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Technical Report — *April 1977*

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By: J. VICTOR ROWNEY, ROBERT S. GARNERO, JOHN C. BOBICK

Prepared for:

OPERATIONAL DECISION AIDS PROJECT (CODE 431)
OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
ARLINGTON, VIRGINIA 22217

CONTRACT N00014-75-C-0742

Task NR 274-199

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This report describes research on augmenting the task force decision-aiding system with an innovative and efficient outcome calculator to assist a task force commander (TFC) in obtaining outcome estimates for various possible sequences of decisions and events. The research was limited to the naval air-strike warfare area and the necessary associated consideration for air defense. The research characterizes the relationships between the outcome calculator (OC) and the other components of the decision-aiding system. The report includes next page

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cont. definitions of the inputs and outputs required for the OC and the form of communications required between the OC and the TFC. Candidate outcome calculators were examined, and a new outcome calculator was constructed to meet the identified function, requirements, and constraints posed for the OC.

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ILLUSTRATIONS

TABLES

EXHIBITS

I INTRODUCTION

The Office of Naval Research (ONR) is presently pursuing a five-year multicontractor program[1] to promote the development of decision aids and procedures in support of Fleet operations.* Stanford Research Institute (SRI) is a continuing participant in the program, researching into the nature of the task force decision environment and into the development of decision techniques for use in this complex decision environment. A large portion of the total ONR effort in developing decision aids and procedures in support of Fleet operations has been involved with structuring a data base of information relevant to task force decisions, designing computer display formats for the presentation of information, and applying decision-analysis research in the Fleet environment. The decision-analysis research has focused primarily on the decision-problem structuring, the probability encoding, and the value-encoding components of the decision-aiding system. A vital component of this system is the outcome calculator (OC). This technical report describes research involving the development of a functional outcome calculator.

The purpose of an OC is to determine quantitatively the outcomes of various combinations of decisions and events (situations) that evolve in analyzing a decision. Figure 1 depicts the role of the OC in the decision-aiding system. As originally conceived, the basic decision model shown in Figure 1 is a classical "decision tree," a method of formal decision structuring. The tree branch ends are combinations of alternative courses of action and chance events. After an outcome is estimated for each tree branch end, it is transformed into a utility value. The tree is then "folded back," so that an expected value for

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*A complete list of all references for this report is found in Section V, References.

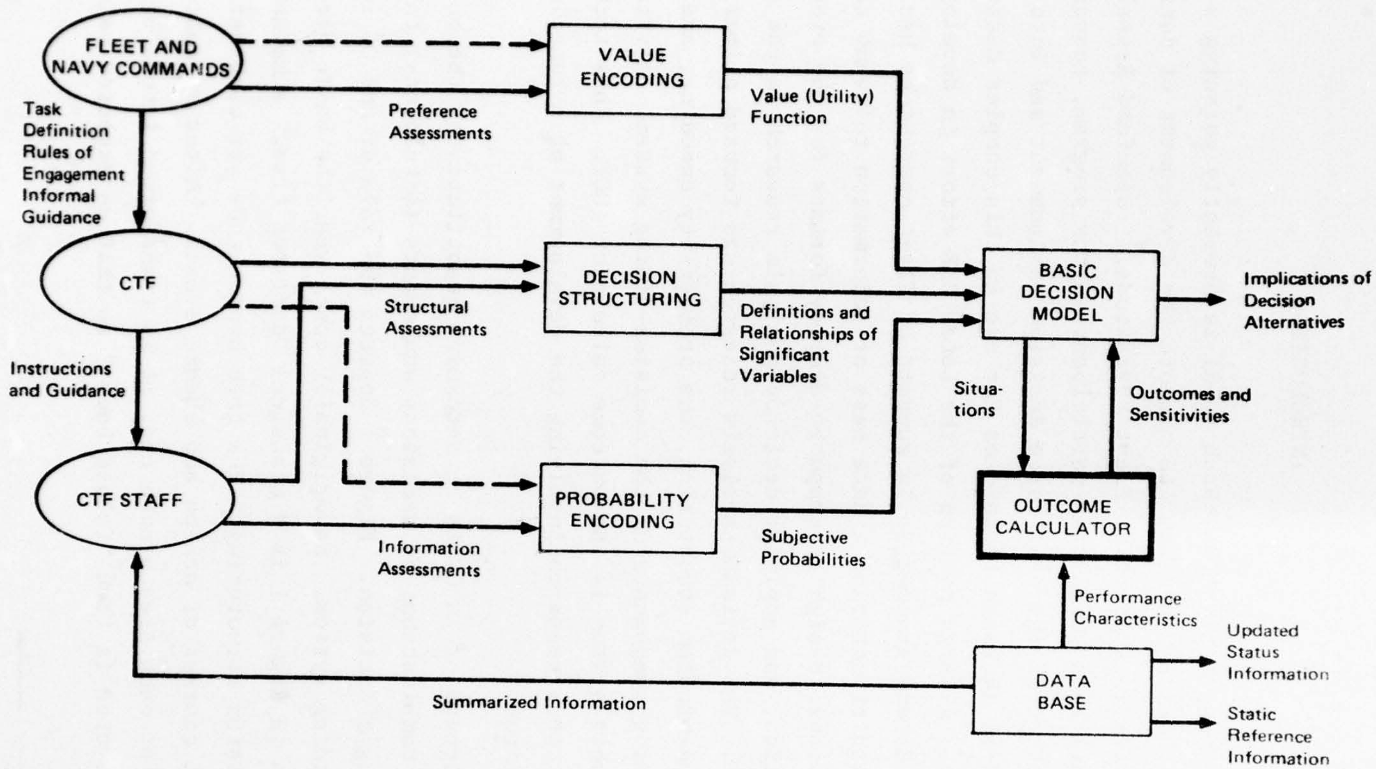


FIGURE 1 ROLE OF THE OUTCOME CALCULATOR IN THE DECISION-AIDING SYSTEM

each decision alternative is calculated, using probability factors and outcome utility values associated with each branch. The decision yielding the greatest expected value is, then, the best alternative.

Currently, the outcome calculators used by the Fleet consist primarily of officers using their experience, empirical data, and qualitative judgment to estimate outcomes associated with possible situations. This method is inadequate for the task force commander (TFC) in his efforts to perform such demanding tasks as the following: (1) determine and treat the complex interrelationships among variables involved in the decision-making process, (2) evaluate the sensitivity of outcomes to variations in many uncertain parameters, (3) consider the dynamic nature of the events affecting the outcomes, and (4) plan for numerous contingencies that could occur as a mission is being performed. These complex, interrelated tasks generated the need for the ongoing research described in this report.

The purpose of this research is to provide the task force decision-aiding system with an innovative and efficient outcome calculator to assist a task force commander in obtaining outcome estimates of various possible sequences of decision, events, and results. The research for this report was limited to the naval air strike warfare area and the necessary associated consideration for air defense. Within the scope of the Office of Naval Research (ONR) total operational decision-aids program, this initial research effort could be justified only in one specific warfare area. Because strike warfare did not present overly restrictive couplings with other warfare areas and, in a sense, could be treated independently, it was chosen as the focus. The research characterizes the relationships between the OC and the other components of the decision-aiding system. This report includes the definition of the inputs and outputs required for the OC and the form of communications required between the OC and the TFC. Several candidate outcome calculators were examined, and a new outcome calculator was constructed to meet the identified functions, requirements, and constraints posed for the OC. The structure of this report parallels the research. This report concludes with some conclusions and recommendations that resulted from the research.

