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ACHIEVING A SYSTEM OPERATIONAL AVAILABILITY REQUIREMENT (ASOAR) MODEL VERSION 3 USER'S MANUAL

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Achieving a System Operational Availability Requirement (ASOAR) model is a macro-analysis tool. It is basically used for an early-on Logistics Support Analysis (LSA) and macro-level Reliability, Availability and Maintainability (RAM) analysis. ASOAR can determine whether a weapon system operational availability (Ao) requirement is attainable. If attainable, ASOAR estimates optimal end item operational availabilities from the system requirement.

As an early-on LSA tool, ASOAR requires only system and end item level input data, not Line Replaceable Unit (LRU) input data. ASOAR usage provides concepts for major logistics support savings in attaining a system operational availability requirement. It outputs cost effective logistics downtimes and LRU order fill rates at the most forward level of supply support for each end item and the system. It also outputs optimal end item Ao goals usable as the Ao input to an end item sparing to availability model or an end item maintenance concept optimization model.

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19. ABSTRACT (Continued)

As a macro-level RAM analysis tool, ASOAR can aid in the selection of a system Ao requirement. The cost effective logistics downtime outputs in achieving Ao goals can improve RAM Rational analyses. It can output the effective system reliability and maintainability based on the weapon system reliability block diagram configuration design. ASOAR also outputs the effective reliability of redundant end item configurations relative to attaining its cost effective end item Ao.

The Users' Manual describes ASOAR model Version 3.0 inputs and outputs, explains how to use the model, and takes the reader through sample runs, enabling the user to perform system level LSA analysis or RAM analysis using the ASOAR model.

PREFACE

The purpose of this manual is to enable an analyst, engineer or logistician to perform system level Logistics Support Analysis or Reliability, Availability and Maintainability Analysis using the ASOAR model. This manual describes ASOAR model inputs and outputs, explains how to use the model, and takes the reader through sample runs. Readers interested in the general description and application of the model should refer to the "ASOAR Model Version 3" paper published July 1992. Readers interested in the algorithms internal to the model and their derivation should refer to the "ASOAR Version 3 Methodology" paper of June 1991.

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CHAPTER 1. GENERAL

This manual was developed to assist the user in operating the Achieving a System Operational Availability Requirement (ASOAR) computer model. Currently, ASOAR can handle a system with as many as 99 end items.

ASOAR is written in Fortran 77. This is relevant because Fortran has strict input and output formats. Real numbers are distinguished by columns headed with the letter "F", while integer numbers are headed with the letter "I". Alphanumeric inputs are distinguished by columns headed with the letter "A". When asked to input a number, line up the numerals and the decimal point under the column headings that appear. For real numbers, leading and trailing zeros may be left out. For example, 0.5 may be inputted as .5, and 2.50 may be inputted as 2.5. Only leading zeros may be omitted for integer numbers, but the numerals must be right-adjusted under the column headings.

When creating a file, the rules for naming the file follow the conventions of MS-DOS. A filename can be up to 8 characters in length and may have an optional extension of up to 3 characters (XXXXXXXX.XXX). The first character of the filename must be alphanumeric. There is no allowance for an optional drive or pathname in the filename. The location of the data file is on the same default drive that contains the ASOAR executable file.

ASOAR computes Operational Availability (A_o) goals, order fill rates, and other values by doing hundreds of iterations where initial values are incremented in very small amounts. The output of a diagnostic printout shows all of these intermediate values. Therefore, it is recommended that a diagnostic printout not be chosen unless the user is prepared to spend considerable time analyzing all of these intermediate values. A detailed explanation of the diagnostic printout is found in CHAPTER 10. DIAGNOSTIC PRINTOUT INFORMATION.

CHAPTER 2. GETTING STARTED: A SAMPLE RUN

Place the floppy disk containing the ASOAR model into the A floppy disk drive. The user will copy two files from the floppy disk: the ASOAR executable file, ASOAR.EXE, and the error file, F77L.EER. The error file is executed to print out the error messages when the program run has errors such as 0 divisors or when the user tries to open a non-existing file. These two files should be in the same drive in order to be worked properly. At the C:\> prompt (or the prompt of your default drive) type:

```
C:\>COPY A:ASOAR.EXE
```

After the C:\> prompt reappears, type

```
C:\>COPY A:F77L.EER
```

Now the user has the two files in the default drive necessary to run ASOAR model. At the C:\> prompt type

```
C:\>ASOAR
```

The following messages will appear welcoming you to Version 3 of the ASOAR computer model.

When ASOAR is started, the first message to the user appears as follows:

```
WELCOME TO VERSION 3.0 OF THE ACHIEVING A SYSTEM
OPERATIONAL AVAILABILITY REQUIREMENT (ASOAR) COMPUTER MODEL.
THIS VERSION OF ASOAR WAS CREATED BY CHRISTINE SHIN AND
BERNARD PRICE OF THE US ARMY COMMUNICATIONS ELECTRONICS
COMMAND.  WITHOUT THE USE OF SPECIAL CASES, THE MODEL
DETERMINES THE COST EFFECTIVE OPERATIONAL AVAILABILITY GOALS
FOR EACH END ITEM SERIALLY CONFIGURED HAVING THEIR LINE
REPLACEABLE UNIT (LRU) SPARES SUPPLIED FORWARD WITH THE
SYSTEM.  SPECIAL CASES ARE USED TO HANDLE OTHER EQUIPMENT
CONFIGURATIONS, PERIODIC DOWNTIME, CENTRALIZED FORWARD
SUPPORT, AND END ITEM FLOATS STOCKED FORWARD.

PRESS ENTER KEY FOR NO DIAGNOSTIC PRINTOUT OR ENTER 1 FOR
DIAGNOSTIC PRINTOUT.
NOTE:  RECOMMEND PRESSING THE RETURN KEY UNLESS INTERMEDIATE
COMPUTATION VALUES ARE NECESSARY.
ENTER THE KEY NOW:
```

A diagnostic printout will considerably delay the final system and end item level output data. The data that ASOAR requires depends on the type of equipment reliability and maintainability being

specified by the user, whether or not any special cases are being considered, and whether the value for the Mean Time To Obtain (MTTO) spares is inputted directly or is computed. The user can create files with ASOAR to store some of the inputted data. A list of inputted data required for ASOAR is found in CHAPTER 5. INPUT DATA REQUIRED FOR ASOAR. For this exercise, simply hit the "RETURN" (or "ENTER") key.

DO YOU WISH TO SAVE THE OUTPUT DATA(Y/N)?

If the response is "Y", ASOAR will ask for the output file name by prompting the following:

ENTER OUTPUT FILE NAME:

After inputting the file name, the output table will be saved in the output file for later use. For this exercise, input "N".

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

SHOULD THERE BE ANY INPUT MISTAKE WHICH CANNOT BE CORRECTED, YOUR INPUT FILE CAN BE MODIFIED AFTER THIS PROGRAM RUN.

ENTER FAILURE DATA FILE NAME:

Type the desired filename and hit the RETURN key.

ASOAR will create or use an existing file with the name inputted to the question ENTER FAILURE DATA FILENAME. The data is stored in that file and the file can be changed later if different reliability, maintainability or cost data is desired. In this example, type "TEST1.DAT".

WILL USER ENTER DATA FROM KEYBOARD(Y/N)?

If the response is "N", ASOAR will search for the file TEST1.DAT for its reliability, maintainability, and cost data. The data in the file will be displayed before proceeding to a set of questions dealing with the mean time to obtain LRU spares for the end items of the system. If the response is "Y," a file will be created from answers to future questions about each end item's cost, reliability and maintainability. If the file already exists and the response is "Y", an error message will eventually appear saying that the file called by INPUT in ASOAR cannot be opened.

Since this file does not yet exist, type "Y" and hit the RETURN key.

HOW MANY END ITEMS ARE SERIALLY CONFIGURED?
II

This number represents the number of different kinds of end items making up the system. Type "05" for our examples and hit the RETURN key. The list of reliability input options then follows:

IS THE MEAN CALENDAR TIME BETWEEN FAILURE (MCTBF) INPUTTED OR COMPUTED?

1. MCTBF IS INPUTTED FOR EACH END ITEM.
2. MCTBF IS COMPUTED FROM INPUTS OF MEAN TIME BETWEEN FAILURE (MTBF) AND OPERATING HOURS PER YEAR INPUTS.
3. MCTBF IS COMPUTED FROM INPUTS OF MTBF, OPERATING HOURS PER YEAR, AND NON-OPERATING MEAN TIME TO FAILURE INPUTS.
4. MCTBF IS COMPUTED FROM FAILURE FACTOR INPUTS (FAILURES PER 100 END ITEMS PER YEAR).

ENTER THE CODE:

Mean Calendar Time Between Failure (MCTBF) is reliability terminology used internally for computations by the ASOAR model. Since operational availability represents the probability that an item will be in an operable or committable condition at any random point in calendar time, computations are performed with calendar time units.

To describe end item reliability inputs familiar to the user, ASOAR is flexible to use either MCTBF, Mean Time Between Failure (MTBF) or Failure Factors. MTBF is equipment design reliability terminology specified in operating hours rather than calendar time hours. Failure factors are the number of failures per 100 end items per year.

If the response if "1", MCTBF is directly inputted for each end item. If the response is "2", MTBF and the Number of Operating Hours per Year will be inputted. "2" assumes that the end item does not fail when it is not operating. If the response is "3", MTBF, the Number of Operating Hours per year and the Non-Operating Mean Time to Failure will be inputted. The Non-Operating Mean Time to Failure accounts for the end item failing during hiatus which is when the end item is not operating. If the response is "4", the failure factor of each end item will be inputted. When MCTBF is not directly inputted, the ASOAR model will internally compute the MCTBF so that operational availability computations are correct. ASOAR reliability outputs will be recomputed and displayed into the terminology inputted here by the user.

For our examples, type "1" and hit the RETURN key. The list of maintainability input options then follows:

IS THE MEAN TIME RESTORE (MTR) INPUTTED OR COMPUTED?

1. MTR IS INPUTTED FOR EACH END ITEM.
2. MTR IS EQUAL TO THE MEAN TIME TO REPAIR (MTTR) AND MTTR IS INPUTTED FOR EACH END ITEM.
3. MTR IS COMPUTED FOR EACH END ITEM FROM INPUTS OF MTTR AND ADDITIONAL DOWN TIME PER FAILURE AT THE ORGANIZATIONAL LEVEL EVEN WHEN LRU SPARES ARE ALWAYS AVAILABLE.

ENTER THE CODE:

Mean Time to Restore (MTR) is maintainability terminology used internally for computations by the ASOAR model. MTR represents the average amount of calendar time hours that an end item would be down if Line Replaceable Unit (LRU) spares were always on-hand to restore the end item to an operable or committable condition.

To describe end item maintainability inputs familiar to the user, ASOAR is flexible to use either MTR or Mean Time to Repair (MTTR). MTTR is equipment design maintainability terminology where LRU spares are always on-hand to restore the end item in an ideal logistics support environment.

If the response is "1", MTR is directly inputted for each end item. If the response is "2", MTTR will be inputted. "2" assumes that additional logistics down time that delays end item restoral despite the spare LRU being on-hand is negligible. If the response is "3", MTTR and the Additional Downtime per Failure when LRU spares are always available will be inputted. Additional Downtime per Failure accounts for the delayed restoral time that may come from obtaining on-hand LRU spares from storage, not always having appropriately educated or skilled personnel available, lack of complete and correctly written maintenance procedures in the Organizational Level technical manuals, and not always having functioning tools and test equipment available with the system. When MTR is not directly inputted, the ASOAR model will internally compute MTR so that operational availability computations are correct. ASOAR maintainability outputs will later be recomputed and displayed in the terminology inputted here by the user.

For our examples, type "1" and hit the RETURN key. The following header will appear:

SERIALLY CONFIGURED END ITEMS

END ITEM NAME	END ITEM NUMBER	END ITEM COST	LOW FAILURE HIGH COST ASSEMBLY EXPENSE
AAAAAAAA	II	FFFFFFF.	FFFFFFF.

Each END ITEM NAME and corresponding END ITEM NUMBER are assigned by the user. The END ITEM COST can represent the actual dollar cost of one end item, the sum of the cost of all assemblies making up the end item, or the relative cost of that end item in proportion to the cost of the other end items. The basis for the END ITEM COST input must be consistent for all end items. The last column, "LOW FAILURE, HIGH COST ASSEMBLY EXPENSE", allows for the cost of a particular assembly to be subtracted from the cost of the end item (end items are composed of assemblies). The total costs of assemblies with a significant percentage of the end item cost and a very low chance of failure (such as strategic satellite dish structural components in a communication system) are to be entered. If such an assembly exists and its cost entered, the end item cost will then be internally computed to be the value in the column "END ITEM COST" less the value in the column "LOW FAILURE, HIGH COST ASSEMBLY EXPENSE". If the end item cost is determined from the relative cost of all the end items, or if a significant cost, very low failure rate assembly does not exist for the end item, then a value of zero should be entered in the "LOW FAILURE, HIGH COST ASSEMBLY EXPENSE" column.

Type in the following input data for our examples under the appropriate column headings using the space bar and the backspace key to move between fields. When you are finished entering the data for an end item, hit the RETURN key and you may then begin entering data for the next end item.

item1	01	5000.	0.
item2	02	4000.	0.
item3	03	1000.	0.
item4	04	2000.	0.
item5	05	4000.	0.

After the data for the last end item has been entered and the RETURN key hit, ASOAR asks for the reliability data of each end item. The END ITEM NUMBER will automatically appear and reliability information corresponding to that end item will need to be inputted. The reliability inputs required for each end item depends on the response previously made to the list of reliability input options. After the end item inputs are done, the next end item number will automatically appear before the user enters its inputs.

If Option "1" was selected, the following header would appear:

```
END ITEM          MEAN CALENDAR TIME BETWEEN FAILURE
 NUMBER           FFFFFFF.
   1
```

The cursor will be right below the first F of FFFFFFF.

The MEAN CALENDAR TIME BETWEEN FAILURES (MCTBF) of each end item represents the average calendar time hours between failures of the end item. Besides the designed reliability, MCTBF also accounts for each end item's operating tempo.

If Option "2" was selected, the following header would appear:

```
END                MEAN TIME          OPERATING HOURS
 ITEM          BETWEEN FAILURE          PER YEAR
NUMBER             FFFFFFF.             FFFF.F
   1
```

The MEAN TIME BETWEEN FAILURE (MTBF) of each end item represents the average operating hours between failures. MTBF is the designed reliability based on equipment operation. The OPERATING HOURS PER YEAR accounts for the operating tempo of each end item and the system. It is needed to internally convert the inputted MTBF to MCTBF. After results are computed internally, the OPERATING HOURS PER YEAR inputs are used again to internally convert MCTBF results to MTBF outputs.

If Option "3" was selected, the following header would appear:

```
 END       MEAN TIME        OPERATING HOURS    NON-OPERATING MEAN
 ITEM  BETWEEN FAILURE        PER YEAR          TIME TO FAILURE
NUMBER     FFFFFFF.           FFFF.F             FFFFFFF.
   1
```

Option "3" is similar to Option "2" except significant failures can additionally occur when the end item is not operating. The NON-OPERATING MEAN TIME TO FAILURE of each end item represents the average non-operating hours per failure in a hiatus environment which is based on the equipment not being in operation. The non-operating hours per years is computed internally as (8760. - OPERATING HOURS PER YEAR).

If option "2" or "3" were selected, ASOAR will also ask for the system operating hours per year after end item level data inputs. The following header would appear:

```
ENTER THE OPERATING HOURS PER YEAR OF THE SYSTEM:
FFFF.F
```

This input is necessary for computing the system MTBF from internal MCTBF computation.

If Option "4" was selected, the following header would appear:

```
END ITEM          FAILURE FACTOR
 NUMBER           FFFFFF.F
   1
```

The FAILURE FACTOR of each end item represents the average number of failures for 100 end items over a calendar year.

Type in the following MCTBF input data associated to choosing reliability input Option 1 in our example. When you are finished entering the data for an end item, hit the RETURN key and you may begin entering data for the next end item.

```
1       150.
2       250.
3       150.
4       100.
5       150.
```

After the data for the last item has been entered and the RETURN key hit, ASOAR asks for the maintainability data of each end item. The END ITEM NUMBER will automatically appear and maintainability information corresponding to that end item will need to be inputted. The maintainability inputs required for each end item depends on the response previously made to the list of maintainability input options.

If maintainability input Option "1" was selected, the following header would appear:

```
END ITEM          MEAN TIME TO RESTORE
 NUMBER           FFF.FF
   1
```

The MEAN TIME TO RESTORE (MTR) of each end item represents the average calendar hours per failure that an end item would be down if LRU spares were always on-hand to restore the end item. MTR covers both the designed maintainability of the end item and logistics down time that delays restoral time despite LRU spares always being available.

If Option "2" was selected, the following header would appear.

```
END ITEM        MEAN TIME TO REPAIR
 NUMBER         FFF.FF
   1
```

The MEAN TIME TO REPAIR (MTTR) of each end item represents the average hours per failure that an end item would be down if LRU spares are always on-hand to restore the end item in an ideal logistics support environment. MTTR is the designed maintainability of the end item.

