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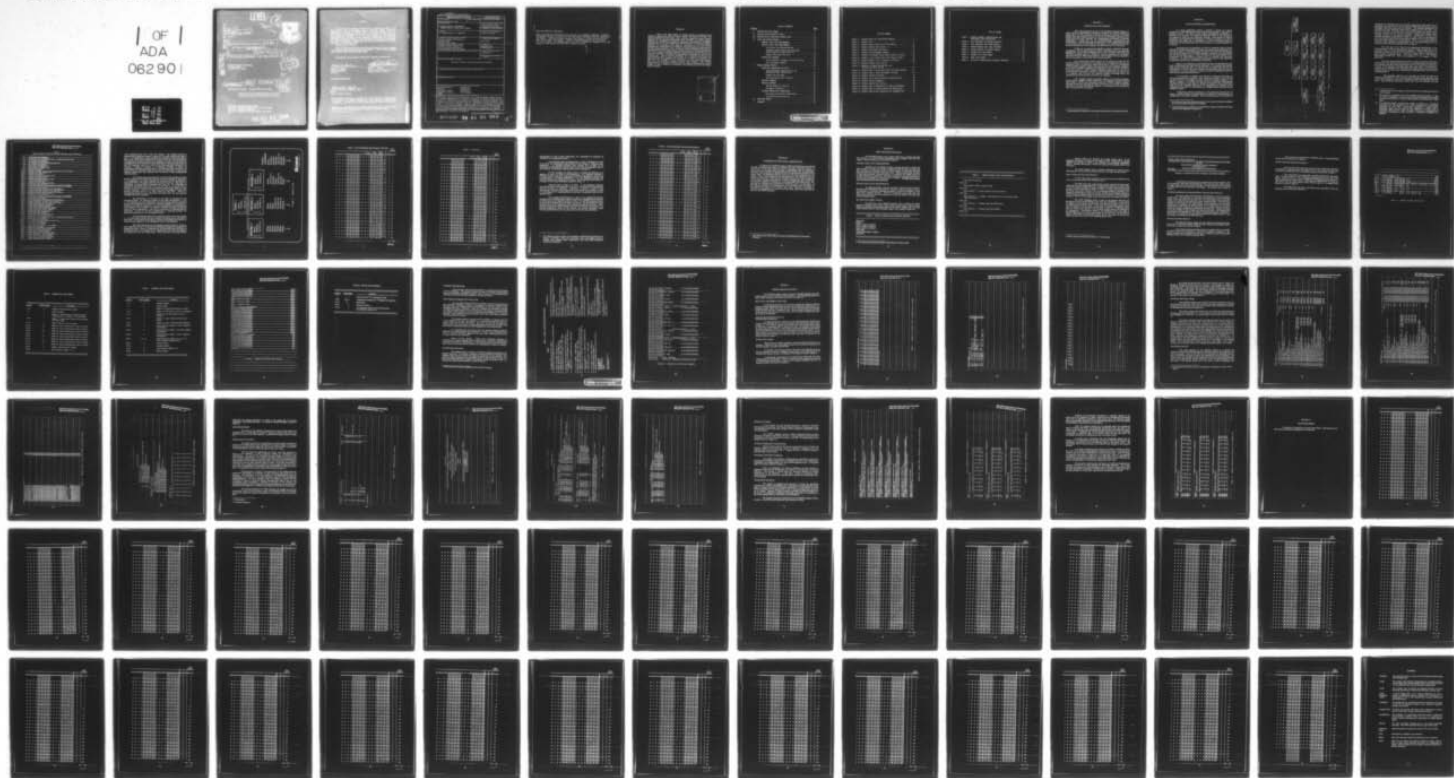
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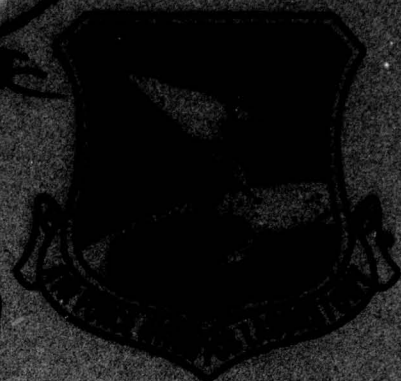
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PART III

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KA-BAND RELIABILITY IMPROVEMENT, Part III.
User's Manual for TASA/DEKIND Program



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report contains details instructions for using the DEPEND computer program to evaluate dependability, availability, reliability and other performance parameters for avionics and other systems and subsystems on aerospace vehicles. The program is run as the evaluation step in a comprehensive system performance analysis. In this manual, extensive computer experience is not assumed, but the user should have a basic knowledge of computer usage, and a technical understanding of the functional relationships among components of the system to be analyzed, and the effect on system, subsystem, and functional assembly perfor- (Continued)		

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mance resulting from malfunctions and failures of the system components. Complete information is given for setting up the input data, obtaining a run and interpreting the results. Figures defining the punch card formats for input data are provided that can be used as data sheets. Examples illustrating the use of the program are also included. The DEPEND program is written in FORTRAN IV language for the CDC Cyber 70, 6000 Series and 7000 Series computer systems.

PREFACE

This is the Final Report on studies related to Ka-Band System Reliability Improvement under Air Force Contract No. F33615-75-C-1208. The report is organized in three parts. Part I, Volume I, depicts the system model as organized in its functional relationship form; describes the overall program; presents the probabilistic estimates of reliability, maintainability, availability, dependability, etc. of the Ka-Band SATCOM Set based on all the data available; identifies the components most likely to malfunction or fail; and presents guidelines for the specification of reliability and maintainability requirements for the next generation system. Part I, Volume II, contains Appendix B which presents detailed results of the Tabular System Analysis (TASA) of the Ka-Band SATCOM Set. Part I, Volume III contains Appendix C which presents detailed results of the numerical reliability, availability and dependability predictions for the Ka-Band SATCOM Set. Part II contains guidelines for an Integrated Reliability and Maintainability (R/M) Program Plan intended as a model for the specific R/M plans that will be required for the procurement of future generation systems. Part III is the DEPEND Computer Program User's Manual. The DEPEND (Determination of Equipment Performance and Expected Nonoperational Delay) program is used to perform the arithmetic and documentation for the Tabular System Analysis.

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SECTION I

INTRODUCTION AND SUMMARY

This manual describes the use of the **DEPEND*** computer program to obtain values for dependability, availability, reliability and related performance parameters for all the assemblies of a system's functional hierarchy. The model utilized with this program provides for the use of alternative malfunction and failure definitions and calculates the corresponding probabilities of assembly malfunction or failure; that is, the undependabilities, unavailabilities and unreliabilities. The **DEPEND** program keeps track of all the organizational details of the model as well as performing the arithmetic. The mathematical basis and historical development of this technique are described in Part I of this report.

Except for two subroutines, **DEPEND** is coded in FORTRAN Extended 4.6 language. The two subroutines are coded in **COMPASS** which is the assembly language for Control Data Corporation (CDC) Cyber 70 Series, 6000 Series and 7000 Series computer systems. **DEPEND** is currently operational on the Wright-Patterson AFB CDC 6600 computer system. Some adaptation will be required to operate the program on other than CDC computer systems.

The mathematical models, details of the analysis methods and the results obtained in an analysis of an airborne EHF communications terminal are presented in Part I of this 3-part final project report. Part II is an integrated Reliability/Maintainability Program Plan that uses the **TASA/DEPEND** methodology as a tool for program visibility and management control. This part, Part III, of the project report is a User's Manual, containing instructions for use of the **TASA/DEPEND** methodology. Extensive computer experience is not required, but it is assumed that the user has detailed technical knowledge about the organization and functioning of the system to be analyzed.

The complete analysis procedure consists of the three processes, Tabular System Analysis (**TASA**), acquisition of the required functional element data (**MTBF** or **MTTR**) and computation using the **DEPEND** computer program. Although the primary concern of this part of the report is to provide the detailed instructions for using the **DEPEND** program, it is necessary to also discuss the other two processes of the analysis.

* Determination of Equipment Performance and Expected Nonoperational Delay.

SECTION II

TABULAR SYSTEM ANALYSIS (TASA)

It is usual engineering practice to describe a system as a nested organization of interdependent and interacting devices operating to accomplish a specified function. To assess overall system dependability, availability, or reliability, it is necessary to consider the individual "ilities" of the components and subsystems which are the constituent elements. This assessment requires considering the consequences of malfunctions or failures occurring in the various subsystems, both singly and in combination, in terms of functional states of components and other assemblies that can be defined in an overall description of the system.

The initial step in an application of TASA is to develop a chart or charts showing the functional hierarchy of the elements, assemblies and subsystems that make up the system. The partitioning of the system into functional assemblies is not critical with respect to the DEPEND program. However, it is recommended that the partitioning be done in a way that simplifies the determination of the consequences of malfunctions or failures; that is, simplifies the functional complexity. Otherwise, the consequence determination step of TASA (which will be described later) becomes unnecessarily complicated.

Figure 1 is an example of a functional hierarchy that describes the upper levels of the airborne Ka-Band SATCOM Terminal*. The Ka-Band Terminal has three primary functional links, the forward link, the report-back link and the conference link. Part of the system elements are functionally common to two or more links**. It is also necessary to consider the system initialization (start-up) function and the primary power source.

It is important to recognize that function is distributed across time as well as across hardware components. This is illustrated in Figure 1 by noting that the three links of the Ka-Band Terminal operate for different lengths of time during a mission. To simplify the logic as well as facilitate computations, functional blocks have been added to express the transition from one functional cycle of use of a specific assembly to the transmission or reception of one message and ultimately the total numbers of messages transmitted and received during the mission.

Concurrently with the development of the functional hierarchy for the system, mutually exclusive functional states are defined for each assembly and subassembly in the system hierarchy. Thus, the functional state of the system is

* The numbers in the lower left hand corners of the functional blocks are assigned for use as identifiers throughout the analysis.

** Functionally common means that a malfunction or failure will cause more than one link to be degraded or inoperative.

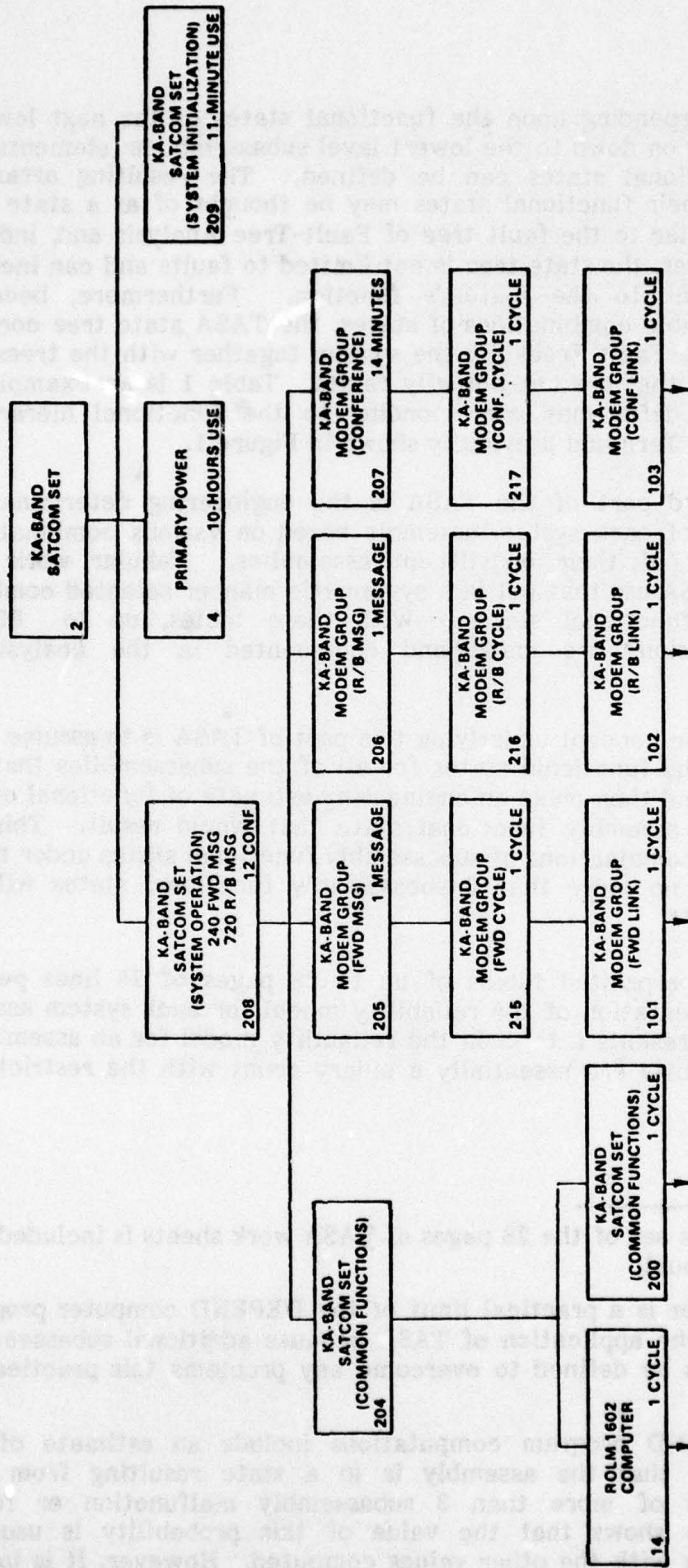


FIGURE 1. KA-Band Satcom Set Functional Diagram

represented as depending upon the functional states of the next lower level of assemblies and so on down to the lowest level subassemblies (elements) for which meaningful functional states can be defined. The resulting arrangement of assemblies and their functional states may be thought of as a state tree. This state tree is similar to the fault tree of Fault-Tree Analysis and, indeed, that is its origin. However, the state tree is not limited to faults and can include almost anything pertinent to the system's function. Furthermore, because TASA considers all possible combinations of states, the TASA state tree corresponds to all of the possible Fault Trees for the system together with the trees associated with other states that are not actually faults. Table 1 is an example listing of functional state definitions corresponding to the functional hierarchy of the airborne Ka-Band Terminal previously shown in Figure 1.

