31); WBS$(34)
PRINT #1, TAB(1); SWBS$(5); TAB(30); SWBS$(6)
FOR I = 13 TO 14: PRINT #1, TAB(3); WBS$(I); TAB(31); WBS$(I + 4): NEXT I
PRINT #1, TAB(3); WBS$(15); TAB(31); WBS$(9)
PRINT #1, TAB(3); WBS$(16)
PRINT #1, TAB(1); SWBS$(7); TAB(30); SWBS$(8)
FOR I = 19 TO 23: PRINT #1, TAB(3); WBS$(I); TAB(33); WBS$(I + 6): NEXT I
PRINT #1, TAB(3); WBS$(24)
PRINT #1, CHR$(12);
PRINT #1, TAB(25); "Aggregated System Report - page 2": PRINT #1,
PRINT #1, : PRINT #1, TAB(2); "Aggregated"; TAB(20); "Nbr of"; TAB(35); "On-Veh MTTR"; TAB(50); "On-Veh Sched"; TAB(65); "Ave Crew"
PRINT #1, TAB(2); "System"; TAB(20); "Maint Actions"; TAB(35); "per MA (hrs)"; TAB(48); "maint time(hrs)"; TAB(65); "Size"
PRINT #1,
T0 = 0: T1 = 0: T2 = 0
FOR I = 1 TO 9
T0 = T0 + MAs(I)
T1 = T1 + MTROS(I): T2 = T2 + SMT(I): T3 = T3 + SC(I)
IF MAs(I) > 0 THEN
  NC = NC + 1
  PRINT #1, TAB(1); SWBS$(I); TAB(20); MAs(I); TAB(35); MTROS(I); TAB(50); SMT(I); TAB(65); SC(I)
```

```
END IF
NEXT I
PRINT #1,
PRINT #1, TAB(2); "Total"; TAB(20); T0; TAB(35); T1; TAB(50); T2; TAB(65); T3
PRINT #1, TAB(2); "Average"; TAB(20); T0 / NC; TAB(35); T1 / NC; TAB(50); T2 / NC; TAB(65); T3 / NC
PRINT #1, : COLOR 7: PRINT #1, "note:  MTTR's assume the Avg Crew Size and are based"
PRINT #1, "upon a weighted avg (wts-fraction of total failures) of each subsystem."
PRINT #1,
PRINT #1, TAB(25); "Aggregated System Report - page 3": PRINT #1,
PRINT #1, : PRINT #1, TAB(2); "Aggregated"; TAB(20); "Removal"; TAB(35); "Off-Veh MTTR"; TAB(50); "Off-Veh Sched"; TAB(65); "Nbr Crews"
PRINT #1, TAB(2); "System"; TAB(20); "Rate"; TAB(35); "in hours"; TAB(48); "maint time(hrs)"; TAB(65); "Assigned"
PRINT #1,
T0 = 0: T1 = 0: T2 = 0: T3 = 0
FOR I = 1 TO 9
T0 = T0 + REMS(I)
T1 = T1 + MTRFS(I): T2 = T2 + SMTF(I): T3 = T3 + CZ(I)
IF MAs(I) > 0 THEN PRINT #1, TAB(1); SWBS$(I); TAB(20); REMS(I); TAB(35); MTRFS(I); TAB(50); SMTF(I); TAB(65); CZ(I)
NEXT I
PRINT #1,
PRINT #1, TAB(2); "Total"; TAB(35); T1; TAB(50); T2; TAB(65); T3
PRINT #1, TAB(2); "Average"; TAB(20); T0 / NC; TAB(35); T1 / NC; TAB(50); T2 / NC; TAB(65); T3 / NC
PRINT #1, : PRINT #1, "note:  MTTR's assume the Avg Crew Size and are based"
PRINT #1, "upon a weighted avg (wts- fraction of total failures) of each subsystem."

END SUB

SUB WRFILE
'module to write output to a file

OPEN "TEMP1.ASC" FOR OUTPUT AS #3  'create temp file
WRITE #3, X(1), X(2), X(3)
CLOSE #3

CLS : COLOR 11
PRINT : PRINT TAB(10); "RAM-TEXT OUTPUT FILES": PRINT
   FILES "*.ASC "
   PRINT : COLOR 11

   PRINT TAB(12); "OUTPUT WILL BE SAVED IN FILE "; VNAM$; ".ASC"
LOCATE 20, 12: INPUT "ENTER RETURN TO PROCEED OR A POSITIVE NBR TO ABORT"; RET
IF RET > 0 THEN EXIT SUB
PRINT : INPUT "ENTER TITLE OF REPORT"; RTITLE$
INPUT "ENTER COMMENT"; COMMENT$

