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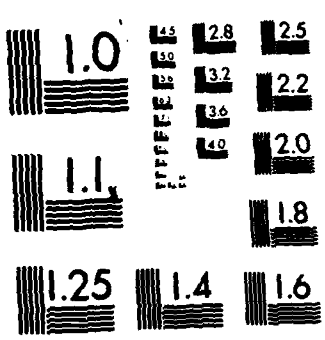

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Report No. V-1891-02

Enhancement and Verification of the Navy CASEE Model (Calendar Year 1983 Task)

Final Technical Report
12 December 1983

Prepared Under Contract Number
N60921-82-C-0220
(CDRL Item No. A002)
for
Naval Surface Weapons Center (E06)

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Computer simulation of Naval Fleet air operations and their subsequent maintenance and supply related activities, has been utilized extensively for evaluation purposes during the past two decades. The Navy CASEE (Comprehensive Aircraft Support Effectiveness Evaluation) Model is a primary computer simulation model used in the analysis of Integrated Logistic Support (ILS) concepts in support of the fleet air operations. Periodic updates to this model are required to enable it to conform to the evolutionary changes in

20. ABSTRACT (continued)

fleet maintenance reporting procedures and related evaluation requirements. Coupled with changing fleet requirements are advances in computer hardware and software technologies. Such technological advances allow for increased simulation capabilities without restrictive increased costs in model development during simulation run time and execution.

ABSTRACT

In order to respond to evolving fleet requirements and procedures in operating systems and maintenance reporting systems, the Navy Comprehensive Aircraft Support Effectiveness and Evaluation (CASEE) Model requires periodic updating and restructuring. The CASEE enhancements described in this report resulted from basic needs within the CASEE users community to have CASEE reflect the changing criteria that are instrumental in analyzing fleet operating and maintenance policies.

Enhancements were selected and implemented based on projected utility in CASEE applications. A prototype data base, consisting of S-3A aircraft reliability and maintainability data, was generated for use in installing and bench marking CASEE Version 5 at required user's facilities. A new CASEE version, Version 6, was developed as an initial attempt to integrate the V/STOL, multiship operational aspects of Version 4 with the maintenance generation speedup routine and the Subsystem Capability Impact Reporting (SCIR) system analytical capability of Version 5. Program Listings incorporating the integration of this logic were generated. It is recommended that further efforts be expended to refine existing enhancements and include additional enhancement candidates.

The verification process that was conducted to ensure the integrity of the CASEE enhancements was similar to that employed in previous updating efforts. This process consists of functional logic checks of all enhancements and numerical validation of the enhancements where necessary. This process was performed in a manner to ensure that the enhanced model performs all initial functions in a credible manner.

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INTRODUCTION

Computer simulation of Naval Fleet air operations and their subsequent maintenance and supply related activities, has been utilized extensively for evaluation purposes during the past two decades. The Navy CASEE (Comprehensive Aircraft Support Effectiveness Evaluation) Model is a primary computer simulation model used in the analysis of Integrated Logistic Support (ILS) concepts in support of the fleet air operations. Periodic updates to this model are required to enable it to conform to the evolutionary changes in fleet maintenance reporting procedures and related evaluation requirements. Coupled with changing fleet requirements are advances in computer hardware and software technologies. Such technological advances allow for increased simulation capabilities without restrictive increased costs in model development during simulation run time and execution.

The CASEE Model is now represented by Version 4 and Version 5. Version 5 is used primarily in the analysis of carrier-based and land-based aircraft operations. Version 4 incorporates features unique to Vertical/Short Take-Off and Landing (V/STOL) aircraft operations, with multiple host ships operating either in the vicinity of a maintenance-capable parent ship or as separate entities operating with or without shore-based supply support. The General Purpose Simulation System (GPSS) language is used for all versions of CASEE.

Recent Sea Based Air activity and CASEE evaluation considerations resulted in the identification of two major configuration updates. The first update was a speed up option which enhances maintenance action generation and significantly reduces simulation execution time. The second update was the implementation of the Subsystem Capability Impact Reporting (SCIR) readiness reporting criteria per OPNAVINST 4790.2 and 5442.4 series. Both of these enhancements were accomplished by December 1982 and subsequently led to the creation of the Version 5 model.

The two enhancements described above have proven their worth in improved model utilization and in increased post-run analytical capability. They provided the user community with the capability to model real world events based on current reporting procedures with increased efficiency. Because of the complexity involved in adding these features to Version 4, it has been decided to take the features that differentiated Version 4 from Version 5 and incorporate them into Version 5 by integrating the required Version 4 logic with Version 5. Incorporating the changes in this manner is much more cost effective in terms of programming time and subsequent debugging time. The resultant version, identified as Version 6, has the combined attributes of both Versions 4 and 5 and provides the users with a single model which incorporates all of the currently available capabilities.

A second CASEE related effort is concerned with the data preparation aspects of utilizing CASEE rather than the actual considerations of model utilization and model output analysis. To facilitate use of Version 5 among the user community it has been decided to generate a prototype CASEE data base, normally called a Matrix Library (MXLIB), from fleet operational data for an existing aircraft. The aircraft chosen for the basis for this effort was the S-3A. The S-3A MXLIB will serve as a baseline for the verification of the pre-processing reprogrammed logic, unique to Version 5. This MXLIB would also be provided to the user community as part of the CASEE software package. This file could be used by each user as a bench mark to verify proper installation and operation of the most recent CASEE version at each of the user's facilities.

Norden Systems was instrumental in providing computer program development and implementation of the described enhancements. In conformance with a long-standing policy of encouraging periodic enhancement in CASEE, the Naval Air Systems Command (NAVAIR) provided the support required for the final selection and implementation of the enhancement candidates identified under this task. The direct technical participation of both the SBA Logistics Manager (AIR-4105B) and the CASEE Manager (AIR-5143) facilitated the successful accomplishment of the overall enhancement and verification endeavor.

