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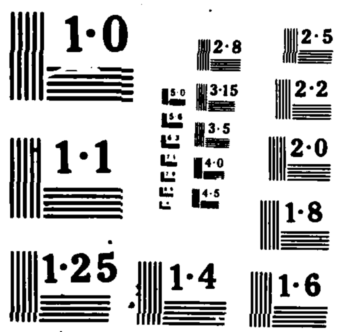

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AN ANALYSIS OF AIRCREW RATIOS IN STRATEGIC AIRLIFT -- A SLAM SIMULATION

THESIS

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A SLAM SIMULATION

THESIS

Presented to the Faculty of the School of Engineering

of the Air Force Institute of Technology

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In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Operations Research

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Preface

The purpose of this study was to develop a simulation model for helping Air Force decision makers to choose optimal ratios of aircrews to aircraft. The immediate need for this model is in evaluating crew ratios for MAC's new airlifter, the C-17; but the approach should be valid for any strategic airlift aircraft.

The model primarily measured four attributes: aircraft utilization rate, average monthly flying time, average work month, and average time away from home station. Second order regression equations were also derived as estimators of the first three of these measures.

Sensitivity analysis was performed on various crew ratios, target utilization rates, flying time limits, and staging policies. The results seemed plausible, but analysis should continue. The study could be of significant value to planners at HQ MAC and the Air Staff.

In performing the modeling, experimentation, and writing of this thesis, I had a great deal of help from others. I am deeply indebted to my faculty advisor, Lt Col Charles Ebeling, for his continuing patience and assistance. His high standards and insistence on an operationally useful model has set an ideal for future studies. I also wish to thank Capt David Tate at Studies and Analysis and Maj Wayne Stanberry and Maj Glen Moses at HQ MAC for assistance throughout the project. Finally, I wish to thank my wife, Linda, and daughters for their understanding and concern during the entire eighteen months at AFIT.

Brian L. Sutter

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Abstract

This investigation examined the C-17's mission capability in terms of each aircraft's utilization and that utilization's effect on the aircrew. Specifically, average monthly flying times and average work months, as well as aircraft utilization, were found to be affected by changes in flying time limits, staging policies, target utilization rates, the number of crews, and the launch reliabilities.

The analysis was accomplished through a SLAM simulation of a portion of the MAC airlift system. A single homestation and two homestations were modeled; however, only the single homestation model was analyzed. The output of the simulation was regressed to yield an estimating equation for achieved utilization, average monthly flying time, and average work month for both a NATO and a SWA scenario.

Parameters varied in the sensitivity analysis were crew ratios, target utilization, monthly and quarterly flying limits, and staging policies. Results pointed toward 4.8 crews per C-17 without considering the cost tradeoffs. Staging one crew at an enroute base for every forty-five planned mission transits seemed to be optimal. The results also showed a significant benefit in the sustained phase when the 30/90 day limits were raised to 150/450 hours.

I. Introduction

General Issue

The Air Force doctrine states that the United States Air Force "must be able to surge and expand to any part of the globe within hours" (8:5). In order to accomplish this mission, Military Airlift Command (MAC) plays a vital role -- that of transporting the troops and equipment. If this mission can be accomplished with one less crew per aircraft, MAC can save approximately $1.526 billion (17). This, in fact, was the justification in the 1985 budget process for funding a 4.0 crew ratio for the new C-17 as opposed to the proposed 5.0.

HQ MAC and Air Force Studies and Analysis need a model for determining mission capability given the number of authorized crews and the impact of changing that number. They need a model that is capable of answering such "What if?" questions as: What is the impact on aircraft utilization if monthly and quarterly flying time limits are raised?

Objectives

The purpose of this research is twofold: 1) to provide a prediction equation that will give decision makers a quick answer as to the utilization rates of their aircraft that can be expected given certain system characteristics, and 2) to provide a model that can show, in a dynamic manner, results when parameters are varied and is flexible enough to be applied to various aircraft and/or scenarios.

Air Staff and HQ MAC planners do not currently have an adequate, portable (capable of being used at more than a single location) methodology for assessing mission capability. This study will address the capability of MAC to accomplish its mission given a specific scenario and associated aircrew, aircraft, and system characteristics.

In order to make this determination, the following subsidiary questions must be answered:

1. How does an aircraft flow through the airlift system?
2. How does an aircrew flow through the airlift system?
3. What input parameters need to be considered in determining aircrew ratios?

Scope and Limitations

This study will address MAC's intertheater (between theater) airlift. The specific aircraft referenced will be the C-17, although it could be any aircraft currently in the Air Force inventory or a future acquisition, assuming its characteristics are known.

MAC plans for two different types of contingencies, surge and sustained, each lasting forty-five days. Typically, sustained operation has driven the crew ratios because of the high utilization rates, maintenance "catch up" from surge, and tired aircrews. Recently, concern has also been increasing over peacetime capability and transition into surge. This study will model forty-five days of both surge and sustained as well as forty-five days of peacetime operation.

To maintain a manageable model, only major factors will be addressed. Air refueling will not be addressed to reduce scenario complexity and because SAC support is uncertain at this time. Secondly, degradation due to chemical warfare will not be addressed. Third, local, test, and ferry flights will not be included for simplicity and also because they did not affect results of a previous study (11:44). Finally, integral crews will be maintained to avoid a complex scheduling algorithm on the front end of the model. Integral crews and additional assumptions associated with the input data will be discussed in Chapter II.

Historical Background

Making credible minimum cost estimates of the productivity of the airlift force demands having the minimum number of aircrews per aircraft (aircrew ratio) that still allows the mission to be accomplished.

The primary reason for minimizing aircrew requirements is money. A Government Accounting Office report to Congress illustrates this fact:

> A reduction of the aircrew ratio of 3.25:1 to 3:1 crews per aircraft for the C-5, and 4:1 to 3:1 aboard the C-141 would trim AF funding requirements by as much as $105 million for the airlift forces if only active duty crews were cut and $66 million if only reserve personnel were cut. (3:4)

Aircrew ratios are used not only in the budgeting process, but also in evaluating wartime requirements, squadron manning, crew welfare, tolerable workloads, and mission effectiveness.

An Air Force-wide conference was held at the Pentagon 18-20 March 1985 to discuss the uses of aircrew ratios, the multitudes of approaches for determining these ratios, and command responsibilities. The conference concluded that the aircrew process is a MAJCOM responsibility. They recommended a detailed analysis of both wartime and peacetime mission taskings as a start. Then, with whatever methodology is appropriate, the commands should justify the aircrew ratios, new or revised, in a Program Decision Package. Once approved, if the validated ratio is to satisfy a wartime need, the data is incorporated into the Wartime Requirements Model which studies a total force engagement. The funded ratios are then used to update peacetime rated requirements, manning levels, and budgets. They are published in AFR 173-13, US Air Force Cost and Planning Factors (4).

In 1967, General Estes, Commander Military Airlift Command, motivated MAC to formally study its aircrew manning for the first time when he stated that he did not want the future C-5's capability to be limited by aircrews (10). It was then necessary to determine the minimum crew force required to maximize the C-5's productivity. Many studies have been completed since that time.

Lockheed Corporation offered to accomplish this study for the yet unreceived C-5 at a cost of 2.5 to 6.5 million dollars. Opting for a cheaper alternative, a joint MAC / System Program Office study was begun in April 1967. The School of Aerospace Medicine (USAFSAM) became consultants on the human factors aspects in May and ultimately were given the entire project in September (10). Among their goals was to optimize the crew manning ratio, crew composition, and crew management.

The first simulation model was completed in 1969 and modified in 1974 to include isochronal (calendar based) maintenance, multiple routes, and 1973 Yom-Kippur War data.

In 1979, The General Accounting Office (GAO) had numerous criticisms. Among those were surging longer than required, unduly restricting flying hours, ignoring attrition, assuming staff duties during wartime, and not modeling transition between phases. The accusation was that "unrealistic information was fed into the model" (3). Many improvements have been incorporated since that time, but a few deficiencies still exist: transition between peace and surge and between surge and sustained has not been modeled; alert crews have not been utilized; and enroute maintenance has not been modeled. In addition, since the USAFSAM model has been revised so many times, the documentation is incomplete in some cases and voluminous in others. In fact, in June 1985, Studies and Analysis was unsuccessful in attempts to fully understand and use the USAFSAM model in-house at the Pentagon (24).

Other studies have been completed. The "TAC Flier" model (TAC's counterpart in crew ratio determination) is under revision at this time. However, because of the divergence of missions between TAC and MAC, it is unusable. For instance, in TAC all sorties return to the launching base, and in MAC the aircraft may not return for two to three weeks. The obvious place to look for a workable model is the commercial airlines whose missions are somewhat akin to MAC's. Unfortunately, the airlines contacted were reluctant to divulge proprietary information.

Analytic studies have been accomplished. Robert L. Stowell published an analytic method in 1980 that depends heavily on simulation output (23). The Center for Cybernetic Studies at the University of Texas attacked the mission planning and scheduling problems. Their algorithm starts with a solution to a linear programming problem of scheduling aircraft and then uses Bender's decomposition technique for the assignment of crews to the flight legs (1:7,13). They also showed the relationship between minimizing total completion time and its dual, a transhipment problem, that can be solved as a network (1:9). In 1966, a MAC crew ratio (MACRO) study group was formed to determine the appropriate aircrew ratios for MAC airlift. The end result was a set of regression equations with two independent variables each depending on the known quantities. The equations are still in use today for aircrew activity planning (13:44). Another result of this study group was Eq (1) for a quick guess crew ratio. It is still in use at HQ MAC plans.

$$CR = \frac{(45 \text{ days} \times \text{surge PUR}) + (45 \text{ days} \times \text{sustained PUR})}{(\text{avg. 90 day flying time}) \times (\text{percent available})} \quad (1)$$

The results of the Cybernetic study were accurate for small problems, and the MACRO equation gives a lower bound on the crew ratio. However, practical airlift problems have given rise to a "mixed integer programming problem with about 32000 constraints, 35000 linear variables (including logicals) and 10000 zero-one variables" (1:6). Because of the dynamic nature of the airlift system and the extremely large dimensions of an analytic model, simulation will be the general technique applied in this study.

Overview

The remainder of this thesis consists of four chapters. Chapter II describes the simulation model, its input data, and inherent assumptions. Chapter III contains the methodology. The experimental design, major factors, factor screening, measures of effectiveness, scenarios, and verification/validation are discussed. Chapter IV describes the results. Included are the statistical results of Analysis of Variance, regression results, and sensitivity analysis.

The final chapter, Chapter V, discusses the conclusions reached during the course of this research and recommendations for future analysis.

II. Model

The purpose of this chapter is to explain how aircraft and aircrews are modeled as they flow through the airlift system. The first section of the chapter briefly describes the SLAM simulation language. The second section gives a narrative description of the model and describes the interaction of the FORTRAN and SLAM network sections of the model. The third section discusses the input data, its sources, and the assumptions made when applying it. The final section then describes the output of the model.

SLAM Background

Rather than presenting a detailed description of SLAM, this section provides a simplified description of the language that is necessary for understanding the development of the crew ratio model. Further detail on SLAM can be found in Pritsker (20) and Banks and Carson (2).

SLAM is a special purpose FORTRAN-based simulation language which allows an event-scheduling and/or a process-interaction orientation toward modeling (2:99). The type of orientation used depends on the level of complexity needed and the extent to which the model will have to be embellished for future uses.

The event scheduling orientation concentrates on events and how they affect the states of the system. It uses a FORTRAN model to schedule events to occur at predetermined times.

The process-interaction approach concentrates on entities and the sequence of events and activities they undergo as they flow through the system. The processes are represented by the nodes and branches of a network.

The interaction of the FORTRAN and network models allows events to alter the flow of entities in the network and also allows entities in the network to initiate events in the FORTRAN model.

Narrative Description

The model developed in this research is a discrete-event network simulation employing both orientations (event-scheduling and process-interaction) to model a portion of the MAC airlift system. Fig. 2.1 shows the basic flow through the network as well as how the crews, missions, and aircraft are integrated.

The SLAM network consists of eight major sections: initialization, mission generation, crew rest, preflight, mission sortie, enroute stop, postmission, and scheduled maintenance. In addition, some events are more conveniently handled with FORTRAN interaction. Examples of these events include contingency phase changes from peace to surge and surge to sustained, alert crew regeneration, and mission cancellation. Appendix A shows a more detailed flow of crews and missions (entities) and aircraft (resources) through the system. Appendices B and C contain the SLAM and FORTRAN code respectively. Each subsection is described

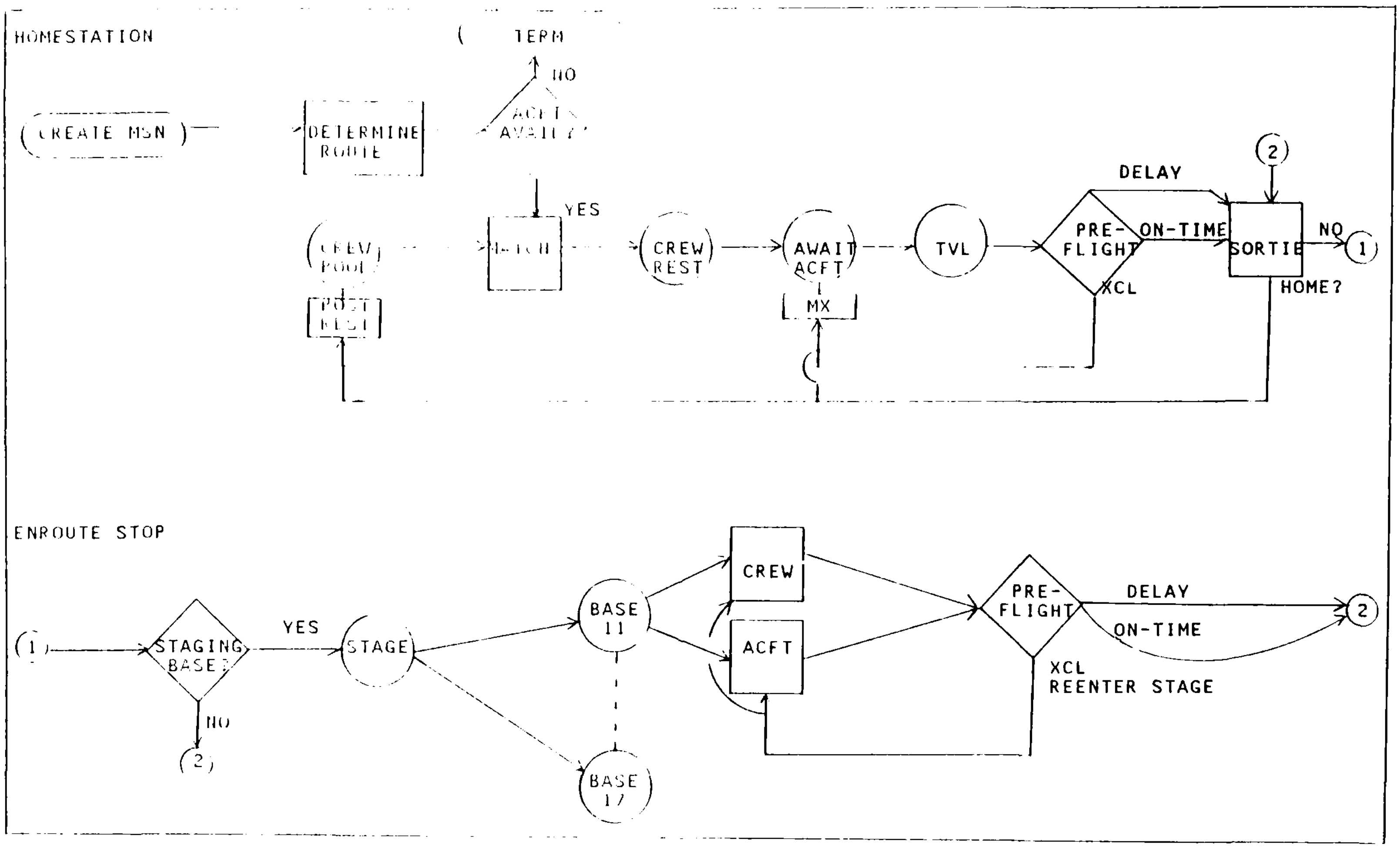

Fig. 2.1. Model Flow

below followed by a description of the input data and inherent assumptions. The time increment in the model is hours.

SLAM Network.

Initialization. In the initialization section of the SLAM model, the user defines:

1. Staging policy
2. 30/90 day flying time limits
3. Launch reliabilities
4. Percent of assigned crews that are mission capable and available
5. Ratio of crews to aircraft
6. Number of crews initially available
7. Peacetime maximum ramp time before reentering crew rest
8. Length of time within which a crew may be alerted without requiring additional crew rest
9. Number of hours after which a scheduled mission is cancelled if no crew or aircraft is available

These parameters will be described in detail later in this chapter.

Scenario data is input through an external file, "ROUTE". This file encompasses routing, scheduled flight times, scheduled ground times, whether a base is a staging location, and target utilization rates for peace, surge, and sustained operations. Appendix D shows the format for this data file.

After the scenario is established, the aircraft are created, the crews are created, and identification numbers are assigned to each crew. One crew is put in BRAVO alert status (i.e. on telephone alert and capable of launch in three hours). Incidentally, MAC's utilization of BRAVO crews is uncertain for contingency operations. Quite possibly all crews will be on telephone alert, but using one crew here is sufficient to model the effect desired. Accrued flying time is then tested and if a crew is within twenty hours of its monthly or quarterly flying time limits, it is delayed twelve hours and placed at the end of the crew pool. If a crew has exceeded either of these two limits, it is delayed twenty-four hours. These rules do not force low time crews to be scheduled first, but it does preempt high time crews.

Mission Generation. Missions are generated at a rate commensurate with the target utilization rate. For example, if the peacetime target rate is 3.5 and the expected flying time for a mission is 19.1672 hours (from the scenario), a mission would be generated every 4.381 hours as shown in Eq (2).

$$\frac{3150 \text{ hrs.}}{\text{mo.}} \div \frac{19.1672 \text{ hrs.}}{\text{msn.}} = 164.343 \text{ msns./mo.}$$

$$\frac{164.343 \text{ msns.}}{720 \text{ hrs.}} = \frac{1 \text{ msn.}}{X \text{ hrs.}} \qquad (2)$$

$$X = 4.381 \text{ hrs.}$$

These missions are assigned a mission number and are either passed to a mission pool to wait for a crew or cancelled if there are no aircraft on station or projected inbound.

Crew Rest. When a crew and mission are matched, the crew enters predeparture crew rest and waits for an aircraft. Predeparture crew rest is normally twenty-four hours waiverable to twelve. Since schedulers usually have enough notice to put the crew into crew rest earlier, this model will observe only the inviolate twelve hours. The crew is allowed one hour travel time to the base once the crew, aircraft, and mission are matched together.

Preflight. Preflight (ground) time (normally 2.3 hours) is distributed as depicted in TABLE 2.2 and will be discussed later in this chapter. Probabilities of an on-time launch, delayed launch or rescheduled launch (launch reliabilities) are as specified in the initialization section of the model.

Mission Sortie. During the flight portion, the next leg is looked at to ensure duty day limits will not be broken. If the basic sixteen hour duty day would be exceeded, the crew reenters crew rest and subroutine 'Cancel' is initiated (the FORTRAN subroutines will be defined later). The actual flying time is distributed with a triangular distribution from one-half hour early to one hour late. This variation will account for wind changes, traffic control delays, diversions, etc. At the end of each sortie, flying time is updated and the average achieved utilization rate over that phase of the conflict is computed.

Enroute Stops. At an enroute stop, unless it is a scheduled staging location, a throughflight is accomplished taking approximately 2.3 hours, and the flying phase is entered again. If the mission is at a staging location, duty day and interarrival statistics are compiled and the mission is routed to the appropriate stage base subprogram. An identical (except for statement labels and queue numbers) subprogram exists for each enroute stop in the model. The aircraft and mission are assigned to the next available crew, and the previous crew enters crew rest and subsequently enters the available pool. If a crew exceeds its 30/90 day flying time limits, that crew is transported (deadheaded) home (after a minimum crew rest) taking approximately twenty-four hours. Enroute station preflight times and launch reliabilities are obtained in a similar manner as those at home station.

Postmission. If the next station is the home base, statistics are collected on mission lengths, time away from station, average work month, and average monthly flying hours. Unscheduled maintenance is performed (normally distributed with a mean of six hours) and if scheduled maintenance is not required, the aircraft is freed for the next mission.

Scheduled Maintenance. Scheduled maintenance for the C-17 will include two days down every sixty days for a homestation check, ten days down every eighteen months for refurbishment, and thirty days down every thirty-six months for an Analytic Condition Inspection (A.C.I.) (21:3). MAC has stated that A.C.I. and refurbishment will not be accomplished during surge.

The aircraft are removed for scheduled maintenance only at home station at the completion of a mission. The frequency at which an aircraft is removed is dependent on the number of aircraft:

Homestation: 60 days x 24 hrs/NACFT

Refurbishment: 547.92 hrs (18 mos) x 24 hrs/NACFT

A.C.I.: 1095.84 hrs (36 mos) x 24 hrs/NACFT

FORTRAN Events.

Bravo. Anytime a mission is being rescheduled at home station, a check is made to see if a BRAVO alert crew is available. If so, the new crew is matched with the mission and 'Upbrav' is called to regenerate the alert crew.

Cancel. Every hour the mission pool is checked. If a mission has been scheduled for more than twelve hours (specified by user) and is still lacking a crew or aircraft, that mission is removed from the pool and cancelled.

Midup. Every twenty-four hours, the index is incremented for accumulating flying time. Since the model is concerned with quarterly flying time, the index resets to one after ninety-one. Additionally, if no flying time is flown in a particular day, the previous day's total is carried forward.

Mission. When a mission is generated, it is assigned a mission number based on its frequency of usage during the particular phase of conflict.

Next. 'Next' determines a new sortie's destination, scheduled air time, scheduled ground time, and whether the next stop is a staging location.

Stagecr. At the beginning of each phase (peace, surge, and sustained), stage crews are either positioned to or removed from staging locations. These crews are used to pick up an aircraft and mission when they transit that base allowing the previous crew to enter crew rest. The total number at each base is based on the number of missions projected to transit that location in a month. It is equal to:

$$\sum\left(\text{Route freq.} \times \frac{\text{hrs per mo}}{\text{msn exp. fly time}} \div \text{stage factor}\right) \qquad (3)$$

Once again, MAC does not have a definite staging "policy" (17). This technique (based on mission transits) was used in the USAFSAM model and appears adequate.

Surge. As surge is entered, missions are generated at a higher rate and the remainder of the reserve complement is added. MAC assumes that a full reserve complement (crew ratio equal to that of active duty) will be available during surge and sustained operations whereas only half is available during peacetime. (24) In addition, scheduled maintenance is cancelled and crew work rules are changed. Specifically, maximum ramp times and alert windows are extended to twelve hours, and post mission crew rest is reduced to twelve hours.

Sustain. After forty-five days of surge, normal work rules and scheduled maintenance are resumed. Mission frequency is also updated based on the utilization rates desired for the next forty-five days.

Upbrav. Every forty-eight hours, or when a BRAVO crew is utilized, a new BRAVO crew must be generated. If no crews are available, the next available crew assumes the duty after twelve hours of crew rest.

Upfltm. At the end of each duty day, monthly and quarterly flying times are updated.

Warmup. The simulation is assumed to reach steady-state after 600 hours. At that time, flying time, duty time, and time away from station are reinitiated to zero to force the statistics to apply only to the current phase of conflict. Warmup is discussed further in Chapter III.

Window. Every hour, all crew pools (at home and enroute) are checked for the length of time they have been legal for alert. If this user specified limit is exceeded, the crew reenters crew rest and the mission goes to the next available crew.

Input Data and Assumptions

Previous models of this type have become so complicated that they are virtually unintelligible. To help reduce the complexity of this model, many assumptions have been made at the outset. Factors shown previously to be of little importance are omitted or aggregated. Historical C-141 experience was used with adjustments for a C-17 contingency environment. Note, however, that the computer code can be modified if future analysis suggests revision. In other words, initiating the model with different input values is easy in the initiation section of the SLAM portion, whereas a change in logic would require computer code revision.

A major assumption has to do with diversions. All missions will start and terminate at their home bases. Diversions and their subsequent rescheduling are difficult to plan for and model accurately. Their effect overall (except possibly some inefficiency) should average out as the cargo has the same ultimate destination.

Another parameter, attrition, will not be modeled. Traditionally, it has not been modeled in MAC studies because it is assumed that it will only affect Backup Inventory Aircraft (BIA) and not impact the Primary Assigned Aircraft (PAA) (22). In addition, losing a PAA aircraft improves the crew ratio unless replaced with a BIA. The system would then have more aircrews per aircraft to accomplish the same mission. Thus, the assumption is a conservative one.

Augmented crews (additional crewmembers added to a crew for air refueling or to lengthen the crew duty day) will not be considered. This is necessary in order to maintain an integral crew as an entity. Integral crews are not used in MAC, but treating them that way allows for easier bookkeeping and a way to aggregate many schedule related parameters such as illnesses and emergency leave (incorporated in percent of crews available). This assumption should have little effect as augmented crews put an additional resource requirement on schedulers, and this extra burden would be offset with the added scheduling flexibility of non-integral crews. It is also a reasonable assumption since crews are generally not split up once they leave homestation, and quite often crews are rescheduled together during heavy flying activity.

In this model, peacetime is treated the same as wartime in many respects. MACR 28-2 states that no formal training will be conducted during contingencies (7:12), and ordinary leave will be suspended at least through the third month of a general war (7:33). Obviously, during peacetime these two factors play a role but the benefits gained by adding the scheduling algorithm alluded to early in this chapter are not worth the costs of the additional run time. Also, thus far at the Air Staff, peacetime capability is not as important as the transition from peacetime to surge. The important thing is that the drivers of MAC's capability (surge and sustained) are not affected by the peacetime simplification.

HQ MAC and MAC Numbered Air Forces have waiver authority over many aircrew restrictions such as length of crew rest, flying time limits, duty day limits, etc. (6:4-1).

This model will be capable of addressing these waivers, but the only ones that will specifically be addressed in the analyses are the 30 and 90 day flying time limits.

Engine running on/offloads (ERO's) will not be considered directly. Their reduced ground times would definitely impact the model output, but a definite MAC policy does not exist for their utilization. Scheduled ground time will be varied in the model which will measure the effect of the reduced ground time.

All missions are assumed to have the same priority. In peacetime, this is definitely not the case. For instance, nuclear airlift missions and exercise missions have priority over static displays. But during wartime, it is realistic to assume approximately equal priority for all missions.

Input data carries with it many of these assumptions. It falls into two categories, crew related and system related. Some are stochastic, and others are set by policy. TABLES 2.1 and 2.2 below summarize the data and its origin (excluding the experimental factors which will be covered in detail in the next chapter). Lack of a source indicates that the value is based on personal experience.

Output

Appendix E contains excerpts of the output generated by this simulation. Four measures of effectiveness will be discussed in the next chapter: achieved aircraft utilization, average work month, average monthly flying hours, and

TABLE 2.1

Crew Related Characteristics

Parameter	Value	Source
Alert Window	Peace: 6 hrs. Surge & sustained: 12 hrs.	MACR 55-1
Predeparture Rest	12 hrs. inviolate	MACR 55-141
Enroute Rest	UNFRM(13,14) 12 hrs. min. + 1 hr. tvl + post msn duties	-----------
Post mission Rest	12 hrs. if gone < 36 Time gone ÷ 3 < 72	MACR 55-141
Crew Duty Day	16 hrs.	MACR 55-141
Max Ramp (before crew rest)	Peace: 6 hrs. (4 by reg. + 2 ground time) Surge & sustained: 12 hrs.	MACR 55-1
Deadhead Time (back home)	RNORM(24,3)	-----------

TABLE 2.2

System Related Characteristics

Parameter	Value	Source
Sched. Maintenance	H.S.C.: RNORM(48,1) Refurb: RNORM(240,5) A.C.I.: RNORM(720,10)	C-17 Ute Rate Staff Study
Max. Resched. Delay	12 hrs.	USAF/SAGM
Ground Time (on-time)	UNFRM(2.0,2.3)	HQMAC/LG
Ground Time (delay)	UNFRM(2.3,Max ramp)	(29 mos C-141)
Ground Time (2nd crew)	EXPON(3.3) incl. travel	
Enroute Gnd (on-time)	UNFRM(Sched-.5,Sched+.2)	
Enroute Gnd (delay)	UNFRM(Sched+.2,Max ramp)	
Ground Time (resched)	TRIAG(Max ramp-2,Max ramp)	
MX After Cancel	UNFRM(3,12)	-----------
Number Aircraft	30	USAF/SA

time away from station. In table and graphical format, these measures are compiled every five days for the peacetime, surge, and sustained phases. This makes trend analysis very easy.

Besides the primary MOE's, statistics are gathered on the number of crews at home station, number of mission capable aircraft, duty days, mission lengths, overall flying times, cancellations, and enroute station interarrival times. In addition, statistics are generated for every queue (file), activity, and type of resource in the model.

Not all of these statistics are used in this analysis, but the advantage of having them all printed out is their availability for any "after the fact" analysis that may be requested by the users. They also serve a valuable purpose in model validation (discussed in Chapter III).

III. Methodology

This chapter discusses the tactics and strategy followed in running the simulation model. The objective is to answer the last of the research questions: What input parameters need to be considered in determining aircrew ratios? In answering this question the model validity will be established as well as its best use. Included in the chapter is a discussion of the warmup period, the experimental factors, the primary measures of effectiveness, model validation/verification, and the experimental design.

Warmup and Phase Transition

Pilot simulation runs indicated that it took approximately six hundred hours for the aircrew distribution, utilization rates, etc. to stabilize. Therefore, a warmup period of six hundred hours is added to the front end of the simulation to reach steady state.

Surge and sustained operations never reach steady state, which is typical of short real world conflicts. This transition period is a very complex issue.

> The inherent variables pose questions such as: does warning time permit gradual buildup or require a prompt response; are we in a normal peacetime operation, standing down in preparation, or operating at a higher than normal level; are reserves mobilized at once or only after the situation worsens, and how many days does it take to make the decision to mobilize? (Response to GOA) (17)

The model developed in this research balances these issues. Stage crews are positioned instantaneously simulating strategic warning and time to build up. Reserves are mobilized at the beginning of surge; and at the same time, activity rate is increased.

Experimental Factors

Anyone with knowledge of MAC's worldwide airlift system could list hundreds of factors that could influence the number of crews required to accomplish the mission. Reducing this list of factors to the most significant ones results in a simpler model. A simpler model is less expensive and allows for a more thorough analysis of the most significant factors. It requires fewer inputs, is easier to document and interpret, and facilitates transfer from one computer to another or incorporation into a larger system.

Based primarily on personal experience, eight factors are investigated in the experimental design. Other factors in the model are assumed either to be less subject to change or are such that changes in them would not significantly alter the final results. The eight factors are discussed below and summarized in TABLE 3.1.

a) Staging Policy. Staging policy is based upon the number of staging transits of a base. A MAC policy does not exist for staging its aircrews, however the USAFSAM study indicated that staging policy was a significant factor with the optimal near 45 (i.e., stage a crew for every 45 transits in a month).

TABLE 3.1

Experimental Factors

Factor	Range
a) Staging Policy	30 to 60
b) 30/90 Day Fly Limits	125/330 to 150/450
c) Target Ute. Rates (peace/surge/sustained)	3.5/15.1/13.4 to 4.5/16.1/14.4
d) Percent of Crews Available	.80 to .90
e) Crew Ratio	4.0 to 5.0
f) Launch Reliability (on-time/delay/reschedule)	.948/.044/.008 to .955/.044/.001
g) Ground Time	2.1 to 2.3
h) Scenario	NATO to S.W. Asia

b) Monthly and Quarterly Flying Time Limits. During periods of heavy flying, the monthly and quarterly flying time limits are often scheduling limitations. USAF/SA is presently studying a proposed change to AFR 60-1, changing the present limits of 125/330 to 150/450 hours per month and quarter respectively (24).

c) Target Aircraft Utilization Rates. L.K. McSemann,II, Acting Assistant Secretary of the Air Force for Research, Development, and Logistics, has directed the Air Force to use the design utilization rates of 13.9 hours per day sustained and 15.6 hours per day surge for all systems comparisons (21:2). This study will vary these numbers by 0.5 hours on either side. The 4.0 peacetime rate was suggested by Studies and Analysis (24).

d) Percent of Crews Available. HQ MAC uses a .90 crew mission capable rate (per manpower directives) for most studies (22). Considering essential wartime additional duties and crew management inefficiencies, this value will be ranged between .80 and .90. It will take into account crewmembers in pipeline training, sick, on emergency leave, or committed to other duties.

e) Crew Ratio. The ratio of assigned crews to each aircraft will range from 4.0 to 5.0. 4.0 is the current ratio for C-141 crews. 5.0 is the proposed C-17 ratio needed to fill our airlift shortfall. Realistically, the required ratio will fall somewhere in-between.

f) Launch Reliability. Analyzing two years of C-141 data gives an average on-time (0.2 hrs. before scheduled to 0.3 hrs. after) departure reliability of 0.948 at home and 0.955 enroute, with the probabilities of having to be re-scheduled equal to 0.008 and 0.001 respectively (12). These figures include local training flights which this model ignores. Also, even though maintenance reliability for the C-17 should be greater, supply, refueling, passenger processing, etc. will hold the rates down. It should be noted that a pilot run showed significance in this small range.

g) Ground Time. Scheduled ground time for C-141's and C-17's is 2.3 hours. Frequently, this time can be shortened in high threat areas with engine running on/offloads, etc. This screening will consider an average between 2.1 and 2.3.

h) Scenarios. Scenarios were suggested by USAF/SAGM. Pilot runs of multiple home base scenarios do not warrant using the expanded model for analysis. For the user's interest, Appendices F and G contain a workable multiple home base model. Asterisks indicate differences from the single base model. The screening will use two scenarios, one S.W. Asia and one NATO, each with a single home base (See Appendix H).

Measures of Effectiveness

Since the ratio of crews to aircraft is an input to the simulation, it would be nice to have the output portray a crew related statistic, a mission related statistic, and an aircraft related statistic. Achieved utilization rates (AUR) of aircraft, average flying hours per month, and mission cancellations are all useful, quantifiable measures.

Target utilization rates (TUR) are inputs to the model; so instead of analyzing just AUR, it must be analyzed with respect to the programmed target rates. Utilization rates will be measured at the end of each phase and will be the average of only that phase.

Average flying hours per month will also be measured for each phase. An alternative measure here could be the work hours per month since it is a common manpower measure.

The number of missions cancelled due to no aircraft or crew, to be consistent, will also be measured at the end of each phase.

Model Verification and Validation

Credibility is of utmost importance for a model to be considered for implementation. If the model's asumptions and logic are valid and the results have been verified, this credibility is guaranteed.

Validation will be somewhat difficult since the C-17 is not yet operational and wartime scenarios are not often tested operationally. However, the trends discovered during the analysis closely resemble the results of the USAFSAM study completed earlier this summer. For example, the peacetime achieved utilization rate (steady state) was within .2 hours of their results. The USAFSAM model measured steady state utilization rates between 11 and 15.5 hours during the surge phase and between 11 and 14 hours during the sustained phase. For the same target rates, this study found average rates of approximately 10 and 9 hours surge and sustained respectively. The lower rates are due to measuring an overall average for the phase rather than a steady state average, sacrificing some statistical robustness. An overall average seems more appropriate as realworld mission flow change during a phase and steady state is seldom reached. The lack of disparities between the models, in a sense, validates both models. In addition, Maj Wayne Stanberry, HQ MAC/XPSR, who has extensive experience both in SLAM simulations and modeling the MAC airlift system, critically reviewed the model, its assumptions, and results for face validity.

The logic has been verified primarily through periodic flow charting, concurrent debugging during the programming, pilot runs, and a SLAM TRACE option tracing missions, crews, and aircraft through the system. Assessing the reasonableness of output also helps verify the model. Partially mission capable (PMC) rate for the C-17 is guaranteed to be at least 82.5% (21). PMC in this simulation refers to any aircraft not in a preflight status or scheduled maintenance. The mean PMC rate through surge for the 64 initial screening runs was 78.223%. If the PMC aircraft in a preflight status were added, the numbers would be very close. Finally, consistency of the output was examined both over the ranges of interest and at extreme values to stress the system and check for reasonableness.

Design

The goal in the design phase is to investigate the relationships between the independent variables (factors) and the response (simulation output), determining, if possible, which factors exert the greatest effect on the response, and the extent of interaction between or among the factors. In the screening experiments, only two levels of each factor are investigated. These levels should be "far enough apart to measure anticipated effects, but not so far as to cause nonlinearities in the functional relationship to distort or mask significant effects (15:348)". This analysis will use the extreme values of the factors listed in TABLE 3.1.

