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PLANS, CONCEPTS AND EVALUATION DIRECTORATE

Optimum Supply and Maintenance Model
Users' Guide

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The Optimum Supply and Maintenance Model (OSAMM) is designed to simultaneously optimize support and maintenance policies for a new equipment. Inputs to the model are limited to the types of information that should be available early in development when the maintenance concept is being formulated. The model determines optimal Maintenance Task Distribution (MTD) and Replacement Task Distributions (RTD) for the major items in an equipment. It also compares the cost of throwing away an item with the cost of repairs. In making these decisions the model considers the spares, special test equipment and special repairmen that

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20. Abstract (continued)

will be needed to support the maintenance policy. Other costs such as transportation, cataloging and documentation are also considered. The user's guide gives a brief description of the model and defines the inputs that are required. It also explains the model's output.

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CHAPTER 1

THE MODEL

1.1 INTRODUCTION

The Optimal Supply and Maintenance Model (OSAMM) is designed to simultaneously optimize support and maintenance policies for a new equipment. Inputs to the model are limited to the types of information that should be available early in development when the maintenance concept is being formulated. The model determines optimal Maintenance Task Distributions (MTD) and Replacement Task Distributions (RTD) for the major items in an equipment. It also compares the cost of throwing away an item with the cost of repairs. In making these decisions the model considers the spares, special test equipment and special repairmen that will be needed to support the maintenance policy. Other costs such as transportation, cataloging and documentation are also considered.

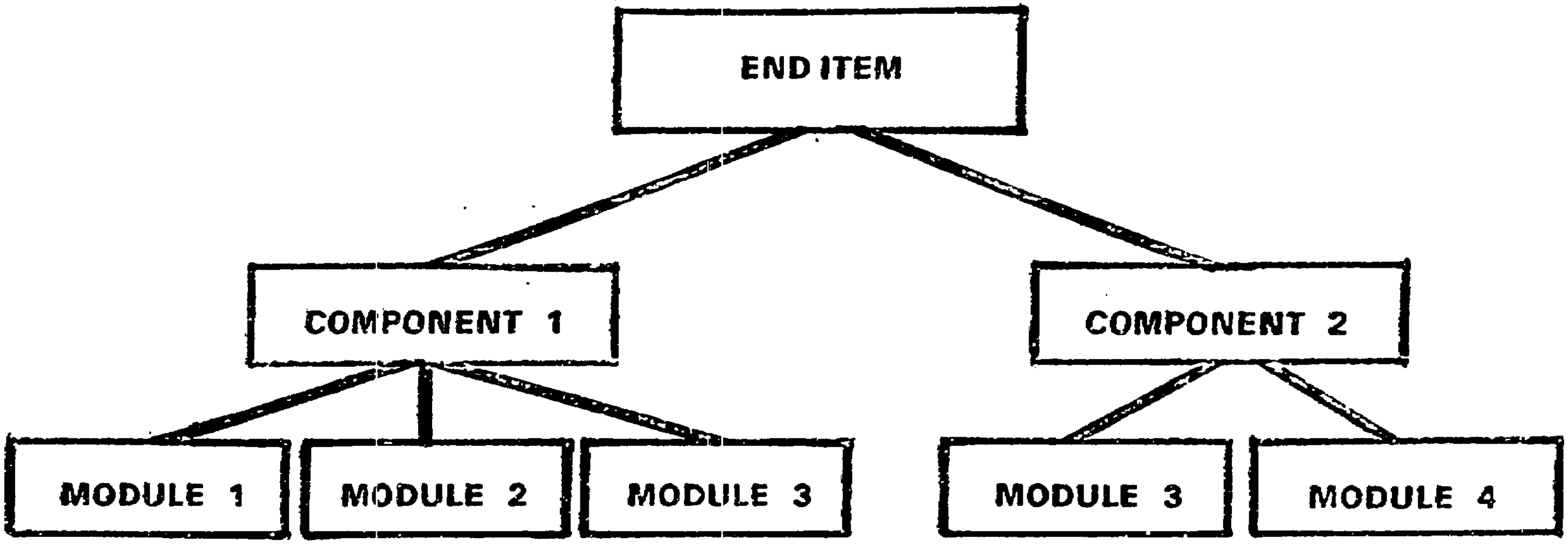
The SESAME model is used in OSAMM to optimize supply. It should be noted, however, that the model is not designed to replace SESAME. The OSAMM model should be used early in development to help establish a maintenance concept when detailed data on a new equipment is unknown. The SESAME model should be used later in development after the maintenance concept has been determined and more detailed data is available.

1.2 INDENTURE LEVELS

The model looks at three levels of indenture within an end item; components, modules and piece parts. The end item in Figure 1 is broken down into two components. Component 1 is composed of three modules, and component 2 is composed of two modules. There

FIGURE 1

EQUIPMENT BREAKDOWN



APPLICATION 1: COMPONENT 1 —— MODULE 1

APPLICATION 2: COMPONENT 1 —— MODULE 2

APPLICATION 3: COMPONENT 1 —— MODULE 3

APPLICATION 4: COMPONENT 2 —— MODULE 3

APPLICATION 5: COMPONENT 2 —— MODULE 4

is a module 3 in both component 1 and component 2. The applications listed on the bottom of the figure describe how the components and modules are assembled. Piece parts contained in the modules are not shown. Since detailed piece part data is not generally available in early development, the piece parts are considered only in an aggregate manner.

The model is based on applications. This gives OSAMM greater flexibility than most models. Commonality within an end item can be considered. The same module may be contained in two different components, e.g. module 3 in Figure 1. Since failure data is input by application, the model can account for the fact that the module may have a different failure rate depending on the component in which it is installed.

The maintenance decisions made by the model are output by application. The model will describe what should be done when the end item fails due to the failure of a certain module in a certain component. As an example, suppose that the end item pictured in Figure 1 has failed because module 3 has failed in component 2. The model might suggest that the end item be repaired at the organizational level, component 2 be repaired at the direct support unit (DSU) and module 3 be repaired at the depot. If module 4 had caused the failure, however, the model might suggest that because module 4 requires more skill and more expensive test equipment to remove, repair of component 2 should be done at a general support unit (GSU). The model will also determine which components and modules should be thrown away instead of repaired. This information is ultimately used to develop MTD's and RTD's for individual components and modules.

Occasionally there are parts or groups of parts that do not fit exactly into the indenture level structure. These parts or groups can be designated as pseudo components or pseudo modules.

One example of a pseudo component would be a component that contains no modules and has a washout rate of one. Another would be a set of wires connecting components. In general, a pseudo component is not repaired. It is not removed and replaced as a unit, unless it consists of only one part. When parts that make up a pseudo component are replaced, the end item is repaired directly. Since the end item and not the component is repaired by such a maintenance action, special test equipment or special repairmen required are associated with end item repair as described in paragraph 1.3b below. Repair times should be considered in the development of the end item mean time to repair.

In order for a group of parts to be combined into a pseudo module, they must be contained in a component which is removed and replaced as a unit. Replacement of the parts will repair the component outside of the end item. Special test equipments or special repairmen needed are associated with the application as described in paragraph 1.3e. Repair times should be considered in the development of the mean time to repair for the component.

The difference between a pseudo component and a pseudo module lies more in how repair is accomplished rather than in the actual construction. Suppose an automobile is considered as an end item. The engine would clearly be a major component. Considering the spark plugs as a pseudo module would mean that when the spark plugs fail, the engine (component) will be replaced with a new engine. The old engine will be placed in stock after the spark plugs are changed. This is obviously not how one goes about changing the spark plugs in a car. The car (end item) is repaired directly without removing the engine. The spark plugs should therefore be considered as a pseudo component. A spark plug wrench would be listed with special test equipment needed to repair the end item when the spark plug pseudo component fails.

1.3 SPECIAL TEST EQUIPMENT AND SPECIAL REPAIRMEN

A special test equipment or special repairman is peculiar at an echelon if it is not currently located at that echelon. A decision to perform a repair action requiring the use of such an equipment or repairman at that echelon would necessitate an addition to the equipment or skill level already there. New pieces of equipment would have to be purchased, or repairmen with skills not common to the echelon would have to be moved in. The model assumes that if an equipment/repairman is peculiar to an echelon it will be peculiar to all echelons below that echelon. An equipment that is peculiar at a GSU cannot be common at a DSU, for example. On the other hand, an equipment/repairman common at a higher echelon may be peculiar at lower echelons. Common depot equipment may be peculiar to the retail echelons. The placement of special test equipment/repairmen can be constrained allowing the user to prevent their deployment below a specified echelon.

Special test equipment and repairmen are needed for five different kinds of repair actions:

a. Repair end item whenever it fails.

The equipment/repairman is needed whenever the end item fails and is required until the end item is repaired.

b. Repair end item when it fails due to the failure of a specific component.

The equipment/repair is not normally needed to repair the end item, but it is needed when a specific component fails. One example of this type of equipment would be an equipment needed to realign or tune the end item when a specific component is replaced. Another would be an equipment needed to remove and replace a specific component. These equipments/repairmen are needed for a time period which is input by the user.

c. Repair a component whenever it fails.

The equipment/repairman is needed whenever the component fails and is required until the component is repaired.

d. Repair a module whenever it fails.

e. Repair a component when it fails due to the failure of a specific module.

The equipment/repairman is not normally needed to repair the component, but it is needed when a specific module fails. (See b above).

Note: An equipment or repairman can be used for more than one of the above purposes and can be used on any number of different components and modules.

1.4 COST FACTORS

One time and annual recurring costs are both considered in the model. Comparisons are made using the net present value method as per DODI 7041.3. Details are given in Appendix B.