OPEN VNAM$ + ".ASC" FOR OUTPUT AS #1

PRINT #1, TAB(5); RTITLE$
PRINT #1, TAB(5); COMMENT$: PRINT #1, : PRINT #1,
PRINT #1, TAB(25); "INPUT PARAMETERS & DATA - page 1": PRINT #1,
PRINT #1, TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$: PRINT #1,
PRINT #1, : PRINT #1,
PRINT #1, TAB(5); "SYSTEM PARAMETER VALUES": PRINT #1,
PRINT #1, TAB(10); "PARAMETER"; TAB(50); "VALUE": PRINT #1,
FOR I = 1 TO 25
PRINT #1, TAB(10); NAM$(I); TAB(50); X(I)
IF I = 2 THEN PRINT #1, TAB(10); "WING SPAN"; TAB(50); WING
NEXT I
PRINT #1, TAB(10); "Depot LRU TAT in days"; TAB(50); DTAT;
PRINT #1, : PRINT #1, : PRINT #1, TAB(5); "SECONDARY VARIABLE VALUES"
PRINT #1, : PRINT #1, TAB(10); "VARIABLE"; TAB(40); "VALUE": PRINT #1,
FOR I = 1 TO 13
PRINT #1, TAB(10); SNAM$(I); TAB(40); V(I)
NEXT I
PRINT #1, CHR$(12);
PRINT #1, TAB(25); "INPUT PARAMETERS & DATA - page 2": PRINT #1,
PRINT #1, TAB(5); "SUBSYSTEM WEIGHTS & CALIBRATION FACTORS"
IF X(16) = 0 THEN PRINT #1, : PRINT #1, TAB(1); "WBS"; TAB(30); "WEIGHT"; TAB(40); "PCT WGT"; TAB(52); "MTBM FACTOR"; TAB(65); " MH/MA FACTOR"; : GOTO
FEX2
PRINT #1, : PRINT #1, TAB(1); "WBS"; TAB(28); "WEIGHT"; TAB(38); "MTBM FAC"; TAB(55); "MH/MA FACTOR"
PRINT : ADD = 0
FEX2: FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO FXE1
ADD = ADD + W(I)
IF X(16) = 0 THEN PRINT #1, TAB(1); WBS$(I); TAB(30); W(I); TAB(40); PWTS(I); TAB(52); MW(I); TAB(65); CM(I): GOTO FXE1
PRINT #1, TAB(1); WBS$(I); TAB(30); W(I); TAB(40); MW(I); TAB(55); CM(I)
FXE1: NEXT I
PRINT #1, : PRINT #1, TAB(1); "TOTAL WEIGHT"; TAB(30); ADD; TAB(45); "WEIGHT FACTOR IS "; PWF
PRINT #1,
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PRINT #1, CHR$(12);

PRINT #1, TAB(25); "INPUT PARAMETERS & DATA - page 3": PRINT #1,
PRINT #1, : PRINT #1, : PRINT #1, TAB(5); "SUBSYSTEM OPERATING HOURS": PRINT #1,
PRINT #1, TAB(1); "SUBSYSTEM"; TAB(30); "PROCESS"; TAB(39); "PAD"; TAB(46); "BOOST"; TAB(52); "RE TIME"; TAB(61); "ORBIT"; TAB(68); "REENTRY"
PRINT #1, TAB(32); "TIME"; TAB(39); "TIME"; TAB(46); "TIME"; TAB(52); "TO-ORBIT"; TAB(61); "TIME"; TAB(68); "TIME"
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO FEX4
PRINT #1, TAB(1); WBS$(I); TAB(32); POH(I); TAB(39); GOH(I); TAB(46); LOH(I); TAB(53); TOH(I); TAB(60); OOH(I); TAB(67); ROH(I)
FEX4: NEXT I
PRINT #1, CHR$(12);


PRINT #1, TAB(25); "INPUT PARAMETERS & DATA - page 4": PRINT #1,
PRINT #1, : PRINT #1, : PRINT #1, TAB(5); "SUBSYSTEM COMPUTATION FACTORS": PRINT #1,
PRINT #1, TAB(1); "SUSBSYTEM"; TAB(28); "TECH GRWTH"; TAB(40); "CRITICAL"; TAB(55); "REMOVAL"; TAB(70); "FRACTION"
PRINT #1, TAB(28); "FACTOR"; TAB(40); "FAIL RATE"; TAB(55); "RATE"; TAB(70); "OFF EQUIP": PRINT #1,
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO FEX5
PRINT #1, TAB(1); WBS$(I); TAB(28); TG(I); TAB(40); PA(I); TAB(55); RR(I); TAB(70); PF(I)
FEX5: NEXT I
PRINT #1,
PRINT #1, TAB(5); "Notes:  1.  CRITICAL FAILURE RATE - fraction of total maintenance actions"
PRINT #1, TAB(29); "resulting in a mission abort"
PRINT #1, TAB(5); "2.  REMOVAL RATE - probability of a removal per maintenance action"
PRINT #1, TAB(5); "3.  FRACTION OFF VEHICLE - fraction of total maintenance manhours"
PRINT #1, TAB(5); "performed off the vehicle - does not impact vehicle turntime"

PRINT #1, CHR$(12);

PRINT #1, TAB(25); "INPUT PARAMETERS & DATA - page 5": PRINT #1,
PRINT #1, : PRINT #1, : PRINT #1, TAB(5); "MORE SUBSYSTEM COMPUTATION FACTORS": PRINT #1,
PRINT #1, TAB(1); "SUSBSYTEM"; TAB(28); "CREW"; TAB(40); "NBR CREWS"; TAB(55); "FRACTION INHERENT"
PRINT #1, TAB(28); "SIZE"; TAB(40); "ASGN"; TAB(55); "FAILURES": PRINT #1,
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO FEX6
PRINT #1, TAB(1); WBS$(I); TAB(29); C(I); TAB(40); CA(I); TAB(55); PI(I)
FEX6: NEXT I
PRINT #1,
PRINT #1, TAB(3); "Note - FRACTION INHERENT FAILURES - fraction of total maint. actions resulting"
PRINT #1, TAB(3); "from inherent failures; separates MTBM into a ground & mission MTBM"
PRINT #1, CHR$(12);

PRINT #1, TAB(25); "INPUT PARAMETERS & DATA - page 6": PRINT #1,
PRINT #1, : PRINT #1, : PRINT #1, TAB(5); "SUBSYSTEM REDUNDANCY & SCHEDULED MAINTENANCE": PRINT #1,
PRINT #1, TAB(1); "SUSBSYTEM"; TAB(28); "REDUNDANT"; TAB(45); " MIN NBR"; TAB(60); "SCHEDULED"
PRINT #1, TAB(28); "SUBSYS"; TAB(37); "REQUIRED"; TAB(50); "MAINT. HOURS"; TAB(65); "PCT OF UNSCH": PRINT #1,
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO FEY6
IF K(I) = 0 THEN K(I) = 1
PRINT #1, TAB(1); WBS$(I); TAB(29); NRD(I); TAB(37); K(I); TAB(50); SP(I); TAB(65); 100 * SP(I) / (OMH(I) + FMH(I))
FEY6: NEXT I
PRINT #1,
PRINT #1, TAB(5); "CURRENT SCHEDULED MAINTENANCE PERCENT (of unsch maint hrs) "; TAB(50); 100 * SCHP
PRINT #1, TAB(5); "Parametric equation default Percent"; TAB(50); 100 * DSCH
PRINT #1, : PRINT #1, TAB(10); "Periodic (phase) Maintenance Requirement"
PRINT #1,
PRINT #1, TAB(5); "1 - NBR missions btwn inspections"; TAB(50); NP
PRINT #1, TAB(5); "2 - Length of inspection in hours"; TAB(50); LE
PRINT #1, TAB(5); "3 - Crew size for phase inspection"; TAB(50); CSZ
PRINT #1, CHR$(12);