II OUTCOME CALCULATOR SPECIFICATION

A. Introduction

As shown in Figure 1, the outcome calculator is a subsystem of the overall decision-aiding system. The purpose of the OC is to translate alternative course of action (COA) decisions and assumptions concerning the factors that affect COA decisions into estimates of the likely outcomes. It was therefore of prime importance to identify the functions, requirements, and constraints that characterize the relationships of the OC and to ensure its utility and compatibility within the overall system. Identifying relationships provided insight into the general types of OC inputs, the level of detail appropriate for the OC, and the constraints on the application of the OC within the decision-aiding system. The acceptabillty and efficiency of alternative means of translating OC inputs into the desired outputs are affected by many factors. Constraints on the time, resources, and user training are among the factors that influence the choice of alternative OCs. Also timeliness, precision, and flexibility bear upon the choice of the OC. These factors were all considered in specifying the desired characteristics of the OC.

As a first step in specifying an OC, the SRI research team characterized the kinds of decisions that might confront the TFC under various air strike situations. Three representative naval air strike situations were formulated, and a tentative list of the general type of decisions that would face the TFC was developed. Decision-analysis techniques were used to study the decisions that would be of most concern to the TFC, and a general list of decision variables and factors affecting those variables was prepared. Through this type of analysis, SRI was able to define the OC function specifically and delineate requirements and constraints for the OC.

B. Identification of Decision Areas and Decision-Affecting Factors

1. Representative Air-Strike Situations

In attempting to characterize the kinds of decisions of interest, SRI drew from earlier SRI research reports in this area, Navy documents, and the Naval air strike background research prepared by SRI and presented in Appendix A. From these sources, a tentative list of general types of decisions to be examined was developed. A methodology was then designed to test for important decisions that might have been omitted from the tenative list, as well as confirm the list of decisions developed. First, six descriptors for characterizing an air strike mission were defined. These descriptors were: (1) mission objective, (2) weather conditions, (3) type of military target, (4) level of threat to the task force, (5) whether a condition of war exists, and (6) whether an attempt is to be made to surprise the enemy. Using these descriptors, the following three representative air strike situations were formed:

SIT 1 - Antiair Warfare Strike (AAW)

Objective: destroy enemy air power in the objective area.
Weather : good
Targets : enemy air power and facilities
Threat : medium to high
Timing : attempt surprise attack
(Scenario: ONRODA)

SIT 2 - War At Sea (WAS)

Objective: destroy enemy SSM capability
Weather : good
Targets : enemy ships (SSM ships)
Threat : medium to high
Timing : attempt surprise
(Scenario: ONRODA - red and orange ships attack first)

SIT 3 - Interdiction and Close Air Support (CAS)

Objective:	support own ground forces
Weather :	good and/or bad
Targets :	enemy lines of communication and supply, ground targets, vehicles, troops, etc.
Threat :	low in area (air superiority established but SAM/AAA effective)
Timing :	no surprise necessary
	(Scenario: ONRODA, (amphibious warfare)

It was determined that the above three situations covered the breadth and scope of the majority of the air strike warfare decision problems. Specific scenarios were defined as examples of each of the three situations. The specific scenarios were derived from, or were an extension of, the ONRODA scenario[a]. Decision analysis methods were applied to the scenarios to identify the decisions arising from these situations that would be of most concern to the TFC.

Situation 1 had been examined[3] prior to this research, and the situation was based on the original version of the ONRODA scenario. A list of decisions and factors affecting those decisions were identified for this scenario. One of the most important decisions identified in the scenario was whether the TFC should plan to neutralize Orange forces on ONRODA using an air strike or blockade. This decision was structured and resolved in decision-tree form. Outcome estimates needed for the resolution of the decision tree were provided by hand calculations. Indeed, it was this type of formal decision analysis that clearly demonstrated the need for the present research.

For Situation 2, war at sea, a scenario was derived from an extension of the basic ONRODA scenario, in which it was assumed that Orange and Red ships would defend ONRODA Island. According to this scenario, the Orange and Red ships posed a threat to the Blue commander whose main objective was to launch air strikes against land based air support on ONRODA.

One of the most important decisions appeared to be whether the Blue Task Force Commander should attack ONRODA immediately or delay attacking land targets until after destroying enemy ships. The situation was such that it was to Blue's advantage to act quickly, but enemy tactics were such that it was difficult to locate, much less destroy, all enemy ships before it became desirable to launch an attack against the shore. At a very aggregate analytical level, the attack decision might have been structured as shown by the decision tree in Figure 2. Further analysis would be required to refine this decision tree, but the major factors relevant to the decision appear to be the Blue planning decision, the Orange actions and tactics, and the Blue action decision.

An attempt was made to identify the types of lower-level decisions that would be important in this case and the factors that would affect these decisions. Some of the decisions and factors that were identified have been summarized as follows:

(1) Decisions

Offensive/defensive asset tradeoff

How to position forces

How to time use of forces

(2) Factors affecting decisions

Orange and Red formations and tactics (especially threat axis)

Composition of force

Weather

For Situation 3, interdiction and close air support, an amphibious warfare extension of the ONRODA scenario was used. According to the scenario, a task force commander has been ordered to supply air support for an amphibious assault on Orange forces in Grey, a country friendly to Blue. The troops have been successfully landed and local air superiority achieved. The main objective for the task force at this time is, through interdiction, to stop resupply of enemy troops.

Compared to antiair warfare and war at sea, interdiction is a relatively easy decision-situation for the task force commander if the threat to his task force is low. Situation 3 is based on the assumptions that air superiority has been established and that the threat to the task