Full deployment is assumed in year 1. This means cost estimates produced are not true life cycle costs, but are useful for ranking policy alternatives. This approach was taken to simplify data requirements and processing with the expectation that this would not unduly bias choice of one alternative over another. It does tend to exaggerate the impact of costs which will phase in over time, so some refinements to the current model may ultimately be necessary. Note that not only do annual costs such as requisition processing build up to full deployment levels, but even "one-time" costs such as purchase price for test equipment, are not really all incurred at one time; test equipment, for example, need only be deployed as the weapon system is introduced over time to additional fighting units.

CHAPTER 2

INPUT

2.1 INPUT CARD DECK

The data for the model is input on 80 column data cards as described below. All cards are mandatory except where noted. The input deck is summarized in Figure 2. The first card in the deck is the end item card containing general information about the end item. Following this card is a card with a list of equipments/repairmen identification numbers. These equipments/repairmen are needed to repair the end item whenever it fails as described in 1.3a. This card is optional. The next set of cards lists the identification numbers of equipments/repairmen that are needed to repair the end item when specific components fail as described in 1.3b. These cards are also optional, but if they are used, there must be two cards for each component that has this type of equipment/repairman associated with it. If used, this set of cards must be followed by a card with 9999 in columns 1-4 to signal the end of this data.

The next card is the deployment information card which contains SESAME type input data about the supply support structure. The policy selector card follows the deployment card. The GEMM maintenance policies that are to be considered are listed on this card. (See Table 1). After the policy selector card comes the echelon parameters card. This card contains information about the maintenance echelons. The final card in this group is the cost parameters card which has some overall cost information.

The special test equipment cards are next in the deck. These cards contain all of the data for special test equipment. The

Figure 2. Summary of Input Data Deck

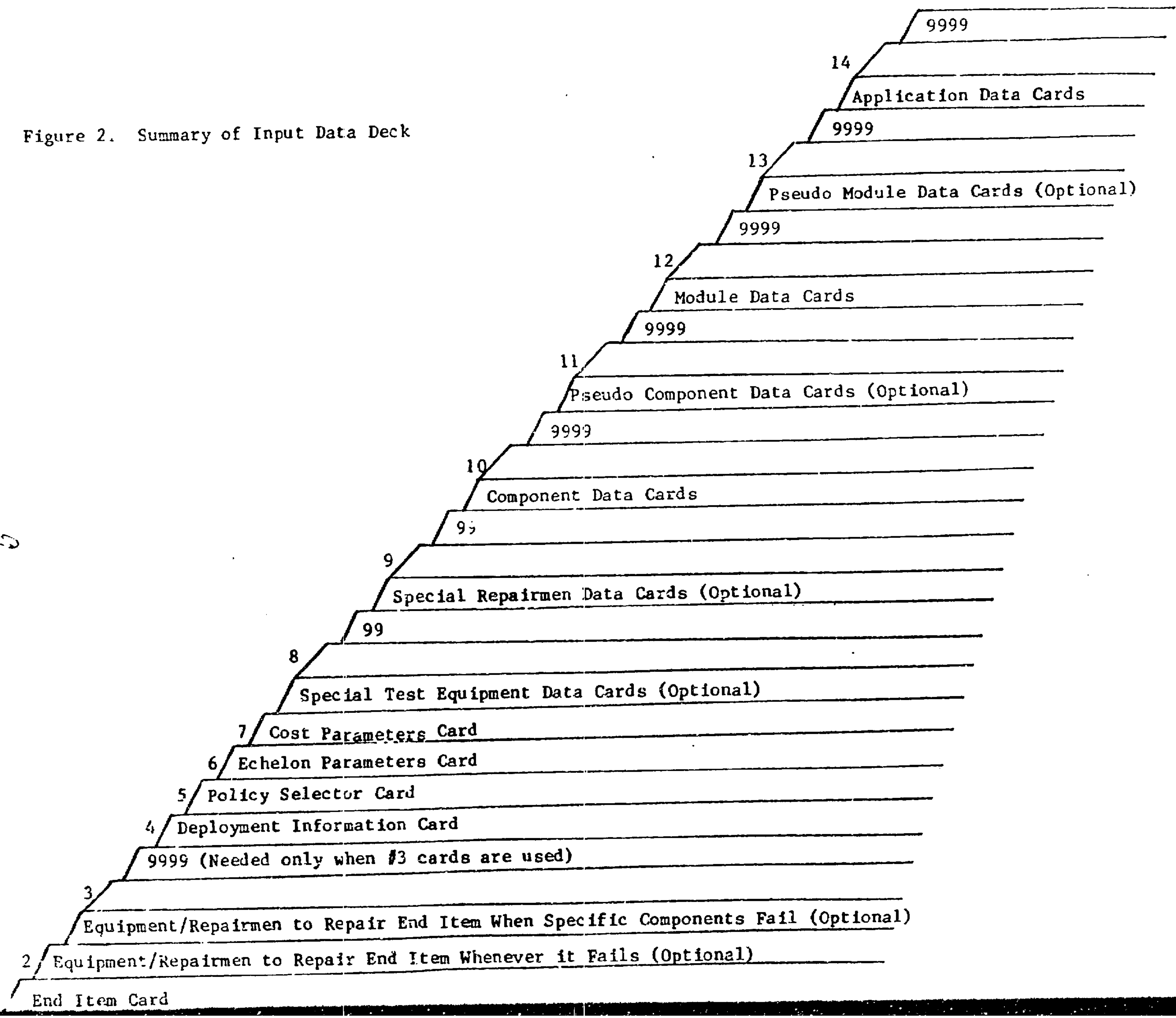


TABLE 1

GEMM Policies

1 = ORG   2 = DSU   3 = GSU   4 = DEPOT   5 = Throwaway

Policy Number	End Item Repair	Component Repair	Module Repair
1	1	1	1
2	1	1	2
3	1	1	3
4	1	1	4
5	1	1	5
6	1	2	2
7	1	2	3
8	1	2	4
9	1	2	5
10	1	3	3
11	1	3	4
12	1	3	5
13	1	4	4
14	1	4	5
15	1	5	5
16	2	2	2
17	2	2	3
18	2	2	4
19	2	2	5
20	2	3	3
21	2	3	4
22	2	3	5
23	2	4	4
24	2	4	5
25	2	5	5
26	3	3	3
27	3	3	4
28	3	3	5
29	3	4	4
30	3	4	5
31	3	5	5
32	4	4	4
33	4	4	5
34	4	5	5
35	5	5	5

user gives each type of special test equipment an identification number between 1 and 30. The equipment cards need not be in any particular order. This set of cards must be followed by a card with 99 in columns 1 and 2. If there are no special test equipments, simply place a card with 99 in columns 1 and 2 after the cost parameter card.

The special repairman data cards follow the special test equipment cards. There can be one, two or four cards for each type of repairman. If there is only one set of cost data for a repairman only one card is necessary. Two cards are used if there is separate data for the wholesale and retail echelons. Finally, if there are different costs at each echelon for a repairman that performs the same functions, four cards are needed. If there are multiple data cards for a single repairman, they must be kept in the specified order. The special repairman cards are followed by a card with 99 in columns 1 and 2. If there are no special repairmen, two cards with 99 in columns 1 and 2 must be placed after the special test equipment data instead of one. If there are neither special test equipments nor special repairmen, the two cards with 99 in the first two columns follow the cost parameters card.

The special repairmen are also given identification numbers between 1 and 30. These numbers must be different than the numbers given to the special test equipment. Thus, there can be no more than a total of thirty special test equipments and special repairmen.

The component data cards which follow the repairman cards contain information about the individual components. There are one or two cards for each component. The first card contains the component information. The preprocessor uses the identifications which must be different for each component and module. Component and module names are input only for the convenience of the user. The second card, which is optional, contains the identification numbers of the equipments/repairmen which are needed to repair the component (See 1.3c). If there are two cards for a component, they must be kept together and in the proper order. Otherwise, the component cards may be arranged by any order. A card with 9999 in the first four columns should follow the component cards.

The pseudo component cards follow the regular component cards. These cards are optional. The price and weight should be the price and weight of parts consumed during an average repair action. The MTBF should be the MTBF of a representative part. This entry will be converted to failures per year and will be multiplied in the main program by the number of parts to give the total number of component failures per end item per year. There is one data card for each pseudo component. Since these components themselves are not reparable, no special test equipments or repairmen are listed here. Equipments/repairmen needed for maintenance actions associated with a pseudo component are repairing the end item and must be listed with equipments/repairmen used to repair the end item when the specific pseudo component fails (see 1.3b). This set of cards is followed by a card with 9999 in the first four columns. If there are no pseudo components, two cards with 9999 in the first four columns must follow the regular component cards.

The module data cards follow the component cards and are arranged in exactly the same menner. The identification numbers listed are those of the equipment/repairmen used to repair the modules as described in 1.3d. Failure information is input with the applications. The module data is also followed by a card with 9999 in the first four columns.

The pseudo module cards follow the regular module cards.

These cards are also optional. The price and weight data should be the price and weight of parts consumed during an average repair action. As with regular modules, the failure information is input with the application data. The MTBF should be the MTBF of a representative part. This entry will be converted to failures per year and will be multiplied in the main program by the number of parts to give the total number of module failures per year. Since these modules themselves are not reparable, no special test equipments or repairmen are listed here. Equipments/repairmen needed for maintenance actions associated with a pseudo module are repairing the component and must be listed with the application (see 1.3e). This set of cards is followed by a card with 9999 in the first four columns. If there are no pseudo modules, two cards with 9999 in the first four columns must follow the regular module cards.

The final set of cards in the input deck contains the application data. As with component and module data, there can be one or two cards for each application. The first lists a module and the components to which it belongs. Since there can be several copies of the same module in the end item, a module may appear in several applications. The failure data is also on the first application card. Thus, the failure rates depend not only on the module itself, but also on where it is installed. The second card associated with an application is optional. This card contains the identification numbers of the equipments/repairmen that are needed to repair the component listed when the failure is due to the module listed as described in 1.3e. These equipments are not needed every time the component fails. Equipments/repairmen needed every time the component fails should not be listed here since they are already listed with the component. This second card also contains the length of time for which each of the equipments/repairmen listed is needed. The two cards for an application must be kept together and in the proper order. Otherwise, the application cards may also be arranged in any order. The last card of the input deck following the application data must have a 9999 in columns 1 to 4.