TABLE 3.2

1/4 Replication of 8 Factors (9:22)

(1)	cdgh	abcg	abdh	bdefh	bcefg	acdefgh	aef
abcfgh	abdf	fh	cdfg	acdeg	aeh	bde	bcegh
bcdeg	beh	ade	acegh	cfgh	df	abfh	abcdfg
adefh	acefg	bcdefgh	bef	ab	abcdgh	cg	dh
efgh	cdef	abcefh	abdefg	bdg	bch	acd	agh
abce	abdegh	eg	cdeh	acdfh	afg	bdfgh	bcf
bcdfh	bfg	adfgh	acf	ce	degh	abeg	abcdeh
adg	ach	bcd	bgh	abefgh	abcdef	cefh	defg

It is difficult to account for aliases in a Resolution III or IV (some or all two factor interactions confounded) design because interactions that can be ignored are not obvious. Initial screening, therefore, will assume three factor and higher interactions to be negligible and will use a 2^{8-2} or 1/4 replication of a 2^8 factorial to analyze all main factor effects and all two way interactions. This reduces the number of simulation runs from 256 for a full factorial to 64 with the fractional and also gives 27 degrees of freedom for error. The number of runs is reasonable since each run uses 2.5 minutes of C.P.U. time. The result is a Resolution V design in which no main effect or two factor interaction is aliased with any other main effect or two factor interaction.

The design chosen for screening is shown in TABLE 3.2. Small letters indicate a particular factor is at its high level. (1) indicates all factors are at their low levels. The defining contrast is I=ABCEG=ABDFH=CDEFGH. For further explanation, refer to Montgomery (14) or any Design of Experiments text.

In the second stage, the results of the initial screening were analyzed and the best set of subsequent runs chosen. It will be shown in the next chapter that two factors are insignificant and can be removed. This makes this fractional factorial design equivalent to a 2^6 full factorial. By adding center points and axial points to the original design, orthogonality and uniform precision (variance) can be maintained. To keep all observations independent in the initial screening, a different set of random number seeds was used for each run. Also for the screening, measures of effectiveness were only evaluated during surge.

IV. Analysis and Results

The goal of this chapter is to give decision makers a tool to use in determining aircrew ratios. Results of the initial screening experiment will be discussed. Then the subsequent runs, setup, and results of the regression analyses will be described. Finally, sensitivity analysis on the major factors will be presented.

Initial Screening Results

Analyses of variance were accomplished for the fractional factorial design using the BMDP2V statistical package. The data and an example input program are included as Appendix I. Analyses for three measures of effectiveness (achieved utilization rate, average work month, and average flying hours) will be discussed separately. The small number of mission cancellations eliminated cancellations from consideration.

At the 99% confidence level, there are three main effects which significantly affect achieved utilization: staging policies, flying time limits, and scenarios. These and the significant two-factor interactions are shown in TABLE 4.1. Target utilization rates, crew ratios, and ground times are not significant at this level. However, since the crew ratio is as much a determinant of the number of crews as the percentage of crews available, it has

TABLE 4.1

Analysis of Variance -- AUR

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
MEAN	6230.07312	1	6230.07312	36550.70*
STAGE	2.36165	1	2.36165	13.86*
FLYLMT	2.88767	1	2.88767	16.94*
TUR	.18953	1	.18953	1.11
PERCENT	.00396	1	.00396	.02
CR	.01747	1	.01747	.10
RELIAB	.00010	1	.00010	.00
GND	.08075	1	.08075	.47
LEGS(Scenario)	3.56454	1	3.56454	20.91*
SF	5.53338	1	5.53338	32.46*
ST	.26665	1	.26665	1.56
FT	.54438	1	.54438	3.19
SP	.02561	1	.02561	.15
FP	.04248	1	.04248	.25
TP	.03145	1	.03145	.18
SC	.04274	1	.04274	.25
FC	.00125	1	.00125	.01
TC	.00022	1	.00022	.00
PC	.01041	1	.01041	.06
SR	.04789	1	.04789	.28
FR	.00012	1	.00012	.00
TR	.18293	1	.18293	1.07
PR	3.97575	1	3.97575	23.32*
CR	.02129	1	.02129	.12
SG	.25184	1	.25184	1.48
FG	.00194	1	.00194	.01
TG	.00101	1	.00101	.01
PG	.35375	1	.35375	2.08
CG	.67867	1	.67867	3.98
RG	.04575	1	.04575	.27
SL	2.42980	1	2.42980	14.26*
FL	3.54130	1	3.54130	20.78*
TL	.01789	1	.01789	.10
PL	.20469	1	.20469	1.20
CL	.00106	1	.00106	.01
RL	.12956	1	.12956	.76
GL	.18162	1	.18162	1.07
ERROR	4.60216	27	.17045	

*-Significant at 99%

probably been masked by a higher level interaction and will not be omitted.

TABLE 4.2

Analysis of Variance -- AVGWORK

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
MEAN	1037637.62919	1	1037637.62919	37508.56
STAGE	1853.73322	1	1853.73322	67.01*
FLYLMT	525.78509	1	525.78509	19.01*
TUR	1.75561	1	1.75561	.06
PERCENT	3224.82020	1	3224.82020	116.57*
CR	12002.29767	1	12002.29767	433.86*
RELIAB	10.93956	1	10.93956	.40
GND	8.41000	1	8.41000	.30
LEGS(Scenario)	576.72047	1	576.72047	20.85*
SF	929.03049	1	929.03049	33.58*
ST	54.39063	1	54.39063	1.97
FT	52.56253	1	52.56253	1.90
SP	20.36263	1	20.36263	.74
FP	32.91892	1	32.91892	1.19
TP	33.55301	1	33.55301	1.21
SC	.71403	1	.71403	.03
FC	38.06890	1	38.06890	1.38
TC	5.88066	1	5.88066	.21
PC	81.22517	1	81.22517	2.94
SR	43.65908	1	43.65908	1.58
FR	4.54755	1	4.54755	.16
TR	29.02516	1	29.02516	1.05
PR	694.84963	1	694.84963	25.12*
CR	3.03631	1	3.03631	.11
SG	33.06250	1	33.06250	1.20
FG	1.89063	1	1.89063	.07
TG	1.48840	1	1.48840	.05
PG	12.72709	1	12.72709	.46
CG	156.25000	1	156.25000	5.65
RG	32.63263	1	32.63263	1.18
SL	1165.19811	1	1165.19811	42.12*
FL	569.29954	1	569.29954	20.58*
TL	3.25803	1	3.25803	.12
PL	15.86026	1	15.86026	.57
CL	3.36725	1	3.36725	.12
RL	21.97266	1	21.97266	.79
GL	16.56493	1	16.56493	.60
ERROR	746.92862	27	27.66402	

*=Significant at 99%

TABLE 4.3

Analysis of Variance -- AVGFLY

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
MEAN	409913.65988	1	409913.65988	33932.31
STAGE	165.25099	1	165.25099	13.68*
FLYLMT	170.43301	1	170.43301	14.11*
TUR	16.66681	1	16.66681	1.38
PERCENT	1235.69840	1	1235.69840	102.29*
CR	4652.60411	1	4652.60411	385.14*
RELIAB	.04410	1	.04410	.00
GND	4.69806	1	4.69806	.39
LEGS(Scenario)	250.03513	1	250.03513	20.70*
SF	386.51556	1	386.51556	32.00*
ST	24.42828	1	24.42828	2.02
FT	31.38806	1	31.38806	2.60
SP	1.85640	1	1.85640	.15
FP	13.56081	1	13.56081	1.12
TP	5.19840	1	5.19840	.43
SC	1.31103	1	1.31103	.11
FC	5.73604	1	5.73604	.47
TC	.61231	1	.61231	.05
PC	43.85752	1	43.85752	3.63
SR	14.47800	1	14.47800	1.20
FR	.19802	1	.19802	.02
TR	6.48975	1	6.48975	.54
PR	288.40528	1	288.40528	23.87*
CR	.00722	1	.00722	.00
SG	30.49802	1	30.49802	2.52
FG	.97515	1	.97515	.08
TG	.76562	1	.76562	.06
PG	10.85703	1	10.85703	.90
CG	63.56075	1	63.56075	5.26
RG	5.67629	1	5.67629	.47
SL	171.93766	1	171.93766	14.23*
FL	211.77522	1	211.77522	17.53*
TL	2.48062	1	2.48062	.21
PL	12.63800	1	12.63800	1.05
CL	.33931	1	.33931	.03
RL	9.81257	1	9.81257	.81
GL	9.67210	1	9.67210	.80
ERROR	326.16904	27	12.08033	

*-Significant at 99%

At the same confidence level, average work month is significantly affected by five main factors: staging policies, flying time limits, percent of crews available, crew ratios, and scenarios. These and significant interactions are indicated in TABLE 4.2. Again target utilization rates and ground times are not significant.

Factors and interactions affecting average monthly flying times are exactly the same as those affecting average work month; a somewhat intuitive result. TABLE 4.3 illustrates.

Regression Analyses

The fractional factorial design indicates that six potential independent variables explain achieved utilization rates, average work month, and average flying times. As target utilization rates and ground times are eliminated, all experimental combinations containing them are also eliminated. Thus, the 2^{8-2} fractional factorial becomes a 2^6 full factorial (15:330). Since an objective of this study is to fit second order regression equations to the data, the next logical step is to perform additional runs at other levels in order to estimate the nonlinear relationships.

Subsequent Runs. Myers suggests thirty-six additional runs, twenty-four at center points and twelve at axial points with $\alpha = \pm 2.828$ (18:153). α is the multiplying factor used to set levels for the independent variables used in estimating nonlinear relationships. These are needed, not only to generate results at intermediate levels, but to

TABLE 4.4

Composite Levels

	Low Axial	High Axial	Center
a) Staging policy	3	87	45
b) Fly time limits	102.15/220.32	172.85/559.68	137.5/390
c) Target ute.	4.0/15.6/13.9	4.0/15.6/13.9	4.0/15.6/13.9
d) Percent avail.	.709	.991	.85
e) Crew ratio	3.086	5.914	4.5
f) Launch reliab	.942/.044/.014	.962/.038/0	.952/.044/.004
g) Ground time	2.1	2.1	2.1
h) Scenario	NATO	SWA	NATO, SWA

maintain an approximately orthogonal and uniform precision design. Orthogonality will give enhanced meaning to the regression coefficients in the next section (i.e. uncorrelated estimates), and uniform precision (rotatability) ensures uniform variance in the responses. In addition, the replicated center points allow an evaluation of the appropriateness of the equations (18:153).

The factor levels for these subsequent runs are listed in TABLE 4.4. Five of the six main factors (all except scenario) have quantitative midpoints. To account for the sixth factor, twelve center points will be run for each of the two scenarios. The axial levels can be computed using Eq (4) with α=2.828.

$$e_i = \pm 2.828(.5)d_i + \bar{e}_i \qquad (4)$$

where d_i=difference between high and low levels

$\bar{e}_i$=midpoint between high and low levels

Additionally, levels for the deleted factors (ground times and target utilization rates) must be preset. Since intuition suggests that target utilization rates should be significant, they were set at an intermediate level. Ground time was set at 2.1 hours arbitrarily.

Regression Results. The regression equations presented in this section will enable a decision maker to give initial capability estimates of the achieved utilization rates, average work months, or average monthly flying times given values for the input values.

A problem with including data from axial input values is the extreme responses (outliers) that sometimes arise, as is the case here. Referring to TABLE 4.4, staging policy and flying time limits are well outside the range of interest. For this reason, those observations will not be included in the regression analyses. Other potential outliers were investigated for accuracy but were not eliminated. The reason axial results were not eliminated completely was to maintain a higher degree of uniform precision and orthogonality. This study did conduct analyses without the axial points for comparison's sake; the results were better in some cases and worse in others (not included).

Stepwise regression analyses were performed with BMDP9R using adjusted squared multiple correlation ($\bar{R}^2$). This method recognizes the tradeoff between additional degrees of freedom and the reduced variance associated with adding another variable. It is analogous to minimizing the residual mean square which enhances the predictive capability

(25:179). Separate regression analyses were performed for each scenario to study differences. Appendix J contains the axial and centerpoint data, an example input program, and output from BMDP9R. Analyses of residual plots, scatter plots, and correlation matrices did not show any marked deviations from the model assumptions. The coefficients in the equations on the following pages (TABLES 4.5-4.7) have been decoded to correspond to real data values as opposed to those coded for design matrix values of -1, 0, and 1 found in the appendix.[1] Separate equations are shown for peace, surge, and sustained because of the changes in target utilization from one phase to another; but, they did come from the same regression model. Interactions, where one factor level is dependent on the level of a second factor, can be represented by a cross product term (i.e. multiplying the level of the first term by that of the second). TABLE 4.8 shows the allowable ranges for the parameters.

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[1] Design matrix values are obtained from $x_i = 2(e_i - \bar{e}_i)/d_i$, where d_i is the difference between high and low levels and $\bar{e}_i$ is the mean. The coefficients in Appendix J, C_i, are in terms of x_i. To translate: $C_i x_i = C_i 2(1/d_i)(e_i - \bar{e}_i) = C_i(2/d_i)e_i - C_i(2/d_i)\bar{e}_i$. $C_i' = C_i(2/d_i)$ and $\beta_0 = \beta_0 - \Sigma C_i(2/d_i)\bar{e}_i$.

TABLE 4.5

Regression Results -- Average Work Month

Peacetime AVGWORK (SWA) = 258.77389-.64325(STAGE)-29.4086(CR)
+.4679(FLYLMT)-139.162(PERCENT)+140.55391(PERCENT*RELIAB)
+.4066667(CR^2)-1.8291225(TUR^2)

Peacetime AVGWORK (NATO) = 377.60656-.0743333(STAGE)-28.1394(CR)
-151.7312(PERCENT)+4.5602($PERCENT^2$)+.3387133(CR^2)-.[illegible](TUR^2)

Surge AVGWORK (SWA) = 347.26515-.64325(STAGE)-29.4086(CR)+.4679(FLYLMT)
-139.162(PERCENT)+140.5539(PERCENT*RELIAB)+.406667(CR^2)-.4690058(TUR^2)

Surge AVGWORK (NATO) = 392.43066-.0743333(STAGE)-28.1394(CR)
-151.7312(PERCENT)+4.5602($PERCENT^2$)+.3387133(CR^2)-.0822487(TUR^2)

Sustained AVGWORK (SWA) = 330.84145-.64325(STAGE)-29.4086(CR)
+.4679(FLYLMT)-139.162(PERCENT)+140.5539(PERCENT*RELIAB)
+.4066667(CR^2)-.5257662(TUR^2)

Sustained AVGWORK (NATO) = 390.25194-.0743333(STAGE)-28.1394(CR)
-151.7312(PERCENT)+4.5602($PERCENT^2$)+.3387133(CR^2)-.09[illegible](TUR^2)

Statistics	SWA	NATO
Squared Multiple Correlation	.92566	.98776
Multiple Correlation	.96[illegible]	.99386
Adjusted Squared Mult. Corr.	.91273	.98538
Residual Mean Square	35.401571	3.805333
Standard Error of Est.	5.949922	1.950726
F-Statistic	78.11	417.70
Numerator Degrees of Freedom	7	8
Denominator Degrees of Freedom	42	41
Significance (Tail Prob.)	.0000	.0000

TABLE 4.6

Regression Results -- Average Fly Time

Peacetime AVFLTM (SWA) = 161.94887-.216396(STAGE)-18.54672(CR)
+.2760752(FLYLMT)-84.816(PERCENT)+90.609496(PERCENT×RELIAB)
+.2452822(CR^2)-1.58227(TUR^2)

Peacetime AVFLTM (NATO) = 139.08643-17.69142(CR)-97.1856(PERCENT)
+111.346(RELIAB)+2.5706235(PERCENT^2)+.2042978(CR^2)-.3325725(TUR^2)

Surge AVFLTM (SWA) = 235.07216-.216396(STAGE)-18.54672(CR)
+.2760752(FLYLMT)-84.816(PERCENT)+90.609496(PERCENT×RELIAB)
+.2452822(CR^2)-.4057103(TUR^2)

Surge AVFLTM (NATO) = 154.45597-17.69142(CR)-97.1856(PERCENT)
+111.346(RELIAB)+2.5706235(PERCENT^2)+.2042978(CR^2)-.085275(TUR^2)

Sustained AVFLTM (SWA) = 224.72507-.216396(STAGE)-18.54672(CR)
+.2760752(FLYLMT)-84.816(PERCENT)+90.609496(PERCENT×RELIAB)
+.2452822(CR^2)-.4553295(TUR^2)

Sustained AVFLTM (NATO) = 152.19709-17.69142(CR)-97.1856(PERCENT)
+111.346(RELIAB)+2.5706235(PERCENT^2)+.2042978(CR^2)-.1957147(TUR^2)

Statistics	SWA	NATO
Squared Multiple Correlation	.90753	.99012
Multiple Correlation	.95270	.99505
Adjusted Squared Mult. Corr.	.89224	.98790
Residual Mean Square	16.890127	1.253142
Standard Error of Est.	4.107326	1.119478
F-Statistic	58.96	445.19
Numerator Degrees of Freedom	7	9
Denominator Degrees of Freedom	42	40
Significance (Tail Prob.)	.0000	.0000

TABLE 4.7

Regression Results -- Achieved Utilization Rates

Peacetime AUR (SWA) (Revised)

$$\text{Peacetime AUR (SWA)} = 2.310045 - .0157651(\text{STAGE}) + .0247301(\text{FLYLMT}) + .449596(\text{TUR}) + 8.007181(\text{PERCENT} \times \text{RELIAB}) - .1497965(\text{TUR}^2)$$

Peacetime AUR (NATO)

$$\text{Peacetime AUR (NATO)} = 1.2719897 - .79809(\text{PERCENT}) - .0039662(\text{CR}^2) - .8862156(\text{PERCENT} \times \text{RELIAB}) + 13.353543(\text{RELIAB}) - 2.8745414(\text{RELIAB}^2) + .0753974(\text{TUR}) - .0263263(\text{TUR}^2)$$

Surge AUR (SWA) (Revised)

$$\text{Surge AUR (SWA)} = 4.0174422 - .0157651(\text{STAGE}) + .0247301(\text{FLYLMT}) + .449596(\text{TUR}) + 8.007181(\text{PERCENT} \times \text{RELIAB}) - .0384094(\text{TUR}^2)$$

Surge AUR (NATO)

$$\text{Surge AUR (NATO)} = 1.6140239 - .79809(\text{PERCENT}) - .0039662(\text{CR}^2) - .8862156(\text{PERCENT} \times \text{RELIAB}) + 13.353543(\text{RELIAB}) - 2.8745414(\text{RELIAB}^2) + .0753974(\text{TUR}) - .0067503(\text{TUR}^2)$$

Sustained AUR (SWA) (Revised)

$$\text{Sustained AUR (SWA)} = 3.7643136 - .0157651(\text{STAGE}) + .0247301(\text{FLYLMT}) + .449596(\text{TUR}) + 8.007181(\text{PERCENT} \times \text{RELIAB}) - .1471059(\text{TUR}^2)$$

Sustained AUR (NATO)

$$\text{Sustained AUR (NATO)} = .4176096 - .79809(\text{PERCENT}) - .0039662(\text{CR}^2) - .8862156(\text{PERCENT} \times \text{RELIAB}) + 13.353543(\text{RELIAB}) - 2.8745414(\text{RELIAB}^2) + .0753974(\text{TUR}) - .0075755(\text{TUR}^2)$$

Statistics	SWA	NATO
Squared Multiple Correlation	.65525	.54700
Multiple Correlation	.80948	.73959
Adjusted Squared Mult. Corr.	.58427	.45560
Residual Mean Square	.064878	.010333
Standard Error of Est.	.254633	.101357
F-Statistic	9.33	6.19
Numerator Degrees of Freedom	7	8
Denominator Degrees of Freedom	34	41
Significance (Tail Prob.)	.0000	.0000

TABLE 4.8

Variable Ranges for Regressions

Variable	Definition	Range
STAGE	1 crew prepositioned for every ?? transits	30 to 60
FLYLMT	30/90 day fly limits	125*/330 to 150 /450
PERCENT	Percent of crews avail	*.80 to .90
RELIAB	Prob. of on-time, delayed or cancelled takeoff	.948*/.044/.008 to .955 /.044/.001
TUR	Peace, surge, & sustained target ute rates	3.5/15.1/13.4 to 4.5/16.1/14.4
CR	Crew ratio	4.0 to 5.0

* = Value to enter regression equation with.

The quadratic response functions for average work month and average flying time for the NATO scenario resulted in a $R^2 > .98$ and a standard error of the estimate ($MSE^{1/2}$) < 1.96. For the SWA scenario, R^2 was still over .90, but the standard error was larger (5.95 and 4.11 for average work month and flying time respectively). Thus, the predictive capability could be somewhat impaired. See TABLES 4.5 and 4.6.

R^2 for achieved utilization rates were lower (.54700 and .76544 for NATO and SWA scenarios respectively), but the standard error was less than .44 in both cases (See Appendix J). To further investigate the fit of these response functions, the center point replications were used to estimate pure error, thereby splitting the sums of squares into components. The results are shown in Fig. 4.1. This analysis indicates that the NATO regression is adequate and the SWA regression is not. In other words, the SWA numerator

SWA Scenario

$\bar{Y} = 10.35667$

$\sum(Y_i - \bar{Y})^2 = .5364667$ df = 12 - 1 = 11

MSPE = .0487697 SSE = 44(.191196) = 8.412624

SSLF = 8.412624 - .5364667 = 7.8761573 df = 44 - 11 = 33

MSLF = .2386714

F = MSLF/MSPE = 4.8938467 $F(.05;11,33) = 2.12$

Reject hypothesis of good fit.

NATO Scenario

$\bar{Y} = 9.7825$

$\sum(Y_i - \bar{Y})^2 = .167467$ df = 12 - 1 = 11

MSPE = .0152243 SSE = 41(.010375) = .425375

SSLF = .425375 - .167467 = .257908 df = 41 - 11 = 30

MSLF = .0085969

F = MSLF/MSPE = .564685 $F(.05;11,30) = 2.11$

Cannot reject hypothesis of good fit.

Fig. 4.1. Lack of Fit Analysis for AUR Response Functions

mean square is estimating something which is in excess of σ^2, the experimental error variance. This could possibly be due to higher order terms that are not included or, more likely, the small number of degrees of freedom for pure error associated with only twelve center point replications.

Further analysis of the residuals for this case (Appendix J) showed three potential outliers, cases 15, 37, and 50. Upon investigation of the simulation output, ten cases

SWA Scenario

$\bar{Y} = 10.85667$

$\sum(Y_i - \bar{Y})^2 = .5364667$ $\quad$ df = 12 - 1 = 11

MSPE = .0513334 $\quad$ SSE = 34(.064838) = 2.204492

SSLF = 2.204492 - .5364667 = 1.6680253 $\quad$ df = 34 - 11 = 23

MSLF = .0725228

F = MSLF/MSPE = 1.4870471 $\quad$ F(.05:11,23) = 2.24

Cannot reject hypothesis of good fit.

Fig. 4.2. Lack of Fit -- AUR Revised

were found where achieved utilization rate in surge had peaked out earlier in the phase and were on a downward trend when measured; the difference between the peak average and overall average was significant in eight cases. Incidentally, in the NATO scenario, three cases peaked early but only by a very small amount. Deleting these cases (3,13,24,28, 37,41,50, and 62) resulted in an adequate regression. See Fig. 4.4 for the lack of fit analysis and Appendix J for revised residual plots.

Since the equations are scenario dependent, they should only be used to approximate capability, work month, and monthly flying time. Users should keep in mind that the work month and flying time figures do not include duties or training missions at home station.

Confidence Limits. A confidence region is hard to visualize on surfaces such as these but limits could easily be placed on individual input combinations. Boundaries for a Working-Hotelling confidence region over all input combinations, X_h, are indicated in Eq (5).

$$\hat{Y}_h \pm Ws(\hat{Y}_h) \qquad (5)$$

$$\text{where } W^2 = pF(1-\alpha;p,n-p) \quad (19:244)$$

The standard error of the predicted value, $s(\hat{Y}_h)$, is available from BMDP for combinations in the experimental design. Unfortunately, the interval obtained is only valid at that particular input combination. For example, if one were interested in an estimate of achieved utilization rate for a SWA scenario at input values matching Case 1 where all eight variables are at their high level, $s(Y_h) = .1065$, the number of parameters (p) =8, and $F(.95;8,34) = 2.23$. It follows that:

$$W^2 = 8(2.23)$$

$$\hat{Y}_h + Ws(\hat{Y}_h) = 10.9670 \pm 4.22374(.1065)$$

$$= 10.9670 \pm .4498$$

$$= (10.517, 11.4168) \text{ with 95\% confidence}$$

One can readily see here that in spite of the relatively low R^2, the predictive capability is acceptable.

Sensitivity Analysis

Analysts at HQ MAC and Studies and Analysis are interested in the effect of changing one main factor. The coefficients of the regression equations approximate a unit change in the input parameters, assuming a high degree of orthogonality has been maintained. Most decision makers, however, would prefer a graphical analysis. This section will present graphical comparisons holding all variables constant except one. The variables varied are crew ratio, staging policy, target utilization rates, and flying time limits. The effect of these changes on achieved utilization rates, average work month, average monthly flying times, and time away from station for the NATO scenario will be shown. Appendix K shows the results of three replications for each factor. The variables held constant will take on the center point values from TABLE 4.4.

Crew Ratio Sensitivity. The crew ratio was given values 4.0, 4.2, 4.4, 4.6, 4.8, and 5.0. The impact of these changes is shown in Figs. 4.3-4.7. There seems to be no AUR benefit in increasing the crew ratio to 5.0 as it peaks at 4.8. 4.8 also results in the least amount of time away from home. Another factor in the system is apparently restraining increased benefit. There is an anomaly in the results for a crew ratio of 4.0 that is partially explainable. The crews at homestation were depleted quite early and the number of cancellations due to either no aircraft or

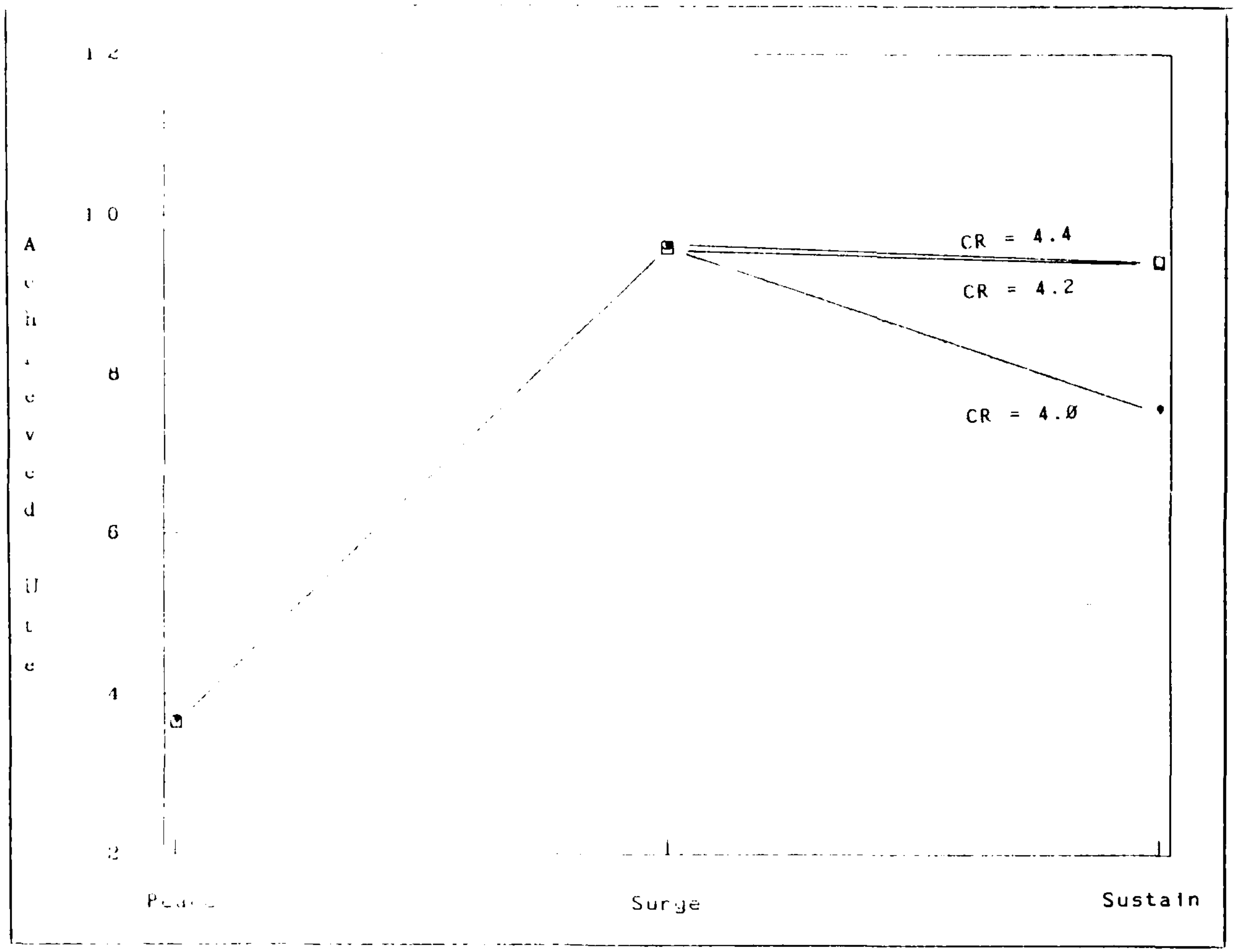


Fig. 4.[illegible]. Effect of CR(4.0,4.2,4.4) on AUR (NATO)

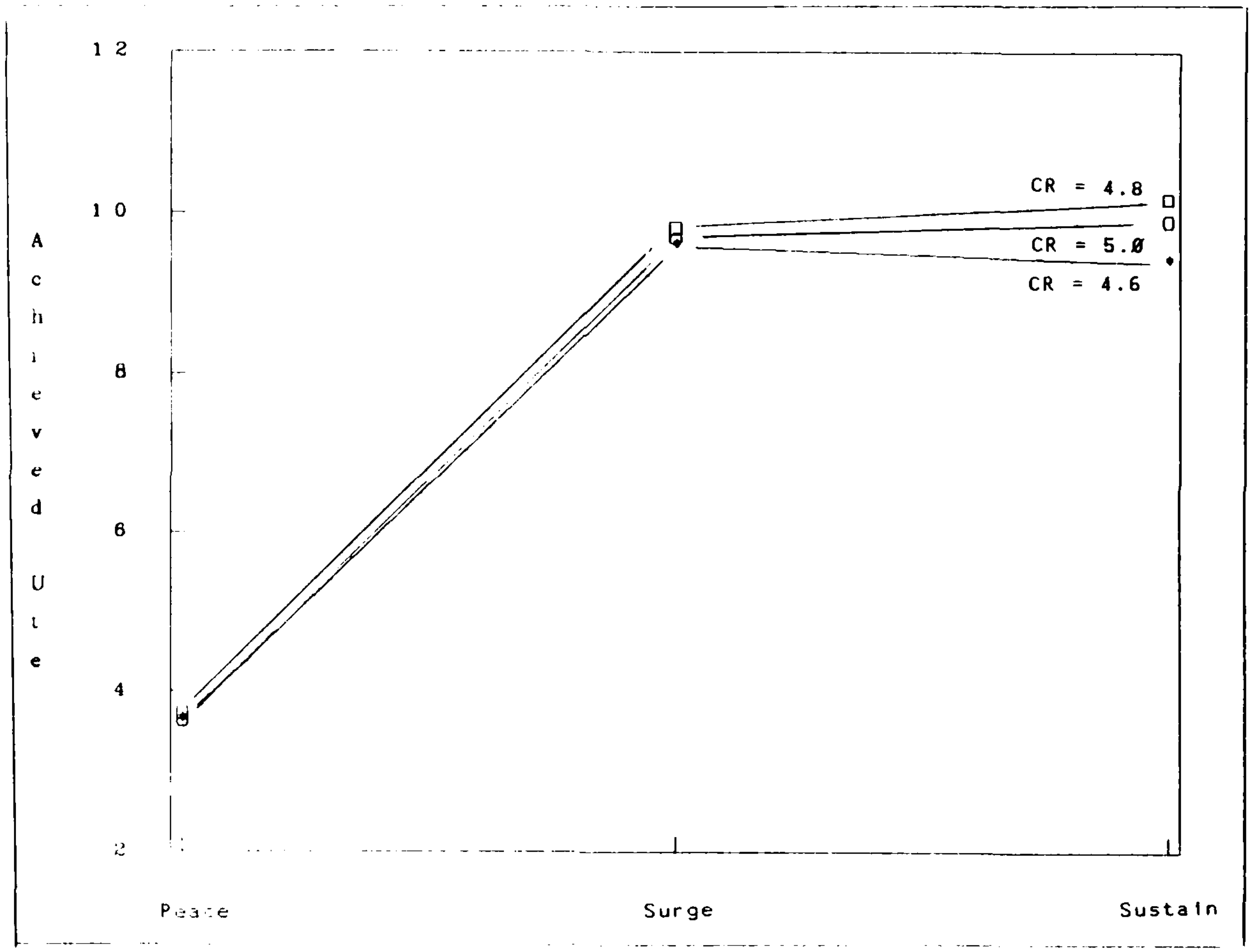


Fig. 4.4. Effect of CR(4.6,4.8,5.Ø) on AUR (NATO)

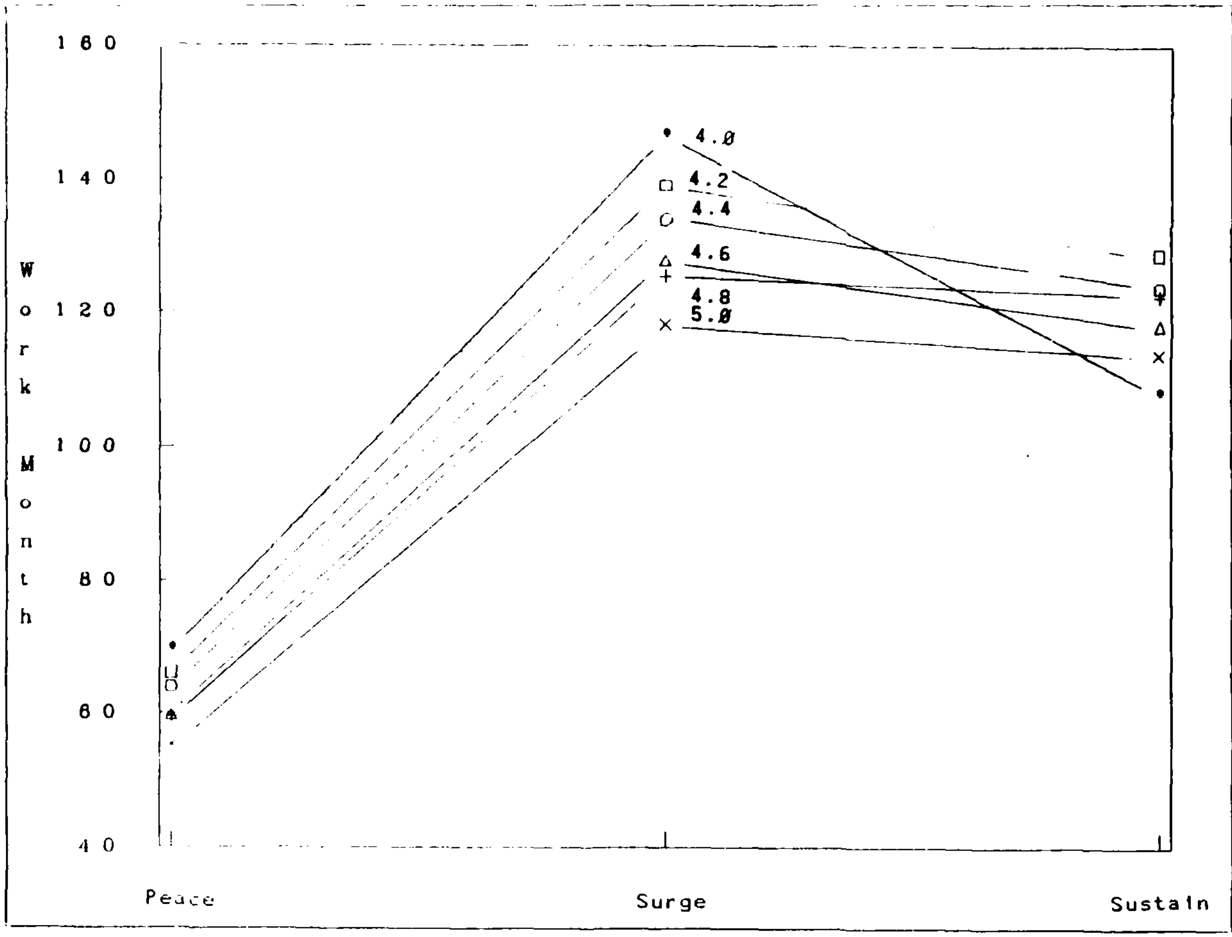


Fig. 4.5. Effect of CR on Avg Work Month (NATO)