PRINT #1, TAB(25); "INPUT PARAMETERS & DATA - page 7": PRINT #1,
PRINT #1, : PRINT #1, : PRINT #1, TAB(5); "SHUTTLE (User Specified) UTILIZED VALUES": PRINT #1,
PRINT #1, : PRINT #1, TAB(1); "SUBSYSTEM"; TAB(30); "MTBM"; TAB(50); "MH/MA";
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO FEX7
IF SEL$(I) = "AIRCRAFT" THEN GOTO FEX7
PRINT #1, TAB(1); WBS$(I); TAB(30); SMA(I); TAB(50); SMR(I);
FEX7: NEXT I
PRINT #1, CHR$(12);

'***** PRINT #1, MODULE FOR RELIABILITY REPORT *******
   X = 0: Y = 0: Z = 0   'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NA1
   IF RELF(I) = 1 THEN GOTO NA1
   X = X + 1 / FMA(I)
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```
   Y = Y + 1 / FMAT(I)
   Z = Z + 1 / FMAS(I)
NA1: NEXT I
   IF X > 0 THEN XA = 1 / X
   IF Y > 0 THEN YA = 1 / Y
   IF Z > 0 THEN ZA = 1 / Z
   IO = 1: IE = 34
PRINT #1, TAB(5); RTITLE$: PRINT #1, : PRINT #1,
PRINT #1, TAB(20); "RELIABILITY REPORT - at mission nbr."; X(24); " - page 1": PRINT #1,
PRINT #1, TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$: PRINT #1,
PRINT #1, "all MTBM's are for a single subsystem, e.g. one engine": PRINT #1,
PRINT #1, TAB(1); "WBS"; TAB(26); "TECH/GROWTH MTBM"; TAB(45); "GRND PROC MTBM"; TAB(61); "MISSION MTBM"
PRINT #1, TAB(29); "(all)"; TAB(45); "(External)"; TAB(61); "(inherent)": PRINT #1,


FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO SA1
   IF I = 9 THEN PRINT #1, TAB(1); WBS$(I); "  MSN'S/FAILURE "; TAB(35); FMA(I); TAB(48); FMAT(I); TAB(61); FMAS(I)
   IF I < > 9 THEN PRINT #1, TAB(1); WBS$(I); TAB(35); FMA(I); TAB(48); FMAT(I); TAB(61); FMAS(I)
   IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(32); XA; TAB(45); YA; TAB(58); ZA
SA1: NEXT I

PRINT #1, : PRINT #1,
PRINT #1, TAB(5); "VEHICLE"; TAB(35); VFMA; TAB(48); TVFMA; TAB(61); SVFMA
PRINT #1, CHR$(12);

   X = 0: Y = 0: Z = 1: K = 0 'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NA2
   K = K + 1
   X = X + PA(I)
   Y = Y + 1 / FMAC(I): YA = 1 / Y
   Z = Z * R(I)
NA2: NEXT I
   IF K = 0 THEN K = 1
   XA = X / K
IO = 1: IE = 34
PRINT #1, TAB(20); "RELIABILITY REPORT - at mission nbr."; X(24); " - page 2": PRINT #1,
PRINT #1, TAB(5); COMMENT$: PRINT #1, : PRINT #1,
PRINT #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 MSN REL"
 IF X(25) = 1 THEN PRINT #1, TAB(28); "RATE-air only"; TAB(48); "MTBM"; TAB(60); "REDUNDANT MSN REL"
 PRINT #1,
 FOR I = IO TO IE
 IF OP$(I) = "DELETE" THEN GOTO SA2
PRINT #1, TAB(1); WBS$(I); TAB(33); PA(I); TAB(48); FMAC(I); TAB(65); R(I)
   IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(27); XA; "AVG"; TAB(45); YA; TAB(62); Z
SA2: NEXT I
 PRINT #1, : PRINT #1,
 PRINT #1, TAB(5); "VEHICLE"; TAB(48); CVFMA; TAB(65); VR
 PRINT #1, CHR$(12);

IO = 1: IE = 34
PRINT #1, TAB(20); "RELIABILITY REPORT - at mission nbr."; X(24); " - page 3": PRINT #1,
   X = 1: Y = 1: Z = 1    'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NA3
   X = X * R1(I)
   Y = Y * R2(I)
   Z = Z * R3(I)
NA3: NEXT I
PRINT #1, "reliabilities based upon redundancy": PRINT #1,
PRINT #1, TAB(1); "WBS"; TAB(33); "LAUNCH"; TAB(45); "END OF"; TAB(60); "ORBIT"
PRINT #1, TAB(33); "TIME"; TAB(45); "POWER FLT"; TAB(60); "INSERTION": PRINT #1,
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO SA3
PRINT #1, TAB(1); WBS$(I); TAB(33); R1(I); TAB(45); R2(I); TAB(60); R3(I)
  IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(30); X; TAB(42); Y; TAB(57); Z
SA3: NEXT I
 PRINT #1, : PRINT #1,
PRINT #1, TAB(5); "VEHICLE"; TAB(33); VR1; TAB(45); VR2; TAB(60); VR3
PRINT #1, CHR$(12);

X = 1: Y = 1: Z = 1    'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NA4
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    X = X * R4(I)
    Y = Y * R5(I)
NA4: NEXT I