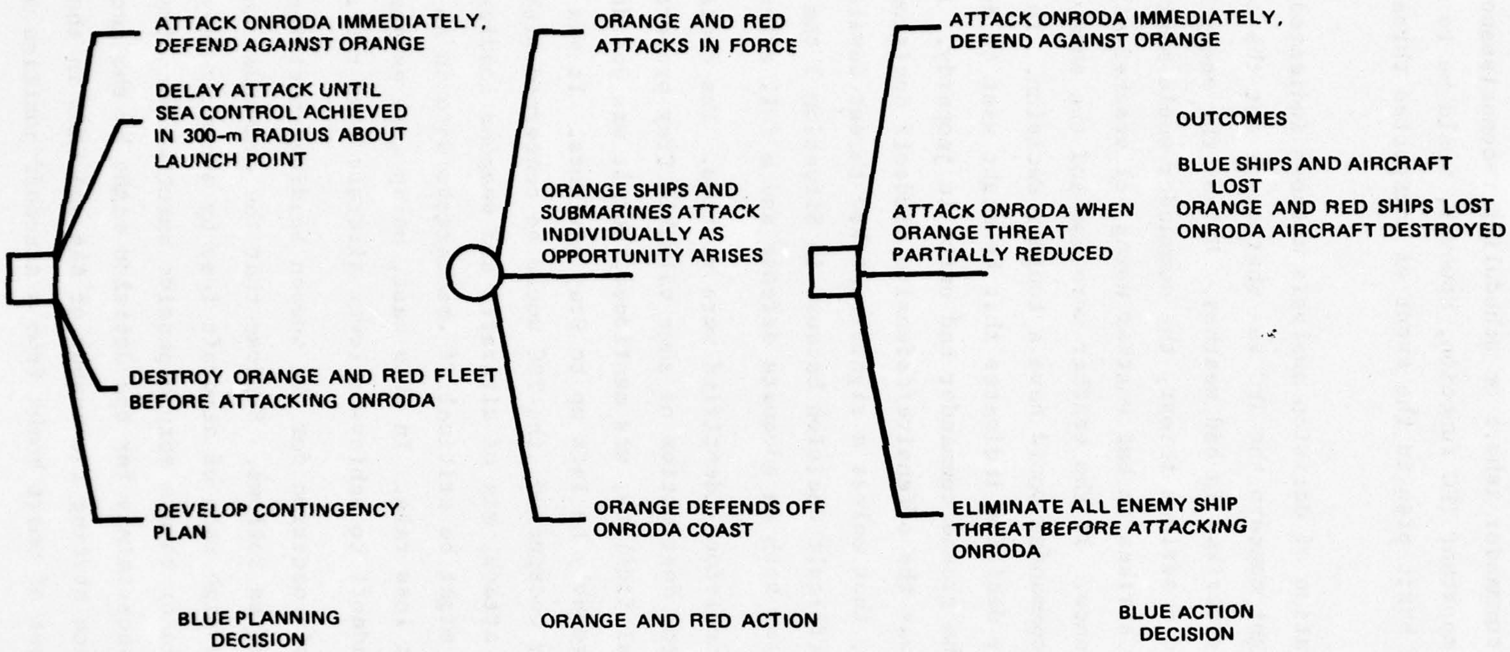


FIGURE 2 PRELIMINARY DECISION TREE FOR SITUATION 2

force has been minimized. The task force commander would work closely with the ground commander ashore on scheduling reconnaissance and routing decisions. An important TFC function, however, would be to make decisions for altering the basic plan in the event of unexpected threat or other contingencies.

Application of decision analysis methods indicated that one decision that might concern the TFC was whether or not the commander should delay running air strikes in bad weather. Unless the enemy had SAM batteries that posed a serious threat, the commander would most likely continue to run his strikes in bad weather using all weather aircraft on armed reconnaissance. If the weather were bad and the enemy had a SAM capability, the commander would have a tougher decision. In this latter case, preliminary decision indicates that he might want to delay his strikes unless the ground commander had units in jeopardy. Another decision identified was the offensive/defensive tradeoff decision. It was decided, however, that unless a significant Red threat developed, this would not be a difficult decision because in Situation 3 the blue forces were sufficient for both an adequate defense and a full offense.

Other decisions identified were routine. The decision of whether to risk the destruction of some valuable Grey property, such as a major industrial facility, was mentioned, but it was decided that this decision would probably be left up to Grey advisors. It was concluded that, barring the unexpected, the TFC would be concerned with such decisions as type of attack, mix of aircraft, and weapons loading. The weapons loading decision might be critical if the targets were in an area known for high aircraft loss rate. In this case, using more expensive "smart" weapons was a tradeoff to achieve a lower aircraft loss rate.

The basic decision for the weapon loading/attrition trade-off can be illustrated as follows. Suppose that the commander must decide whether to risk a high rate of aircraft loss by dropping many dumb weapons from low altitudes or to use more expensive smart weapons from standoff distances. The uncertainty for the decision might be the accuracy of ground intelligence stating the number of AAA and SAMs in the area. Dropping a small number of smart bombs from a standoff position might provide marginally better accuracy at a much lower aircraft loss rate than a large number of dumb bombs from a low altitude. A simple decision tree that illustrates the structure for this problem might appear as shown in Figure 3. To compute the outcomes for this decision tree, the outcome calculator would have to compute expected losses and enemy losses, under both dumb bombing tactics and under smart tactics.

2. General Decision Areas and Factors

The decisions that were identified during the above discussed probings of the three representative air strike situations were used to verify and augment the tentative list of air strike decisions. The study determined that through a slight modification of the tentative list, a list of general decision types could be obtained that appears to include all major decisions that might be required of a task force commander in determining the course of action for an air strike mission. This list of general decision types is outlined below:

(1) Positioning forces

(a) Task force
(b) Aircraft striking forces

(2) Use of assets

(a) Task force assets
- Electronic warfare
- AAW, ASW, strike, support

(b) Aircraft assets
- Strike forces and weapons
- Offensive/defensive tradeoff

(3) Timing of events

(a) Contingency plans
(b) Duration of events

Similarly, a list of general factors that might affect these decisions was obtained by adding to the original tentative list those additional items that were identified during the probing of the three

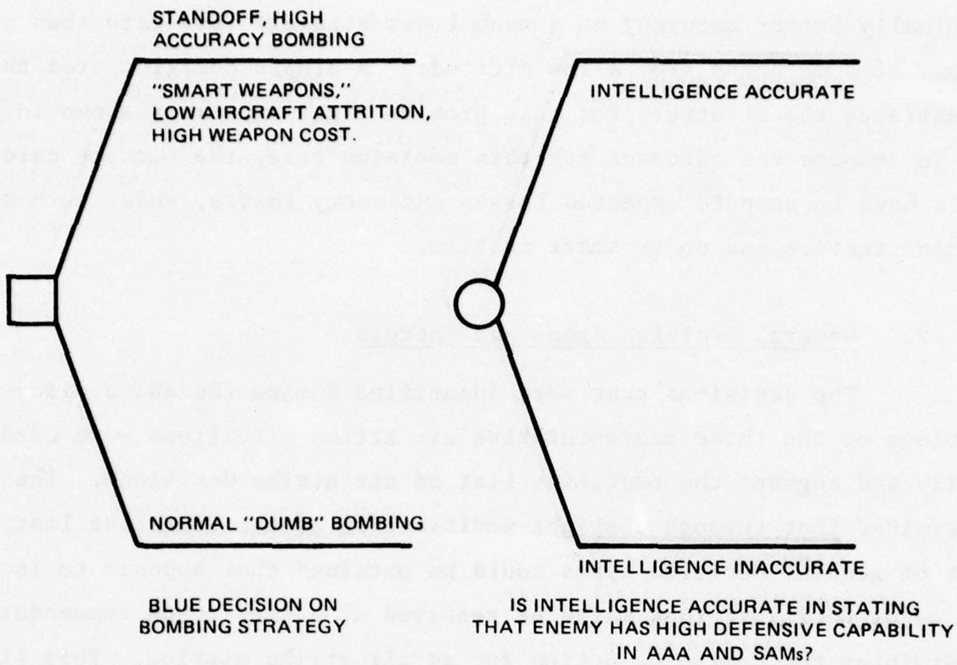


FIGURE 3 SIMPLE DECISION STRUCTURE FOR A LOW-LEVEL TFC DECISION

representative situations. The list of the general factors affecting TFC decisions in air strike missions is:

- Task Force composition.
- Aircraft complement and capability (sortie rate, combat radius payload).
- Weapons capability and delivery accuracy.
- Force mobility and endurance.
- Enemy offensive/defensive capabilities and deployment.
- Weather.
- Support factors:
  - Intelligence
  - Communications
  - Logistics
  - Interservice coordination
  - Operational limitations
  - Rules of engagement.