The third part of the TASA is the engineering determination of the functional state of each system assembly based on various combinations of the functional states of their constituent assemblies. Tabular work sheets are provided* for TASA use that list in a systematic manner selected combinations of input assembly functional states. With these tables, up to 697 separate engineering decisions are made and documented in the analysis of each assembly**.

The basic concept underlying this part of TASA is to assume a particular combination of the functional states for all of the subassemblies that make up a given assembly and then make an engineering estimate of functional consequences in terms of the assembly functional state that would result. This process is repeated for all combinations of subassembly functional states under the practical constraints that no more than 3 subassembly functional states will be varied simultaneously.***

The preprinted tables of up to 28 pages of 25 lines per page are a shorthand representation of the reliability model for each system assembly. Each line (or row) represents a term in the reliability model for an assembly functional state. These tables are essentially a binary count with the restriction that only

-
- * A complete set of the 28 pages of TASA work sheets is included as Section VI of this manual.
 - ** This number is a practical limit of the DEPEND computer program. It does not limit the application of TASA because additional subassembly groupings can always be defined to overcome any problems this practical limit might cause.
 - *** The DEPEND program computations include an estimate of a "residual" probability that the assembly is in a state resulting from simultaneous occurrence of more than 3 subassembly malfunction or failure states. Experience shows that the value of this probability is usually small in comparison with the other values computed. However, it is incorporated in subsequent calculations so that its effect is considered throughout the analysis.

TABLE 1
EXAMPLE ASSEMBLY IDENTIFICATIONS AND FUNCTIONAL STATE DEFINITIONS

2.0	KA-BAND SATCOM SET (SUMMARY)
2.1	ALL KA-BAND LINKS INOPERATIVE
2.2	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
2.3	ALL KA-BAND LINKS DEGRADED
2.4	TWO KA-BAND LINKS INOPERATIVE
2.5	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
2.6	TWO KA-BAND LINKS DEGRADED
2.7	ONE KA-BAND LINK INOPERATIVE
2.8	ONE KA-BAND LINK DEGRADED
4.0	SATCOM TERMINAL (PRIMARY POWER)
4.1	PRIMARY POWER FAILURE
14.0	ROM 1682 COMPUTER
14.1	CPU STOP; NO UPLINK, PRINTER AND CRT EXCEPT FWD. LINK OR CINCPAC
101.0	KA-BAND MODEM GROUP (FORWARD LINK)
101.1	INOPERATIVE FORWARD LINK
101.2	DEGRADED FORWARD LINK
102.0	KA-BAND MODEM GROUP (REPORT-BACK LINK)
102.1	INOPERATIVE REPORT-BACK LINK
102.2	DEGRADED REPORT-BACK LINK
103.0	KA-BAND MODEM GROUP (CONFERENCE LINK)
103.1	INOPERATIVE CONFERENCE LINK
103.2	DEGRADED CONFERENCE LINK
200.0	KA-BAND SATCOM SET (COMMON FUNCTIONS)
200.1	ALL KA-BAND LINKS INOPERATIVE
200.2	FORWARD AND CONFERENCE LINKS INOPERATIVE AND R/B LINK DEGRADED
200.3	R/B AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED
200.4	ALL KA-BAND LINKS DEGRADED
200.5	KA-BAND FORWARD AND CONFERENCE LINKS INOPERATIVE
200.6	KA-BAND REPORT-BACK AND CONFERENCE LINKS INOPERATIVE
200.7	KA-BAND FORWARD AND CONFERENCE LINKS DEGRADED
200.8	KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED
204.0	KA-BAND SATCOM SET (COMMON FUNCTIONS)
204.1	ALL KA-BAND LINKS INOPERATIVE
204.2	FORWARD AND CONFERENCE LINKS INOPERATIVE AND R/B LINK DEGRADED
204.3	R/B AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED
204.4	ALL KA-BAND LINKS DEGRADED
204.5	KA-BAND FORWARD AND CONFERENCE LINKS INOPERATIVE
204.6	KA-BAND REPORT-BACK AND CONFERENCE LINKS INOPERATIVE
204.7	KA-BAND FORWARD AND CONFERENCE LINKS DEGRADED
204.8	KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED
205.0	KA-BAND MODEM GROUP (FORWARD MESSAGE)
205.1	KA-BAND FORWARD MESSAGE INOPERATIVE
205.2	KA-BAND FORWARD MESSAGE DEGRADED
206.0	KA-BAND MODEM GROUP (REPORT-BACK MESSAGE)
206.1	KA-BAND REPORT-BACK MESSAGE INOPERATIVE
206.2	KA-BAND REPORT-BACK MESSAGE DEGRADED
207.0	KA-BAND MODEM GROUP (CONFERENCE)
207.1	KA-BAND CONFERENCE INOPERATIVE
207.2	KA-BAND CONFERENCE DEGRADED
208.0	KA-BAND SATCOM SET (SYSTEM OPERATION)
208.1	ALL KA-BAND LINKS INOPERATIVE
208.2	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
208.3	ALL KA-BAND LINKS DEGRADED
208.4	TWO KA-BAND LINKS INOPERATIVE
208.5	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
208.6	TWO KA-BAND LINKS DEGRADED
208.7	ONE KA-BAND LINK INOPERATIVE
208.8	ONE KA-BAND LINK DEGRADED
209.0	KA-BAND SATCOM SET (SYSTEM INITIALIZATION)
209.1	UNABLE TO START SYSTEM
209.2	ALTERNATE INITIALIZATION MODE REQUIRED
215.0	KA-BAND MODEM GROUP (FORWARD CYCLE)
215.1	KA-BAND FORWARD CYCLE INOPERATIVE
215.2	KA-BAND FORWARD CYCLE DEGRADED
216.0	KA-BAND MODEM GROUP (REPORT-BACK CYCLE)
216.1	KA-BAND REPORT-BACK CYCLE INOPERATIVE
216.2	KA-BAND REPORT-BACK CYCLE DEGRADED
217.0	KA-BAND MODEM GROUP (CONFERENCE CYCLE)
217.1	KA-BAND CONFERENCE CYCLE INOPERATIVE
217.2	KA-BAND CONFERENCE CYCLE DEGRADED

rows containing three "1's" or less are included. The analysis proceeds by assigning input subassembly states to columns of the table working from right to left. A "1" appearing in a column signifies the occurrence of the malfunction or failure state of the input subassembly or element which that column represents. The engineering analysis proceeds by determining for each row of the table the consequences of the combination of input malfunction or failure states denoted by the "1's" appearing in that row in terms of the functional states defined for the assembly. During this analysis it is frequently necessary to assign the consequential assembly functional state for simultaneous input malfunction and failure states on a dominance basis; that is, one input malfunction or failure state produces consequences that dominate over the effect of other simultaneously occurring states.

At the basic level, each column of the TASA table represents an input element malfunction or failure state that has a known probability of occurrence. A "1" appearing in this column signifies the occurrence of that malfunction or failure state while a "0" signifies that the state has not occurred. Thus, there is a "probability of nonoccurrence" associated with each "0". By multiplying the probabilities associated with each of the "1's" and "0's" in a row, one term is obtained of the "ility" equation for the assembly function state assigned to that row by the analyst. The sum of the terms for all rows assigned to a particular assembly functional state is an "ility" model for that state. There is a corresponding model for each malfunction and failure state for each assembly throughout the system hierarchy.

The performance of this part of the TASA is illustrated by the following example. Let Assembly 4 consists of functional subassemblies 1, 2 and 3. The Assembly, and each subassembly, has three mutually exclusive functional states; normal, degraded and inoperative. Whenever Subassembly 1 is inoperative, Assembly 4 will also be inoperative. However, Subassembly 2 and Subassembly 3 are redundant so that Assembly 4 will continue to operate (although in a degraded mode) as long as Subassembly 1 and either of the other two subassemblies are operational. If none of the three subassemblies is operating normally, the assembly is considered to be in the inoperative state.

The functional hierarchy for this example is shown at the top of Figure 2. For this simple example, the list of possible functional states is included in each block. At the bottom of the figure, a number of the possible combinations of states are listed together with the consequence state for the assembly.

The TASA Work Sheet for this example is shown in Table 2. First note that consequence state "9" is reserved for identifying impossible combinations of subassembly states. Since it is required that the functional state definitions be mutually exclusive, it is impossible for one subassembly to be in both the degraded (not failed) state and the failed state. When the TASA work sheet directs

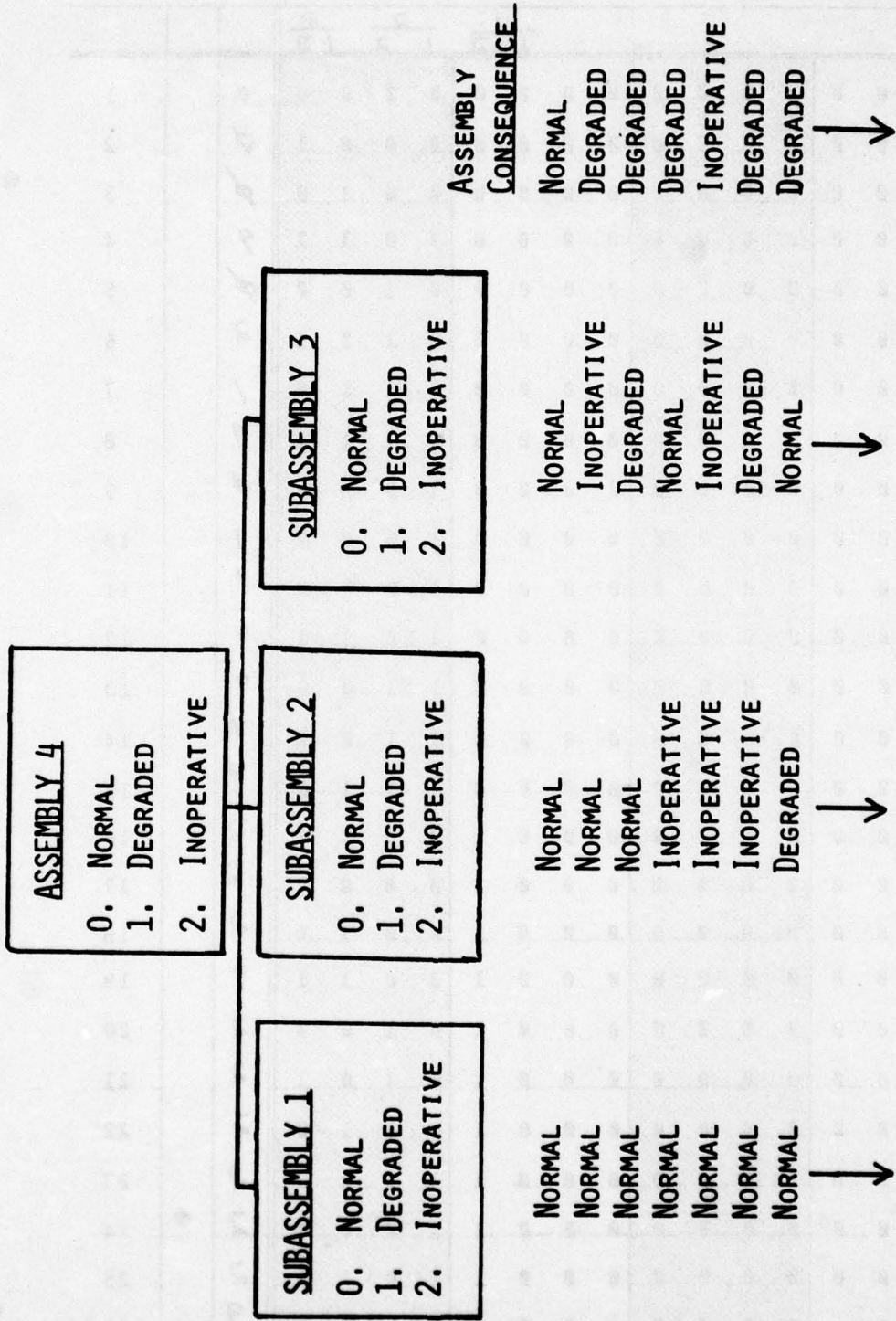


FIGURE 2. EXAMPLE TASA

TABLE 2. TASA WORKSHEET FOR EXAMPLE ANALYSIS

Card
Column

				$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$			
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0		1
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0		2
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 1 0	0		3
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 1 1	9		4
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 1 0 0	0		5
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 1 0 1	2		6
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 1 1 0	1		7
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 1 1 1	9		8
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 0 0 0	0		9
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 0 0 1	1		10
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 0 1 0	1		11
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 0 1 1	9		12
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 1 0 0	9		13
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 1 0 1	9		14
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 1 1 0	9		15
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0 0 0 0	2		16
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0 0 0 1	2		17
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0 0 1 0	2		18
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0 0 1 1	9		19
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0 1 0 0	2		20
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0 1 0 1	2		21
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0 1 1 0	2		22
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	1 0 0 0	2		23
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	1 0 0 1	2		24
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	1 0 1 0	2		25
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	1 1 0 0	9		26