IO = 1: IE = 34
PRINT #1, TAB(20); "RELIABILITY REPORT - at mission nbr."; X(24); " - page 4": PRINT #1,
PRINT #1, "reliabilities based upon redundancy": PRINT #1,
PRINT #1, TAB(1); "WBS"; TAB(45); "REENTRY"; TAB(60); "MISSION"
PRINT #1, TAB(60); "COMPLETION": PRINT #1,
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO SA4
PRINT #1, TAB(1); WBS$(I); TAB(45); R4(I); TAB(60); R5(I)
   IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(42); X; TAB(57); Y
SA4: NEXT I
PRINT #1, : PRINT #1,
PRINT #1, TAB(5); "VEHICLE"; TAB(45); VR4; TAB(60); VR5
PRINT #1, CHR$(12);


' PRINT #1, MODULE FOR MAINTAINABILITY REPORT
    X = 0: Y = 0: Z = 0: K = 0 'AVIONICS ROLLUP
    FOR I = 19 TO 24
    IF OP$(I) = "DELETE" THEN GOTO SA7
    K = K + 1
    X = X + NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))
    Y = Y + MHMA(I)
    Z = Z + (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I))) * MHMA(I)
SA7: NEXT I
   YA = Y / K
IO = 1: IE = 34
 PRINT #1, TAB(5); RTITLE$: PRINT #1,
 PRINT #1, TAB(5); COMMENT$: PRINT #1, : PRINT #1,
 PRINT #1, TAB(20); "MAINTAINABILTY REPORT - at mission nbr."; X(24); " - page 1": PRINT #1,
 PRINT #1, TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$: PRINT #1,
 PRINT #1, TAB(5); "UNSCHEDULED-on/off veh"; TAB(65); "UNSCHEDULED"
 PRINT #1, TAB(1); "WBS"; TAB(30); "MAINT ACTIONS/MSN"; TAB(50); "AVG MANHR/MA"; TAB(65); "AVG MANHRS/MSN"
 PRINT #1,
 FOR I = IO TO IE
 IF OP$(I) = "DELETE" THEN GOTO SAM
 PRINT #1, TAB(1); WBS$(I); TAB(32); NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)); TAB(50); MHMA(I); TAB(65); (NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)))
* MHMA(I)
   IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(29); X; TAB(47); YA; "(AVG)"; TAB(63); Z
SAM: NEXT I
 PRINT #1,
 PRINT #1, TAB(5); "TOTALS -unsch on/off"; TAB(32); TMA; TAB(47); AMHMA; "WT-AVG"; TAB(65); OMHMA + OFMHMA
PRINT #1, CHR$(12);

AV = 0: KA = 0
FOR I = 1 TO 34
IF OP$(I) = "DELETE" THEN GOTO NZY
   AV = AV + ((1 - PF(I)) * MHMA(I) / C(I)) * (1 / FMA(I))
   KA = KA + (1 / FMA(I))
NZY: NEXT I

IO = 1: IE = 34
PRINT #1, TAB(20); "MAINTAINABILTY REPORT - at mission nbr."; X(24); " - page 2"
PRINT #1, : PRINT #1, TAB(5); "note:  MTTR is for a single maintenance action"
    X = 0: Y = 0: Z = 0: K = 0 'AVIONICS ROLLUP
    FOR I = 19 TO 24
    IF OP$(I) = "DELETE" THEN GOTO SA6
    K = K + (1 / FMA(I))
    X = X + OMH(I)
    Y = Y + FMH(I)
    Z = Z + ((1 - PF(I)) * MHMA(I) / C(I)) * (1 / FMA(I))
 SA6: NEXT I
    ZA = Z / K
 PRINT #1, : PRINT #1,
 PRINT #1, TAB(32); "UNSCHEDULED"; TAB(47); "UNSCHEDULED"
 PRINT #1, TAB(1); "WBS"; TAB(32); "ON-VEH MH"; TAB(47); "OFF-VEH MH"; TAB(62); "ON-VEH MTTR (hrs)": PRINT #1,
 FOR I = IO TO IE
  IF OP$(I) = "DELETE" THEN GOTO SA5
 PRINT #1, TAB(1); WBS$(I); TAB(32); OMH(I); TAB(50); FMH(I); TAB(65); (1 - PF(I)) * MHMA(I) / C(I)
    IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(29); X; TAB(47); Y; TAB(62); ZA; "(WAVG)"
 SA5: NEXT I
 PRINT #1, : PRINT #1,
 PRINT #1, TAB(3); "UNSCHEDULED"; TAB(32); TOMH; TAB(50); TFMH; TAB(65); AV / KA; "(WAVG)"
 PRINT #1, TAB(5); "SCHEDULED"; TAB(32); TSCH
 PRINT #1, TAB(5); "PHASE INSPECTION"; TAB(32); PH
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PRINT #1, TAB(5); "TOTAL"; TAB(32); TOMH + TSCH + PH
PRINT #1, CHR$(12);

IO = 1: IE = 34
PRINT #1, TAB(15); "MAINTAINABILTY REPORT - at mission nbr."; X(24); " - page 3"
   X = 0: Y = 0    'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO NT6
   X = X + OMH(I) + FMH(I)
   Y = Y + SP(I)
NT6: NEXT I
PRINT #1, TAB(1); "WBS"; TAB(32); "SCHED MH/MSN"; TAB(47); "UNSCHED MH/MSN"; TAB(65); "TOTAL MH/MSN"
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO NT7
PRINT #1, TAB(1); WBS$(I); TAB(32); SP(I); TAB(50); OMH(I) + FMH(I); TAB(65); SP(I) + OMH(I) + FMH(I)
IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(29); Y; TAB(47); X; TAB(62); X + Y
NT7: NEXT I
PRINT #1,
PRINT #1, TAB(5); "TOTAL"; TAB(32); TSCH; TAB(50); TOMH + TFMH; TAB(65); TSCH + TOMH + TFMH
PRINT #1, CHR$(12)