C. Outcome Calculator Function

The function of the OC, derived from the preceding material, becomes clear in the decision-aiding system; should provide assistance in generating quantitative estimates of outcomes for investigating the various alternatives associated with the decisions. Specifically, the OC must provide outcomes associated with decisions regarding positioning of forces, use of assets, and timing of events. The outcome calculator should also provide assistance for estimating outcomes for contingency plans based on weather conditions and threat actions.

The OC must accept as inputs the quantitative variables and parameters that are derived from the more qualitative decision structuring process. These quantitative inputs, listed previously, will be referred to as course of action (COA) inputs. However, certain other input data are required also to compute outcomes (see Figure 4). These data are called Background data and Scenario data. Background data are data which are constant over a wide range of scenarios. Such data include own and enemy force units, weapon system performance, availability, and effectiveness characteristics (engagement data). Scenario data include data that varies with the scenario being considered, such as own and enemy resources, force concentrations, and environment. These data generally will be available in a data base, but are subject to modification by the staff experts. The COA data will always remain, however, the primary concern to the decision-maker.

The output function of the OC was established by defining those battle results that would be of interest to a military commander estimating a situation. This output must conform to a format that is compatible with the inputs to a formal decision model in the decision-aiding system. With these facts in mind, outputs for the OC were limited to the general areas of:

(1) Mission accomplishment
(2) Battle attrition

The most important functional specification for the OC is that it operate within the constraints of the decision-aiding system. A

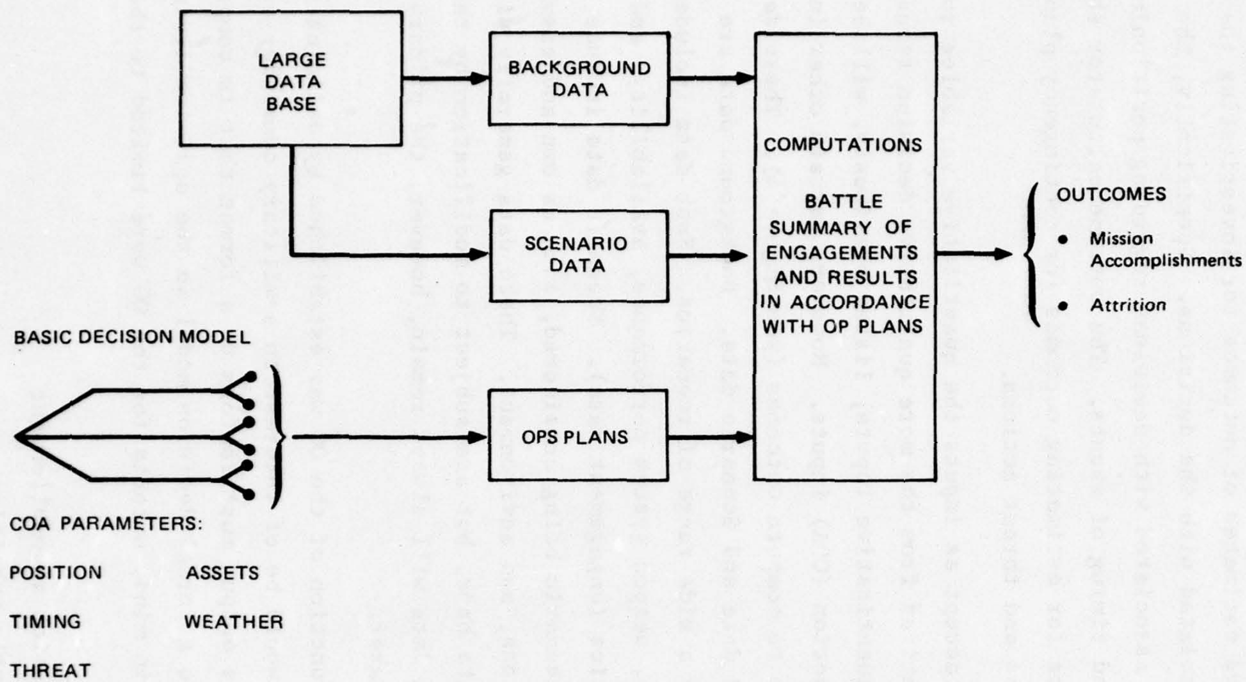


FIGURE 4 OUTCOME CALCULATOR CONCEPT

decision-aiding system may be described as a formal structuring of the decision cycle.

This decision cycle is shown in Figure 5. It consists of the ten steps shown in the figure. This cycle may be formalized by a decision-aiding system with such improvements as rigorous problem structuring and a machine-aided decision model. However, an efficient method of outcome determination would be useful in the decision cycle, whether or not the cycle functions in the content of a formal rigorous system. The structuring of alternative courses of action could be done in a heuristic manner, and an outcome estimate still would in itself be useful as well as provide a test of the acceptability of a chosen plan.

The requirement that the OC must operate within the decision system or decision cycle essentially means that the OC will accept as inputs the problem structuring (alternative courses of action) results from the decision analyst, and that the OC will provide outputs, to be assigned utility values, that can be accommodated in a decision model.

D. Outcome Calculator Constraints and Requirements

Several constraints and requirements for use of the OC within the task force decision environment were identified in the initial research. One constraint is that the OC must be capable of "speaking" at the level of detail of concern to the TFC. Thus, the OC must be capable of accepting as inputs a description of a situation in terms relevant to the task force commander (e.g., weather, position, threat, timing, defenses), translating this description into a set of variable values required for computing battle outcomes, and then transforming the results into a description of the outcome meaningful to the TFC. The specific set of variables with which the TFC will interface with the outcome calculator have been defined previously by structuring the set of miniscenarios that encompass the major air defense/air strike warfare decisions.

A second constraint on the OC is that the number generating routines incorporated into the OC be as simple as possible, consistent with credible results. It has been observed that a certain level of sophistication of