2.2 INPUT FORMAT

The input variables are listed below. Definitions of input variables are given in Appendix C. Some of the variables have default values which will be used if a zero is input or if the data field for that variable is left blank. Care should be taken when using default values since the correct values may change, but the defaults may not reflect the change for some time.

All data entries should be right justified in their field unless otherwise noted. The decimal point will automatically be placed so that the entry has the number of decimal places indicated. The user may insert his own decimal point which will override the assumed decimal point.

As an example, suppose the variable SAMPLE is to be input in card columns (cc) 25-30 with 2 decimal places. The following

cc	25	26	27	28	29	30
			1	0	2	5

would set SAMPLE equal to 10.25. The following

cc	25	26	27	28	29	30
	2	5	.	3	7	5

would set SAMPLE equal to 25.375.

End Item Card

Variable	Units	Default	cc	Decimal Places
End Item Identification	Alphanumeric	None	1-8	N/A
End Item Price	Dollars	None	10-19	0
Operating Life	Years	None	21-23	0
Operating Hours/Year	Hours	None	25-31	0
Mean Time Between Failures (MTBF)	Hours	None	33-39	1
Mean Time to Repair End Item (MTR)	Hours	.5	41-45	2
Availability Target	N/A	None	49-51	3
Erroneous Removal Rate	N/A	.1	56-57	2
Number (Quantity) of Equipment/Repairmen Types for End Item Repair	N/A	0	59-60	INTEGER
Indicator (1) for Equipment/ Repairmen as Described in Para 1.3b	N/A	0	62	INTEGER
MTBF multiplier*	N/A	1.	64-68	2

*All MTBFs are multiplied by this factor. It is used when performing sensitivity analysis.

Equipment/Repairmen to Repair End Item Whenever it Fails (Optional)

This card is needed if there is a number other than 0 in card columns 59-60. Special test equipment/repairmen that are needed whenever the end item fails (1.3a) are listed on this card. Equipment identification numbers are listed (right justified) in cc

1-2, 3-4, 5-6, ..., 59-60

If the number in cc 59-60 of end item card is 0 (blank) this card should be omitted.

Equipment/Repairmen to Repair End Item When Specific Components Fail (Optional)

If a 1 is placed in column 62 of the end item card, special test equipment/repairmen that are needed to repair the end it m when specific components fail (1.3b) must be entered as follows. Two data cards are required for each component that needs equipment/repairmen for this purpose. If this type data is input, it must be followed by a card with 9999 in columns 1-4.

Variable	Units	Defaults	cc	Decimal Places
Card 1				
Component Identification	Alphanumeric	N/A	1-4	N/A
Number (quantity) of equip/rep type associated with this component	N/A	None	7-8	INTEGER
Card 2				
First equipment/Repairman Identification number	N/A	None	1-2	INTEGER
Time Needed	Hours	None	4-8	2
Second Equipment/ Repairman Identification Number	N/A	None	9-10	INTEGER
Time Needed	Hours	None	12-16	2
Third Equipment/Repairman Identification Number	N/A	None	17-18	INTEGER
Time Needed	Hours	None	20-24	2
:	:	:	:	:

Deployment Information Card

Variable	Units	Default	cc	Decimal Places
Retail Stockage Criteria (RSC)		None	1	INTEGER
SESAME Support System Indicator	V = Vertical D = Direct Exchange N = Nonvertical	None	2	N/A
Claimants	N/A	None		
Number of Shops at:				
Org			3-6	0
DSU			7-10	0
GSU			11-14	0
Density			15-20	0
Order Ship Time (OST)	Days	None		
Org-DSU			21-24	1
DSU-GSU			25-28	1
GSU-DEPOT			29-32	1
Procurement Lead Time	Days	None	33-36	1
Contact Team Delay Time	Days	None	37-40	1
Operating Level	Days	None		
Org			42-45	0
DSU			46-49	0
GSU			50-53	0

Policy Selection Card

Place a 1 in card I column if GEMM maintenance policy I is to be considered. Default is 0 which means policy will not be considered.

Echelon Parameters Card

Variable	Units	Default	cc	Decimal Places
Shift Hours Per Day	Hours			
Org		16	1-2	0
DSU		12	3-4	0
GSU		8	5-6	0
DEPOT		8	7-8	0
Days in Workweek	Days			
Org		7	10-11	0
DSU		5	12-13	0
GSU		5	14-15	0
DEPOT		5	16-17	0
Common Labor Rate	Dollars			
Org		6.00	19-22	2
DSU		9.00	23-26	2
GSU		17.25	27-30	2
DEPOT		17.25	31-34	2
Distance Between Echelons	Miles			
Org-DSU		7	36-41	0
DSU-GSU		250	42-47	0
GSU-DEPOT		3500	48-53	0
Transportation Cost per Pound-Mile	Dollars			
Org-DSU		.01	55-61	5
DSU-GSU		.00029	62-68	5
GSU-DEPOT		.0003	69-75	5

Cost Parameter Card

Variable	Units	Default	cc	Decimal Places
First Year Cataloging Cost	Dollars	555.00	11-16	2
Subsequent Years Cataloging Cost (per year)	Dollars	138.00	18-23	2
Annual Cost to Maintain Item in ASL	Dollars	30.00	25-30	2
Inventory Holding Cost Percentage	N/A	.03(3%)	36-37	2
Cost per Requisition	Dollars	20.20	39-44	2
Cost of Technical Documentation per page	Dollars	200.00	46-51	2
One Time Cost to Add a Line to ASL	Dollars	187.00	53-58	2

Special Test Equipment

(one card per equipment)

Variable	Units	Default	cc	Decimal Places
Equipment Identification Number	N/A	None	1-2	INTEGER
Equipment Price * (Each, Excluding Development)	Dollars	None	4-11	0
Useful Life	Years	End Item Life	13-15	0
Annual Maintenance Cost Factor (CF)	N/A	.27	19-20	2
Other One Time Initial Costs* (Each)	Dollars	0	22-28	0
Availability	N/A	.65	32-33	2
Highest Echelon at Which Peculiar	1 = Org. 2 = DSU 3 = GSU 4 = DEPOT	4	35	INTEGER
Lowest Echelon at Which Can be Placed		1	36	INTEGER

*These costs are for one unit of the special test equipment and will be multiplied by the quantity deployed.

Special Repairmen Data

Option 1 - Same Costs for All Echelons

Variable	Units	Default	cc	Decimal Places
Repairmen Identification Number	N/A	None	1-2	INTEGER
Military/Civilian Indicator	1 = Military 2 = Civilian	1	6	INTEGER
Annual Salary	Dollars	None	8-12	0
Salary Loading Factor (LF)	N/A	Mil .682 Civ .45	16-17	2
Training Cost per Man	Dollars	None	19-23	0
Turnover	Years	Mil 2.5 Civ 5.0	25-28	2
Availability	N/A	.70	32-33	2
Highest Echelon at Which Peculiar		4	35	INTEGER
Lowest Echelon at Which Can be Placed		1	36	INTEGER

Special Repairmen Data

Option 2 - Different Costs for Wholesale and Retail Echelons

Card 1 Retail Costs

Variable	Units	Default	cc	Decimal Places
Repairmen Identification Number	N/A	None	1-2	INTEGER
"2" Place a 2 in this column			4	INTEGER
Military/Civilian Indicator	1 = Military 2 = Civilian	1	6	INTEGER
Annual Salary	Dollars	None	8-12	0
Salary Loading Factor (LF)	N/A	Mil = .682 Civ = .45	16-17	2
Training Cost	Dollars	None	19-23	0
Turnover	Years	Mil 2.5 Civ 5.0	25-28	2
Availability	N/A	.70	32-33	2
Highest Echelon at Which Peculiar	N/A	4	35	INTEGER
Lowest Echelon at Which Can Be Placed	N/A	1	36	INTEGER

Special Repairmen Data

Option 2 - Different Costs for Wholesale and Retail Echelon

Card 2 Wholesale Costs

Variable	Units	Default	cc	Decimal Places
Military/Civilian Indicator	1 = Military 2 = Civilian	1	6	INTEGER
Annual Salary	Dollars	None	8-12	0
Salary Loading Factor	N/A	Mil =.682 Civ =.45	16-17	2
Training Cost	Dollars	None	19-23	0
Turnover	Years	Mil 2.5 Civ 5.0	25-28	2

Special Repairmen Data

Option 3 - Different Costs for Each Echelon

Card 1 - Organization

Variable	Units	Default	cc	Decimal Places
Repairman Identification Number	N/A	None	1-2	INTEGER
"4" Place a 4 in this column			4	INTEGER
Military/Civilian Indicator	1 = Military 2 = Civilian	1	6	INTEGER
Annual Salary	Dollars	None	8-12	0
Salary Loading Factor	N/A	Mil .682 Civ .45	16-17	2
Training Costs	Dollars	None	19-23	0
Turnover	Years	Mil 2.5 Civ 5.0	25-28	2
Availability	N/A	.70	32-33	2
Highest Echelon at Which Peculiar	N/A	4	35	INTEGER
Lowest Echelon at Which Can Be Placed	N/A	1	36	INTEGER

Special Repairman Data

Option 3 - Different Costs for Each Echelon

Card 2 DSU

Variable	Units	Default	cc	Decimal Places
Military/Civilian Indicator	1 = Military 2 = Civilian	1	6	INTEGER
Annual Salary	Dollars	None	8-12	0
Salary Loading Factor	N/A	Mil = .682 Civ = .45	16-17	2
Training Cost	Dollars	None	19-23	0
Turnover	Years	Mil = 2.5 Civ = 5.0	25-28	2

Card 3 - GSU

Same format as Card 2 above.