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TABLE 2. (Continued)

												Card Column
				$\frac{1}{1\ 2}$	$\frac{2}{1\ 2}$	$\frac{3}{1\ 2}$						
0 0 0 0	0 0 0 0	0 0 1 0	0 0 0 0	1								1
0 0 0 0	0 0 1 0	0 0 0 0	0 0 0 0	1								2
0 0 0 0	0 0 1 0	0 0 0 0	0 0 1 0	1								3
0 0 0 0	0 0 1 0	0 0 0 0	0 0 1 0	1								4
0 0 0 0	0 0 1 0	0 0 0 0	0 0 1 1	9								5
0 0 0 0	0 0 1 0	0 0 0 0	0 0 1 0	1								6
0 0 0 0	0 0 1 0	0 0 0 0	0 0 1 1	2								7
0 0 0 0	0 0 1 0	0 0 0 0	0 0 1 1	2								8
0 0 0 0	0 0 1 0	0 0 0 0	0 0 0 0	1								9
0 0 0 0	0 0 1 0	0 0 0 0	0 0 0 1	2								10
0 0 0 0	0 0 1 0	0 0 0 0	0 0 1 0	2								11
0 0 0 0	0 0 1 0	0 0 0 0	0 0 1 0	9								12
0 0 0 0	0 0 1 1	0 0 0 0	0 0 0 0	9								13
0 0 0 0	0 0 1 1	0 0 0 0	0 0 0 1	9								14
0 0 0 0	0 0 1 1	0 0 0 0	0 0 1 0	9								15
0 0 0 0	0 0 1 1	0 0 0 0	0 0 1 0	9								16
0 0 0 0	0 0 1 1	0 0 0 0	0 0 0 0	9								17
0 0 0 0	0 1 0 0	0 0 0 0	0 0 0 0									18
0 0 0 0	0 1 0 0	0 0 0 0	0 0 0 1									19
0 0 0 0	0 1 0 0	0 0 0 0	0 0 1 0									20
0 0 0 0	0 1 0 0	0 0 0 0	0 0 1 1									21
0 0 0 0	0 1 0 0	0 0 0 0	0 0 1 0									22
0 0 0 0	0 1 0 0	0 0 0 0	0 0 1 1									23
0 0 0 0	0 1 0 0	0 0 0 0	0 0 1 1									24
0 0 0 0	0 1 0 0	0 0 0 0	0 0 0 0									25
0 0 0 0	0 1 0 0	0 0 0 0	0 0 0 1									26

consideration of such a state combination, the impossibility is indicated by entering "9" as a consequence state*.

The inoperative state of Subassembly 1 is seen to dominate the state of the other two subassemblies (card columns 16-26 of page 1). However, when Subassembly 1 is operating normally, (card columns 1-15 of page 1), the redundancy of Subassemblies 2 and 3 is seen in that only the inoperative state of both results in an inoperative assembly (card column 6 of page 1).

For this example, the analyst chose to consider the assembly to be degraded if there is a fault in any subassembly. In a different example, a different definition might have been used for assembly degradation so that as long as Subassembly 1 and either Subassembly 2 or 3 are operating normally, the assembly operation is considered to be normal. This would affect card columns 2-9 of page 1 of the TASA Work Sheet as shown in Table 3.

Referring back to Page 2 of Table 2, the inoperative assembly consequence shown in card columns 7, 8, 10 and 11 is the result of the requirement that the assembly be considered inoperative if there is a fault in each subassembly. Removal of this requirement would permit card columns 8, 10 and 11 to be changed to "1" indicating that in these cases the assembly would be in the degraded state.

The complete documentation of each of the engineering decisions pertaining to the consequences of a given combination of subassembly malfunction or failure states is an important benefit of TASA. The DEPEND program provides for an optional reproduction of the TASA work sheets. This documentation makes detailed review of the analysis by other engineering personnel practical. This is particularly beneficial where problems have been detected by the analysis. The detailed engineering review of the analysis can provide significant insight concerning possible causes of the problem and potential technical solutions.

* The DEPEND program checks for "impossible" combinations and corrects the analyst if necessary. When such corrections occur, the analysis should be checked since possible state combinations may have been incorrectly declared as impossible.

TABLE 3. TASA WORKSHEET FOR SECOND EXAMPLE

												Card Column	
				<u>1</u>	<u>2</u>	<u>3</u>							
				<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>		
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	0	1
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	2
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	3
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	4
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	5
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	6
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	7
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	8
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	9
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	10
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	11
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	12
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	13
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	14
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	15
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	16
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	17
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	18
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	19
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	20
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	21
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	22
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	23
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	24
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	25
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	26

74 - 78

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SECTION III
ACQUISITION OF FUNCTIONAL ELEMENT DATA

To operate the DEPEND program, MTBF and MTTR data are required for each malfunction and failure state defined for each functional element* of the system. In the early stages of system development, when the emphasis is placed on "ility" prediction, the procedures of MIL-HDBK-217B and MIL-HDBK-472 can be used to predict the MTBF and MTTR for each element malfunction and failure state. The resulting DEPEND outputs are the "ility" predictions for the system. Where actual experience data are available for the functional elements, these data can be used. In this case the DEPEND outputs are an "ility" assessment of the system. Bayesian combinations of predicted, experience and test data can also be used to generate a practical set of element MTBF and MTTR values. One procedure for making such combinations is described in Part 1 of this report. In any case, the credibility and interpretation of the analysis results will depend on the validity and choice of the element data used. Thus, it is necessary to document and substantiate the source of element MTBF and MTTR values used as input for the DEPEND program.

* Note that element refers only to the lowest functional block of the system hierarchy.

SECTION IV

USING THE DEPEND PROGRAM

The DEPEND program runs in batch mode from a punched card deck that consists of a control record, relocatable binary program, and four data records. The card deck structure is shown in Table 4.

GENERAL INPUT DATA REQUIREMENTS

Operation of the DEPEND program requires the user to supply four types of data: (1) output control data, (2) assembly identifications and functional state definitions, (3) element MTBF and MTTR values, (4) functional operation data, structure data and fault consequence data. Specific requirements for input of these data are given in the next section. As a general rule, integer data must be right justified in its card field. Fixed point numbers may be placed anywhere in the data field providing the decimal point is included. Floating point numbers must be right justified in their card field.

SPECIFIC INPUT DATA REQUIREMENTS

As stated previously, the input card deck consists of five records in addition to the relocatable binary program. Initially it will be necessary to obtain the assistance of computer operating personnel to compile the program on the user's CDC computer system*. After the relocatable binary deck has been obtained and verified with a check program, the user can assemble the input card deck as described below.

Job Control and Program Records

The operation of the DEPEND computer code to perform the TASA calculation requires a job control record similar to that shown in Table 5 which utilizes a relocatable binary program deck via the INPUT. program call. The copy utility routines are then used to transfer results to the computer output file.

TABLE 5. TYPICAL DEPEND JOB CONTROL RECORD

JOBCARD.
INPUT.
COPY, TAPE 9, OUTPUT.
COPY, TAPE 8, OUTPUT.
COPY, TAPE 1, OUTPUT.
(789.) EOR
Relocatable Binary Program
(789) EOR

* The FORTRAN Extended Compiler (FTN) Version 4 should be used.

TABLE 4. DEPEND PROGRAM INPUT DECK STRUCTURE

[Job Control Record]
(789) EOR

[Relocatable Binary Program Deck]
(789) EOR

[Data Record 1 -- Output Control Card and Title]
(789) EOR

[Data Record 2 -- Assembly Identification and Functional State
Identification]
(789) EOR

[Data Record 3 -- Element MTBF and MTRR Data]
(789) EOR

[Data Record 4 -- System Functional Model]
(6789) EOJ

Several options are available by deleting control cards. If the paragraph summaries of results* are not desired, TAPE 1 should not be printed. Deleting the printing of TAPE 9 will eliminate the percentage contribution tables*. Deleting the printing of TAPE 8 will eliminate the analysis tables* from the output.

The binary program deck is inserted following the control record. Following this, the four data records are inserted in the order described below.

Output Control and Title (Data Record 1)

The first data record consists of an output control card followed by up to five title cards and ends with a (789) EOR card.

The first card of this record (output control card) contains four logical values and the ATTR Weighting Factor all separated by commas. A .TRUE. value of the first logical variable will cause a listing of the state identifications to be printed. If the second logical variable is .TRUE., a listing of the element MTBF and MTTR values and a listing of the corresponding reliability/unreliability and availability/unavailability values are printed. Setting the third logical variable to .TRUE. causes the analysis tables to be recorded on TAPE 8. If the fourth logical variable is .TRUE. the percentage contribution tables will be recorded on TAPE 9.

The ATTR Weighting Factor is used by the program whenever the calculations involve states including more than one malfunction. In such cases, the largest of the pertinent restore times is extended by a portion of the sum of the other pertinent restore times. If the value of the Weighting Factor is zero, only the longest of the pertinent restore times is utilized. A Weighting Factor value of 1.0 will cause the sum of the pertinent restore times to be employed in the calculations. Intermediate values of the Weighting Factor will cause a corresponding portion of the summed restore times to be used. The first card of Figure 3 illustrates the control card format for the case where all outputs are required and the value of the ATTR Weighting Factor is 0.8.

* These outputs are described in Section V of this manual.

.TRUE.,.TRUE.,.TRUE.,.TRUE.,0.8
DEPENDABILITY/RELIABILITY/AVAILABILITY/MAINTAINABILITY ANALYSIS
OF THE
ADM SATCOM COMMUNICATIONS TERMINAL
PREPARED FOR
THE AIR FORCE AVIONICS LABORATORY

(789) EOR

FIGURE 3. EXAMPLE OUTPUT CONTROL AND TITLE RECORD

Following the control card, up to 5 cards may be used to provide a title for the analysis. Each card is an 80-character line of the title that will be printed starting in column 22 of the output title page. If fewer than five cards are used, the (789) EOR card will control the title length. An example title is shown in Figure 3.

Assembly Identification and Functional State Definition (Data Record 2)

The second data record consists of identifications of all the elements, subassemblies and assemblies in the system and definitions of their functional states. The cards may be in any order but it is recommended that the numeric sequence be retained within cards for a given functional block. The first three columns of each card are the identification number assigned for the element, subassembly or assembly; the fourth column is a decimal point and the fifth column is the state number in the range from 0 to 8. State number 0 is used to denote the element, subassembly and assembly identifications. Columns 6 through 10 are not utilized by the computer and may be left blank. The alphanumeric identification corresponding to the numeric identification appears in columns 11 through 80. An example of this data record was shown previously in Table 1. This data record is terminated by a (789) EOR card.

Element Data (Data Record 3)

The third data record contains the input data for the analysis elements in the form of MTBF and MTTR values for each malfunction and failure state. The format of these data is listed in Table 6.

If the number of element states (column 5) is greater than 4, the MTBF and MTTR values are continued on a second card starting in column 16. The element number must be repeated on this card in columns 1-3 and 76-78 and the sequence number 02 is punched in columns 79-80.

Data Record 3 is terminated by a (789) EOR card. An example listing of this data record is shown in Figure 4.

System Functional Model (Data Record 4)

Data record 4 must contain an entry for each nonelemental assembly in the system. Each such entry will consist of two or more cards. The first card describes the characteristics of the assembly using the format listed in Table 7.

The model data for the assembly is entered starting with the second card. This data consists of the consequence assignments from the TASA Work Sheets. There may be up to 697 such assignments depending upon the number of input malfunction or failure states. These data are entered with 25 values per card (26 for the first card) using the format shown in Table 8. An example Data Record 4 is shown in Figure 5.

The (6789) EOJ, end-of-job, card follows the model data for the last assembly and terminates Data Record 4.