ENHANCEMENTS

General

The enhancements implemented under this task are intended to satisfy two basic needs of the CASEE user community. The first is the need to provide a version of CASEE with V/STOL multiship capability that utilizes the speed up option and the SCIR system reporting characteristics (Version 6 model). The second need is for a prototype data base that may be used to bring the existing Version 5 on line at a user's facility and may also serve as a model for other Version 5 data bases.

These enhancements are defined in detail in the following paragraphs. The descriptions of the speed up option and the SCIR enhancement parallel the descriptions provided in the December 1981 and December 1982 Final Technical Reports, respectively. Changes in detail will be provided where necessary to reflect changes unique to the Version 6 model. Verification that these two enhancements were satisfactorily accomplished was included in the two referenced reports. As a result, it will be unnecessary to perform a detailed verification similar to that previously accomplished. Rather, checks will be made to ensure that the new version has properly integrated the V/STOL multiship capability related logic with the existing enhancements. A description of these checks will be provided, if needed, along with the results of the checks. Verification of the prototype MXLIB data base will consist of manual calculations performed on samples of the raw data to ensure that the pre-processing programs are working according to specification.

Maintenance Action Generation

This enhancement was selected for implementation due to the appreciable run time reductions expected and the associated potential for accomplishing simulations currently considered too demanding in terms of computer run time requirements. The existing CASEE failure determination technique generates maintenance actions by computing the failure probability of each Weapons Replaceable Assembly (WRA) during a given aircraft event, such as inflight, turnaround inspection, and daily inspection. This process is executed for each flight and inspection event during the simulation run and is considered to be statistically valid, since each WRA is tested independently during each aircraft event. However, this process can involve a tremendous number of GPSS block executions within the failure determination logic, and can in some cases consume 50 percent or more of the execution time for a long simulation run with a large number of WRAs.

The corrective action involves the use of the cumulative WRA failure probability distribution to determine the failed WRA. Perhaps the best way to explain this approach is by means of a simple example.

Consider a system composed of four WRAs with the following failure rates:

WRA	Failure Rate (Per 10,000 F.H.)	Normalized Failure Rate	Cumulative Failure Probability
A	100	0.118	(0.118)
B	150	0.176	(0.294)
C	200	0.235	(0.529)
D	400	0.471	(1.000)
Total	850	1.0	-

By using a uniformly distributed random number from 0 to 1.0, the selection of the failured WRA (given that a failure has occurred) is made by means of the following test:

If 0 $\leq$ Random Number $\leq$ 0.118, Failed WRA = A
If 0.118 < Random Number $\leq$ 0.294, Failed WRA = B
If 0.294 < Random Number $\leq$ 0.529, Failed WRA = C
If 0.529 < Random Number $\leq$ 1.0, Failed WRA = D

This type of distribution can be represented in a GPSS model by means of a discrete numerical valued function having a random number argument. Using such a function, the failed WRA can be determined with only a single random number draw which is a far more efficient approach to failure determination than the existing CASEE scheme. Unfortunately however, it has a serious drawback, owing to the fact that the GPSS function must be provided as an input to the model. This means that before submitting the CASEE run, the normalized failure distribution must be computed and the GPSS functions coded, either manually or by means of a pre-processing program. This procedure must be repeated whenever any of the WRA failure rates are changed. This becomes unattractive as well as uneconomical for most practical applications of the model.

A unique alternative has been identified which retains the computational efficiency of the cumulative probability methodology, while completely avoiding the need for off-line pre-processing. Using the above example, let the normalized failure rate and the cumulative failure probability distribution be restructured into four equal intervals representing the total number of WRAs. Each interval is subdivided into at least one, but never more than two sub-intervals. Interval No. 1 contains the "contribution" of WRA A plus a "piece" of WRA D, D_1. Interval No. 2 contains WRA B plus another piece of WRA D. Interval No. 3 contains WRA C plus another piece of WRA D. Finally, interval No. 4 consists entirely of the remaining piece of WRA D, as follows:

	Interval No. 1			Interval No. 2	
A	0.118	(0.118)	B	0.176	(0.426)
D_1	0.132	(0.250)	D_2	0.074	(0.500)
Total	0.250	-		0.250	-

	Interval No. 3			Interval No. 4	
C	0.235	(0.735)	D_4	0.250	(1.0)
D_3	0.015	(0.750)		-	-
Total	0.250	-		-	-

This restructured cumulative probability distribution is equivalent to the original distribution as far as the overall contributions of the respective WRAs are concerned, however; it has two significant advantages. First, the distribution can be mapped into the model in the form of a matrix rather than as a GPSS function. Then, using this matrix, the failed WRA can be determined with a single random number draw.

For the example under consideration, the matrix would have the following form:

(ROW = Interval No.)	COLUMN 1 (Dividing point)	COLUMN 2 (Below)	COLUMN 3 (Above)
1	0.118	A	D
2	0.426	B	D
3	0.735	C	D
4	-----	D	D

Given that a failure has occurred, two tests are needed to determine the failed WRA. First, establish the matrix row, i.e. the interval number, by dividing the random number by the interval width. Then determine whether the random number is below or above the dividing point (the entry in Column 1).

For example, suppose the random number drawn is 0.632. Dividing this by 0.250 gives 2.528, establishing the row number as 3. Since $0.632 < 0.735$, the failed WRA is WRA C. Although this random draw would have identified WRA D as the failed WRA under the previous method, it should be emphasized that both methods would produce identical results for an infinite number of draws made since the contribution of each WRA remains the same.

It can be shown that this technique is valid regardless of the total number of WRAs and their individual failure rates.