If Option "3" was selected, the following header would appear:

```
 END       MEAN TIME          ADDITIONAL ORG DOWNTIME
 ITEM      TO REPAIR               PER FAILURE
NUMBER      FFF.FF                  FFFF.FF
  1
```

Option "3" is similar to Option "2" except additional restoral time per failure beyond the designed MTTR occurs. The ADDITIONAL ORG DOWNTIME PER FAILURE represents the average calendar hours per failure that an end item would be down due to logistics factors which delays restoral time despite LRU spares always being available. These logistics factors may account for obtaining on-hand LRU spares from storage, not always having appropriately educated or skilled personnel available, lack of complete or correctly written maintenance procedures in the Organizational Level technical manuals, and not always having functioning tools or test equipment available with the equipment.

Type in the following MTR input data associated to choosing maintainability input option 1 in our example. When you finish entering the data for an end item, hit the RETURN key and you may begin entering data for the next end item.

```
1     1.25
2     1.5
3     1.
4      .5
5     1.
```

After the data for the last end item has been entered and the RETURN key hit, ASOAR asks for data on whether the Mean Time To Obtain (MTTO) LRU spares is the same or different for each end item within the system. The MTTO represents the average time it takes the most forward level of supply support to receive LRU spares when needed.

IS THE MEAN TIME TO OBTAIN (MTTO) LRU SPARES TO BE THE SAME INPUT VALUE FOR ALL END ITEMS? (Y/N)

If the response is "N," ASOAR will prompt for an MTTO value for each end item. If the response is "Y", all the end items will have the same MTTO value. For this exercise, all the end items will have the same inputted MTTO value, so type "Y" and hit the RETURN key. The list of supply support combination codes then follows:

ENTER LRU SUPPLY SUPPORT COMBINATION CODE,(1-7)
1) ORG, DS, GS, DEP
2) ORG, DS, DEP
3) ORG, GS, DEP
4) ORG, DEP
5) DS, GS, DEP (USED WITH SPECIAL CASE 8 OR 9)
6) DS, DEP (USED WITH SPECIAL CASE 8 OR 9)
7) GS, DEP (USED WITH SPECIAL CASE 10)

ENTER CODE:

The support levels shown in choice 1 represents the four level supply chain used by the Army. They are the Organizational (ORG), Direct Support (DS), General Support (GS), and Depot (DEP) levels. Other code choices, however, allow for a sparing scheme that does not employ all of the levels.

Choices 1 through 4 have the ORG level as the most forward level of LRU spare location. Choices 5 thru 7 have either the DS or GS as the most forward level of LRU spare location. Choices 5 thru 7 also require the appropriate special case to be used with the chosen code. Information on special cases 8, 9, and 10 may be found in CHAPTER 4 under their respective sections. For our example, type "1" for the supply support combination code and hit the RETURN key.

ENTER MTTO INPUT CODE (1,2)
1) MEAN TIME TO OBTAIN (MTTO) IS AVAILABLE FOR INPUT
2) MEAN TIME TO OBTAIN (MTTO) IS TO BE COMPUTED

ENTER CODE:

If Option "1" is used, the MEAN TIME TO OBTAIN (MTTO) value(s) will be directly inputted. The previous supply support combination code input screen appeared for informational purposes.

If Option "2" is used, the MTTO value(s) will be computed based on additional supply support and maintenance information. The previous supply support combination code input will become important in eliminating unnecessary supply support and maintenance information inputs. Option "2" . . . . . described completely in CHAPTER 3 of this manual. For the exercise, type "1" and hit the RETURN key.

```
ENTER MTTO (IN HOURS) FOR LRU SPARES AT MOST
FORWARD LEVEL OF SUPPORT
FFFFF.FF
```

The units for MTTO are to be in calendar hours. For this exercise, type "48." and hit the RETURN key.

The table below is what appears to the user. It shows the entered input data for the end items. If errors are present, the user may restart the program from the beginning or modify the data file. CHAPTER 8 explains data file creation and modification. Either choice would first require termination of the current ASOAR run.

```
THE FOLLOWING IS THE DATA BASE FOR TEST1.DAT.
HIT THE ENTER KEY TO SEE EACH ENTRY.

                                          LOW FAILURE
 END        END                END        HIGH COST
ITEM       ITEM               ITEM       ASSEMBLY
NAME       NUMBER             COST       EXPENSE
item1        1                5000.            0.

MEAN CALENDAR TIME      MEAN TIME
 BETWEEN FAILURES       TO RESTORE
       150.                 1.25


                                          LOW FAILURE
 END        END                END        HIGH COST
ITEM       ITEM               ITEM       ASSEMBLY
NAME       NUMBER             COST       EXPENSE
item2        2                4000.            0.

MEAN CALENDAR TIME      MEAN TIME
 BETWEEN FAILURES       TO RESTORE
       250.                 1.50
```

END ITEM NAME	END ITEM NUMBER	END ITEM COST	LOW FAILURE HIGH COST ASSEMBLY EXPENSE
item3	3	1000.	0.

MEAN CALENDAR TIME BETWEEN FAILURES	MEAN TIME TO RESTORE
150.	1.00

END ITEM NAME	END ITEM NUMBER	END ITEM COST	LOW FAILURE HIGH COST ASSEMBLY EXPENSE
item4	4	2000.	0.

MEAN CALENDAR TIME BETWEEN FAILURES	MEAN TIME TO RESTORE
100.	.50

END ITEM NAME	END ITEM NUMBER	END ITEM COST	LOW FAILURE HIGH COST ASSEMBLY EXPENSE
item5	5	4000.	0.

MEAN CALENDAR TIME BETWEEN FAILURES	MEAN TIME TO RESTORE
150.	1.00

At the end of the input table is the question:

ENTER SYSTEM OPERATIONAL AVAILABILITY(Ao(SYS))

F.FFFF

The SYSTEM OPERATIONAL AVAILABILITY (system A_o) represents the probability that the system is in an operable or committable condition at any random point in time. It represents the percentage of calendar time that the equipment is up. Frequently, the desired system A_o is found in a system requirements document. For this example, type ".93" and hit the RETURN key.

ARE THERE ANY SPECIAL CASES INVOLVED(Y/N)?

If "Y" was selected, a listing of the 10 special cases in ASOAR would follow. CHAPTER 4 special case Inputs and Prompts deals with situations where the special cases are If "N" is selected, ASOAR computations will begin which should lead to an output of results. For this exercise type "N" and hit the RETURN key. The system and end item level outputs follow indicating the completion of the ASOAR model run.

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.93000
END ITEM OPERATIONAL AVAIL PRODUCT = 0.93008

MEAN CALENDAR TIME BETW FAILURES (HRS)= 29.4
SYSTEM MEAN TIME TO RESTORE (HRS) = 0.96
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 1.188
SYSTEM ORDER FILL RATE OF LRUS = 0.9753

HIT ENTER TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUTS

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	FILL RATE
item1	1	150.	1.25	1.893	0.97947	0.9606
item2	2	250.	1.50	2.524	0.98416	0.9474
item3	3	150.	1.00	0.379	0.99089	0.9921
item4	4	100.	0.50	0.505	0.99005	0.9895
item5	5	150.	1.00	1.515	0.98351	0.9684

****

NOTE: ******** IN THE RELIABILITY COLUMN REPRESENTS A RELIABILITY EXCEEDING 9,999,999. HOURS

THANK YOU FOR USING THE ASOAR MODEL

ASOAR COMPLETED

CHAPTER 8. ANALYSIS OF OUTPUT TABLES" explains the system and end item level output results. Essentially, the tables say that the end item data provided by the user allows the system to meet the inputted A_o requirement of .93. CHAPTER 7 explains output messages that may appear instead of or in addition to the tables.

CHAPTER 3. COMPUTING THE MEAN TIME TO OBTAIN (MTTO) SPARES

The most forward level of support's Mean Time To Obtain (MTTO) LRU spares becomes important when the equipment fails and the appropriate LRU is not stocked forward to restore the equipment. The MTTO value is dependent on the LRU supply support and maintenance concepts being considered. The following information is used to compute MTTO.

Data required:

- LRU Stock Availability (SA) percentage at all supply support levels except the most forward level of support.
- Order and Ship Time (OST) in days between support levels.
- Percentage of LRUs Not Repaired (PCTNREP) or returned to stock.
- Percentage of LRUs Repaired (PCTREP) at various maintenance support levels.
- Average Repair Cycle Time (RCT) in days at all maintenance levels.
- Mean Time to Obtain a Back Order (BOMTTO) in days at DEP.

Inputs to the above data is optional because there are default values for the variables. If the user chooses to accept the default values, supplying the above data is not necessary.

When the most forward level of supply support's MTTO of LRU spares is computed, the LRU supply support combination code previously inputted as described in Chapter 2, may eliminate the need for some supply support and maintenance information. For example, if LRU supply support combination code "2" was used where there is no General Support (GS) level, information regarding LRU stock availability at GS, repair cycle time at GS, and order and ship times from Depot to GS and from GS to DS all become unnecessary.

Computation of the MTTO is initiated by entering a MTTO input code of "2" to the question.

ENTER MTTO INPUT CODE (1,2)
1) MEAN TIME TO OBTAIN (MTTO) IS AVAILABLE FOR INPUT
2) MEAN TIME TO OBTAIN (MTTO) IS TO BE COMPUTED

ENTER CODE: 2

The supply support combination code chosen earlier by the user determines which data values are needed by ASOAR to properly compute the MTTO. After the MTTO input code has been entered and the RETURN key hit, the following message appears:

```
FOR MTTO CALCULATION, YOU CAN EITHER WORK WITH THE SCREE
OR A FILE.
SHOULD YOU RUN ANY SENSITIVITY ANALYSIS,
RECOMMEND CREATING THE FILE.

FOR THIS ITEM, USER WISHES TO WORK WITH
  1) EXISTING/NEW FILES
  2) THE SCREEN WITHOUT SAVING DATA
ENTER THE CODE 1 OR 2:
```

If the user wishes to save the MTTO data or to use already existing files, the code 1 should be selected. Each end item will have a separate MTTO data file. For the items which share the same data, the identical MTTO data file can be recalled without creating separate files. If the code 1 is entered, ASOAR will ask the user to input the file name. After the file name is given, the user should respond "Y" or "N" to the prompt asking if the file will be created from the keyboard. For this exercise, enter "1".

```
ENTER MTTO DATA FILE NAME:
```

Now type MTTO.DAT.

```
WILL USER ENTER DATA FROM KEY BOARD(Y/N)?
```

If the user inputs "N", ASOAR will show the contents of the existing file. The following is a example.

```
LRU STOCK AVAILABILITIES AT DS, GS, AND DEPOT LEVELS ARE
0.9500 0.9500 0.8500 RESPECTIVELY.

ORDER AND SHIP TIMES FROM DS TO ORG, FROM GS TO DS AND FROM
DEPOT TO GS ARE      48.0     720.0    720.0  HOURS RESPECTIVELY.

PERCENTAGE OF LRUS NOT REPAIRED OR RETURNED TO STOCK IS 0.1500

PERCENTAGES REPAIRED AT ORG, DS, GS, AND DEPOT LEVELS ARE
0.0000 0.0000 0.0000 0.8500 RESPECTIVELY.

AVERAGE REPAIR CYCLE TIMES AT ORG, DS, GS, AND DEPOT LEVELS ARE
     0.0          0.0     0.0    1800.0 HOURS RESPECTIVELY.

MEAN TIME TO OBTAIN BACKORDER AT DEPOT IS    2880.0 HOURS.


Press Enter to Continue.
```

Since MTTO.DAT does not exit, type "Y" to create the file. As the user goes through the following instruction, the file MTTO.DAT will be created. Now ASOAR will lead you to the following message.

TO COMPUTE THE MTTO CORRESPONDING TO THE CHOSEN SUPPLY SUPPORT COMBINATION CODE, INDICATE WHETHER THE DEFAULT VALUES FOR THE FOLLOWING INFORMATION IS ACCEPTABLE (Y=ACCEPTABLE, N=NOT ACCEPTABLE):

Data on LRU Stock Availability (SA) is prompted for first. The SA at a particular support level is the percentage of time the needed LRU is at that level when a demand for an LRU occurs. If it is not at that level, the LRU is obtained from the next level back in the supply chain, which has its own percentage of availability. The last question that the user supplies data for (or accepts the default value) is the prompt for the BOMTTO at DEP. If the LRU is not available at any level, this number represents the average time it takes to get the LRU to the DEP level and hence into the supply chain when needed.

LRU STOCK AVAILABILITY AT DS LEVEL IS .95 (Y/N):

Type "Y" and hit the RETURN key.

LRU STOCK AVAILABILITY AT GS LEVEL IS .95 (Y/N):

Type "N," to enter a value different from the default value, and hit the RETURN key.

ENTER NEW VALUE:
.FFFF

Type ".90" and hit the RETURN key.

LRU STOCK AVAILABILITY AT DEPOT LEVEL IS .85 (Y/N):

Type "Y" and hit the RETURN key. The next set of questions are on OST between the levels in the chosen supply support code. It is the time from the need to place a requisition until receipt of the requisition and placement of the order in stock.

ORDER AND SHIP TIME FROM DEPOT TO GS IS 30 DAYS (Y/N):

Type "Y" and hit the RETURN key.

ORDER AND SHIP TIME FROM GS TO DS IS 30 DAYS (Y/N):

Type "Y" and hit the RETURN key.

ORDER AND SHIP TIME FROM DS TO ORG IS 2 DAYS (Y/N):

Type "Y" and hit the RETURN key. The next set of questions concern the PCTREP or percentage repaired at appropriate support levels. The first prompt asks for the PCTNREP or percentage not repaired and returned to stock due to washout of the LRUs, the user not returning LRUs for repair, and loss of the LRUs in shipment.

PERCENTAGE OF LRUS NOT REPAIRED OR RETURNED TO STOCK IS .15 (Y/N):

Type "Y" and hit the RETURN key.

THE PERCENTAGE OF LRUS ABLE TO BE REPAIRED MUST THEREFORE NOT EXCEED .8500. WHEN THAT VALUE IS REACHED, ANY REMAINING SUPPORT LEVELS WILL HAVE A 0.00 PERCENTAGE OF LRUS ABLE TO BE REPAIRED.

PERCENTAGE REPAIRED AT DEPOT LEVEL IS .8500 (Y/N):

All of the support levels may have a certain PCTREP at their location. The total of all repair percentages and percentage not repaired or returned sums to one. The first LRU prompt allows the user to input a value or accept the default value for PCTNREP. This percentage is subtracted from 1.00 and the remaining percentage represents the maximum amount of LRUs that can be repaired or returned to stock. Thus, for this example, the sum of the PCTREP from all levels must not exceed .8500.

ASOAR assigns the maximum allowable percentage to the default value of the DEP level (.8500). If the user accepts this value, then the percentage repaired at the remaining levels (GS, DS, ORG) will be zero. Type "N" and hit the RETURN key.

ENTER NEW VALUE:
.FFFF

Type ".8" and hit the RETURN key.

PERCENTAGE REPAIRED AT GS LEVEL IS .0500 (Y/N):

Notice that ASOAR has calculated a new maximum default value of .0500 (1.-.15-.80) for the next level of support. Type "N" and hit the RETURN key.

ENTER NEW VALUE
.FFFF

Type ".045" and hit the RETURN key.

PERCENTAGE REPAIRED AT DS LEVEL IS .0050 (Y/N):

Type "Y" and hit the RETURN key. The PCTREP at the ORG level now defaults to .0000 (since the maximum value was accepted for the DS level).

ASOAR then asks for data on the average Repair Cycle Time (RCT) at the support levels. This is the average time from failure that it takes for repair of an LRU to occur at the particular support level. It includes the time from when the LRU is removed from the end item, shipped, screened/repaired, and put back into stock at the support level. If a support level has a zero PCTREP there, then the corresponding question for the average RCT at that support level will not be asked. For example, since there was a zero PCTREP at the ORG level for this exercise, the question for the average RCT at the ORG level will not be asked.

AVERAGE REPAIR CYCLE TIME AT DEPOT LEVEL IS 75 DAYS (Y/N):

Type "Y" and hit the RETURN key.

AVERAGE REPAIR CYCLE TIME AT GS LEVEL IS 30 DAYS (Y/N):

Type "Y" and hit the RETURN key.

AVERAGE REPAIR CYCLE TIME AT DS LEVEL IS 2 DAYS (Y/N):

Type "N" and hit the RETURN key.

ENTER NEW VALUE (IN DAYS):
FFFF.FF

Type "6." and hit the RETURN key. ASOAR then prompts for data concerning the average time it takes for the Depot level to obtain a backorder.

MEAN TIME TO OBTAIN BACKORDER AT DEPOT IS 120 DAYS (Y/N)?

Type "Y" and hit the RETURN key. ASOAR now has all the information necessary to compute the MTTO.

******* COMPUTED VALUE OF MTTO = 88.79 HRS *******

The computation of the MTTO is complete and ASOAR now returns the user to the point in the program where data in the failure data file appears on the screen before the system A$_o$ input is requested as shown in CHAPTER 2. GETTING STARTED: A SAMPLE RUN.

```
THE FOLLOWING IS THE DATA BASE FCR TEST1.DAT
HIT THE RETURN KEY TO SEE EACH ENTRY.

                    .
                    .
                    .
```

CHAPTER 4. SPECIAL CASE INPUTS AND PROMPTS

ASOAR has 10 special cases to handle equipment commonalities, equipment redundancies, scheduled maintenance or periodic startup causing downtime, multiple systems per site, and systems with end item spares, and systems without LRUs stocked forward at the operating level.