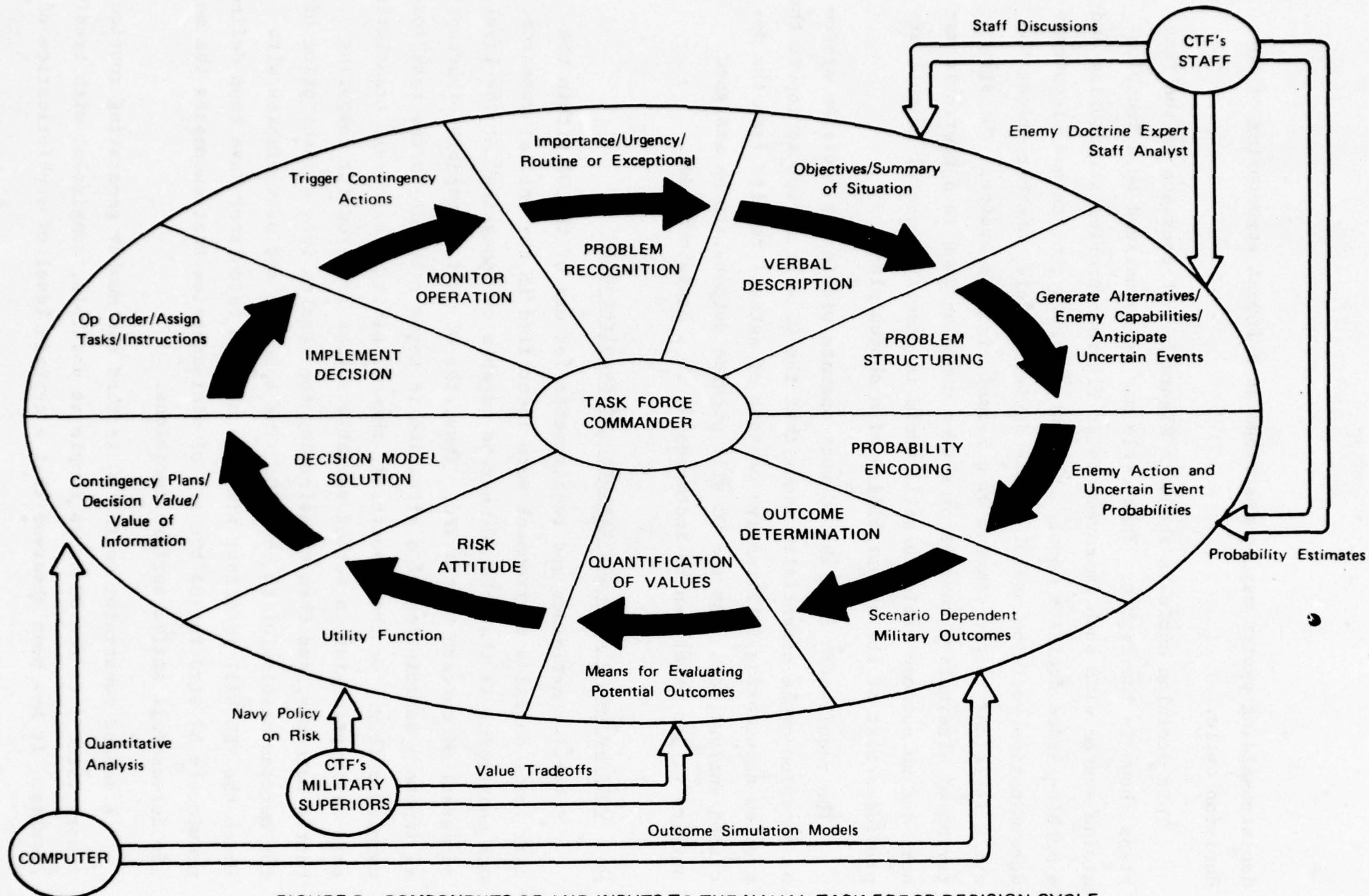


FIGURE 5 COMPONENTS OF AND INPUTS TO THE NAVAL TASK FORCE DECISION CYCLE

a battle model is essential to achieve any degree of credibility. However, as the level of sophistication rises, it becomes apparent that the level of credibility, and hence reliability, decreases rapidly. The numerical routines within the OC should be at a level of sophistication where results are credible, yet the routines are transparent enough for an interested TFC to understand the number generating procedures.

Another constraint for effective utilization of the OC is that it be an interactive package. The user should be able to sit at a console and provide the required inputs upon being prompted by the computer. The user should be able to view on the console the data presently being used by the OC, and selectively modify data elements. Such an interactive package should be designed for an individual who has the following characteristics:

(1) Is highly intelligent

(2) Requires a large amount of information

(3) Is too busy for an extensive training course in system usage

(4) Needs timely calculations

(5) Requires credible results.

The utility of the outcome calculator appears to degrade if the computer time required to estimate an outcome for a course of action becomes excessive. It is felt that the OC should be capable of providing an outcome within a minute of computer (CPU) time.

III CANDIDATE OUTCOME CALCULATORS

A. Introduction

After the relationship between the OC and the decision-aiding structure was specified and characterized, it became desirable to focus on candidate systems that could meet the functions, requirements, and constraints for an OC. In examining candidates, the OC was not treated strictly as a number generator. It was treated as a package consisting of the means by which a user can transorm descriptions of a sequence of events and decisions into outcome estimates. This OC package consists of a number generator, a media for communicating inputs and outputs, and the required interfaces with the user. Thus, in evaluating the alternative designs, the human element, including required operator training, skills, and capabilities, together with the number generator, was also considered.

A preliminary screening reduced the potential alternatives to three. The three chosen approaches were examined in more detail; a discussion of each is contained in this section. The three alternatives were:

(1) The Pencil, Paper, Pub method

(2) An off-the-shelf combat simulation

(3) A NWRC original design concept.

B. The Pencil, Paper, Pub Method

1. Description

The Pencil, Paper, Pub method has been used in the U.S. Fleet for years. It is the classical part of planning used in the Commander's Estimate of the Situation as shown in "NAVAL OPERATIONAL PLANNING, NWP11(B)." Actually, the estimate of own losses is the test of the plan for "feasibility and acceptability." The remaining test for "suitability" may include mission accomplishment which, in large, is an estimate of enemy losses.

The title "Pencil, Paper, Pub Method" refers to the fact that the staff officer usually makes these loss estimates for a given plan with paper, pencil, and tactical publications. The officer collects data as shown in Table 1, assigns probabilities of kills from tactical publications, and compiles the estimated losses for both sides either on a

Table 1

DATA FOR ESTIMATE OF SITUATION

A. Force Data

1. Own Force Assets
   - a. Sortie rates by type
   - b. Planned sorties for strike and defense

2. Enemy Force Assets
   - a. Attack and defense estimates by Intelligence
   - b. Sorties and sortie rates
   - c. Aircraft and weapon capability

B. Engagement Data

1. Air to Air Exchange
   - a. Blue attrition from Red air intercepts
   - b. Red attrition from Blue CAP
   - c. Blue CAP attrition from Red escorts
   - d. Red interceptor attrition from Blue escort