Another advantage of this approach is that it is implemented by means of a straightforward, user-transparent GPSS algorithm which dynamically loads the proper values into the cumulative distribution matrix using failure rate data derived from the CASEE MXLIB. This is done automatically at model initialization time, after the matrix library is read into core memory, and user specified run-time modifications within the CASEE update deck have been executed. This implementation also includes a GPSS algorithm for determining the number of maintenance actions generated for each aircraft event, using a random number draw and a corresponding Poisson distribution.

The actual savings in CASEE operating costs achieved by this enhancement cannot be uniformly predicted, since it is dependent upon several variables. The version of GPSS employed by the user could affect the rate of change, as well as any "local" CASEE modifications that may be introduced; the most important factor is the level of aircraft definition. An aircraft that is defined to the 2-digit level of Work Unit Codes (WUCs) will show almost no change, while a 5-digit definition will result in substantial savings. In the verification effort for this enhancement, initial set-up costs increased slightly, due to the cost of generating the new failure matrix, but the overall cost reduction achieved was better than 55 percent for a 6-month simulation.

Differences Between ASD and SCIR Readiness Reporting Systems

Prior to this effort, CASEE, Version 4 Mod 0 was modelled to measure and track weapon system readiness status using the Aviation Statistical Data (ASD) reporting system. The Navy SCIR reporting system was implemented on 1 July 1979 for Department of the Navy aircraft, Ground Support Equipment (GSE) and training devices. The implementing instruction replaced all ASD reporting. This new readiness reporting system was implemented to provide a better and more complete method of determining subsystem availability and relating its performance to aircraft mission capability. To implement this readiness reporting system, newly developed maintenance policies, procedures and responsibilities were established and delineated by the Navy. The objective of this enhancement of CASEE was intended to modify the appropriate model logic to take into consideration the readiness implications brought about by this new reporting system. This enhancement was to provide the CASEE user's community with the means to generate simulation results using the same reporting procedures and mission performance definitions which are consistent with those currently generated by all aircraft reporting custodians.

Under the ASD system there were anomalies inherent in the reporting system which greatly reduced visibility into the impact of maintenance actions upon weapon system readiness. The basic problem in the ASD system is in the occurrences of multiple aircraft downing discrepancies. Under the ASD reporting rules, only one of the discrepancies could be reported as putting the aircraft into a Not Operationally Ready (NOR) or Reduced Material Condition (RMC) status. Under these procedures, only the "worst" discrepancy of those available would be documented. It was at the discretion of the maintenance chief to determine which discrepancy of those available was the most significant in terms of degrading aircraft status.

Because the system limited the reporting of only one discrepancy as the cause of aircraft degradation, information on those equipments which are not documented as downing discrepancies were lost and not properly reflected in the data. This problem was commonly known as the "shadowing" effect.

Unlike the ASD system, all condition status information is documented directly on the Visual Information Display System/ Maintenance Action Form (VIDS/MAF). Information concerning the supply and maintenance conditions along with the Equipment Operational Capability (EOC) code which reflects the capability of the aircraft because of the degraded system is documented against each equipment. Since every discrepancy is documented, "shadowing" is eliminated by the SCIR system.

The most obvious change from the ASD system to the SCIR system is in the reporting terminology. The ASD system is updated in Operational Readiness (OR) related terminology. The SCIR system is reported in Mission Capability (MC) related terminology. The two sets of terminology are generally comparable as is shown in Table 1.

Under the ASD system, an RMC status was a condition status in which the aircraft was capable of flying more than one but not all of its intended missions. However, no provisions were available to define which missions could or could not be flown under this status. For this reason, the SCIR system was designed to correct this problem by ensuring that any discrepancies that degrade WRA and subsystem performance can be related to specific mission capability. This is accomplished by means of a Mission Essential Subsystem Matrix (MESM) which is utilized as a cross reference to relate subsystems to specific mission requirements. All mission essential subsystems are assigned an EOC code. This code is then used to identify which missions can or cannot be flown if this subsystem is not operational. For example, Category B EOC codes designate those subsystems that impact on the optimal performance status of the aircraft while category Z EOC codes designates those equipments

TABLE 1

ASD and SCIR Readiness Reporting Terminology Comparison

ASD System Terminology	SCIR System Terminology
Full System Capable (FSC)	Optimum Performance Capability (OPC)
Full System Capable (FSC)	Full Mission Capable (FMC)
Reduced Material Condition (RMC)	Partial Mission Capable (PMC)
Reduced Material Condition-Maintenance (RMCM)	Partial Mission Capable-Maintenance (PMCM)
Not Fully Equipped (NFE)	Partial Mission capable - Supply (PMCS)
Operationally Ready (OR)	Mission Capable (MC)
Not Operationally Ready (NOR)	Not Mission Capable (NMC)
Not Operationally Ready - Unscheduled Maintenance (NORMU)	Not Mission Capable-Unscheduled Maintenance (NMCMU)
Not Operationally Ready-Scheduled Maintenance (NORMS)	Not Mission Capable-Scheduled Maintenance (NMCMS)
Not Operationally Ready-Supply (NORS)	Not Mission Capable-Supply (NMCS)

that impact on the safety of flight requirements. EOC codes between A and Z are used for other missions of varying degrees. When a given subsystem generates a downing discrepancy, it can then be readily determined what missions are affected. This type of reporting provides much more consistency and visibility in defining and assessing mission capability and availability than was previously provided under the ASD system. SCIR provides exact information as to the availability of the aircraft for each mission type and the needed visibility in defining which subsystem was responsible for any degradation.

In providing more insight into mission capability and subsystem degradation than the ASD system, the SCIR system allows for different and more detailed output reports to be generated. The SCIR system and therefore the SCIR enhancement resulted in a significant increase in the number of output data elements which are produced. Readiness related data are traced and summarized at the weapon system level, subsystem level and component level. In addition, system impact, discrepancy detail and unavailable hours are provided for each readiness level and assigned as either maintenance or supply responsibility.