The prompt for the special cases appears after the following question about the system operational availability is answered.

ENTER SYSTEM OPERATIONAL AVAILABILITY(AO(SYS))

F.FFFF

For our examples, ".93" was answered.

ARE THERE ANY SPECIAL CASES INVOLVED(Y/N)?

A response of "Y" will produce the special cases menu. Type "Y" and hit the RETURN key.

CASE 1: SERIALLY CONFIGURED COMMON END ITEMS

CASE 2: HOT STANDBY REDUNDANT END ITEMS

CASE 3: COLD STANDBY REDUNDANCY OR END ITEM SPARES WITH SYSTEM

CASE 4: DEGRADATIONAL REDUNDANCY OR CAPACITY AVAILABILITY

CASE 5: SYSTEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING DOWNTIME

CASE 6: END ITEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING SYSTEM DOWNTIME

CASE 7: MULTIPLE SYSTEMS RESTORED WITH LRU SPARES AT ORG LEVEL

CASE 8: SYSTEMS RESTORED WITH LRUS STOCKED FORWARD AT DS LEVEL

CASE 9: SYSTEMS RESTORED WITH END ITEM AND LRUS STOCKED FORWARD AT DS LEVEL

CASE 10: SYSTEMS RESTORED WITH END ITEM SPARES AT DS AND LRUS STOCKED FORWARD AT GS LEVEL

ENTER CASE NUMBER(1,2,3....,10)

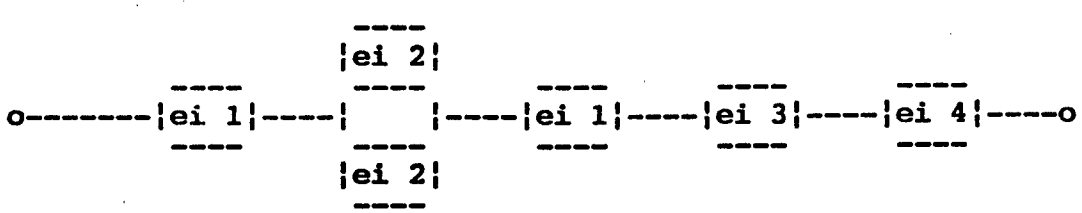
At this point the user selects the desired case. Information and data required for each case is provided in the remainder of this section.

CASE 1: SERIALLY CONFIGURED COMMON END ITEMS

Data Required - the item number [illegible] which is common; the quantity of the common end item(s).

A common end item is an end item that appears in more th [illegible] once in the system. CASE 1 is concerned with commonality [illegible] in a series configuration as opposed to the common end items b [illegible]ng in parallel. For example, FIGURE 1 shows a portion of a possible system configuration. End Item 1 is common in a serial manner and End Item 2 is common in a parallel manner. The distinction is important because if one of the end items of End Item 2 goes down, the system may still be up. However, if one of the end items of End Item 1 goes down, then the system goes down.

FIGURE 1



After CASE "1" has been entered, the user is prompted for the number of end items which are in this category.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

HOW MANY DIFFERENT END ITEMS ARE IN THIS CATEGORY?
II

Two of the 5 end items in the file TEST1.DAT will be used as common for this exercise. Type "02" and hit the RETURN key.

CASE 1 - COMMON END ITEMS (SERIAL END ITEM)

ITEM NUMBER	QUANTITY
II	III

Type in the following data under the appropriate column headings using the space bar and backspace key to move between fields. When you are finished entering the data for an end item, hit the RETURN key and you may then begin entering data for the next end item.

1	2
3	2

The system now consists of 7 end items; 2 end items of type item1, 2 end items of type item3, and 1 end item each of the other end items.

When the data for the last end item is entered and the RETURN key hit, ASOAR asks whether any other cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED(Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.93000
END ITEM OPERATIONAL AVAIL PRODUCT = 0.93004

MEAN CALENDAR TIME BETW FAILURES (HRS)= 21.1
SYSTEM MEAN TIME TO RESTORE (HRS) = 1.01
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 0.538
SYSTEM ORDER FILL RATE OF LRUS = 0.9888

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	Ao of 1	FILL RATE
item1	1	75.	1.25	0.597	0.97597	0.98791	0.9876
item2	2	250.	1.50	1.591	0.98779		0.9668
item3	3	75.	1.00	0.119	0.98529	0.99262	0.9975
item4	4	100.	0.50	0.318	0.99188		0.9934
item5	5	150.	1.00	0.955	0.98714		0.9801

****

NOTE: ******** IN THE RELIABILITY COLUMN REPRESENTS
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CASE 2: HOT STANDBY REDUNDANT END ITEMS

Data Required - the name and item number of the end item which is redundant; the total quantity of the end item and how many of that quantity are needed for the system to be up.

Redundancy is used to describe a situation where there are more end items present than actually are needed. That is, a certain number of end items are required for the system to be fully up and the other end items can be considered extra. The phrase "hot" standby means that when one of the required end items goes down and there is a similar end item operating in a standby mode, control is passed to that extra end item almost instantaneously. This means that practically no additional downtime occurs during this switch and that the system remains fully up. Since the extra end item must be kept operating or "up" for this near instantaneous switch to occur, it fails more frequently than not operating. If it should take a significant amount of time to pass control or switch to hot standby redundant end items, then CASE 6. END ITEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING SYSTEM DOWNTIME can be used to handle this additional downtime.

After CASE "2" has been entered, the user is prompted for the filename which contains the hot standby redundancy data.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

SHOULD THERE BE ANY INPUT MISTAKE WHICH CANNOT BE CORRECTED, YOUR INPUT FILE CAN BE MODIFIED AFTER THIS PROGRAM RUN.

ENTER HOT REDUNDANCY DATA FILE NAME:

Type "CASE2.DAT" and hit the RETURN key.

WILL USER ENTER REDUNDANCY DATA FROM KEYBOARD (Y/N)?

If the response "N" is typed, ASOAR searches for the redundancy data in the file CASE2.DAT. Since this file does not yet exist, the data must be entered from the keyboard. Type "Y" and hit the RETURN key.

The data from the keyboard will be stored in the file CASE2.DAT. ASOAR will lead the user through the following prompts.

HOW MANY DIFFERENT END ITEMS ARE IN THIS [illegible]?
II

Three of the 5 end items in the file TEST1.DAT will be used in this example. Type "3" and hit the RETURN key.

CASE 2 - HOT STANDBY REDUNDANT END ITEMS

ITEM NAME	ITEM NO.	R OF N	
AAAAAAAA	II	II	II

For the given end item, the header "R OF N" says that out of the "N" similar end items, "R" of them are required. The remaining end items, N-R of them, are considered redundant. Instances where R equals N yields results similar to CASE 1. SERIALLY CONFIGURED COMMON END ITEMS.

Enter the following data. Use the space bar and backspace key to move between fields. Hit the RETURN key to enter data for the next end item.

item1	01	02	07
item2	02	01	02
item3	03	01	02

When the data for the last end item is entered and the RETURN key hit, ASOAR asks whether any other cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED(Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear.

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.93000
END ITEM OPERATIONAL AVAIL PRODUCT = 0.92997

MEAN CALENDAR TIME BETW FAILURES (HRS)= 55.2
SYSTEM MEAN TIME TO RESTORE (HRS) = 0.74
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 3.306
SYSTEM ORDER FILL RATE OF LRUS = 0.9017

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	Ao of 1	FILL RATE
item1	1	19234.	1.25	6.958	0.99957	0.79515	0.0000
item2	2	1509.	1.50	23.250	0.98387	0.87298	0.0000
item3	3	1337.	1.00	8.464	0.99297	0.91618	0.6265
item4	4	100.	0.50	1.261	0.98269		0.9737
item5	5	150.	1.00	3.784	0.96909		0.9212

****

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CASE 3: COLD STANDBY REDUNDANCY OR END ITEM SPARES WITH SYSTEM

Data Required - the name and item number of the end item which is redundant; the total quantity of the end item and how many of that quantity are needed for the system to considered up; unscheduled maintenance downtimes (hours) associated with the redundant end items.

The redundancy that exists in CASE 3 is similar to the redundancy that exists in CASE 2 with a major difference. The switch to the redundant end item when the required end item goes down is not an instantaneous switch. Although available, the cold standby redundant end item is not up or operating. There is some unscheduled maintenance downtime required to pass control or switch to the redundant end item and to bring it to an operating condition. The system is down during this unscheduled downtime. However, while there is additional downtime present in the system, the redundant end item is not accruing failure hours in its cold standby mode because it is not operating until it is needed. Redundant end items in the hot standby mode do accrue failure hours because they are operating when not needed.

After CASE "3" has been entered, the user is prompted for the filename which contains the cold standby redundancy data.

CASE 3 - COLD STANDBY REDUNDANCY OR END ITEM SPARES WITH SYSTEM

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

SHOULD THERE BE ANY INPUT MISTAKE WHICH CANNOT BE CORRECTED, YOUR INPUT FILE CAN BE MODIFIED AFTER THIS PROGRAM RUN.

ENTER COLD REDUNDANCY DATA FILE NAME:

The user can either create a new file or use an existing file previously created. Type "CASE3.DAT" and hit the RETURN key.

WILL USER ENTER REDUNCANCY DATA FROM KEYBOARD (Y/N)?

If the response "N" is typed, ASOAR searches for the redundancy data in file CASE3.DAT. Since this file does not yet exist, the data must be entered from the keyboard. Type "Y" and hit the RETURN key. The data from the keyboard will be stored in the file CASE3.DAT.

ASOAR will now prompt the user for cold standby redundancy data. This data covers unscheduled maintenance downtime associated to switching over to a redundant or spare end item. This data also provides system configuration information regarding the number of similar end items operating for the system to be up and the total number of similar end items available with the system.

HOW MANY DIFFERENT END ITEMS ARE IN THIS CATEGORY?
II

Three of the 5 end items in the file TEST1.DAT will be used in this example. Type "3" and hit the RETURN key.

ITEM NAME	ITEM NUMBER	MEAN MAINTENANCE DOWNTIME	R OF N
AAAAAAAA	II	FF.FF	II II

Each end item in cold standby redundancy has unscheduled maintenance downtime associated with it. This downtime represents the switch over time to a redundant end item or end item spare.

For the given end item, the header "R OF N" says that out of the "N" similar end items, "R" of them are required. The remaining end items, N-R of them, are considered redundant. Instances where R equals N are handled by either CASE 1. COMMON END ITEMS or CASE 4. DEGRADATIONAL REDUNDANCY.

Enter the following data. Use the space bar and backspace key to move between fields. Hit the RETURN key to enter data for the next end item.

item1	01	.50	02	07
item2	02	.25	01	02
item3	03	1.50	01	02

When the data for the last end item is entered and the RETURN key hit, ASOAR asks whether any other cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED (Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.94651
END ITEM OPERATIONAL AVAIL PRODUCT = 0.94656

MEAN CALENDAR TIME BETW FAILURES (HRS)= 57.2
SYSTEM MEAN TIME TO RESTORE (HRS) = 0.72
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 2.446
SYSTEM ORDER FILL RATE OF LRUS = 0.9322

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	Ao of 1	FILL RATE
item1	1	774369.	1.25	6.958	0.99999	0.89048	0.0000
item2	2	2854.	1.50	23.250	0.99140	0.90727	0.0000
item3	3	2144.	1.00	10.562	0.99464	0.92675	0.5391
item4	4	100.	0.50	0.989	0.98533		0.9794
item5	5	150.	1.00	2.968	0.97423		0.9382

****

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CASE 4: DEGRADATIONAL REDUNDANCY OR CAPACITY AVAILABILITY

Data Required - the name and item number of the end item which is redundant; the total quantity of the end items needed for the system to be fully up and how many of that quantity are operating in the system; unscheduled maintenance downtimes (hours) associated with the cold standby degradational redundant end items; minimum number of end items for the system to be considered fully up; maximum number of end items for the system to be considered fully down; the percentage of upness associated to states where the number of end items up correspond to the system being neither fully up nor fully down (optional).

Degradational redundancy or capacity availability applies to both hot standby redundancy and cold standby redundancy (CASES 2 and 3). In fact, when the user chooses CASE 4 as the special case for the system, the first question asked is which kind of redundancy applies to CASE 4.

CASE 4 - DEGRADATIONAL REDUNDANCY OR CAPACITY AVAILABILITY

ENTER THE CODE (1,2) ASSOCIATED WITH WHETHER THE DEGRADATIONAL REDUNDANCY IS A HOT OR COLD STANDBY REDUNDANCY.

1)HOT STANDBY DEGRADATIONAL REDUNDANCY
2)COLD STANDBY DEGRADATIONAL REDUNDANCY

ENTER CODE:

Many of the questions and prompts in CASE 4 are identical to those in CASES 2 and 3 also. For this reason, the user is asked to review the previous information on CASE 2 or 3, whichever happens to apply to CASE 4 at the time, for a more detailed explanation on hot and cold redundancies in general.

Degradational redundancy is used to describe a system which is operating at less than 100% capacity. The system is not operating in the fully up mode, but at a level that is a certain percentage of the fully up state. In other words, degradational redundancy is a state of operation of the system between the levels of fully up (100%) and fully down (0%).

An example may best illustrate this concept. Consider a system with 6 end items of type A. Out of the 6 end items of type A, the system needs 4 of them operating to be considered fully up. The other 2 end items of type A are redundant in the

cold standby mode.

The 4 end items of type A would be the minimum number of end items required for the system to be considered fully up. If the system is completely down when only 1 end item of type A is left operating, this would represent the maximum number of end items for the system to be considered fully down. If 1 of the 4 operating end items were to go down, the system would not go down but may operate at a 75% capacity with the 3 remaining end items (until one of the redundant end items would bring the system back up to fully operational). With 2 end items of type A operating, the system may be operating at 50% capacity. ASOAR will ask if the percent capacity or upness percentage is to be inputted directly by the user. For this example, the upness percentages are inputted. If the upness percentages are not inputted, ASOAR will compute values internally. A linear approximation is used for this computation (66.7% upness with 3 end items operating and 33.3% upness with 2 end items operating for this example).

CASE 4 will now be examined in more detail. After CASE "4" has been entered, ASOAR asks the user to choose the code corresponding to which mode of redundancy applies to the system.

ENTER THE CODE (1,2) ASSOCIATED WITH WHETHER THE DEGRADATIONAL REDUNDANCY IS A HOT OR COLD STANDBY REDUNDANCY.

1)HOT STANDBY DEGRADATIONAL REDUNDANCY
2)COLD STANDBY DEGRADATIONAL REDUNDANCY

ENTER CODE:

Type "1" and hit the RETURN key.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

SHOULD THERE BE ANY INPUT MISTAKE WHICH CANNOT BE CORRECTED, YOUR INPUT FILE CAN BE MODIFIED AFTER THIS PROGRAM RUN.

ENTER HOT REDUNDANCY DATA FILE NAME:

If the code for cold standby degradational redundancy had been entered, the first question would have been for the Cold Redundancy Data File name, just as in CASE 3. Since CASE2.DAT is not used in this example run, type "CASE4.DAT" and hit the RETURN key.

WILL USER ENTER REDUNDANCY DATA FROM KEYBOARD (Y/N)?

If the response "N" is typed, ASOAR searches for the redundancy data in the file CASE4.DAT. Since this file does not yet exist, the data must be entered from the keyboard. Type "Y" and hit the RETURN key. The data from the keyboard will be stored in the file CASE4.DAT.

```
HOW MANY DIFFERENT END ITEMS ARE IN THIS CATEGORY?
II
```

For this example, 2 of the 5 end items in TEST1.DAT will have degradational redundancy associated with them. Type "02" and hit the RETURN key. ASOAR indicates the type of degradational redundancy, either CASE 2 or CASE 3, chosen by the user. The end item data is then prompted for:

```
ITEM        ITEM
NAME        NO.       R OF N
AAAAAAAA    II       II    II
```

For the given end item, the header "R OF N" may say that out of the "N" similar end items, "R" of them are operating. Any remaining end items, N-R of them, are needed for full operation but considered missing from the system. Note that the "R" value in CASE 4 may not stand for "required" as in CASES 2 and 3. This is because there may exist a situation where all the end items present are operating, but the system may still not be fully up. For example, 4 end items of type A are available and all of them are operating, but 6 end items of type A are actually needed for the system to be fully up. If this situation did exist, the 4 of 4 operating end items would represent a degradational state of the system. The number 6 would then represent the minimum number of end items required for the system to be considered fully up. For all other situations where enough end items are within the system to operate at full capacity, the minimum number of end items required for the system to be considered fully up is equal to "R."