Card 4 - DEPOT

Same format as Card 2 above.

DRAFT

Component Data

Card 1

Variable	Units	Default	cc	Decimal Places
Component Identification (Do not use 9999)	Alphanumeric	None	1-4*	N/A
Component Name	Alphanumeric	None	5-14	N/A
Component Price	Dollars	None	15-21	2
Weight	Pounds	None	22-27	2
Essentiality Code	N/A	None	28	INTEGER
Washout Rate	N/A	None	30-33	3
Repairman Time to Repair the Component	Hours	.25	34-38	2
Number of Pages of Technical Documentation	N/A	None	39-42	0
New NSN Indicator	1 if NSN exists 0 is no NSN exists	0	43	INTEGER
Number (quantity) of Special Test Equipment Types	N/A	0	44-45	INTEGER
Number (quantity) of Special Repairmen Types	N/A	0	46-47	INTEGER

*LEFT JUSTIFIED

Component Data

Card 2 - Equipment/Repairmen to Repair Component

(Not needed if both number of equipment and number of repairmen is 0)

Variable	Units	Default	cc	Decimal Places
First Equipment/Repairman Identification Number			1-2	
Second Equipment/Repairman Identification Number			3-4	
Third Equipment/Repairman Identification Number			5-6	

AS MANY AS NEEDED

• •

• •

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• •

Variable	Units	Default	cc	Decimal Places
Thirtieth Equipment/Repairman Identification Number			59-60	

Pseudo Component Data

Variable	Units	Default	cc	Decimal Places
Pseudo Component Identification (Do not use 9999)	Alphanumeric	None	1-4*	N/A
Pseudo Component Name	Alphanumeric	None	5-14	N/A
Price of Parts Consumed Per Average Repair Action	Dollars	None	15-21	2
Weight of Parts Consumed Per Average Repair Action	Pounds	None	22-27	2
Essentiality Code	N/A	None	28	INTEGER
Total Number of Parts	N/A	None	29-33	0
Number of Parts Needing a New NSN	N/A	None	34-38	0
Mean Time Between Failures (MTBF) for Representative Part	Hours	None	39-47	0

*LEFT JUSTIFIED

Module Data

Card 1

Variable	Units	Default	cc	Decimal Places
Module Identification (Do not use 9999)	Alphanumeric	None	1-4*	N/A
Module Name	Alphanumeric	None	5-14	N/A
Module Price	Dollars	None	15-21	2
Weight	Pounds	None	22-27	2
Essentiality Code	N/A	None	28	INTEGER
Washout Rate	N/A	None	30-33	3
Repairman Time to Repair the Module	Hours	.25	34-38	2
Number of Pages of Technical Documentation	N/A	None	39-42	0
New NSN Indicator	1 if NSN exists 0 if no NSN exists	0	43	INTEGER
Number (quantity) of Special Test Equipment Types	N/A	0	44-45	INTEGER
Number (quantity) of Special Repairmen Types	N/A	0	46-47	INTEGER
Average Time to Repair Module including waiting time NOT including shipping time to another echelon**	Days	None		
ORG			48-50	0
DSU			51-53	0
GSU			54-56	0
DEPOT			57-59	0
Number of Piece Parts in Module which Need a New NSN	N/A	None	60-64	INTEGER
Average Price of Piece Parts Per Repair Action	Dollars	None	65-70	2

*LEFT JUSTIFIED

**This time is added to the OST to create the "TAT" input to SESAME.

Module Data

Card 2 - Equipment/Repairmen to Repair Module

(Not needed if both number of equipment and number of repairmen is 0)

Variable	Units	Default	cc	Decimal Places
First Equipment/Repairman Identification Number			1-2	
Second Equipment/Repairman Identification Number			3-4	
Third Equipment/Repairman Identification Number			5-6	

AS MANY AS NEEDED

•   •

•   •

•   •

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Variable	Units	Default	cc	Decimal Places
Thirtieth Equipment/Repairman Identification Number			59-60	

Pseudo Module Data

Variable	Units	Default	cc	Decimal Places
Pseudo Module Identification (Do not use 9999)	Alphanumeric	None	1-4*	N/A
Pseudo Module Name	Alphanumeric	None	5-14	N/A
Price of Parts Consumed Per Repair Average Action	Dollars	None	15-21	2
Weight of Parts Consumed Per Average Repair Action	Pounds	None	22-27	2
Essentiality Code	N/A	None	28	INTEGER
Total Number of Parts	N/A	None	29-33	0
Number of Parts Needing a New NSN	N/A	None	34-38	0

*LEFT JUSTIFIED

Application Data

Card 1

Variable	Units	Default	cc	Decimal Places
Component Identification	Alphanumeric	None	1-4*	N/A
Module Identification	Alphanumeric	None	5-8*	N/A
Mean Time Between Failures (MTBF) of the Module in the Component (or of part for pseudo module)	Hours	None	12-20	0
Average Time to Fault Isolate to Module and Repair Component (remove and replace faulty module) plus waiting time**	Days	None		
ORG			21-23	0
DSU			24-26	0
GSU			27-29	0
DEPOT			30-32	0
Number (quantity) of Special Test Equipment and Repairman Types	N/A	0	33-34	INTEGER

*LEFT JUSTIFIED

**These times are compiled for components and added to the OST to create the component "TAT" inputs for SESAME.

Application Data

Card 2 Equipment/Repairmen as in 1.3e

(Not needed if number of special test equipments and repairmen is 0)

Variable	Units	Default	cc	Decimal Places
First Equipment/Repairman Identification Number	N/A	None	1-2	INTEGER
Time Required	Hours	None	4-8	2
Second Equipment/Repairman Identification Number	N/A	None	9-10	INTEGER
Time Required	Hours	None	12-16	2

•

• AS MANY AS NEEDED •

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DRAFT

CHAPTER 3

PREPROCESSOR OUTPUT

3.1 INTRODUCTION

The preprocessor generates an output which can be used to check the input data for errors. Several error messages, which will be discussed in 3.3, point to specific errors in the input data. Most of the preprocessor output is a simple listing of the inputs. Some computations done by the preprocessor are reflected in the output, however. A sample output is given in 3.4.

3.2 NORMAL OUTPUT

Preprocessor output is divided into several sections. The first contains end item, deployment, and general cost data. The next section has special test equipment and special repairmen data. The final sections list data associated with specific components, modules and applications.

Most of the data listed in the first section is self-explanatory. The average OUPS is computed from the claimants and the deployment density. The column headed, "policies allowed", lists the GEMM maintenance policies which will be considered by the model. The wage rate is the hourly salary of a common repairman loaded with the cost of benefits. The base rates are adjusted by a military loading factor at the organization and DSU, and by a civilian loading factor at the GSU and depot. Transportation costs between echelons are computed from inputs. The present value per unit of various other costs is output at the end of this section. Details of the present value computations can be found in Appendix B.

The second section of output contains data pertaining to special test equipment and special repairmen. Identification numbers assigned by the user are listed under the column headed "numbers". The only data for special test equipment that is not input by the user is listed under the column headed "present value". Details of this computation are given in Appendix B. The numbers listed under the column headed "common above" give the highest echelon at which a special test equipment is peculiar. It will be considered as common for all echelons above that echelon. The only outputs not input by the user for special repairmen are listed under the columns headed "org, DSU, GSU and DEPOT". These values are the present value for each type of repairman at the repair echelons. Details of the computations used to derive these costs are also given in Appendix B. The column headings in this section are printed even if there are no special test equipments or special repairmen.

The final sections of preprocessor output contain all of the data associated with the individual components, modules, and applications. The component and module names are only for the convenience of the user. The component and module ID's, however, are used by the preprocessor for identification. Each component, module and application is given a reference number by the preprocessor to aid in debugging. These numbers are cumulative. The modules and applications are also given separate numbers which are not cumulative. A component's number would be the same as its reference number.

The component data has a few entries which require explanation. The equipment count is the number of special equipments or special repairmen needed to repair the component. The entry in the "NSN" columns will be 0 if the component does not have an existing NSN and 1 if it has an NSN. Pseudo component data is a simple listing of the inputs except for the failures per year which are derived from the MTBF and the end item operating hours.

The module data listed is essentially the same as the component data. The additional columns contain information about module repair which has been input by the user. The "arr-shelf" column lists the average elapsed time from the arrival of a failed module at the maintenance echelon where it is to be repaired until the time is on the shelf and ready for use. The "new parts" column gives the number of piece parts in the module which will require a new NSN if the module is to be repaired. The column headed "parts price per repair" lists the average price of piece parts required for each repair action. Pseudo module data is simply a listing of the inputs.

Each application has only two data outputs. The "arr-shelf" time is the average elapsed time from the arrival at the repair echelon of the component which has failed because of the specific module until the component is on the shelf and ready for use. The failures per year are computed from the MTBF of the module in the component and the annual operating hours of the end item.

The equipment stack which follows the applications describes how special test equipments and special repairmen are used to repair the end item, components, and modules when specific failures occur. Components, modules and applications are identified by reference number for this list. The integer part of a piece of equipment information is the special test equipment or special repairman identification number. The fractional part is the reciprocal of the number of special repair actions the equipment/repairman can perform in one year.

The special test equipments and special repairmen are not grouped in the same manner as they are input. An equipment/repairman listed with a component is needed to repair the end item when that component fails (See 1.3a or 1.3b). Equipments/repairmen listed with a module are used to repair that module (See 1.3d). Finally, equipments/repairmen listed with an application are used to repair the component when the module fails (See 1.3c or 1.3e). These groupings are necessary because the module works with applications. An equipment or repairman used to repair a component every time it fails is input with the component. Since the module works with applications, however, this equipment/repairman must be listed with every application involving that component. Similarly, an equipment or repairman used to repair the end item must be associated with the component that has caused it to fail. If an equipment or repairman is needed every time the end item fails, it must be associated with every component, since the failure of any component will mean that the equipment/repairman is needed to repair the end item. The preprocessor performs these manipulations automatically, and it is not essential for the user to understand the details of the groupings.