CASEE SCIR Logic Description

The purpose of modifying the current Version 5 to allow incorporation of the features of Version 4 (V/STOL multiship capability) is to minimize the amount of reprogramming needed to provide a version of CASEE that includes all of the existing major capabilities. Changes to the existing SCIR related logic now incorporated in Version 5 are expected to be minimal. While some reprogramming is to be expected in this area, the major reprogramming effort should be primarily aimed at incorporating the SCIR reporting criteria on all ships and their associated aircraft.

The major SCIR related changes will be reflected in the various input and output matrices. The ASD System and SCIR System input data comparisons are provided in Table 2.

The actual logic flow in Version 6 used to determine the status of a discrepancy is shown in Figure 1. It should be noted that in Table 2, there are two entries for EOC inputs 1 through 6. The two sets of inputs are used to differentiate between Remove and Replace (R/R) and a Repair in Place (RIP) action. The projected logic flow for determining discrepancy EOC status is the same for both R/R and RIP actions. The following discussion will explain the logic flow diagram in terms of the numbers assigned to the logic blocks shown in Figure 1.

Block Number 1. A newly generated maintenance discrepancy initiates processing. Using the input in column 36 a determination is made to see if the WRA that generated the

TABLE 2

ASD System and SCIR System Input Data Comparison

<u>ASD System Inputs</u>

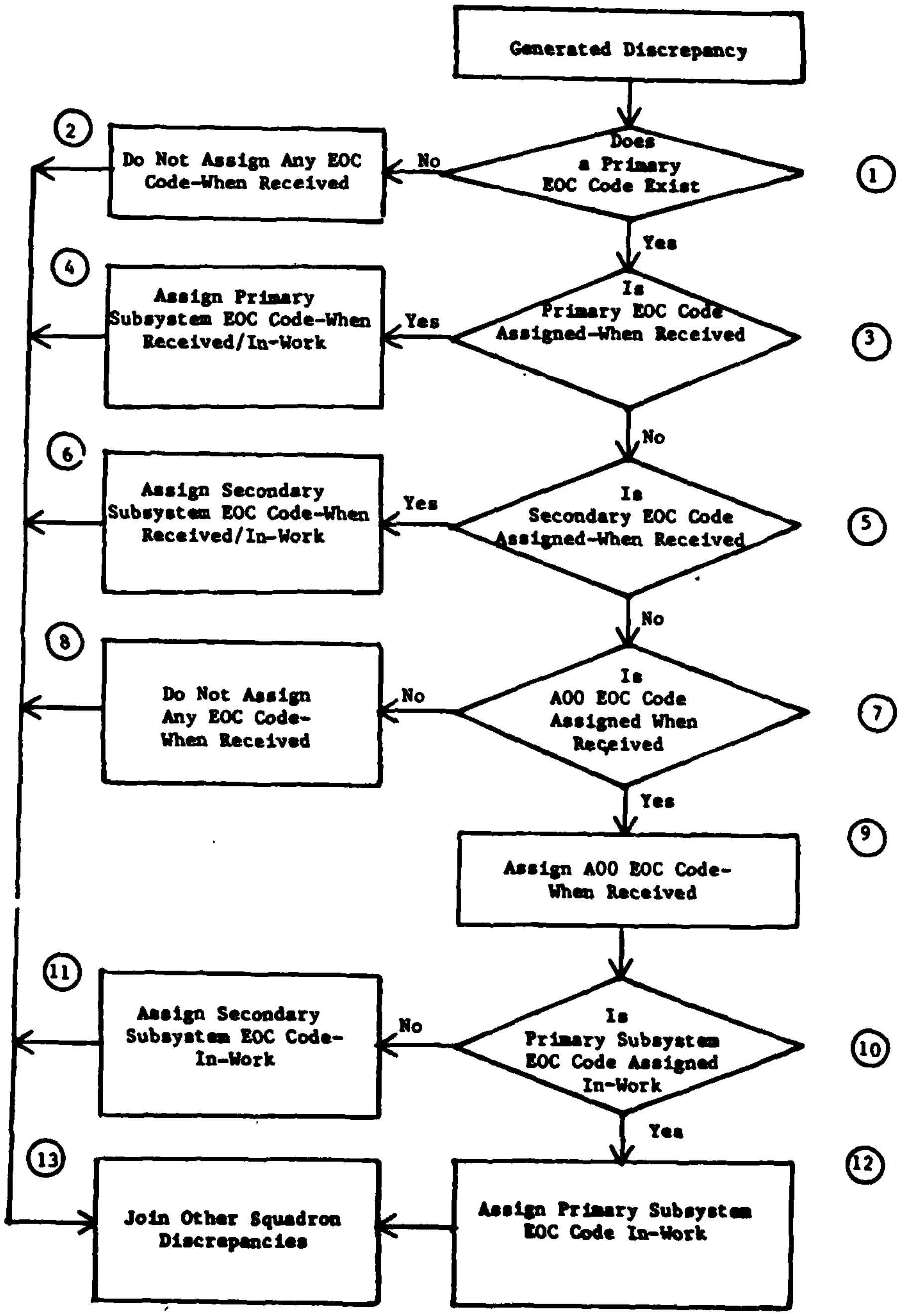
1.	Column #10. -	Ground Abort Probability (X1000)
2.	Column #33. -	Probability (X1000) of causing NOR - Ground Crew Inspection
3.	Column #34. -	Probability (X1000) of causing NOR - Air Crew Inspection
4.	Column #35. -	Probability (X1000) of causing NOR - Daily Inspection
5.	Column #36 -	Probability (X1000) of causing NOR - Inflight
6.	Column #37 -	Probability (X1000) of causing NMC - Ground Crew Inspection
7.	Column #38 -	Probability (X1000) of causing NMC - Air Crew Inspection
8.	Column #39 -	Probability (X1000) of causing NMC - Daily Inspection
9.	Column #40 -	Probability (X1000) of causing NMC - Inflight