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4	1	136000	1.155E+03	1.0						401
14	1	4.2	5.177E+02	1.0						1401
101	2	1 4.2	881.924	0.914	2599.41	0.977				10101
102	2	1 4.2	1020.74	0.504	551.015	1.				10201
103	2	1 4.2	1390.09	0.503	593.092	0.986				10301
108	8	1 4.2	539.761	0.504678487000	0.903	48347.9	0.516	1871.11	0.50410801	
108			500.023	0.503	12541.3	0.5	1128.01	1.965	10401.7	0.5
209	2	1660	59.3306	0.83513219.2	0.5					20901
40	2	1 4.2	832.215	1.75	20150.	2.0				4001
31	1	1 4.2	1647.67	1.						3101
32	2	1 4.2	1927.42	2.17	13790.1	0.5				3201
33	1	1 4.2	726.08	0.76						3301
34	3	1 4.2	3028.02	1.	3226.4	0.92	1567.99	0.5		3401
35	3	1 4.2	1065.64	3.	362.95	3.42	2555.0	2.0		3501

(789) EOR

Figure 4. Example Element Data Record

TABLE 6. ELEMENT DATA CARD FORMAT

Column	Field Length	Contents
1-3	3	Element identification number
4	1	Must be blank
5	1	Number of malfunction or failure states value must be in range 0 to 8 inclusive
6-10	5	Number of functional cycles of use during the time, TUSE
11-15	5	TUSE = time of use in seconds
16-25	10	MTBF for first malfunction state in hours
26-30	5	MTTR for first malfunction state in hours
31-40	10	MTBF for second malfunction state in hours
41-45	5	MTTR for second malfunction state in hours
46-55	10	MTBF for third malfunction state in hours
56-60	5	MTTR for third malfunction state in hours
61-70	10	MTBF for fourth malfunction state in hours
71-75	5	MTTR for fourth malfunction state in hours
76-78	3	Element identification number
79-80	2	Card sequence number = 01

TABLE 7. ASSEMBLY DATA CARD FORMAT

<u>Column</u>	<u>Field Length</u>	<u>Contents</u>
1-3	3	Assembly Number
4	1	Blank Column
5	1	Number of malfunction/failure states
6-10	5	Number of functional cycles for assembly
11-15	5	Length of one functional cycle in seconds
16-17	2	Number of input malfunction/failure states
18-19	2	Number of input elements/subassemblies
20-22	3	Identification number of first element/subassembly
23-25	3	Identification number of second element/subassembly
26-28	3	Identification number of next element/subassembly
29-67	13 x 3	Identification numbers of up to 13 more elements/subassemblies
68-73	5	Blank columns
74-76	3	Assembly Number
77-78	2	Card Sequence Number = 01
79-80	2	Blank columns

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204 8 5928 4.2 9 2 14200	20401
08796999599999949999999999	20402
*399999999999999299999999	20403
*99999999999999919999999999	20404
*99999999999999911191991	20405
*9991999919999919999991999	20406
*9999	20407
205 2 240 21.0 2 1215	20501
0219	20502
206 2 720 12.6 2 1216	20601
0219	20602
207 2 12898.8 2 1217	20701
0219	20702
208 8 13600014 4204225206207	20801
08798659754999906596325229	20802
*7549522421999999665966555	20803
*593323222229665933222292	20804
*653255422999999944494444	20805
*449222221111999999999999	20806
*59994449222211194442144421	20807
*999999999999999999999999	20808
*332933222293323222229999	20809
*999999999999999999999999	20810
*999999922292222292222111	20811
*119999999999999999999999	20812
*999999959999999999999922	20813
*292221119222212222199999	20814
*999999999999999999999999	20815
*999999999999999999999999	20816
*991119111119111111111199	20817
*999999999999999999999999	20818
*999999999999999999999999	20819
*999999999999999999999999	20820
062 8 13600011 3 4209208	201
08796999599999949999999999	202
*399999999999999299999999	203
*99999999999999919999999999	204
*9999999999999999999933293992	205
*9992999939999929999991999	206
*9999111919919991999919999	207
*91999999199999999999999999	208
*1119199199919999199999199	209
*99991999999911111111111111	210
*111119	211

Figure 5. Example Tasa Model Data Record

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TABLE 8. MODEL DATA FORMAT

<u>Column</u>	<u>Field length</u>	<u>Contents</u>
1	1	0 on first card, "*" on subsequent cards
2-26	25 x 1	Consequence assignments - (Integers 0-9, inclusive)
27-73	47	Blank field
74-76	3	Assembly number
77-78	2	Card sequence number -02 for first card up to a maximum value of 29

RUNNING THE PROGRAM

After the input card deck is assembled, it is entered into the computer via the card reader. The program performs an audit of the input data and issues data error diagnostic messages as required. Also, a summary of run performance is entered into the DAYFILE record printed at the end of the run.

Error Diagnostic Messages and Location Aids

The data audit routines check for a number of common data errors and issue diagnostic messages as required. The program will attempt to examine all of the data input even though errors are encountered so that the number of data debugging iterations is minimized. Table 9 is a listing of the diagnostic messages that may be issued together with an interpretation of meaning. In several cases, the program makes checks of its stored data and issues diagnostics if errors are detected. These diagnostics should not appear and if they do the help of computer operating personnel is needed.

The computer system will issue a FATAL ERROR - ILLEGAL DATA IN FIELD diagnostic and abort the program if it encounters non-numeric data in a numeric field of the input card decks. This error will also be encountered in certain cases when the number of model (consequence) cards does not agree with the number of subassembly/element states designated on the structure card.

It is essential that the format rules for the data cards be followed. Otherwise the results obtained will be incorrect. A Mode 2 error **"*ERROR DATA INPUT * DATA OVERFLOW*** diagnostic may result when a floating point entry is not right justified in the card field.

When a FATAL ERROR - INDEX KEY UNKNOWN diagnostic is encountered, the usual meaning is that an assembly has referenced a subassembly or element for which no identification or state definition data have been entered. Thus, either the structure card is incorrect or a subassembly or element is missing.

Run Performance Summary

The program prints a number of DAYFILE messages pertaining to the program operation. In particular, messages are printed giving the starting time*, finishing time* and time used* for important subroutines in the program. The number of passes required by the scheduling routines is also reported. In case of a fatal error these data help to indicate the progress through the program code. An example Run Performance Summary is shown in Figure 6.

* These times are in terms of elapsed central processor seconds.

TABLE 9. LISTING OF DEPEND ERROR DIAGNOSTIC MESSAGES

Message

DATA ERRORS DETECTED nnnn ANALYSIS ABORTED
 *** INSUFFICIENT DATA FOR ELEMENT NBR nnn WHICH HAS nn FUNCTIONAL STATES
 *** MISSING ID FOR ELEMENT STATE NBR nnn.n
 *** MISSING IDENTIFICATION FOR ASSEMBLY NBR nnn
 *** ASSEMBLY NBR nnn IS AN ELEMENT - ENTRY IGNORED
 *** EXPECTED SEQUENCE NBR nnn BUT READ nnn - ENTRY IGNORED
 *** UNEXPECTED EOF WHILE READING DATA FOR ASSEMBLY NBR nnn
 *** MAX STATE NBR IS nn FOR SUBASSEMBLY nnn BUT ONLY COUNTED nn IN ASSEMBLY nnn
 *** ASSEMBLY nnn HAS nn SUBASSEMBLY STATES BUT nn WERE COUNTED
 *** nnn IS NOT AN ELEMENT - TRANSFER ABORTED
 *** DUPLICATE ASSEMBLY NUMBER nnn - ENTRY IGNORED
 *** ASSEMBLY nnn USES SUBASSEMBLY nnn FOR WHICH NO DATA WERE ENTERED
 *** SUBASSEMBLY nnn HAS nn STATES BUT nn ARE SPECIFIED FOR ASSEMBLY nnn
 *** UNABLE TO SCHEDULE RUN - nnn ASSEMBLIES ARE UNSCHEDULED AFTER nnn TRIES
 *** ILLEGAL NOS VALUE (nnnnn) - ENTRY IGNORED
 *** STORAGE ERROR - READ nnn WHEN I EXPECTED nnn
 *** STATE IDENTIFICATION NOT RECORDED ***
 *** EXPECTED ID FOR ELEMENT STATE nnn.n BUT READ ID FOR nnn.n
 MISSION TRUNCATED
 FOR ASSEMBLY nnn
 SUBASSEMBLY nnn
 MAXIMUM CYCLES nnn
 CORRECT
 INDEX ERROR FOR ASSY nnn
 ANALYSIS ABORTED

Interpretation

Computations are not possible because of data errors
 The number of states required by an assembly conflicts with the number given for the element
 Missing Identification
 Missing Identification
 Duplicate usage of numerical identification
 Cards missing or out of sequence. Cards will be dumped until start of next sequence.
 Missing model data
 Conflict between number of states defined for a subassembly and that needed by the assembly which uses it
 Either an error in the number of subassembly states on the structure card or in the number of states defined for one of the subassemblies
 Inconsistent use of numerical identifications
 Duplicate usage of numerical identification
 Missing Data
 Conflict between number of states defined for a subassembly and that needed by the assembly which uses it
 Missing elements/subassemblies
 The number of output states (assembly states) must be in the range from 0 to 8.
 Computer system error
 Missing state definition
 Missing state definition or out of sequence
 The number of cycles specified for the subassembly times its use time is greater than the assembly use time. A correction in number of cycles is made.
 The consequence of this impossible state combination has been corrected to "9".
 Computer system error

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09.21.26.START READID	4.71199999999998
09.21.26.E+000	
09.21.37.FINISHED READID	7.19199999999997
09.21.37.E+000	
09.21.37.READID TIME	2.47999999999998
09.21.37.E+000	
09.21.37.START ELMTS	7.19699999999997
09.21.37.E+000	
09.21.39.FINISHED ELMTS	7.43599999999997
09.21.39.E+000	
09.21.39.ELMTS TIME	2.39000000000004 E-001
09.21.41.START ADATA	7.72099999999997
09.21.41.E+000	
09.21.41.FINISHED ADATA	8.61799999999999
09.21.41.E+000	
09.21.41.ADATA TIME	8.96399999999991
09.21.41.E-001	
09.21.49.BEGIN SKEDUL	8.63399999999995
09.21.49.E+000	
09.21.58.FINISHED TRY 1	8.98299999999994
09.21.58.E+000	
09.21.58.TIME FOR TRY 1 =	3.48999999999998
09.21.58.E-001	
09.21.58.TRY=	3.500000000000250 E-002
09.22.00.FINISHED SKEDUL	9.15399999999999
09.22.00.E+000	
09.22.00.SKEDUL TIME=	5.200000000000038
09.22.00.E-001	
09.22.00.BEGIN XSUB	9.15799999999995 E+000
09.22.29.FINISHED XSUB	9.83799999999996
09.22.29.E+000	
09.22.29.XSUB TIME IS	6.800000000000006
09.22.29.E-001	
09.22.29.BEGIN ANALIZE	9.83999999999997
09.22.29.E+000	
09.23.15.FINISHED ANALIZE	3.34299999999997
09.23.15.E+001	
09.23.16.ANALIZE TOOK	2.35699999999996
09.23.16.E+001	
09.23.16. END DEPEND	
09.23.16. 28.746 CP SECONDS EXECUTION TIME	

Figure 6. Example Run Performance Summary

SECTION V

DEPEND PROGRAM OUTPUTS

The DEPEND program outputs a number of listings relating to the audit of input data as well as the results of the calculation. The following descriptions of these outputs are given in the order they occur in a typical run.

INPUT DATA PROCESSING AND AUDIT

As discussed previously, the input data required for using the DEPEND program includes identifications for the elements and assemblies, definitions of the functional states, MTBF and MTTR data for all the elements, and the functional model structure and state consequence data. Several output listings are provided to document the data used in the run and to aid in the audit or correction of the input data when necessary.

Assembly/Element Identification and Functional State Definitions

As noted previously in Section IV, the assembly/element identification is input as the definition for the normal functional state and has the numeric label ending in .0. The DEPEND program output offers an optional alphanumeric listing of these data in ascending order of the numeric label. An example of this listing was shown previously in Table 1. This listing is obtained by setting the first field of the output control card to .TRUE. and is eliminated if this field is .FALSE. In any case, a sorted list is printed of the numeric labels of all the assembly or element identifications and functional state definitions that were read. An example of this output is shown in Figure 7.

Element Data Listings

Several types of outputs relating to the element data are printed by the computer. These are: input card images, numerical list of elements processed, and optional listings of processed element data.

To provide a record of the element data used in the DEPEND run and to aid the correction of errors or changing of input data, a card image listing of the element data record is printed. An example of this output is shown in Figure 8.

A numerically ordered list of the elements for which data have been read is printed by the computer. This list is useful for cross checking the structure of the functional model and as a record of the elements included in the run. An example of such a list is shown in Figure 9.