   X = 0: Y = 0: 'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO MY8
   X = X + NRD(I) * POH(I) / FMAT(I)
   Y = Y + NRD(I) * THRS(I) / FMAS(I)
MY8: NEXT I
IO = 1: IE = 34
TXX = 0: TYY = 0
MY7: PRINT #1, TAB(10); "MAINTAINABILTY REPORT - at mission nbr."; X(24); " - page 4": PRINT #1,
   PRINT #1, TAB(5); "Note:  Ground processing MA's consist of induced and no defect MA's."
   PRINT #1, TAB(5); "Mission MA's are inherent equipment failures": PRINT #1,
   PRINT #1, TAB(1); "WBS"; TAB(32); "GRND PROC MA"; TAB(50); "MSN MA"; TAB(65); "TOTAL MA": PRINT #1,
   FOR I = IO TO IE
   IF OP$(I) = "DELETE" THEN GOTO MY9
   XX = NRD(I) * POH(I) / FMAT(I): YY = NRD(I) * THRS(I) / FMAS(I)
   TXX = TXX + XX: TYY = TYY + YY
   PRINT #1, TAB(1); WBS$(I); TAB(32); XX; TAB(50); YY; TAB(65); XX + YY
   IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(29); X; TAB(47); Y; TAB(62); X + Y
MY9: NEXT I
   PRINT #1,
   PRINT #1, TAB(5); "TOTAL"; TAB(32); TXX; TAB(50); TYY; TAB(65); TXX + TYY
   PRINT #1, CHR$(12)

 'PRINT #1, MANPOWER MODULE
   X = 0: Y = 0: Z = 0  'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO SA8
   X = X + MH(I)
   Z = Z + MP(I)
SA8: NEXT I
   Y = X(15) * X / 12
   MT = 0
 IO = 1: IE = 34: ASTP = 0
PRINT #1, TAB(5); RTITLE$: PRINT #1,
PRINT #1, TAB(5); COMMENT$: PRINT #1, : PRINT #1,
PRINT #1, TAB(20); "MANPOWER REPORT - at mission nbr."; X(24); "- page 1": PRINT #1,
PRINT #1, TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$: PRINT #1,
PRINT #1, "manpwr is computed from manhrs/mo divided by avail direct hrs per mo per person"
   PRINT #1, "available hrs per mo is"; X(11); "and the percent indirect is"; 100 * X(12)
   PRINT #1,
PRINT #1, TAB(1); "WBS"; TAB(25); "MAINT MANHRS/MSN"; TAB(45); "MANHRS/MO"; TAB(60); "MANPWR"
PRINT #1,
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO MP1
PRINT #1, TAB(1); WBS$(I); TAB(30); MH(I); TAB(45); X(15) * MH(I) / 12; TAB(60); MP(I)
   IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(28); X; TAB(43); Y; TAB(58); Z
MP1:  NEXT I
PRINT #1, TAB(5); "TOTAL"; TAB(30); VMH; TAB(45); VMH * X(15) / 12; TAB(60); TMP
   PRINT #1, TAB(5); "Pad Svc"; TAB(60); X(14)
   PRINT #1, TAB(5); "Phase inspt"; TAB(30); PH; TAB(45); PH * X(15) / 12; TAB(60); MPH
PRINT #1, CHR$(12)
IO = 1: IE = 34
PRINT #1, TAB(20); "MANPOWER REPORT - at mission nbr."; X(24); " - page 2"
PRINT #1, : PRINT #1, "Rqd crews is computed from manpwr divided by avg crew.  Asgn manpwr is based on"
PRINT #1, "a posn manning fac of"; PMF; ".  Max mpwr is MAX {manpwr, asgn manpwr}": PRINT #1,
PRINT #1, TAB(28); "AVG"; TAB(38); "RQD"; TAB(47); "CUR ASGD"; TAB(56); "ASGN"; TAB(65); "ASGN"; TAB(72); "MAX"
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PRINT #1, TAB(1); "WBS"; TAB(28); "CREW SIZE"; TAB(38); "CREWS"; TAB(47); "CREWS"; TAB(56); "POSNS"; TAB(65); "MNPWR"; TAB(72); "MPWR"
PRINT #1,
FOR I = IO TO IE
 IF OP$(I) = "DELETE" THEN GOTO MP2
 IF MPC(I) > MP(I) THEN XM = MPC(I) ELSE XM = MP(I)
 NC = INT(MP(I) / C(I) + 1)
PRINT #1, TAB(1); WBS$(I); TAB(28); C(I); TAB(38); NC; TAB(47); CA(I); TAB(56); INT(CA(I) * C(I) + .999); TAB(65); MPC(I); TAB(72); XM
IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(28); ASTP
MP2: NEXT I
PRINT #1, TAB(5); "TOTAL"; TAB(56); C1; TAB(65); STP; TAB(72); TMEN
PRINT #1, TAB(5); "Pad Svc"; TAB(65); X(14); TAB(72); X(14)
PRINT #1, TAB(5); "Phase Inspect"; TAB(56); CSZ; TAB(65); MPH; TAB(72); MPH
PRINT #1, TAB(5); "TOTAL RQMT"; TAB(72); TMEN + X(14) + MPH
PRINT #1, CHR$(12);

' PRINT #1, SPARES RESULTS
   X = 0: Y = 0: Z = 0: K = 0 'AVIONICS ROLLUP
   FOR I = 19 TO 24
   IF OP$(I) = "DELETE" THEN GOTO SB7
   K = K + 1
   X = X + RR(I)
   Y = Y + NR(I)
   Z = Z + S(I)
   ZX = ZX + FR(I)
SB7: NEXT I
   XA = X / K
   ZX = ZX / K
IO = 1: IE = 34
PRINT #1, TAB(5); RTITLE$: PRINT #1,
PRINT #1, TAB(5); COMMENT$: PRINT #1, : PRINT #1,
PRINT #1, TAB(25); "SUBSYSTEM SPARES REPORT - at mission nbr."; X(24); " ": PRINT #1,
PRINT #1, TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$: PRINT #1,
 PRINT #1, TAB(5); "NOTE:  failures are assumed to be Poisson": PRINT #1,
PRINT #1, TAB(32); "REMOVAL"; TAB(42); "MEAN NUMBER"; TAB(56); "SPARES"; TAB(65); "EFFECTIVE"
PRINT #1, TAB(1); "WBS"; TAB(32); "RATE/MA"; TAB(42); "IN REPAIR"; TAB(56); " RQMT"; TAB(65); "FILL RATE"
PRINT #1,
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO SA9
PRINT #1, TAB(1); WBS$(I); TAB(30); RR(I); TAB(41); NR(I); TAB(55); S(I); TAB(65); FR(I)
   IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(25); XA; "(AVG)"; TAB(40); Y; TAB(56); Z; TAB(62); ZX; "(AVG)"
SA9: NEXT I
PRINT #1, : PRINT #1,
PRINT #1, TAB(5); "TOTALS"; TAB(27); ARR; "(AVG)"; TAB(43); TNR; TAB(55); TS
PRINT #1, TAB(5); "WGT AVG"; TAB(27); AREM
PRINT #1, CHR$(12);