<u>SCIR System Inputs</u>

1.	Column #s 36 & 42 -	Primary Subsystem EOC code for a Remove and Replace and a Repair-In-Place action respectively.
2.	Column #s 37 & 43 -	Secondary Subsystem EOC code for a Remove-and Replace and a Repair-In-Place action respectively.
3.	Column #s 38 & 44 -	Probability (X1000) of discrepancy having the Primary EOC code when received for a Remove and Replace and a Repair-In-Place action respectively.
4.	Column #s 39 & 45 -	Probability (X1000) of discrepancy having the Secondary EOC code when received for a Remove and Replace and a Repair-In-Place action respectively.
5.	Column #s 40 & 46 -	Probability (X1000) of discrepancy having an A00 EOC code when received for a Remove and Replace and a Repair-In-Place action respectively.
6.	Column #s 41 & 47 -	Probability (X1000) of discrepancy having an A00 EOC code when received being assigned the Primary Subsystem EOC code in-work.

FIGURE 1

SCIR Logic Flow Diagram



discrepancy has a primary subsystem EOC code assigned in that column. If the determination is negative it is sent to block #2 for processing. If the discrepancy has a primary subsystem EOC code it is sent to block #3 for processing.

Block Number 2. A discrepancy entering this block is not assigned any EOC code - when received and is considered to be a non-SCIR event. It is sent to block #13 to join other squadron discrepancies where it will await processing.

Block Number 3. Upon entering this block a probabilistic determination using the inputs in columns 36 (or 42) and 38 (or 44) is made to see if the discrepancy should be assigned the primary subsystem EOC code - when received and in-work. If the determination is positive, the discrepancy is sent to block #4 for processing. If the determination is negative, the discrepancy is sent to block #5 for processing.

Block Number 4. A discrepancy entering this block is assigned the primary subsystem EOC code when received and the in-work categories. The discrepancy is then sent to block #13 to join the other squadron discrepancies.

Block Number 5. Upon entering this block a probabilistic determination is made using the input in column 37 (or 43) and 39 (or 45) to see if the discrepancy should be assigned the secondary subsystem EOC code - when received and in-work. If the determination is positive, the discrepancy is sent to block #6 for processing. If the determination is negative, the discrepancy is sent to block #7 for processing.

Block Number 6. A discrepancy entering this block is assigned the secondary subsystem EOC code when received and the in-work categories. The discrepancy is then sent to block #13 to join other squadron discrepancies.

Block Number 7. Upon entering this block a probabilistic determination is made using the input in column 40 (or 46) to see if the discrepancy should be assigned the A00 EOC code when received. The A00 Code is used to indicate that the discrepancy is non-SCIR related until it is eventually worked on. If the determination is positive the discrepancy is sent to block #9 for processing. If the determination is negative the discrepancy is sent to block #8 for processing.

Block Number 8. A discrepancy entering this block is not assigned any EOC code - when received. It is considered as a non-SCIR discrepancy and does not impact on the aircraft mission status. This discrepancy is now sent to block #13 to join other squadron discrepancies.

Block Number 9. A discrepancy entering this block is assigned the A00 EOC code - when received and remains in that status until it is in-work. The discrepancy is then sent to block #10 for processing.

Block Number 10. Upon entering this block a probabilistic determination is made using the input in column 41 (or 47) to determine the appropriate EOC code which will be assigned to an A00 discrepancy once it is in-work. A test is conducted to determine whether this discrepancy will be assigned the primary or secondary EOC code.

Block Number 11. A discrepancy entering this block is assigned the primary subsystem EOC code in-work prior to being sent to block #13 to join the other squadron discrepancies.

Block Number 12. A discrepancy entering this block is assigned the secondary EOC code in-work and is then sent to block #13 to join other squadron discrepancies.

Block Number 13. A discrepancy entering this block joins other squadron discrepancies to await future processing.

Version 6 General Structure

As mentioned earlier, the CASEE Version 6 model integrates the features of both the Version 4 model and the Version 5 model. As a single model, Version 6 now has the capabilities of simulating the following scenarios.

1. Non-Dispersed-Cyclic Operations
2. Non-Dispersed-Non Cyclic Operations
3. Dispersed-Integrated Operations
4. Dispersed Detached Operations
5. Dispersed-Independent Operations

Under these scenarios, Non-Dispersed operations consist primarily of two categories, carrier and shore based operations. These operations were previously simulated under the Version 5 model. Similarly, dispersed operations were previously simulated under Version 4. Integrated operations consist of an air capable mothership such as a CV or an LPH providing both supply and maintenance support to a number of individual detachments, which are members of the same task force as needed. Detached operations consist of having individual air capable ships having no I-level capability but with resupply provisions from either shore based supply support locations or nearby support ships. Finally, the Independent operations concept is an air capable ship operating independently with no supply and maintenance support or spares replenishment provisions from outside sources.

Numerous changes had to be made to the Version 5 model to incorporate V/STOL unique logic. In most cases these changes were the result of adding additional input and output data elements to the CASEE matrices so as to provide the user with the option of simulating V/STOL scenarios and adapting the model to provide additional output data unique to V/STOL operations. Although additional input & output matrices were not required to be defined, selected changes were made to the majority of the matrices. In some cases matrix data elements apply to dispersed operations while in others they apply only to non-dispersed operations. Clear identification of these data elements is provided in the description of the CASEE entities.

SCIR Output Data Description

Under the ASD reporting versions (Version 4), readiness parameters were measured against each individual aircraft and reported in the REDI matrix for each aircraft in a squadron and in the RDSUM matrix for each organizational unit. ASD related Awaiting Maintenance hours (AWM) are reported in the AWMR matrix for each aircraft in a squadron and in the AMSUM matrix for each organizational unit. These hours are summarized by NORM and RMC categories.