Enter the following data for the first end item. Use the space bar and the backspace key to move between fields. Hit the RETURN key when the data is finished being entered.

```
item1       01        03    04
```

ASOAR now prompts for the data associated with the degradational redundancy.

```
ENTER MINIMUM NUMBER OF END ITEMS
OPERATIONAL TO BE CONSIDERED FULLY UP
II
```

As was mentioned in the previous page, this number may be equal to the inputted "R" value when enough end items are within the system to operate at full capacity. The exception would be equal to the "N" value if the R value, represented a degradational state. Type "3" and hit the RETURN key.

```
ENTER MAXIMUM NUMBER OF END ITEMS
OPERATIONAL TO BE CONSIDERED FULLY DOWN
(GENERALLY ZERO)
II
```

While a value of zero does apply to most end items, the user may input a value up to and including R-1. Type "0" and hit the RETURN key. ASOAR now asks for the upness percentages.

```
ARE UPNESS PERCENTAGES TO BE MANUALLY ENTERED (Y/N)?
```

If "N" is entered as the response, ASOAR internally computes the upness percentages for 2 out of 4 end items of type item1 operating and also for 1 out of 4 operating. Column headings would then appear indicating that data for the next end item is to be entered. Type "Y" and hit the RETURN key.

```
ENTER UPNESS PERCENTAGE FOR 2 OUT OF 4 ITEMS OPERATING
(A PERCENTAGE IN THE RANGE 0-1)
.FFFF
```

Type ".9" and hit the RETURN key.

```
ENTER UPNESS PERCENTAGE FOR 1 OUT OF 4 ITEMS OPERATING
(A PERCENTAGE IN THE RANGE 0-1)
.FFFF
```

Type ".75" and hit the RETURN key. The column header appears indicating that data for the next end item is to be entered.

```
ITEM        ITEM
NAME        NO.       R OF N
AAAAAAAA    II       II   II
```

```
Enter the following data for the next end item.

item4       04       01   02
```

After the RETURN key is hit, ASOAR asks for the minimum and maximum number of end item values for item4.

```
    ENTER MINIMUM NUMBER OF END ITEMS
    OPERATIONAL TO BE CONSIDERED FULLY UP
II
```

Type "1" and hit the RETURN key.

```
    ENTER MAXIMUM NUMBER OF END ITEMS
    OPERATIONAL TO BE CONSIDERED FULLY DOWN
    (GENERALLY ZERO)
II
```

Type "0" and hit the RETURN key. ASOAR does not ask for upness percentages when there is no possibility of operation between the fully up and fully down modes. For item4 in this example, it is similar to using CASE 2.

When the data for the last end item is entered and the RETURN key hit, ASOAR asks whether any other cases are to be used for this system.

```
    ARE THERE ANY ADDITIONAL CASES INVOLVED(Y/N)?
```

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.93000
END ITEM OPERATIONAL AVAIL PRODUCT = 0.92994

MEAN CALENDAR TIME BETW FAILURES (HRS)= 51.8
SYSTEM MEAN TIME TO RESTORE (HRS) = 1.09
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 2.710
SYSTEM ORDER FILL RATE OF LRUS = 0.9172

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	Ao of 1	FILL RATE
item1	1	1194.	1.25	19.410	0.98299	0.82925	0.1652
item2	2	250.	1.50	3.279	0.98124		0.9317
item3	3	150.	1.00	0.492	0.99015		0.9898
item4	4	891.	0.50	5.816	0.99296	0.91609	0.7472
item5	5	150.	1.00	1.967	0.98060		0.9590

****

NOTE: ******** IN THE RELIABILITY COLUMN REPRESENTS
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CASE 5: SYSTEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING DOWNTIME

Data Required - system mean calendar time between maintenance (hours); system mean maintenance downtime (hours).

ASOAR allows the user to input additional downtime when the system is not available due to scheduled maintenance or some other foreseen reason causing additional periodic downtime. This additional downtime adjusts the system A_o requirement so that a higher A_o goal must be reached. CASE 5 may also be used more than once during an ASOAR run. For example, a system may be unavailable for 4 hours every 1000 hours due to preventive maintenance and it may have to be relocated every 5000 hours. During this relocation process, the system may be down for 10 hours due to tear down time, movement and setup time.

After CASE "5" has been entered, ASOAR asks for the time between scheduled maintenance and the actual amount of time that the system is down.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

CASE 5: SYSTEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING DOWNTIME

SYSTEM MEAN CALENDAR TIME BETWEEN MAINTENANCE	SYSTEM MEAN MAINTENANCE DOWNTIME
FFFFF.FF	FFF.FF

The Mean Calendar Time Between Maintenance (MCTBM) is a measure of downtime frequency. It says that additional downtime occurs every x number of hours. The Mean Maintenance Downtime (MMDT) represents the actual amount of downtime associated with a maintenance action. Type in the following values and hit the RETURN key when finished.

500.0 6.0

When the data for the end item is entered and the RETURN key hit, ASOAR asks whether any other cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED(Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.94116
END ITEM OPERATIONAL AVAIL PRODUCT = 0.94121

MEAN CALENDAR TIME BETW FAILURES (HRS)= 29.4
SYSTEM MEAN TIME TO RESTORE (HRS) = 0.96
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 0.833
SYSTEM ORDER FILL RATE OF LRUS = 0.9826

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITME: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	FILL RATE
item1	1	150.	1.25	1.328	0.98311	0.9723
item2	2	250.	1.50	1.770	0.98709	0.9631
item3	3	150.	1.00	0.266	0.99163	0.9945
item4	4	100.	0.50	0.354	0.99153	0.9926
item5	5	150.	1.00	1.062	0.98644	0.9779

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CASE 6: END ITEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING SYSTEM DOWNTIME

Data Required - the number of end items with periodic maintenance causing system downtime; the name and item number of the end item with periodic maintenance; end item mean calendar time between maintenance (hours); end item mean maintenance downtime (hours).

CASE 6 allows the user to input additional downtime when an end item is not operational and causing the system to be down. This may be due to scheduled maintenance, hot standby redundancy switch over time or some other foreseen reason causing additional periodic downtime. The additional downtime in CASE 6 adjusts the system A_o requirement so that a higher A_o goal must be reached. CASE 6 can be used on all end items except for those that are used in cold standby redundancy (CASE 3) and cold degradational redundancy (CASE 4, choice 2). This is because CASE 6 is already incorporated into CASE 3 and CASE 4(2) via the Mean Calendar Time Between Maintenance being computed internally from the end item MCTBF and quantity of end items operating for each end item in these two cases. The Mean Maintenance Downtime in CASE6 expresses the average amount of both end item and system downtime associated to the maintenance action or proiodic startup of the end item.

After CASE "6" has been entered, ASOAR asks for the time between scheduled maintenance and the actual amount of time that the system is down.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

SHOULD THERE BE ANY INPUT MISTAKE WHICH CANNOT BE CORRECTED, YOUR INPUT FILE CAN BE MODIFIED AFTER THIS PROGRAM RUN.

ENTER MAINTENANCE DOWNTIME DATA FILE NAME:

Type "CASE6.DAT" and hit the RETURN key.

WILL USER ENTER DATA FROM KEYBOARD(Y/N)?

If the response "N" is typed, ASOAR searches for the maintenance downtime data in the file CASE6.DAT. Since this file does not yet exist, the data must be entered from the keyboard. The data from the keyboard will be stored in the file CASE6.DAT. Type "Y" and hit the RETURN key.

HOW MANY DIFFERENT END ITEMS ARE IN THIS CATEGORY?
II

Type "2" and hit the RETURN key.

CASE 6: END ITEM SCHEDULED MAINTENANCE
OR PERIODIC STARTUP CAUSING SYSTEM DOWNTIME

ITEM NAME	ITEM NUMBER	MEAN CALENDAR TIME BETWEEN MAINTENANCE	MEAN MAINTENANCE DOWNTIME
AAAAAAA	II	FFFFF.FF	FFFF.FF

As in CASE 5, the Mean Calendar Time Between Maintenance (MCTBM) tells how frequent this additional downtime occurs and the Mean Maintenance Downtime (MMDT) tells how long that the end item and system are additionally down.

Enter the following data. Use the space bar and backspace key to move between fields and hit the RETURN key when the data for an end item is finished being entered.

item1	01	500.	.50
item3	03	1000.	2.50

When the data for the last end item is entered and the RETURN key hit, ASOAR asks whether any other cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED (Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.93326
END ITEM OPERATIONAL AVAIL PRODUCT = 0.93333

MEAN CALENDAR TIME BETW FAILURES (HRS)= 29.4
SYSTEM MEAN TIME TO RESTORE (HRS) = 0.96
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 1.084
SYSTEM ORDER FILL RATE OF LRUS = 0.9774

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	FILL RATE
item1	1	150.	1.25	1.727	0.98054	0.9640
item2	2	250.	1.50	2.303	0.98502	0.9520
item3	3	150.	1.00	0.345	0.99111	0.9928
item4	4	100.	0.50	0.461	0.99049	0.9904
item5	5	150.	1.00	1.382	0.98437	0.9712

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CASE 7: MULTIPLE SYSTEMS RESTORED WITH LRU SPARES AT ORG LEVEL

Data Required - whether the system configuration contains multiple identical systems; number of systems serviced at Organization Level.

CASE 7 handles the situation where the ORG level supports more than just one system and the operational availability requirement is for a system configuration of multiple identical systems. The LRU spares are storable at the ORG level and can be used to bring up any one of these identical systems.

After CASE "7" has been entered, ASOAR asks for the number of systems serviced by the ORG level.

CASE 7 - MULTIPLE SYSTEMS RESTORED WITH LRU SPARES AT ORG LEVEL

ENTER 1 OR 2

1) THE SYSTEM CONFIGURATION CONTAINS MULTIPLE IDENTICAL SYSTEMS
2) ORG LEVEL SUPPORTS MULTIPLE INDIVIDUAL SYSTEMS.

**

If the operational availability requirement is for a configuration of more than one individual system, "1" should be chosen. If the operational availability requirement is for an individual system, "2" should be chosen. If "2" is chosen, ASOAR would run as if no application of Case 7 is involved because the LRU order fill rate for the multiple individual system is identical to the individual system. The same order fill rate with more LRU demands will generate greater LRU stock. For this run, type "1" to run Case 7, and the following prompt will appear.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

NO. OF SYSTEMS WITHIN SYSTEM CONFIGURATION
II

Type "02" and hit the RETURN key. ASOAR now asks whether any additional cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED(Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.93000
END ITEM OPERATIONAL AVAIL PRODUCT = 0.92999

MEAN CALENDAR TIME BETW FAILURES (HRS)= 14.7
SYSTEM MEAN TIME TO RESTORE (HRS) = 0.96
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 0.115
SYSTEM ORDER FILL RATE OF LRUS = 0.9976

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	FILL RATE
item1	1	75.	1.25	0.183	0.98126	0.9962
item2	2	125.	1.50	0.243	0.98624	0.9949
item3	3	75.	1.00	0.037	0.98637	0.9992
item4	4	50.	0.50	0.049	0.98915	0.9990
item5	5	75.	1.00	0.146	0.98495	0.9970

****

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CASE 8: SYSTEMS RESTORED WITH LRUS STOCKED FORWARD AT DS LEVEL

CASES 8, 9, and 10 describe systems without spares at the operating level or ORG level. These cases imply that N systems are serviced by a centralized area that brings any of these systems to an up state after going down. This centralized support stores the spares that restore the system and is the most forward level of supply. One example might be a Contact Maintenance Team where maintenance personnel travel with spares to the system to restore it. Another example could be a Direct Exchange point where failed end items or LRUs are brought and exchanged for a working spare to restore the system. A final example could be a DS shop to where failed systems are evacuated for restoral. The similarities of these examples are that spares are not stored forward with the system and some delay time occurs before restoral of the system can be accomplished.

Data Required - the number of end items with LRUs stocked forward at DS level; the item number of the end item serviced by the DS level; the mean delay time to restore from a DS level (hours).

CASE 8 is used for system restoral with LRUs located at the DS level. The DS level is a centralized support area servicing various system sites. The average down time between the time the end item and system have failed and the time required for the LRU to be brought to the equipment is the Mean Delay Time to Restore (MDTR). MDTR may also represent the average time to evacuate the equipment to DS to start its maintainability maintenance plus the time to return the repaired equipment back to the site if applicable.

After CASE "8" has been entered, ASOAR asks for the MDTR from the DS level.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

CASE 8: SYSTEM RESTORED WITH LRUS AT DIRECT SUPPORT LEVEL

MEAN DELAY TIME TO RESTORE FROM DIRECT SUPPORT LEVEL FFFF.

For this example, enter "3." hours for the MRDT. After entering this value, ASOAR will ask for the number of different end items in this category and their item numbers, prompting the following.

ENTER THE QUANTITY OF DIFFERENT END ITEMS
AND THE ITEM NUMBER OF THESE END ITEMS WHERE THE SYSTEM
IS RESTORED WITH LRU SPARES AT DIRECT SUPPORT LEVEL

HOW MANY DIFFERENT END ITEMS ARE IN THIS CATEGORY?
II

Enter "2" and hit return for this exercise. The following prompt will now appear:

ITEM NUMBER
II

Type in as the following:

1
3

ASOAR now asks whether any additional cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED(Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATICNAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.93000
END ITEM OPERATIONAL AVAIL PRODUCT = 0.92998

MEAN CALENDAR TIME BETW FAILURES (HRS)= 29.4
SYSTEM MEAN TIME TO RESTORE (HRS) = 2.14
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 0.022
SYSTEM ORDER FILL RATE OF LRUS = 0.9996

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	FILL RATE
item1	1	150.	4.25	0.034	0.97223	0.9993
item2	2	250.	1.50	0.046	0.99385	0.9990
item3	3	150.	4.00	0.007	0.97398	0.9999
item4	4	100.	0.50	0.009	0.99493	0.9998
item5	5	150.	1.00	0.027	0.99320	0.9994

****

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CASE 9: SYSTEMS RESTORED WITH END ITEM SPARES AND LRU SPARES STOCKED FORWARD AT DS LEVEL

Data Required - the number of systems serviced by a DS level; the mean delay time to restore from a DS level (hours); the number of end items with end item and LRU spares stocked forward at DS level; the item number of the end item serviced by the DS level; number of floats for each end item.

CASE 9 is similar in some ways to CASE 8. However, CASE 9 has the system being restored with either end item floats or LRUs. Both the end item spares and the LRUs are stocked at the DS level. Since the DS level has end item spares stored at a centralized support area for more than one system, ASOAR must know the number of systems serviced by the DS level. MDTR is the average time required for the LRU or the end item float to be brought to the equipment from DS once the end item and system have failed. MDTR may also represent the average time to evacuate the equipment to DS, perform end item removal and replacement at DS, and return the repaired equipment back to the site if applicable. ASOAR must also be supplied with the number of floats at DS associated with the end item.

After CASE "9" has been entered, ASOAR asks for the number of systems serviced by the DS level and for the MDTR from the DS level.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

CASE 9 - SYSTEM RESTORED WITH END ITEM SPARES AND LRUS AT DIRECT SUPPORT LEVEL

NO. OF SYSTEMS SERVICED BY DIRECT SUPPORT LEVEL	MEAN DELAY TIME TO RESTORE FROM DIRECT SUPPORT
II	FFFF.

For this example, the DS level will service 5 systems and the MDTR will be 3 hours. Enter the following data values:

5 3.

ASOAR now prompts for data on the number of floats for each of the end items in the system.

ENTER THE QUANTITY OF DIFFERENT END ITEMS,
THE ITEM NUMBERS OF THESE END ITEMS, AND THE NUMBER
OF END ITEM FLOATS AT THE DIRECT SUPPORT
LEVEL FOR EACH RESPECTIVE END ITEM

HOW MANY DIFFERENT END ITEMS ARE IN THIS CATEGORY?
II

Three different end items in the sample system will have floats. Type "3" and hit the RETURN key.

ITEM NUMBER	NUMBER OF FLOATS
II	II

Items 1, 3, and 5 will have 2 floats each at the DS level. Enter the following data using the space bar and backspace key to move between fields. Hit the RETURN key to enter data for the next end item.

1	2
3	2
5	2

When the data for the last end item is entered and the RETURN key hit, ASOAR asks whether any other cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED(Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.98692
END ITEM OPERATIONAL AVAIL PRODUCT = 0.98700

MEAN CALENDAR TIME BETW FAILURES (HRS)= 69.7
SYSTEM MEAN TIME TO RESTORE (HRS) = 0.79
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 0.121
SYSTEM ORDER FILL RATE OF LRUS = 0.9936

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	Ao of 1	FILL RATE
item1	1	6463.	1.25	3.128	0.99932	0.97241	0.7524
item2	2	250.	1.50	0.128	0.99353		0.9973
item3	3	16179.	1.00	1.597	0.99984	0.98309	0.8585
item4	4	100.	0.50	0.026	0.99477		0.9995
item5	5	7726.	1.00	2.943	0.99949	0.97495	0.7744

********** **********

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CASE 10: SYSTEM RESTORED WITH END ITEM SPARES AT DS LEVEL AND LRUS STOCKED FORWARD AT GS LEVEL

Data Required - the number of systems serviced by a DS level; the mean delay time to restore from a DS level (hours); the mean shipping and handling time between th.)S and GS levels (hours); the number of end items with end :em spares stocked forward at DS level; the item number of ..e end items serviced by the DS level; the number of floats for each end item.