LAST OF ASSEMBLY STATES FOR WHICH JOBS WERE READ

2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0
15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0
18.0	18.1	18.2	18.3	18.4	18.5	18.6	18.7	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0
21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.1	23.2	23.3	23.4	23.5	23.6	23.7	23.8	23.9	24.0
25.0	25.1	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.9	26.0	26.1	26.2	26.3	26.4	26.5	26.6	26.7	26.8	26.9	27.0	27.1	27.2	27.3	27.4	27.5	27.6	27.7	27.8	27.9	28.0
28.0	28.1	28.2	28.3	28.4	28.5	28.6	28.7	28.8	28.9	29.0	29.1	29.2	29.3	29.4	29.5	29.6	29.7	29.8	29.9	30.0	30.1	30.2	30.3	30.4	30.5	30.6	30.7	30.8	30.9	31.0
31.0	31.1	31.2	31.3	31.4	31.5	31.6	31.7	31.8	31.9	32.0	32.1	32.2	32.3	32.4	32.5	32.6	32.7	32.8	32.9	33.0	33.1	33.2	33.3	33.4	33.5	33.6	33.7	33.8	33.9	34.0
35.0	35.1	35.2	35.3	35.4	35.5	35.6	35.7	35.8	35.9	36.0	36.1	36.2	36.3	36.4	36.5	36.6	36.7	36.8	36.9	37.0	37.1	37.2	37.3	37.4	37.5	37.6	37.7	37.8	37.9	38.0
39.0	39.1	39.2	39.3	39.4	39.5	39.6	39.7	39.8	39.9	40.0	40.1	40.2	40.3	40.4	40.5	40.6	40.7	40.8	40.9	41.0	41.1	41.2	41.3	41.4	41.5	41.6	41.7	41.8	41.9	42.0
43.0	43.1	43.2	43.3	43.4	43.5	43.6	43.7	43.8	43.9	44.0	44.1	44.2	44.3	44.4	44.5	44.6	44.7	44.8	44.9	45.0	45.1	45.2	45.3	45.4	45.5	45.6	45.7	45.8	45.9	46.0
47.0	47.1	47.2	47.3	47.4	47.5	47.6	47.7	47.8	47.9	48.0	48.1	48.2	48.3	48.4	48.5	48.6	48.7	48.8	48.9	49.0	49.1	49.2	49.3	49.4	49.5	49.6	49.7	49.8	49.9	50.0
51.0	51.1	51.2	51.3	51.4	51.5	51.6	51.7	51.8	51.9	52.0	52.1	52.2	52.3	52.4	52.5	52.6	52.7	52.8	52.9	53.0	53.1	53.2	53.3	53.4	53.5	53.6	53.7	53.8	53.9	54.0
55.0	55.1	55.2	55.3	55.4	55.5	55.6	55.7	55.8	55.9	56.0	56.1	56.2	56.3	56.4	56.5	56.6	56.7	56.8	56.9	57.0	57.1	57.2	57.3	57.4	57.5	57.6	57.7	57.8	57.9	58.0
59.0	59.1	59.2	59.3	59.4	59.5	59.6	59.7	59.8	59.9	60.0	60.1	60.2	60.3	60.4	60.5	60.6	60.7	60.8	60.9	61.0	61.1	61.2	61.3	61.4	61.5	61.6	61.7	61.8	61.9	62.0
63.0	63.1	63.2	63.3	63.4	63.5	63.6	63.7	63.8	63.9	64.0	64.1	64.2	64.3	64.4	64.5	64.6	64.7	64.8	64.9	65.0	65.1	65.2	65.3	65.4	65.5	65.6	65.7	65.8	65.9	66.0
67.0	67.1	67.2	67.3	67.4	67.5	67.6	67.7	67.8	67.9	68.0	68.1	68.2	68.3	68.4	68.5	68.6	68.7	68.8	68.9	69.0	69.1	69.2	69.3	69.4	69.5	69.6	69.7	69.8	69.9	70.0
71.0	71.1	71.2	71.3	71.4	71.5	71.6	71.7	71.8	71.9	72.0	72.1	72.2	72.3	72.4	72.5	72.6	72.7	72.8	72.9	73.0	73.1	73.2	73.3	73.4	73.5	73.6	73.7	73.8	73.9	74.0
75.0	75.1	75.2	75.3	75.4	75.5	75.6	75.7	75.8	75.9	76.0	76.1	76.2	76.3	76.4	76.5	76.6	76.7	76.8	76.9	77.0	77.1	77.2	77.3	77.4	77.5	77.6	77.7	77.8	77.9	78.0
79.0	79.1	79.2	79.3	79.4	79.5	79.6	79.7	79.8	79.9	80.0	80.1	80.2	80.3	80.4	80.5	80.6	80.7	80.8	80.9	81.0	81.1	81.2	81.3	81.4	81.5	81.6	81.7	81.8	81.9	82.0
83.0	83.1	83.2	83.3	83.4	83.5	83.6	83.7	83.8	83.9	84.0	84.1	84.2	84.3	84.4	84.5	84.6	84.7	84.8	84.9	85.0	85.1	85.2	85.3	85.4	85.5	85.6	85.7	85.8	85.9	86.0
87.0	87.1	87.2	87.3	87.4	87.5	87.6	87.7	87.8	87.9	88.0	88.1	88.2	88.3	88.4	88.5	88.6	88.7	88.8	88.9	89.0	89.1	89.2	89.3	89.4	89.5	89.6	89.7	89.8	89.9	90.0
91.0	91.1	91.2	91.3	91.4	91.5	91.6	91.7	91.8	91.9	92.0	92.1	92.2	92.3	92.4	92.5	92.6	92.7	92.8	92.9	93.0	93.1	93.2	93.3	93.4	93.5	93.6	93.7	93.8	93.9	94.0
95.0	95.1	95.2	95.3	95.4	95.5	95.6	95.7	95.8	95.9	96.0	96.1	96.2	96.3	96.4	96.5	96.6	96.7	96.8	96.9	97.0	97.1	97.2	97.3	97.4	97.5	97.6	97.7	97.8	97.9	98.0
99.0	99.1	99.2	99.3	99.4	99.5	99.6	99.7	99.8	99.9	100.0	100.1	100.2	100.3	100.4	100.5	100.6	100.7	100.8	100.9	101.0	101.1	101.2	101.3	101.4	101.5	101.6	101.7	101.8	101.9	102.0

Figure 7. Example of Assembly State Identification Listing

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LIST OF ELEMENTS

6 13 16 21 22 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000

Figure 9. Example Numeric List of Elements Processed

By setting the second field of the output control card to .TRUE. two listings of processed element data are obtained. Both listings are ordered by increasing numeric label and include the element identifications and functional state definitions. Also included are the data for number of functional cycles and use time per functional cycle. The first listing documents the MTBF and MTTR values. An example of this listing is shown in Figure 10. The second listing shows the calculated values of reliability and availability based on these data.* An example of this output is shown in Figure 11 .

Functional Model Data Listings

The DEPEND program output includes two types of listings to document the functional model data. These are a listing of input card images and an optional listing that reproduces the TASA work sheet format to show the details of the state combinations and consequence assignments.

The listing of input card images from the model input deck documents the data used for the DEPEND run. It is a primary means of tracking down errors and debugging the model data. An example page of this listing is shown in Figure 12.

The system functional model is actually documented in the TASA work sheets. Setting the third field of the output control card to .TRUE. causes the computer to reproduce the TASA data in tabular form on a file named TAPE 8. Copying TAPE 8 to output provides a printed record of the TASA including the identification of the elements, subassemblies and assemblies and the consequences determined for each combination of element/subassembly states for each assembly. As a general rule, once the model has been debugged and a finalized copy of this listing obtained the listing will not be printed for runs made with updated element data. However, this listing does provide a comprehensive documentation of the model structure and consequence assignments used for the DEPEND run. An example page of this State Assignment Listing is shown in Figure 13. Note that the listing for just this one assembly continues for 4 more pages of the computer output. The total listing for a system of any size is quite large. A title page is provided for the listing so that it is an independent documentation of the model.

ANALYSIS SCHEDULE

The actual operation of the DEPEND program is to perform the computations for each functional assembly separately once all the necessary input data are available. Prior to the start of any computations a scheduling routine is used to determine the order in which the computations will be performed. This routine prints the resultant analysis schedule showing the elements/subassemblies used by each assembly and the next assemblies to use the results obtained. Since the order of the printed results are in the order in which computations are

* The mathematical model used for the calculation is discussed in Part I of the report.

ELEMENT DATA LABEL IDENTIFICATION	CYCLES	USE SFC	WBF.MHS	WTR.MHS
4.0 SATCOM TERMINAL (PRIMARY POWER)	1	136000.000		
4.1 PRIMARY POWER FAILURE			.11558E+04	1.00
14.0 POLM 1602 COMPUTER	1	4.200		
14.1 CPU STOP NO UP LINK, PRINTER AND CRT EXCEPT FWD. LINK OK SINCE			.5177E+03	1.00
31.0 COMMUNICATIONS TERMINAL POWER AND CONFERENCE LINKS INOPERATIVE	1	4.200		
31.1 COMMUNICATIONS TERMINAL POWER FAILURE			.16977E+04	1.00
32.0 HEAT EXCHANGING	1	4.200		
32.1 NO HEAT EXCHANGING			.19274E+04	2.17
32.2 DEGRADED HEAT EXCHANGING			.13798E+05	.50
33.0 FREQUENCY GENERATION	1	4.200		
33.1 NO/INCORRECT FREQUENCY GENERATION			.72608E+03	.76
34.0 KA-BAND RECEPTION	1	4.200		
34.1 AUTO-TRACK RECEIVER FAILURE			.30208E+04	1.00
34.2 NO KA-BAND RECEPTION			.32264E+04	.92
34.3 DEGRADED KA-BAND RECEPTION			.15688E+04	.50
35.0 KA-BAND TRANSMISSION	1	4.200		
35.1 DEGRADED RF POWER OUTPUT (50 WATTS MAX)			.18656E+04	2.00
35.2 INSUFFICIENT RF POWER OUTPUT (LESS THAN 100 MW)			.36295E+03	3.62
35.3 NO/INCORRECT DOPPLER CORRECTION			.25558E+04	2.00
40.0 ANTENNA CONTROL GROUP (KA-BAND)	1	4.200		
40.1 NO KA-BAND TRANSMISSION AND RECEPTION			.03228E+03	1.75
40.2 DEGRADED KA-BAND TRANSMISSION AND RECEPTION			.28158E+05	2.00
101.0 KA-BAND MODEM GROUP (FORWARD LINK)	1	4.200		
101.1 INOPERATIVE FORWARD LINK			.00192E+03	.91
101.2 DEGRADED FORWARD LINK			.25996E+06	.00
102.0 KA-BAND MODEM GROUP (REPORT-BACK LINK)	1	4.200		
102.1 INOPERATIVE REPORT-BACK LINK			.10207E+04	.50
102.2 DEGRADED REPORT-BACK LINK			.55102E+03	1.00
103.0 KA-BAND MODEM GROUP (CONFERENCE LINK)	1	4.200		
103.1 INOPERATIVE CONFERENCE LINK			.13981E+04	.50
103.2 DEGRADED CONFERENCE LINK			.59309E+03	.99
104.0 KA-BAND MODEM GROUP (COMMON FUNCTIONS)	1	4.200		
104.1 ALL KA-BAND LINKS INOPERATIVE			.53976E+03	.50
104.2 FORWARD AND CONFERENCE LINKS INOPERATIVE AND W/B LINK DEGRADED			.87049E+02	.30
104.3 W/B AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED			.60368E+05	.52
104.4 ALL KA-BAND LINKS DEGRADED			.10711E+04	.50
104.5 KA-BAND FORWARD AND CONFERENCE LINKS INOPERATIVE			.58002E+03	.50
104.6 KA-BAND REPORT-BACK AND CONFERENCE LINKS INOPERATIVE			.12581E+05	.50
104.7 KA-BAND FORWARD AND CONFERENCE LINKS DEGRADED			.11208E+04	1.97
104.8 KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED			.11882E+05	.50
209.0 KA-BAND SATCOM SFT SYSTEM INITIALIZATION	1	660.000		
209.1 UNABLE TO START SYSTEM			.59331E+02	.04
209.2 ALTERNATE INITIALIZATION MODE REQUIRED			.13219E+05	.50