In the SCIR reporting version, readiness hours against the aircraft and organizational units are reported in the UTIL matrices. This matrix type is comparable to the old REDI matrices in Verson 4, but uses SCIR terminology. The AWM matrices are used in Version 6. However, awaiting maintenance hours are summarized by FMC, PMC, and NMC categories. Unlike the ASD reporting version both SCIR impact hours and SCIR discrepancy hours are reported. One UTIL matrix and AWMR matrix is required for each aircraft type or mission configuration.

The SYST matrix in Version 6 is analogous to the SYSH matrix in Version 4. Both matrices are a compilation of the information in the MXLIB. However, the SYST matrix has been expanded to accumulate impact and discrepancy time by subsystem for NMC, PMC, and AWM categories.

Version 6 includes two matrices not found in Version 4. These matrices are needed to accommodate the additional reporting outputs generated by the SCIR system. The first of these is the MCAP matrix. Impact hours for the reporting period are logged against each aircraft in the squadron and then against each mission code that the aircraft is capable of flying. The second additional matrix included in Version 6 is the SCIM (SCIR Impact Summary) matrix. This matrix summarizes impact and discrepancy hours against each possible EOC code for both maintenance and supply categories. One MCAP matrix and one SCIM matrix is required for each aircraft type or mission configuration.

A complete description of the CASEE Version 6 input and output matrices is provided in Appendix A of this report.

Version 5 Prototype Data Base (S-3A Data)

The Version 5 prototype data base, normally called a matrix library, consists of all of the individual systems matrices (defined at the two-digit WUC level) that characterize the behavior of the S-3A aircraft. The rows of each matrix represent the WRAs within each system/subsystem. A description of these parameters, along with the matrix library column number, is provided in Table 3. During the simulation, CASEE references these matrices in simulating the unscheduled maintenance workload generated against the aircraft.

The S-3A MXLIB inputs were developed using historical S-3A data generated by the Navy 3-M data collection system. Fleet data generated from three Pacific squadrons and two Atlantic squadrons during the January through December 1982 time period was used to develop this S-3A matrix library. The 3-M data used for this analysis was obtained for all five S-3A squadrons during the calendar year 1982 from the Navy Maintenance Support Office (NAMSO).

The data obtained from NAMSO was processed using a series of data reduction programs, which will extract and summarize the data at the five-digit WUC level. A total of nine different reports were generated at the completion of the data processing. These reports consist of the following:

- Maintenance Action Summary
- When Discovered Summary
- Action Taken Summary - Organizational Level
- Action Taken Summary - Intermediate Level
- Work Center Summary - Organizational Level
- Work Center Summary - Intermediate Level
- Man Hour Summary - Organizational and Intermeidate Levels
- SCIR Reporting Summary - Action Taken Code R
- SCIR Reporting Summary - Action Taken Codes excluding R

The Maintenance Action Summary identified a total of 3,882 WUCs. In order to reduce the WRAs in the matrix library to a manageable number, and still account for a large majority of the total maintenance actions generated against the S-3A aircraft, a decision was made to exclude from the matrix library, any WUC which generated less than six maintenance actions during the 1982 period. This procedure resulted in a matrix library consisting of 1,483 WRAs, which accounted for 93.8 percent of the total unscheduled maintenance actions generated against the S-3A.

TABLE 3

Description of Matrix Library Inputs

Column Number	Description
1.	First & Second Digits of Work Unit Code
2.	Third & Fourth Digits of Work Unit Code
3.	Fifth Digit of Work Unit Code
4.	Probability of Discovering a MA During a Ground Crew Inspection (X 10,000)
5.	Probability of Discovering a MA During an Air Crew Inspection (X 10,000)
6.	Probability of Discovering a MA During a Daily Inspection (X 10,000)
7.	Probability of Discovering a MA During a Phase Inspection (X 10,000)
8.	Probability of Discovering a MA After Receiving a Part from Supply (X 10,000)
9.	Probability of Discovering a MA In-Flight (X 10,000)
10.	Not Used
11.	Probability that a MA will cause an Air Abort (X 1,000)
12.	Primary Organizational Work Center Code
13.	Organizational Level Crew Size (X 10)
14.	Not Used
15.	Alternate Organizational Work Center Probability (X 1,000)
16.	Alternate Organizational Work Center Code
17-18.	Not Used
19.	Intermediate Level Work Center Code
20.	Intermediate Level Crew Size (X 10)
21.	Not Used
22.	Organizational Level Mean Time to Repair (X 10)
23.	Intermediate Level Mean Time to Repair (X 10)
24.	Probability that the Organizational Level Action is a Remove and Replace Action (X 1,000)
25.	Probability that the Intermediate Level Action is BCM 1-8 Code (X 1,000)
26.	Probability that the Intermediate Level Action is BCM-9 Code (X 1,000)
27.	Probability that the Organizational Level Action Requires No Repair (X 1,000)
28.	Probability that the Intermediate Level Action Requires No Repair (X 1,000)
29.	Post-Maintenance Test Flight Requirement Code (0 = No, 1 = Yes)
30.	Probability of being Throwaway Item at the Organizational Level (X 1,000) (Cyclic Ops)
31.	Probability that a Repair can be done on the Flight Deck (X 1,000) (Cyclic Ops)
32.	Probability that In-Cycle Flight Deck Maintenance can be Performed (X 1,000) (Cyclic Ops)

TABLE 3 (Cont'd)