3.3 ERROR MESSAGES

The preprocessor has several error messages to aid in checking input data. The program may execute normally even though an error message is printed, but every error message should be investigated. In addition, any time a data field on the preprocessor output is filled with asterisks, the data for that field should be verified. The asterisks indicate that the number to be written in the field is too large. Since the data fields should be big enough to accommodate the entries that are supposed to fill them, asterisks usually indicate an error in the input data. There can be no asterisks on the data file that is passed to the main program.

Incorrect data cards may cause warning or error messages that are not part of the preprocessor to be printed. These errors must also be investigated. The preprocessor is designed so that component, module and application data is printed soon after it is input. Thus, the user can easily identify the data card that is causing a problem. The bad data is most likely on the card immediately following the last card printed.

The preprocessor error messages and possible causes are as follows:

a. OPERATING LIFE IS ZERO CAUSING DIVISION BY ZERO- The operating life of the end item has been set to zero. None of the present value computations will be correct.

b. POLICY SELECTOR CARD INCORRECT OR MISSING - The entries on what is being read as the policy selector card are other than zeros, blanks, or ones. This will occur if the first few cards are out of order or if a card is missing.

c. COST DATA CARD STARTS IN WRONG CARD COLUMN MUST HAVE BLANK CARD(S) IF USING ALL DEFAULTS - The first ten columns of the cost data card must be left blank. If some other card is read as the cost data card, this error will occur. The cost data card and echelon parameters card must be included in the input deck even if they are blank. (using all defaults)

d. EQUIPMENT NUMBER FIELD IS BLANK, etc. - Data for a special test equipment was input without assigning an identification number. The message gives the unit price to help locate the incorrect data card.

e. NUMBER FIELD IS BLANK FOR REPAIRMAN, etc. - Data for a special repairman was input wihout assigning an identification number. The error could occur if multiple cost cards are input for a repairman and cc 4 of the first one is incorrect. The repairman will be identified by his salary.

f. BLANK MILITARY/CIV INDICATOR FOR REPAIRMAN, etc. - This is a warning message. It reminds the user that since no indicator was input, the repairman will be considered as military. For repairmen with multiple cost cards, the incorrect card is identified. For repairman with only one cost card, the message says that the error is on the first cost card.

g. TRAINING COST BLANK FOR REPAIRMAN, etc. - This message warns the user that the training cost for a special repairman is zero. While zero is a possible input, it is hardly realistic and should be reconsidered. The message identifies the repairman and the cost card where the error occurs.

h. MODULE IS A DUMMY WITH NO PARTS PRICE - The parts price per repair action for a dummy module is zero.

i. COMPONENT XXXX HAS NOT BEEN INPUT. THIS APPLICATION IS INCORRECT - This message precedes the printout of the incorrect application. The component identification listed on the application card does not match any of the component which have been input. The component identification on the application card must be identical to the component identification on the component card.

j. MODULE XXX HAS NOT BEEN INPUT. THIS APPLICATION IS INCORRECT - This message precedes the printout of the incorrect application. The module identification listed on the application card does not match any of the modules which have been input. The module identification on the application card must be identical to the module identification on the module card.

3.4 EXAMPLE

An example of a preprocessor run is given in this section. The data for this run is not meant to be realistic. It is designed only to illustrate how the preprocessor works. The input data deck is listed in Figure 3. The output sections described above are shown in Figures 4a-f.

Card No.*

```
1      ABCDEFGE      123456  10    8760   1000            995          2 1
2      0104
       CCCC    1
       02    5
       AAAA    2
3      02    5    6   10
       BBBB    1
       09    5
       9999
4      6N 300  100  10   1000    2   43   43 180   10     15   30   30   30
5      1      1     1111111 111 11111111 11 111
6      13            6              21                      255                 2
7
       01       1000   10    25      100     95 32
       02      10000   10    1       500
8      07       1000   10    25      100     95 32
       08      10000   10    1       500
       99
       03     1 10000    25   1000   200     75 31
       09     1 10000    25   1000   200     75 31
       10     1 20000    20   2000   100        21
       04  2  1 20000    20   2000   100        21
              2 30000         10000
9      11     1 10000    30   1000
       05  4  1 10000    30   1000
              1 20000         2000   300
              1 30000         3000              32
              2 40000         4000
       99
       AAAACOMP. 1     432100  34561    34   25   1001 1 1
        3 1
10     BBBBCOMP. 2     543210  12343    78   1     50   1
        7
       9999
11     CCCCPCOMP. 1     1111        51    20    10       8760
       DDDDPCOMP. 2     2222        1    100    25        100
       9999
       1234MODULE 1      5600     1007    25          1      100101102103  123   11
12     MOD MODULE 2    123400     2505   100   500   20   1 112012112212З 1234  1050
        2 3
       9999
13     EEEEPMODULE 1    2222       1     100    25
       FFFFPMODULE 2    1111      51      20    10
       9999
       AAAAEEEE         8760 80 81 82 83
       AAAAFFFF         8760 80 81 82 83 2
       09 10    10   15
       AAAA1234         8760 80 81 82 83 2
14     09 10    10   15
       BBBB1234         4380 90 91 92 93 1
       11   5
       AAAAMOD            10 70 71 72 73 1
        5    25
       9999
```

*See Figure 2.

```
END ITEM    UNIT COST    LIFE     OPERATING    MTBF      MTR     FALSE     AVAILABILITY
                         (YEARS)  HOURS                          REMOVAL   GOAL
ABCDEFGE    123456.      10.0     8760.0       1000.0    0.50    0.10      0.995

           CLMNTS      DENSITY          OST              PLT    CTDEL         OPSL              IVSYS   RSC
300.  100.    10.  1000.       2.0   43.0   43.0   180.0   10.0    15. 30. 30.  0.     N       D

   AVERAGE OUPS
3.3   10.0  100.0

POLICIES ALLOWED
            1
            7
           12
           13
           14
           15
           16
           17
           18
           20
           21
           22
           24
           25
           26
           27
           28
           29
           30
           31
           33
           34

                  ORG     DSU     GSU    DEPOT
WAGE RATE        10.09   15.14   30.45   25.01
(LOADED)

SHIFT HOURS      13.     12.      8.      8.

DAYS/WEEK         7.      6.      5.      5.

SHIFT RATIO      1.000   0.791   0.440   0.440

TRANSPORTATION COST PER POUND
  ORG-DSU   DSU-GSU   GSU-DEPOT
   0.07      0.51      1.05

     OTHER COSTS (PRESENT VALUE)
COST PER NEW NSN       1313.62
BIN COST                193.55
HOLDING COST PERCENT      0.03
COST PER REQUISITION    130.33
TECH DOC PER PAGE       200.00
```

Figure 4a. Sample Output

SPECIAL TEST EQUIPMENT DATA

NUMBER	PRICE	USEFUL LIFE	MAINT COST FACTOR	ONE-TIME COST	PRESENT VALUE	AVAIL	COMMON ABOVE	NOT ALLOWED BELOW
1	1000.	10.0	0.25	100.	2713.	0.95	3	2
2	10000.	10.0	0.10	500.	16952.	0.65	4	1
7	1000.	10.0	0.25	100.	2713.	0.95	3	2
8	10000.	10.0	0.10	500.	16952.	0.65	4	1

SPECIAL REPAIRMEN

NUMBER	AVAIL	COMMON ABOVE	NOT ALLOWED BELOW	ORG	DSU	GSU	DEPOT
3	0.75	3	1	83873.	83873.	83873.	83873.
9	0.75	3	1	83873.	83873.	83873.	83873.
10	0.70	2	1	167746.	167746.	167746.	167746.
4	0.70	2	1	167746.	167746.	167746.	293555.
11	0.70	4	1	86454.	86454.	86454.	86454.
5	0.70	4	1	86454.	221338.	333298.	379364.

43

Figure 4b. Sample Output

COMPONENT INFORMATION

REF	ID	NAME	PRICE	WGT	ESS	WASH	EQUIP COUNT	PAGE	NSN	LABOR TIME (HOURS)
1	AAAA	COMP. 1	4321.00	34.56	1	0.034	2	100.	1	2.50
2	BBBB	COMP. 2	5432.10	12.34	3	0.078	1	50.	0	1.00

PSEUDO COMPONENTS

REF	ID	NAME	AVERAGE PRICE	WGT	ESS	TOTAL PARTS	NEW PARTS	FAILURES PER YEAR
3	CCCC	PCOMP. 1	111.10	0.05	1	20.	10.	1.000
4	DDDD	PCOMP. 2	222.20	0.10	0	100.	25.	87.600

NUMBER OF COMPONENTS= 4

Figure 4c. Sample Output

MODULE INFORMATION

REF	MOD NUM	ID	NAME	PRICE	WGT	ESS	WASH	ARR-SHELF ORG	DSU	GSU	DEP	NEW PARTS	PARTS PRICE PER REPAIR	EQUIP COUNT	PAGE	NSN	LABOR TIME (HOURS)
5	1	1234	MODULE 1	56.00	1.00	7	0.025	100.	101.	102.	103.	123.	11.00	0	1.	0	0.25
6	2	MOD	MODULE 2	1234.00	2.50	5	0.100	120.	121.	122.	123.	1234.	10.50	2	20.	0	5.00

PSEUDO MODULES

REF	MOD NUM	ID	NAME	AVERAGE PRICE	WGT	ESS	TOTAL PARTS	NEW PARTS
7	3	EEEE	PMODULE 1	222.20	0.10	0	100.	25.
8	4	FFFF	PMODULE 2	111.10	0.05	1	20.	10.