'MODULE TO PRINT VEHICLE TURN TIME
 IO = 1: IE = 34
PRINT #1, : PRINT #1, TAB(5); RTITLE$: PRINT #1,
PRINT #1, TAB(5); COMMENT$: PRINT #1, : PRINT #1,
PRINT #1, TAB(20); "VEHICLE TURN TIME REPORT - at mission nbr."; X(24); " - page 1": PRINT #1,
PRINT #1, TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
PRINT #1,
PRINT #1, TAB(25); "ON-VEHICLE"; TAB(38); " TOT "; TAB(52); "NBR CREWS"; TAB(62); "AVG ON-VEH MAINT."
PRINT #1, TAB(1); "WBS"; TAB(25); "MTTR (HRS)"; TAB(38); "MAIN ACT"; TAB(52); "ASSIGNED"; TAB(62); "TIME PER MSN-hrs"
PRINT #1,
FOR I = IO TO IE
IF OP$(I) = "DELETE" THEN GOTO TT1
PRINT #1, TAB(1); WBS$(I); TAB(28); TSKT(I); TAB(40); NRD(I) * (POH(I) / FMAT(I) + THRS(I) / FMAS(I)); TAB(54); CA(I); TAB(62); TT(I)
   IF I = 24 THEN PRINT #1, TAB(5); "AVIONICS ROLLUP"; TAB(27); "WAVG"; TTYA; TAB(40); TTW; TAB(53); TTX; TAB(61); TTZ; "TOT"
TT1: NEXT I
PRINT #1,
PRINT #1, TAB(1); "WAVG CREW SIZE"; AVCREW; TAB(26); "WAVG TASK TIME"; ATSK; TAB(60); GTT; "(TOTAL)"
PRINT #1,
PRINT #1, "Note: Avg subsystem repair time includes on-veh scheduled maintenance."
PRINT #1, CHR$(12);
PRINT #1, TAB(15); "VEHICLE TURN TIME REPORT - at mission nbr."; X(24); " - page 2"
    PRINT #1,
    PRINT #1, TAB(5); "INTEGRATION TIME"; TAB(48); X(17); "DAYS"
    PRINT #1, TAB(5); "LAUNCH PAD TIME"; TAB(48); X(18); "DAYS"
    PRINT #1, TAB(5); "PHASE INSPECTION TIME (per msn)"; TAB(48); LE / NP; "hrs"
    PRINT #1, TAB(5); "MISSION TIME -INC GRND PWR TIME"; TAB(48); T(0) + T(4); "HRS"
    PRINT #1,
    VTT = T(4) + TJJ + X(17) * 24 + X(18) * 24
    MVTT = T(4) + GTT + X(17) * 24 + X(18) * 24: COLOR 12
    WVTT = T(4) + TXY + X(17) * 24 + X(18) * 24
    PRINT #1, TAB(5); "CATEGORY"; TAB(30); "MIN TURN TIME"; TAB(45); "WT-AVG"; TAB(60); "MAX TURN TIME"
    PRINT #1, TAB(26); "(parallel tasks)"; TAB(45); 100 * X(20); "% OF MAX"; TAB(60); "(sequential tasks)"
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    PRINT #1,
PRINT #1, TAB(1); "SCHED/UNSCHED MAINT TIME"; TAB(30); TJJ; TAB(45); TXY; TAB(60); GTT; "HRS"
PRINT #1, TAB(1); "VEH GRN PROC TIME"; TAB(30); VTT - T(4); "HRS"; TAB(45); WVTT - T(4); TAB(60); MVTT - T(4); "HRS"
    PRINT #1, TAB(1); "TOT VEH TURNAROUND TIME"; TAB(30); VTT; "HRS"; TAB(45); WVTT; TAB(60); MVTT; "HRS"
    FOR I = 1 TO 3
    PRINT #1,
    PRINT #1, TAB(1); I; "-SHIFT/DAY MAINTENANCE"
    DVTT = (T(4)) / 24 + TJJ / (8 * I) + X(17) + X(18)
    MDVTT = (T(4)) / 24 + GTT / (8 * I) + X(17) + X(18)
    WDVTT = (T(4)) / 24 + TXY / (8 * I) + X(17) + X(18)
    MDA = (T(4)) / 24
    PRINT #1, TAB(5); "VEH GRND PROCESSING DAYS"; TAB(30); DVTT - MDA; TAB(45); WDVTT - MDA; TAB(60); MDVTT - MDA
    PRINT #1, TAB(5); "TOT VEH TURNAROUND DAYS"; TAB(30); DVTT; TAB(45); WDVTT; TAB(60); MDVTT
    TP = MDA + X(17) + X(18)
    DAD = ((DVTT - TP) * 21 + TP * 30.44) / DVTT
    DAMD = ((MDVTT - TP) * 21 + TP * 30.44) / MDVTT
    DAWD = ((WDVTT - TP) * 21 + TP * 30.44) / WDVTT
    PRINT #1, TAB(5); "AVG MISSIONS/YR/VEHICLE"; TAB(30); 12 * DAD / DVTT; TAB(45); 12 * DAWD / WDVTT; TAB(60); 12 * DAMD / MDVTT
    PRINT #1, TAB(5); "COMPUTED FLEET SIZE "; TAB(30); INT((X(15) / 12) / (DAD / DVTT) + .99); TAB(45); INT((X(15) / 12) / (DAWD / WDVTT) + .99); TAB(60);
INT((X(15) / 12) / (DAMD / MDVTT) + .99)
    NEXT I
    PRINT #1,
    PRINT #1, TAB(5); "NOTE: assumes 8 hr shifts, and 21 work days a month"