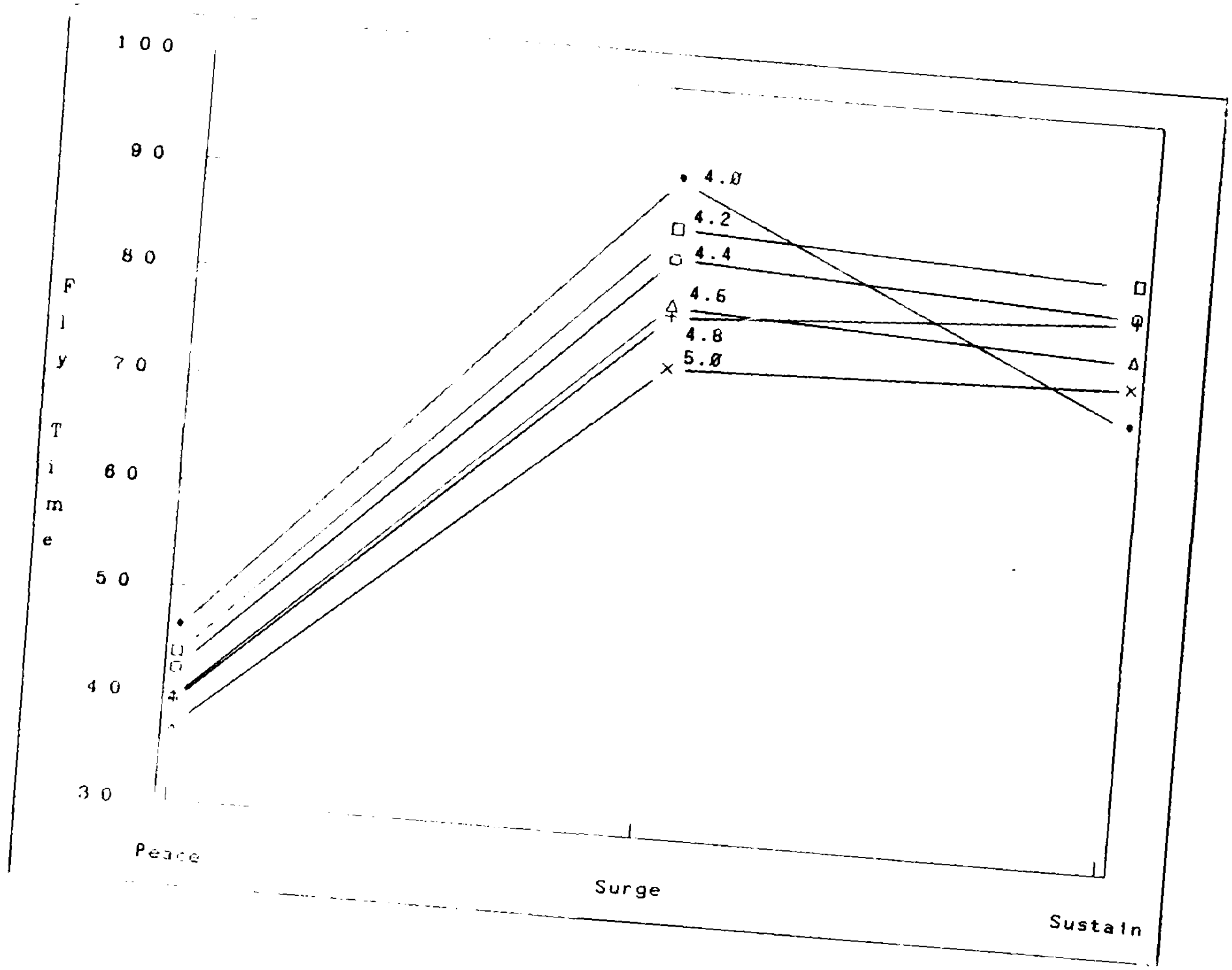


Fig. 4.6. Effect of CR on Avg Mo Fly Time (NATO)

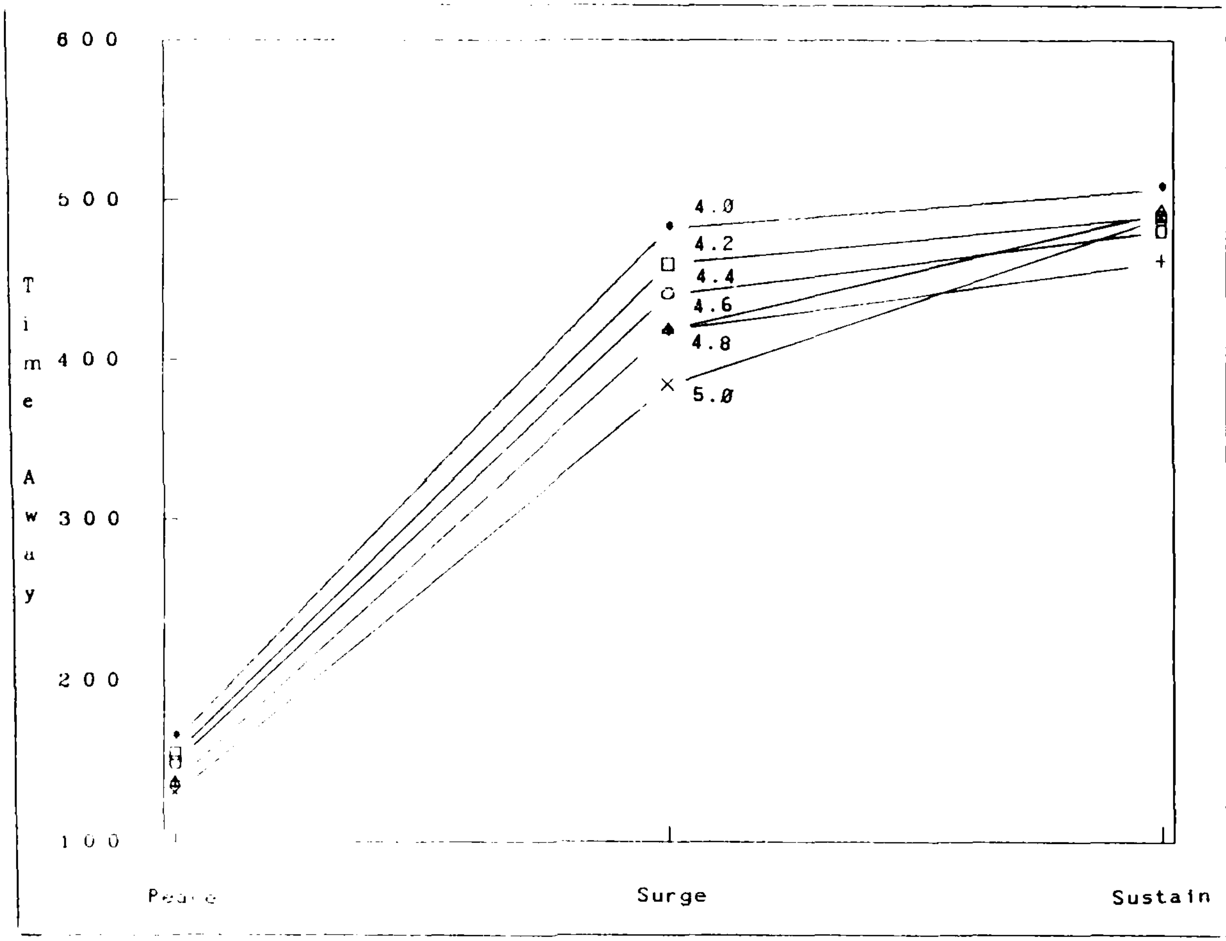


Fig. 4.7. Effect of CR on Time Away From Home

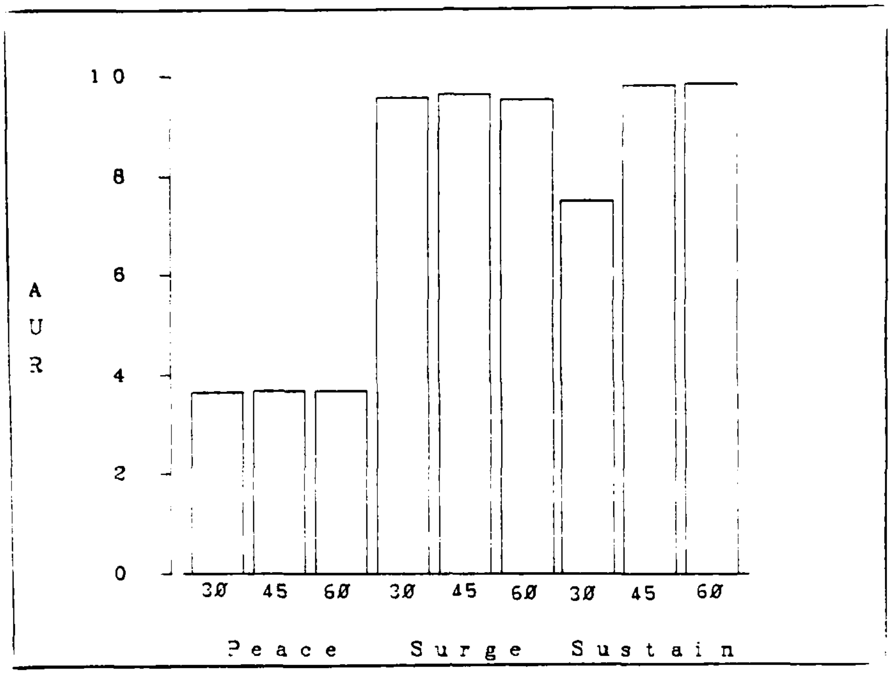


Fig. 4.8. Effect of Staging Policy on Ute Rate (NATO)

no crews available was an order of magnitude higher than other cases. Apparently, 4.0 crews per aircraft is simply not enough to maintain the desired utilization with the associated values of the other factors. The significant drop in work month, flying time, and achieved utilization going from surge to sustained when CR = 4.0 could be a result of flying time limits.

Staging Policy Sensitivity. Staging policy was given values 30, 45, and 60. There is apparently no benefit in staging more crews than one every 45 transits (See Figs. 4.8 -4.10). However, staging a crew for every 30 transits rather than 45 significantly reduces aircraft utilization in the sustained phase by approximately two hours a day.

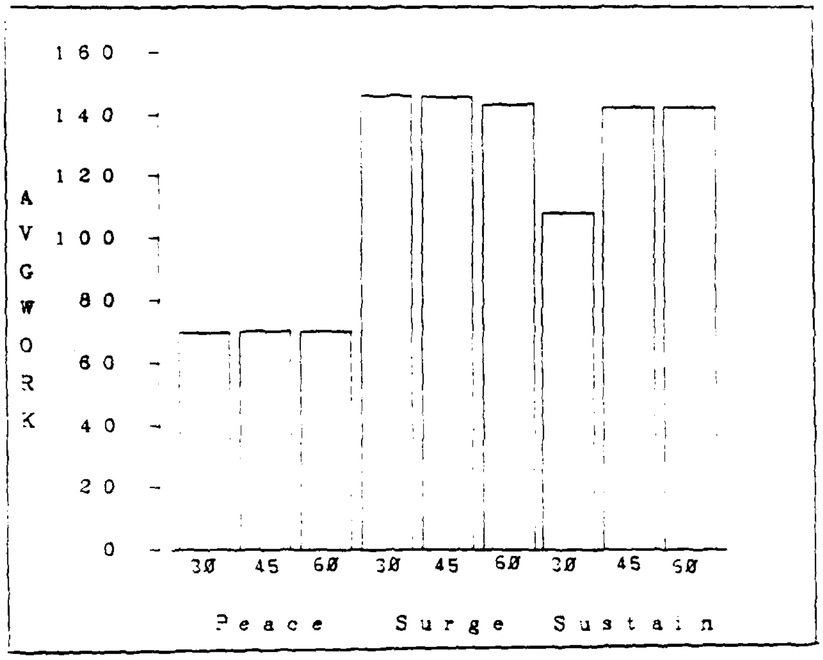


Fig. 4.9. Effect of Staging Policy on Work Month (NATO)

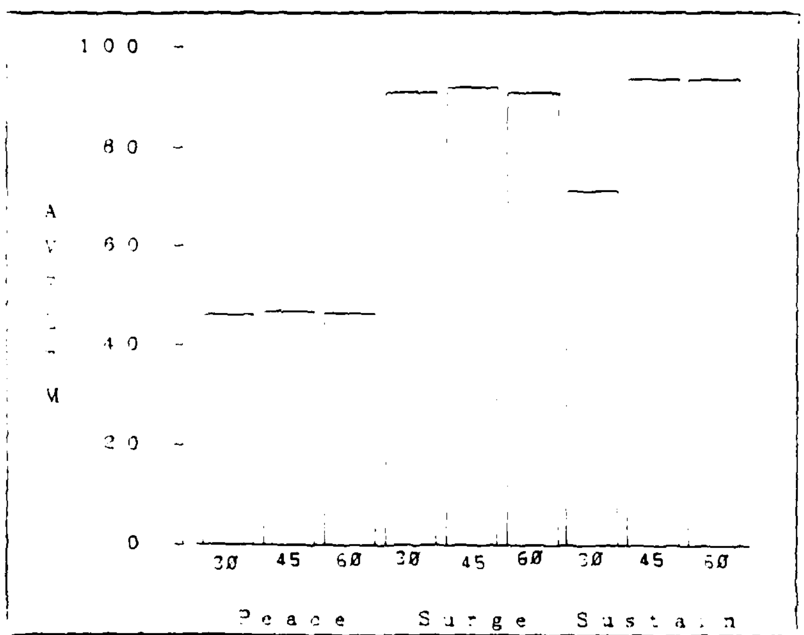


Fig. 4.10. Effect of Staging Policy on Avg Mo Fly Time (NATO)

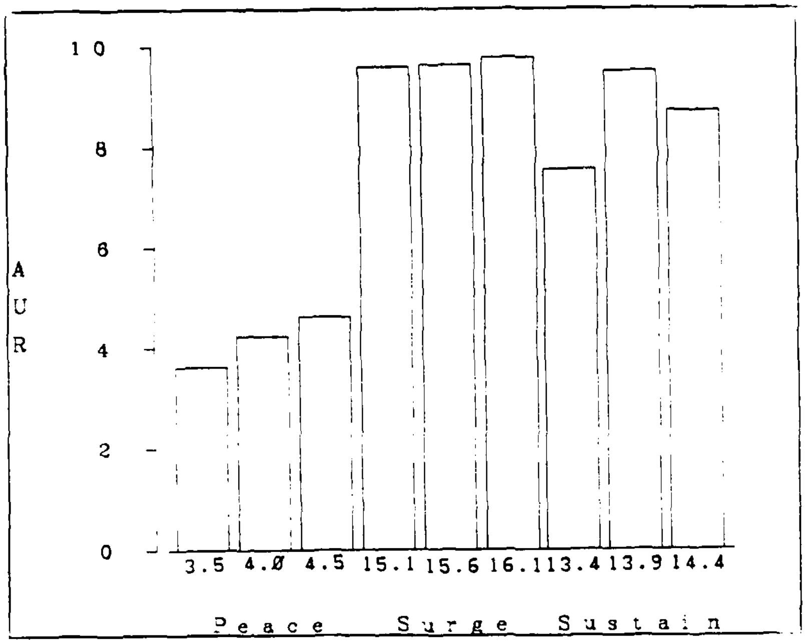


Fig. 4.11. Effect of Target Ute Rate on Achieved (NATO)

Target Utilization Rate Sensitivity. Peace, surge, and sustained TUR's were given values 3.5/15.1/13.4, 4.0/15.6/13.9, and 4.5/16.1/14.4. Increasing TUR beyond 4.0/15.6/13.9 reduces utilization rate, work month, and flying time in the sustained phase. This is quite possibly an indication that the sustained phase is the primary driver in restricting capability. It also indicates that the C-17 cannot be flown above the 13.9 projected utilization rate during a sustained conflict. Figs. 4.11-4.13 illustrate.

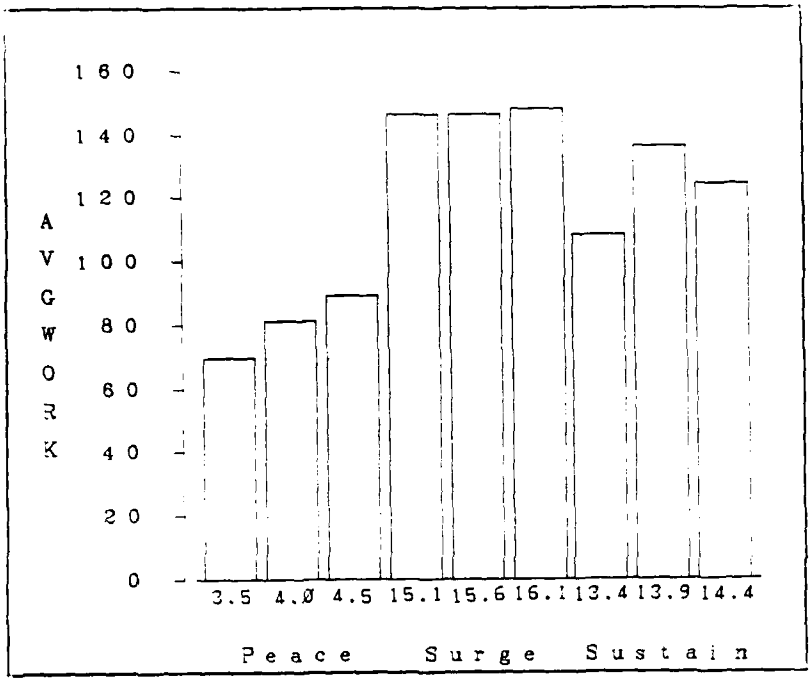


Fig. 4.12. Effect of Target Ute Rate on Work Month (NATO)

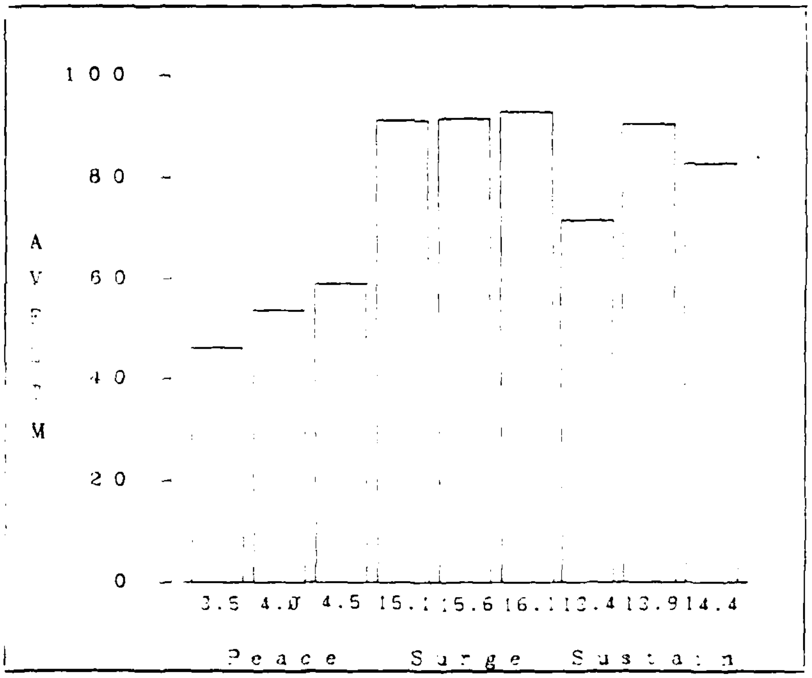


Fig. 4.13. Effect of Target Ute Rate on Avg Mo Fly Time (NATO)

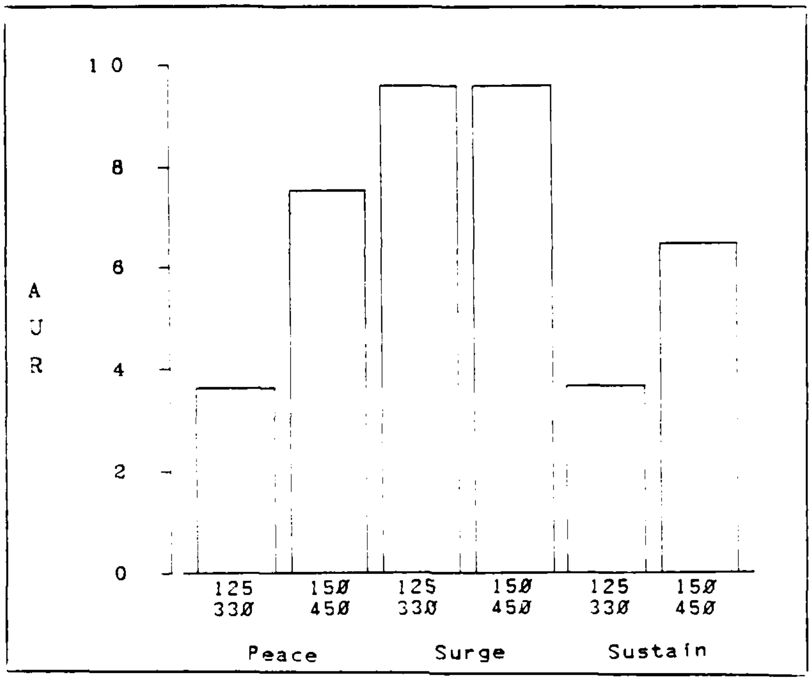


Fig. 4.14. Effect of 30/90 Day Limits on Achieved Ute (NATO)

<u>Fly Time Limit Sensitivity</u>. Fly time limits were evaluated at 125/330 and 150/450. Raising the limits had a positive impact in both peacetime and sustained operations whereas surge characteristics were unaffected (See Figs. 4.14-4.16). Aircraft utilization was increased by almost four hours a day in peacetime and almost three hours a day in sustained operations. This increased utilization obviously increases monthly flying time and the crew's work month; therefore, the length of conflict plays a definite role. These results indicate that the proposed increase in AFR 60-1 to 150/450 should definitely be considered.

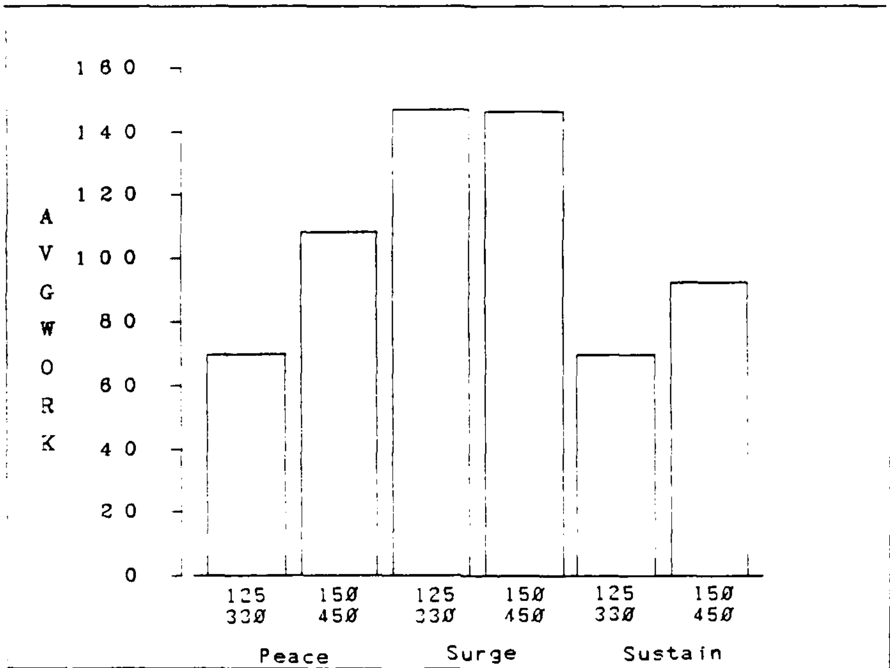


Fig. 4.15. Effect of 3Ø/9Ø Day Limits on Work Month (NATO)

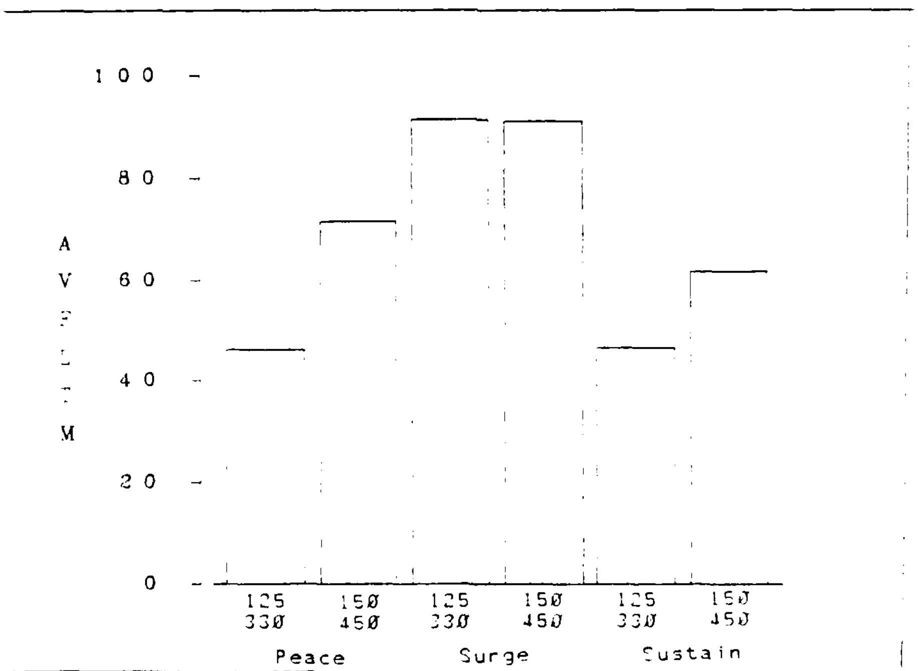


Fig. 4.16. Effect of 3Ø/9Ø Day Limits on Avg Mo Fly Time (NATO)

V. Observations and Recommendations

Observations

This study examined the C-17's mission capability in terms of each aircraft's utilization and that utilization's effect on the aircrew. Specifically, average monthly flying times and average work months, as well as aircraft utilization, were found to be affected by changes in flying time limits, staging policies, target utilization rates, the number of crews, and the launch reliabilities.

The equations in the previous chapter show the relationships between these factors and responses for various levels of these parameters. The simulation then can accurately measure the dynamic effects of those changes. The simulation also gives the capability to vary work rules, change scenarios, analyze parameter values outside the ranges of the regressions, and answer many other "What if?" questions.

The sensitivity analysis yielded the following conclusions:

1. There is no benefit in staging more than one crew for every forty-five planned mission transits. Capability is significantly reduced, however, if thirty missions are used for the basis instead of forty-five.

2. Sustained capability is degraded if target utilization rates are increased above 4.0, 15.6, and 13.9

hours per day for peacetime, surge, and sustained respectively. These surge and sustained values were directed by the SECDEF for C-17 planning.

3. Monthly and quarterly flying time limits are a major restricting factor in both peacetime and sustained operations. Surge operations are only slightly affected.

4. 4.8 crews per aircraft yield the highest payoffs in utilization and crew workloads. 4.0 crews per aircraft are not enough. In-between these values, tradeoffs must be considered between the number of crews and the associated cost.

Future Studies

The value of this study lies in future research. As it exists now, valuable insights can be gained on the factor effects; but the model was not designed to produce optimal answers.

Costs need to be included in the analysis in order to weigh the effects of crew ratio changes. To say that 4.8 crews per aircraft yields the highest utilization is one thing; but is the extra $305 million worth increasing the ratio from 4.6?

MAC does not have a staging policy for its contingencies. Major Charles Dillard, USAF/SAGM, has developed an analytic solution assuming exponential interarrival rates. This needs to be verified and expanded into a usable policy, as it is doubtful that (during a contingency) accurate estimates of the number of mission transits or interarrival times can be made.

This simulation model could be an integral component of a decision support system. The system could mesh a multitude of attributes (cost, utilization, work month, etc.) and help decision makers to choose optimal crew ratios and optimal staging policies, not only to maximize aircraft utilization, but to maximize overall mission effectiveness.

Appendix A

Model Flow Charts

This appendix illustrates the flow of missions, crews, and aircraft through the SLAM model. It gives a pictoral representation of the interactions of the model segments.