NUMBER OF MODULES= 4

45

Figure 4d. Sample Output

APPLICATION INFORMATION

REF	APP NUM	COMP ID	MOD ID	FAILURES PER YEAR	ORG	ARR-SHELF DSU	GSU	DEP
9	1	AAAA	EEEE	1.000	80.	81.	82.	83.
10	2	AAAA	FFFF	1.000	80.	81.	82.	83.
11	3	AAAA	1234	1.000	80.	81.	82.	83.
12	4	BBBB	1234	2.000	90.	91.	92.	93.
13	5	AAAA	MOD	876.000	70.	71.	72.	73.

NUMBER OF APPLICATIONS= 5

Figure 4e. Sample Output

EQUIPMENT STACK

COM/MOD/APP	EQUIPMENT INFORMATION			
1	1.00011	4.00015	2.00163	8.00325
2	1.00011	4.00015	9.00141	
3	1.00011	4.00015	2.00163	
4	1.00011	4.00015		
6	2.00163	3.00141		
9	3.00070	1.00056		
10	9.02818	10.00453	3.00070	1.00056
11	9.02818	10.00453	3.00070	1.00056
12	11.00151	7.00022		
13	5.00075	3.00070	1.00056	

Figure 4f. Sample Output

CHAPTER 4

FINAL OUTPUT

4.1 MAINTENANCE POLICIES

The final output from the model is divided into several sections. The first section lists the maintenance policies suggested by the model. The level at which end item, component, and module repair should be done is given for each application. Suppose application 1 consisted of MODULE1 and COMPONENT1, and the repair levels for end item, component and module were ORG, DSU, and DEP respectively. This would mean that when the end item failed because MODULE1 failed in COMPONENT1, the end item should be repaired at the organizational level, COMPONENT1 should be repaired at the DSU, and MODULE1 should be repaired at the depot. If the component should be thrown away instead of repaired, no repair level will be listed for the module.

To avoid the deployment of an extra special test equipment/repairman which would be idle for most of the time, it may sometimes be advantageous to have two different maintenance policies for the same application. As an example, suppost that one special test equipment can handle almost all repair of a module at a DSU. Instead of buying a second piece of test equipment to handle all repair of the module, it may be better to ship a few modules to the GSU when the test equipment is unavailable at the DSU. It may even be better to throw away a few modules rather than buy an extra piece of special test equipment that is hardly ever needed. When the model suggests such a split maintenance policy, the number in the percent column will be the fraction of repairs performed according to the maintenance policy listed.

Certain approximations are made by the model when considering split maintenance policies. The approximations are not made in evaluating the costs for these policies, however. Although the approximations do not introduce a significant error, split maintenance policies suggested by the model should be examined by the user in his sensitivity analysis. A more detailed discussion of the approximations can be found in the theoretical documentation to the model. [2]

The column headed, "MODULE PROMOTED", will generally be blank. An asterisk in this column indicates that the module is considered as an LRU for this application and is included in the availability computation. A module is promoted if it is removed from a component at the same level as the end item is repaired and if the component has a washout rate of zero. If the promoted module is the only module in the component, the MTD and RTD for the component will be zero. The component will not be stocked since it never washes out and the end item is repaired by replacing the module. There is no reason to stock the component if the module is stocked and considered in the availability computation.

The washout rate, MTD and RTD for each component and module are listed after the maintenancne policies. The washout rate, which may be different from what was input, considers any throw away decisions made by the model. The entries for a component will be zero if all modules in the component have been promoted as described above. The entries for a module will be zero if it is only part of components which are not repaired.

4.2 SPECIAL TEST EQUIPMENT AND REPAIRMAN REQUIREMENTS

The special test equipment/repairman requirements are divided into two categories. The first consists of the requirements for equipment/repairman where they are peculiar. These equipment/repairmen are not currently located at these echelons. The requirements are given as whole numbers since fractions of an equipment or of a repairman cannot be deployed. Requirements for equipment/repairman where they are common, given next, can be fractional, however. These equipment/repairmen are already in use at the echelon. Additional equipment/repairmen may have to be deployed, but the quantity depends on what is currently done at the echelon. As an example, suppose a piece of special test equipment at a DSU is only used to fifty percent of its capacity. If the requirement for this equipment to support the new end item were 2.4 only two more need be deployed. Three more would have to be deployed if the requirement were 2.9.

4.3 LOGISTICS COSTS

The logistics cost section follows the test equipment/repairman section. These costs are not true "life cycle costs" as noted in paragraph 1.4. The spares costs are separated from other logistics costs. Initial spares costs are computed from the unit price (input) and the allowances per claimant. Consumption spares costs are given in terms of present value. These costs are the present value of the replacement spares that will be purchased over the operating life of the end item. All other logistics costs are also given in terms of present value over the operating life of the end item. Repair costs include the cost of technical documentation. When all of the modules in a component have been promoted to LRUs, the component is not stocked and there are no inventory costs. If a module is only part of components that are not repaired, no logistics costs are listed. Parts costs are listed with module logistics costs. These costs will be zero for modules that are not repaired. Back order costs are given for modules and parts. These are penalty costs charged when a module or part is out of stock. No back order costs are charged for components since component back orders are considered directly in the availability computation. Back order costs for modules which have been promoted reflect the fraction of time that the module is not considered as an LRU. A more detailed discussion of backorder costs is presented in the theoretical documentation of the model. [2]

The last section of output contains totals for all of the logistics costs. The operational availability achieved given the suggested maintenance policies and stockage is also listed in this section.

REFERENCES

1. Kaplan, Alan J., "Mathematics of SESAME Model," AMSAA Army Inventory Research Office, Philadelphia, February 1980.

2. Kaplan, Alan J. and Orr, Donald A., "The OATMEAL Model - Optimum Allocation of Test Equipment/Manpower Evaluated Against Logistics," AMSAA Army Inventory Research Office, Philadelphia, February 1983.

3. DARCOM Pamphlet 700-18, "User's Guide for the Selected Essential-Item Stockage for Availability Method (SESAME) Program," March 1980.

4. DoDI 7041.3, "Economic Analysis and Program Evaluation for Resource Management," October 1972.

5. "Generalized Electronics Maintenance Model (GEMM) for Integrated Logistic Support," CECOM, Fort Monmouth, NJ, June 1980.

APPENDIX A

Preprocessor Variable List

AVAIL(J) - availability of special test equipment or special repairman J

INPUT

DEFAULT: Test Equipment .65
Repairman .7

AVTAR - target availability

INPUT

CF - annual maintenance cost factor for special test equipment

INPUT

DEFAULT: .27

COSBIN - cost to maintain an item on the authorized stockage list (ASL)

INPUT

DEFAULT: 30.

See Present value

COSHOL - holding cost percentage

INPUT

DEFAULT: .03

See Present value

COSNSI - first year cataloging cost

INPUT

DEFAULT: 555.

COSNSN - present value of NSN cataloging costs

COMPUTED

$$COSNSN = COSNSI+COSNSR\ (PVF - \frac{1}{2} - \frac{1}{2(1.1)})$$

COSNSR - annual NSN cost in subsequent years

INPUT

DEFAULT: 138

COSREQ - cost per requisition

INPUT

DEFAULT: 20.20

See Present value

COSTD - total cost of technical documentation per page

INPUT

DEFAULT: 200.

COSTRA - transportation cost between echelons (per pound)

J = 1: Org - DSU, J = 2: DSU-GSU, J = 3: GSU - DEPOT

COMPUTED

CPM(J) * (DIST(J)

See Present value

CPM - transportation cost per lb-mile

J = 1: Org-DSU, J = 2: DSU-GSU, J = 3: GSU-DEPOT

INPUT

DEFAULTS:	Org-DSU	.01
	DSU-GSU	.00029
	GSU-DEPOT	.0003

CTDEL - contact team delay time

DSU-Org

INPUT

DIST(J) - distance between echelons (miles)

J = 1: Org-DSU, J = 2: DSU-GSU, J = 3: GSU-DEPOT

INPUT

DEFAULTS:	Org-DSU	7
	DSU-GSU	250
	GSU-DEPOT	3500

DOC(I) - cost of technical documentation for component/module I

COMPUTED

PAGE(I) * COSTD

DWK - days in workweek at echelon J

INPUT

DEFAULTS: Org 7

DSU 5

GSU 5

DEPOT 5

EID1, EID2 - end item identification

INPUT

EQCST(J,K) - present value of special test equipment/repairman J at echelon K

COMPUTED

Test Equipment: EVP + CF * EUP * PVF + ETC + REPCST

Repairman: (SAL * (1 + FL) + TRMOS/RTR) * PVF

EQPEC - highest echelon at which a special test equipment or repairman is peculiar

INPUT

DEFAULT: 4 (DEPOT)

EQPLA - lowest echelon at which a special test equipment or repairman is allowed

INPUT

DEFAULT: 1 (Org)

EQSTK (integer part) - list of equipments needed by component, module and application

COMPUTED

ERR - erroneous removal rate

INPUT

DEFAULT: .1

ETC - one time initial cost for special test equipment

INPUT

DEFAULT: 0

ETIME - time required for special repairman or test equipment for end item repair associated with specific component or component repair associated with specific applications

INPUT

EUP - special test equipment unit price

INPUT

FAIL - failure rate of a module in a particular component

INPUT: MTBF of module in component

COMPUTED: FAIL = OH/MTBF

i.e. failures per year

FL - salary loading factor for special repairman

INPUT

DEFAULTS: Military .682

Civilian .45

ID(I) - component or module identification

INPUT

IDL(L) - identification number of component in application L

COMPUTED

IDS(L) - identification number of module in application L

COMPUTED

IESS - essentiality code of component or module

INPUT

INDSTK(I) - end of equipment stack for component, module or application I

COMPUTED

IPOL(I) - policy indicator

IPOL(I) = 1 if policy I is allowed

INPUT

DEFAULT: 0 (policy not considered)

IREP - number of times a special test equipment must be purchased

COMPUTED

IRSC - retail stockage criterion

INPUT

IVSYS - SESAME supply support systems

V = vertical support

D = direct exchange

N = non-vertical support

INPUT

MAXEQ - maximum special test equipment/repairman identification number

COMPUTED

MCTBF - mean calendar time between failures of end item

COMPUTED

MCTBF = MTBF*365./OH

MIL - military/civilian indicator

1: military, 2: civilian

INPUT

DEFAULT: 0 - assumes military and prints warning message

MTBF - mean time between failures of end item (hours)

INPUT

MTR - mean time to repair (hours)

INPUT

DEFAULT: .25

MULT - indicates multiple cost cards for special repairman

INPUT

DEFAULT: 0 (one set of costs for all echelons)

NAPP - number of applications

COMPUTED

NEQ - number of special test equipments for a component or module

INPUT

DEFAULT = 0

NLE - test equipment life

COMPUTED

NLE = UL

NLET -

COMPUTED

NLET = NLE *IREP

NLIFE - end item life

COMPUTED

NLIFE = OLIFE

NLRU - number of components

COMPUTED

NNSN - new NSN indicator: 0 if component or module does not have an existing NSN. 1 if component or module has an existing NSN.