Figure 10. Example Element Data Listing

ELEMENT DATA LABEL IDENTIFICATION	CYCLFS	USE SEC	RELIABILITY	AVAILABILITY	MTR, HRS
9.0 SATCOM TERMINAL (PRIMARY POWER)	136000.000		.991379E+00	.990135E+00	1.000
9.1 PRIMARY POWER FAILURE			.862054E-02	.865426E-03	1.000
10.0 KOLM 1082 COMPUTER	1	6.200	.999990E+00	.998070E+00	1.000
10.1 CPU STOPPED NO UPLINK, PRINTER AND CRT EXCEPT FWD. LINK OR CINCPAC	1	6.200	.275395E-05	.192974E-02	1.000
31.0 COMMUNICATIONS TERMINAL POWER FAILURE	1	6.200	.999999E+00	.999393E+00	1.000
31.1 COMMUNICATIONS TERMINAL POWER FAILURE	1	6.200	.708878E-06	.606738E-03	1.000
32.0 HEAT EXCHANGING	1	6.200	.999999E+00	.998039E+00	2.170
32.1 NO HEAT EXCHANGING	1	6.200	.605299E-06	.112522E-02	.500
33.0 FREQUENCY GENERATION	1	6.200	.999999E+00	.998954E+00	.760
33.1 NO/INCORRECT FREQUENCY GENERATION	1	6.200	.160608E-05	.104617E-02	1.000
34.0 KA-BAND RECEPTION	1	6.200	.999999E+00	.999068E+00	1.000
34.1 AUTO-TRACK RECEIVER FAILURE	1	6.200	.805290E-06	.338194E-03	.928
34.2 NO KA-BAND RECEPTION	1	6.200	.361600E-06	.265107E-03	.500
34.3 DEGRADED KA-BAND RECEPTION	1	6.200	.746052E-06	.318029E-03	.500
35.0 KA-BAND TRANSMISSION	1	6.200	.999999E+00	.987828E+00	3.000
35.1 DEGRADED RF POWER OUTPUT (50 WATTS MAX)	1	6.200	.109408E-05	.201125E-02	3.420
35.2 INSUFFICIENT RF POWER OUTPUT (LESS THAN 100 MW)	1	6.200	.321440E-05	.937851E-02	2.000
35.3 NO/INCORRECT DOPPLER CORRECTION	1	6.200	.656521E-06	.702673E-03	2.000
40.0 ANTENNA CONTROL GROUP (KA-BAND)	1	6.200	.999999E+00	.997828E+00	1.750
40.1 NO KA-BAND TRANSMISSION AND RECEPTION	1	6.200	.108106E-05	.210059E-02	2.000
40.2 DEGRADED KA-BAND TRANSMISSION AND RECEPTION	1	6.200	.515466E-07	.210059E-02	2.000
101.0 KA-BAND MODEM GROUP (FORWARD LINK)	1	6.200	.999998E+00	.998508E+00	.914
101.1 INOPERATIVE FORWARD LINK	1	6.200	.132206E-05	.103504E-02	.977
101.2 DEGRADED FORWARD LINK	1	6.200	.648020E-06	.375704E-03	.504
102.0 KA-BAND MODEM GROUP (REPORT-BACK LINK)	1	6.200	.999997E+00	.997697E+00	1.000
102.1 INOPERATIVE REPORT-BACK LINK	1	6.200	.113407E-05	.649000E-03	1.000
102.2 DEGRADED REPORT-BACK LINK	1	6.200	.211730E-05	.101319E-02	1.000
103.0 KA-BAND MODEM GROUP (CONFERENCE LINK)	1	6.200	.999997E+00	.997972E+00	.593
103.1 INOPERATIVE CONFERENCE LINK	1	6.200	.039274E-06	.361702E-03	.986
103.2 DEGRADED CONFERENCE LINK	1	6.200	.196709E-05	.166109E-02	.584
100.0 KA-RAM MODEM GROUP (COMMON FUNCTIONS)	1	660.000	.999994E+00	.999534E+00	.835
100.1 ALL KA-BAND LINKS INOPERATIVE	1	660.000	.216145E-05	.933311E-03	.584
100.2 FORWARD AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED	1	660.000	.171951E-11	.133090E-00	.516
100.3 R/B AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED	1	660.000	.291307E-07	.106726E-04	.584
100.4 ALL KA-BAND LINKS DEGRADED	1	660.000	.623516E-06	.26323E-03	.503
100.5 KA-BAND FORWARD AND CONFERENCE LINKS INOPERATIVE	1	660.000	.233322E-05	.100545E-02	.500
100.6 KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED	1	660.000	.988268E-07	.390875E-04	.500
100.7 KA-BAND FORWARD AND CONFERENCE LINKS DEGRADED	1	660.000	.103627E-05	.174049E-02	.500
100.8 KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED	1	660.000	.112161E-06	.608679E-04	.500
209.0 KA-BAND SATCOM SET (SYSTEM INITIALIZATION)	1	660.000	.996901E+00	.985987E+00	.835
209.1 UNABLE TO START SYSTEM	1	660.000	.308526E-02	.139751E-01	.500
209.2 ALTERNATE INITIALIZATION MODE REQUIRED	1	660.000	.1188666E-04	.378231E-04	.500

Figure 11. Example of Element Reliability and Availability Data Listing

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Figure 12. Example Page of Functional Model and Image Listing

performed, this analysis Schedule is an index to the results and to the State Assignment Listing described above. An example Analysis Schedule is shown in Figure 14.

ANALYSIS SUMMARY

The results of the DEPEND calculations are output in both tabular and statement form. A title page is provided to document the date and time of the DEPEND run and the title of the analysis. An example title page is shown in Figure 15.

Tabular Summary of Results

The results of the "ility" computations for each functional assembly are printed in an Analysis Summary on one page of the computer output. An example Analysis Summary is shown in Figure 16. At the top of the summary, the assembly is identified together with the other assemblies which use it if any.

Next are listed the subassembly or element state data employed in terms of the probability of state occurrence during use (unreliability) and unavailability. The entry ENT* following the label denotes an element while CMP** denote a subassembly. The number of functional cycles, the time used per cycle and the average restore time are also listed. Note that the unreliabilities and unavailabilities for the assembly functional states are only printed in the Analysis Summary for the next level Assembly where it is used. In the case the assembly is a top level one, a separate listing is printed on the next page to record the "ility" data and the undependability, unreliability and unavailability for each non-normal state. An example of such a System Data listing is shown in Figure 17.

Referring again to Figure 16, the second part of the Analysis Summary records the probabilities of occurrence of each functional state defined for the assembly. The probability of normal operation is the dependability while the probabilities of occurrence of the other functional states are the corresponding undependabilities. An extra "residual" state is included to account for the occurrence of states not explicitly defined including those cases of four or more simultaneous state occurrences. Included in this part of the summary are calculated predictions of the average time between occurrences of the non-normal states and the average time to restore normal operation after such an occurrence.

The combined prediction for ATBO expresses the average time between occurrences of any of the non-normal states. The combined ATTR is the average restore time taking into account the probability of occurrence of each non-normal state.

* Entered data

** Computed estimate

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ANALYSIS SCHEDULE

ITERATION	ELEMENTS/SUBASSEMBLIES					ASSEMBLY	NEXT ASSEMBLIES
	31	32	33	34	35		
1						30	39
2	101					215	205
3	215					205	208
4	102					216	206
5	216					206	208
6	103					217	207
7	217					207	208
8	50	36				59	208
9	100	39				200	211 212 213 204
10	14	200	101			211	201
11	211					211	6
12	14	200	102			212	202
13	212					202	7
14	14	200	103			213	203
15	213					203	0
16	16	200				204	208
17	204	205	206	207		208	2
18	6	209	201			6	0
19	6	209	202			7	0
20	6	209	203			8	0
21	6	209	204			2	0

ITERATIONS END

Figure 14. Example Analysis Schedule

0 E P E 4 0

DETERMINATION OF EQUIPMENT PERFORMANCE (INSPECTION AND (NON)OPERATIONAL (DELAY

(TASRA VERSION IV - 3/28/78)

PHYSICS, ELECTRONICS, AND NUCLEAR TECHNOLOGY DEPARTMENT

ENGINEERING PHYSICS AND ELECTRONICS SECTION

BATTELLE-COLUMBUS LABORATORIES

06/15/78

09-22-30

DEPENDABILITY/RELIABILITY/AVAILABILITY/MAINTAINABILITY ANALYSIS

OF THE

ADM SATCOM COMMUNICATIONS TERMINAL

PREPARED FOR

THE AIR FORCE AVIONICS LABORATORY

Figure 15. Example Title Page for Depend Program Results

ANALYSIS SUMMARY

FOR ASSEMBLY NUMBER 2

KA-BAND SATCOM SET (SUMMARY)

SUBASSEMBLY STATE DATA

IDENTIFICATION

STATE	PROBABILITY	ATRO, MRS.	ATTR, MRS.	IDENTIFICATION
0	.78422676			NORMAL OPERATION
1	.049110E-01	1.44913E+02	1.323	ALL KA-BAND LINKS INOPERATIVE
2	.345400E-02	2.97200E+03	1.001	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
3	.654402E-02	1.59044E+03	1.028	ALL KA-BAND LINKS DEGRADED
4	.402460E-01	2.98649E+02	3.047	TWO KA-BAND LINKS INOPERATIVE
5	.077162E-01	1.18124E+04	1.983	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
6	.177973E-01	6.72484E+02	2.065	TWO KA-BAND LINKS DEGRADED
7	.188518E-01	5.45102E+02	.671	ONE KA-BAND LINK INOPERATIVE
8	.271311E-01	3.92079E+02	.992	ONE KA-BAND LINK DEGRADED
9	.141095E-01	5.02127E+01	1.510	OTHER STATES
COMBINED				

ASSEMBLY STATES

STATE	PROBABILITY	ATRO, MRS.	ATTR, MRS.	IDENTIFICATION
209-1 ENT	136000.00	.06206E-02	1.00	PRIMARY POWER FAILURE
209-2 ENT	1 640.00	.30953E-02	.44	UNABLE TO START SYSTEM
200-1 CMP	136000.00	.46106E-01	1.49	ALTERNATE INITIALIZATION MODE REQUIRED
200-2 CMP	136000.00	.71724E-02	1.08	ALL KA-BAND LINKS INOPERATIVE
200-3 CMP	136000.00	.56160E-02	1.03	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
200-4 CMP	136000.00	.29690E-01	3.05	ALL KA-BAND LINKS DEGRADED
200-5 CMP	136000.00	.90279E-04	1.99	TWO KA-BAND LINKS INOPERATIVE
200-6 CMP	136000.00	.13871E-01	2.07	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
200-7 CMP	136000.00	.54579E-02	.67	TWO KA-BAND LINKS DEGRADED
200-8 CMP	136000.00	.09047E-02	.94	ONE KA-BAND LINK INOPERATIVE
				ONE KA-BAND LINK DEGRADED

ASSEMBLY 2 OPERATES FOR 16000.000 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .9567965216, RELIABILITY IS .0194246407 AND DEPENDABILITY IS .7040226476.
215.98 MAJFUNCTIONS ARE EXPECTED TO OCCUR DURING 1000 FUNCTIONAL CYCLES
AND A DELAY OF 45.56 MINUTES IS EXPECTED WHEN A MAJFUNCTION OCCURS.

Figure 16. Example Analysis Summary

S Y S T E M D A T A

LABEL	AVAILABILITY	RELIABILITY	KA-BAND SATCOM SET (SUMMARY)	DEPENDABILITY	IDENTIFICATION
2.0	.95680E+00	.01942E+00	.74682E+00		NORMAL OPERATION
2.1	.21959E-01	.66608E-01	.04912E-01		ALL KA-BAND LINKS IMPERATIVE
2.2	.29829E-01	.33590E-02	.8549E-02		COMBINATION OF 1, 121 IMPERATIVE AND 2 (11) DEGRADED KA-BAND LINKS
2.3	.66378E-01	.62631E-02	.65468E-02		ALL KA-BAND LINKS DEGRADED
2.4	.18268E-01	.82267E-01	.82267E-01		TWO KA-BAND LINKS IMPERATIVE
2.5	.18879E-06	.98765E-08	.07736E-03		ONE IMPERATIVE AND ONE DEGRADED KA-BAND LINK
2.6	.43952E-02	.54762E-01	.21757E-01		TWO KA-BAND LINKS DEGRADED
2.7	.17541E-02	.18178E-01	.18862E-01		ONE KA-BAND LINK IMPERATIVE
2.8	.35916E-02	.25196E-01	.27131E-01		ONE KA-BAND LINK DEGRADED
2.9	.31722E-03	.12313E-01	.16198E-01		OTHER STATES

Figure 17. Example System Data Listing

EMERGENCY TYPING PERMITS TO BE USED
FOR THE REPAIR OF EQUIPMENT
DURING THE REPAIR PERIOD

Statement of Results

At the bottom of each Analysis Summary is printed a statement summarizing the operation, "ility" results, expected number of occurrences of non-normal states and the delay that the system user is expected to experience in case of a malfunction.

The DEPEND program writes a slightly expanded version of these statements of results on the file named TAPE 1. By copying this file to OUTPUT, a compilation of all the statements of results is obtained. An example page of this listing is shown in Figure 18.

OPTIONAL SENSITIVITY TABULATIONS

When the fourth field of the output control card is set to .TRUE., the DEPEND program will output the results of sensitivity calculations for each assembly onto a file named TAPE 9. Copying this file to OUTPUT produces a printed listing of these results.

Percentage Contribution Tabulations

The results of the sensitivity calculations are presented in terms of the percentage contribution of each element or subassembly state to the unavailability, unreliability and undependability for each defined assembly state. An example page of this output is shown in Figure 19.

From this tabulation the relative importance of each element or subassembly state to the malfunctioning or failure of the assembly can be easily observed. This provides a rational basis for allocating resources to achieve improvement of the assembly. It also gives a basis for specifying "ility" requirements for the elements and subassemblies to assure that the assembly meets its "ility" goals.

Tracing System Sensitivity

The number of possible paths involved in tracing the percentage contribution to system undependabilities, unreliabilities and unavailabilities makes using a computer routine for this purpose impractical. A large amount of output would be obtained for the large number of low or zero percentage paths which are not of interest. However, a simple calculator procedure has been developed that can be used to evaluate the significant percentage contribution of components to the system undependability, unreliability and unavailability.

The assembly sensitivity tabulations from the DEPEND program results are used in a top-down chain calculation that proceeds as follows.