PRINT #1, CHR$(12);


  PRINT #1, TAB(20); "SYSTEM PERFORMANCE SUMMARY - at mission nbr."; X(24); " - page 1"
  PRINT #1, TAB(1); "VEHICLE IS "; VNAM$; TAB(35); "DATE: "; DATE$; TAB(60); "TIME: "; TIME$
  PRINT #1, TAB(5); "RELIABILITY REPORT "
  PRINT #1, :
  PRINT #1, TAB(1); "CATEGORY"; TAB(33); "LAUNCH"; TAB(45); "END OF"; TAB(60); "ORBIT"
  PRINT #1, TAB(33); "TIME"; TAB(45); "POWER FLT"; TAB(60); "INSERTION"
  PRINT #1,
  PRINT #1, TAB(5); "VEHICLE"; TAB(33); VR1; TAB(45); VR2; TAB(60); VR3
  IF SRBREL < 1 THEN PRINT #1, TAB(5); "VEHICLE+LRB"; TAB(33); SRBREL * VR1; TAB(45); SRBREL * VR2; TAB(60); SRBREL * VR3
  IF ETREL < 1 THEN PRINT #1, TAB(5); "VEHICLE+LRB+ET"; TAB(33); ETREL * SRBREL * VR1; TAB(45); ETREL * SRBREL * VR2; TAB(60); ETREL * SRBREL * VR3
  PRINT #1,
  PRINT #1, TAB(1); TAB(45); "REENTRY"; TAB(60); "MISSION"
  PRINT #1, TAB(60); "COMPLETION"
  PRINT #1, TAB(5); "VEHICLE"; TAB(45); VR4; TAB(60); VR5
  IF SRBREL < 1 THEN PRINT #1, TAB(5); "VEHICLE+LRB"; TAB(45); SRBREL * VR4; TAB(60); SRBREL * VR5
  IF ETREL < 1 THEN PRINT #1, TAB(5); "VEHICLE+LRB+ET"; TAB(45); ETREL * SRBREL * VR4; TAB(60); ETREL * SRBREL * VR5
  PRINT #1,

  IF MTE = 0 THEN MTE = 1
PRINT #1, : PRINT #1, TAB(5); "MAINTAINABILITY REPORT"
   PRINT #1, TAB(66); "UNSCHED"
    PRINT #1, TAB(1); "CATEGORY"; TAB(28); "MAINT ACTIONS/MSN"; TAB(48); "WT-AVG MANHR/MA"; TAB(66); "AVG MANHRS/MSN"
    PRINT #1,
    PRINT #1, TAB(5); "VEHICLE"; TAB(32); TMA; TAB(50); AMHMA; TAB(65); TOMH + TFMH
    IF ETREL < 1 THEN PRINT #1, TAB(5); "EXTERNAL TANK"; TAB(32); MTE; TAB(50); STE / MTE; TAB(65); STE
    IF SRBREL < 1 THEN PRINT #1, TAB(5); "BOOSTER"; TAB(32); MTF; TAB(50); STF / MTF; TAB(65); STF
    PRINT #1, TAB(32); "ON-VEH MH"; TAB(47); "OFF-VEH MH"; TAB(62); "TOTAL MH"
    PRINT #1, TAB(5); "VEHICLE"

    PRINT #1, TAB(7); "UNSCHED"; TAB(32); TOMH; TAB(50); TFMH; TAB(65); TOMH + TFMH
    PRINT #1, TAB(7); "SCHEDULED"; TAB(32); .98 * TSCH; TAB(50); .02 * TSCH; TAB(65); TSCH
    PRINT #1, TAB(7); "PERIODIC INSPECTION"; TAB(32); .98 * PH; TAB(50); .02 * PH; TAB(65); PH
    PRINT #1, TAB(7); "TOTAL"; TAB(32); .98 * TSCH + TOMH + .98 * PH; TAB(50); .02 * (PH + TSCH) + TFMH; TAB(65); TOMH + TFMH + PH + TSCH

    IF ETREL < 1 THEN PRINT #1, TAB(5); "EXTERNAL TANK"
    IF ETREL < 1 THEN PRINT #1, TAB(7); "SCHED/UNSCHED"; TAB(32); STE + ETS * STE
    IF SRBREL < 1 THEN PRINT #1, TAB(5); "BOOSTER"
    IF SRBREL < 1 THEN PRINT #1, TAB(7); "SCHED/UNSCHED"; TAB(32); STF + SRBS * STF