Description of Matrix Library Inputs

Column Number	Description
33.	Cannibalization Susceptability Flag
34.	Not Available for Cannibalization Flag
35.	Initially Outfitted Spares
36.	Primary EOC Code for a R/R Discrepancy
37.	Secondary EOC Code for a R/R Discrepancy
38.	Probability that a R/R Discrepancy will have the Primary EOC Code When Received (X 1,000)
39.	Probability that a R/R Discrepancy will have the Secondary EOC Code When Received (X 1,000)
40.	Probability that a R/R Discrepancy will have the A00 EOC Code When Received (X 1,000)
41.	Probability that a R/R Discrepancy with the A00 EOC Code When Received will take on the Primary Subsystem EOC Code In-Work (X 1,000)
42.	Primary EOC Code for a RIP Discrepancy
43.	Secondary EOC Code for a RIP Discrepancy
44.	Probability that a RIP Discrepancy will have the Primary EOC Code When Received (X 1,000)
45.	Probability that a RIP Discrepancy will have the Secondary EOC Code When Received (X 1,000)
46.	Probability that a RIP Discrepancy will have the A00 EOC Code When Received (X 1,000)
47.	Probability that a RIP Discrepancy with the A00 EOC Code When Received will take on the Primary Subsystem EOC Code In-Work (X 1,000)

Since the MXLIB values were intended to represent only unscheduled maintenance tasks, the S-3A data was processed using data documented only on the VIDS/MAF record types A & B and with a transaction code beginning with a 1,2 or 3. Having established this groundrule, all of the parameters that could be generated using the 3-M data, were computed using a series of equations. A summary of the appropriate equations used to define the elements of the matrix library is shown in Table 4.

A Hard Copy of the final S-3A matrix library is provided in Appendix B. This matrix library can be exercised using the original Version 5 Mod 3 source program with the latest errata deck.

TABLE 4

Derivation of Matrix Library Inputs

COLUMN	DERIVATION
1-3	FIVE-DIGIT WORK UNIT CODE USING CODING PROCEDURES DESCRIBED IN CASEE SOURCE PROGRAMS
4	$\frac{\text{TOTAL O-LEVEL MA WITH WDCs H \& K}}{\text{TOTAL GROUND CREW INSPECTIONS}} \times 10{,}000$
5	$\frac{\text{TOTAL O-LEVEL MA WITH WDCs A, B, \& E}}{\text{TOTAL AIR CREW INSPECTIONS}} \times 10{,}000$
6	$\frac{\text{TOTAL O-LEVEL MA WITH WDC F, G, J, L, P, Q, R, S, U, V, W, \& X}}{\text{TOTAL DAILY INSPECTIONS}} \times 10{,}000$
7	$\frac{\text{TOTAL O-LEVEL MA WITH WDCs M \& N}}{\text{TOTAL PHASE INSPECTIONS}} \times 10{,}000$
8	$\frac{\text{TOTAL O-LEVEL MA WITH WDC Y}}{\text{TOTAL O-LEVEL RECORDS WITH ATC R}} \times 10{,}000$
9	$\frac{\text{TOTAL O-LEVEL MA WITH WDCs C \& D}}{\text{TOTAL FLIGHT HOURS}} \times 10{,}000$
10	NOT USED
11	$\frac{\text{TOTAL O-LEVEL MA WITH WDC C}}{\text{TOTAL O-LEVEL MA WITH WDCs C \& D}} \times 1{,}000$
12	THE WORK CENTER CODE WITH THE HIGHEST NUMBER OF O-LEVEL RECORDS PROCESSED
13	$\frac{\text{TOTAL O-LEVEL MAN-HOURS AGAINST ALL ACTIONS}}{\text{TOTAL O-LEVEL ELAPSED TIME FOR ALL ACTIONS}} \times 1{,}000$
15	$\frac{\text{TOTAL O-LEVEL RECORDS PROCESSED BY OTHER THAN PRIMARY WORK CENTER}}{\text{TOTAL O-LEVEL RECORDS PROCESSED BY ALL WORK CENTERS}} \times 1{,}000$
16	THE WORK CENTER CODE WITH THE SECOND HIGHEST NUMBER OF O-LEVEL RECORDS PROCESSED
19	THE WORK CENTER CODE WITH THE HIGHEST NUMBER OF I-LEVEL RECORDS PROCESSED
20	$\frac{\text{TOTAL I-LEVEL MAN-HOURS FOR ALL ACTIONS}}{\text{TOTAL I-LEVEL ELAPSED TIME FOR ALL ACTIONS}} \times 10$
22	$\frac{\text{TOTAL O-LEVEL ELAPSED MAINTENANCE TIME FOR ALL RECORDS}}{\text{TOTAL O-LEVEL ITEMS PROCESSED}} \times 10$

TABLE 4 (continued)

Derivation of Matrix Library Inputs

COLUMN	DERIVATION
23	$\frac{\text{TOTAL I-LEVEL ELAPSED MAINTENANCE TIME FOR ALL RECORDS}}{\text{TOTAL I-LEVEL MA}} \times 10$
24	$\frac{\text{TOTAL O-LEVEL MA WITH ATC R}}{\text{TOTAL O-LEVEL RECORDS WITH ATCs A, B, C, J, K, P, Q, R, Y, \& Z}} \times 1{,}000$
25	$\frac{\text{TOTAL I-LEVEL RECORDS WITH ATC BCM 1-8}}{\text{TOTAL I-LEVEL RECORDS EXCLUDING ATCs D, E, L, N, \& ZERO}} \times 1{,}000$
26	$\frac{\text{TOTAL I-LEVEL RECORDS WITH ATC BCM 9}}{\text{TOTAL I-LEVEL RECORDS EXCLUDING ATCs D, E, L, N, \& ZERO}} \times 1{,}000$
27	$\frac{\text{TOTAL O-LEVEL RECORDS WITH ATC A}}{\text{TOTAL O-LEVEL RECORDS WITH ATCs A, B, C, J, K, P, Q, R, Y, \& Z}} \times 1{,}000$
28	$\frac{\text{TOTAL I-LEVEL RECORDS WITH ATC A}}{\text{TOTAL I-LEVEL RECORDS EXCLUDING ATCs D, E, L, N, \& ZERO}} \times 1{,}000$
29	NOT INITIALIZED
31	NOT INITIALIZED
32	NOT INITIALIZED
33	ZERO, IF TOTAL O-LEVEL ACTIONS WITH ATCs T GREATER THAN ZERO, 1 IF ATCs T EQUAL TO ZERO
34	NOT INITIALIZED
35	NOT INITIALIZED
36	THE EOC CODE WITH THE HIGHEST NUMBER OF O-LEVEL RECORDS (ATC R) PROCESSED
37	THE EOC CODE WITH THE SECOND HIGHEST NUMBER OF O-LEVEL RECORDS (ATC R) PROCESSED
38	$\frac{\text{TOTAL NUMBER OF O-LEVEL RECORDS (ATC R) AGAINST PRIMARY SUBSYSTEM EOC CODE}}{\text{TOTAL NUMBER OF O-LEVEL RECORDS (ATC R)}} \times 1{,}000$
39	$\frac{\text{TOTAL NUMBER OF O-LEVEL RECORDS (ATC R) AGAINST SECONDARY SUBSYSTEM EOC CODE}}{\text{TOTAL NUMBER OF O-LEVEL RECORDS (ATC R)}} \times 1{,}000$
40	$\frac{\text{TOTAL NUMBER OF O-LEVEL RECORDS (ATC R) AGAINST SUBSYSTEM EOC CODE 'A00' WHEN RECEIVED}}{\text{TOTAL NUMBER OF O-LEVEL RECORDS (ATC R)}} \times 1{,}000$