CASE 10 is the last of the special cases in the ASOAR model. This special case accomplishes system restoral by end item floats located at the DS level. The end items are repaired by LRUs located forward at the GS level. However, since the DS level has end item spares stored at a centralized support area for more than one system, ASOAR must know the number of systems serviced by the DS level. The GS level is a more centralized support area servicing various DS levels. The MDTR is the average time required for the end item float to be brought to the equipment. MDTR may also represent the average time to evacuate the equipment to DS, perform end item removal and replacement at DS, and return the repaired equipment back to the site if applicable. Finally, ASOAR must be supplied with the Mean Shipping and Handling Time (MSHT) between the DS and GS levels for the LRUs, and the number of floats at DS associated with the end item.

After CASE "10" has been entered, ASOAR asks for the following data:

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

CASE 10: SYSTEM RESTORED WITH END ITEM SPARES AT DIRECT SUPPORT AND LRUS AT GENERAL SUPPORT

NO. OF SYSTEMS SERVICED BY DIRECT SUPPORT LEVEL II	MEAN DELAY TIME TO RESTORE FROM DIRECT SUPPORT FFFF.	MEAN SHIPPING AND HANDLING BETWEEN DS AND GS FFFF.
5	2.	2.

Type in the following values. Use the space bar and backspace key to move between fields.

After the value of "2." has been entered for the MSHT between DS and GS and the RETURN key hit, ASOAR asks for the number of different end items in this category, their item numbers and the number of floats present for each of the end items.

ENTER THE QUANTITY OF DIFFERENT END ITEMS,
THE ITEM NUMBERS OF THESE END ITEMS, AND THE NUMBER
OF END ITEM FLOATS AT THE DIRECT SUPPORT
LEVEL FOR EACH RESPECTIVE END ITEM

HOW MANY DIFFERENT END ITEMS ARE IN THIS CATEGORY?
II

Three different end items in the sample system will have floats. Type "3" and hit the RETURN key.

ITEM NUMBER	**NUMBER OF FLOATS**
II	**II**

End items 1, 3, and 5 have 2 floats each at the DS level. Enter the following data using the space bar and backspace key to move between fields. Hit the RETURN key to enter data for the next end item.

1	2
3	2
5	2

When the data for the last end item is entered and the RETURN key hit, ASOAR asks whether any other cases are to be used for this system.

ARE THERE ANY ADDITIONAL CASES INVOLVED (Y/N)?

If "Y" is typed and the RETURN key hit, then the special cases menu reappears. CHAPTER 5. MULTIPLE SPECIAL CASE RUNS explains the order and combinations of permissible multiple cases. Type "N" and hit the RETURN key. The output tables then appear:

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.96770
END ITEM OPERATIONAL AVAIL PRODUCT = 0.96763

MEAN CALENDAR TIME BETW FAILURES (HRS)= 64.2
SYSTEM MEAN TIME TO RESTORE (HRS) = 1.02
SYSTEM MEAN LOGISTIC DOWNTIME (HRS) = 1.101
SYSTEM ORDER FILL RATE OF LRUS = 0.9343

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	Ao of 1	FILL RATE
item1	1	1484.	3.25	8.241	0.99232	0.93557	0.3495
item2	2	250.	1.50	1.007	0.99007		0.9790
item3	3	3295.	3.00	3.620	0.99800	0.95985	0.6487
item4	4	100.	0.50	0.201	0.99303		0.9958
item5	5	1680.	3.00	7.477	0.99380	0.94033	0.4077

****

NOTE: ******** IN THE RELIABILITY COLUMN REPRESENTS
A RELIABILITY EXCEEDING 9,999,999. HOURS

THANK YOU FOR USING THE ASOAR MODEL

ASOAR COMPLETED

CHAPTER 5. MULTIPLE SPECIAL CASE RUNS

More than one special case may be used on to describe the system or its support during the same ASOAR run. For some combinations of special cases, the order in which the special cases are performed is important. Incorrect answers will result if these special case combinations are not used in their proper sequence.

The following is a review of the special cases menu.

CASE 1: SERIALLY CONFIGURED COMMON END ITEMS

CASE 2: HOT STANDBY REDUNDANT END ITEMS

CASE 3: COLD STANDBY REDUNDANCY OR END ITEM SPARES WITH SYSTEM

CASE 4: DEGRADATIONAL REDUNDANCY OR CAPACITY AVAILABILITY

CASE 5: SYSTEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING DOWNTIME

CASE 6: END ITEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING SYSTEM DOWNTIME

CASE 7: MULTIPLE SYSTEMS RESTORED WITH LRU SPARES AT ORG LEVEL

CASE 8: SYSTEMS RESTORED WITH LRUS STOCKED FORWARD AT DS LEVEL

CASE 9: SYSTEMS RESTORED WITH END ITEM AND LRUS STOCKED FORWARD AT DS LEVEL

CASE 10: SYSTEMS RESTORED WITH END ITEM SPARES AT DS AND LRUS STOCKED FORWARD AT GS LEVEL

With 10 special cases available, the number of case combinations is extensive. The use of some special cases should automatically exclude the use of others. Other special cases, such as CASE 5, can be reused more than once. Some special cases are independent of their order of usage.

The user must also be careful not to have conflicting end item configuration data when reusing special CASES 1 through 4. For example, consider a system having 5 end items labeled A, B, C, D, and E and utilizing special CASES 2 (hot redundancy) and 3 (cold redundancy). If special CASE 2 used end items A, B, and D and special CASE 3 used end items D and E, then there is clearly a contradiction present because end item D should not be used in both special cases.

CASES 5 and 6 are special cases that are independent of usage order. Regardless of the order with any other special cases the order of CASES 5 and 6 does not affect th outcome. However, model running time can be reduced by using CASES 5 and 6 first.

CASES 8, 9, and 10 regarding centralized support without LRUs forward at ORG are mutually exclusive cases. Using any one of these 3 cases means that the remaining 2 cases cannot be used in the same ASOAR run.

The actual system configuration must be known prior to introducing any end item floats or any unusual sparing schemes. This means that any commonalities or redundancies among the end items must be considered before any other system support characteristics. Therefore, special CASES 1 through 4 must be used prior to special CASES 9 through 10 in an ASOAR run. The order of the system configuration special cases are irrelevant. The order of centralized support without LRUs at ORG are also independent among themselves.

The rules for the mentioned special cases help to considerably restrict the usage combinations existing for all 10 special cases. FIGURE 2 is a sequence diagram showing the recommended usage order for the combinations of special cases. Cases are listed in descending order of use where cases at the top of the tree are to be used first.

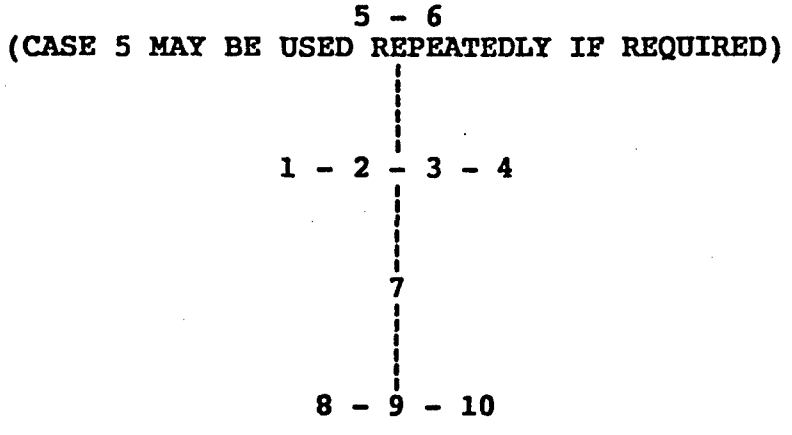

FIGURE 2: RECOMMENDED SEQUENCE OF SPECIAL CASE USAGE

CHAPTER 6. INPUT DATA REQUIRED FOR ASOAR

This chapter lists the input data requirements for the ASOAR model. Its purpose is to aid in collecting the necessary data to utilize ASOAR in the analysis of a weapon system.

EQUIPMENT DATA

END ITEM NAME - Up to 8 characters

END ITEM NUMBER - A number between 01-99, to identify each end item

END ITEM COST - Any unit is acceptable (dollars, K dollars, M dollars, etc.) as long as it is the same unit or relative cost used for all end items in the system

LOW FAILURE, HIGH COST ASSEMBLY EXPENSE - Must be the same unit as end item cost

SYSTEM Ao - A number between .0001 and .9999. This number must be a positive number and less than 1.

RELIABILITY INPUTS

MEAN CALENDAR TIME BETWEEN FAILURE (MCTBF) - in hours

or

MEAN TIME BETWEEN FAILURE (MTBF) and OPERATING HOURS PER YEAR - in hours

or

MTBF, OPERATING HOURS PER YEAR and NON-OPERATING MEAN TIME TO FAILURE - in hours

or

FAILURE FACTOR - Number of end item failures for 100 end items over a calendar year

MAINTAINABILITY INPUTS

MEAN TIME TO RESORE (MTR) - in hours

or

MEAN TIME TO REPAIR (MTTR) - in hours

or

MTTR and ADDITIONAL ORG LEVEL DOWNTIME PER FAILURE - in hours

LOGISTICS DATA

Will the MEAN TIME TO OBTAIN (MTTO) LRU SPARES be the same or different for each identified end item?

LRU SUPPLY SUPPORT COMBINATION CODE (1,7) :
1) ORG, DS, GS, DEP
2) ORG, DS, DEP
3) ORG, GS, DEP
4) ORG, DEP
5) DS, GS, DEP (Used with special case 8 or 9)
6) DS, DEP (Used with special case 8 or 9)
7) GS, DEP (Used with special case 10)

Will the MEAN TIME TO OBTAIN (MTTO) LRU SPARES be an input or be calculated by the model?

IF MTTO IS INPUTTED FOR THE SYSTEM OR EACH DIFFERENT END ITEM

MEAN TIME TO OBTAIN (MTTO) LRU SPARES - in hours

IF MTTO IS CALCULATED FOR THE SYSTEM OR EACH DIFFERENT END ITEM

DEFAULT VALUES CHANGABLE BY INPUT DATA

1) LRU Stock Availability at
   a. DS = .95
   b. GS = .95
   c. Depot = .85

2) Order Ship Time
   a. Depot to GS = 30 days
   b. GS to DS = 30 days
   c. DS to ORG = 2 days

3) Washout Rate (Percentage of LRUS Not Repaired or Returened to Stock) = .15

4) Percentage Repaired at
   a. Depot = .8500 *
   b. GS = 0.0 **
   c. DS = 0.0 **
   d. ORG = 0.0 **

5) Average Repair Cycle Time at
   a. Depot = 75 Days
   b. GS = 30 Days ***
   c. DS = 2 Days ***
   d. ORG = 1 Day ***

6) Mean Time to Obtain Backorder at Depot = 120 Days

* If the Washout Rate Percentage is changed, the Depot repair Percentage Default will automatically change so that the total adds to 1.00.

** If the Depot repair Percentage is changed, the GS Repair Percentage Default will automatically change so that the Washout Rate and Repair Percentages adds to 1.00. Changes to Repair Percentage Defaults may similarly continue.

*** If the Repair Percentage is 0.0, the Average Repair Cycle Time is not inputted.

SPECIAL CASE INPUTS AND PROMPTS

CASE 1: Serially Configured Common End Items

CASE 2: Hot Standby Redundant End Items

CASE 3: Cold Standby Redundancy or End Item Spares with Sys m

CASE 4: Degradational Redundancy or Capacity Availability

CASE 5: System Scheduled Maintenance or Periodic Startup Causing Downtime

CASE 6: End Item Scheduled Maintenance or Periodic Startup Causing System Downtime

CASE 7: Multiple Systems Restored with Line Replaceable Unit (LRU) Spares Stocked Forward at Organizational (ORG) Level

CASE 8: System Restored with LRU Spares Stocked Forward at Direct Support (DS) Level

CASE 9: System Restored with End Item Spares and LRU Spares Stocked Forward at DS Level

Case 10: System Restored with End Item Spares at DS Level and LRU Spares Stocked Forward at General Support (GS) Level

CASE 1: SERIALLY CONFIGURED COMMON END ITEMS

This case implies that there is more than one common end item in a series configuration in the system. All of the end items must be operational for the system to be in an up state.

DATA REQUIRED:

1) Number of different end items having common end items

2) For each common end item list:
   a. Item Name
   b. Item Number
   c. Quantity of end item within system

CASE 2: HOT STANDBY REDUNDANT END ITEMS

This case implies that there are redundant end items in the system configuration. That is, a certain number of end items are required for the system to be fully up and other end items can be considered extra. Hot standby means when one end item goes down, there is usually a similar end item operating that can be switched to almost instantaneously.

DATA REQUIRED:

1) Number of different end items with hot standby redundancy

2) For each hot standby redundant end item list:
   a. Item Name
   b. Item Number
   c. Number of End Items within system required for the system to be up
   d. Quantity of End Items operating within system

CASE 3: COLD STANDBY REDUNDANCY OR END ITEM SPARES WITH SYSTEM

This case implies that the cold standby redundant er items or extra end items are not operating p... ...tch over The certain number of end items required for the system to b fully up are operating. Cold standby redundancy has the advar ge of operating less total end items than hot standby redunda /. However, when one of the required operating end items .is, the system is down until a similar extra end item is swit d to and operating. Therefore, downtime is associated to swit over to a cold standby redundant end item or end item spare s .cked forward with the system.

DATA REQUIRED:

1. For each cold standby redundant end item list:
   a. Item Name
   b. Item Number
   c. Mean Maintenance Downtime to switch over

2. For each cold standby redundant end item list:
   a. Item Name
   b. Item Number
   c. Number of end items operating and required to be up
   d. Quantity of end items with the system

CASE 4: DEGRADATIONAL REDUNDANCY OR CAPACITY AVAILABILITY

Degradational redundancy is used to describe the existence of a state of operation where the system can be between the levels of being fully up and fully down. This is analogous to operating at less than 100% of the required capacity, but operating at some percent of upness greater than 0%. It applies to both hot standby and cold standby redundancies.

DATA REQUIRED:

1. Is the Degradational Redundancy Hot or Cold Standby Redundancy?

2. For each redundant End Item list:
   a. Item Name
   b. Item Number
   c. Inputs 2.c. and 2.d. of Case 2 or Case 3

3. Minimum number of end items operational to be considered fully up

4. Maximum number of end items operational to be considered fully down

5. Enter the percentage of upness associated with each state between the one end item less than the minimum number of end items operational to be considered fully up and one end item more than the maximum number of end items operational to be considered fully down.

6. For each cold standby redundant end item list:
   a. Item Name
   b. Item Number
   c. Mean Maintenance Downtime to Switch Over

CASE 5: SYSTEM SCHEDULED MAINTENANCE OR PERIODIC STARTUP CAUSING DOWNTIME

This case implies that there is system preventative maintenance, periodic relocation of the system which transitions the system to a down state, or some other foreseen reason causing additional periodic downtime. With preventative maintenance, the system is serviced at a specified time interval. With the periodic relocation of the system; the system is torn down, transported and set up after some duration of time or usage. An example of other foreseen reasons may include computer startup time when periodically switching the system on.

DATA REQUIRED:

1. System Mean Calendar Time Between Maintenance - in hours

2. System Mean Maintenance Downtime - in hours

Note: Case 5 can be input more than once if necessary.

CASE 6: END ITEMS SCHEDULED MAINTENANCE DOWNTIME OR PERIODIC STARTUP CAUSING SYSTEM DOWNTIME

This case is analogous to Case 5 when dealing with end item preventative maintenance that causes the system to not be available. Case 6 can also be used to account for additional end item downtime due to some other foreseen reason such as the possibility of switching to hot standby redundant end items when the time to switch over is significant. It should be noted that switching time associated with cold standby redundancy is already incorporated in Cases 3 and 4.

DATA REQUIRED :

1. For each end item causing periodic system downtime
   a. Item Name
   b. Item Number
   c. Mean Calendar Time Between Maintenance - in hours
   d. Mean Maintenance Downtime - in hours

CASE 7: MULTIPLE SYSTEMS RESTORED WITH LINE REPLACEABLE UNIT (LRU) SPARES STOCKED FORWARD AT ORGANIZATIONAL (ORG) LEVEL

This case implies that there is a system configuration of multiple identical systems being serviced at the Organizational level. If the operational availability requirement is for an individual system, the ORG level supports multiple individual systems and no additional inputs are needed. If the operational availability requirement covers more than one identical system, the system configuration contains multiple identical systems.

Does the ORG level support multiple individual systems or does the system configuration contain multiple identical systems?

DATA REQUIRED IF THE SYSTEM CONFIGURATION CONTAINS MULTIPLE IDENTICAL SYSTEMS:

1. Number of Systems within the System Configuration

CASE 8: SYSTEM RESTORED WITH LRUs STOCKED FORWARD AT DIRECT SUPPORT (DS) LEVEL

This case implies that multiple systems are serviced by a centralized area that brings any of these systems to an up state after going down. The DS level is considered the centralized support which stores the LRU spares and is the most forward level of supply.