INPUT

DEFAULT: 0

NREP - number of special repairmen for a component or module

INPUT

DEFAULT: 0

NSPEC - indicators for special test equipment/repairmen to repair end item associated with specific components

INPUT

DEFAULT: 0

NSRU - number of modules

COMPUTED

NSTACK(I) - number of special test equipment/repairmen associated with component, module or application

INPUT

NSTKT - <u>temporary</u> number of equipments in STK5

INPUT: if NSPEC = 1

NSTK1 - number of special test equipments/repairmen to repair end-item

INPUT

DEFAULT: 0

NSTK2(I) - number of special test equipment/repairmen for component repair

COMPUTED: NEQ+NREP

NSTK3(I) - number of special test equipment/repairmen for module repair

COMPUTED: NEQ+NREP

NSTK4(I) - number of special test equipments/repairmen for component repair associated with specific module, application I

INPUT

DEFAULT: 0

NSTK5(I) - number of special test equipments/repairmen for end item repair associated with specific component I

COMPUTED: from NSTKT

OH - end item operating hours per year

INPUT

OLIFE - operating life (years) of end item

INPUT

OPSL - operating safety level

INPUT

ORGHR - number of hours an organization works in a year

COMPUTED

ORGHR = SHOURS (1) * DWK(1) * 52

OST(J) - order ship time (days) between echelons

J=1: ORG - DSU, J=2: DSU-GSU, J=3: GSU-DEPOT

J-4: Procurement Lead time

INPUT

PAGE - number of pages of technical documentation required for component or module repair

INPUT

PARTSP - average price of piece parts used in repair of a module

INPUT

See present value

PARTSR - number of parts requiring an NSN in a module

INPUT

PVF - present value factor for recurring costs

COMPUTED

$$PVF = \tfrac{1}{2} + \frac{1 - 1.1^{-(NLIFE-1)}}{.1} + \frac{1}{2(1.1)\ NLIFE}$$

RATL - common labor rates

See present value

INPUT - base rate per hour

DEFAULTS: ORG 6
DSU 9
GSU 17.25
DEPOT 17.25

COMPUTE: loaded rate

ORG, DSU RATL= RATL*1.682
GSU, DEPOT RATL=RATL*1.45

REPC(I,J) - common labor cost to repair component or module I at level J

COMPUTED
TMTR*RATL(J)

See present value

REPCST - special test replacement equipment cost

COMPUTED:

$$(1.1^{-(NLET-1)} + 1.1^{-NLET}) /2*EUP$$

RTR - turnover period for special repairmen (year)

INPUT

DEFAULTS: Military 2.5
Civilian 5.0

SAL - annual salary of special repairmen

INPUT

SHOURS(J) - hours in a workday at echelon J

INPUT

DEFAULTS:

ORG	16
DSU	12
GSU	8
DEPOT	8

STK1 - list of special test equipments/repairmen to repair end item

INPUT

STK2 - list of special test equipments/repairmen to repair components (added to application with that component)

STK3 - list of special test equipments/repairmen to repair modules

INPUT

STK4 - list of special test equipment/repairmen for applications

INPUT

STK5 - list of special test equipments/repairmen for end item repair that are associated with specific component failure

INPUT

TAT - The average elapsed time from turn in of a failed item at the maintenance unit until that item is repaired and ready for use.

INPUT for modules

INPUT by application

COMPUTED for components from application data

TEQSTK - fractional part of EQSTK

reciprocal of number of repair actions which can be performed by a special test equipment/repairman in one year

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COMPUTED:

(1) End item repair
MTR/(ORGHR*AVAIL)

(2) End item repair associated with specific component ETIME/(ORGHR*AVAIL)

(3) Component repair
TMTR (of component)/(ORGHR*AVAIL)

(4) Module repair
TMTR (module)/(ORGHR*AVAIL)

(5) Application (repair component with specific module) ETIME/(ORGHR*AVAIL)

TMTR - common repairman time (hours) for component or module repair

INPUT

TRAT(J) - ratio of operating hours at

J=1; ORG, J=2: DSU, J=3 GSU, J=4: DEPOT

to operating hours at ORG

COMPUTED:

TRAT(J) = SHOURS(J)*DWK(J)*52./ORGHR

TRMOS - training cost for special repairman

INPUT

DEFAULT: 0 prints error message

UL - special test equipment useful life (years)

INPUT

DEFAULT: OLIFE

UP - unit price of component or module

INPUT

See present value

UPEI - end item cost

INPUT

WASH - washout rate of component or module

INPUT

WGT = weight of component or module

INPUT

APPENDIX B

Present Value Formulation

Present value of recurring costs is computed using a 10% discount rate as per DoDI 7041.3

$$PVF = \tfrac{1}{2} + \frac{1 - 1.1^{-(LIFE-1)}}{.1} + \frac{1}{2(1.1)^{LIFE}}$$

Variables Which Consider Present Value

$$COSNSN = COSNSI + COSNSR\left(PVF - \tfrac{1}{2} - \frac{1}{2(1.1)}\right)$$

COSBIN = COSBIN*PVF + COSBINI

COSREQ = COSREQ*PVF

RATL = RATL*PVF

EQCST = EUP+CF*EUP*PVF+ETC+REPCST (equipment)

= (SAL*(1.+FL)+TRMOS/RTR)*PVF (repairmen)

COSTRA = COSTRA*PVF

Pipeline Stock

UP = UP + COSHOL*UP*PVF

PARTSP = PARTSP + COSHOL*PARTSP*PVF

Replenishment Stock

UP = UP*PVF

PARTSP = PARTSP*PVF

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APPENDIX C

Definitions of Input Variables

1. End Item Card

End Item Price: The unit purchase price of one end item.

Operating Life: The expected number of years the end item is to be supported. This variable is used to compare one-time costs with annual recurring costs.*

Operating Hours/Year: The number of hours that the end item operates in one year. This value is used to convert mean time between failure data into failures per year.*

Mean Time Between Failures (MTBF): The MTBF of the end item. This value is used in the computation of operational availability.

Mean Time to Repair End Item: The average time it takes for end item repair. Include in this variable the time required to transport the end item to the organization or the time it takes organizational personnel to travel to the user. This time is used in the computation of operational availability.

Availability Target: The desired operational availability of the end item.*

Erroneous Removal Rate: The percent of removals of operational items. All failure rates are increased by this percentage to reflect the burden placed on the maintenance and supply system by the removal of operational components and modules.

Number of Equipment/Repairman Types for end Item Repair: This variable tells the preprocessor how many equipments/repairmen identification numbers to look for on the next card. These are equipments/repairmen needed to repair the end item whenever it fails as described in paragraph 1.3a.

Indicator (1) for Equipment/Repairmen as Described in Para 1.3b: This is only an indicator variable. If it is equal to one (1), the preprocesor expects equipment/repairmen as described in paragraph 1.3b to be input. If it is equal to zero, no equipment/repairmen needed to repair the end item when specific component failures are expected.

MTBF Multiplier: All MTBFs, including the end item, are multiplied by this factor. This variable is used in performing sensitivity analyses.

2. Equipment/Repairmen to Repair end Item Whenever It Fails

This card contains a list of the identification numbers of equipment/repairmen that are needed to repair the end item whenever it fails. This card is included only if the variable in CC 62 of the end item card is non-zero.

3. Equipment/Repairmen to Repair End Item When Specific Components Fail

Component Identification: The four character alphanumeric identification of the component whose failure necessitates the use of a special equipment or repairmen to repair the end item.

Number of Equipment/Repairmen Associated with This Component: How many equipment/repairmen types are required to repair the end item when this specific component fails. This variable tells the preprocessor how many equipment/repairmen identification numbers to look for on the next card.

Time Needed: The length of time each particular test equipment/repairman will be needed when the specific component fails.