2. SAM Effectiveness on Aircraft
   - a. Blue attrition from Red SAM batteries
   - b. Red attrition from Blue SAM ships

3. Air to Surface Effectiveness
   - a. Red damage from Blue attacks
   - b. Blue ship damage from Red attacks

C. Environment Data

1. Range of Strikes
2. Weather Effect

D. COA Data

1. Alternative COA's
2. "What If" Contingencies

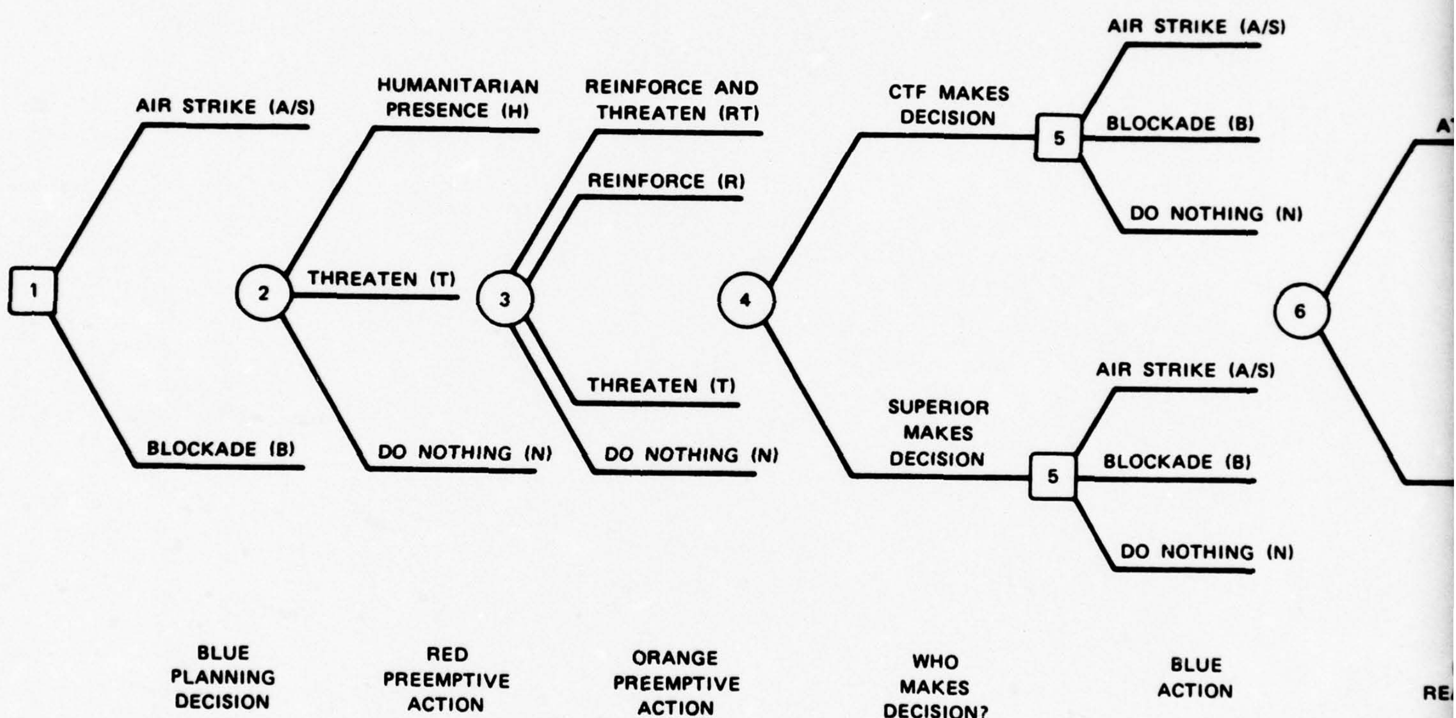
day-to-day basis or on an event-to-event basis. The elements of this method, and any other method used to estimate battle losses, are essentially data collection, engagement calculations, and course of action alternatives.

Table 1 is an outline of this data collection, and is composed of force data, engagement data, environment data, and COA data. These data are needed whether or not the engagement calculations are done by hand calculation or by another method. Engagement calculations (loss estimates) should be made for each event, then cumulated for the day or the days of the total effort. A decreased effectiveness should be considered for bad-weather operations. Additionally, calculations should be made for each alternative course of action selected by the commander or determined to be important by decision analysis.

In addition to the loss calculations, the methods of obtaining the COA alternatives are a major consideration. In classical decision analysis, theory outcomes must be calculated for each branch of a decision tree. A utility factor is attached to these outcomes and the tree "folded back" to the decision point to find the best decision (highest expected utility or worth). Such a method was used in the "TFC Decision Structuring Process" report, referenced earlier. The base elements of the decision tree for that problem are shown in Figure 6. Using this method, it appeared at first glance, that a total of 1728 tree branches was needed to compare the alternative courses of action with each possible enemy capability in the ONRODA scenario. Fortunately, with further analysis, the number of branches was reduced to 288 outcome calculations, which still represents a large computational effort. Table 2 shows the magnitude of the effort required to provide the outcome estimation function, and Appendix B shows the supporting calculations for a subset of the alternatives.

2. Analysis

The pencil and paper process of the estimation of military outcomes for the subject report required about three days' work for an


AIR STRIKE (A/S)
BLOCKADE (B)
HUMANITARIAN PRESENCE (H)
THREATEN (T)
DO NOTHING (N)
REINFORCE AND THREATEN (RT)
REINFORCE (R)
THREATEN (T)
DO NOTHING (N)
CTF MAKES DECISION
SUPERIOR MAKES DECISION
AIR STRIKE (A/S)
BLOCKADE (B)
DO NOTHING (N)
AIR STRIKE (A/S)
BLOCKADE (B)
DO NOTHING (N)
1
2
3
4
5
5
6
BLUE PLANNING DECISION
RED PREEMPTIVE ACTION
ORANGE PREEMPTIVE ACTION
WHO MAKES DECISION?
BLUE ACTION