DATA REQUIRED:

1. Mean Delay Time to Restore from DS Level - in hours
2. Number of different end items with LRUs stocked forward at DS
3. Item Numbers of the end items in this category

CASE 9: SYSTEM RESTORED WITH END ITEM SPARES AND LRU SPARES SOTCKED FORWARD AT DS LEVEL

This case implies that the system is being restored with either end item floats or LRU spares which are both stocked at the DS level and the DS level is the most forward level of supply.

DATA REQUIRED:

1. Number of systems serviced by the Direct Support (DS) level

2. Mean Delay Time to Restore from the DS level - in hours

3. Number of different end items with floats and LRU spares stocked forward at the DS level

4. For every end item in this category list:
   a. Item number
   b. Quantity of end item floats at the DS level

CASE 10: SYSTEM RESTORED WITH END ITEM SPARES AT DS LEVEL AND LRUS STOCKED FORWARD AT GENERAL SUPPORT (GS) LEVEL

This case implies that end item floats at the DS level rather that LRUs will be used to restore the failed end items. LRUs that repair failed end items are located forward at the more centralized GS level.

DATA REQUIRED:

1. Number of systems serviced by the DS level

2. Mean Delay Time to Restore from the DS level - in hours

3. Mean Shipping and Handling Time between DS and GS - in hours

4. Number of different end items with floats stocked forward at the DS level and LRUs stocked forward at the GS level

5. For every end item in this category list:
   a. Item number
   b. Quantity of end item floats at the DS level

MULTIPLE SPECIAL CASE RUNS

Nore: The best order for inputting multiple special cases are as follows:

1st Group: Cases 5 and 6
2nd Group: Cases 1, 2, 3, and 4
3rd Group: Case 7
Last Group: Cases 8, 9, and 10

CHAPTER 7. USING A FILE EDITOR TO MODIFY EXISTING DATA FILES AND TO CREATE NEW DATA FILES

If the user is familiar with an ASCII file editor, existing data files can be easily manipulated to be used in new ASOAR runs. The modification may involve changing just one of the values of an end item or it may involve duplicating an existing data file. This duplicate file can then be completely changed to represent a different system design. Any changes or creations can lead to a variety of sensitivity analysis being done.

The failure data file is the main file used by ASOAR. It is supplied by the user in response to the question.

ENTER INFORMATION AS REQUESTED. WHEN COLUMN HEADINGS ARE GIVEN ENTER DATA UNDER THE PROPER HEADING.

SHOULD THERE BE ANY INPUT MISTAKE WHICH CANNOT BE CORRECTED, YOUR INPUT FILE CAN BE MODIFIED AFTER THIS PROGRAM RUN.

ENTER FAILURE DATA FILE NAME:

The user may create 12 different types of failure data files by choosing 4 different options for the reliability inputs and 3 different options for the maintainability inputs. However, since MTR and MTTR have the same format, the failure data file can have 8 different formats according to its combinations of reliability and maintainability inputs. The data file formats of all possible combinations will be explained.

First of all, the file TEST1.DAT, which the user just created, contains variables for the end item name, the end item number, the end item cost, the cost of low failure rate high cost assemblies, the end item MCTBF, and the end item MTR. If you type out its contents, the file will show the following values:

```
 5   1
item1       1      5000.      0.       150.      1.25
item2       2      4000.      0.       250.      1.50
item3       3      1000.      0.       150.      1.00
item4       4      2000.      0.       100.      1.50
item5       5      4000.      0.       150.      1.00
```

The first value in the first row is the number of different end items in the system. It is the user inputted value to the question.

```
HOW MANY END ITEMS ARE SERIALLY CONFIG. .D?
II
```

Recall that this value cannot exceed 99, the maximum numb r of end items allowed for a system being modeled by ASOAR.

The second value is the combination code created automatically according to the reliability and maintainability options which the user chooses when inputting the failure data. This value is used internally for program execution only. In this exercise, since the user selected option 1 for reliability data and option 1 for maintainability data in inputting failure data, the combination code became 1. As discussed in chapter 2, there are 4 options for inputting reliability data and 3 options for inputting maintainability data. This leads to 12 different ways to input the reliability and maintainability data. Therefore, this combination code in an integer between 1 and 12.

The remaining 5 rows show end item data corresponding to the variables described in the preceding paragraph. Using a file editor, the user can change some of the end item data values and compare ASOAR runs between the original data set and a modified data set.

Before changing any numbers, it is imperative that the user know the exact field length and position of the variables in the file. This will prevent any misreading of data by ASOAR. FIGURE 3 shows the field width of the variables in a failure data file of combination code 1 with MCTBF and MTR such as TEST1.DAT. The failure data file of combination code 2 with MCTBF and MTTR also follows the format in FIGURE 3.

Combination code 1 or 2 - MCTBF for reliability and MTR or MTTR for maintainability data

```
column 1 is always blank!
|
| e.i.   e.i.  e.i.  high cost   e.i.    e.i.
| name   num   cost  low fail   mctbf  mtr(mttr)
|       10         20         30        40        50
|        |         |          |         |         |
|2345678901234567890123456789012345678901234567890
| II  II
| AAAAAAAA II FFFFFFF. FFFFFFF. FFFFFFF. FFF.FF
|    .      .    .        .        .       .
|    .      .    .        .        .       .
```

FIGURE 3. COMBINATION CODE 1 OR 2 FAILURE DATA FILE

The first column in the data file must always be left blank, and there should also be no blank rows anywhere in the file. As was mentioned in the general section, integer values must be right adjusted. For real numbers, the decimal point acts as a reference.

All characters must be included when trying to determine the field width of a variable. For example, the end item name has 8 alphanumeric characters; the end item number is an integer variable 2 characters wide; the end item cost, the cost of a low failure rate high cost assemblies, and the end item MCTBF are real variables 8 characters wide, giving it a maximum input value of 9999999. hours. The last variable, end item MTR is a real number which can have maximum value of 999.99.

In addition to the previously mentioned failure data file, there are other data files associated with the other combinations of the reliability and maintainability inputs. FIGURE 4 shows the format for all failure data files for combination codes 3 through 12.

Combination code 3 - MCTBF for reliability and MTTR and Additional Down Time per Failure (ADTF) for maintainability data

```
column 1 is always blank!
|
| e.i   e.i.  e.i.   high cost  e.i.     e.i.   e.i.
| name  num   cost   low fail   mctbf    mttr   adtf
|       10        20         30        40        50
|       |         |          |         |         |
1234567890123456789012345678901234567890123456789012345
 II  II
 AAAAAAAA II FFFFFFF. FFFFFFF. FFFFFFF. FFF.FF FFFF.FF
    .      .    .       .        .       .       .
    .      .    .       .        .       .       .
```

Combination code 4 or 5 - MTBF and Operating Hours per Year (OPHR) for reliability and MTR or MTTR for maintainability data

column 1 is always blank!

```
 e.i   e.i.  e.i.   high cost  e.i.     e.i.    e.i.
 name  num   cost   low fail   mtbf     ophr  mtr(mttr)
       10        20         30        40        50
       |         |          |         |         |
12345678901234567890123456789012345678901234567890123456789012345
 II  II
 AAAAAAAA II FFFFFFF. FFFFFFF. FFFFFFF. FFFF.F FFF.FF
    .       .    .      .         .       .       .
    .       .    .      .         .       .       .
```

Combination code 6 - MTBF and OPHR for reliability and MTTR and ADTF for maintainability data

column 1 is always blank!

```
 e.i   e.i.  e.i.   high cost  e.i.     e.i.   e.i.    e.i.
 name  num   cost   low fail   mtbf     ophr   mttr    adtf
       10        20         30        40        50        60
       |         |          |         |         |         |
123456789012345678901234567890123456789012345678901234567890123456
 II  II
 AAAAAAAA II FFFFFFF. FFFFFFF. FFFFFFF. FFFF.F FFF.FF FFFF.FF
    .       .    .      .         .       .       .       .
    .       .    .      .         .       .       .       .
```

Combination code 7 or 8 - MTBF, OPHR, and Non-Operating Mean Time to Failure (NMTTF) for reliability and MTR or MTTR for maintainability data

column 1 is always blank!

```
 e.i   e.i.  e.i.   high cost  e.i.     e.i.   e.i.     e.i.
 name  num   cost   low fail   mtbf     ophr   nmttf  mtr(mttr)
       10        20         30        40        50        60
       |         |          |         |         |         |
12345678901234567890123456789012345678901234567890123456789012345
 II  II
 AAAAAAAA II FFFFFFF. FFFFFFF. FFFFFFF. FFFF.F FFFFFFF. FFF.FF
    .       .    .      .         .       .       .       .
    .       .    .      .         .       .       .       .
```

Combination code 9 - MTBF, OPHR, and NMTTF for reliability and MTTR and ADTF for maintainability data

```
column 1 is always blank!
|
| e.i   e.i.  e.i.   high cost  e.i.     e.i.   e.i.     e.i.   e.i.
| name  num   cost   low fail   mtbf     ophr   nmttf    mttr   adtf
|       10        20         30        40        50        60        70
|       |         |          |         |         |         |         |
1234567890123456789012345678901234567890123456789012345678901234567890
 II  II
 AAAAAAAA II FFFFFFF. FFFFFFF. FFFFFFF. FFFF.F FFFFFFF. FFF.FF FFFF.FF
    .      .   .       .       .       .       .       .       .
    .      .   .       .       .       .       .       .       .
```

Combination code 10 or 11 - Failure Factor (FF) for reliability and MTR or MTTR for maintainability data

```
column 1 is always blank!
|
| e.i   e.i.  e.i.   high cost  e.i.     e.i.
| name  num   cost   low fail    ff    mtr(mttr)
|       10        20         30        40        50
|       |         |          |         |         |
12345678901234567890123456789012345678901234567890
 II  II
 AAAAAAAA II FFFFFFF. FFFFFFF. FFFFFF.F FFF.FF
    .      .   .       .       .       .
    .      .   .       .       .       .
```

Combination code 12 - FF for reliability and MTTR and ADTF for maintainability data

```
column 1 is always blank!
|
| e.i   e.i.  e.i.   high cost  e.i.     e.i.    e.i.
| name  num   cost   low fail    ff      mttr    adtf
|       10        20         30        40        50
|       |         |          |         |         |
123456789012345678901234567890123456789012345678901234567890123456789012345
 II  II
 AAAAAAAA II FFFFFFF. FFFFFFF. FFFFFF.F FFF.FF FFFF.FF
    .      .   .       .       .       .       .
    .      .   .       .       .       .       .
```

FIGURE 4. COMBINATION CODE 3 TO 12 FAILURE DATA FILES

FIGURE 5 shows the format for the supportability data file needed for MTTO calculation. The same restrictions and conditions that applied to the failure data file with respect to column 1 being blank, no blank rows in the file, 99 being the maximum number of end items allowed, integer values being right adjusted, and the decimal point of real number acting as a reference also applies to all other special cases data files.

```
column 1 is always blank!
|
|        10         20         30         40         50
|        |          |          |          |          |
12345678901234567890123456789012345678901234567890123456789012345
 F.FFFF   F.FFFF   F.FFFF   FFFFFF.F   FFFFFF.F   FFFFFF.F
 F.FFFF   F.FFFF   F.FFFF   F.FFFF   F.FFFF
 FFFFFF.F   FFFFFF.F   FFFFFF.F   FFFFFF.F   FFFFFF.F
```

The variables from left to right are:

line 1: LRU Stock Availabilities at DS, GS, and Depot
Order and Ship Times from DS to ORG, from GS to DS, and from Depot to GS in hours

line 2: Percentage of LRUs not repaired or returned to stock
Percentage repaired at ORG, DS, GS, and Depot

line 3: Average Repair Cycle Times at ORG, DS, GS, and Depot
Mean Time to Obtain Backorder at Depot in hours

FIGURE 5. MTTO DATA FILE

FIGURE 6 through 8 show the formats of files that may be created which are associated to the following special cases.

CASE 2: HOT REDUNDANCY DATA FILE
CASE 3: COLD REDUNDANCY DATA FILE
CASE 4: HOT DEGRADATIONAL REDUNDANCY DATA FILE OR
COLD DEGRADATIONAL REDUNDANCY DATA FILE
CASE 6: MAINTENANCE DOWNTIME DATA FILE

column 1 is always blank!

```
| e.i.   e.i.
| name   num        r of n
|       10         20         30
|        |          |          |
1234567890123456789012345678 90
 II
 AAAAAAAA II       II    II
 AAAAAAAA II       II    II
    .     .        .     .
    .     .        .     .
```

FIGURE 6. HOT REDUNDANCY DATA FILE

column 1 is always blank!

```
| e.i.        e.i.      maint.
| name        num     downtime                r of n
|       10          20          30          40          50
|        |           |           |           |           |
12345678901234567890123456789012345678901234567890
 II
 AAAAAAAA      II        FF.FF               II     II
 AAAAAAAA      II        FF.FF               II     II
    .          .          .                  .      .
    .          .          .                  .      .
```

FIGURE 7. COLD REDUNDANCY DATA FILE

```
column 1 is always blank!
|
|  e.i.       e.i.        time          maint.
|  name       num      betw. maint.   downtime
|        10         20         30         40         50
|         |         |          |          |          |
12345678901234567890123456789012345678901234567890
 II
 AAAAAAAA    II        FFFFF.FF     FFFF.FF
 AAAAAAAA    II        FFFFF.FF     FFFF.FF
    .         .          .            .
    .         .          .            .
```

FIGURE 8. MAINTENANCE DOWNTIME DATA FILE

CHAPTER 8. ANALYSIS OF OUTPUT TABLES

This section examines the ASOAR output tables from CHAPTER 2. GETTING STARTED: A SAMPLE RUN. The tables are divided into two sections. The first section displays the system level outputs. The second section displays end item level outputs. After each section of output are definitions of the terminology used and explanations on how the special cases affect certain values.

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL	=	0.93000
ADJUSTED OPERATIONAL AVAIL GOAL	=	0.93000
END ITEM OPERATIONAL AVAIL PRODUCT	=	0.93008
MEAN CALENDAR TIME BETW FAILURES (HRS)	=	29.4
SYSTEM MEAN TIME TO RESTORE (HRS)	=	0.96
SYSTEM MEAN LOGISTIC DOWNTIME (HRS)	=	1.188
SYSTEM ORDER FILL RATE OF LRUS	=	0.9753

SYSTEM OPERATIONAL AVAILABILITY GOAL: An inputted value. It is the percentage of time that the user requires the system to be up (in an operating or a committable state).

ADJUSTED OPERATIONAL AVAILABILITY GOAL: The system A_o goal is adjusted whenever additional maintenance down times are introduced into the system. ASOAR then computes end item level output values and other system level output values towards this goal instead of the system A_o goal. If there are no additional maintenance down times or delay times present, then this value has the same value as the system A_o goal.

These additional maintenance down times which cause system A_o adjustments can occur for a variety of reasons. Downtime is present due to unscheduled maintenance for cold standby redundant end items (CASE 3 and CASE 4, choice 2). Downtime is present for system scheduled maintenance or periodic startups (CASE 5) and end item scheduled maintenance or periodic startups causing system downtime (CASE 6). Also, there exists additional delay times associated with system restoral using end item floats (CASE 9 and CASE 10).

END ITEM OPERATIONAL AVAILABILITY PRODUCT: This value is the product of the A_o of all the end items comprising the system. These end item A_o values are located in the end item level output table under the column heading "A_o."

ASOAR generates the end item A_o values by continually updating an end item's order fill rate, MCTBF and MLDT. This updating is done until ASOAR gets A_o values for the end items whose product (the end item A_o product) is within tolerance of the targeted A_o goal. This targeted value is the system A_o goal or its adjusted value when system A_o goal adjustments are applied.

MEAN CALENDAR TIME BETWEEN FAILURES: It is the reciprocal of the calendar time failure rate of the system. ASOAR internally sums the failure rates of all the serially configured end items in the system to get the system failure rate. An equivalent MCTBF is computed for those end items not serially configured so that the summation of all the end item failure rates produces the correct system MCTBF. Other failure data combinations will show the system Failure Factor (FF) or system Mean Time Between Failure (MTBF).

SYSTEM MEAN TIME TO RESTORE: An MTR represents the average amount of time the system would be down if spares were always on hand to restore the item to an operable condition. The system MTR depends on each end item's relative contribution to system failure and their associated restoral time. For serially configured end items, the weighted average from each end item's failure frequency which causes the system to fail multiplied by their respective MTR determines the system MTR. When the forward sparing level is not with the operating equipment and end item floats are not collocated with the forward sparing level (CASE 8 and CASE 10), additional time for the LRU to restore the end item is applied. Other failure data combinations will show the system Mean Time to Repair (MTTR) which is based on maintainability design data only. When using MTTR data, the additional delay time from special Cases 8 or 10 will be reflected in the system Average Logistics Down Time (ALDT) per failure instead of the system MTR.

SYSTEM MEAN LOGISTIC DOWNTIME: An estimate of the amount of downtime caused by spares not always being on-hand to restore the end item and hence the system when end item failure causes the system to go down. The system MLDT depends on the weighted average of each end item's failure frequency which causes the system to fail multiplied by their respective MLDT. Other failure data combinations will show the system ALDT. The system ALDT value covers all downtime per system failure not associated to design MTTR.