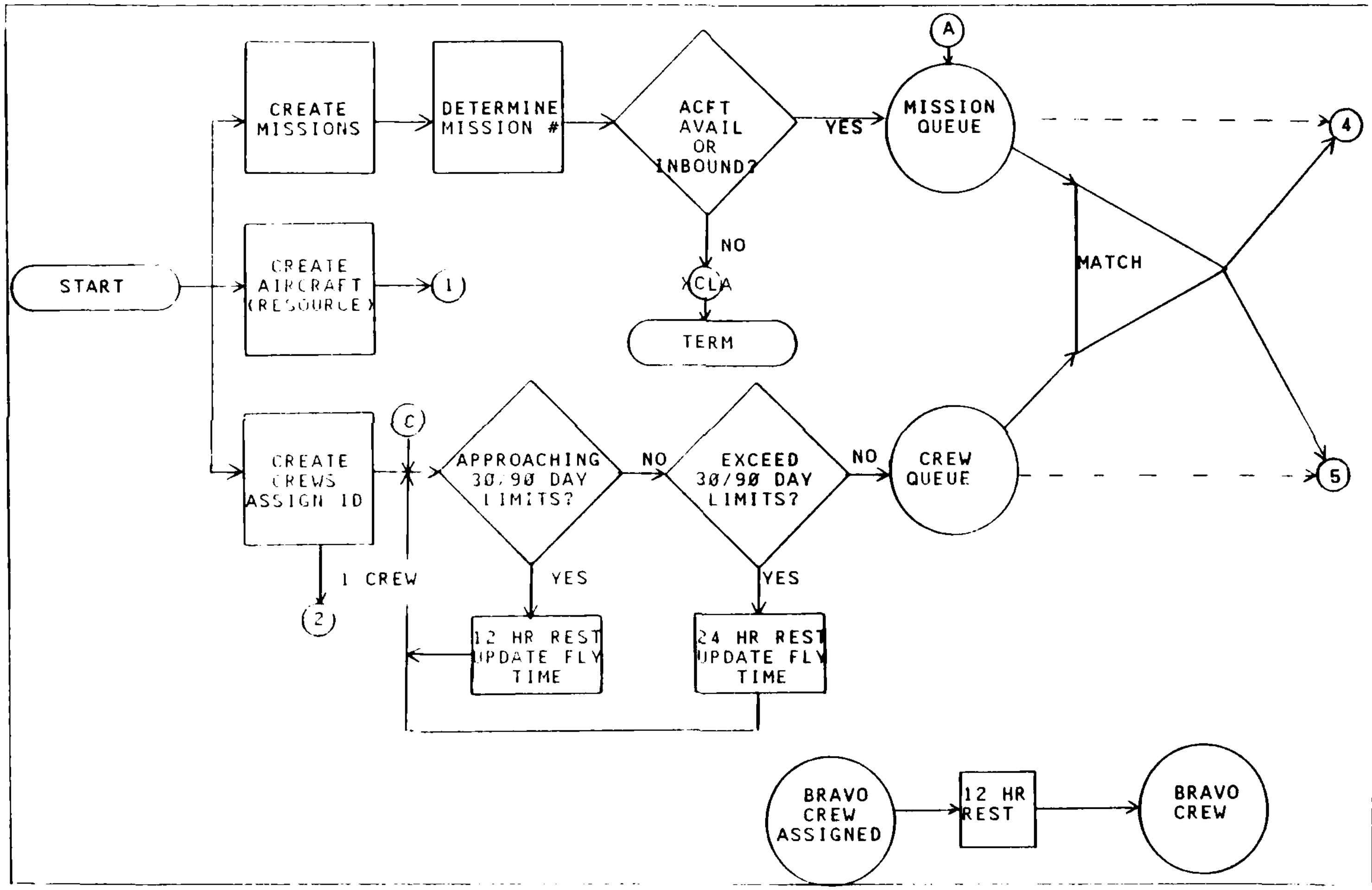


Fig. A.1. Generation

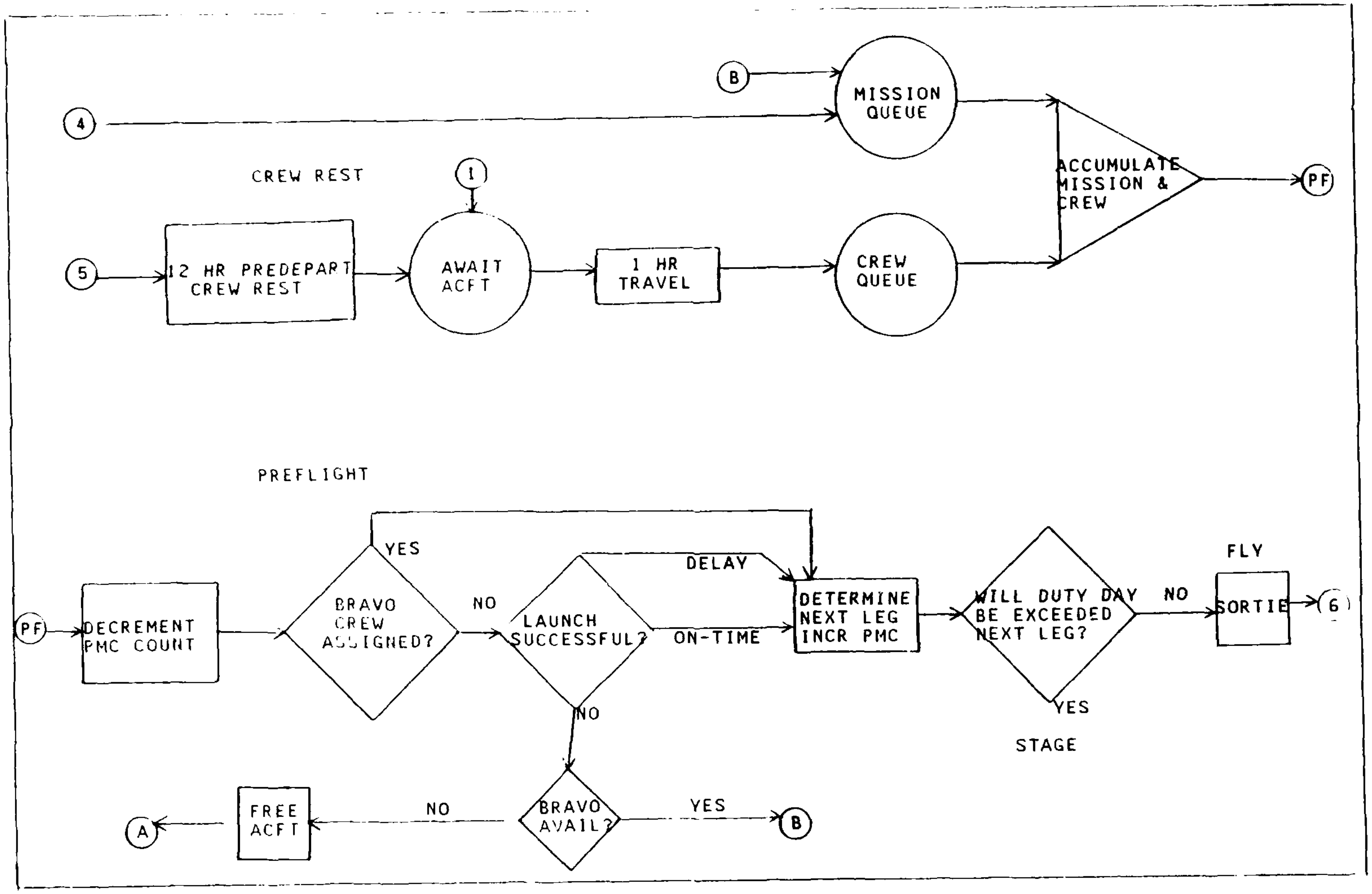


Fig. A.2. Crew Rest & Preflight

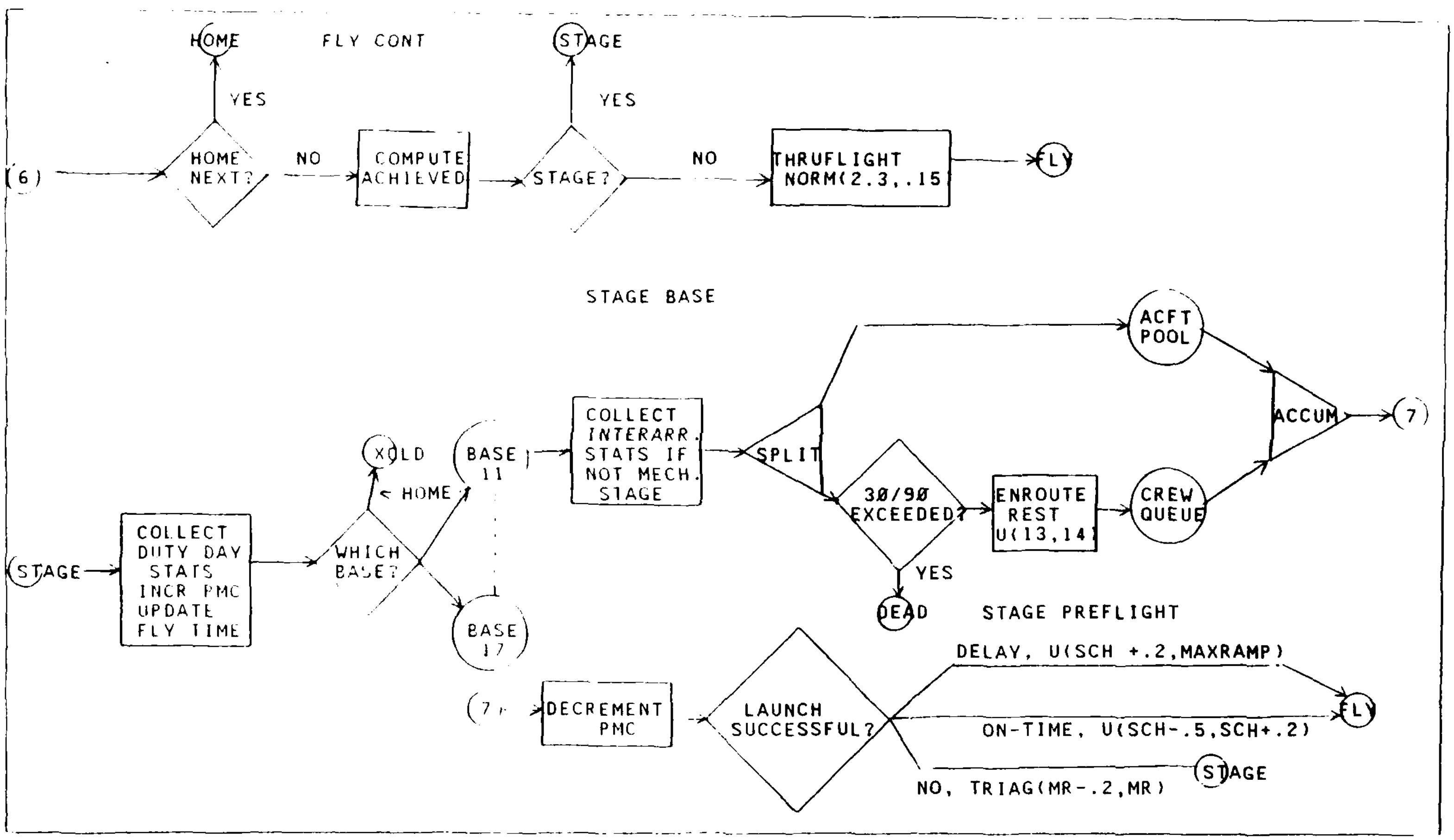


Fig. A.3. Enroute Base

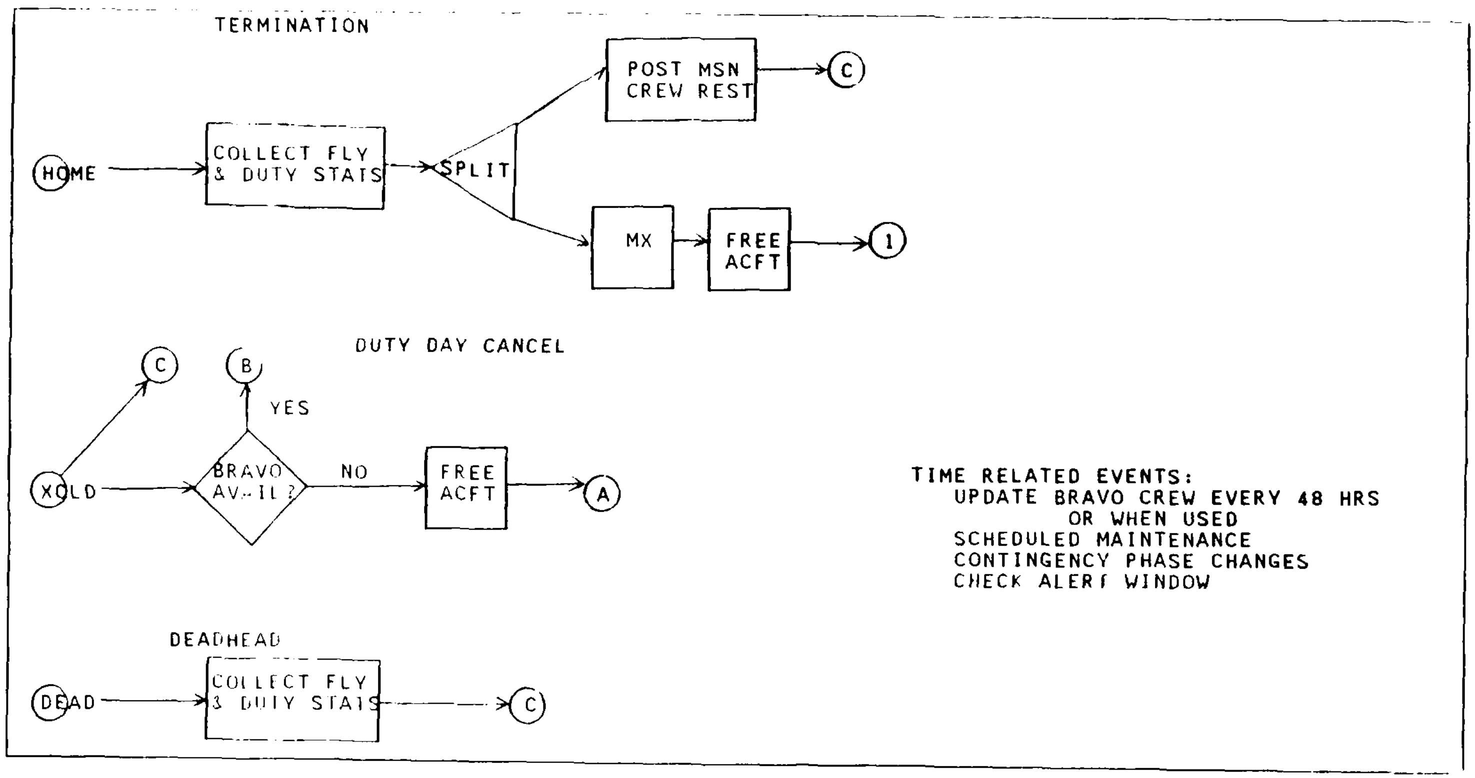


Fig. A.4. Termination

Appendix B

SLAM Network Code

```
GEN,BSUTTER,THESIS2,9/14/85,,,,,,,72;
LIMITS,28,28,400;
TIMST,NNQ(2),CREWS AT HOME,20/0/5;
TIMST,NNQ(11),CREWS AT CYYR;
TIMST,NNQ(12),CREWS AT EGXX;
TIMST,NNQ(14),CREWS AT CYXX;
TIMST,XX(51),MISSIONS CANCEL;
TIMST,XX(56),BURNOUT;
TIMST,XX(19),# ACFT PMC;
RECORD,TNOW,TIMEHRS,0,B,120; EVERY FIVE DAYS
VAR,XX(28),U,AUR;
VAR,XX(41),W,AVG WORK MONTH;
VAR,XX(42),F,AVG FLY HRSMO;
VAR,XX(46),T,AVG TIME AWAYMO;
PRIORITY/2,HVF(20)/11,HVF(20)/12,HVF(20)/13,HVF(20)/14,HVF(20)/15,HVF(20)/16,
HVF(20)/17,HVF(20);          GIVES PRIORITY TO A CREW THAT HAS BEEN MECH. STAGED
;########################.#############################################
;                                                             INITIALIZATION
;                                                                USER INPUTS
;######################################################################
INTL,XX(1)=30; STAGING POLICY
INTL,XX(2)=125; 30 DAY FLYING TIME LIMIT
INTL,XX(3)=330; 90 DAY FLYING TIME LIMIT
INTL,XX(4)=.949; ON TIME RELIABILITY
INTL,XX(5)=.044; DELAY RELIABILITY
INTL,XX(6)=.008; PROB OF RESCHEDULING
;                NOTE: XX(60)+XX(61)+XX(62)=1
INTL,XX(7)=.30; PERCENT AVAILABLE
INTL,XX(8)=4.0; CREW RATIO
;INSERT SCENARIO, TIMES, AND TARGET UTE. RATES INTO FILE 'ROUTE.'
;INSERT INITIAL NUMBER OF CREWS INTO FIRST CREATE STATEMENT & ASSIGN TO XX(47)
;# CREWS AVAIL=(C.R.*NACFT(3)+C.R.*NACFT(4))*PERCENT AVAILABLE
INTL,XX(9)=72; # CREWS AVAILABLE INITIALLY
INTL,XX(10)=6; PEACETIME MAX RAMP
INTL,XX(11)=6; PEACETIME ALERT WINDOW
INTL,XX(12)=12; # HRS AFTER WHICH A SCHED. MISSION IS CANCELLED IF NO CREW OR AC
;######################################################################

NETWORK;
     RESOURCE/ACFT(30),1,4;                              CREATE 30 AIRCRAFT

     CREATE,0,0,,72; CREWS
     ENTER,1,;
     ASSIGN,XX(13)=XX(13)+1,ATRIB(14)=XX(13),ATRIB(11)=0,ATRIB(5)=1,
     ATRIB(1)=10,ATRIB(4)=1,ATRIB(3)=0,ATRIB(16)=TNOW,ATRIB(9)=0,ATRIB(2)=10;
;                                                              ATRIB(14)=ID
     GOON,1;
     ACT,,ATRIB(14).EQ.1,QUE3;                        POSITIONS FIRST GRAVG CREW
```

```
      ACT;
START ASSIGN,ATRIB(5)=1,ATRIB(1)=10,ATRIB(4)=1,ATRIB(9)=0,
         ATRIB(3)=0,ATRIB(2)=10; INIT BASIC CREW, PRESENT BASE, STAGE,
;                              MISSION, SORTIE FLY TIME, NEXT BASE
      ASSIGN,XX(14)=NNQ(2),1;
      ACT/32,12,XX(14).GE.1.AND.ATRIB(11)+20.GE.XX(2),RET;    APPROACHING 30 LMT
      ACT/33,12,XX(14).GE.1.AND.ATRIB(12)+20.GE.XX(3),RET;    APPROACHING 90 LMT
      ACT;
      GOON,1;
      ACT/20,24,ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),RET;       ENTER 24 HOUR
;                                     CREW REST IF 30 OR 90 DAY LIMIT EXCEEDED
      ACT,,,QUE2;
RET   EVENT,10,1;                                        UPDATE 30/90 FLY TIME
      ACT,,,START;
;
      QUEUE(10):
      ACT/34,12;                                               BRAVO CREW REST
QUE3  QUEUE(3);                                                BRAVO CREW FILE
QUE2  QUEUE(2),,,,MAT1;                                          AWAIT MISSION
;**********************************************************************
;                                                     ****CREATE MISSIONS****
;**********************************************************************
      CREATE,RNORM(XX(15),1,3),0;             CREATE MISSION AT FREQ OF XX(15)
MSN   EVENT,4,1;                                             DETERMINE MISSION
      ACT/10;                                                   COUNT MISSIONS
      ASSIGN,ATRIB(2)=10,ATRIB(3)=0,ATRIB(4)=1,ATRIB(5)=1;   INTLC TO MATCH CREW
;                                                  IS AN AIRCRAFT AVAILABLE?
      ASSIGN,XX(16)=NNRSC(ACFT)+XX(17);              ACFT AVAIL + ACFT INBOUND
      GOON,1;
      ACT,,XX(16).LE.0,XCLA;                            CANCEL DUE TO NO ACFT
      ACT;
      ASSIGN,XX(17)=XX(17)-1;                            ONE ACFT SPOKEN FOR
Q10   ASSIGN,ATRIB(15)=TNOW;
QUE3  QUEUE(3),,,,MAT1;                                          MISSION QUEUE
MAT1  MATCH,5,QUE3/QU6,QUE2/REST;                    MATCH CREW WITH MISSION
QU6   ASSIGN,II=ATRIB(9);
      ACT,,,QUE6;
;**********************************************************************
;                                                         ****CREW REST****
;**********************************************************************
REST  GOON;
      ASSIGN,ATRIB(9)=II,ATRIB(7)=0,ATRIB(10)=0;      MISSION NUMBER, FLY TIME
;                                                   & TIME AWAY INIT=0
      ACT/1,12,,;                                                    CREW REST
      ASSIGN,ATRIB(16)=TNOW;
      AWAIT(4),ACFT;
      ASSIGN,XX(17)=XX(17)+1;                     RESETS AVAIL OR PROJECTED ACFT
      GOON;
      ACT,I,,;                                                          TRAVEL
```

```
;****************************************************************************
;                                                       ****CREW SHOWS AT SQDN****
;****************************************************************************
QUE5  QUEUE(5),,,,MAT2;                                                      CREW
;
;                                                               ****PREFLIGHT****
;                                                               *****************
QUE6  QUEUE(6),,,,MAT2;                                                   MISSION
MAT2  MATCH,9,QUE6/ACC,QUE5/ACC;
ACC   ACCUM,2,2,LAST;                 ATTACHES MSN TO CREW, RETAINS MSN ATTRIB
      ASSIGN,ATRIB(13)=0,ATRIB(6)=TNOW,ATRIB(8)=TNOW;         LEG NUMBER INIT=0
      ASSIGN,XX(18)=XX(18)-1;
      GOON,1;
      ACT,EXPON(3.3,3),ATRIB(17).NE.0,FLY1;     BRAVO CREW FLYING (ADD 1 HR TVL)
      ACT/22;
      ASSIGN,XX(19)=XX(10)-2.;
      GOON,1;
      ACT/3,UNFRM(2.0,2.3,3),XX(4),FLY;                                  ON TIME
      ACT/27,UNFRM(2.3,XX(10),2),XX(5),FLY;                PREFLIGHT < MAX RAMP
      ACT/7,TRIAG(XX(19),XX(10),XX(10),3),XX(6),XCL;   RAMP EXCEEDED, RESHEDULE
;****************************************************************************
;                                                      ****MISSION SORTIE****
;****************************************************************************
FLY1  ASSIGN,ATRIB(17)=0;                                         BRAVO UTILIZED
FLY   GOON,1;
      EVENT,5,1;                                     COMPUTE NEXT LEG & FLY TIME
      GOON,1;
      ACT/19,,TNOW+ATRIB(3)-ATRIB(6).GT.16,MECH;
;                                                 WILL EXCEED DUTY DAY ON NEXT LEG
      ACT/24,,,;
      ASSIGN,XX(19)=ATRIB(3)-.5,XX(20)=ATRIB(3)+1.;
      ASSIGN,XX(21)=TRIAG(XX(19),ATRIB(3),XX(20),4);
      ASSIGN,ATRIB(7)=ATRIB(7)+XX(21);
      ASSIGN,ATRIB(15)=ATRIB(15)+XX(21);
      ASSIGN,XX(18)=XX(18)+1;
      GOON,1;
      ACT/5,XX(21),ATRIB(13).EQ.XX(22),HOME;  NEXT HOME
      ACT/5,XX(21);
      ASSIGN,XX(18)=XX(18)-1;
      ASSIGN,XX(23)=TNOW-XX(24),XX(25)=XX(26)-XX(27);
      ASSIGN,XX(28)=XX(29)*XX(23)/24,XX(28)=XX(25)/XX(28)+ATRIB(7)/XX(28);
;                                                     COMPUTE ACHIEVED UTE RATE
;****************************************************************************
;                                                      ****ENROUTE STOPS****
;****************************************************************************
      GOON,1;
      ACT/2,,ATRIB(4).EQ.1,,STAGE;                                    STAGE CREW
      ACT;
      GOON;
      ASSIGN,ATRIB(1)=ATRIB(2);
      ACT/8,RNORM(2.3,.15,2),,FLY;                               SCHEDULED GND TIME
```

```
MECH  GOON;                                       DUTY DAY EXCEEDED-MECHANICAL STAGE
      ASSIGN,ATRIB(2)=ATRIB(1),ATRIB(13)=ATRIB(13)-1;
      ACT,,,STAGE;
;
;                                                                             STAGE
STAGE  GOON;
       ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);                         ACCUM. DUTY TIME
       ASSIGN,XX(18)=XX(18)+1;
       EVENT,10,1;
       COLCT,INT(6),DUTY DAY,,1;
       ACT/26,,ATRIB(2).EQ.10,XCLD;                 HOME STATION DUTY DAY EXCEEDED
       ACT,,ATRIB(2).EQ.11,CYYR;                                        WHICH BASE?
       ACT,,ATRIB(2).EQ.12,EGXX;
       ACT,,ATRIB(2).EQ.13,KPXX;
       ACT,,ATRIB(2).EQ.14,CYXX;
       ACT,,ATRIB(2).EQ.15,EDXX;
       ACT,,ATRIB(2).EQ.16,ENXX;
       ACT,,ATRIB(2).EQ.17,KTIK;
       CREATE,0,0,,1,1;DUMMY TO INIT QUEUE(9)
       ACT;
QUE9   QUEUE(9);                                    CYCLE IF ALERT WINDOW EXCEEDED
       ACT;
       GOON,1;
       ACT,,ATRIB(2).EQ.10,QUE2;
       ACT,,ATRIB(2).EQ.11,CY;
       ACT,,ATRIB(2).EQ.12,EG;
       ACT,,ATRIB(2).EQ.13,KP;
       ACT,,ATRIB(2).EQ.14,CYX;
       ACT,,ATRIB(2).EQ.15,ED;
       ACT,,ATRIB(2).EQ.16,EN;
       ACT,,ATRIB(2).EQ.17,KT;
       ACT;
       TERM;
;################################################################################
;                                                   ####STAGE BASE SUBPROGRAMS####
;################################################################################
;                                                                        CYYR STAGE
CYYR   GOON,1;
       ACT,,ATRIB(1).EQ.ATRIB(2),ME11;                   ARRIVAL DUE TO MECH STAGE
       ACT;
       COLCT,BET,INTER AT CYYR,,1;                                    INTERARRIVAL
ME11   GOON,2;
       ACT,,,Q111;
       ACT;
       GOON,1;
       ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
;                                        CHECK 30/90 TIME & DEADHEAD HOME IF EXCEEDED
       ACT;
CY     GOON;
       ACT,UNFRM(12.,14.,3);                                             CREW REST
       ASSIGN,ATRIB(16)=TNOW;
```

```
        ACT,,,Q112;
Q111    QUEUE(21),,,,MAT3;                                  ACFT
Q112    QUEUE(11),,,,MAT3;                                  CREWS AVAIL
MAT3    MATCH,5,Q111/AX1,Q112/AC1;                          MATCH ACFT WITH CREW
AX1     GOON;
        ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC1     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
        ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
        ATRIB(19)=XX(37),ATRIB(20)=0;
        ACT,,,CONT;
;
;                                                           EGXX STAGE
EGXX    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME12;
        ACT;
        COLCT,BET,INTER AT EGXX,,1;
ME12    GOON,2;
        ACT,,,Q121;
        ACT;
        GOON,1;
        ACT/21,RNORM(26.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
        ACT;
EG      GOON;
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q122;
Q121    QUEUE(22),,,,MAT4; ACFT
Q122    QUEUE(12),,,,MAT4; CREWS AVAIL
MAT4    MATCH,5,Q121/AX2,Q122/AC2;
AX2     GOON;
        ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC2     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
        ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
        ATRIB(19)=XX(37),ATRIB(20)=0;
        ACT,,,CONT;
;
;                                                           KPXX STAGE
KPXX    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME13;
        ACT;
        COLCT,BET,INTER AT KPXX,,1;
ME13    GOON,2;
        ACT,,,Q131;
        ACT;
        GOON,1;
```

```
        ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(25).OR.ATRIB(12).GE.XX(3),DEAD;
        ACT;
KP      GOON;
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q132;
Q131    QUEUE(23),,,,MAT5; ACFT
Q132    QUEUE(13),,,,MAT5; CREWS AVAIL W/2
MAT5    MATCH,5,Q131/AX3,Q132/AC3;
AX3     GOON;
        ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC3     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
        ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
        ATRIB(19)=XX(37),ATRIB(20)=0;
        ACT,,,CONT;
;
;                                                         CYXX STAGE
CYXX    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME14;
        ACT;
        COLCT,BET,INTER AT CYXX,,1;
ME14    GOON,2;
        ACT,,,Q141;
        ACT;
        GOON,1;
        ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
        ACT;
CYX     GOON;
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q142;
Q141    QUEUE(24),,,,MAT6; ACFT
Q142    QUEUE(14),,,,MAT6; CREWS AVAIL
MAT6    MATCH,5,Q141/AX4,Q142/AC4;
AX4     GOON;
        ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC4     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
        ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
        ATRIB(19)=XX(37),ATRIB(20)=0;
        ACT,,,CONT;
;
;                                                         EDXX STAGE
EDXX    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME15;
        ACT;
```

```
        COLCT,BET,INTER AT EDXX,,1;
ME15    GOON,2;
        ACT,,,Q151;
        ACT;
        GOON,1;
        ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
        ACT;
ED      GOON;
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q152;
Q151    QUEUE(25),,,,MAT7; ACFT
Q152    QUEUE(15),,,,MAT7; CREWS AVAIL
MAT7    MATCH,5,Q151/AX5,Q152/AC5;
AX5     ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC5     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
        ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
        ATRIB(19)=XX(37),ATRIB(20)=0;
        ACT,,,CONT;
;
;                                                          ENXX STAGE
ENXX    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME16;
        ACT;
        COLCT,BET,INTER AT ENXX,,1;
ME16    GOON,2;
        ACT,,,Q161;
        ACT;
        GOON,1;
        ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
        ACT;
EN      GOON;
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q162;
Q161    QUEUE(26),,,,MAT8; ACFT
Q162    QUEUE(16),,,,MAT8; CREWS AVAIL
MAT8    MATCH,5,Q161/AX6,Q162/AC6;
AX6     ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC6     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
        ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
        ATRIB(19)=XX(37),ATRIB(20)=0;
        ACT,,,CONT;
```

```
;                                                                      KTIK STAGE
KTIK   GOON,1;
       ACT,,ATRIB(1).EQ.ATRIB(2),ME17;
       ACT;
       COLCT,BET,INTER AT KTIK,,1;
ME17   GOON,2;
       ACT,,,Q171;
       ACT;
       GOON,1;
       ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
       ACT;
KT     GOON;
       ACT,UNFRM(13.,14.,3);
       ASSIGN,ATRIB(16)=TNOW;
       ACT,,,Q172;
Q171   QUEUE(27),,,,MAT9; ACFT
Q172   QUEUE(17),,,,MAT9; CREWS AVAIL
MAT9   MATCH,5,Q1772/AC7;
AX7    ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
       XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
       XX(37)=ATRIB(19);
AC7    ACCUM,2,2,LAST;
       ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
       ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
       ATRIB(19)=XX(37),ATRIB(20)=0;
       ACT,,,CONT;
;****************************************************************************
;                                                  ****MISSION CONTINUATION****
;****************************************************************************
CONT  GOON;
      ACT/23;                                               ENROUTE DEPARTURES
      ASSIGN,XX(19)=ATRIB(19)-.5,XX(20)=ATRIB(19)+.2,XX(38)=XX(10)-2;
      ASSIGN,XX(18)=XX(18)-1;
      ASSIGN,ATRIB(1)=ATRIB(2),ATRIB(6)=TNOW,1;         PRESENT NODE=ATRIB(2)
      ACT/4,UNFRM(XX(19),XX(20)),XX(4),FLY;                      NO MAJOR MX
      ACT/23,UNFRM(XX(20),XX(10),2),XX(5),FLY;                          DELAY
      ACT/6,TRIAG(XX(33),XX(10),XX(10),3),XX(6),STAGE;          RAMP EXCEEDED
;****************************************************************************
;                       ****CK MISSION QUEUES FOR WAIT TIME AND ALERT WINDOWS****
;****************************************************************************
        CREATE,1,1,,3840,;
        EVENT,2;
        EVENT,12;
        TERM;
;****************************************************************************
;                                                                  ****HOME****
;****************************************************************************
HOME  GOON;
      EVENT,10,1;                                             UPDATE 30/90 TIME
      COLCT,INT(8),MISSION LENGTH;                            TRACK MSN LENGTHS
      COLCT,INT(6),LAST DUTY DAY;                          TRACK FINAL DUTY DAY
```

```
     ASSIGN,ATRIB(10)=ATRIB(10)+TNOW-ATRIB(8);                TRACK TIME AWAY
     GOON;
     ASSIGN,XX(18)=XX(18)-1;
     ASSIGN,XX(26)=XX(26)+ATRIB(7),ATRIB(7)=0;         ACCUMULATE FLYING TIME
     ASSIGN,XX(25)=XX(26)-XX(27);                          FLY TIME THIS PHASE
     ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);                     ACCUM. DUTY TIME
     ASSIGN,XX(23)=TNOW-XX(24),XX(39)=XX(30)-XX(40);      DUTY TIME THIS PHASE
     ASSIGN,XX(41)=XX(9)*XX(23)/730.56,XX(41)=XX(39)/XX(41);    AVG WORK MONTH
     ASSIGN,XX(42)=XX(9)*XX(23)/730.56,XX(42)=XX(25)/XX(42);       AVG FLY HRS
     ASSIGN,XX(43)=XX(43)+TNOW-ATRIB(8);                       CUM. TIME AWAY
     ASSIGN,XX(44)=XX(43)-XX(45);                         TIME AWAY THIS PHASE
     ASSIGN,XX(46)=XX(9)*XX(23)/730.56,XX(46)=XX(44)/XX(46);     AVG TIME AWAY
     ASSIGN,XX(17)=XX(17)+1;                                     ACFT INBOUND
     COLCT,XX(25),SYS FLY TIME,,2;                         FLY TIME THIS PHASE
     ACT,USERF(2),,START;                                         CREW AVAIL.
     ACT,USERF(3);                                                    ACFT MX
     FREE,ACFT/1;
     ASSIGN,XX(17)=XX(17)-1;                      RESET COUNTER, ACFT INBOUND
     ASSIGN,XX(18)=XX(18)+1;
     TERM;
;*******************************************************************************
;                                   ****UNSUCCESSFUL HOMESTATION PREFLIGHT****
;*******************************************************************************
XCL  GOON;                                                      RAMP EXCEEDED
     ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);                       ADD DUTY TIME
     ASSIGN,XX(18)=XX(18)+1;
     GOON,2;
     ACT,,,START;                                      CREW BACK TO CREW REST
     ACT/9,UNFRM(3,12,2);
     EVENT,1,1;                                               IS BRAVO AVAIL?
     ACT/25,,ATRIB(17).NE.0,DUE6;                         BRAVO AVAIL-REMATCH
     ACT;
     GOON,2;
     ACT,,,D10;                                           RESCHEDULE MISSION
     FREE,ACFT/1;
     TERM;
XCLD GOON;                                          DUTY DAY EXCEEDED AT HOME
     ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);                       ADD DUTY TIME
     GOON,2;
     ACT,,,START;
     ACT;
     EVENT,1,1;                                               IS BRAVO AVAIL?
     ACT,,ATRIB(17).NE.0,DUE6;                            BRAVO AVAIL-REMATCH
     ACT;
     GOON,2;
     ACT,,,D10;                                           RESCHEDULE MISSION
     ACT;
     FREE,ACFT/1;
     TERM;
XCLA GOON,1;
     ACT/18;                             COUNT MISSIONS CANCELLED DUE TO NO ACFT
```

```
     TERM;
;
;*****************************************************************************
;                                                  ****SCHEDULED MAINTENANCE*******
;*****************************************************************************
;                                      A.C.I AND REFURB NOT ACCOMPLISHED DURING SURGE
;                                          HOMESTATION CHECK: 2 DAYS DOWN EACH 60 DAYS
     CREATE,XX(47),0;
     AWAIT(1),ACFT;
     ASSIGN,XX(18)=XX(18)-1;
     ACT/29,RNORM(48.,1.,3);
     ASSIGN,XX(18)=XX(18)+1;
     FREE,ACFT/1;
     TERM;
;                                              REFURBISHMENT: 10 DAYS DOWN EACH 18 MOS
     CREATE,XX(48),0;
     GOON,1;
     ACT,,XX(49).EQ.1,TERM;
     ACT;
     AWAIT(1),ACFT;
     ASSIGN,XX(18)=XX(18)-1;
     ACT/30,RNORM(240.,5.,3);
     ASSIGN,XX(18)=XX(18)+1;
     FREE,ACFT/1;
TERM TERM;
;                                 A.C.I. (REPLACING ISOCH): 30 DAYS DOWN EACH 36 MOS
     CREATE,XX(50),100;                                       ARBITRARILY START AT 100
     GOON,1;
     ACT,,XX(49).EQ.1,TERM;                                             NO INSP IF SURGE
     ACT;
     AWAIT(1),ACFT;
     ASSIGN,XX(18)=XX(18)-1;
     ACT/31,RNORM(720.,10.,3);
     ASSIGN,XX(18)=XX(18)+1;
     FREE,ACFT/1;
     TERM;
;*****************************************************************************
;                                              ****DEADHEAD HOME: EXCEEDED FLY TIME****
;*****************************************************************************
DEAD QUEUE(7);
     ACT;
     COLCT,INT(9),MISSION LENGTH;                                TRACK MISSION LENGTH
     ASSIGN, ATRIB(10)=ATRIB(10)+TNOW-ATRIB(9);                                TIME AWAY
     ASSIGN,XX(30)=XX(30)+UNFRM(9.,16.,2),XX(23)=TNOW-XX(24);ADD DH TIME TO DTY
     ASSIGN,XX(43)=XX(43)+TNOW-ATRIB(9),XX(44)=XX(43)-XX(45);
     ASSIGN,XX(46)=XX(9)*XX(23)/730.56,XX(46)=XX(44)/XX(46);                      AWAY
     ASSIGN,XX(39)=XX(30)-XX(40);
     ASSIGN,XX(41)=XX(9)*XX(23)/730.56,XX(41)=XX(39)/XX(41);                      WORK
     GOON;
     ASSIGN,XX(26)=XX(26)+ATRIB(7),ATRIB(7)=0;                            ACCUM FLY TIME
     ASSIGN,XX(25)=XX(26)-XX(27);
```

```
ASSIGN,XX(42)=XX(9)*XX(23)/730.56,XX(42)=XX(25)/XX(42);                FLY
COLCT,XX(25),SYS FLY TIME,,2;
ACT,USERF(2),,START;                                           CREW AVAIL.
ACT;
TERM;
ENDNETWORK;


;**************************************************************************
;                                       ****DESCRIPTION OF COMPONENTS****
;**************************************************************************
;QUEUES
;  1)  HOME STATION SCHEDULED MAINTENANCE
;  2)  CREW PRIOR TO MISSION ASSIGNMENT
;  3)  MISSION
;  4)  AWAIT ACFT
;  5)  CREW PRIOR TO MATCHING WITH MISSION (MAT2)
;  6)  MSN PRIOR TO MATCHING WITH CREW (MAT2)
;  7)  DEADHEAD TRANSITION
;  8)  BRAVO CREW FILE
;  9)  BRANCHING FOR WINDOW (FORTRAN)
;  10) ENTRY TO BRAVO IF CREW REST NEEDED
;  11-17) CREW ENROUTE
;  20-27) ACFT ENROUTE
;ACTIVITIES
;  1)  CREW REST
;  2)  STAGE
;  3)  PREFLIGHT HOME STATION - ON TIME
;  4)  PREFLIGHT/MX AT STAGE
;  5)  FLY
;  6)  RAMP EXCEEDED ENROUTE
;  7)  RAMP EXCEEDED AT HOME
;  8)  QUICK TURN GND TIME
;  9)  MX AFTER XCL
;  10) NUMBER OF MISSIONS
;  11-17) BASE COUNT
;  18) CANCEL NO ACFT
;  19) DUTY DAY CANCEL
;  20) EXCEEDS 30/90 LIMITS AT HOME
;  21) EXCEEDS 30/90 LIMITS IN SYSTEM
;  22) # MSNS NOT CANCELLED PRIOR TO PREFLIGHT
;  23) # ENROUTE MISSIONS
;  24) DEPARTURES
;  25) BRAVO FLIES
;  26) DUTY DAY XCL AT HOME
;  27) PREFLIGHT HOME STATION - LATE DEPARTURE
;  28) PREFLIGHT ENROUTE - LATE DEPARTURE
;  29) HSC
;  30) REFURB
;  31) A.I.I.
```

```
;  32) APPROACHING 30 DAY LIMITS
;  33) APPROACHING 90 DAY LIMITS
;  34) CREW REST FOR BRAVO
;USERFS
;  1)  FLY TIME
;  2)  HOME CREW REST
;  3)  MX
;  4)  CALC MISSION FREQ TO MEET TUR
;  5)  STAGE

;ATTRIBUTES
;  1)  PRESENT NODE
;  2)  NEXT NODE
;  3)  SORTIE FLY TIME
;  4)  STAGE=1
;  5)  BASIC=1
;  6)  SHOW TIME FOR DAY
;  7)  CUM. FLY TIME
;  8)  SHOW TIME FOR MSN
;  9)  ROUTE NUMBER
;  10) CUM. TIME AWAY FROM HOME
;  11) CUM. FLY TIME FOR 30 DAYS
;  12) CUM. FLY TIME FOR 90 DAYS
;  13) WHICH LEG NUMBER
;  14) CREW ID
;  15) DAILY CUM FLY TIME
;  16) START TIME MISC
;  17) MISSION FOR BRAVO CREW
;  18) EVENT NUMBER
;  19) SCHED GROUND TIME
;SLAM
;  1)  STAGING POLICY - 1 CREW FOR EVERY ?? ARRIVALS
;  2)  30 DAY FLY TIME LIMIT
;  3)  90 DAY FLY TIME LIMIT
;  4)  ON-TIME PROBABILITY
;  5)  DELAY PROBABILITY
;  6)  RESCHEDULE PROBABILITY
;  7)  PERCENT AVAILABLE
;  8)  CREW RATIO
;  9)  # CREWS CREATED
;  10) MAX RAMP TIME
;  11) ALERT WINDOW
;  12) # OF HOURS AFTER WHICH MSN IS CANCELLED IF NO ACFT OR CREW
;  13) COUNTER FOR CREW ID
;  14) XNG(2)
;  15) MISSION FREQUENCY
;  16) RESOURCE COUNT OF INBOUND ACFT
;  17) ACFT HOME PENDING MAINTENANCE
;  18) # PMC ACFT
;  19) MISC
;  20) MISC
```

```
; 21) MISC
; 22) NUMBER OF LEGS
; 23) TIME SINCE PHASE CHANGE
; 24) TIME OF PHASE CHANGE
; 25) FLY TIME SINCE PHASE CHANGE
; 26) SYSTEM FLY TIME
; 27) FLY TIME AT PHASE CHANGE
; 28) UTE RATE
; 29) # ACFT CREATED
; 30) ACCUM. DUTY HOURS
; 31-37) SAVE ATTRIBUTES AT STAGE BASES
; 38) MISC
; 39) DUTY TIME SINCE PHASE CHANGE
; 40) DUTY TIME AT PHASE CHANGE
; 41) AVG WORK MONTH
; 42) AVG MO FLY HOURS
; 43) TOTAL TIME FROM HOME
; 44) TIME AWAY SINCE PHASE CHANGE
; 45) TIME AWAY AT PHASE CHANGE
; 46) AVG MO TIME FROM HOME
; 47) FREQ OF HSC
; 48) FREQ OF REFURBISHMENT
; 49) 0=PEACE, 1=SURGE, 2=SUSTAINED
; 50) FREQ OF ACI
; 51) RENEGES FROM RESCHEDULING
; 52) STAGE CREW UTILIZED
; 53) INDEX FOR CREW REST (2=PEACE/SUSTAINED, 4=SURGE)
; 54) 30 DAY FLY TIME
; 55) 90 DAY FLY TIME
; 56) # EXCEEDING ALERT WINDOW
;
INIT,0,3840;          135 DAYS (45 PEACE,45 SURGE,45 SUSTAINED) + 600 HR WARMUP
SEEDS,1111(1)/NO,2222(2)/NO,3333(3)/NO,4444(4)/NO,55(5)/NO,6(6)/NO,
      7(7)/NO,888(8)/NO,9999(9)/NO,1010110(10)/NO;
MONTR,CLEAR,600;                                                         WARMUP
MONTR,SUMRY,1681,1080;                                       SUMMARY EACH PHASE
SIMULATE;
FIN;
```