4. Deployment Information Card

Retail Stockage Criterion: The number of demands per year that must be experienced by a retail stock point to qualify for stockage of a spare of that part. It is usually six per year for all items except aircraft, missile systems, and ammunition which all require three. This number is the basis of SIP stock.*

SESAME Support System Indicator: The supply support system that is used by SESAME in computing stockage levels. Under a vertical system (V), the GSU performs a normal supply mission. Under a non-vertical system (N), the GSU performs a maintenance function and stocks only those items removed and replaced at the GSU in quantities necessary to provide shop stock. If an item is repaired by a GSU it is assumed that the item is being repaired for a DSU on a job order basis, and that it is returned immediately. The repair time is considered in computing DSU stock. Under a direct exchange system (D), the GSU is permitted to stock only those items which are repaired at the GSU. These items are stocked if the number of issues at the GSU equals or exceeds the stockage criterion.*

Claimants: The number of maintenance/supply shops at each echelon which support the end item in the field.*

Density: The total number of end items which are fielded.*

Order Ship Time: The time between the initiation of a stock replenishment action and the receipt of the material by the requesting activity.*

Procurement Lead Time: The time it takes for the wholesaler to procure spares from the manufacturer.*

Contact Team Delay Time: The time it takes for a DSU contact team to travel to the organization or for the end item to be evacuated to the DSU for repair and returned to the user. In either case, repair is considered as being performed by the DSU. Do not include actual repair time in this variable since it will be added automatically. The contact team delay time is added to the end item downtime whenever the end item is repaired by the DSU.*

Operating Level: The number of days worth of stock intended to sustain normal operation during the interval between receipt of replenishment shipment and submission of a subsequent replenishment requisition.*

5. Policy Selector Card: The GEMM policies that are to be considered are indicated on this card. In the current version of the model only policies 1 through 25 should be considered.

6. Echelon Parameters Card

Shift Hours Per Day: The number of hours per day that an echelon is open for maintenance.*

Days in Workweek: The number of days per week that a maintenance echelon operates.*

Common Labor Rate: The unloaded hourly labor rate for a common repairman. The salary is loaded by the model at a rate of 45% for Depot and GSU (civilian loading rate) and 68.2% for DSU and organization (military loading rate).*

Distance between Echelons: The average one way distance between echelons.*

Transportation Cost Per Pound/Mile: The cost of shipping one pound one mile between echelons.*

7. Cost Parameters Card

First Year Cataloging Cost: The initial cost to obtain an NSN for a new item entering the inventory system.*

Subsequent Years Cataloging Cost: The annual cost of maintaining the new NSN in the inventory system.*

Annual Cost to Maintain an Item in ASL: The annual administrative cost of stocking an item at an echelon.*

Inventory Holding Cost Percentage: Annual inventory holding costs are computed as a percentage of the dollar value of stock. This percentage is multiplied by the pipeline stockage to give inventory holding costs.*

Cost per Requisition: The cost to process a requisition. It is assumed that every demand for an item results in a requisition. There is a limit, however, of twelve requisitions per item per year.*

Cost of Technical Documentation per Page: The cost of one page of technical documentation needed for repair of a component or module. The resulting documentation cost is incurred only if the item is repaired.

One Time Cost to Add a Line to ASL: The initial cost of adding a line to an authorized stockage list (ASL).*

8. Special Test Equipment Card

Equipment Identification Number: A number between 1 and 30 which identifies the test equipment.

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Equipment Price: The per unit purchase price of a piece of test equipment. The amount of test equipment required will be determined by the model. Research and development costs should not be included in this figure.

Useful Life: The expected life of the test equipment. If this life is less than the end item life, the test equipment will be replaced when it wears out. No salvage value is considered.(* only if common)

Annual Maintenance Cost Factor: This percentage will be multiplied by the test equipment purchase price to yield the annual cost to maintain the test equipment. Test equipment maintenance costs are treated in this simple manner to limit the input data required to run the model.(* only if common)

Other One-Time Initial Costs Any other one-time, per unit cost such as installation associated with a piece of test equipment.(* only if common)

Availability: The percent of time that a piece of test equipment is available for use. If an organization operates 2080 hours per year and the test equipment availability is .80, then the equipment has 2080 x .80 = 1664 available test hours.*

Highest Echelon at Which Peculiar: This variable tells the model where a test equipment is common and peculiar. An entry of 2 means the equipment is peculiar at Org and DSU and common at GSU and Depot. In the current model, a test equipment must at least be peculiar at the organizational level. Integer requirements are computed for test equipment where it is peculiar. The requirements for a test equipment where it is common can be fractional.*

Lowest Echelon at Which Can Be Placed: The lowest echelon at which the test equipment will be authorized. An entry of 2, for example, means that the equipment is not allowed at the organizational level.*

9. Special Repairman Data

Identification Number: A number between 1 and 30 which identifies the repairman. A special repairman and a special test equipment cannot have the same identification number.

Military/Civilian Indicator: A variable used to indicate whether a special repairman is military or civilian. Military and civilian repairmen have different default values for salary loading factor and turnover rate.

Annual Salary: The base (unloaded) salary of the repairman.*

Salary Loading Factor: This percentage is used to load the annual salary of the special repairman with benefits, overhead, etc.*

Training Cost per Man: The cost of training each special repairman.*

Turnover: The average length of time a special repairman stays at the same maintenance location. After this period of time a new repairman must be trained.*

Availability: The percent of time this special repairman is available. If the organization operates 2080 hours per year and the special repairman availability is .80, than the repairman is available 2080 x .80 = 1664 hours per year.*

Highest Level at Which Peculiar: Same as for test equipment.*

Lowest Echelon at Which Can Be Placed: Same as for test equipment.*

10. Component Data

Component Identification: The four character alphanumeric identification of the component. This identifies the component for use in the preprocessor. Each component must have a unique identifier.

Component Name: Any ten character name to identify the component for the user.

Component Price: The price that one expects to pay for spare components.

Weight: The packaged shipping weight of the component.

Essentiality Code: A component coded 1, 5, or 7 is essential to the operation of the end item. A component coded 3, 6 or blank is not essential and is not considered in the availability computation.

Washout Rate: The percent of failures that are non-reparable because of physical damage, loss, etc.

Repairman Time: The amount of hands-on repairman time (common or special) required to repair the components. Component repair consists of isolation to and removal and replacement of a faulty module. This time is also used to compute test equipment requirements. It is assumed that a piece of test equipment is required for the entire time the repairman is working on the component.

Number of Pages of Technical Documentation: The number of pages of technical documentation that must be purchased if the component is repaired. Test Program Set (TPS) development cost can be considered in this variable. If the TPS costs $100,000 and the cost of technical documentation is $200 per page, the number of pages entered would be 500 plus the number of pages in the technical manual devoted to repair of the component. This cost is incurred only if the component is repaired.

New NSN Indicator: This variable should be set to one (1) if the component has an existing NSN. If it is zero, no NSN exists and the cost of acquiring one is incurred.

Number (Quantity) of Special Test Equipment Types, Number (Quantity) of Special Repairmen Types: The sum of these two variables tells the preprocessor how many special test equipment/repairmen identification numbers to look for on the next data card.

11. Pseudo Component Data

Pseudo Component Identification, Pseudo Component Name: Same as for component.

Price of Parts Consumed Per Average Repair Action: An average repair action of a pseudo component results in the replacement of some parts. The price of the parts used in an average repair action is to be entered here.

Weight of Parts Consumed Per Average Repair Action: The weight of the parts replaced in an average repair action.

Essentiality Code: Same as for component.

Total Number of Parts: The total number of parts that have been grouped together to form a pseudo component.

Number of Parts Needing a New NSN: The number of parts described above which do not have an existing NSN.

Mean Time Between Faiures (MTBF) for a Representative Part: The average mean time between failures, $MTBF_{av}$, for n parts is computed as follows:

$$\frac{1}{MTBF_{av}} = \frac{1}{n}\left(\frac{1}{MTBF_1} + \frac{1}{MTBF_2} + \cdots + \frac{1}{MTBF_n}\right)$$

The number of failures of an average part is computed from $MTBF_{av}$ and the end item operating hours. The failures are multiplied by the total number of parts in the main program to yield the number of failures of the pseudo component.

12. Module Data

Identification, Name, Price, Weight, Essentiality Code, Washout, Repairman Time, Pages of Technical Documentation, New NSN Indicator, Number of Special Test Equipment Types, Number of Special Repairman Types: Same as for components.

Average Time to Repair Module Including Waiting Time NOT Including Shipping Time: The average elapsed time from the arrival of a failed module at the maintenance echelon where it is to be repaired until the module is repaired and ready for use. This time includes waiting time, processing time, and actual repair time. It does not include shipping time.*

Number of Piece Parts in Module Which Need a New NSN: If the module is repaired, the cost of obtaining NSNs for the new repair parts will be added. It will not be added if the module is thrown away.

Average Price of Piece Parts per Repair Action: A module repair action results in the replacement of piece parts. The cost of the parts used in an average repair action is entered here. This amount will be charged for each module repair action.

13. Pseudo Module Data

All pseudo module data is the same as pseudo component data. The MTBF for a representative part is, however, entered on the application card.

14. Application Data

Component Identification: The four character alphanumeric identification of the component.

Module Identification: The four character alphanumeric identification of the module. An application consists of a component and module pair.

Mean Time Betwen Failure (MTBF) of the Module in the Component: The MTBF of the module is entered here. If the module is part of several components, the MTBF must be entered separately for each application. Multiple occurences of a module in the same component should be entered as one application with the MTBFs combined. The number of failures of the module in each component will be computed by the model and added to obtain the total number module failures. In the case of a pseudo module, the MTBF of a representative part, which is computed in the same way as described above for a pseudo component, is entered here.

Average Time to Fault Isolate to Module and Repair Component, etc.: The average elapsed time from the arrival of the failed component at the maintenance echelon until the component is repaired and ready for use. This time includes waiting time, processing time, time to fault isolate to the module, and time to remove and replace the faulty module. It does NOT include shipping time.*

Number (Quantity) of Special Equipment and Repairman Types: This variable tells the preprocessor how many test equipment/repairman identification numbers and repair times to read from the next data card.

Equipment/Repairman Identification Number: The identification number(s) of the test equipment/repairman necessary to repair the component when the particular module fails.

Time Required: The length of time each particular test equipment/repairman is needed when this module fails in this component.

Note: Possible government furnished data indicated by an asterisk (*)