2

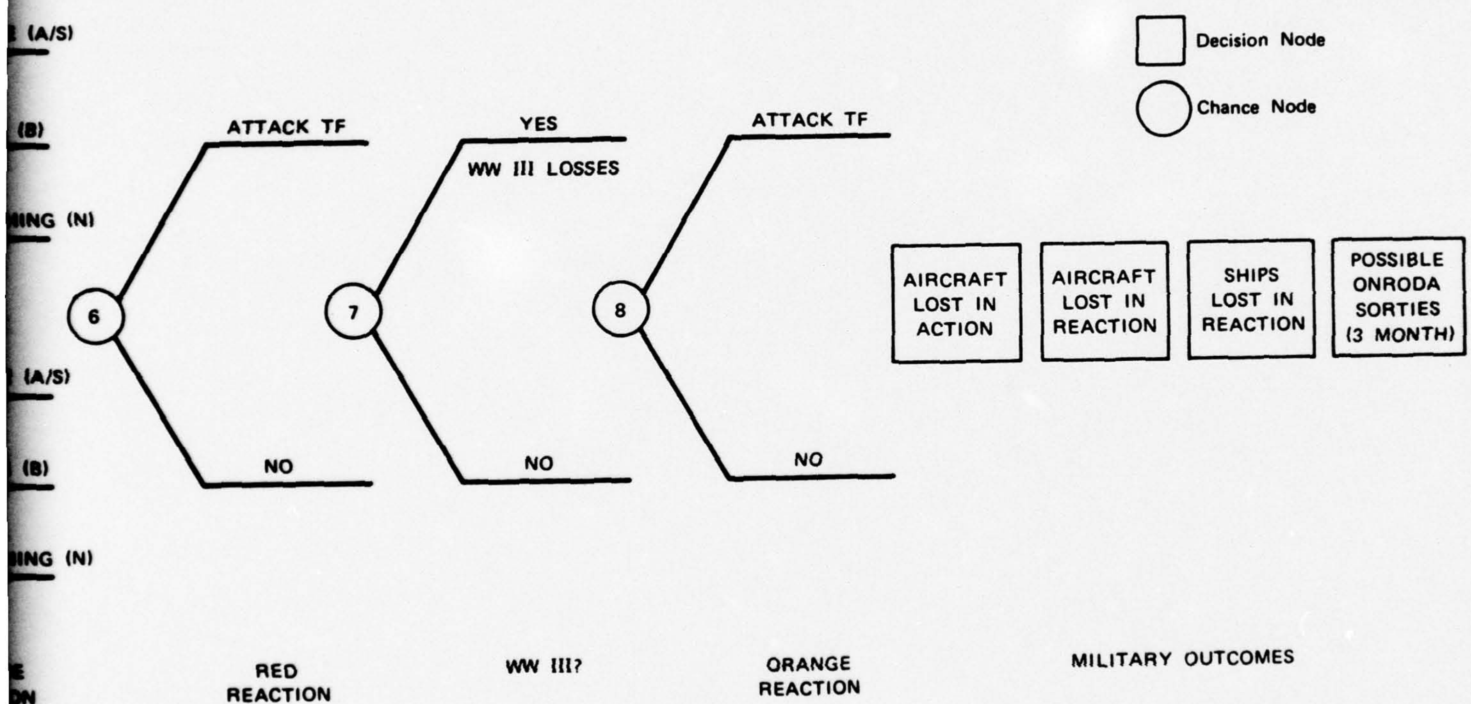


FIGURE 6 DECISION TREE USED IN ONRODA ANALYSIS

Table 2

ONRODA EXPECTED MILITARY OUTCOMES

Blue Plan	Red Preemptive Action	Orange Preemptive Action	Blue Action	Red Attack	Orange Attack	Aircraft Lost in Action (aircraft equivalents)	Aircraft Lost in Reaction (aircraft equivalents)	Ships Lost in Reaction (ship equivalents)	Possible Sorties ($\times 10^3$)
A/S	H,T,N	RT	A/S	Yes	Yes	36.20	18.00	5.50	6.20
A/S	H,T,N	RT	A/S	Yes	No	*	*	*	*
A/S	H,T,N	RT	A/S	No	Yes	36.20	18.00	2.75	6.20
A/S	H,T,N	RT	A/S	No	No	36.20	0.00	0.00	6.20
A/S	H,T,N	RT	B	Yes	Yes	0.00	37.20	20.80	6.80
A/S	H,T,N	RT	B	Yes	No	*	*	*	*
A/S	H,T,N	RT	B	No	Yes	0.00	37.20	10.40	6.80
A/S	H,T,N	RT	B	No	No	0.00	19.20	9.99	16.50
A/S	H,T,N	RT	N	Yes	Yes	0.00	18.00	5.50	20.70
A/S	H,T,N	RT	N	Yes	No	*	*	*	*
A/S	H,T,N	RT	N	No	Yes	0.00	18.00	2.75	20.70
A/S	H,T,N	RT	N	No	No	0.00	0.00	0.00	20.70
A/S	H,T,N	R	A/S	Yes	Yes	36.20	18.00	5.50	6.20
A/S	H,T,N	R	A/S	Yes	No	*	*	*	*
A/S	H,T,N	R	A/S	No	Yes	36.20	18.00	2.75	6.20
A/S	H,T,N	R	A/S	No	No	36.20	0.00	0.00	6.20
A/S	H,T,N	R	B	Yes	Yes	0.00	37.20	20.80	6.80
A/S	H,T,N	R	B	Yes	No	*	*	*	*
A/S	H,T,N	R	B	No	Yes	0.00	37.20	10.40	6.80
A/S	H,T,N	R	B	No	No	0.00	19.20	0.00	16.50
A/S	H,T,N	R	N	Yes	Yes	0.00	18.00	5.50	20.70
A/S	H,T,N	R	N	Yes	No	*	*	*	*
A/S	H,T,N	R	N	No	Yes	0.00	18.00	2.75	20.70
A/S	H,T,N	R	N	No	No	0.00	0.00	0.00	20.70
A/S	H,T,N	T	A/S	Yes	Yes	21.80	18.00	5.50	3.75
A/S	H,T,N	T	A/S	Yes	No	*	*	*	*
A/S	H,T,N	T	A/S	No	Yes	21.80	18.00	2.75	3.75
A/S	H,T,N	T	A/S	No	No	21.80	0.00	0.00	3.75
A/S	H,T,N	T	B	Yes	Yes	0.00	24.00	11.80	4.30
A/S	H,T,N	T	B	Yes	No	*	*	*	*
A/S	H,T,N	T	B	No	Yes	0.00	24.00	5.90	4.30
A/S	H,T,N	T	B	No	No	0.00	12.60	0.00	11.30
A/S	H,T,N	T	N	Yes	Yes	0.00	18.00	5.50	15.10
A/S	H,T,N	T	N	Yes	No	*	*	*	*
A/S	H,T,N	T	N	No	Yes	0.00	18.00	2.75	15.10
A/S	H,T,N	T	N	No	No	0.00	0.00	0.00	15.10
A/S	H,T,N	N	A/S	Yes	Yes	21.80	18.00	5.50	3.75
A/S	H,T,N	N	A/S	Yes	No	*	*	*	*
A/S	H,T,N	N	A/S	No	Yes	21.80	18.00	2.75	3.75
A/S	H,T,N	N	A/S	No	No	21.80	0.00	0.00	3.75
A/S	H,T,N	N	B	Yes	Yes	0.00	24.00	11.80	4.30
A/S	H,T,N	N	B	Yes	No	*	*	*	*
A/S	H,T,N	N	B	No	Yes	0.00	24.00	5.90	4.30
A/S	H,T,N	N	B	No	No	0.00	12.60	0.00	11.30
A/S	H,T,N	N	N	Yes	Yes	0.00	18.00	5.50	15.10
A/S	H,T,N	N	N	Yes	No	*	*	*	*
A/S	H,T,N	N	N	No	Yes	0.00	18.00	2.75	15.10
A/S	H,T,N	N	N	No	No	0.00	0.00	0.00	15.10
B	H,T,N	RT	A/S	Yes	Yes	55.70	18.00	5.50	6.80
B	H,T,N	RT	A/S	Yes	No	*	*	*	*
B	H,T,N	RT	A/S	No	Yes	55.70	18.00	2.75	6.80
B	H,T,N	RT	A/S	No	No	55.70	0.00	0.00	6.80
B	H,T,N	RT	B	Yes	Yes	16.20	27.60	20.80	5.76
B	H,T,N	RT	B	Yes	No	*	*	*	*
B	H,T,N	RT	B	No	Yes	16.20	27.60	10.40	5.76
B	H,T,N	RT	B	No	No	27.60	0.00	0.00	15.00
B	H,T,N	RT	N	Yes	Yes	0.00	18.00	5.50	20.70
B	H,T,N	RT	N	Yes	No	*	*	*	*

Table 2 (Concluded)