SUMMARY OF RESULTS

ASSEMBLY 205 KA-BAND MODEM GROUP (FORWARD MESSAGE)

IS USED BY ASSEMBLY(S) 205
OPERATES FOR 6.200 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .999907065. RELIABILITY IS .999907065 AND DEPENDABILITY IS .999907065.
16.66 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING 1000 FUNCTIONAL CYCLES
AND A DELAY OF 03.04 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 215 KA-BAND MODEM GROUP (FORWARD CYCLE)

IS USED BY ASSEMBLY(S) 205
OPERATES FOR 6.200 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .999907065. RELIABILITY IS .999907065 AND DEPENDABILITY IS .999907065.
1.41 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING 1000 FUNCTIONAL CYCLES
AND A DELAY OF 27.95 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 205 KA-BAND MODEM GROUP (FORWARD MESSAGE)

IS USED BY ASSEMBLY(S) 206
OPERATES FOR 21.000 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .999999999. RELIABILITY IS .999999999 AND DEPENDABILITY IS .999999999.
30 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING A MISSION CONSISTING OF 240 FUNCTIONAL CYCLES
AND A DELAY OF 20.49 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 216 KA-BAND MODEM GROUP (REPORT-BACK CYCLE)

IS USED BY ASSEMBLY(S) 206
OPERATES FOR 6.200 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .997699999. RELIABILITY IS .9999997065 AND DEPENDABILITY IS .997699999.
2.31 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING 1000 FUNCTIONAL CYCLES
AND A DELAY OF 28.89 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 206 KA-BAND MODEM GROUP (REPORT-BACK MESSAGE)

IS USED BY ASSEMBLY(S) 206
OPERATES FOR 12.600 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .997699999. RELIABILITY IS .9999997065 AND DEPENDABILITY IS .997699999.
1.66 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING A MISSION CONSISTING OF 720 FUNCTIONAL CYCLES
AND A DELAY OF 38.93 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 217 KA-BAND MODEM GROUP (CONFERENCE CYCLE)

IS USED BY ASSEMBLY(S) 207
OPERATES FOR 6.200 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .999999999. RELIABILITY IS .999999999 AND DEPENDABILITY IS .999999999.
.43 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING A MISSION CONSISTING OF 216 FUNCTIONAL CYCLES
AND A DELAY OF 27.82 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 207 KA-BAND MODEM GROUP (CONFERENCE)

IS USED BY ASSEMBLY(S) 206
OPERATES FOR 896.000 SECONDS TO COMPLETE ITS FUNCTION.

Figure 18. Example Page of Compilation of Result Statements

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PERCENTAGE CONTRIBUTION TO ASSEMBLY 2 UNAVAILABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES	209.1	209.2	209.1	209.2	209.1	209.2	209.5	209.6	209.7	209.8	TOTAL
2.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.4		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.8		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PERCENTAGE CONTRIBUTION TO ASSEMBLY 1 UNRELIABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES	209.1	209.2	209.1	209.2	209.1	209.2	209.5	209.6	209.7	209.8	TOTAL
2.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.4		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.8		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PERCENTAGE CONTRIBUTION TO ASSEMBLY 2 UNDEPENDABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES	209.1	209.2	209.1	209.2	209.1	209.2	209.5	209.6	209.7	209.8	TOTAL
2.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.4		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.8		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 19. Example Page of Depend Sensitivity Tabulation

Utilizing the Percentage Contribution to Assembly listings at the system level (e.g. Assembly 2), select a system state of interest and an assembly state that is a significant contributor to that system state. The computer listings give the percentage contribution of the selected assembly state to the total system undependability, unavailability and unreliability.

From the computer listings for the assembly select the subassembly state of interest and divide its percentage contribution (from the body of the tables) by the assembly state percentage contribution (from the right-hand column of the table). Multiplying the value previously determined for the percentage contribution of assembly state to the system "ility" by this ratio gives the percentage contribution of subassembly state to the system "ility".

A similar ratio, determined from the subassembly listings and its' product with the subassembly percentage contribution obtained above, gives the percentage contribution of the sub-assembly state to the system "ility". The calculations may be continued down to any desired level included in the computer analysis.

An example illustrating this procedure is as follows: referring to Figure 19, 42.5% of the system undependability is contributed by state 2.1 and about two thirds of this is the 28.2% contribution of assembly state 208.1. From the listing for assembly 208, shown in Figure 20, it is seen that 33.1% of the assembly contribution is attributed to state 208.1, and subassembly 204.1 is responsible for 29.5% of the assembly 208 contribution. Hence, $(29.5/33.1) \times 28.2\% = 25.1\%$ of the system undependability is contributed by subassembly state 204.1.

This process is continued by referring to the sensitivity tabulations for assembly 204 and so on down through the functional hierarchy. The results obtained by tracing all the significant paths may be tabulated to identify and rank the least dependable (or reliable or available) system elements. These results again provide the basis for guiding "ility" improvement and specification efforts.

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SECTION VI

TASA WORK SHEETS

Following is a complete set of TASA Work Sheets. These sheets can be reproduced as needed for analyzing the User's system.

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0	0	0	0	0	0	1	0	0	1	0	0	0	1		3	
0	0	0	0	0	0	0	0	0	1	0	0	0	1	0		4
0	0	0	0	0	0	0	0	0	1	0	0	0	1	1		5
0	0	0	0	0	0	0	0	0	1	0	0	1	0	0		6
0	0	0	0	0	0	0	0	0	1	0	0	1	0	1		7
0	0	0	0	0	0	0	0	0	1	0	0	1	1	0		8
0	0	0	0	0	0	0	0	0	1	0	1	0	0	0		9
0	0	0	0	0	0	0	0	0	1	0	1	0	0	1		10
0	0	0	0	0	0	0	0	0	1	0	1	0	1	0		11
0	0	0	0	0	0	0	0	0	1	0	1	1	0	0		12
0	0	0	0	0	0	0	0	0	1	1	0	0	0	0		13
0	0	0	0	0	0	0	0	0	1	1	0	0	0	1		14
0	0	0	0	0	0	0	0	0	1	1	0	0	1	0		15
0	0	0	0	0	0	0	0	0	1	1	0	1	0	0		16
0	0	0	0	0	0	0	0	0	1	1	1	0	0	0		17
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		18
0	0	0	0	0	0	0	0	1	0	0	0	0	0	1		19
0	0	0	0	0	0	0	0	1	0	0	0	0	1	0		20
0	0	0	0	0	0	0	0	1	0	0	0	0	1	1		21
0	0	0	0	0	0	0	0	1	0	0	0	1	0	0		22
0	0	0	0	0	0	0	0	1	0	0	0	1	0	1		23
0	0	0	0	0	0	0	0	1	0	0	0	1	1	0		24
0	0	0	0	0	0	0	0	1	0	0	1	0	0	0		25
0	0	0	0	0	0	0	0	1	0	0	1	0	0	1		26

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0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	2
0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	3
0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	4
0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	5
0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	6
0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	7
0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	8
0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	9
0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	10
0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	11
0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	12
0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	13
0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	14
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	15
0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	16
0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	17
0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	18
0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	19
0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	20
0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	21
0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	22
0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	23
0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	24
0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	25
0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	26

Card
Column

												Card Column				
												*	1			
0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	2
0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	3
0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	4
0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	5
0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	6
0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	7
0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	8
0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	9
0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	10
0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	11
0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	12
0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	13
0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	14
0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	15
0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	16
0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	17
0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	18
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	19
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	20
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	21
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	22
0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	23
0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	24
0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	25
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	26

									*	1						
0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	2
0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	3
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0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	5
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	7
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	8
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	9
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	10
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	11
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	12
0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	13
0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	14
0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	15
0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	16
0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	17
0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	18
0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	19
0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	20
0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	21
0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	22
0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	23
0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	24
0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	25
0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	26

										*		1
0	0	0	0	0	0	0	1	1	0	0	0	2
0	0	0	0	0	0	0	1	0	0	0	0	3
0	0	0	0	0	0	0	1	0	0	0	0	4
0	0	0	0	0	0	0	1	0	0	0	1	5
0	0	0	0	0	0	0	1	0	0	0	1	6
0	0	0	0	0	0	0	1	0	0	1	0	7
0	0	0	0	0	0	0	1	0	1	0	0	8
0	0	0	0	0	0	0	1	1	0	0	0	9
0	0	0	0	0	0	0	1	0	0	0	0	10
0	0	0	0	0	0	0	1	0	0	0	0	11
0	0	0	0	0	0	0	1	0	0	0	1	12
0	0	0	0	0	0	0	1	0	0	0	0	13
0	0	0	0	0	0	0	1	0	0	0	0	14
0	0	0	0	0	0	0	1	0	0	1	0	15
0	0	0	0	0	0	0	1	0	1	0	0	16
0	0	0	0	0	0	0	1	1	0	0	0	17
0	0	0	0	0	0	0	1	0	0	0	0	18
0	0	0	0	0	0	0	1	1	0	0	0	19
0	0	0	0	0	0	0	1	1	0	0	0	20
0	0	0	0	0	0	0	1	1	0	0	0	21
0	0	0	0	0	0	0	1	1	0	0	0	22
0	0	0	0	0	0	0	1	1	0	0	0	23
0	0	0	0	0	0	0	1	1	0	0	0	24
0	0	0	0	0	0	0	1	1	0	0	0	25
0	0	0	0	0	0	0	1	1	0	0	0	26

74 - 78

08

				*	1
0 0 0 0	0 1 0 0	0 1 0 0	0 1 0 0		2
0 0 0 0	0 1 0 0	0 1 0 0	1 0 0 0		3
0 0 0 0	0 1 0 0	0 1 0 1	0 0 0 0		4
0 0 0 0	0 1 0 0	0 1 1 0	0 0 0 0		5
0 0 0 0	0 1 0 0	1 0 0 0	0 0 0 0		6
0 0 0 0	0 1 0 0	1 0 0 0	0 0 0 1		7
0 0 0 0	0 1 0 0	1 0 0 0	0 0 1 0		8
0 0 0 0	0 1 0 0	1 0 0 0	0 1 0 0		9
0 0 0 0	0 1 0 0	1 0 0 0	1 0 0 0		10
0 0 0 0	0 1 0 0	1 0 0 1	0 0 0 0		11
0 0 0 0	0 1 0 0	1 0 1 0	0 0 0 0		12
0 0 0 0	0 1 0 0	1 1 0 0	0 0 0 0		13
0 0 0 0	0 1 0 1	0 0 0 0	0 0 0 0		14
0 0 0 0	0 1 0 1	0 0 0 0	0 0 0 1		15
0 0 0 0	0 1 0 1	0 0 0 0	0 0 1 0		16
0 0 0 0	0 1 0 1	0 0 0 0	0 1 0 0		17
0 0 0 0	0 1 0 1	0 0 0 0	1 0 0 0		18
0 0 0 0	0 1 0 1	0 0 0 1	0 0 0 0		19
0 0 0 0	0 1 0 1	0 0 1 0	0 0 0 0		20
0 0 0 0	0 1 0 1	0 1 0 0	0 0 0 0		21
0 0 0 0	0 1 0 1	1 0 0 0	0 0 0 0		22
0 0 0 0	0 1 1 0	0 0 0 0	0 0 0 0		23
0 0 0 0	0 1 1 0	0 0 0 0	0 0 0 1		24
0 0 0 0	0 1 1 0	0 0 0 0	0 0 1 0		25
0 0 0 0	0 1 1 0	0 0 0 0	0 1 0 0		26

Card
Column

				*	1
0 0 0 0	0 1 1 0	0 0 0 0	1 0 0 0		2
0 0 0 0	0 1 1 0	0 0 0 1	0 0 0 0		3
0 0 0 0	0 1 1 0	0 0 1 0	0 0 0 0		4
0 0 0 0	0 1 1 0	0 1 0 0	0 0 0 0		5
0 0 0 0	0 1 1 0	1 0 0 0	0 0 0 0		6
0 0 0 0	0 1 1 1	0 0 0 0	0 0 0 0		7
0 0 0 0	1 0 0 0	0 0 0 0	0 0 0 0		8
0 0 0 0	1 0 0 0	0 0 0 0	0 0 0 1		9
0 0 0 0	1 0 0 0	0 0 0 0	0 0 1 0		10
0 0 0 0	1 0 0 0	0 0 0 0	0 0 1 1		11
0 0 0 0	1 0 0 0	0 0 0 0	0 1 0 0		12
0 0 0 0	1 0 0 0	0 0 0 0	0 1 0 1		13
0 0 0 0	1 0 0 0	0 0 0 0	0 1 1 0		14
0 0 0 0	1 0 0 0	0 0 0 0	1 0 0 0		15
0 0 0 0	1 0 0 0	0 0 0 0	1 0 0 1		16
0 0 0 0	1 0 0 0	0 0 0 0	1 0 1 0		17
0 0 0 0	1 0 0 0	0 0 0 0	1 1 0 0		18
0 0 0 0	1 0 0 0	0 0 0 1	0 0 0 0		19
0 0 0 0	1 0 0 0	0 0 0 1	0 0 0 1		20
0 0 0 0	1 0 0 0	0 0 0 1	0 0 1 0		21
0 0 0 0	1 0 0 0	0 0 0 1	0 1 0 0		22
0 0 0 0	1 0 0 0	0 0 0 1	1 0 0 0		23
0 0 0 0	1 0 0 0	0 0 1 0	0 0 0 0		24
0 0 0 0	1 0 0 0	0 0 1 0	0 0 0 1		25
0 0 0 0	1 0 0 0	0 0 1 0	0 0 1 0		26

74 - 78

11

									*	1							
0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2
0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	3
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0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	5
0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	6
0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	7
0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	8
0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	9
0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	10
0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	11
0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	12
0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	13
0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	14
0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	15
0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	16
0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	17
0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	18
0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	19
0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	20
0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	21
0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	22
0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	23
0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	24
0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	25
0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	26