SYSTEM ORDER FILL RATE OF LRUs: The percentage of time that the appropriate LRU must be spared at the most forward level of supply support to restore the system when it fails. Stock Availability differs from the LRU order fill rate when all end item failures do not cause system failures. Stock availability is based on demands for the LRU whether or not the system had failed, and order fill rate is based on LRU demands only when the system has failed.

END ITEM LEVEL OUTPUTS

MEAN TIME TO OBTAIN (MTTO) FOR EACH END ITEM: 48.0

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	FILL RATE
item1	1	150.	1.25	1.893	0.97947	0.9606
item2	2	250.	1.50	2.524	0.98416	0.9474
item3	3	150.	1.00	0.379	0.99089	0.9921
item4	4	100.	0.50	0.505	0.99005	0.9895
item5	5	150.	1.00	1.515	0.98351	0.9684

****

NOTE: ******** IN THE RELIABILITY COLUMN REPRESENTS A RELIABILITY EXCEEDING 9,999,999. HOURS

MTTO FOR EACH END ITEM: This is the average time it takes the most forward level of supply support to receive LRUs when needed. This value is either user inputted or calculated based on the supply support and maintenance concept inputs. If any end item has a different MTTO value, then this output table will have separate column listing each end item MTTO value.

EFFECTIVE MCTBF: For an end item having multiple quantities, computations for determining optimal end item A_o goals require that the common or redundant network of like end items (CASES 1 through 4) be combined to represent one end item. The MCTBF causing a system failure from this group of similar end items is called the effective MCTBF. An end item that is not common or not redundant where no multiple systems or end item spares exist will have its effective MCTBF equal to the user inputted MCTBF for that end item. Other failure data combinations will show EFFECTIVE FF or EFFECTIVE MTBF.

EFFECTIVE MTR: This value is usually the same as the user input. However, for the special cases 8 or 10, extra delay time will be added to this value. Other failure data combinations will show EFFECTIVE MTTR instead of EFFECTIVE MTR. When using MTTR data, the additional del[illegible] will be added to the value of EFFECTIVE ALDT.

EFFECTIVE MLDT: It is approximately equal to the probability of not filling an order from operating level stock times the mean time to obtain LRU spares. ASOAR actually computes the effective MLDT by using the relative cost to failure rate ratio of the end items to the system cost to failure rate ratio and the system MLDT requirement needed to achieve the system A_o goal. The MLDT also accounts for previous orders due in from end item redundancies (CASES 2 through 4) and end item floats (CASES 9 and 10). Other failure data combinations will show EFFECTIVE ALDT values in this column. EFFECTIVE ALDT covers all downtime per system failure not associated to the design MTTR.

A_o: It is the percentage of time that an end item or group of similar end items must be up (operating or in a committable state) in order to achieve the system A_o goal.

A_o OF 1 END ITEM (A_o of 1): It is the percentage of time that 1 end item from a group of similar end items must be up (operating or in a committable state) in order to achieve the system A_o goal. This value is not shown in this example, but end items associated with special CASES 1 through 4 (redundant and common end items) or CASES 9 or 10 will have a separate column for this value. This value is also applied as the end item A_o goal input to end item sparing and maintenance optimization models.

FILL RATE: It is the percentage of end item failures requiring appropriate LRUs to be spared at the most forward level of supply support to restore the failed end item when it caused the system to fail. Stock Availability used in MTTO computations often differs from the LRU order fill rate. Stock availability is based on demands for LRUs whether or not the system has failed, and order fill rate is based on demands for LRUs only when the system has failed.

Finally, the remark on high reliability is noted. This value of ******** will appear if the end item is so reliable that the Effective MCTBF or MTBF value exceeds 9,999,999 hours.

CHAPTER 9. OUTPUT MESSAGES

This chapter examines the output messages that may appear with an ASOAR run. An output message will always accompany a failed ASOAR run but it may be present with a successful run also.

A successful ASOAR run is indicated by the appearance of the system and end item level output tables. A non-zero value for any end item LRU order fill rate means that to meet the A_o goal, some of the end item's LRUs are needed to be stocked forward at the most forward level of supply support to restore a failed end item and system. A non-zero value for any end item fill rate also produces a non-zero value for the system order fill rate of LRUs.

When the fill rates for all of the end items are equal to zero, no sparing of LRUs are needed at the forward level of supply support to meet the system A_o goal. This happens when the input data provided by the user produces end item A_o values without forward level spares, that when multiplied together, exceed the A_o goal to be met by the system. The following message then appears before the output tables are shown:

THE MINIMUM ACHIEVABLE END ITEM OPERATIONAL AVAILABILITY PRODUCT IS .xxxxx.
THIS VALUE EXCEEDS THE (ADJUSTED) OPERATIONAL AVAILABILITY PRODUCT OF .xxxxx.

This implies that some design and logistics characteristics of the system or of the end items causes the inputted or adjusted A_o goal to be met without having to spare at the operating level. It may be that some or all of the end items are very reliable with high effective MCTBF values, that the inputted or adjusted system A_o value is low, and/or that spares can be obtained from the next higher support level quickly yielding small MTTO values. To illustrate one of these points, if the sample session in CHAPTER 3. GETTING STARTED: A SAMPLE RUN was repeated with the same data except that the end item MCTBF's were all increased by a factor of 100, the following would result:

MINIMUM ACHIEVABLE END ITEM OPERATIONAL AVAILABILITY PRODUCT =0.98352
WHICH EXCEEDS THE ADJUSTED OPERATIONAL AVAILABILITY GOAL OF 0.93000

SYSTEM LEVEL OUTPUTS

SYSTEM OPERATIONAL AVAIL GOAL = 0.93000
ADJUSTED OPERATIONAL AVAIL GOAL = 0.93000
END ITEM OPERATIONAL AVAIL PRODUCT = 0.98352

MEAN CALENDAR TIME BETW FAILURES (HRS)= 2941.2
SYSTEM MEAN TIME TO RESTORE (HRS) = 0.96
SYSTEM MEAN LOGISTIC DOWN TIME (HRS) = 48.000
SYSTEM ORDER FILL RATE OF LRUS = 0.0000

HIT RETURN TO SEE END ITEM OUTPUT DATA

END ITEM LEVEL OUTPUT

ITEM NAME	ITEM NUMBER	EFFECTIVE MCTBF	EFFECTIVE MTR	EFFECTIVE MLDT	Ao	FILL RATE
item1	1	15000.	1.25	48.000	0.99673	0.0000
item2	2	25000.	1.50	48.000	0.99802	0.0000
item3	3	15000.	1.00	48.000	0.99674	0.0000
item4	4	10000.	0.50	48.000	0.99517	0.0000
item5	5	15000.	1.00	48.000	0.99674	0.0000

****

NOTE: ******** IN THE RELIABILITY COLUMN REPRESENTS
A RELIABILITY EXCEEDING 9,999,999. HOURS

THANK YOU FOR USING THE ASOAR MODEL

ASOAR COMPLETED

There are instances when ASOAR is not able to provide system and end item level output tables even though the sytem Ao goal can be achieved. If no output tables can be provided, the following message appears:

(ADJUSTED) SYSTEM OPERATIONAL AVAILABILITY GOAL OF .xxxxx IS ACHIEVABLE.
THE MAXIMUM ACHIEVABLE SYSTEM OPERATIONAL AVAILABILITY WITH 100% LRU ORDER FILL RATES FOR ALL END ITEMS IS .xxxxx.
ASOAR PRESENTLY CANNOT PRORATE TO THE END ITEM LEVEL BECAUSE THE END ITEM OPERATIONAL AVAILABILITY PRODUCT IS NOT REFINING TO WITHIN .0001 OF THE ADJUSTED OPERATIONAL AVAILABILITY GOAL.

This situation may occur when there is a lot of redundancy and floats present for all or most of the end items in the system. CASES 2, 3, 4, 9, and 10 are associated with end item redundancies and floats. ASOAR starts its internal calculations with a "worst" case situation which does not take into account sparing to those redundancies and floats. This produces minimum values for reliability and Ao variables which may cause the Ao goal to appear not achievable. If the Ao appears unachievable, ASOAR then internally calculates a "best" case situation using full sparing for the end item reduncancies and floats which provides the largest effective reliability. The present version of ASOAR sometimes fails to prorate the system Ao to the optimal end item requirements. The appearance of the above output message, however, will indicate to the user that the inputted system Ao is achievable, and the maximum Ao achievable if all end items have a 100% LRU order fill rate. The next release of ASOAR is expected to prorate the system Ao to the end item requirements and produce the system and end item level output tables.

System and end item level output tables are also not provided when the system Ao goal is too large and cannot be achieved even with a 100% LRU order fill rate. ASOAR will produce the following message before terminating the program:

(ADJUSTED) SYSTEM OPERATIONAL AVAILABILITY GOAL OF .xxxxx IS NOT ACHIEVABLE.
THE MAXIMUM ACHIVABLE SYSTEM OPERATIONAL AVAILABILITY IS .xxxxx.

This message means that when the system is down due to an end item failure, the system maintainability cannot restore the system in enough time to meet its A_o goal. This type of ASOAR run can occur for a number of reasons. Sometimes the user can perform sensitivity analysis on some of the input data to achieve an obtainable system Ao

goal. The system A_o goal may be made obtainable by either lowering the system A_o requirement or by improving the system design which increases its effective MCTBF or decreases its effective MTTR. If a sensitivity analysis does not correct the problem, it may identify an area that needs some reconsideration to produce a successful run. You can contact the US Army Communications-Electronics Command Systems Analysis Division at DSN 992-8752 or 4684 or commercial (908)532-8752 or 4684.

There are several diagnostic messages caused by dividing by 0 or unrealistic values such as 0 operating hours, resulting in unsuccessful ASOAR run. The following are the samples of these output messages:

THE NET COST OF EACH END ITEM MUST BE A POSITIVE NUMBER.
YOUR ITEM NUMBER XX HAS A NEGATIVE VALUE OF XXXXXXX.
PLEASE TRY AGAIN.

RELIABILITY INPUT OF MCTBF OR MTBF OF EACH END ITME SHOULD EXCEED 0.
TRY AGAIN.

BOTH RELIABILITY INPUTS OF MTBF AND NON-OPERATING MEAN TIME TO FAILURE SHOULD EXCEED 0, OR OPERATING HOURS PER YEAR SHOULD NOT EXCEED 8760 HOURS.
PLEASE TRY AGAIN.

RELIABILITY INPUT OF FAILURE FACTOR OF EACH END ITEM SHOULD EXCEED 0.
PLEASE TRY AGAIN.

MTR OR MTTR INPUT OF EACH END ITEM SHOULD BE A POSITIVE NUMBER OR 0.
TRY AGAIN.

BOTH MTR AND ADDITIONAL ORG DOWN TIME PER FAILURE INPUTS SHOULD BE GREATER THAN OR EQUAL TO 0.
PLEASE TRY AGAIN.

A failure will occur if the product of the end item A_o values does not reach the desired system A_o goal because ASOAR was forced to suspend computations. This suspension will occur when the MLDT for all of the end items have reached their maximum realistic value, thereby preventing any further adjustments. The following failure message then appears:

THE END ITEM OPERATIONAL AVAILABILITY PRODUCT IS .xxxxx.
THE (ADJUSTED) OPERATIONAL AVAILABILITY GOAL OF .xxxxx
IS NOT ACHIEVABLE BECAUSE ALL END ITEMS ARE FROZEN
AT THEIR MAXIMUM LOGISTICS DOWNTIMES.

Every end item has an upper limit, or maximum, on its MLDT value. This upper limit is equal to the end item MTTO value plus its MTR value, with any redundancy factored in. When that limit is reached, ASOAR "freezes" the MLDT at that value and this prevents any further adjustments to that end item. As long as ASOAR can perform adjustments and computations on at least 1 end item, there is a chance to meet the system A_o goal. But if the MLDTs of all the end items are frozen, no more iterations or adjustments can be performed and ASOAR terminates the program. A higher A_o goal may be inputted and the program run again, but the diagnostic may be saying that the system A_o goal is more than achievable without forward level LRU sparing due to the high level of redundancy.

Finally, a failure to obtain a system and end item level output table can occur during inputting. When failing to enter an input, entering a mistaken input or attempting to enter data from a file that does not exit, the inputting may be terminated before the ASOAR program computes with the data. If this happens, the input file can be modified after program termination before making another ASOAR run using the input file or the user can start another ASOAR run and enter new inputs from the keyboard.

CHAPTER 10. DIAGNOSTIC PRINTOUT INFORMATION

The diagnostic printout feature of ASOAR allows the user to track the internal calculations and iterations that produce the values in the output tables. This feature can be useful in determining why a particular ASOAR run failed, or in simply trying to understand how some system and end item values were obtained. However, regardless of whether a run is successful or unsuccessful, a diagnostic printout can add considerable time to an ASOAR run. For a system containing many different kinds of end items or for a system that utilizes some special cases, choosing the diagnostic printout feature can make an ASOAR run last several minutes or possibly hours.

A diagnostic printout is obtained by responding to the following first prompt in the ASOAR program with a "1."

PRESS ENTER KEY FOR NO DIAGNOSTIC PRINTOUT OR ENTER 1 FOR DIAGNOSTIC PRINTOUT.
NOTE: RECOMMEND PRESSING THE RETURN KEY UNLESS INTERMEDIATE COMPUTATION VALUES ARE NECESSARY.
ENTER THE KEY NOW:

Essentially, the diagnostic procedure shows the user the values of key variables as they are being changed and updated. These variables ultimately relate to a final set of variables that appear in the system and end item level output tables. Except for some immediate calculations done when a redundancy special case is chosen, no diagnostic output appears to the user until the following question is answered with a "N."

ARE THERE ANY ADDITIONAL CASES INVOLVED(Y/N)?

The response of "N" indicates that there is no more input data to be supplied and that ASOAR can begin its computations.