    B1 = 0: B4 = 0: A1 = 0: A4 = 0
    PRINT #1, : PRINT #1, TAB(30); "MANPOWER/SPARES REPORT"
    PRINT #1, TAB(1); "Mission rate is"; X(15); "missions per year. Position manning factor is"; PMF
    PRINT #1, TAB(5); "TOTAL SPARES REQUIRED ="; TS
    PRINT #1, TAB(31); "MANPOWER RQMTS"; TAB(58); "MISSION RQMTS"
    PRINT #1, TAB(1); "CATEGORY"; TAB(20); "MANHR DRIVEN"; TAB(35); "MANHR DRIVEN"; TAB(49); "ASGN POS"; TAB(60); "ASGN MANPWR"; TAB(72); "MAX"
    PRINT #1, TAB(20); "AGGREGATE"; TAB(35); "BY SUBSYS"; TAB(49); "BY SUBSYS"; TAB(60); "BY SUBSYS"; TAB(72); "MANPWR"
    PRINT #1,
    PRINT #1, TAB(3); "VEHICLE"
    A2 = (VMH * X(15)) / (12 * X(11) * (1 - X(12)))
    A2 = INT(A2 + .999)
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IF ETREL = 1 THEN TME = 0
PRINT #1, TAB(5); "VEH MANPWR"; TAB(20); A2; TAB(35); TMP; TAB(50); C1; TAB(60); STP; TAB(72); TMEN
PRINT #1, TAB(5); "PAD"; TAB(20); X(14); TAB(35); X(14); TAB(60); X(14); TAB(72); X(14)
PRINT #1, TAB(5); "PHASE INSP"; TAB(20); MPH; TAB(35); MPH; TAB(50); CSZ; TAB(60); MPH; TAB(72); MPH
PRINT #1, TAB(5); "TOTAL"; TAB(20); A2 + X(14) + MPH; TAB(35); TMP + X(14) + MPH; TAB(50); C1 + CSZ; TAB(60); STP + X(14) + MPH; TAB(72); TMEN + X(14)
+ MPH
PRINT #1, TAB(3); "EXT TANK"
A1 = ((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 #1, TAB(5); "SCHD/UNSCH MANPWR"; TAB(25); A1; TAB(40); TME; TAB(55); B1; TAB(65); B1
PRINT #1, TAB(3); "LRB"
A4 = ((SRBS * STF + STF) * X(15)) / (12 * X(11) * (1 - X(12)))
A4 = INT(A4 + .999)
B4 = SRBCREW(1) + SRBCREW(2) + SRBCREW(3) + SRBCREW(4)
B4 = INT(B4 + .999)
IF ETREL = 1 THEN B1 = 0
IF SRBREL = 1 THEN B4 = 0: TMF = 0: A4 = 0
IF SRBREL < 1 THEN PRINT #1, TAB(5); "SCHD/UNSCH MANPWR"; TAB(25); A4; TAB(40); TMF; TAB(55); B4; TAB(65); B4
'PRINT #1, : PRINT #1, TAB(10); "TOTALS"; TAB(25); A2 + A1 + A4; TAB(40); TMP + TME + TMF; TAB(55); C1 + B1 + B4; TAB(65); STP + B1 + B4

' VEHICLE TURN TIME SUMMARY
PRINT #1, : PRINT #1, TAB(35); "VEHICLE TURN TIMES": PRINT #1,
PRINT #1, TAB(30); "MIN TURN TIME"; TAB(45); "WT-AVG"; TAB(60); "MAX TURN TIME"
FOR I = 1 TO 3
PRINT #1, TAB(1); I; "-SHIFT/DAY MAINTENANCE"
DVTT = (T(4)) / 24 + TJJ / (8 * I) + X(17) + X(18)
MDVTT = (T(4)) / 24 + GTT / (8 * I) + X(17) + X(18)
WDVTT = (T(4)) / 24 + TXY / (8 * I) + X(17) + X(18)
MDA = (T(4)) / 24
PRINT #1, TAB(5); "VEH GRND PROCESSING DAYS"; TAB(30); DVTT - MDA; TAB(45); WDVTT - MDA; TAB(60); MDVTT - MDA
PRINT #1, TAB(5); "TOT VEH TURNAROUND DAYS"; TAB(30); DVTT; TAB(45); WDVTT; TAB(60); MDVTT
TP = MDA + X(17) + X(18)
DAD = ((DVTT - TP) * 21 + TP * 30.44) / DVTT
DAMD = ((MDVTT - TP) * 21 + TP * 30.44) / MDVTT
DAWD = ((WDVTT - TP) * 21 + TP * 30.44) / WDVTT
PRINT #1, TAB(5); "AVG MISSIONS/YR/VEHICLE"; TAB(30); 12 * DAD / DVTT; TAB(45); 12 * DAWD / WDVTT; TAB(60); 12 * DAMD / MDVTT
PRINT #1, TAB(5); "COMPUTED FLEET SIZE "; TAB(30); INT((X(15) / 12) / (DAD / DVTT) + .99); TAB(45); INT((X(15) / 12) / (DAWD / WDVTT) + .99); TAB(60);
INT((X(15) / 12) / (DAMD / MDVTT) + .99)
NEXT I
PRINT #1, CHR$(12);
CALL WARGT

CLOSE #1

END SUB
```

APPENDIX D
VARIABLE DEFINITIONS

Variable Name	Basic Variable	Definition
DRY WGT	X(1), X1	Empty weight (without fuel, oil, crew, or cargo) of vehicle in pounds.
LEN+WING	X2	Aircraft length plus wing span in feet.
WETTED AREA	V(3)	Total external surface area of vehicle in square feet (includes canopy). External skin laid flat.
FUSELAGE VOL	V(2)	Total volume of fuselage in cubic feet excluding any engine inlet duct volume.
FUSELAGE AREA	V(1)	External area of fuselage in square feet including canopy.
CREW SIZE	X(3)	Total number of crew members in a normal flight crew for the vehicle.
NBR PASSENGERS	X(4)	Maximum number of passengers.
NBR MAIN ENGINES	X(5)	Number of primary engines.
NBR WHEELS	V(4)	Total number of primary landing gear wheels normally used during taxi, take-off or landing.
NBR ACTUATORS	V(5)	Total number of actuators to operate all vehicle moveable flight surfaces. May be hydraulic or electro-mechanical.
NBR CONT SUR	V(6)	Total number of control surfaces - ailerons, rudders, elevator tabs, flaps, spoilers and slats both primary and secondary.

KVA MAX	V(7)	Total normal electrical power output capacity of engines, motors and APU driven generators/alternators in KVA.
NBR HYDR. SUBSYS	V(8)	Total number of subsystems requiring use of hydraulic or pneumatic power in their normal and/or auxiliary operating role.
NBR FUEL TK	V(9)	Number of separate internal fuel cells, bladders and tanks.
NBR OXIDIZER TK	V(13)	NBR of separate, internal oxidizer tanks.
NBR TOT AVIONICS SUBS	V(10)	Total number of avionics (AN nomenclature) subsystems.
NBR DIF AVIONICS SUBS	V(11)	Total number of different avionics subsystems (two or more identical units count as one).
BTU COOLING	V(12)	Total cooling capacity of air-conditioning equipment used for personnel and equipment cooling. Measured in BTU/HR/1000.