										*	1			
0	0	0	1	0	0	0	0	0	0	0	0	1	0	2
0	0	0	1	0	0	0	0	0	0	0	0	1	1	3
0	0	0	1	0	0	0	0	0	0	0	1	0	0	4
0	0	0	1	0	0	0	0	0	0	0	1	0	1	5
0	0	0	1	0	0	0	0	0	0	0	1	1	0	6
0	0	0	1	0	0	0	0	0	0	1	0	0	0	7
0	0	0	1	0	0	0	0	0	0	1	0	0	1	8
0	0	0	1	0	0	0	0	0	0	1	0	1	0	9
0	0	0	1	0	0	0	0	0	0	1	1	0	0	10
0	0	0	1	0	0	0	0	0	1	0	0	0	0	11
0	0	0	1	0	0	0	0	0	1	0	0	0	1	12
0	0	0	1	0	0	0	0	0	1	0	0	1	0	13
0	0	0	1	0	0	0	0	0	1	0	1	0	0	14
0	0	0	1	0	0	0	0	0	1	1	0	0	0	15
0	0	0	1	0	0	0	0	0	1	0	0	0	0	16
0	0	0	1	0	0	0	0	0	1	0	0	0	1	17
0	0	0	1	0	0	0	0	0	1	0	0	1	0	18
0	0	0	1	0	0	0	0	0	1	0	0	1	0	19
0	0	0	1	0	0	0	0	0	1	0	1	0	0	20
0	0	0	1	0	0	0	0	0	1	1	0	0	0	21
0	0	0	1	0	0	0	0	0	1	0	0	0	0	22
0	0	0	1	0	0	0	0	0	1	0	0	0	1	23
0	0	0	1	0	0	0	0	0	1	0	0	1	0	24
0	0	0	1	0	0	0	0	0	1	0	0	1	0	25
0	0	0	1	0	0	0	0	0	1	0	0	1	0	26

										*		1	
0	0	0	1	0	0	1	0	0	0	1	0	0	2
0	0	0	1	0	0	1	0	0	1	0	0	0	3
0	0	0	1	0	0	1	0	1	0	0	0	0	4
0	0	0	1	0	0	1	1	0	0	0	0	0	5
0	0	0	1	0	1	0	0	0	0	0	0	0	6
0	0	0	1	0	1	0	0	0	0	0	0	0	7
0	0	0	1	0	1	0	0	0	0	0	0	1	8
0	0	0	1	0	1	0	0	0	0	0	0	1	9
0	0	0	1	0	1	0	0	0	0	0	1	0	10
0	0	0	1	0	1	0	0	0	0	1	0	0	11
0	0	0	1	0	1	0	0	0	0	1	0	0	12
0	0	0	1	0	1	0	0	0	1	0	0	0	13
0	0	0	1	0	1	0	0	1	0	0	0	0	14
0	0	0	1	0	1	0	1	0	0	0	0	0	15
0	0	0	1	0	1	1	0	0	0	0	0	0	16
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0	0	0	1	1	0	0	0	0	0	0	0	1	19
0	0	0	1	1	0	0	0	0	0	0	1	0	20
0	0	0	1	1	0	0	0	0	0	1	0	0	21
0	0	0	1	1	0	0	0	0	0	1	0	0	22
0	0	0	1	1	0	0	0	0	1	0	0	0	23
0	0	0	1	1	0	0	0	0	1	0	0	0	24
0	0	0	1	1	0	0	0	1	0	0	0	0	25
0	0	0	1	1	0	0	1	0	0	0	0	0	26

												Card Column				
												*	1			
0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	2
0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	3
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	5
0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	6
0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	7
0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	8
0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	9
0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	10
0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	11
0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	12
0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	13
0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	14
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	15
0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	16
0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	17
0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	18
0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	19
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	20
0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	21
0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	22
0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	23
0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	24
0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	25
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	26

										*		1						
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	
0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	3
0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	4
0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	5
0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	6
0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	7
0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	8
0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	9
0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	10
0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	11
0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	12
0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	13
0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	14
0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	15
0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	16
0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	17
0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	18
0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	19
0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	20
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0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	22
0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	23
0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	24
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	25
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	26

				*	1
0 1 0 0	0 0 0 0	0 0 0 0	0 1 1 0		2
0 1 0 0	0 0 0 0	0 0 0 0	1 0 0 0		3
0 1 0 0	0 0 0 0	0 0 0 0	1 0 0 1		4
0 1 0 0	0 0 0 0	0 0 0 0	1 0 1 0		5
0 1 0 0	0 0 0 0	0 0 0 0	1 1 0 0		6
0 1 0 0	0 0 0 1	0 0 0 0	0 0 0 0		7
0 1 0 0	0 0 0 1	0 0 0 0	0 0 0 1		8
0 1 0 0	0 0 0 1	0 0 0 0	0 0 1 0		9
0 1 0 0	0 0 0 1	0 0 0 0	0 1 0 0		10
0 1 0 0	0 0 0 1	0 0 0 0	1 1 0 0		11
0 1 0 0	0 0 1 0	0 0 0 0	0 0 0 0		12
0 1 0 0	0 0 1 0	0 0 0 0	0 0 0 1		13
0 1 0 0	0 0 1 0	0 0 0 0	0 0 1 0		14
0 1 0 0	0 0 1 0	0 0 0 0	0 1 0 0		15
0 1 0 0	0 0 1 0	0 0 0 0	1 0 0 0		16
0 1 0 0	0 0 1 1	0 0 0 0	0 0 0 0		17
0 1 0 0	0 1 0 0	0 0 0 0	0 0 0 0		18
0 1 0 0	0 1 0 0	0 0 0 0	0 0 0 1		19
0 1 0 0	0 1 0 0	0 0 0 0	0 0 1 0		20
0 1 0 0	0 1 0 0	0 0 0 0	0 1 0 0		21
0 1 0 0	0 1 0 0	0 0 0 0	1 0 0 0		22
0 1 0 0	0 1 0 1	0 0 0 0	0 0 0 0		23
0 1 0 0	0 1 1 0	0 0 0 0	0 0 0 0		24
0 1 0 0	1 0 0 0	0 0 0 0	0 0 0 0		25
0 1 0 0	1 0 0 0	0 0 0 0	0 0 0 1		26

										Card Column							
										*	1						
0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	2
0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	3
0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	4
0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	5
0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	6
0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	7
0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	8
0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	9
0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	10
0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	11
0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	12
0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	13
0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	14
0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	15
0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	16
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	17
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	18
0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	19
0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	20
0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	21
0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	22
0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	23
0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	24
0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	25
0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	26

									*	1	
0	1	0	1	0	0	0	0	0	0	0	2
0	1	0	1	0	0	0	0	0	0	0	3
0	1	0	1	0	0	0	0	0	1	0	4
0	1	0	1	0	0	0	0	1	0	0	5
0	1	0	1	0	0	0	0	0	1	0	6
0	1	0	1	0	0	0	0	0	1	0	7
0	1	0	1	0	0	0	0	1	0	0	8
0	1	0	1	0	0	0	0	0	0	0	9
0	1	0	1	0	0	0	1	0	0	0	10
0	1	0	1	0	0	1	0	0	0	0	11
0	1	0	1	0	0	0	0	0	0	0	12
0	1	1	0	0	0	0	0	0	0	0	13
0	1	1	0	0	0	0	0	0	0	0	14
0	1	1	0	0	0	0	0	0	0	1	15
0	1	1	0	0	0	0	0	0	0	1	16
0	1	1	0	0	0	0	0	0	1	0	17
0	1	1	0	0	0	0	0	1	0	0	18
0	1	1	0	0	0	0	1	0	0	0	19
0	1	1	0	0	0	0	0	1	0	0	20
0	1	1	0	0	0	0	1	0	0	0	21
0	1	1	0	0	0	0	0	0	0	0	22
0	1	1	0	0	0	1	0	0	0	0	23
0	1	1	0	0	1	0	0	0	0	0	24
0	1	1	0	1	0	0	0	0	0	0	25
0	1	1	1	0	0	0	0	0	0	0	26

Card
Column

				*		1
1 0 0 0	0 0 1 0	0 0 0 0	1 0 0 0			2
1 0 0 0	0 0 1 0	0 0 0 1	0 0 0 0			3
1 0 0 0	0 0 1 0	0 0 1 0	0 0 0 0			4
1 0 0 0	0 0 1 0	0 1 0 0	0 0 0 0			5
1 0 0 0	0 0 1 0	1 0 0 0	0 0 0 0			6
1 0 0 0	0 0 1 1	0 0 0 0	0 0 0 0			7
1 0 0 0	0 1 0 0	0 0 0 0	0 0 0 0			8
1 0 0 0	0 1 0 0	0 0 0 0	0 0 0 1			9
1 0 0 0	0 1 0 0	0 0 0 0	0 0 1 0			10
1 0 0 0	0 1 0 0	0 0 0 0	0 1 0 0			11
1 0 0 0	0 1 0 0	0 0 0 0	1 0 0 0			12
1 0 0 0	0 1 0 0	0 0 0 1	0 0 0 0			13
1 0 0 0	0 1 0 0	0 0 1 0	0 0 0 0			14
1 0 0 0	0 1 0 0	0 1 0 0	0 0 0 0			15
1 0 0 0	0 1 0 0	1 0 0 0	0 0 0 0			16
1 0 0 0	0 1 0 1	0 0 0 0	0 0 0 0			17
1 0 0 0	0 1 1 0	0 0 0 0	0 0 0 0			18
1 0 0 0	1 0 0 0	0 0 0 0	0 0 0 0			19
1 0 0 0	1 0 0 0	0 0 0 0	0 0 0 1			20
1 0 0 0	1 0 0 0	0 0 0 0	0 0 1 0			21
1 0 0 0	1 0 0 0	0 0 0 0	0 1 0 0			22
1 0 0 0	1 0 0 0	0 0 0 0	1 0 0 0			23
1 0 0 0	1 0 0 0	0 0 0 1	0 0 0 0			24
1 0 0 0	1 0 0 0	0 0 1 0	0 0 0 0			25
1 0 0 0	1 0 0 0	0 1 0 0	0 0 0 0			26

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							*	1
1	0	0	0	1	0	0	0	2
1	0	0	0	1	0	0	0	3
1	0	0	0	1	0	0	0	4
1	0	0	0	1	1	0	0	5
1	0	0	1	0	0	0	0	6
1	0	0	1	0	0	0	0	7
1	0	0	1	0	0	0	0	8
1	0	0	1	0	0	0	0	9
1	0	0	1	0	0	0	0	10
1	0	0	1	0	0	0	1	11
1	0	0	1	0	0	0	0	12
1	0	0	1	0	0	0	0	13
1	0	0	1	0	0	0	0	14
1	0	0	1	0	0	0	0	15
1	0	0	1	0	0	0	0	16
1	0	0	1	0	0	0	0	17
1	0	0	1	0	0	0	0	18
1	0	1	0	0	0	0	0	19
1	0	1	0	0	0	0	0	20
1	0	1	0	0	0	0	0	21
1	0	1	0	0	0	0	0	22
1	0	1	0	0	0	0	0	23
1	0	1	0	0	0	0	1	24
1	0	1	0	0	0	0	0	25
1	0	1	0	0	0	0	0	26

						*			1												
1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9
1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	10
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	11
1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	12
1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	13
1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	14
1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	15
1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	16
1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	17
1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22

GLOSSARY

Assembly	The functional block at levels of the functional hierarchy above the elemental level.
ATBO	The average Time Between Occurrences of a specified malfunction or failure state for an assembly based on an assumption that the time distribution of their occurrences is exponential.
ATTR	The Average Time To Restore the assembly function to normal following occurrence of a specified malfunction or failure state.
ATTR Weighting Factor	A factor ranging from 0 to 1 used to determine the time to restore an assembly's function following the occurrence of a combination of two or three subassembly or element malfunction and failure states.
Availability	The probability that a specified assembly is functional at the start of each of the specified number of uses during the specified mission time interval.
Average Delay	The delay that the user can expect when a malfunction or failure occurs. (Also called Average Nonoperational Delay.)
Dependability	The probability of completing a specified number of functional cycles during a specified interval of time of an assembly (or element) without experiencing a malfunction or failure induced delay.
Element	The basic functional building block in the system functional hierarchy. The MTBF and MTTR data are input at this level.
Functional Cycle	The performing of an assembly's function from start to finish.
"ility"	dependability, availability and reliability
MTBF	Mean Time Between Failures of malfunctions for an element.
MTTR	Mean Time to Restore an element's function by repair, replacement or other means following occurrence of a malfunction or failure. MTTR includes the time needed to detect malfunction or failure occurrence.

Reliability	The probability that a specified assembly successfully performs its function during each of the specified number of functional cycles given that it is capable of performing its function at the start of each cycle.
Subassembly	A functional assembly becomes a subassembly when it is used at a higher level of the functional hierarchy.
TASA	Tabular System Analysis: An orderly procedure for developing the functional hierarchy of a system, defining the malfunction and failure states and recording the consequences of malfunction and failure occurrences, singly and in combination.
Unavailability	The probability that a specified assembly will not be capable of performing its function when needed because of the occurrence of a specified malfunction or failure state.
Unreliability	The probability of occurrence of a specified malfunction or failure state during one (or more) of the specified number of functional cycles of specified duration.
Use Time	The interval of time required to complete a specified number of functional cycles not counting any time between the completion of one cycle and the start of the next.