The following pages show a partial diagnostic printout obtained by running the diagnostic feature on the cold redundancy example in CHAPTER 4. The diagnostic feature activation is only encouraged when the entire output of internal computation is desired to be seen.

```
    MLDTT=      2.424
     I=      1 MLDT(I)=    10508.1 MLDTT =     2.424 MCTBF(I) = 774369.
COST(I) =  5000.00 MCTBFS =      56. COSTSY =16000.000
     I=      2 MLDT(I)=       31.0 MLDTT =     2.42
COST(I) =  4000.00 MCTBFS =      56. COSTSY =16000.000
     I=      3 MLDT(I)=        3.0 MLDTT =     2.424 MCTBF(I) =    1114.
COST(I) =  1000.00 MCTBFS =      56. COSTSY =16000.000
     I=      4 MLDT(I)=        0.5 MLDTT =     2.424 MCTBF(I) =     100.
COST(I) =  2000.00 MCTBFS =      56. COSTSY =16000.000
     I=      5 MLDT(I)=        1.6 MLDTT =     2.424 MCTBF(I) =     150.
COST(I) =  4000.00 MCTBFS =      56. COSTSY =16000.000
    I=      1MLDT(I)=    6.95833POINT(I,2)=       2.00POINT(I,3)=       7.00
    POINT(I,4)= 0.00000POINT(I,5)=      48.00COST(I)=    5000.00MCTBF(I)=  774369.
    I=      2MLDT(I)=   23.25000POINT(I,2)=       1.00POINT(I,3)=       2.00
    POINT(I,4)= 0.00000POINT(I,5)=      48.00COST(I)=    4000.00MCTBF(I)=    2854.
    I=      3MLDT(I)=    7.62843POINT(I,2)=       1.00POINT(I,3)=       2.00
    POINT(I,4)= 0.66200POINT(I,5)=      48.00COST(I)=    1000.00MCTBF(I)=    2811.
    I=      4MLDT(I)=    0.54280POINT(I,2)=       0.00POINT(I,3)=       0.00
    POINT(I,4)= 0.00000POINT(I,5)=       0.00COST(I)=    2000.00MCTBF(I)=     100.
    I=      5MLDT(I)=    1.62839POINT(I,2)=       0.00POINT(I,3)=       0.00
    POINT(I,4)= 0.00000POINT(I,5)=       0.00COST(I)=    4000.00MCTBF(I)=     150.

    MCTBFS=       56.COSTSY=   16000.00MLDTT=    2.42371

4100

Press Enter to Continue.

    I =      1 MCTBF(I) =  774369. MTR(I) =       1.25 MLDT(I) =       6.96
    I =    1 AO(I) =    0.99999
    I =      2 MCTBF(I) =    2854. MTR(I) =       1.50 MLDT(I) =      23.25
    I =    2 AO(I) =    0.99140
    I =      3 MCTBF(I) =    2811. MTR(I) =       1.00 MLDT(I) =       7.63
    I =    3 AO(I) =    0.99694
    I =      4 MCTBF(I) =     100. MTR(I) =       0.50 MLDT(I) =       0.54
    I =    4 AO(I) =    0.98968
    I =      5 MCTBF(I) =     150. MTR(I) =       1.00 MLDT(I) =       1.63
    I =    5 AO(I) =    0.98278
    I=      1 AO(I)=    0.99999 TEMP AOTAR =    0.94652
    I=      2 AO(I)=    0.99140 TEMP AOTAR =    0.95473
    MLDTT=      1.984
     I=      3 MLDT(I)=        5.5 MLDTT =     1.984 MCTBF(I) =    1114.
COST(I) =  1000.00 MCTBFS =      57. COSTSY = 7000.000
     I=      4 MLDT(I)=        1.0 MLDTT =     1.984 MCTBF(I) =     100.
COST(I) =  2000.00 MCTBFS =      57. COSTSY = 7000.000
     I=      5 MLDT(I)=        3.0 MLDTT =     1.984 MCTBF(I) =     150.
COST(I) =  4000.00 MCTBFS =      57. COSTSY = 7000.000
    I=      1MLDT(I)=    6.95833POINT(I,2)=       2.00POINT(I,3)=       7.00
    POINT(I,4)= 0.00000POINT(I,5)=      48.00COST(I)=    5000.00MCTBF(I)=  774369.
    I=      2MLDT(I)=   23.25000POINT(I,2)=       1.00POINT(I,3)=       2.00
    POINT(I,4)= 0.00000POINT(I,5)=      48.00COST(I)=    4000.00MCTBF(I)=    2854.
    I=      3MLDT(I)=   10.63215POINT(I,2)=       1.00POINT(I,3)=       2.00
    POINT(I,4)= 0.53700POINT(I,5)=      48.00COST(I)=    1000.00MCTBF(I)=    2135.
    I=      4MLDT(I)=    0.99587POINT(I,2)=       0.00POINT(I,3)=       0.00
    POINT(I,4)= 0.00000POINT(I,5)=       0.00COST(I)=    2000.00MCTBF(I)=     100.
    I=      5MLDT(I)=    2.98760POINT(I,2)=       0.00POINT(I,3)=       0.00
    POINT(I,4)= 0.00000POINT(I,5)=       0.00COST(I)=    4000.00MCTBF(I)=     150.

    MCTBFS=       57.COSTSY=    7000.00MLDTT=    1.98441

4100

Press Enter to Continue.
```

```
    I =      1 MCTBF(I) =  774369. MTR(I) =       1.25 MLDT(I) =       6.96
    I =     1 AO(I) =   0.99999
    I =      2 MCTBF(I) =    2854. MTR(I) =       1.50 MLDT(I) =      23.25
    I =     2 AO(I) =   0.99140
    I =      3 MCTBF(I) =    2135. MTR(I) =       1.00 MLDT(I) =      10.63
    I =     3 AO(I) =   0.99458
    I =      4 MCTBF(I) =     100. MTR(I) =       0.50 MLDT(I) =       1.00
    I =     4 AO(I) =   0.98526
    I =      5 MCTBF(I) =     150. MTR(I) =       1.00 MLDT(I) =       2.99
    I =     5 AO(I) =   0.97410
    MCTBFS=     57.MTRSYS=  0.72
    N =      5 PROD= 0.94633 AOTAR= 0.94651
ALPHA

Press Enter to Continue.

    PROD=  0.94633MCTBFS=     57.2MTRSYS=  0.72
     MCTBFS =  57.18625 MLDTT =    1.98766 AOTM =    0.96641 AOAM =    0.96659ADJIN =    0.99442
ADJMLDT

Press Enter to Continue.

     I=      1 ITMNUM(I)=      1 MLDT(I)=    6.95833 AO(I)=    0.99999
     I=      1 ITMNUM(I)=      1 MLDT(I)=    6.95833 AO(I)=    0.99999
     I=      2 ITMNUM(I)=      2 MLDT(I)=   23.25000 AO(I)=    0.99140
     I=      2 ITMNUM(I)=      2 MLDT(I)=   23.25000 AO(I)=    0.99140
     I=      3 ITMNUM(I)=      3 MLDT(I)=   10.63215 AO(I)=    0.99458
     I=      3 ITMNUM(I)=      3 MLDT(I)=   10.57280 AO(I)=    0.99461
     I=      4 ITMNUM(I)=      4 MLDT(I)=    0.99587 AO(I)=    0.98526
     I=      4 ITMNUM(I)=      4 MLDT(I)=    0.99031 AO(I)=    0.98532
     I=      5 ITMNUM(I)=      5 MLDT(I)=    2.98760 AO(I)=    0.97410
     I=      5 ITMNUM(I)=      5 MLDT(I)=    2.97092 AO(I)=    0.97421
     I=      3 MLDT(I)=   10.56223 ALPHA=  0.99900
     I=      4 MLDT(I)=    0.98932 ALPHA=  0.99900
     I=      5 MLDT(I)=    2.96795 ALPHA=  0.99900
     L=     2 NN=     7 MM=     6 COEF=     0.000 NFUP=     0 NFDN=     0 IDUM=     3
     NWKREL=   0.99994 L=      2 NN=      7 LN= -0.00006
     MDTX=    49.250 LN=     0.000 NTMCBF= 774369.
     L=     1 NN=     2 MM=     2 COEF=     0.000 NFUP=     0 NFDN=     0 IDUM=     3
     NWKREL=   0.98280 L=      1 NN=      2 LN= -0.01735
     MDTX=    49.500 LN=    -0.017 NTMCBF=    2854.
     L=     1 NN=     2 MM=     2 COEF=     0.000 NFUP=     0 NFDN=     0 IDUM=     3
     NWKREL=   0.98927 L=      1 NN=      2 LN= -0.01079
     MDTX=    23.124 LN=    -0.011 NTMCBF=    2144.
4100

Press Enter to Continue.

     I =      1 MCTBF(I) =  774369. MTR(I) =       1.25 MLDT(I) =       6.96
     I =     1 AO(I) =   0.99999
     I =      2 MCTBF(I) =    2854. MTR(I) =       1.50 MLDT(I) =      23.25
     I =     2 AO(I) =   0.99140
     I =      3 MCTBF(I) =    2144. MTR(I) =       1.00 MLDT(I) =      10.56
     I =     3 AO(I) =   0.99464
     I =      4 MCTBF(I) =     100. MTR(I) =       0.50 MLDT(I) =       0.99
     I =     4 AO(I) =   0.98533
     I =      5 MCTBF(I) =     150. MTR(I) =       1.00 MLDT(I) =       2.97
     I =     5 AO(I) =   0.97423
     MCTBFS=     57.MTRSYS=  0.72
     N =      5 PROD= 0.94656 AOTAR= 0.94651
      L=     2 NN=     7 MM=     6 COEF=     0.000 NFUP=     0 NFDN=     0 IDUM=     3
      NWKREL=   0.99994 L=      2 NN=      7 LN= -0.00006
      MDTX=    49.250 LN=     0.000 NTMCBF= 774369.
      L=     1 NN=     2 MM=     2 COEF=     0.000 NFUP=     0 NFDN=     0 IDUM=     3
      NWKREL=   0.98280 L=      1 NN=      2 LN= -0.01735
      MDTX=    49.500 LN=    -0.017 NTMCBF=    2854.
      L=     1 NN=     2 MM=     2 COEF=     0.000 NFUP=     0 NFDN=     0 IDUM=     3
      NWKREL=   0.98927 L=      1 NN=      2 LN= -0.01079
      MDTX=    23.124 LN=    -0.011 NTMCBF=    2144.
```

The following list defines the variables that are used during a diagnostic printout. Some of the variables are used only if certain special cases had been chosen. Those variables are distinguished by a number, or numbers, next to their name indicating the associated special case(s). Note also that a variable may take on more than one meaning depending on the special case used. Finally, some variables have an asterisk next to their name. These represent variables that appear directly in the output tables once their final values have been calculated.

VARIABLE NAME	MEANING
ADJIN	Initial adjustment factor used on MLDT prior to alpha/beta adjustment. It is a function of AOAM and AOTM.
ALPHA	Factor used to reduce MLDT.
AO(I)*	A_o value for each end item.
AOAM	System A_o downtime computed with adjusted MLDT.
AOSYS*	System A_o (an entered number).
AOTAR* (3, 4(2), 5, 6, 9, 10)	Target A_o. It is the system A_o value with additional delay times factored in. If no additional delay times are present, then AOTAR = AOSYS.
AOTM	System A_o downtime computed with MLDT (the target MLDT).
BETA	Factor used to increase MLDT.

VARIABLE NAME	MEANING
COST(I)	Cost of each end item minus the cost for a low failure, high cost assembly.
COSTSY*	Cost of system counting cost of the redundant or common end items only once.
COEF (4)	Degradation co-efficient for the end items that are degradational in an R of NN redundant network. It is equal to one if degradational redundancy does not apply to that end item.
ENDRT (9, 10)	End item return time from DS.
FILL1X (2, 3, 4)	Order fill rate at the most forward level of supply support for the end item.
FROZEN MLDT(I)	The maximum realistic MLDT value for an end item.
ITEM NO	End item number.
ITMNUM(I)*	End item number.
L (2, 3, 4)	Represents R in an R of NN redundant network.
L (9, 10)	NSYS serviced by a DS level for those end items having floats.
LN (2, 3, 4, 9, 10)	Natural log of the network reliability calculation result.

VARIABLE NAME	MEANING
MCTBF(I)*	MCTBF for each end item. For those end items having multiple quantities or occurring more than once in a system, this value represents the effective MCTBF.
MCTBFS*	System MCTBF.
MDTRDS	MDTR the system with LRU spares at DS level.
MDTX (2, 3, 4, 9, 10)	MDT per failure for an end item.
MFSL (10)	Number of DS levels serviced by a GS.
MLDT(I)*	MLDT for each end item. Appears in the end item level output tables as the effective MLDT.
MLDTT	MLDT target for the system.
MM	A value equal to NN-R. It represents the actual number of redundant end items.
MTR(I)	MTR for each end item. A user supplied value.
MTTO1X (2, 3, 4, 9, 10)	MTTO a spare when spares are not available at the most forward level of supply support. Used in redundancy calculations and for end items with floats. It is used instead of but is equal to the inputted or computed MTTO value for that end item.

VARIABLE NAME	MEANING
N	Number of different end items in the system.
NAME*	End item name.
NFDN (4)	The maximum number of end items operational to be considered fully down. An inputted value used in degradational redundancy calculations.
NFUP (4)	The minimum number of end items operational to be considered fully up. An inputted value used in degradational redundancy calculations.
NN (2, 3, 4)	Total number of end items in a redundant network.
NN (9, 10)	For an end item having floats, this value is equal to the number of those floats plus the number of systems serviced by a DS level (NSYS).
NSYS (7, 8, 9, 10)	Number of systems serviced by a DS level.
NTMCBF	Network MCTBF. It is used in redundancy calculations as the MCTBF value for all NN end items in an R of NN redundancy, and it is also used as the MCTBF value for end items having floats.

VARIABLE NAME	MEANING
NWKREL (2, 3, 4, 9, 10)	Network reliability. It is used in redundancy calculations as the reliability value for all NN end items in an R of NN redundancy. It is also used as the reliability value for end items having floats. The natural log of this value divided into the end item Mean Downtime (MDT) yields the network MCTBF.
POINT (2, 3, 4)	Two dimensional array variable used in redundancy calculations to hold relevant variables temporarily.

```
POINT(I,1) = MCTBF(I)
POINT(I,2) = L
POINT(I,3) = NN
POINT(I,4) = FILL1X
POINT(I,5) = MTTO1X
```

POINT (9, 10)	Two dimensional array variable used with end items having floats to hold relevant variables temporarily.

```
POINT(I,1) = MCTBF(I)
POINT(I,2) = NSYS
POINT(I,3) = NSYS+(# of floats)
POINT(I,4) = FILL1X
POINT(I,5) = MTTO1X
```

PROD	The product of the A_o values of all the different end items.
STDSGS (10)	MSHT from DS to GS.
TEMP AOTAR	Temporary system A_o target (AOTAR). An end item with a frozen MLDT will have its A_o requirement factored out of the AOTAR value. This new, temporary AOTAR value is used as a goal for the other end items.

CHAPTER 11. GLOSSARY OF TERMS AND DEFINITIONS

AVERAGE LOGISTICS DOWNTIME (ALDT): The average amount of downtime per failure due to logistics support. It is essentially the total downtime per failure less the end item's or system's designed maintainability.

AVERAGE REPAIR CYCLE TIME (RCT): Time from when an LRU fails in the end item and is shipped, screened/repaired, and put into stock under conditions when stockage has been depleted at the support level.

EFFECTIVE FAILURE FACTOR: The average number of end item failures causing a system failure for 100 end items over a calendar year.

EFFECTIVE MEAN CALENDAR TIME BETWEEN FAILURE: It is the MCTBF of an end item or group of similar end items causing a system failure. An equivalent end item group factors in the impact of end item redundancy or commonality in the end item network.

EFFECTIVE MEAN LOGISTICS DOWNTIME: It is the MLDT of an end item causing system downtime including any end item redundancy factored in to account for previous orders due in prior to a system failure.

EFFECTIVE MEAN TIME BETWEEN FAILURE: It is the MTBF of an end item causing a system failure including any end item redundancy factored in to represent the impact of the end item network.

FAILURE FACTOR (FF): The average number of end item failures for 100 end items over a calendar year. An end item with a failure factor of 100 means that, on average, the end item will fail once a year.

LINE REPLACEABLE UNITS (LRUs): The secondary items spared forward to restore an end item. These items are necessary to accomplish end item maintainability.

MEAN CALENDAR TIME BETWEEN FAILURE (MCTBF): The reciprocal of the calendar time failure rate of an item. Besides designed reliability, MCTBF also accounts for the system operating tempo. An end item or system with an MCTBF of 100 hours means that, on average, the end item or system will fail every 100 calendar hours.

MEAN DELAY TIME TO RESTORE (MDTR): Average downtime between the time the end item and system have failed and the time required for the spare to be brought to the equipment. MDTR may also represent the average downtime to evacuate the equipment to DS, perform end item removal and replacement at DS if applicable, and return the repaired equipment back to the site.

MEAN LOGISTICS DOWNTIME (MLDT): Average amount of downtime caused by spares not always being on-hand to restore the end item and hence the system. This downtime can also be thought of as the average amount of calendar time permissible per failure to lack spares and still meet the system A_o requirement.

MEAN TIME BETWEEN FAILURE (MTBF): The average operating hours per failures. MTBF reflects the designed reliability based on the end item's or system's operation.

MEAN TIME TO REPAIR (MTTR): The average hours per failure that an end item would be down if LRU spares are always on hand to restore the end item in an ideal logistics support environment. MTTR reflects the designed maintainability of the end item or system.

MEAN TIME TO RESTORE (MTR): The average amount of time an item would be down if LRU spares were always on hand to restore the item to an operable condition. Besides designed maintainability, MTR also accounts for delayed restoral time in obtaining on-hand spares from storage, not always having appropriately skilled personnel available, lack of complete and correctly written technical manuals, and not always having functioning tools and test equipment available.

MEAN TIME TO OBTAIN (MTTO): The average time it takes the most forward level of supply support to receive LRUs when needed. It is approximately the time to receive LRUs from the next higher level of supply plus some additional average delay time for that level of support's time to obtain spares from maintenance or resupply because its LRU SA is less than 100%.

NON-OPERATING MEAN TIME TO FAILURE (NMTTF): The average non-operating hours per failure of an end item in a hiatus environment which is based on an equipment not being in operation.

OPERATING HOURS PER YEAR (OPHR): The average number of end item or system operating hours per year. 8760 hours per year represents full time equipment operation.

OPERATIONAL AVAILABILITY (A_o): The probability that an end item or system will be in an operable or committable condition at any random point in time. Mathematically, it represents the percentage of total calendar time that the equipment is up.

ORDER AND SHIP TIME (OST): The average time from the need to place a requisition until receipt and placement of the order into stock.

ORDER FILL RATE: The percentage of equipment failures requiring the appropriate LRU to be at the most forward level of stockage to restore a failed end item when it causes a system failure. It is determined only for the most forward level of supply support. The order fill rate can only be equivalent to SA if every end item failure causes the system to fail.

STOCK AVAILABILITY (SA): The percentage of orders or demands for LRUs that is filled by the supply support level regardless of whether or not the system had failed. It is most meaningful for levels of supply support higher than the most forward level of stockage.

CHAPTER 12. GLOSSARY OF ACRONYMS

Operational Availability	A_o
Operational Availability of a Single End Item	Ao of 1
Average Logistics Downtime	ALDT
Mean Time to Obtain a Back Order	BOMTTO
Depot	DEP
Direct Support	DS
Failure Factor	FF
General Support	GS
Hours	HRS
Line Replaceable Units	LRUs
Mean Calendar Time Between Failure	MCTBF
Mean Calendar Time Between Maintenance	MCTBM
Mean Downtime	MDT
Mean Delay Time to Restore from Direct Support	MDTR
Mean Maintenance Downtime	MMDT
Mean Shipping and Handling Time between DS and GS	MSHT
Mean Time Between Failure	MTBF
Mean Time to Repair	MTTR
Mean Time to Restore	MTR
Mean Time to Obtain Line Replaceable Unit Spares	MTTO
Number of Similar End Items in a System	N

Non-Operating Mean Time to Failure ..... NMTTF

Operating Hours per Year ..... OPHR

Organizational Level ..... ORG

Order and Ship Time ..... OST

Percentage of Line Replaceable Units Not Repaired ..... PCTNREP

Percentage of Line Replaceable Units Repaired ..... PCTREP

Number of Required End Items Operating for System to Be Up ..... R

Repair Cycle Time ..... RCT

Stock Availability ..... SA