TABLE 4 (continued)

Derivation of Matrix Library Inputs

COLUMN	DERIVATION
41	$\frac{\text{TOTAL NUMBER OF O-LEVEL RECORDS (ATC R) WITH 'A00' EOC CODE-WHEN RECEIVED THAT CONVERTED TO THE PRIMARY EOC CODE IN WORK}}{\text{TOTAL NUMBER OF O-LEVEL RECORDS (ATC R) WITH 'A00' EOC CODE WHEN RECEIVED}} \times 1{,}000$
42-47	SAME AS EQUATIONS USED FOR COLUMNS 36-41 RESPECTIVELY EXCEPT USING ATC OTHER THAN R
48	NOT INITIALIZED
49	NOT INITIALIZED
50	NOT INITIALIZED

VERIFICATION

The need to provide the user community and other interested observers with the assurance that a simulation will accurately portray the "real world," is as an ever present committment that must be met by those engaged in simulation model development. In verification tasks involving the CASEE model enhancement to date, a consistent approach has been followed for several years. The two elements employed in this approach are functional logic checks and where possible a numerical validation. While these two verification elements are certainly valid and will be utilized for the speedup and SCIR enhancements described in this report, they will not be stressed as heavily as in previous enhancement efforts. The fact that both of these enhancements have been successfully accomplished in Version 5 has been adequately proven. By integrating the V/STOL, multiship attributes of Version 4 into Version 5, the modification of the existing speedup and SCIR logic is minimized. Verification that these enhancements are statistically valid and will perform as designed will not be necessary, for this has already been verified in Version 5. Rather, the verification process simply showed that these enhancements have been properly integrated with the new V/STOL multiship logic. Functional logic check that compare those functions on the original listing being modified with the final listing configuration has shown that all needed changes have been accomplished and therefore provided a partial verification of the enhancements.

To verify that the data in the Version 5 prototype database (S-3A data) is properly generated, a series of extensive manual checks were performed to test the agreement between the raw data and the MXLIB values. The checks were accomplished by sampling several WUCs and manually computing the necessary information, using an appropriate data dump of the NAMSO tape and comparing it with the MXLIB values. No differences between calculations using the raw data and the MXLIB data were encountered. This lengthy verification check provided the needed experience relative to the aircraft reliability, maintainability and supportability characteristics. As a final test on the S-3A matrix library, a GPSS utility program was created to make additional checks of the library to ensure that it can be compiled and run with CASEE without any errors. This was needed to convert for deficiencies in the raw data and to define additional data elements not available in the 3-M data.

SUMMARY

The enhancements developed under this contract have accomplished the desired preliminary results. Initial steps toward developing a CASEE version which combines the features of two previous versions has been completed. It is believed that this effort will provide for easier configuration management by the CASEE developer and provide CASEE users with the flexibility to simulate dispersed and non-dispersed configurations with relative ease and minimum changes.

The creation of the S-3A matrix library, also accomplished under this effort, demonstrated that 3-M data can be processed to create a matrix library file which is compatible with the Version 5 model. This data base could be used to exercise and debug the model during the test & development phase of future model enhancements efforts.

CONCLUSION

The versatility & efficiency of the CASEE model have been considerably enhanced by this effort. However, the additional enhancements identified in this report should be pursued at the earliest possible date.

RECOMMENDATIONS

It is recommended that additional enhancements be developed and incorporated into the model at the earliest possible date. It is also believed that additional efforts to refine and perform additional testing to the Version 6 model is warranted. It is recommended that all appropriate CASEE users exercise this version as much as possible. Increasing use of this model by the user community will substantially reduce the total time that is required to completely debug this version.

It is further recommended that the following enhancement candidates be implemented. These enhancements respond to recently identified and growing needs by both current users as well as prospective first time users to benefit from the CASEE model. The following efforts will significantly increase the utilization of the model as well as provide an incentive to potential users in applying this model to generate significant fleetwide benefits.

- Prepare CASEE User Reference guides to supplement the currently available annotated CASEE listing.
- Generate additional CASEE compatible data bases for major Weapon Systems such as the F-14, A-7E, A-6E, E-2C, etc. for use by the Navy community.
- Perform general updating on current versions as required to reflect Navy policies and procedures.

APPENDIX A

DESCRIPTION OF CASEE VERSION 6 MOD 0 INPUT AND OUTPUT MATRICES

(PROVIDED UNDER SEPARATE COVER)

APPENDIX B

CASEE S-3A MATRIX LIBRARY PRINTOUT

(PROVIDED UNDER SEPARATE COVER)

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FILM