Appendix C

FORTRAN Main

```
      PROGRAM MAIN
      DIMENSION NSET(40000)
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      COMMON/FLY/ACFLTM(160,91),MAN,N
      COMMON QSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      NNSET=40000
      NCRDR=5
      NPRNT=6
      NTAPE=7
      NPLOT=2
      CALL SLAM
      STOP
      END

      SUBROUTINE EVENT(JEVNT)
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12) JEVNT
1     CALL BRAVO
      RETURN
2     CALL CANCEL
      RETURN
3     CALL MIDUP
      RETURN
4     CALL MISSION
      RETURN
5     CALL NEXT
      RETURN
6     CALL STAGEOF
      RETURN
7     CALL SURGE
      RETURN
8     CALL SUSTAIN
      RETURN
9     CALL UPBRAV
      RETURN
10    CALL UPFLTM
      RETURN
11    CALL WARMUP
      RETURN
12    CALL WINDOW
      RETURN
      END
```

```
      SUBROUTINE BRAVO
C     ***********************************************IS BRAVO CREW AVAILABLE?
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON QSET(40000)
      DIMENSION NSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(30)
      NQ=NNQ(8)
      IF (NQ.EQ.0) GO TO 12
      CALL RMOVE(1,8,A)
      A(9)=ATRIB(9)
      A(6)=TNOW
      A(8)=TNOW
      A(17)=1
      XX(52)=1
      CALL FILEM(5,A)
      ATRIB(17)=1
12    CALL UPBRAV
      RETURN
      END

      SUBROUTINE CANCEL
C     **********CANCEL IF IN SCHEDULED MSN QUEUE(3) FOR MORE THAN 12 HRS.
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      DIMENSION NSET(40000)
      COMMON QSET(40000)
      INTEGER RANK
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION B(34)
      RANK=1
      NY=NNQ(3)
9     IF(RANK.GT.NY) GO TO 11
      CALL COPY(RANK,3,B)
      TT=TNOW-B(15)
      IF (TT.LE.XX(12)) GO TO 11
      CALL RMOVE(RANK,3,B)
      NY=NY-1
      XX(51)=XX(51)+1
      YY(17)=YY(17)+1
      GO TO 9
11    RETURN
      END

      SUBROUTINE MIDUP
C     **************************************************CHANGE DAY FOR UPFLTM
C               AND CARRY FORWARD PREVIOUS DAY'S TIME IF NONE FLOWN TODAY
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/FLY/ACFLTM([illegible],[illegible]),MAN,N
```

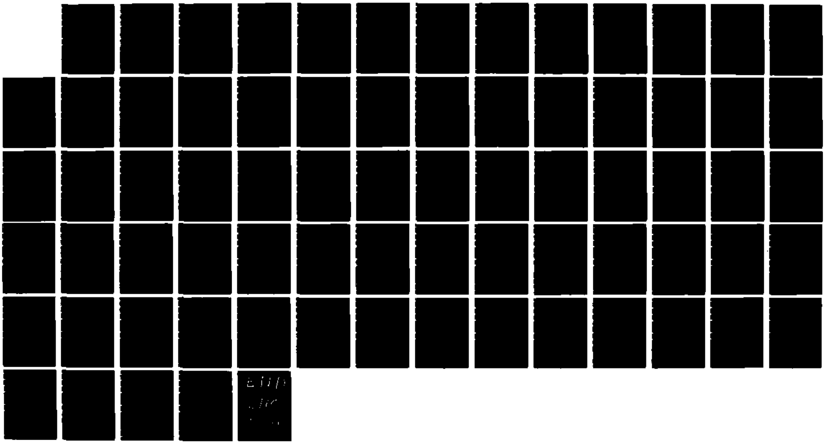
```
      IF (N.EQ.91) THEN
        N=1
        ELSE
        N=N+1
      ENDIF
      DO 30 L=1,160
        IF (N.EQ.1.AND.ACFLTM(L,N).LT.ACFLTM(L,N+1)) THEN
          ACFLTM(L,N)=ACFLTM(L,91)
        ELSEIF (N.EQ.91.AND.ACFLTM(L,N).LT.ACFLTM(L,1)) THEN
          ACFLTM(L,N)=ACFLTM(L,N-1)
        ELSEIF (N.LE.90.AND.N.GT.1.AND.ACFLTM(L,N).LT.ACFLTM(L,N+1))
     1  THEN
          ACFLTM(L,N)=ACFLTM(L,N-1)
        ENDIF
30    CONTINUE
      CALL SCHDL(3,.2400E-02,ATRIB)
      RETURN
      END

      SUBROUTINE MISSION
C     ##########################################################WHICH MISSION?
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      X=DRAND(2)
      CUM=0
      P=1
      DO 25 J=1,NUMRTE
           IF (XX(49).EQ.0) CUM=CUM+FREQPC(J)
           IF (XX(49).EQ.1) CUM=CUM+FREQSG(J)
           IF (XX(49).EQ.2) CUM=CUM+FREQSU(J)
           IF (X.GE.CUM) P=P+1
25    CONTINUE
      ATRIB(1)=NBASE(P,0)
      ATRIB(9)=P
      RETURN
      END

      SUBROUTINE NEXT
C     #################################################################NEXT LEG
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      ATRIB(13)=ATRIB(13)+1
      ATRIB(2)=NBASE(ATRIB(9),ATRIB(13))
      ATRIB(3)=SAT(ATRIB(9),ATRIB(13))
      ATRIB(4)=STAGE(ATRIB(9),ATRIB(13))
```

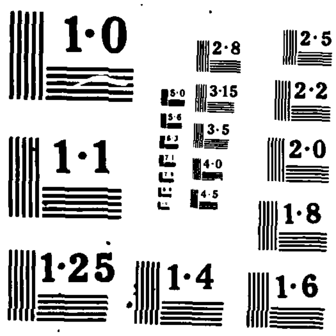
```
      ATRIB(5)=1
      ATRIB(19)=SGT(ATRIB(9),ATRIB(17))
      XX(22)=NLEGS(ATRIB(9))
      RETURN
      END

      SUBROUTINE STAGECR
C     **************************************************POSITION STAGE CREWS
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      DIMENSION NSET(40000)
      COMMON QSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(20),NNTOT(17)
      DO 3 I=11,17
        NNTOT(I)=0
3     CONTINUE
      DO 15 I=1,NUMRTE
        DO 20 J=1,NLEGS(I)-1
          IF (STAGE(I,J).EQ.1) THEN
            SB=NBASE(I,J)
            IF (XX(49).EQ.0) NNTOT(SB)=NNTOT(SB)+FREQPC(I)*(HRSMO/
     1EXPFLY)/XX(1)
            IF (XX(49).EQ.1) NNTOT(SB)=NNTOT(SB)+FREQSG(I)*(HRSMO/
     1EXPFLY)/XX(1)
            IF (XX(49).EQ.2) NNTOT(SB)=NNTOT(SB)+FREQSU(I)*(HRSMO/
     1EXPFLY)/XX(1)
          ENDIF
20      CONTINUE
15    CONTINUE
      DO 25 K=11,17
        IF (XX(49).EQ.0) WRITE(NPRNT,100)K,NNTOT(K)
        IF (XX(49).EQ.1) WRITE(NPRNT,101)K,NNTOT(K)
        IF (XX(49).EQ.2) WRITE(NPRNT,102)K,NNTOT(K)
25    CONTINUE
      DO 22 K=11,17
21      IF (NNTOT(K).LT.NNQ(K)) THEN
          CALL ULINK(1,K)
          CALL LINK(7)
          GO TO 21
        ELSEIF (NNTOT(K).GT.NNQ(K)) THEN
          IF (NNQ(2).EQ.0) GO TO 22
          CALL RMOVE(1,2,A)
          A(2)=K
C         START MISSION FOR STAGE CREW ALLOWING FOR DEADHEAD & REST
          A(3)=TNOW-UNFRM(6.,16.,2)-12
          CALL FILEM(K,A)
          NNTOT(K)=NNTOT(K)-1
```

```
          GO TO 21
        ENDIF
20    CONTINUE
100     FORMAT(' PEACE STAGE CREWS AT ',I2,': ',I2)
101     FORMAT(' SURGE STAGE CREWS AT ',I2,': ',I2)
102     FORMAT(' SUSTAINED STAGE CREWS AT ',I2,': ',I2)
      RETURN
      END

      SUBROUTINE SURGE
C     **************************************************TRANSITION TO SURGE
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLESS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SST(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      XX(49)=1
      XX(53)=4
      XX(15)=USERF(4)
      XX(10)=12
      XX(11)=12
      XX(24)=.1680E+04
      XX(27)=XX(26)
      XX(40)=XX(30)
      XX(45)=XX(47)
      NCREW=(XX(8)*NACFT/4)*XX(7)
      DO 10 I=1,NCREW
        CALL ENTER(1,A)
10    CONTINUE
      XX(8)=XX(8)+NCREW
      CALL STAGECR
      RETURN
      END

      SUBROUTINE SUSTAIN
C     **************************************************TRANSITION TO SUSTAINED
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLESS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SST(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      XX(49)=0
      XX(53)=2
      XX(15)=USERF(4)
      XX(10)=6
      XX(11)=6
      XX(24)=.2760E+04
      XX(27)=XX(25)
      XX(40)=XX(30)
      XX(45)=XX(47)
      CALL STAGECR
```

AD-A168 898 AN ANALYSIS OF AIRCREW RATIOS IN STRATEGIC AIRLIFT - A SLAM SIMULATION(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING B L SUTTER DEC 85 AFIT/ENS/GOR/85D-19 2/2

UNCLASSIFIED F/G 5/9 NL





1·0
2·8
2·5
3·15
2·2
3·5
1·1
4·0
2·0
4·5
1·8
1·25
1·4
1·6

```
      RETURN
      END

      SUBROUTINE UPBRAV
C     ********************CHANGE BRAVO CREW EVERY 48 HRS OR WHEN UTILIZED
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON QSET(40000)
      DIMENSION NSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(30)
      ATRIB(18)=0.
      NQ=NNQ(8)
      IF (XX(52).NE.0.OR.NQ.EQ.0) GO TO 12
      CALL ULINK(1,8)
      CALL LINK(2)
12    XX(52)=0
      NQ=NNQ(2)
      IF (NQ.EQ.0.OR.NNACT(34).GE.1) GO TO 11
      CALL ULINK(1,2)
      IF (ATRIB(17).EQ.0) CALL LINK(8)
      IF (ATRIB(17).NE.0) CALL LINK(10)
11    NRANK=NFIND(1,NCLNR,18,0,9.,0.0)
      IF (NRANK.NE.0) CALL RMOVE(NRANK,NCLNR,A)
      ATRIB(18)=9.
      CALL SCHDL(9,.4800E+02,ATRIB)
      ATRIB(18)=0.
      RETURN
      END

      SUBROUTINE UPFLTM
C     ********************************************UPDATE 90 AND 30 DAY TIME
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/FLT/ACFLTM(150,91),MAN,N
      IF (N.EQ.91) THEN
        N90=1
        ELSE
        N90=N+1
      ENDIF
      IF (N.GE.31) THEN
        N30=N-30
      ELSE
        N30=91+N-30
      ENDIF
      ATRIB(12)=ACFLTM(ATRIB(14),N)+ATRIB(15)-ACFLTM(ATRIB(14),N90)
      ATRIB(11)=ACFLTM(ATRIB(14),N)+ATRIB(15)-ACFLTM(ATRIB(14),N30)
      ACFLTM(ATRIB(14),N90)=ACFLTM(ATRIB(14),N)+ATRIB(15)
      ATRIB(15)=0
      XX(54)=ATRIB(11)
      XX(55)=ATRIB(12)
```

```
      RETURN
      END

      SUBROUTINE WARMUP
C     ****************************REINITIATE STATISTICS AFTER WARMUP PERIOD
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      XX(24)=.6000E+03
      XX(27)=XX(26)
      XX(40)=XX(30)
      XX(45)=XX(43)
      RETURN
      END

      SUBROUTINE WINDOW
C     ***********************************CK ALERT WINDOW IN ALL CREW QUEUES
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON QSET(40000)
      DIMENSION NSET(40000)
      INTEGER RANK,Z
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(30), B(30)
      RANK=1
      I=4
      Z=NNQ(I)
9     IF (RANK.GT.Z) GO TO 11
      CALL COPY(RANK,I,A)
      IF (TNOW-A(16).LE.XX(11)) GO TO 11
      CALL RMOVE(RANK,I,A)
      IF (I.EQ.4) THEN
        XX(17)=XX(17)+1
        TP=A(9)
        NRANK=NFIND(1,6,9,0,TP,0.0)
        CALL RMOVE(NRANK,6,B)
        XX(51)=XX(51)+1
      ENDIF
      Z=Z-1
      A(20)=1
      CALL FILEM(9,A)
      XX(56)=XX(56)+1
      GO TO 9
11    IF (I.EQ.4) THEN
        I=11
      ELSE
        I=I+1
      ENDIF
      IF (I.LE.17) THEN
        Z=NNQ(I)
        GO TO 9
      ENDIF
```

```
      RETURN
      END

      SUBROUTINE INTLC
C     ##############################################################INITIALIZE
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      COMMON/FLY/ACFLTM(160,91),MAN,N
      CHARACTER*6 BASE(10,0:10)
      NUMRTE=0
      WRITE(NPRNT,200)
200   FORMAT(' ROUTE DATA')
      OPEN (UNIT=13, FILE='ROUTE.',STATUS='OLD')
      REWIND(13)
      READ(13,*)ROUTE
10    IF (ROUTE.LE.9999) THEN
             READ(13,*)BASIC(ROUTE),NLEGS(ROUTE),FREQPC(ROUTE)
     1,FREQSG(ROUTE),FREQSU(ROUTE)
             READ(13,201)(BASE(ROUTE,J), J=0,NLEGS(ROUTE))
201          FORMAT(11A6)
             READ(13,*)(STAGE(ROUTE,J),J=1,NLEGS(ROUTE))
             READ(13,*)(SGT(ROUTE,J),J=1,NLEGS(ROUTE))
             READ(13,*)(SAT(ROUTE,J),J=1,NLEGS(ROUTE))
C             WRITE(NPRNT,202)ROUTE,BASIC(ROUTE),NLESS(ROUTE)
202          FORMAT(' ROUTE: ',F3.0,2X,'1 IF BASIC: ',F2.0,2X,'NUMBER OF
     1  LEGS: ',I2)
             WRITE(NPRNT,208)FREQPC(ROUTE),FREQSG(ROUTE),FREQSU(ROUTE)
208          FORMAT(' PEACE USAGE: ',F5.3,2X,' SURGE USAGE: ',F5.3,2X,
     1'SUSTAINED USAGE: ',F5.3)
             WRITE(NPRNT,203)(BASE(ROUTE,J),J=0,NLEGS(ROUTE))
203          FORMAT(' BASES: ',5X,11A6)
             WRITE(NPRNT,204)(STAGE(ROUTE,J),J=1,NLEGS(ROUTE))
204          FORMAT(' STAGE? ',9X,11F6.0)
             WRITE(NPRNT,205)(SGT(ROUTE,J),J=1,NLEGS(ROUTE))
205          FORMAT(' SCHED GND TIME: ',11F6.1)
             WRITE(NPRNT,206)(SAT(ROUTE,J),J=1,NLEGS(ROUTE))
206          FORMAT(' SCHED AIR TIME: ',11F6.2)
             NUMRTE=NUMRTE+1
             READ(13,*)ROUTE
        GO TO 10
        ENDIF
        READ(13,*)NACFT,TURPC,TURSG,TURSU
        WRITE(NPRNT,207)NACFT,TURPC,TURSG,TURSU
207     FORMAT(' AIRCRAFT AT KCHS: ',I2,' PEACE TUR: ',F5.2,' SURGE TUR:'
     1,F5.2,' SUSTAINED TUR: ',F5.2)
        DO 25 ROUTE=1,NUMRTE
           DO 30 J=0,NLEGS(ROUTE)
```

```
            IF (BASE(ROUTE,J).EQ.'KCHS') NBASE(ROUTE,J)=10
            IF (BASE(ROUTE,J).EQ.'CYYR') NBASE(ROUTE,J)=11
            IF (BASE(ROUTE,J).EQ.'EGXX') NBASE(ROUTE,J)=12
            IF (BASE(ROUTE,J).EQ.'KPXX') NBASE(ROUTE,J)=13
            IF (BASE(ROUTE,J).EQ.'CYXX') NBASE(ROUTE,J)=14
            IF (BASE(ROUTE,J).EQ.'EDXX') NBASE(ROUTE,J)=15
            IF (BASE(ROUTE,J).EQ.'ENXX') NBASE(ROUTE,J)=16
            IF (BASE(ROUTE,J).EQ.'KTIK') NBASE(ROUTE,J)=17
30        CONTINUE
25      CONTINUE
C     PEACETIME CREW REST POLICY
      XX(52)=2
      XX(47)=60*24/NACFT
      XX(48)=547.92*24/NACFT
      XX(50)=1095.84*24/NACFT
      XX(29)=NACFT
      XX(18)=NACFT
      N=91
      DO 40 I=1,160
        ACFLTM(I,91)=UNFRM(25.,330.,2)
        RC=ACFLTM(I,91)
        IF (RC.GE.125.) THEN
          SC=UNFRM(0.,125.,3)
          ACFLTM(I,61)=RC-SC
        ELSEIF (RC.LT.125.) THEN
          ACFLTM(I,61)=UNFRM(0.,RC,2)
        ENDIF
        SC=ACFLTM(I,61)
        DO 50 K=62,90
          ACFLTM(I,K)=ACFLTM(I,K-1)+(RC-SC)/29
50      CONTINUE
        ACFLTM(I,1)=0
        DO 30 K=2,60
          ACFLTM(I,K)=ACFLTM(I,K-1)+ACFLTM(I,61)/59
30      CONTINUE
40    CONTINUE
C     MISSION FREQUENCY
      XX(15)=USERF(1)
      ATRIB(19)=0.
      CALL SCHDL(7,.2400E+02,ATRIB)
      CALL SCHDL(7,.1691E+04,ATRIB)
      ATRIB(19)=9.
      CALL SCHDL(9,.4800E+02,ATRIB)
      ATRIB(19)=0.
      CALL SCHDL(6,.0100E+02,ATRIB)
      CALL SCHDL(8,.2761E+04,ATRIB)
      CALL SCHDL(11,.6000E+03,ATRIB)
      RETURN
      END
```

```
      SUBROUTINE OTPUT
C     ************************************************************OUTPUT
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(90),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      COMMON/FLY/ACFLTM(160,91),MAN,N
      WRITE(NPRNT,102),XX(1)
102   FORMAT(' STAGE CREW FOR EVERY ',F3.0,' ARRIVALS')
      WRITE(NPRNT,103),XX(2),XX(3)
103   FORMAT(' 30 & 90 DAY LIMITS: ',2F4.0)
      WRITE(NPRNT,104),XX(9)
104   FORMAT(' # CREWS AVAILABLE: ',F4.0)
      WRITE(NPRNT,105),XX(4),XX(5),XX(6)
105   FORMAT(' RELIABILITY FACTORS: ',F5.3,2X,F5.3,2X,F5.3)
      RETURN
      END

      FUNCTION USERF(IFN)
C     ****************************************************USER FUNCTIONS
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY,SB
      COMMON/FLY/ACFLTM(160,91),MAN,N
      DIMENSION VAL(10)
      GO TO (1,2,3,4,5) IFN
C     COMPUTE SCHED FLY TIME
1     RETURN
C     **********************************COMPUTE HOME STATION CREW REST
      IF ((TNOW-ATRIB(9)).LT.36) USERF=12
      IF ((TNOW-ATRIB(9)).LE.216) USERF=(TNOW-ATRIB(9))/3
      IF ((TNOW-ATRIB(9)).GT.216) USERF=72
      RETURN
C     **********************HOME STATION ESTIMATED UNSCHED MAINTENANCE
3     USERF=RNORM(6.,2.,3)
      RETURN
4     EXPFLY=0
C     ****************COMPUTE SCHEDULING FREQUENCY FOR TARGET UTE RATE
C                               HRS PER MO./ EXP FLY TIME = #MSNS PER MO.
C                           730.56 HRS IN A MO./ MSNS PER MO. = FREQUENCY
      IF (XX(49).EQ.0) HRSMO=NACFT*TURPC*30.44
      IF (XX(49).EQ.1.) HRSMO=NACFT*TURSG*30.44
      IF (XX(49).EQ.2.) HRSMO=NACFT*TURSU*30.44
      DO 15 I=1,NUMRTE
        VAL(I)=0
        DO 20 J=1,NLEGS(I)
          VAL(I)=VAL(I)+SAT(I,J)
20      CONTINUE
```

```
      IF (XX(49).EQ.0) EXPFLY=EXPFLY+(FREQPC(I)*VAL(I))
      IF (XX(49).EQ.1.) EXPFLY=EXPFLY+(FREQSG(I)*VAL(I))
      IF (XX(49).EQ.2.) EXPFLY=EXPFLY+(FREQSU(I)*VAL(I))
15    CONTINUE
      USERF=730.56/(HRSMO/EXPFLY)
      RETURN
C     ******************************************IS BASE STAGING LOCATION?
5     USERF=STAGE(ATRIB(9),ATRIB(13)-1)
      RETURN
6     USERF=0
      RETURN
      END
```

Appendix D

Scenario Files

This appendix contains the scenario data files used for both single homebase models and the multiple homebase model. See Appendix H for scenario information.

"Route" for NATO Single Base

```
1
1 3 .22 0.0 .16
KCHS   KPXX   EGXX   KCHS
0 1 1
2.1 2.1 2.1
0.83 7.72 8.87

2
1 5 .78 .39 .53
KCHS   KPXX   CYXX   EDXX   EGXX   KCHS
0 1 0 1 1
2.1 2.1 2.1 2.1 2.1
0.83 3.23 5.52 1.21 8.87

3
1 5 0.0 .08 0.0
KCHS   KFXX   CYXX   ENXX   EGXX   KCHS
0 1 0 1 1
2.1 2.1 2.1 2.1 2.1
0.83 3.23 5.07 2.64 8.87

4
1 5 0.0 .53 .31
KCHS   KTIK   CYYR   EDXX   EGXX   KCHS
0 1 0 1 1
2.1 2.1 2.1 2.1 2.1
2.33 4.30 5.51 1.21 7.91

99999999
30 4.5 16.1 14.4
```

"Route1" for NATO Multi-homebase

```
1 3 .11 0.0 .08
KCHS  KPXX  EGXX  KCHS
0 1 1
2.3 2.3 2.3
0.93 7.72 8.87

2
1 5 .39 .20 .26
KCHS  KPXX  CYXX  EDXX  EGXX  KCHS
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3
0.83 3.23 5.52 1.21 9.87

3
1 5 0.0 .04 0.0
KCHS  KPXX  CYXX  ENXX  EGXX  KCHS
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3
0.83 3.23 5.07 2.64 8.87

4
1 5 0.0 .257 .16
KCHS  KTIK  CYYR  EDXX  EGXX  KCHS
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3
2.55 4.70 5.51 1.21 7.91

5
1 5 .5 .177 .27
KWRI  KDOV  CYYR  EDXX  EGXX  KWRI
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3

6
1 5 0.0 .33 .23
KWRI  KTIK  CYYR  EDXX  EGXX  KWRI
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3
3.11 4.7 5.51 1.21 7.72

0000000
30 3.3 15.1 13.4
```

"Route2" for SWA Single Homebase

```
1
1 7 1.0 .184 .105
KWRI  KDOV  LPLA  HEXX  OOXX  OEXX  LPLA  KWRI
0 1 1 0 1 1 1
2.1 2.1 2.1 2.1 2.1 2.1 2.1
0.83 5.00 6.67 3.50 2.67 9.14 5.69

2
1 7 0.0 .395 .895
KWRI  KTIK  LPLA  HEXX  OOXX  OEXX  LPLA  KWRI
0 1 1 0 1 1 1
2.1 2.1 2.1 2.1 2.1 2.1 2.1
3.11 7.06 6.67 3.50 2.67 9.14 5.69

3
1 7 0.0 .421 0.0
KWRI  KPXX  LPLA  HEXX  OOXX  OEXX  LPLA  KWRI
0 1 1 0 1 1 1
2.1 2.1 2.1 2.1 2.1 2.1 2.1
1.24 5.43 6.67 3.50 2.67 9.14 5.69

99999999
30 4.0 15.6 13.9
```

Appendix E

Simulation Output

```
ROUTE DATA
PEACE USAGE: 0.220   SURGE USAGE: 0.000   SUSTAINED USAGE: 0.160
BASES:       KCHS  KPXX  EGXX  KCHS
STAGE?             0.    1.    1.
SCHED GND TIME:    2.1   2.1   2.1
SCHED AIR TIME:    0.83  7.72  8.97
PEACE USAGE: 0.780   SURGE USAGE: 0.390   SUSTAINED USAGE: 0.530
BASES:       KCHS  KPXX  CYXX  EDXX  EGXX  KCHS
STAGE?             0.    1.    0.    1.    1.
SCHED GND TIME:    2.1   2.1   2.1   2.1   2.1
SCHED AIR TIME:    0.87  3.23  5.52  1.21  3.87
PEACE USAGE: 0.000   SURGE USAGE: 0.090   SUSTAINED USAGE: 0.000
BASES:       KCHS  KPXX  CYXX  ENXX  EGXX  KCHS
STAGE?             0.    1.    0.    1.    1.
SCHED GND TIME:    2.1   2.1   2.1   2.1   2.1
SCHED AIR TIME:    0.83  3.23  5.07  2.64  8.87
PEACE USAGE: 0.000   SURGE USAGE: 0.530   SUSTAINED USAGE: 0.310
BASES:       KCHS  KTIK  CYYR  EDXX  EGXX  KCHS
STAGE?             0.    1.    0.    1.    1.
SCHED GND TIME:    2.1   2.1   2.1   2.1   2.1
SCHED AIR TIME:    2.55  4.30  5.51  1.21  7.91
AIRCRAFT AT KCHS: 30 PEACE TUR:  7.50 SURGE TUR:15.10 SUSTAINED TUR: 13.40

SUSTAINED STAGE CREWS AT 11:  0
SUSTAINED STAGE CREWS AT 12:  9
SUSTAINED STAGE CREWS AT 13:  0
SUSTAINED STAGE CREWS AT 14: 10
SUSTAINED STAGE CREWS AT 15:  0
SUSTAINED STAGE CREWS AT 16:  0
SUSTAINED STAGE CREWS AT 17:  0


              S L A M   S U M M A R Y   R E P O R T


 SIMULATION PROJECT THESIS2                      BY RSUTTER

 DATE  9/14/1985                                 RUN NUMBER    1 OF    1


 CURRENT TIME   0.2761E+04
 STATISTICAL ARRAYS CLEARED AT TIME  0.6000E+03
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
DUTY DAY	0.108E+02	0.171E+01	0.158E+00	0.275E+01	0.181E+02	1743
INTER AT CYYR	0.310E+01	0.273E+01	0.882E+00	0.586E-02	0.156E+02	339
INTER AT EGXX	0.249E+01	0.249E+01	0.100E+01	0.549E-02	0.159E+02	868
INTER AT KPXX			NO VALUES RECORDED			
INTER AT CYXX	0.459E+01	0.367E+01	0.800E+00	0.403E-01	0.275E+02	472
INTER AT EDXX			NO VALUES RECORDED			
INTER AT ENXX			NO VALUES RECORDED			
INTER AT KTIK			NO VALUES RECORDED			
MISSION LENGTH	0.102E+03	0.349E+02	0.342E+00	0.327E+02	0.262E+03	864
LAST DUTY DAY	0.107E+02	0.833E+00	0.778E-01	0.914E+01	0.158E+02	864
SYS FLY TIME	0.520E+04	0.375E+04	0.721E+00	0.196E+02	0.129E+05	864
MISSION LENGTH	0.617E+02	0.000E+00	0.000E+00	0.617E+02	0.617E+02	1
SYS FLY TIME	0.818E+04	0.000E+00	0.000E+00	0.818E+04	0.818E+04	1

STATISTICS FOR TIME-PERSISTENT VARIABLES

	MEAN VALUE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	TIME INTERVAL	CURRENT VALUE
CREWS AT HOME	32.231	14.708	12.00	50.00	2161.000	14.00
CREWS AT CYYR	2.095	2.732	0.00	11.00	2161.000	4.00
CREWS AT EGXX	6.125	6.536	0.00	23.00	2161.000	7.00
CREWS AT CYXX	3.338	3.404	0.00	13.00	2161.000	2.00
MISSIONS CANCEL	0.000	0.000	0.00	0.00	2161.000	0.00
BURNOUT	449.820	337.824	92.00	1168.00	2161.000	1168.00
# ACFT PMC	21.307	3.423	9.00	29.00	2161.000	18.00

FILE STATISTICS

FILE NUMBER	ASSOCIATED NODE TYPE	AVERAGE LENGTH	STANDARD DEVIATION	MAXIMUM LENGTH	CURRENT LENGTH	AVERAGE WAIT TIME
1	AWAIT	0.001	0.028	1	0	0.035
2	QUEUE	32.231	14.708	50	0	70.855
3	QUEUE	0.000	0.000	1	0	0.000
4	AWAIT	0.007	0.086	2	0	0.019
5	QUEUE	0.000	0.000	1	0	0.000
6	QUEUE	5.391	3.831	15	9	12.347
7	QUEUE	0.000	0.000	0	0	0.000
8	QUEUE	0.750	0.433	1	1	33.082
9	QUEUE	0.000	0.000	0	0	0.000
10	QUEUE	0.000	0.000	0	0	0.000
11	QUEUE	2.095	2.732	11	4	8.575
12	QUEUE	6.125	6.536	23	7	9.180
13	QUEUE	0.000	0.000	1	0	0.000
14	QUEUE	3.338	3.404	13	2	8.597
15	QUEUE	0.000	0.000	1	0	0.000

16	QUEUE	0.000	0.000	0	0	0.000
17	QUEUE	0.000	0.000	1	0	0.000
18		0.000	0.000	0	0	0.000
19		0.000	0.000	0	0	0.000
20		0.000	0.000	0	0	0.000
21	QUEUE	0.035	0.278	4	0	0.216
22	QUEUE	0.069	0.334	6	0	0.167
23	QUEUE	0.056	0.231	1	0	13.549
24	QUEUE	0.044	0.239	3	0	0.196
25	QUEUE	0.050	0.219	1	0	13.598
26	QUEUE	0.000	0.000	0	0	0.000
27	QUEUE	0.031	0.174	1	0	13.461
28		0.000	0.000	0	0	0.000
29	CALENDAR	53.058	17.809	104	96	1.586

****REGULAR ACTIVITY STATISTICS****

ACTIVITY INDEX	AVERAGE UTILIZATION	STANDARD DEVIATION	MAXIMUM UTILIZATION	CURRENT UTILIZATION	ENTITY COUNT
1	4.8786	2.6588	14	8	875
2	0.0000	0.0000	1	0	1680
3	0.8009	0.8102	5	1	804
4	1.4753	1.3392	8	3	1638
5	8.4767	4.5911	21	12	4225
6	0.0840	0.2936	2	0	18
7	0.0258	0.1585	1	0	6
8	1.7933	1.4672	9	2	1681
9	0.0221	0.1479	1	0	6
10	0.0000	0.0000	1	0	1169
18	0.0000	0.0000	1	0	289
19	0.0000	0.0000	1	0	45
20	0.0000	0.0000	0	0	0
21	0.0122	0.1096	1	0	1
22	0.0000	0.0000	1	0	851
23	0.0000	0.0000	1	0	1742
24	0.0000	0.0000	1	0	4231
25	0.0000	0.0000	1	0	5
26	0.0000	0.0000	1	0	1
27	0.1179	0.3417	2	0	40
28	0.2660	0.5222	3	0	83
29	0.9968	0.1225	2	1	45
30	0.2633	0.4399	1	0	3
31	0.4245	0.4943	1	0	2
32	0.8047	1.3143	6	6	105
33	0.0000	0.0000	0	0	0

RESOURCE STATISTICS

RESOURCE NUMBER	RESOURCE LABEL	CURRENT CAPACITY	AVERAGE UTIL	STANDARD DEVIATION	MAXIMUM UTIL	CURRENT UTIL
1	ACFT	30	18.62	7.551	30	26

RESOURCE NUMBER	RESOURCE LABEL	CURRENT AVAILABLE	AVERAGE AVAILABLE	MINIMUM AVAILABLE	MAXIMUM AVAILABLE
1	ACFT	4	11.3783	0	22

TIME-PERSISTENT HISTOGRAM NUMBER 1
CREWS AT HOME

```
CELL RELA   UPPER
TIME FREQ  CELL LIM 0         20        40        60        80        100
                    +    +    +    +    +    +    +    +    +    +    +
  0. 0.00 0.000E+00 +                                                 +
  0. 0.00 0.500E+01 +                                                 +
  0. 0.00 0.100E+02 +                                                 +
143. 0.07 0.150E+02 +***                                              +
849. 0.39 0.200E+02 +********************  C                          +
 65. 0.03 0.250E+02 +**                     C                         +
 22. 0.01 0.300E+02 +*                       C                        +
  1. 0.00 0.350E+02 +                        C                        +
  0. 0.00 0.400E+02 +                        C                        +
215. 0.10 0.450E+02 +*****                        C                   +
868. 0.40 0.500E+02 +********************                             C
  0. 0.00 0.550E+02 +                                                 C
  0. 0.00 0.600E+02 +                                                 C
  0. 0.00 0.650E+02 +                                                 C
  0. 0.00 0.700E+02 +                                                 C
  0. 0.00 0.750E+02 +                                                 C
  0. 0.00 0.800E+02 +                                                 C
  0. 0.00 0.850E+02 +                                                 C
  0. 0.00 0.900E+02 +                                                 C
  0. 0.00 0.950E+02 +                                                 C
  0. 0.00 0.100E+03 +                                                 C
  0. 0.00    INF    +                                                 C
---                 +    +    +    +    +    +    +    +    +    +    +
****                0         20        40        60        80        100
```

STATISTICS FOR TIME-PERSISTENT VARIABLES

	MEAN VALUE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	TIME INTERVAL	CURRENT VALUE
CREWS AT HOME	32.231	14.708	12.00	50.00	2161.000	14.00

TABLE NUMBER 1
RUN NUMBER 1

TIMEHRS	AUR	AVG WORK MONTH	AVG FLY HRSMO	AVG TIME AWAYMO
0.1800E+04	0.5047E+01	0.1216E+03	0.4797E+02	0.2792E+03
0.1920E+04	0.7197E+01	0.1353E+03	0.6888E+02	0.4222E+03
0.2040E+04	0.8292E+01	0.1414E+03	0.7917E+02	0.4651E+03
0.2160E+04	0.8545E+01	0.1421E+03	0.8144E+02	0.4742E+03
0.2280E+04	0.9088E+01	0.1450E+03	0.8652E+02	0.4923E+03
0.2400E+04	0.9159E+01	0.1454E+03	0.8725E+02	0.4907E+03
0.2520E+04	0.9413E+01	0.1465E+03	0.8946E+02	0.4975E+03
0.2640E+04	0.9499E+01	0.1472E+03	0.9047E+02	0.5011E+03
0.2760E+04	0.9567E+01	0.1476E+03	0.9118E+02	0.5003E+03
MINIMUM	0.5047E+01	0.1216E+03	0.4797E+02	0.2792E+03
MAXIMUM	0.9567E+01	0.1476E+03	0.9118E+02	0.5011E+03

PLOT NUMBER 1
RUN NUMBER 1

```
                                           SCALES OF PLOT
U=AUR             0.505E+01                0.731E+01                    0.957E+01
W=AVG WORK MON0.122E+03                    0.135E+03                    0.148E+03
F=AVG FLY HRSM0.480E+02                    0.696E+02                    0.912E+02
T=AVG TIME AWA0.279E+03                    0.390E+03                    0.501E+03
                  0    10    20    30    40    50    60    70    80    90   100 DUPS
TIMEHRS

  0.1800E+04      U                         +                          + UW UF
  0.1920E+04      +                        U+W      T                  + UF
  0.2040E+04      +                         +              U W    T    + UF
  0.2160E+04      +                         +                  -    T  + UW UF
  0.2280E+04      +                         +                     U   T + UW UF
  0.2400E+04      +                         +                     UW  T + UF
  0.2520E+04      +                         +                        UT+ UW UF
  0.2640E+04      +                         +                         UT UW UF
  0.2760E+04      +                         +                          U UW UF
                  0    10    20    30    40    50    60    70    80    90   100 DUPS
TIMEHRS
```

Appendix F

Multi-Base SLAM Network Code

```
GEN,BSUTTER,THESIS3,3/5/85,1,,,,,,72;
LIMITS,32,32,800;                                                    *
TIMST,NNQ(2),CREWS AT HOME;20/0/15
TIMST,NNQ(11),CREWS AT CYYR;
TIMST,NNQ(12),CREWS AT EGXX;
TIMST,NNQ(14),CREWS AT CYXX;
TIMST,XX(51),MISSIONS CANCEL;
TIMST,XX(56),BURNOUT;
TIMST,XX(18),# ACFT PMC
RECORD,TNOW,TIMEHRS,0,8,120; EVERY FIVE DAYS
VAR,XX(28),U,AUR;
VAR,XX(41),W,AVG WORK MONTH;
VAR,XX(42),F,AVG FLY HRSMO;
VAR,XX(46),T,AVG TIME AWAYMO;
PRIORITY/2,HVF(20)/11,HVF(20)/12,HVF(20)/13,HVF(20)/14,HVF(20)/15,HVF(20)/16,
HVF(20)/17,HVF(20); GIVES PRIORITY TO A CREW THAT HAS BEEN MECH. STAGED
;****************************************************************************
;                                                                 USER INPUTS
INTL,XX(1)=45; STAGING POLICY
INTL,XX(2)=125; 30 DAY FLY LIMIT
INTL,XX(3)=330; 90 DAY FLY LIMIT
INTL,XX(4)=.948; PROB. OF ON-TIME
INTL,XX(5)=.044; PROB. OF DELAY
INTL,XX(6)=.008; PROB OF RESCHEDULE
;                   NOTE: XX(50)+XX(51)+XX(52)=1
INTL,XX(7)=.30; PERCENT AVAILABLE
INTL,XX(8)=4.0; CREW RATIO
;INSERT SCENARIO, TIMES, AND TARGET UTE RATES INTO FILE 'ROUTE.'
;INSERT INITIAL NUMBER OF CREWS INTO FIRST CREATE STATEMENT & ASSIGN TO XX(9)
INTL,XX(9)=150; # CREWS AVAILABLE INITIALLY
INTL,XX(10)=6; MAX RAMP PEACE
INTL,XX(11)=6; ALERT WINDOW PEACE
INTL,XX(12)=12; # HRS AFTER WHICH A RESCHED MSN IS CANCELLED IF NO CREW OR AC
;****************************************************************************
NETWORK;
      RESOURCE/ACFT(20),1,4;                                CREATE 20 AIRCRAFT
      RESOURCE/BACFT(3),30,31;                                               *
      CREATE,1,,,150; CREWS
      ASSIGN,XX(13)=XX(13)+1,ATRIB(14)=XX(13),ATRIB(11)=0,ATRIB(5)=1,
      ATRIB(1)=12,ATRIB(4)=1,ATRIB(7)=1,ATRIB(16)=TNOW,ATRIB(9)=0,ATRIB(3)=10;
;                                                                ATRIB(14)=ID
      GOON,1;
      ACT,,ATRIB(14).EQ.1,QUE5;                     POSITIONS FIRST BRAVO CREW
      ACT,,ATRIB(14).EQ.2,QU10;                            SECOND BRAVO CREW*
      ACT;
```

```
START ASSIGN,ATRIB(5)=1,ATRIB(1)=10,ATRIB(4)=1,ATRIB(9)=0,
        ATRIB(3)=0,ATRIB(2)=10,ATRIB(17)=0;       INIT BASIC CREW, PRESENT BASE.
      ASSIGN,XX(14)=NNQ(2),1;
      ACT/32,12,XX(14).GE.1.AND.ATRIB(11)+20.GE.XX(2),START;        APP 30 DAY LMT
      ACT/33,12,XX(14).GE.1.AND.ATRIB(12)+20.GE.XX(3),START;        APP 90 DAY LMT
      ACT;
      EVENT,13,1;                                                       SPLIT BASES*
      ACT/20,24,ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),RET;    ENTER 24 HOUR
;                                    CREW REST IF 30 OR 90 DAY LIMIT EXCEEDED
RET   EVENT,10,1;                                            UPDATE 30/90 FLY TIME
      ACT,,,START;
      QUEUE(32);
      GOON,1;
      ACT/34,12,ATRIB(1).EQ.30,QU10;                                              *
      ACT/35,12;
QUE9  QUEUE(9);                                                    BRAVO CREW FILE
QU10  QUEUE(10);                                                  BRAVO CREW FILE*
QUE2  QUEUE(2),,,,MAT1;                                              AWAIT MISSION
;****************************************************************CREATE*MISSIONS****
;***********************************************************************************
      CREATE,RNORM(XX(15),1,3),0;                    CREATE MISSION AT FREQ OF XX(15)
MSN   EVENT,4,1;                                                 DETERMINE MISSION
      ASSIGN,ATRIB(3)=0,ATRIB(4)=1,ATRIB(5)=1;                    INTLZ COUNTERS
;     ASSIGN,XX(16)=NNRSC(ACFT)+XX(17);                  #GFANADAECRAFRCAVAINBBUND
      ASSIGN,XX(57)=NNRSC(BACFT)+XX(58);                                          *
      GOON,1;
      ACT,,XX(16).LE.0.AND.XX(59).EQ.10,XCLA;                 CANCEL DUE TO NO ACFT*
      ACT,,XX(57).LE.0.AND.XX(59).EQ.30,XCLA;                                BACFT*
      ACT,,XX(16).GT.0.AND.XX(59).EQ.10,UP1;
      ACT;
      ASSIGN,XX(58)=XX(58)-1;                                                     *
      ACT,,,D10;
UP1   ASSIGN,XX(17)=XX(17)-1;                                   ONE ACFT BROKEN FOR
D10   ASSIGN,ATRIB(15)=TNOW;
QUE7  QUEUE(7),,,,MAT1;                                               MISSION QUEUE
MAT1  MATCH,1,QUE2 REST,QUE7/QU6;                         MATCH CREW WITH MISSION*
QU6   ASSIGN,II=ATRIB(9);
      ACT,,,QUE6;
;***********************************************************************************
;                                                                 ****CREW REST****
;***********************************************************************************
REST  GOON;
      ASSIGN,ATRIB(9)=II,ATRIB(7)=0,ATRIB(10)=0;          MISSION NUMBER, FLY TIME
;                                                          & TIME AWAY INIT=0
      ACT/1,12,,;                                                        CREW REST
      ASSIGN,ATRIB(16)=TNOW;
      GOON,1;                                                                     *
      ACT,,ATRIB(1).EQ.30,AW31;                                                   *
      ACT;                                                                        *
      AWAIT(4),ACFT;
      ASSIGN,XX(17)=XX(17)+1;                         RESETS AVAIL OR PROJECTED ACFT
```

```
      GOON;
      ACT,1,,QUE5;                                                 TRAVEL*
AW31  AWAIT(31),BACFT;                                                   *
      ASSIGN,XX(58)=XX(58)+1;                                            *
      GOON;                                                              *
      ACT,1;                                                             *
;*************************************************************************
;                                                    ****CREW SHOWS AT SQDN****
;*************************************************************************
QUE5  QUEUE(5),,,,MAT2;                                               CREW
;
;                                                        ****PREFLIGHT****
;                                                        *****************
QUE6  QUEUE(6),,,,MAT2;                                            MISSION
MAT2  MATCH,9,QUE6/ACC,QUE5/ACC;
ACC   ACCUM,2,2,LAST;                 ATTACHES MSN TO CREW, RETAINS MSN ATTRIB
      ASSIGN,ATRIB(17)=0,ATRIB(5)=TNOW,ATRIB(9)=TNOW;          LEG NUMBER INIT=0
      ASSIGN,XX(18)=XX(19)-1;
      GOON,1;
      ACT,EXPON(2.3,3),ATRIB(17).NE.0,FLY1;                  BRAVO CREW FLYING
      ACT/22;
      ASSIGN,XX(19)=XX(10)-2;
      GOON,1;
      ACT/3,UNFRM(2.0,2.3,3),XX(4),FLY;                                ON TIME
      ACT/27,UNFRM(2.3,XX(10),2),XX(5),FLY;                PREFLIGHT < MAX RAMP
      ACT/7,TRIAG(XX(19),XX(10),XX(10),3),XX(6),XCL;   RAMP EXCEEDED, RESHEDULE
;*************************************************************************
;                                                              ****FLY****
;*************************************************************************
FLY1  ASSIGN,ATRIB(17)=0;                                       BRAVO UTILIZED
FLY   GOON,1;
      EVENT,5,1;                                     COMPUTE NEXT LEG & FLY TIME
      GOON,1;
      ACT/19,,TNOW+ATRIB(3)-ATRIB(6).GT.16,MECH;
;                                                WILL EXCEED DUTY DAY ON NEXT LEG
      ACT/24,,,;
      ASSIGN,XX(19)=ATRIB(3)-.5,XX(20)=ATRIB(3)+1.;
      ASSIGN,XX(21)=TRIAG(XX(19),ATRIB(3),XX(20),4);
      ASSIGN,ATRIB(15)=ATRIB(15)+XX(21);
      ASSIGN,ATRIB(7)=ATRIB(7)+XX(21);                              ACCUM FLY TIME
      ASSIGN,XX(19)=XX(19)+1;
      GOON,1;
      ACT/5,XX(21),ATRIB(17).EQ.ATRIB(20),HOME;                          NEXT HOME
      ACT/5,XX(21);
      ASSIGN,XX(19)=XX(19)-1;
      ASSIGN,XX(23)=TNOW-XX(24),XX(25)=XX(26)-XX(27);
      ASSIGN,XX(28)=XX(29)*XX(23)/24,XX(28)=XX(25)/XX(29)+ATRIB(7)/XX(28);
;                                                    COMPUTE ACHIEVED UTE RATE
```

```
;*****************************************************************************
;                                                       ****ENROUTE STOPS****
;*****************************************************************************
      GOON,1;
      ACT/2,,ATRIB(4).EQ.1,,STAGE;                                 STAGE CREW
      ACT;
      GOON;
      ASSIGN,ATRIB(1)=ATRIB(2);
      ACT/8,RNORM(2.3,.15,2),,FLY;                         SCHEDULED GND TIME
MECH  GOON;                                 DUTY DAY EXCEEDED-MECHANICAL STAGE
      ASSIGN,ATRIB(2)=ATRIB(1),ATRIB(13)=ATRIB(13)-1;
      ACT,,,STAGE;
;
;                                                                       STAGE
STAGE  GOON;
       ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);                   ACCUM. DUTY TIME
       EVENT,10,1;
       COLCT,INT(6),DUTY DAY,,1;
       ACT/25,,ATRIB(2).EQ.10.OR.ATRIB(2).EQ.20,XCLD;HOME STA DUTY DAY EXCEEDED*
       ACT,,ATRIB(2).EQ.11,CYYR;                                  WHICH BASE?
       ACT,,ATRIB(2).EQ.12,ESXX;
       ACT,,ATRIB(2).EQ.13,KPXX;
       ACT,,ATRIB(2).EQ.14,CYXX;
       ACT,,ATRIB(2).EQ.15,EDXX;
       ACT,,ATRIB(2).EQ.16,ENXX;
       ACT,,ATRIB(2).EQ.17,KTIK;
       ACT,,ATRIB(2).EQ.18,KDOV;                                            *
       CREATE,,,,1,1;DUMMY TO INIT QUEUE(9)
       ACT;
QUEP   QUEUE(9);                              CYCLE IF ALERT WINDOW EXCEEDED
       ACT;
       GOON,1;
       ACT,,ATRIB(2).EQ.10.OR.ATRIB(2).EQ.20,QUE2;                          *
       ACT,,ATRIB(2).EQ.11,CY;
       ACT,,ATRIB(2).EQ.12,ES;
       ACT,,ATRIB(2).EQ.13,KP;
       ACT,,ATRIB(2).EQ.14,CYX;
       ACT,,ATRIB(2).EQ.15,ED;
       ACT,,ATRIB(2).EQ.16,EN;
       ACT,,ATRIB(2).EQ.17,KT;
       ACT,,ATRIB(2).EQ.18,KD;                                              *
       ACT;
       TERM;
;*****************************************************************************
;                                               ****STAGE BASE SUBPROGRAMS****
;*****************************************************************************
;                                                                  CYYR STAGE
CYYR   GOON,1;
       ACT,,ATRIB(1).EQ.ATRIB(2),ME11;              ARRIVAL DUE TO MECH STAGE
       ACT;
       COLCT,BET,INTER AT CYYR,,1;                               INTERARRIVAL
```

```
ME11   GOON,2;
       ACT,,,Q111;
       ACT;
       GOON,1;
       ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
;                                                CHECK 30/90 TIME & DEADHEAD
       ACT;
CY     GOON;
       ACT,UNFRM(13.,14.,3):                                       CREW REST
       ASSIGN,ATRIB(16)=TNOW;
       ACT,,,Q112:
Q111   QUEUE(21),,,,MAT3;                                               ACFT
Q112   QUEUE(11),,,,MAT3;                                        CREWS AVAIL
MAT3   MATCH,5,Q111/AX1,Q112/AC1;                       MATCH ACFT WITH CREW
AX1    ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
       XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
       XX(37)=ATRIB(19);
AC1    ACCUM,2,2,LAST;
       ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
       ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
       ATRIB(19)=XX(37);
       ACT,,,CONT;
;
;                                                                 EGXX STAGE
EGXX   GOON,1;
       ACT,,ATRIB(1).EQ.ATRIB(2),ME12:
       ACT;
       COLCT,BET,INTER AT EGXX,,1;
ME12   GOON,2;
       ACT,,,Q121;
       ACT;
       GOON,1;
       ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
       ACT;
EG     GOON:
       ACT,UNFRM(13.,14.,3):
       ASSIGN,ATRIB(16)=TNOW;
       ACT,,,Q122:
Q121   QUEUE(22),,,,MAT4; ACFT
Q122   QUEUE(12),,,,MAT4; CREWS AVAIL
MAT4   MATCH,5,Q121/AX2,Q122/AC2;
AX2    ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
       XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
       XX(37)=ATRIB(19);
AC2    ACCUM,2,2,LAST;
       ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
       ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
       ATRIB(19)=XX(37);
       ACT,,,CONT;
;
;                                                                 KPXX STAGE
```

```
KPXX   GOON,1;
       ACT,,ATRIB(1).EQ.ATRIB(2),ME13;
       ACT;
       COLCT,BET,INTER AT KPXX,,1;
ME13   GOON,2;
       ACT,,,Q131;
       ACT;
       GOON,1;
       ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
       ACT;
KP     GOON;
       ACT,UNFRM(13.,14.,3);
       ASSIGN,ATRIB(16)=TNOW;cIB
       ACT,,,Q132;
Q131   QUEUE(23),,,,MAT5; ACFT
Q132   QUEUE(13),,,,MAT5; CREWS AVAIL W/2
MAT5   MATCH,5,Q131/AX3,Q132/AC3;
AX3    ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
       XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
       XX(37)=ATRIB(19);
AC3    ACCUM,2,2,LAST;
       ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
       ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
       ATRIB(19)=XX(37);
       ACT,,,CONT;
;
;                                                  CYXX STAGE
CYXX   GOON,1;
       ACT,,ATRIB(1).EQ.ATRIB(2),ME14;
       ACT;
       COLCT,BET,INTER AT CYXX,,1;
ME14   GOON,2;
       ACT,,,Q141;
       ACT;
       GOON,1;
       ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
       ACT;
CYX    GOON;
       ACT,UNFRM(13.,14.,3);
       ASSIGN,ATRIB(16)=TNOW;
       ACT,,,Q142;
Q141   QUEUE(24),,,,MAT6; ACFT
Q142   QUEUE(14),,,,MAT6; CREWS AVAIL
MAT6   MATCH,5,Q141/AX4,Q142/AC4;
AX4    ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
       XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
       XX(37)=ATRIB(19);
AC4    ACCUM,2,2,LAST;
       ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
       ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
       ATRIB(19)=XX(37);
```

```
        ACT,,,CONT;
;                                                          EDXX STAGE
EDXX    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME15;
        ACT;
        COLCT,BET,INTER AT EDXX,,1;
ME15    GOON,2;
        ACT,,,Q151;
        ACT;
        GOON,1;
        ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
        ACT;
ED      GOON:
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q152;
Q151    QUEUE(25),,,,MAT7; ACFT
Q152    QUEUE(15),,,,MAT7; CREWS AVAIL
MAT7    MATCH,5,Q151/AX5,Q152/AC5;
AX5     ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC5     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
        ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
        ATRIB(19)=XX(37);
        ACT,,,CONT;
;
;                                                          ENXX STAGE
ENXX    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME16;
        ACT;
        COLCT,BET,INTER AT ENXX,,1;
ME16    GOON,2;
        ACT,,,Q161;
        ACT;
        GOON,1:
        ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
        ACT;
EN      GOON:
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q162;
Q161    QUEUE(26),,,,MAT8; ACFT
Q162    QUEUE(16),,,,MAT8; CREWS AVAIL
MAT8    MATCH,5,Q161/AX6,Q162/AC6;
AX6     ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC6     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
```

```
        ATRIB(4)=XX(34),ATRIB(9)=XX(B(13)=XX(36),
        ATRIB(19)=XX(37);
        ACT,,,CONT;
;
;                                                        KTIK STAGE
KTIK    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME17;
        ACT;
        COLCT,BET,INTER AT KTIK,,1;
ME17    GOON,2;
        ACT,,,Q171;
        ACT;
        GOON,1;
        ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD:
        ACT;
KT      GOON:
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q172:
Q171    QUEUE(27),,,,MAT9; ACFT
Q172    QUEUE(17),,,,MAT9: CREWS AVAIL
MAT9    MATCH,5,Q171/AX7,Q172/AC7;
AX7     ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
        XX(37)=ATRIB(19);
AC7     ACCUM,2,2,LAST;
        ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
        ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
        ATRIB(19)=XX(37);
        ACT,,,CONT;
;
;                                                        KDOV STAGE
KDOV    GOON,1;
        ACT,,ATRIB(1).EQ.ATRIB(2),ME18;
        ACT;
        COLCT,BET,INTER AT KDOV,,1;
ME18    GOON,2;
        ACT,,,Q181;
        ACT;
        GOON,1;
        ACT/21,RNORM(24.,3.,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
        ACT;
KD      GOON:
        ACT,UNFRM(13.,14.,3);
        ASSIGN,ATRIB(16)=TNOW;
        ACT,,,Q182;
Q181    QUEUE(28),,,,MA10; ACFT
Q182    QUEUE(18),,,,MA10; CREWS AVAIL
MA10    MATCH,5,Q181/AX8,Q182/AC8;
AX8     ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
        XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
```

```
       XX(37)=ATRIB(19);
AC8    ACCUM,2,2,LAST;
       ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
       ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
       ATRIB(19)=XX(37);
       ACT,,,CONT;
;********************************************************************************
;                                                   ****MISSION CONTINUATION****
;********************************************************************************
CONT   GOON;
      ACT/23;                                                 ENROUTE DEPARTURES
      ASSIGN,XX(19)=ATRIB(19)-.5,XX(20)=ATRIB(19)+.2,XX(38)=XX(10)-2;
      ASSIGN,ATRIB(1)=ATRIB(2),ATRIB(6)=TNOW,1;            PRESENT NODE=ATRIB(2)
      ACT/4,UNFRM(XX(19),XX(20)),XX(4),FLY;                          NO MAJOR MX
      ACT/29,UNFRM(XX(20),XX(10),2),XX(5),FLY;                             DELAY
      ACT/5,TRIAG(XX(38),XX(10),XX(10),3),XX(6),STAGE;             RAMP EXCEEDED
;********************************************************************************
;                    ****CK MISSION QUEUES FOR WAIT TIME AND ALERT WINDOWS****
;********************************************************************************
      CREATE,1,1,,3840;
      EVENT,2;
      EVENT,12;
      TERM;
;********************************************************************************
;                                                                   ****HOME****
;********************************************************************************
HOME  GOON;
      EVENT,10,1;                                               UPDATE 30/90 TIME
      COLCT,INT(8),MISSION LENGTH;                              TRACK MSN LENGTHS
      COLCT,INT(6),LAST DUTY DAY;                           TRACK FINAL DUTY DAY
      ASSIGN,ATRIB(10)=ATRIB(10)+TNOW-ATRIB(8);                  TRACK TIME AWAY
      GOON;
      ASSIGN,XX(18)=XX(18)-1;
      ASSIGN,XX(26)=XX(26)+ATRIB(7),ATRIB(7)=0;          ACCUMULATE FLYING TIME
      ASSIGN,XX(25)=XX(26)-XX(27);                          FLY TIME THIS PHASE
      ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);                        ACCUM. DUTY TIME
      ASSIGN,XX(23)=TNOW-XX(24),XX(39)=XX(30)-XX(40);       DUTY TIME THIS PHASE
      ASSIGN,XX(41)=XX(9)*XX(23)/730.56,XX(41)=XX(39)/XX(41);     AVG WORK MONTH
      ASSIGN,XX(42)=XX(9)*XX(23)/730.56,XX(42)=XX(25)/XX(42);      AVG FLY HOURS
      ASSIGN,XX(43)=XX(43)+TNOW-ATRIB(8);                          CUM. TIME AWAY
      ASSIGN,XX(44)=XX(43)-XX(45);                          TIME AWAY THIS PHASE
      ASSIGN,XX(46)=XX(9)*XX(23)/730.56,XX(46)=XX(44)/XX(46);     AVG TIME AWAY
      GOON,1;                                                                  *
      ACT,,ATRIB(2).EQ.30,HM30;                                                *
      ACT;
      ASSIGN,XX(17)=XX(17)+1;                                        ACFT INBOUND
      COLCT,XX(25),SYS FLY TIME,,2;                         FLY TIME THIS PHASE
      ACT,USERF(2),,START;                                           CREW AVAIL.
      ACT,USERF(3);                                                      ACFT MX
      FREE,ACFT/1;
      ASSIGN,XX(17)=XX(17)-1;                         RESET COUNTER, ACFT INBOUND
```

```
      ASSIGN,XX(19)=XX(19)+1;
      TERM;
HM30  ASSIGN,XX(58)=XX(58)+1;                                         *
      COLCT,XX(25),SYS FLY TIME,,2;                                   *
      ACT,USERF(2),,START;                                            *
      ACT,USERF(3);                                                   *
      FREE,BACFT/1;                                                   *
      ASSIGN,XX(58)=XX(58)-1;                                         *
      ASSIGN,XX(18)=XX(18)+1;
      TERM;                                                           *
;*****************************************************************************
;                                 ****UNSUCCESSFUL HOMESTATION PREFLIGHT****
;*****************************************************************************
XCL   GOON;
      ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);                 ADD DUTY TIME
      ASSIGN,XX(18)=XX(18)+1;
      GOON,2;                                             RAMP EXCEEDED
      ACT,,,START;                                  CREW BACK TO CREW REST
      ACT/9,UNFRM(3,12,2);
      EVENT,1,1;                                          IS BRAVO AVAIL?
      ACT/25,,ATRIB(17).NE.0,QUE6;                   BRAVO AVAIL-REMATCH
      ACT;
      GOON,2;
      ACT,,,Q10;                                      RESCHEDULE MISSION
      ACT,,ATRIB(1).EQ.30,FR1;                                        *
      ACT,,ATRIB(1).EQ.10;
      FREE,ACFT/1;
      TERM;
FR1   FREE,BACFT/1;                                                   *
      TERM;                                                           *
XCLD  GOON;
      ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);
      GOON,2;                                   DUTY DAY EXCEEDED AT HOME
      ACT,,,START;
      ACT;
      EVENT,1,1;                                          IS BRAVO AVAIL?
      ACT,,ATRIB(17).NE.0,QUE6;                      BRAVO AVAIL-REMATCH
      ACT;
      GOON,2;
      ACT,,,Q10;                                      RESCHEDULE MISSION
      ACT;
      GOON,1;                                                         *
      ACT,,ATRIB(2).EQ.30,FR2;                                        *
      ACT;
      FREE,ACFT/1;
      TERM;
FR2   FREE,BACFT/1;                                                   *
      TERM;                                                           *
XCLA  GOON,1;
      ACT/18;                       COUNT MISSIONS CANCELLED DUE TO NO ACFT
      TERM;
```

```
;*****************************************************************************
;                                         ****SCHEDULED MAINTENANCE*******
;*****************************************************************************
;                              A.C.I AND REFURB NOT ACCOMPLISHED DURING SURGE
;                                HOMESTATION CHECK: 2 DAYS DOWN EACH 60 DAYS
         CREATE,XX(47),0;
         GOON;                                                              *
         ACT,,,AW30;                                                        *
         ACT;
         AWAIT(1),ACFT;
         ASSIGN,XX(18)=XX(18)-1;
         ACT/29,RNORM(48.,1.,3);
         ASSIGN,XX(18)=XX(18)+1;
         FREE,ACFT/1;
         TERM;
AW30     AWAIT(30),BACFT;                                                   *
         ASSIGN,XX(18)=XX(18)-1;                                            *
         ACT/29,RNORM(48.,1.,3);                                            *
         ASSIGN,XX(18)=XX(18)+1;                                            *
         FREE,BACFT/1;                                                      *
         TERM;                                                              *
;                                  REFURBISHMENT: 10 DAYS DOWN EACH 18 MOS
         CREATE,XX(48),0;
         GOON,1;
         ACT,,XX(49).EQ.1,TERM;
         ACT;
         GOON;                                                              *
         ACT,,,AW32;                                                        *
         ACT;                                                               *
         AWAIT(1),ACFT;
         ASSIGN,XX(18)=XX(18)-1;
         ACT/30,RNORM(240.,5.,3);
         ASSIGN,XX(18)=XX(18)+1;
         FREE,ACFT/1;
TERM     TERM;
AW32     AWAIT(30),BACFT;                                                   *
         ASSIGN,XX(18)=XX(18)-1;                                            *
         ACT/30,RNORM(240.,5.,3);                                           *
         ASSIGN,XX(18)=XX(18)+1;                                            *
         FREE,BACFT/1;                                                      *
         TERM;                                                              *
;                        A.C.I. (REPLACING ISOCH): 30 DAYS DOWN EACH 35 MOS
         CREATE,XX(50),100;                          ARBITRARILY START AT 100
         GOON,1;
         ACT,,XX(49).EQ.1,TERM;                             NO INSP IF SURGE
         ACT;
         GOON;                                                              *
         ACT,,,AW33;                                                        *
         ACT;                                                               *
         AWAIT(1),ACFT;
         ASSIGN,XX(18)=XX(18)-1;
```

```
      ACT/31,RNORM(720.,10.,3);
      ASSIGN,XX(18)=XX(18)+1;
      FREE,ACFT/1;
      TERM;
AW33  AWAIT(30),BACFT;                                                    *
      ASSIGN,XX(18)=XX(18)-1;                                             *
      ACT/31,RNORM(720.,10.,3);                                           *
      ASSIGN,XX(18)=XX(18)+1;                                             *
      FREE,BACFT/1;                                                       *
      TERM;                                                               *
;*************************************************************************
;                                  ****DEADHEAD HOME; EXCEEDED FLY TIME****
;*************************************************************************
DEAD  QUEUE(7);
      ACT;
      COLCT,INT(8),MISSION LENGTH;                     TRACK MISSION LENGTH
      ASSIGN, ATRIB(10)=ATRIB(10)+TNOW-ATRIB(8);                  TIME AWAY
      ASSIGN,XX(30)=XX(30)+UNFRM(8.,16.,2),XX(23)=TNOW-XX(24);
      ASSIGN,XX(43)=XX(43)+TNOW-ATRIB(8),XX(44)=XX(43)-XX(45);
      ASSIGN,XX(46)=XX(9)*XX(23)/730.56,XX(46)=XX(44)/XX(46);          AWAY
      ASSIGN,XX(39)=XX(30)-XX(40);
      ASSIGN,XX(41)=XX(9)*XX(23)/730.56,XX(41)=XX(39)/XX(41);          WORK
      GOON;
      ASSIGN,XX(26)=XX(26)+ATRIB(7),ATRIB(7)=0;              ACCUM FLY TIME
      ASSIGN,XX(25)=XX(26)-XX(27);
      ASSIGN,XX(42)=XX(9)*XX(23)/730.56,XX(42)=XX(25)/XX(42);           FLY
      COLCT,XX(25),SYS FLY TIME,,2;
      ACT,USERF(2),,START;                                      CREW AVAIL.
      ACT;
      TERM;
      ENDNETWORK;
SEEDS,65172(1)/NO,4382635(2)/NO;
;
;*************************************************************************
;                                        ****DESCRIPTION OF COMPONENTS****
;*************************************************************************
;QUEUES
;  1) HOME STATION SCHEDULED MAINTENANCE
;  2) CREW PRIOR TO MISSION ASSIGNMENT
;  3) MISSION
;  4) AWAIT ACFT
;  5) CREW PRIOR TO MATCHING WITH MISSION (MAT2)
;  6) MSN PRIOR TO MATCHING WITH CREW (MAT2)
;  7) DEADHEAD TRANSITION
;  8) BRAVO CREW FILE
;  9) BRANCHING FOR WINDOW (FORTRAN)
;  10) B BRAVO*
;  11-18) CREW ENROUTE
;  20-28) ACFT ENROUTE
;  30) AWAIT INSP BACFT
;  31) AWAIT BACFT
```

```
;ACTIVITIES
;  1) CREW REST
;  2) STAGE
;  3) PREFLIGHT HOME STATION - ON TIME
;  4) PREFLIGHT/MX AT STAGE
;  5) FLY
;  6) RAMP EXCEEDED ENROUTE
;  7) RAMP EXCEEDED AT HOME
;  8) QUICK TURN GND TIME
;  9) MX AFTER XCL
;  10) NUMBER OF MISSIONS
;  11-17) BASE COUNT
;  18) CANCELL NO ACFT
;  19) DUTY DAY CANCEL
;  20) EXCEEDS 30/90 LIMITS AT HOME
;  21) EXCEEDS 30/90 LIMITS IN SYSTEM
;  22) # MSNS NOT CANCELLED PRIOR TO PREFLIGHT
;  23) # ENROUTE MISSIONS
;  24) DEPARTURES
;  25) BRAVO FLIES
;  26) DUTY DAY XCL AT HOME
;  27) PREFLIGHT HOME STATION - LATE DEPARTURE
;  28) PREFLIGHT ENROUTE - LATE DEPARTURE
;  29) HSC
;  30) REFURB
;  31) A.C.I.
;  32) APPROACHING 30 DAY LIMIT
;  33) APPROACHING 90 DAY LIMIT
;  34) CR FOR BRAVO
;USERFS
;  1) FLY TIME
;  2) HOME CREW REST
;  3) MX
;  4) CALC MISSION FREQ TO MEET TUR
;  5) STAGE
;ATTRIBUTES
;  1) PRESENT NODE
;  2) NEXT NODE
;  3) SORTIE FLY TIME
;  4) STAGE=1
;  5) BASIC=1
;  6) SHOW TIME FOR DAY
;  7) CUM. FLY TIME
;  8) SHOW TIME FOR MSN
;  9) ROUTE NUMBER
;  10) CUM. TIME AWAY FROM HOME
;  11) CUM. FLY TIME FOR 30 DAYS
;  12) CUM. FLY TIME FOR 90 DAYS
;  13) WHICH LEG NUMBER
;  14) CREW ID
;  15) DAILY CUM FLY TIME
```

```
;  16) START TIME MISC
;  17) MISSION FOR BRAVO CREW
;  18) EVENT NUMBER
;  19) SCHED GROUND TIME
;  20) NLEGS IN MISSION
;SLAM
;  1)  STAGING POLICY - 1 CREW FOR EVERY ?? ARRIVALS
;  2)  30 DAY FLY TIME LIMIT
;  3)  90 DAY FLY TIME LIMIT
;  4)  ON-TIME PROBABILITY
;  5)  DELAY PROBABILITY
;  6)  RESCHEDULE PROBABILITY
;  7)  PERCENT AVAILABLE
;  8)  CREW RATIO
;  9)  # CREWS CREATED
;  10) MAX RAMP TIME
;  11) ALERT WINDOW
;  12) # OF HOURS AFTER WHICH MSN IS CANCELLED IF NO ACFT OR CREW
;  13) COUNTER FOR CREW ID
;  14) NNQ(2)
;  15) MISSION FREQUENCY
;  16) RESOURCE COUNT OF INBOUND ACFT
;  17) ACFT HOME PENDING MAINTENANCE
;  18) # PMC ACFT
;  19) MISC
;  20) MISC
;  21) MISC
;  22) NUMBER OF LEGS
;  23) TIME SINCE PHASE CHANGE
;  24) TIME OF PHASE CHANGE
;  25) FLY TIME SINCE PHASE CHANGE
;  26) SYSTEM FLY TIME
;  27) FLY TIME AT PHASE CHANGE
;  28) UTE RATE
;  29) # ACFT CREATED
;  30) ACCUM. DUTY HOURS
;  31-37) SAVE ATTRIBUTES AT STAGE BASES
;  38) MISC
;  39) DUTY TIME SINCE PHASE CHANGE
;  40) DUTY TIME AT PHASE CHANGE
;  41) AVG WORK MONTH
;  42) AVG MO FLY HOURS
;  43) TOTAL TIME FROM HOME
;  44) TIME AWAY SINCE PHASE CHANGE
;  45) TIME AWAY AT PHASE CHANGE
;  46) AVG MO TIME FROM HOME
;  47) FREQ OF HSC
;  48) FREQ OF REFURBISHMENT
;  49) 0=PEACE, 1=SURGE, 2=SUSTAINED
;  50) FREQ OF ACI
;  51) RENEGES FROM RESCHEDULING
```

```
;  52) STAGE CREW UTILIZED
;  53) INDEX FOR CREW REST (2=PEACE/SUSTAINED, 4=SURGE)
;  54) 30 DAY FLY TIME
;  55) 90 DAY FLY TIME
;  56) # EXCEEDING ALERT WINDOW
;  57) BACFT AVAIL + INBOUND                                      ;
;  58) BACFT INBOUND                                              ;
;  59) HOME STATION FOR MISSION                                   ;
;
INIT,0,3842; 3600               4.5 MOS + 480 HR WARM UP
MONTR,CLEAR,600;
MONTR,SUMRY,1681,1080;        SUMMARY EACH PHASE
SIMULATE;
FIN;
```

APPENDIX G

FORTRAN Main for Multiple Homebase

```
      PROGRAM MAIN
      DIMENSION NSET(40000)
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      COMMON/FLY/ACFLTM(216,91),MAN,N
      COMMON QSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      NNSET=40000
      NCRDR=5
      NPRNT=6
      NTAPE=7
      NPLOT=2
      CALL SLAM
      STOP
      END
      SUBROUTINE EVENT(JEVNT)
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      COMMON/FLY/ACFLTM(216,91),MAN,N
      DIMENSION NSET(40000)
      COMMON QSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14) JEVNT
1     CALL BRAVO
      RETURN
2     CALL CANCEL
      RETURN
3     CALL MIDUP
      RETURN
4     CALL MISSION
      RETURN
5     CALL NEXT
      RETURN
6     CALL STAGECR
      RETURN
7     CALL SURGE
      RETURN
8     CALL SUSTAIN
      RETURN
9     CALL UPBRAV(1)
      RETURN
```

```
10    CALL UPFLTM
      RETURN
11    CALL WARMUP
      RETURN
12    CALL WINDOW
      RETURN
C                                                                    *
13    CALL SPLIT
      RETURN
14    CALL UPBRAV(2)
      RETURN
      END
      SUBROUTINE BRAVO
C     ****************************************************IS BRAVO CREW AVAILABLE?
C                                                     REWRITTEN FOR MULTI-BASE*
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON QSET(40000)
      DIMENSION NSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(34)
      NQ8=NNQ(8)
      NQ10=NNQ(10)
      IF (ATRIB(1).EQ.10..AND.NQ8.EQ.0) GO TO 12
      IF (ATRIB(1).EQ.30..AND.NQ10.EQ.0) GO TO 12
      IF (ATRIB(1).EQ.10..AND.NQ8.NE.0) CALL RMOVE(1,8,A)
      IF (ATRIB(1).EQ.30..AND.NQ10.NE.0) CALL RMOVE(1,10,A)
      A(9)=ATRIB(9)
      A(17)=ATRIB(1)
      XX(52)=ATRIB(1)
      CALL FILEM(5,A)
      ATRIB(17)=ATRIB(1)
12    IF (ATRIB(1).EQ.10.) CALL UPBRAV(1)
      IF (ATRIB(1).EQ.30.) CALL UPBRAV(2)
      RETURN
      END
      SUBROUTINE CANCEL
C     ********************CANCEL IF IN SCHEDULED MSN QUEUE(3) FOR MORE THAN 12 HRS.
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      DIMENSION NSET(40000)
      COMMON QSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION B(34)
      INTEGER RANK
      RANK=1
      NY=NNQ(3)
9     IF (RANK.GT.NY) GO TO 11
      CALL COPY(RANK,3,B)
      TT=TNOW-B(16)
      IF (TT.LE.XX(12)) GO TO 11
```

```
C
      IF (B(1).EQ.10.) XX(17)=XX(17)+1
      IF (B(1).EQ.30.) XX(58)=XX(58)+1
      CALL RMOVE(RANK,3,B)
      NY=NY-1
      XX(51)=XX(51)+1
      GO TO 9
11    RETURN
      END
      SUBROUTINE MIDUP
C     ##############################################################CHANGE DAY FOR UPFLTM
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/FLY/ACFLTM(216,91),MAN,N
      IF (N.EQ.91) THEN
        N=1
        ELSE
        N=N+1
      ENDIF
      DO 30 L=1,216
        IF (N.EQ.1.AND.ACFLTM(L,N).LT.ACFLTM(L,N+1)) THEN
          ACFLTM(L,N)=ACFLTM(L,91)
        ELSEIF (N.EQ.91.AND.ACFLTM(L,N).LT.ACFLTM(L,1)) THEN
          ACFLTM(L,N)=ACFLTM(L,N-1)
        ELSEIF (N.LE.90.AND.N.GT.1.AND.ACFLTM(L,N).LT.ACFLTM(L,N+1))
     1  THEN
          ACFLTM(L,N)=ACFLTM(L,N-1)
        ENDIF
30    CONTINUE
      ATRIB(13)=3.
      CALL SCHDL(3,.2400E+02,ATRIB)
      ATRIB(13)=0.
      RETURN
      END
      SUBROUTINE MISSION
C     ####################################################################WHICH MISSION?
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,3:11),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSG(10),FREQSU(10),TURSU,HRSMO,EXPFLY
       X=DRAND(1)
       CUM=0
       NP=1
       DO 25 J=1,NUMRTE
               IF (XX(49).EQ.0) CUM=CUM+FREQPC(J)
               IF (XX(49).EQ.1) CUM=CUM+FREQSG(J)
               IF (XX(49).EQ.2) CUM=CUM+FREGSU(J)
            IF (X.GE.CUM) NP=NP+1
25     CONTINUE
       ATRIB(1)=NBASE(NP,1)
```

```
C
      XX(59)=NBASE(NP,0)
      ATRIB(9)=NP
      RETURN
      END
      SUBROUTINE NEXT
C     ************************************************************************NEXT LEG
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      ATRIB(13)=ATRIB(13)+1
      ATRIB(2)=NBASE(ATRIB(9),ATRIB(13))
      ATRIB(3)=SAT(ATRIB(9),ATRIB(13))
      ATRIB(4)=STAGE(ATRIB(9),ATRIB(13))
      ATRIB(5)=1
      ATRIB(19)=SGT(ATRIB(9),ATRIB(13))
      ATRIB(20)=NLEGS(ATRIB(9))
      RETURN
      END
      SUBROUTINE SPLIT
C     *******************************************************DIVIDES CREWS BETWEEN BASES
C                                                              NEW FOR MULTI-BASE*
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      I=ATRIB(14)
      IF (MOD(I,2).EQ.0) THEN
        ATRIB(1)=30.
        ATRIB(2)=30.
      ELSE
        ATRIB(1)=10.
        ATRIB(2)=10.
      ENDIF
      RETURN
      END
      SUBROUTINE STAGECR
C     *************************************************************POSITION STAGE CREWS
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      DIMENSION NSET(40000)
      COMMON QSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(24),NNTOT(18)
      DO 3 I=11,19
        NNTOT(I)=0
 3    CONTINUE
      DO 15 I=1,NUMRTE
```

```
        DO 20 J=1,NLESS(I)-1
          IF (STAGE(I,J).EQ.1) THEN
            NB=NBASE(I,J)
            IF (XX(49).EQ.0) NNTOT(NB)=NNTOT(NB)+FREQPC(I)*(HRSMO/
     1EXPFLY)/XX(1)
            IF (XX(49).EQ.1) NNTOT(NB)=NNTOT(NB)+FREQSG(I)*(HRSMO/
     1EXPFLY)/XX(1)
            IF (XX(49).EQ.2) NNTOT(NB)=NNTOT(NB)+FREQSU(I)*(HRSMO/
     1EXPFLY)/XX(1)
          ENDIF
20      CONTINUE
15    CONTINUE
      DO 25 K=11,18
        IF (XX(49).EQ.0) WRITE(NPRNT,100)K,NNTOT(K)
        IF (XX(49).EQ.1) WRITE(NPRNT,101)K,NNTOT(K)
        IF (XX(49).EQ.2) WRITE(NPRNT,102)K,NNTOT(K)
25    CONTINUE
      DO 22 K=11,18
21      IF (NNTOT(K).LT.NNQ(K)) THEN
          CALL ULINK(1,K)
          CALL LINK(7)
          GO TO 21
        ELSEIF (NNTOT(K).GT.NNQ(K)) THEN
          IF (NNQ(2).EQ.0) GO TO 22
          CALL RMOVE(1,2,A)
          A(2)=K
C       START MISSION FOR STAGE CREW ALLOWING FOR DEADHEAD & REST
          A(8)=TNOW-UNFRM(6.,16.,2)-12
          CALL FILEM(K,A)
          NNTOT(K)=NNTOT(K)-1
         GO TO 21
        ENDIF
22    CONTINUE
100     FORMAT(' PEACE STAGE CREWS AT ',I2,': ',I2)
101     FORMAT(' SURGE STAGE CREWS AT ',I2,': ',I2)
102     FORMAT(' SUSTAINED STAGE CREWS AT ',I2,': ',I2)
      RETURN
      END
      SUBROUTINE SURGE
C     ***************************************************************TRANSITION TO SURGE
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),BAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSS(10),TURSU,HRSMO,EXPFLY
      XX(49)=1
      XX(50)=4
      XX(15)=USERF(4)
      XX(10)=12
      XX(11)=12
      XX(24)=.1680E+04
```

```
      XX(27)=XX(26)
      XX(40)=XX(30)
      XX(45)=XX(43)
      NCREW=(XX(8)*NACFT*2/4)*XX(7)
      DO 10 I=1,NCREW
        CALL ENTER(1,A)
10    CONTINUE
      XX(9)=XX(9)+NCREW
      CALL STAGECR
      RETURN
      END
      SUBROUTINE SUSTAIN
C     **********************************************************TRANSITION TO SUSTAINED
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      XX(49)=2
      XX(53)=2
      XX(15)=USERF(4)
      XX(10)=6
      XX(11)=6
      XX(24)=.2760E+04
      XX(27)=XX(26)
      XX(40)=XX(30)
      XX(45)=XX(43)
      CALL STAGECR
      RETURN
      END
      SUBROUTINE UPBRAV(K)
C     ******************************CHANGE BRAVO CREW EVERY 48 HRS OR WHEN UTILIZED
C                                                            REWRITTEN FOR MULTI-BASE*
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON QSET(40000)
      DIMENSION NSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(34),B(34)
      ATRIB(19)=0.
      NQ8=NNQ(8)
      NQ10=NNQ(10)
      GO TO (1,2),K
1     IF (XX(52).EQ.10..OR.NQ8.EQ.0) GO TO 12
      CALL RMOVE(1,8,A)
      CALL FILEM(2,A)
12    NEXT=MMFE(2)
13    IF (NEXT.EQ.0.OR.NNACT(35).GE.1) GO TO 11
      CALL COPY(-NEXT,2,A)
      IF (A(1).EQ.10.) GO TO 15
      NEXT=NSUCR(NEXT)
```

```
      GO TO 13
15    CALL RMOVE(-NEXT,2,A)
      IF (ATRIB(17).EQ.0) CALL FILEM(9,A)
      IF (ATRIB(17).NE.0) CALL FILEM(32,A)
      GO TO 11
2     IF (XX(52).EQ.30..OR.NQ10.EQ.0) GO TO 17
      CALL RMOVE(1,10,A)
      CALL FILEM(2,A)
17    NEXT=MMFE(2)
14    IF (NEXT.EQ.0.OR.NNACT(34).GE.1) GO TO 18
      CALL COPY(-NEXT,2,A)
      IF (A(1).EQ.30.) GO TO 16
      NEXT=NSUCR(NEXT)
      GO TO 14
16    CALL RMOVE(-NEXT,2,A)
      IF (ATRIB(17).EQ.0) CALL FILEM(10,A)
      IF (ATRIB(17).NE.0) CALL FILEM(32,A)
      GO TO 18
11    NRANK=NFIND(1,NCLNR,18,0,9.,0.0)
      IF (NRANK.NE.0) CALL RMOVE(NRANK,NCLNR,B)
      ATRIB(18)=9.
      CALL SCHDL(9.,.4800E+02,ATRIB)
      ATRIB(18)=0.
      XX(52)=0
      RETURN
18    NRANK=NFIND(1,NCLNR,18,0,14.,0.0)
      IF (NRANK.NE.0) CALL RMOVE(NRANK,NCLNR,B)
      ATRIB(18)=14.
      CALL SCHDL(14.,.4800E+02,ATRIB)
      ATRIB(18)=0.
      XX(52)=0
      RETURN
      END
      SUBROUTINE UPFLTM
C     ****************************************************UPDATE 90 AND 30 DAY TIME
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      COMMON/FLY/ACFLTM(216,91),MAN,N
      IF (N.EQ.91) THEN
        N90=1
        ELSE
        N90=N+1
      ENDIF
      IF (N.GE.31) THEN
        N30=N-30
      ELSE
        N30=91+N-30
      ENDIF
```

```
      ATRIB(12)=ACFLTM(ATRIB(14),N)+ATRIB(15)-ACFLTM(ATRIB(14),N90)
      ATRIB(11)=ACFLTM(ATRIB(14),N)+ATRIB(15)-ACFLTM(ATRIB(14),N30)
      ACFLTM(ATRIB(14),N90)=ACFLTM(ATRIB(14),N)+ATRIB(15)
      ATRIB(15)=0
      XX(54)=ATRIB(11)
      XX(55)=ATRIB(12)
      RETURN
      END
      SUBROUTINE WARMUP
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      XX(34)=.6000E+02
      XX(37)=XX(26)
      XX(40)=XX(30)
      XX(45)=XX(43)
      RETURN
      END
      SUBROUTINE WINDOW
C     ****************************************************************CK ALERT WINDOW
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON QSET(40000)
      DIMENSION NSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(34), B(34)
      INTEGER RANK,Z,IFILE
      RANK=1
      I=4
      Z=NNQ(I)
9     IF (RANK.GT.Z) GO TO 11
      CALL COPY(RANK,I,A)
      IF (TNOW-A(16).LE.XX(11)) GO TO 11
      CALL RMOVE(RANK,I,A)
      IF (I.EQ.4) THEN
        XX(17)=XX(17)+1
        TF=A(9)
        NRANK=NFIND(1,6,9,0,TF,0.0)
        CALL RMOVE(NRANK,6,B)
        XX(51)=XX(51)+1
      ELSEIF (I.EQ.31) THEN
        XX(59)=XX(59)+1
        TF=A(9)
        NRANK=NFIND(1,6,9,0,TF,0.0)
        CALL RMOVE(NRANK,6,B)
        XX(51)=XX(51)+1
      ENDIF
      Z=Z-1
      A(20)=1
      CALL FILEM(9,A)
      XX(56)=XX(56)+1
      GO TO 9
```

```
11    IF (I.EQ.4) THEN
        I=31
      ELSEIF (I.EQ.31) THEN
        I=11
      ELSE
        I=I+1
      ENDIF
      IF (I.LE.19) THEN
        Z=NNQ(I)
        GO TO 9
      ENDIF
      RETURN
      END
      SUBROUTINE INTLC
C     ******************************************************************INITIALIZE
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      DIMENSION NSET(40000)
      COMMON QSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      COMMON/FLY/ACFLTM(216,91),MAN,N
      CHARACTER*6 BASE(10,0:10)
      NUMRTE=0
      WRITE(NPRNT,200)
200   FORMAT(' ROUTE DATA')
      OPEN (UNIT=13, FILE='ROUTE1.',STATUS='OLD')
      REWIND(13)
      READ(13,*)ROUTE
10    IF (ROUTE.LE.9999) THEN
            READ(13,*)BASIC(ROUTE),NLEGS(ROUTE),FREQPC(ROUTE)
     1,FREQSG(ROUTE),FREQSU(ROUTE)
            READ(13,201)(BASE(ROUTE,J), J=0,NLEGS(ROUTE))
201         FORMAT(11A6)
            READ(13,*)(STAGE(ROUTE,J),J=1,NLEGS(ROUTE))
            READ(13,*)(SGT(ROUTE,J),J=1,NLEGS(ROUTE))
            READ(13,*)(SAT(ROUTE,J),J=1,NLEGS(ROUTE))
            WRITE(NPRNT,202)ROUTE,BASIC(ROUTE),NLEGS(ROUTE)
202         FORMAT(' ROUTE: ',F3.0,2X,'1 IF BASIC: ',F2.0,2X,'NUMBER OF
     1 LEGS: ',I2)
            WRITE(NPRNT,209)FREQPC(ROUTE),FREQSG(ROUTE),FREQSU(ROUTE)
209         FORMAT(' PEACE USAGE: ',F3.2,2X,' SURGE USAGE: ',F3.2,2X
     1,' SUSTAINED USAGE: ',F3.2)
            WRITE(NPRNT,203)(BASE(ROUTE,J),J=0,NLEGS(ROUTE))
203         FORMAT(' BASES: ',5X,11A6)
            WRITE(NPRNT,204)(STAGE(ROUTE,J),J=1,NLEGS(ROUTE))
204         FORMAT(' STAGE: ',8X,11F6.0)
            WRITE(NPRNT,205)(SGT(ROUTE,J),J=1,NLEGS(ROUTE))
205         FORMAT(' SCHED GND TIME: ',11F6.1)
```

```
          WRITE(NPRNT,206)(SAT(ROUTE,J),J=1,NLEGS(ROUTE))
206       FORMAT(' SCHED AIR TIME: ',11F6.1)
          NUMRTE=NUMRTE+1
          READ(13,*)ROUTE
      GO TO 10
      ENDIF
      READ(13,*)NACFT,TURPC,TURSG,TURSU
      WRITE(NPRNT,207)NACFT,TURPC,TURSG,TURSU
207   FORMAT(' TOTAL AIRCRAFT: ',I2,' PEACE TUR: ',F5.2,' SURGE TUR:'
     1,F5.2,' SUSTAINED TUR: ',F5.2)
      DO 25 ROUTE=1,NUMRTE
        DO 30 J=0,NLEGS(ROUTE)
          IF (BASE(ROUTE,J).EQ.'KCHS') NBASE(ROUTE,J)=10
          IF (BASE(ROUTE,J).EQ.'CYYR') NBASE(ROUTE,J)=11
          IF (BASE(ROUTE,J).EQ.'EGXX') NBASE(ROUTE,J)=12
          IF (BASE(ROUTE,J).EQ.'LPXX') NBASE(ROUTE,J)=13
          IF (BASE(ROUTE,J).EQ.'CYXX') NBASE(ROUTE,J)=14
          IF (BASE(ROUTE,J).EQ.'EDXX') NBASE(ROUTE,J)=15
          IF (BASE(ROUTE,J).EQ.'ENXX') NBASE(ROUTE,J)=16
          IF (BASE(ROUTE,J).EQ.'KTIK') NBASE(ROUTE,J)=17
          IF (BASE(ROUTE,J).EQ.'KDOV') NBASE(ROUTE,J)=18
          IF (BASE(ROUTE,J).EQ.'KWRI') NBASE(ROUTE,J)=30
30      CONTINUE
25     CONTINUE
C     PEACETIME CREW REST POLICY
      XX(57)=2
C     CUMULATIVE DISTRIBUTION OF MISSIONS
      XX(29)=NACFT*2
      XX(19)=NACFT*2
      XX(47)=60*24/NACFT
      XX(48)=547.5*24/NACFT
      XX(50)=1095*24/NACFT
      N=91
      DO 40 I=1,216
        ACFLTM(I,91)=UNFRM(25.,330.,2)
        RC=ACFLTM(I,91)
        IF (RC.GE.125.) THEN
          SC=UNFRM(0.,125.,3)
          ACFLTM(I,61)=RC-SC
        ELSEIF (RC.LT.125.) THEN
          ACFLTM(I,61)=UNFRM(0.,RC,2)
        ENDIF
        SC=ACFLTM(I,61)
        DO 50 K=62,90
          ACFLTM(I,K)=ACFLTM(I,K-1)+(RC-SC)/29
50      CONTINUE
        ACFLTM(I,1)=0
        DO 20 K=2,60
          ACFLTM(I,K)=ACFLTM(I,K-1)+ACFLTM(I,61)/59
20      CONTINUE
40    CONTINUE
```

```
C     MISSION FREQUENCY
      XX(15)=USERF(4)
      ATRIB(18)=0.
C      CALL SCHDL(7,.2400E+02,ATRIB)
      CALL SCHDL(7,.1681E+04,ATRIB)
      ATRIB(18)=9.
      CALL SCHDL(9,.4800E+02,ATRIB)
      ATRIB(18)=6.
      CALL SCHDL(6,.0100E+02,ATRIB)
      ATRIB(18)=8.
      CALL SCHDL(8,.2761E+04,ATRIB)
      ATRIB(18)=11.
      CALL SCHDL(11,.6000E+03,ATRIB)
      ATRIB(18)=14.
      CALL SCHDL(14,.4800E+02,ATRIB)
      ATRIB(18)=0.
      RETURN
      END
      SUBROUTINE OTPUT
C     ##########################################################################OUTPUT
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      COMMON/FLY/ACFLTM(216,91),MAN,N
      WRITE(NPRNT,102)XX(1)
102   FORMAT(' STAGE CREW FOR EVERY ',F3.0,' ARRIVALS')
      WRITE(NPRNT,103)XX(2),XX(3)
103   FORMAT(' 30 & 90 DAY LIMITS: ',2F4.0)
      WRITE(NPRNT,104)XX(9)
104   FORMAT(' # CREWS AVAILABLE: ',F4.0)
      WRITE(NPRNT,105)XX(4),XX(5),XX(6)
105   FORMAT(' RELIABILITY FACTORS: ',F5.3,2X,F5.3,2X,F5.3)
      RETURN
      END
      FUNCTION USERF(IFN)
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
     1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
     1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
     1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
      COMMON/FLY/ACFLTM(216,91),MAN,N
       DIMENSION VAL(10)
       GO TO (1,2,3,4,5) IFN
C      COMPUTE SCHED FLY TIME
1      RETURN
C      ################################################COMPUTE HOME STATION CREW REST
2      IF (XX(53).EQ.4) GO TO 6
       IF ((TNOW-ATRIB(3)).LE.76) USERF=12
       IF ((TNOW-ATRIB(3)).LE.216) USERF=(TNOW-ATRIB(3))/3
```

```
      IF ((TNOW-ATRIB(8)).GT.216) USERF=72
      RETURN
C     **********************************HOME STATION ESTIMATED UNSCHED MAINTENANCE
3     USERF=RNORM(6.,2.,3)
      RETURN
4     EXPFLY=0
C     ***************************COMPUTE SCHEDULING FREQUENCY FOR TARGET UTE RATE
C                                     HRS PER MO./ EXP FLY TIME = *MSNS PER MO.
C                                    726 HRS IN A MO./ MSNS PER MO. = FREQUENCY
      IF (XX(49).EQ.0) HRSMO=NACFT*TURPC*30.44
      IF (XX(49).EQ.1.) HRSMO=NACFT*TURSG*30.44
      IF (XX(49).EQ.2.) HRSMO=NACFT*TURSU*30.44
      DO 15 I=1.NUMRTE
         VAL(I)=0
         DO 20 J=1.NLEGS(I)
           VAL(I)=VAL(I)+SAT(I,J)
20       CONTINUE
         IF (XX(49).EQ.0) EXPFLY=EXPFLY+(FREQPC(I)*VAL(I))
         IF (XX(49).EQ.1.) EXPFLY=EXPFLY+(FREQSG(I)*VAL(I))
         IF (XX(49).EQ.2.) EXPFLY=EXPFLY+(FREQSU(I)*VAL(I))
15    CONTINUE
      USERF=730.56/(HRSMO/EXPFLY)
      RETURN
C     **************************************************IS BASE A STAGING LOCATION?
5     USERF=STAGE(ATRIB(9).ATRIB(13)-1)
      RETURN
6     USERF=0
      RETURN
      END
```

Appendix H

Scenario Extracts

This appendix contains the scenarios used for this study. They were provided by USAF/SAGM.

TABLE H.1

NATO Single Homebase Scenario

Route #	Dept	Dest	GT	FT	Stage
3	KCHS(10)	KPXX(13)	2.3	0.83	No
		EGXX(12)	2.3	7.72	Yes
		KCHS(10)	2.3	8.37	Yes
4	KCHS(10)	KPXX(13)	2.3	0.83	No
		CYXX(14)	2.3	3.23	Yes
		EDXX(15)	2.3	5.52	No
		EGXX(12)	2.3	1.21	Yes
		KCHS(10)	2.3	8.37	Yes
5	KCHS(10)	KPXX(13)	2.3	0.83	No
		CYXX(14)	2.3	3.23	Yes
		ENXX(15)	2.3	5.07	No
		EGXX(12)	2.3	2.64	Yes
		KCHS(10)	2.3	8.37	Yes
6	KCHS(10)	KTIX(17)	2.3	2.55	No
		CYXP(11)	2.3	4.70	Yes
		EDXX(15)	2.3	5.51	No
		EGXX(12)	2.3	1.21	Yes
		KCHS(10)	2.3	7.71	Yes

Route Frequency

Route #	Peace Percentage	Surge Percentage	Sustained Percentage
3	22.0	0.0	16.0
4	78.0	39.0	53.0
5	0.0	8.0	0.0
6	0.0	53.0	31.0

TABLE H.2

SWA Single Homebase Scenario

Route #	Dept	Dest	GT	FT	Stage
1	KWRI(10)	KDOV(11)	2.3	0.83	NO
		LPLA(12)	2.3	5.00	YES
		HEXX(13)	2.3	6.67	YES
		OOXX(14)	2.3	3.50	NO
		OEXX(15)	2.3	2.67	YES
		LPLA(12)	2.3	9.14	YES
		KWRI(10)	2.3	5.69	YES
2	KWRI(10)	KTIK(16)	2.3	3.11	NO
		LPLA(12)	2.3	7.06	YES
		HEXX(13)	2.3	6.67	YES
		OOXX(14)	2.3	3.50	NO
		OEXX(15)	2.3	2.67	YES
		LPLA(12)	2.3	9.14	YES
		KWRI(10)	2.3	5.69	YES
3	KWRI(10)	KPXX(17)	2.3	1.24	NO
		LPLA(12)	2.3	5.43	YES
		HEXX(13)	2.3	6.67	YES
		OOXX(14)	2.3	3.50	NO
		OEXX(15)	2.3	2.67	YES
		LPLA(12)	2.3	9.14	YES
		KWRI(10)	2.3	5.69	YES

Route Frequency

Route #	Peace Percentage	Surge Percentage	Sustained Percentage
1	100.0	18.4	10.5
2	0.0	39.5	89.5
3	0.0	42.1	0.0

TABLE H.3

NATO Multiple Homebase Scenario

Route #	Dept	Dest	GT	FT	Stage
1	KWRI(30)	KDOV(18)	2.3	0.83	NO
		CYYR(11)	2.3	2.65	YES
		EDXX(15)	2.3	5.52	NO
		EGXX(12)	2.3	1.21	YES
		KWRI(30)	2.3	7.72	YES
2	KWRI(30)	KTIK(17)	2.3	3.11	NO
		CYYR(11)	2.3	4.30	YES
		EDXX(15)	2.3	5.51	NO
		EGXX(12)	2.3	1.21	YES
		KWRI(30)	2.3	7.72	YES
3	KCHS(10)	KPXX(13)	2.3	0.83	No
		EGXX(12)	2.3	7.72	Yes
		KCHS(10)	2.3	9.87	Yes
4	KCHS(10)	KPXX(13)	2.3	0.83	No
		CYXX(14)	2.3	3.23	Yes
		EDXX(15)	2.3	5.52	No
		EGXX(12)	2.3	1.21	Yes
		KCHS(10)	2.3	8.87	Yes
5	KCHS(10)	KPXX(13)	2.3	0.83	No
		CYXX(14)	2.3	3.23	Yes
		ENXX(16)	2.3	5.07	No
		EGXX(12)	2.3	1.64	Yes
		KCHS(10)	2.3	9.87	Yes
6	KCHS(10)	KTIK(17)	2.3	2.55	No
		CYYR(11)	2.3	4.30	Yes
		EDXX(15)	2.3	5.51	No
		EGXX(12)	2.3	1.21	Yes
		KCHS(10)	2.3	7.91	Yes

Route Frequency

Route #	Peace Percentage	Surge Percentage	Sustained Percentage
1	50.0	17.3	27.0
2	0.0	32.0	23.0
3	11.0	0.0	9.0
4	39.0	20.0	26.0
5	0.0	4.0	0.0
6	0.0	26.7	16.0

Appendix I

ANOVA

ANOVA Input Program

```
/PROBLEM        TITLE IS 'THESIS'.
/INPUT          VARIABLES ARE 13.
                FORMAT IS FREE.
                FILE IS 'anova1.dat'.
/VARIABLE       NAMES ARE ID,STAGE,FLYLMT,TUR,PERCENT,CR,RELIAB,
                GND,LEGS,AURFUR,AVGWORK,AVGFLY,CANCEL,AUR.
                ADD=1.
                LABEL IS ID.
/TRANSFORM      IF (TUR EQ -1) THEN AUR=AURFUR*15.1.
                IF (TUR EQ 1) THEN AUR=AUFFUR*16.1.
                USE=ID LE 64.
/GROUP          CODES(2) ARE -1,1.
                NAMES(2) ARE THIRTY,SIXTY.
                CODES(3) ARE -1,1.
                NAMES(3) ARE ONETWOFIVE,ONEFIVEZERO.
                CODES(4) ARE -1,1.
                NAMES(4) ARE THREEFIVE,FOURFIVE.
                CODES(5) ARE -1,1.
                NAMES(5) ARE EIGHTY,NINETY.
                CODES(6) ARE -1,1.
                NAMES(6) ARE FOUR,FIVE.
                CODES(7) ARE -1,1.
                NAMES(7) ARE NINEFOUREIGHT,NINEFIVEFIVE.
                CODES(8) ARE -1,1.
                NAMES(8) ARE TWOONE,TWOTHREE.
                CODES(9) ARE -1,1.
                NAMES(9) ARE NATO,SWA.
/DESIGN         GROUPING ARE 2,3,4,5,6,7,8,9.
                DEPENDENT IS 11.
                INCLUDED ARE 1,2,3,4,5,6,7,8,12,13,14,15,16,17,18,
                23,24,25,26,27,29,34,35,36,37,38,45,46,47,48,56,
                57,58,67,68,78.
/END
```

Table I.1

Anova Data

1	1	1	1	1	1	1	1	1	.6671	112.0	73.38	0
2	-1	-1	-1	1	1	-1	-1	-1	.6294	105.0	64.80	0
3	1	-1	-1	-1	-1	1	-1	1	.6197	133.6	88.76	0
4	-1	1	1	-1	-1	-1	1	-1	.5961	148.3	91.23	310
5	1	1	1	1	-1	-1	-1	-1	.5907	127.6	80.54	0
6	-1	-1	-1	1	-1	1	1	1	.6841	144.2	87.39	4
7	1	-1	-1	-1	1	-1	1	-1	.6277	114.6	72.29	0
8	-1	1	1	-1	1	1	-1	1	.6472	130.5	79.08	4
9	1	1	-1	-1	1	1	-1	-1	.6401	114.5	73.63	0
10	-1	-1	1	-1	1	-1	1	1	.6938	136.5	85.14	0
11	1	-1	1	1	-1	1	1	-1	.6094	130.9	83.13	0
12	-1	1	-1	1	-1	-1	-1	1	.6748	143.6	86.17	78
13	1	1	-1	-1	-1	-1	1	1	.6775	154.8	97.36	7
14	-1	-1	1	-1	-1	1	-1	-1	.6023	147.2	92.28	107
15	1	-1	1	1	1	-1	-1	1	.5925	99.43	65.47	5
16	-1	1	-1	1	1	1	1	-1	.6322	105.4	65.06	0
17	-1	-1	-1	1	1	1	-1	1	.7053	116.1	72.61	0
18	1	1	1	1	1	-1	1	-1	.5992	105.6	65.73	0
19	-1	1	1	-1	-1	1	1	1	.6758	164.5	103.1	98
20	1	-1	-1	-1	-1	-1	-1	-1	.6386	143.9	91.82	2
21	-1	-1	-1	1	-1	-1	1	-1	.6335	130.6	80.83	3
22	1	1	1	1	-1	1	-1	1	.6969	143.4	94.86	0
23	-1	1	1	-1	1	-1	-1	-1	.5992	117.0	73.38	0
24	1	-1	-1	-1	1	1	1	1	.6301	114.5	72.47	0
25	-1	-1	1	-1	1	1	1	-1	.6255	123.0	76.67	0
26	1	1	-1	-1	1	-1	-1	1	.6907	122.6	79.44	0
27	-1	1	-1	1	-1	1	-1	-1	.6252	128.9	79.87	0
28	1	-1	1	1	-1	-1	1	1	.5199	108.7	71.17	0
29	-1	-1	1	-1	-1	-1	-1	1	.6460	163.4	93.90	18
30	1	1	-1	-1	-1	1	1	-1	.6394	145.7	91.97	0
31	-1	1	-1	1	1	-1	1	1	.5953	116.7	71.97	1
32	1	-1	1	1	1	1	-1	-1	.5850	99.92	64.16	0
33	1	-1	1	-1	-1	-1	1	-1	.5996	145.7	91.89	0
34	-1	1	-1	-1	-1	1	-1	1	.6676	161.8	96.06	72
35	1	1	-1	1	1	-1	-1	-1	.6378	103.7	65.56	0
36	-1	-1	1	1	1	1	1	1	.6534	129.5	77.95	0
37	1	-1	1	-1	1	1	-1	1	.4707	84.13	57.94	0
38	-1	1	-1	-1	1	-1	1	-1	.6298	118.0	72.36	0
39	1	1	-1	1	-1	1	1	1	.6722	135.8	85.92	0
40	-1	-1	1	1	-1	-1	-1	-1	.5985	129.9	81.63	0
41	1	-1	-1	1	-1	-1	-1	1	.6181	123.0	79.53	0
42	-1	1	1	1	-1	1	1	-1	.5920	130.2	80.83	167
43	1	1	1	-1	1	-1	1	1	.6733	126.8	83.28	0
44	-1	-1	-1	-1	1	1	-1	-1	.6495	119.6	74.68	0
45	1	-1	-1	1	1	1	1	-1	.6794	104.4	65.74	0
46	-1	1	1	1	1	-1	-1	1	.6665	116.2	73.07	0
47	1	1	1	-1	-1	1	-1	-1	.6065	145.7	92.87	0
48	-1	-1	-1	-1	-1	-1	1	1	.6923	163.6	99.39	7

Table I.1 cont.

49	-1	1	-1	-1	-1	-1	-1	-1	.6340	146.4	91.32	83
50	1	-1	1	-1	-1	1	1	1	.4787	111.6	73.33	0
51	-1	-1	1	1	1	-1	1	-1	.5979	106.1	65.58	0
52	1	1	-1	1	1	1	-1	1	.7060	110.1	72.70	0
53	-1	1	-1	-1	1	1	1	1	.6695	130.0	77.03	0
54	1	-1	1	-1	1	-1	-1	-1	.5976	116.0	73.25	5
55	-1	-1	1	1	-1	1	-1	1	.6857	147.6	92.95	31
56	1	1	-1	1	-1	-1	1	-1	.6320	129.5	80.81	0
57	-1	1	1	1	-1	-1	1	1	.6360	145.9	86.51	48
58	1	-1	-1	1	-1	1	-1	-1	.6363	127.1	81.33	0
59	-1	-1	-1	-1	1	-1	-1	1	.6695	129.0	76.73	6
60	1	1	1	-1	1	1	1	-1	.6102	118.0	74.76	0
61	-1	1	1	1	1	1	-1	-1	.5984	104.4	65.96	0
62	1	-1	-1	1	1	-1	1	1	.5560	97.88	57.27	0
63	-1	-1	-1	-1	-1	1	1	-1	.6795	148.2	91.89	312
64	1	1	1	-1	-1	-1	-1	1	.7068	153.6	108.4	2

<u>Appendix J</u>

<u>Regression Analysis</u>

TABLE J.1

<u>Center Point and Axial Data</u>

65	0	0	0	0	0	0	-1	1	.6968	136.2	87.08	0
66	0	0	0	0	0	0	-1	1	.6859	136.5	86.20	0
67	0	0	0	0	0	0	-1	1	.6897	137.2	86.08	0
68	0	0	0	0	0	0	-1	1	.7051	137.6	88.06	0
69	0	0	0	0	0	0	-1	1	.6840	136.8	85.24	0
70	0	0	0	0	0	0	-1	1	.6981	138.0	87.53	0
71	0	0	0	0	0	0	-1	1	.7141	137.3	89.24	0
72	0	0	0	0	0	0	-1	1	.7083	137.3	88.41	0
73	0	0	0	0	0	0	-1	1	.6667	131.4	83.30	0
74	0	0	0	0	0	0	-1	1	.7160	137.5	89.87	0
75	0	0	0	0	0	0	-1	1	.6872	134.8	85.84	0
76	0	0	0	0	0	0	-1	1	.6793	133.9	86.89	0
77	0	0	0	0	0	0	-1	-1	.6506	129.0	81.30	0
78	0	0	0	0	0	0	-1	-1	.6239	123.3	78.11	0
79	0	0	0	0	0	0	-1	-1	.6308	123.6	78.92	0
80	0	0	0	0	0	0	-1	-1	.6241	123.1	78.01	0
81	0	0	0	0	0	0	-1	-1	.6236	123.4	77.89	0
82	0	0	0	0	0	0	-1	-1	.6260	123.8	79.30	0
83	0	0	0	0	0	0	-1	-1	.6208	123.4	77.63	0
84	0	0	0	0	0	0	-1	-1	.6257	124.5	78.35	0
85	0	0	0	0	0	0	-1	-1	.6210	123.0	77.70	0
86	0	0	0	0	0	0	-1	-1	.6252	122.8	78.17	0
87	0	0	0	0	0	0	-1	-1	.6245	122.9	78.03	0
88	0	0	0	0	0	0	-1	-1	.6278	123.6	78.54	1
89	-2.828	0	0	0	0	0	-1	1	.4928	113.8	61.41	513
90	2.828	0	0	0	0	0	-1	1	.5175	100.4	64.38	1
91	0	-2.828	0	0	0	0	-1	1	.7290	63.07	41.31	5
92	0	2.828	0	0	0	0	-1	1	.6923	176.7	86.74	0
93	0	0	0	-2.828	0	0	-1	1	.6686	154.7	100.2	0
94	0	0	0	2.828	0	0	-1	1	.6833	111.3	73.92	0
95	0	0	0	0	-2.828	0	-1	1	.6910	196.5	126.1	9
96	0	0	0	0	2.828	0	-1	1	.7045	104.5	66.03	0
97	0	0	0	0	0	-2.828	-1	1	.6994	136.5	87.29	0
98	0	0	0	0	0	2.828	-1	1	.7308	136.0	91.53	0
99	-2.828	0	0	0	0	0	-1	-1	.5175	107.0	64.96	904
100	2.828	0	0	0	0	0	-1	-1	.6292	123.5	78.64	0
101	0	-2.828	0	0	0	0	-1	-1	.7303	65.04	41.36	3
102	0	2.828	0	0	0	0	-1	-1	.6265	124.4	78.33	0
103	0	0	0	-2.828	0	0	-1	-1	.6267	148.3	94.02	0
104	0	0	0	2.828	0	0	-1	-1	.6186	105.4	66.30	0
105	0	0	0	0	-2.828	0	-1	-1	.6182	179.1	113.0	142
106	0	0	0	0	2.828	0	-1	-1	.6164	93.68	58.53	0
107	0	0	0	0	0	-2.828	-1	-1	.6071	122.0	75.83	8
108	0	0	0	0	0	2.828	-1	-1	.6262	123.1	78.74	0

BMDP Regression Input for AUR

```
/PROBLEM      TITLE IS 'AUR REGRESSION'.
/INPUT        VARIABLES ARE 13.
              FORMAT IS FREE.
              FILE IS 'anoval.dat'.
/VARIABLE     NAMES ARE ID,STAGE,FLYLMT,TUR,PERCENT,CR,RELIAB,
              GND,LEGS,AURPUR,AVGWORK,AVGFLY,CANCEL,AUR,SF,PR,SL,
              FL,SSQ,FSQ,PSQ,CSQ,RSQ,CG,SC,ABEG,DEFG,TSQ.
              ADD=15.
              LABEL IS ID.
/TRANSFORM    IF (TUR EQ -1) THEN AUR=AURPUR*15.1.
              IF (TUR EQ 1) THEN AUR=AURPUR*16.1.
              IF (TUR EQ 0) THEN AUR=AURPUR*15.6.
              SF=STAGE*FLYLMT.
              PR=PERCENT*RELIAB.
              SL=STAGE*LEGS.
              FL=FLYLMT*LEGS.
              SSQ=STAGE*STAGE.
              FSQ=FLYLMT*FLYLMT.
              PSQ=PERCENT*PERCENT.
              CSQ=CR*CR.
              RSQ=RELIAB*RELIAB.
              CG=CR*GND.
              SC=STAGE*CR.
              ABEG=STAGE*FLYLMT*CR*GND.
              DEFG=PERCENT*CR*RELIAB*GND.
              TSQ=TUR*TUR.
              USE=LEGS EQ -1.
              DELETE=99 TO 102.
/REGRESS      DEPENDENT IS AUR.
              INDEPENDENT ARE STAGE,CR,FLYLMT,PERCENT,SF,PR,RELIAB,
              FSQ,RSQ,PSQ,SSQ,CSQ,TUR,TSQ.
              METHOD=NONE.
              TOL=.01.
/PRINT        MATRICES ARE COVA,CORR,RREG,RESI.
/PLOT         YVAR ARE RESIDUAL,PREDICTD.
              XVAR ARE PREDICTD,AVGWORK.
              NORMAL.
              SIZE IS 40,25.
/END
```

TABLE J.2

BMDP Regression Results for AUR (SWA)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	2.41
SQUARED MULTIPLE CORRELATION	.76544
MULTIPLE CORRELATION	.87489
ADJUSTED SQUARED MULT. CORR.	.73878
RESIDUAL MEAN SQUARE	.191196
STANDARD ERROR OF EST.	.437260
F-STATISTIC	28.72
NUMERATOR DEGREES OF FREEDOM	5
DENOMINATOR DEGREES OF FREEDOM	44
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO. NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
INTERCEPT	10.8975	.109315	12.738	99.69*	.000		
2 STAGE	-.386944	.0772974	-.365	-5.01*	.000	1.000000	.13359
7 FLVLMT	.447644	.0772974	.423	5.79*	.000	1.000000	.17879
14 PR	.543230	.0772974	.513	7.03*	.000	1.000000	.26334
21 PSC	-.0440955	.0410955	-.079	-1.08	.288	.998745	.00615
23 TSG	-.751031	.128910	-.426	-5.83*	.000	.998745	.18095

*=significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

CASE No.	OBSERVED AUR	PREDICTED VALUE	STANDARD ERROR OF PRED. VAL.	RESIDUAL	STAND-ARDIZED RESIDUAL	DELETED (PRESS) RESIDUAL	ADJUSTED (PRESS) PRED. VAL.	MAHALA-NOBIS DISTANCE	COOK DISTANCE
[illegible]	[illegible]	[illegible]	.1546	.0340	.09	.0388	10.7015	5.14	.00
7	9.2575	9.7245	.1546	.6330	1.55	.7274	9.5341	5.14	.06
[illegible]	10.3399	10.5849	.1546	-.2550	-.62	-.2915	10.6214	5.14	.01
8	10.4199	10.3977	.1546	.0263	.06	.0300	10.3899	5.14	.00
[illegible]	11.1702	10.5849	.1546	.5852	1.43	.6689	10.5013	5.14	.05
12	10.1895	10.3977	.1546	-.2042	-.50	-.2333	10.4229	5.14	.01
13	10.2302	10.7063	.1546	-.4761	-1.16	-.5441	10.7743	5.14	.03
15	9.5392	8.7245	.1546	.8148	1.99*	.9312	8.6081	5.14	.09
17	10.6500	10.5849	.1546	.0651	.16	.0744	10.5756	5.14	.00
19	10.8804	10.3977	.1546	.4867	1.19	.5563	10.3241	5.14	.03
22	11.2201	10.7063	.1546	.5138	1.26	.5872	10.6329	5.14	.04
24	9.5145	8.7245	.1546	.7900	1.93	.9029	8.6116	5.14	.09

26	10.4296	10.7063	.1546	-.2768	-.68	-.3163	10.7459	5.14	.01
28	8.7704	8.7245	.1546	-.3541	-.87	-.4047	8.7751	5.14	.02
29	10.4006	10.5849	.1546	-.1843	-.45	-.2107	10.6113	5.14	.00
31	10.5594	10.3937	.1546	.1658	.41	.1895	10.3700	5.14	.00
34	10.0204	10.3937	.1546	-.3733	-.91	-.4266	10.4470	5.14	.02
36	10.5197	10.5849	.1546	-.0652	-.16	-.0745	10.5942	5.14	.00
37	7.5783	8.7245	.1546	-1.1462	-2.80‡	-1.3100	8.8882	5.14	.19
39	10.1502	10.7063	.1546	-.5561	-1.36	-.6356	10.7858	5.14	.04
41	9.3333	8.7245	.1546	.6088	1.49	.6958	8.6375	5.14	.05
43	10.8401	10.7063	.1546	.1338	.33	.1529	10.6872	5.14	.00
46	10.7306	10.3937	.1546	.3370	.82	.3851	10.3455	5.14	.02
48	10.4598	10.5849	.1546	-.1252	-.31	-.1430	10.6028	5.14	.00
50	7.7071	8.7245	.1546	-1.0174	-2.49‡	-1.1628	8.8698	5.14	.15
52	10.6606	10.7063	.1546	-.0457	-.11	-.0523	10.7129	5.14	.00
53	10.1095	10.3937	.1546	-.2842	-.69	-.3248	10.4343	5.14	.01
55	11.0398	10.5849	.1546	.4548	1.11	.5198	10.5200	5.14	.03
57	10.2396	10.3937	.1546	-.1541	-.38	-.1761	10.4157	5.14	.00
59	10.1095	10.5849	.1546	-.4755	-1.16	-.5434	10.6529	5.14	.03
62	8.3956	8.7245	.1546	-.3289	-.80	-.3759	8.7715	5.14	.02
64	11.3795	10.7063	.1546	.6731	1.65	.7693	10.6102	5.14	.06
65	10.8701	10.8975	.1093	-.0274	-.06	-.0292	10.8993	2.08	.00
66	10.7000	10.8975	.1093	-.1974	-.47	-.2106	10.9106	2.08	.00
67	10.7593	10.8975	.1093	-.1382	-.33	-.1474	10.9067	2.08	.00
68	10.9996	10.8975	.1093	.1021	.24	.1089	10.8907	2.08	.00
69	10.6704	10.8975	.1093	-.2271	-.54	-.2422	10.9126	2.08	.00
70	10.8904	10.8975	.1093	-.0071	-.02	-.0076	10.8980	2.08	.00
71	11.1400	10.8975	.1093	.2425	.57	.2586	10.8817	2.08	.00
72	11.0495	10.8975	.1093	.1521	.36	.1621	10.8877	2.08	.00
73	10.4005	10.8975	.1093	-.4971	-1.17	-.5301	10.9306	2.08	.02
74	11.1696	10.8975	.1093	.2721	.64	.2902	10.8797	2.08	.00
75	10.7203	10.8975	.1093	-.1772	-.42	-.1890	10.9093	2.08	.00
76	10.9091	10.8975	.1093	.0116	.03	.0123	10.8967	2.08	.00
93	10.4302	10.5448	.3090	-.1147	-.27	-.2257	[illegible]	33.52	.02
94	10.6595	10.5448	.3090	.1147	.27	.2257	[illegible]	33.52	.02
95	10.7796	10.8975	.1093	-.1179	-.28	-.1257	10.9053	2.08	.00
96	10.9902	10.8975	.1093	.0927	.22	.0989	10.8917	2.08	.00
97	10.9106	10.8975	.1093	.0132	.03	.0140	10.8966	2.08	.00
98	11.4005	10.8975	.1093	.5030	1.19	.5365	10.8639	2.08	.02

‡=potential outliers

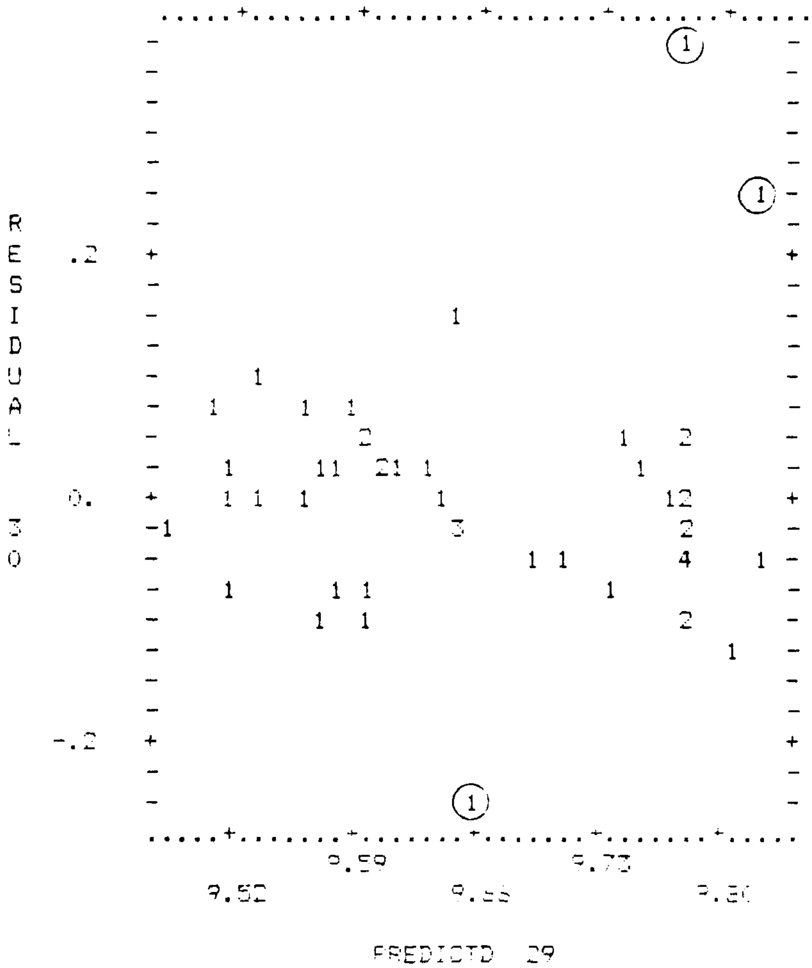


Fig. J.1. Residual Plot--AUP

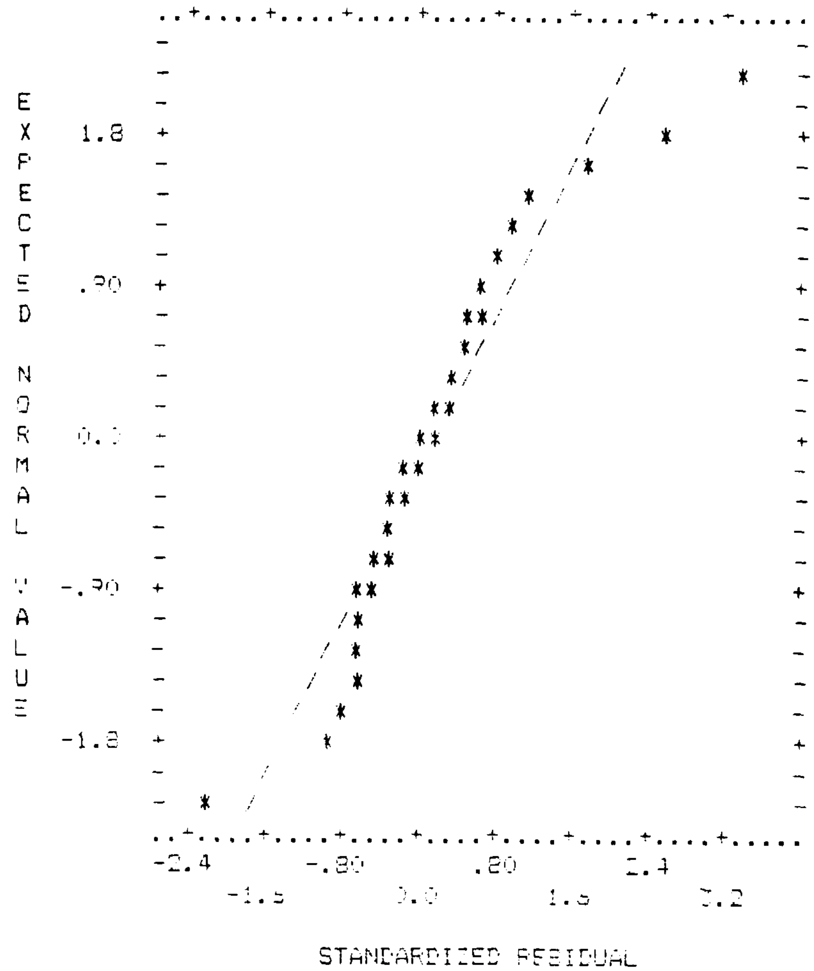


Fig. J.2. Normal Probability Plot--AUR

TABLE J.3

BMDP Regression Results for AUR (SWA) - Revised

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	4.87
SQUARED MULTIPLE CORRELATION	.65525
MULTIPLE CORRELATION	.80948
ADJUSTED SQUARED MULT. CORR.	.58427
RESIDUAL MEAN SQUARE	.064838
STANDARD ERROR OF EST.	.254633
F-STATISTIC	9.23
NUMERATOR DEGREES OF FREEDOM	7
DENOMINATOR DEGREES OF FREEDOM	34
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO. NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
INTERCEPT	10.8606	.0680534	27.501	159.59*	.000		
2 STAGE	-.230477	.0766545	-.432	-3.01*	.005	.490941	.09167
7 FLYLMT	.309126	.0759909	.588	4.07*	.000	.485164	.15779
15 FR	.404763	.0759909	.770	5.33*	.000	.485164	.28767
22 FED	.0368801	.0240678	.156	1.53	.135	.983272	.02381
21 FED	-.0394855	.0240678	-.167	-1.64	.110	.983272	.02729
4 TUR	.224798	.0532602	.435	4.22*	.000	.956175	.18064
23 TSQ	-.599196	.0974381	-.760	-6.15*	.000	.663951	.38343

*=significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

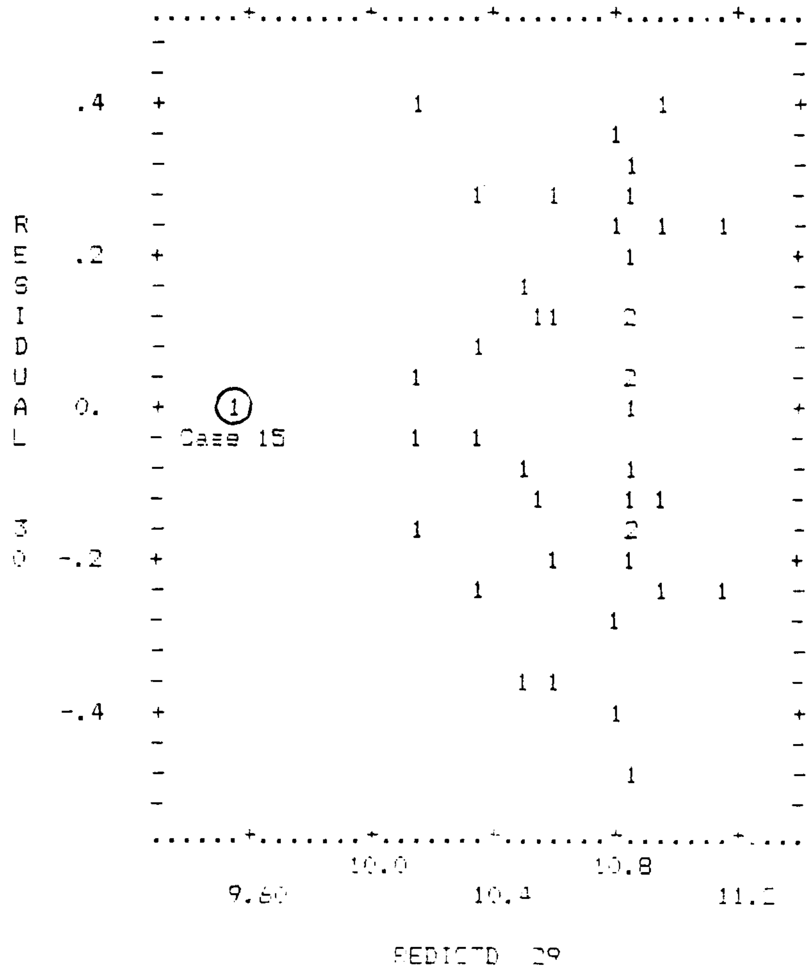


Fig. J.2. Residual Plot Revised

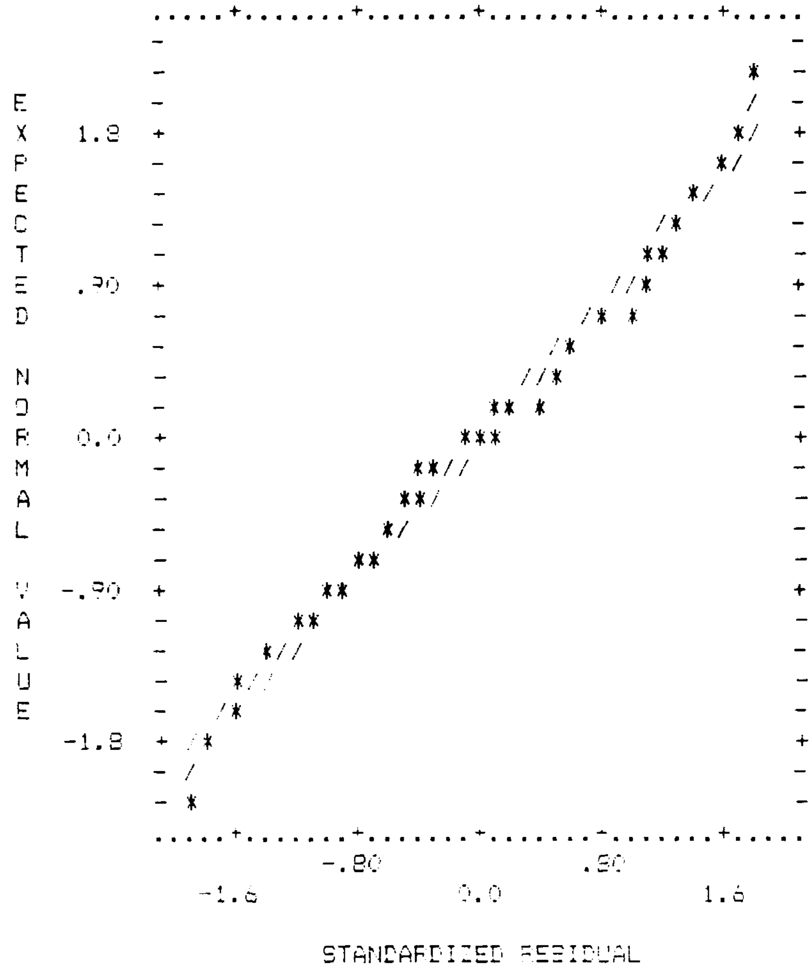


Fig. J.4. Normal Probability Plot Revised

TABLE J.4

BMDP Regression Results for ALR (NATO)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	6.97
SQUARED MULTIPLE CORRELATION	.54700
MULTIPLE CORRELATION	.73959
ADJUSTED SQUARED MULT. CORR.	.45860
RESIDUAL MEAN SQUARE	.010375
STANDARD ERROR OF EST.	.101857
F-STATISTIC	6.19
NUMERATOR DEGREES OF FREEDOM	8
DENOMINATOR DEGREES OF FREEDOM	41
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	9.77262	.0272224	70.596	358.99	.000		
3	FLYLMT	-.0229150	.0180059	-.133	-1.27	.212	1.000000	.01774
5	PERCENT	-.0399045	.0147025	-.285	-2.71*	.010	1.000000	.08139
16	PR	-.0447992	.0180059	-.262	-2.49*	.017	1.000000	.06839
7	RELIAB	.0467374	.0147025	.334	3.18*	.003	1.000000	.11165
27	PSQ	-.0191157	.00962749	-.210	-1.99*	.054	.983179	.04356
22	CSQ	-.0178479	.00962749	-.197	-1.85*	.071	.983179	.03797
4	TUR	.0376987	.0180059	.220	2.09*	.043	1.000000	.04843
29	TSQ	-.105305	.0300530	-.369	-3.50*	.001	.997175	.13566

*=significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

TABLE J.5

BMDP Regression Results for AVGWORK (SWA)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	5.09
SQUARED MULTIPLE CORRELATION	.92866
MULTIPLE CORRELATION	.96367
ADJUSTED SQUARED MULT. CORR.	.91678
RESIDUAL MEAN SQUARE	35.401574
STANDARD ERROR OF EST.	5.949922
F-STATISTIC	78.11
NUMERATOR DEGREES OF FREEDOM	7
DENOMINATOR DEGREES OF FREEDOM	42
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	135.912	1.48748	6.585	91.30	.000		
2	STAGE	-9.64875	1.05181	-.378	-9.17*	.000	1.000000	.14293
6	CR	-14.7043	.858941	-.706	-17.12*	.000	1.000000	.49788
7	FLYLMT	5.84875	1.05181	.229	5.56*	.000	1.000000	.05252
5	PERCENT	-6.95810	.858941	-.334	-8.10*	.000	1.000000	.11148
16	PR	7.10500	1.05181	.278	6.76*	.000	1.000000	.07750
22	CSQ	1.83649	.557974	.136	3.29*	.002	.998745	.01940
29	TSQ	-7.31649	1.75411	-.172	-4.17*	.000	.998745	.02955

*=significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

TABLE J.6

BMDP Regression Results for AVGWORK (NATC)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	7.16
SQUARED MULTIPLE CORRELATION	.98776
MULTIPLE CORRELATION	.99386
ADJUSTED SQUARED MULT. CORR.	.98539
RESIDUAL MEAN SQUARE	3.805333
STANDARD ERROR OF EST.	1.950726
F-STATISTIC	413.70
NUMERATOR DEGREES OF FREEDOM	8
DENOMINATOR DEGREES OF FREEDOM	41
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	123.700	.521354	7.668	237.27	.000		
2	STAGE	-1.11500	.344843	-.056	-3.23*	.002	1.000000	.00312
6	CR	-14.0697	.281577	-.863	-49.97*	.000	1.000000	.74516
3	PERCENT	-7.58656	.281577	-.465	-26.94*	.000	1.000000	.21666
16	PR	-.515000	.344843	-.026	-1.49	.143	1.000000	.00067
21	PSQ	.387617	.184382	.037	2.10*	.042	.993139	.00132
22	CSQ	1.52421	.184382	.144	8.27*	.000	.993139	.02040
4	TUR	.391249	.344843	.020	1.13	.263	1.000000	.00038
23	TSQ	-1.28306	.575563	-.079	-2.23*	.031	.997136	.00148

*=significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

TABLE J.7

BMDP Regression Results for AVGFLY (SWA)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	5.53
SQUARED MULTIPLE CORRELATION	.90763
MULTIPLE CORRELATION	.95270
ADJUSTED SQUARED MULT. CORR.	.89224
RESIDUAL MEAN SQUARE	16.870127
STANDARD ERROR OF EST.	4.107326
F-STATISTIC	58.96
NUMERATOR DEGREES OF FREEDOM	7
DENOMINATOR DEGREES OF FREEDOM	42
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	87.2325	1.02683	6.972	94.95*	.000		
2	STAGE	-3.24594	.726080	-.210	-4.47*	.000	1.000000	.04395
6	CR	-9.27736	.592871	-.734	-15.64*	.000	1.000000	.53805
7	FLYLMT	3.45094	.726080	.223	4.75*	.000	1.000000	.04968
5	PERCENT	-4.24080	.592871	-.335	-7.15*	.000	1.000000	.11252
16	PR	4.58031	.726080	.296	6.31*	.000	1.000000	.08752
22	CSQ	1.10377	.385178	.134	2.87*	.006	.998745	.01806
28	TSQ	-6.32908	1.21089	-.245	-5.23*	.000	.998745	.06008

*=significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

TABLE J.8

BMDP Regression Results for AVGFLY (NATO)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	8.90
SQUARED MULTIPLE CORRELATION	.99012
MULTIPLE CORRELATION	.99505
ADJUSTED SQUARED MULT. CORR.	.98790
RESIDUAL MEAN SQUARE	1.253142
STANDARD ERROR OF EST.	1.119438
F-STATISTIC	445.49
NUMERATOR DEGREES OF FREEDOM	9
DENOMINATOR DEGREES OF FREEDOM	40
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOLERANCE	CONTRIBUTION TO R-SQ
	INTERCEPT	78.4125	.323154	7.705	242.65*	.000		
3	CR	-8.84571	.161585	-.860	-54.74*	.000	1.000000	.74007
5	PERCENT	-4.85929	.161585	-.473	-30.07*	.000	1.000000	.22233
16	PP	-.334687	.197991	-.027	-1.69	.099	1.000000	.00071
7	RELIAB	.391451	.161585	.039	2.42*	.020	1.000000	.00145
20	RSQ	-.165988	.106905	-.025	-1.55	.129	.962075	.00060
21	PSQ	.218507	.106905	.033	2.04*	.048	.962075	.00103
22	CSQ	.91934	.106905	.139	8.60*	.000	.962075	.01826
4	TUR	.313438	.197991	.025	1.58	.121	1.000000	.00062
29	TSQ	-1.33029	.330645	-.063	-4.02*	.000	.994998	.00400

*=significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

Appendix K

Sensitivity Results

TABLE K.1

Crew Ratio Sensitivity

Crew Ratio Effect on AUR

CR	Rep1	Rep2	Rep3	Avg.	
4.0	3.621	3.629	3.676	3.642	
4.2	3.704	3.643	3.608	3.652	
4.4	3.689	3.691	3.615	3.665	Peace
4.6	3.585	3.690	3.595	3.623	
4.8	3.716	3.667	3.777	3.727	
5.0	3.577	3.721	3.606	3.633	
4.0	9.628	9.551	9.610	9.596	
4.2	9.509	9.634	9.642	9.595	
4.4	9.712	9.633	9.604	9.650	Surge
4.6	9.492	9.629	9.650	9.590	
4.8	9.945	9.549	9.942	9.812	
5.0	9.555	9.650	9.875	9.693	
4.0	8.261	7.361	6.912	7.511	
4.2	9.260	9.761	9.201	9.407	
4.4	9.592	10.02	8.643	9.418	Sustained
4.6	9.085	9.498	9.597	9.393	
4.8	10.28	10.03	10.22	10.177	
5.0	9.952	9.728	10.02	9.900	

Crew Ratio Effect on Avg Work Month

CR	Rep1	Rep2	Rep3	Avg.	
4.0	68.99	69.42	70.22	69.54	
4.2	67.08	66.01	63.64	66.24	
4.4	64.16	64.72	62.95	63.94	Peace
4.6	58.20	61.10	59.32	59.74	
4.8	59.59	58.22	60.31	59.56	
5.0	54.71	56.34	54.50	55.35	
4.0	145.9	146.3	145.9	146.4	
4.2	138.2	139.0	140.1	139.1	
4.4	135.5	133.7	133.7	134.0	Surge
4.6	127.4	127.3	129.0	127.9	
4.8	126.8	122.9	127.5	125.7	
5.0	117.3	116.9	121.1	118.4	
4.0	119.2	105.7	99.36	108.1	
4.2	127.8	133.2	125.4	128.8	Sustained

4.4	126.7	131.0	114.2	124.0	Sustained
4.6	114.2	120.2	120.8	118.4	
4.8	123.9	121.1	123.5	122.8	
5.0	114.1	112.0	116.1	114.1	

Effect of Crew Ratio on Avg Fly Hours

CR	Rep1	Rep2	Rep3	Avg.	
4.0	45.97	46.11	46.91	46.33	
4.2	44.57	44.03	43.39	44.00	
4.4	42.78	42.71	41.92	42.47	Peace
4.6	39.46	40.62	39.60	39.89	
4.8	39.42	38.98	40.41	39.60	
5.0	36.57	37.80	36.52	36.96	
4.0	91.63	90.78	91.41	91.27	
4.2	86.09	87.11	87.41	86.87	
4.4	84.79	83.70	83.48	83.99	Surge
4.6	78.85	80.14	80.11	79.7	
4.8	79.71	76.59	79.71	78.67	
5.0	72.69	73.53	75.17	73.80	
4.0	78.78	70.05	65.86	71.56	
4.2	83.80	88.22	83.14	85.05	
4.4	83.39	87.17	75.18	81.91	Sustained
4.6	75.35	78.94	79.73	78.01	
4.8	82.44	80.33	81.83	81.53	
5.0	75.73	74.12	76.23	75.36	

Effect of Crew Ratio on Time Away

CR	Rep1	Rep2	Rep3	Avg.	
4.0	161.9	163.8	164.7	163.5	
4.2	154.9	155.6	153.2	154.6	
4.4	149.3	149.6	148.2	149.1	Peace
4.6	132.5	142.1	139.7	138.1	
4.8	137.1	136.6	139.0	137.6	
5.0	130.8	132.4	129.8	131.0	
4.0	480.7	486.8	479.0	482.0	
4.2	460.4	454.5	463.1	459.1	
4.4	440.1	439.7	443.5	441.1	Surge
4.6	421.4	411.9	424.8	419.4	
4.8	423.8	404.6	428.0	418.8	
5.0	398.3	374.2	380.7	384.4	
4.0	500.9	510.8	508.8	506.8	
4.2	488.4	480.7	502.2	490.4	
4.4	487.4	453.9	501.5	480.9	Sustained
4.6	500.7	491.2	492.4	494.8	
4.8	459.3	475.3	452.7	462.4	
5.0	454.3	411.0	489.5	451.8	

TABLE K.3

TUR Sensitivity

TUR Effect on AUR

TUR	Rep1	Rep2	Rep3	Avg.	
3.5	3.621	3.629	3.676	3.642	
4.0	4.217	4.271	4.249	4.246	Peace
4.5	4.659	4.658	4.618	4.645	
3.5	9.628	9.551	9.610	9.596	
4.0	9.647	9.596	9.616	9.620	Surge
4.5	9.738	9.790	9.731	9.753	
3.5	8.261	7.361	6.912	7.511	
4.0	9.313	9.809	9.336	9.486	Sustained
4.5	8.304	9.851	7.924	8.693	

TUR Effect on Average Work Month

TUR	Rep1	Rep2	Rep3	Avg.	
3.5	68.89	69.42	70.32	69.54	
4.0	80.95	81.37	80.93	81.08	Peace
4.5	88.79	89.28	88.86	88.98	
3.5	146.9	146.3	145.9	146.4	
4.0	146.3	146.1	145.9	146.4	Surge
4.5	147.6	148.2	148.1	148.0	
3.5	119.2	105.7	99.36	108.1	
4.0	133.7	140.8	133.6	136.0	Sustained
4.5	115.9	140.1	117.0	124.0	

TUR Effect on Average Flying Time

TUR	Rep1	Rep2	Rep3	Avg.	
3.5	45.97	46.11	46.91	46.33	
4.0	53.44	54.20	53.91	53.85	Peace
4.5	59.09	59.14	58.69	58.97	
3.5	91.63	90.78	91.41	91.27	
4.0	91.21	91.27	91.51	91.33	Surge
4.5	92.63	93.16	92.39	92.89	
3.5	78.78	70.05	65.86	71.56	
4.0	88.53	93.72	89.16	90.47	Sustained
4.5	78.93	93.77	75.37	82.69	

TABLE K.3

Fly Time Limits Sensitivity

Effect of Fly Time Limits on AUR

FLYLMT	Rep1	Rep2	Rep3	Avg.	
125	3.621	3.629	3.676	3.642	Peace
150	3.573	3.692	3.703	3.656	
125	9.628	9.551	9.610	9.596	Surge
150	9.567	9.598	9.607	9.601	
125	8.261	7.361	6.912	7.511	Sustained
150	6.271	6.048	7.019	6.446	

Effect of Fly Time Limits on Avg Work Month

FLYLMT	Rep1	Rep2	Rep3	Avg.	
125	68.89	69.42	70.32	69.54	Peace
150	68.38	70.26	70.88	69.84	
125	146.9	146.3	145.9	146.4	Surge
150	147.6	146.6	146.4	146.9	
125	119.2	105.7	99.36	108.1	Sustained
150	89.75	86.52	100.8	92.4	

Effect of Fly Time Limits on Avg Fly Time

FLYLMT	Rep1	Rep2	Rep3	Avg.	
125	45.97	46.11	46.91	46.33	Peace
150	45.72	46.72	47.09	46.51	
125	91.63	90.78	91.41	91.27	Surge
150	91.12	91.75	91.60	91.38	
125	75.78	74.05	65.86	71.56	Sustained
150	60.31	57.75	66.64	61.57	

TABLE K.5

Staging Policy Sensitivity

Effect of Staging Policy on AUR

STAGE	Rep1	Rep2	Rep3	Avg.	
30	3.621	3.629	3.676	3.642	
45	3.666	3.677	3.735	3.689	Peace
60	3.676	3.650	3.672	3.666	
30	9.629	9.551	9.610	9.596	
45	9.607	9.629	9.778	9.671	Surge
60	9.468	9.604	9.650	9.574	
30	8.261	7.361	6.912	7.511	
45	9.991	9.726	9.833	9.852	Sustained
60	9.963	9.744	9.903	9.870	

Effect of Staging Policy on Avg Work Month

STAGE	Rep1	Rep2	Rep3	Avg.	
30	68.29	69.42	70.32	69.54	
45	70.16	70.17	71.09	70.47	Peace
60	69.80	70.58	69.92	70.10	
30	146.9	146.3	145.9	146.4	
45	144.8	145.8	146.9	145.8	Surge
60	142.1	143.3	143.3	142.9	
30	119.2	105.7	99.36	108.1	
45	143.1	140.9	141.9	142.0	Sustained
60	142.8	140.5	142.9	142.1	

Effect of Staging Policy on Avg Fly Time

STAGE	Rep1	Rep2	Rep3	Avg.	
30	45.97	46.11	46.91	46.33	
45	46.11	46.75	47.77	46.84	Peace
60	45.63	46.59	46.49	46.57	
30	91.63	90.78	91.41	91.27	
45	91.45	91.62	92.97	92.01	Surge
60	90.02	91.28	91.72	91.01	
30	78.78	70.05	65.86	71.56	
45	95.00	92.79	93.61	93.80	Sustained
60	94.81	92.75	94.23	93.93	

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This investigation examined the C-17's mission capability in terms of each aircraft's utilization and that utilization's effect on the aircrew. Specifically, average monthly flying times and average work months, as well as aircraft utilization, were found to be affected by changes in flying time limits, staging policies, target utilization rates, the number of crews, and the launch reliabilities.

The analysis was accomplished through a SLAM simulation of a portion of the MAC airlift system. A single homestation and two homestations were modeled; however, only the single homestation model was analyzed. The output of the simulation was regressed to yield an estimating equation for achieved utilization, average monthly flying time, and average work month for both a NATO and a SWA scenario.

Parameters varied in the sensitivity analysis were crew ratios, target utilization, monthly and quarterly flying limits, and staging policies. Results pointed toward 4.8 crews per C-17 without considering the cost tradeoffs. Staging one crew at an enroute base for every forty-five planned mission transits seemed to be optimal. The results also showed a significant benefit in the sustained phase when the 30/90 day limits were raised to 150/450 hours.

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