Blue Plan	Red Preemptive Action	Orange Preemptive Action	Blue Action	Red Attack	Orange Attack	Aircraft Lost in Action (aircraft equivalents)	Aircraft Lost in Reaction (aircraft equivalents)	Ships Lost in Reaction (ship equivalents)	Possible Sorties ($\times 10^3$)
B	H,T,N	RT	N	No	Yes	0.00	18.00	2.75	20.70
B	H,T,N	RT	N	No	No	0.00	0.00	0.00	20.70
B	H,T,N	R	A/S	Yes	Yes	55.70	18.00	5.50	6.80
B	H,T,N	R	A/S	Yes	No	*	*	*	*
B	H,T,N	R	A/S	No	Yes	55.70	18.00	2.75	6.80
B	H,T,N	R	A/S	No	No	55.70	0.00	0.00	6.80
B	H,T,N	R	B	Yes	Yes	16.20	27.60	20.80	5.76
B	H,T,N	R	B	Yes	No	*	*	*	*
B	H,T,N	R	B	No	Yes	16.20	27.60	10.40	5.76
B	H,T,N	R	B	No	No	27.60	0.00	0.00	15.00
B	H,T,N	R	N	Yes	Yes	0.00	18.00	5.50	20.70
B	H,T,N	R	N	Yes	No	*	*	*	*
B	H,T,N	R	N	No	Yes	0.00	18.00	2.75	20.70
B	H,T,N	R	N	No	No	0.00	0.00	0.00	20.70
B	H,T,N	T	A/S	Yes	Yes	35.30	18.00	5.50	2.27
B	H,T,N	T	A/S	Yes	No	*	*	*	*
B	H,T,N	T	A/S	No	Yes	35.30	18.00	2.75	2.27
B	H,T,N	T	A/S	No	No	35.30	0.00	0.00	2.27
B	H,T,N	T	B	Yes	Yes	10.80	18.00	11.80	3.24
B	H,T,N	T	B	Yes	No	*	*	*	*
B	H,T,N	T	B	No	Yes	10.80	18.00	5.90	3.24
B	H,T,N	T	B	No	No	18.00	0.00	0.00	9.70
B	H,T,N	T	N	Yes	Yes	0.00	18.00	5.50	15.10
B	H,T,N	T	N	Yes	No	*	*	*	*
B	H,T,N	T	N	No	Yes	0.00	18.00	2.75	15.10
B	H,T,N	T	N	No	No	0.00	0.00	0.00	15.10
B	H,T,N	N	A/S	Yes	Yes	35.30	18.00	5.50	2.27
B	H,T,N	N	A/S	Yes	No	*	*	*	*
B	H,T,N	N	A/S	No	Yes	35.30	18.00	2.75	2.27
B	H,T,N	N	A/S	No	No	35.30	0.00	0.00	2.27
B	H,T,N	N	B	Yes	Yes	10.80	18.00	11.80	3.24
B	H,T,N	N	B	Yes	No	*	*	*	*
B	H,T,N	N	B	No	Yes	10.80	18.00	5.90	3.24
B	H,T,N	N	B	No	No	18.00	0.00	0.00	9.70
B	H,T,N	N	N	Yes	Yes	0.00	18.00	5.50	15.10
B	H,T,N	N	N	Yes	No	*	*	*	*
B	H,T,N	N	N	No	Yes	0.00	18.00	2.75	15.10
B	H,T,N	N	N	No	No	0.00	0.00	0.00	15.10

Notes:

A/S = Air strike
H = Humanitarian action
T = Threaten
N = No action
RT = Reinforce and threaten
B = Blockade

*Denotes an event whose probability of occurrence was assessed as zero.

experienced operations analyst at first attempt. There is no doubt that this time could be improved upon with continued use, but the scope of the calculations and data required appears particularly applicable to automated methods.

After using the Pencil and Paper Method to compute outcomes for the decision analysis uses (the report "TFC DECISION STRUCTURING PROCESS"), the following conclusions became apparent:

- When outcomes are required for many alternative COAs (tree branch ends or heuristic origin), hand calculations are slow and error-prone.
- Numerous data changes are necessary when examining different tree branch end points, with associated extensive recalculations.
- The effectiveness and attrition analysis in the engagement data is based on "one on one" encounter statistics and the synergistic effect of other factors is missing.

C. Off-the-Shelf Combat Simulations

1. Description

The research team reviewed the possible off-the-shelf combat models that might serve directly or in adapted mode as an OC. This effort began with a search through the model catalogs listed in References 4 through 6. Personnel contacts with modeling agencies identified during the literature search were then made. References 7 through 14 document model descriptions or studies, which rely upon modeling methodology, that appeared applicable to the current research. Appendix C presents brief descriptions of the models considered to have the most potential in meeting the function of an OC in the area of Naval strike warfare.

2. Analysis

In the final analysis, none of the studied models were able to sufficiently meet the OC requirements. One stood out above the others, however, and was considered further. It is called C-BASE II[7] and will be discussed in more detail later in this report. Two examples of other models will be cited to show why some of the models were dismissed from further study.

The first model is called CFOAM.[12] This model simulates tactical strike air warfare (aircraft, ASM, and SSM) and air defense against such strikes. The opposing forces have wide discretion in the representation of offensive and defensive actions (land and sea). This flexibility requires a high level of detail to represent and evaluate equipment and doctrinal effects. Unfortunately, this discretion and flexibility require inputs at a level of detail that is highly technical. Massive amounts of input data by a highly trained user are required. Also, the computer model requires large amounts of computer resource (500k words of working core), which casts doubts about its utility in a task force decision environment.

The second model is called AIRCAM;[10] this one does not render enough breadth to the naval air strike planning area. AIRCAM simulates the flight by flight penetration of a defended environment. Although sufficient detail is provided to the specific area of an offensive strike, no treatment is given to such important areas as timing of the strikes, air defense, and the general interaction of competing forces.

The model thought to most closely meet the requirements of an OC is the previously mentioned C-BASE II. The SRI study team consulted with C-BASE II authors, and a copy of the computer program was obtained for analysis at SRI. The model is described in Appendix C, and a few of its input categories are described in Table 3. The reader can immediately sense that the model deals in almost all of the areas that concern Naval strike warfare. It has an interactive capability which enables a user to examine alternatives in a quick and efficient manner, and it has the additional advantage of requiring small amounts of computer time to run.

Unfortunately, the model suffers from a degree of structural rigidity and excessive detail in its input requirements. Consequently, it cannot reflect enough flexibility in simulating an operations plan replete with contingencies. Additionally, its level of detail is not symmetrical because it treats friendly forces with more detail than enemy forces. These comments are not made critically, because it is understood that C-BASE II was originally designed to measure the relative effectiveness of

Table 3

PARTIAL C-BASE II INPUTS

GENERAL INPUT	FIGHTER AIRCRAFT INPUT	ATTACK AIRCRAFT INPUT
Number of operating days.	Initial number.	Initial number.
Length of operating day (hours).	Availability.	Initial availability (first mission, first day).
Number of carriers in task force.	Average number required to support one CAP station.	Deck dud probability.
Task force attack aircraft mission time (hours).	Maximum number of attacks on inbound enemy raid by a single airborne fighter as CAP.	Probability of kill in a single attack by an enemy interceptor (including probability of detection and conversion).
Task force attack aircraft turnaround time (hours). Excludes delays due to damage to carrier by enemy action.	Probability of kill of enemy attack aircraft by a fighter in a single attack as CAP (including probability of detection and conversion).	Probability of releasing payload after attack by enemy local (ground) defenses.
Maximum allowable hits on carrier for transition to second phase of carrier operation; first of two conditions.	Maximum number of attacks on enemy attack aircraft by a single fighter when deck launched and able to engage inbound enemy raid.	Number of attacks on grounded aircraft targets by a single attack aircraft.
Mean time to repair a bomb/missile hit on carrier (hours); applies only to minor damages which cause carrier to be out of action less than one day.	Maximum number of attacks on enemy attack aircraft by a single fighter when deck launched and able to engage outbound enemy raid.	Probability of kill of grounded aircraft target in a single attack by an attack aircraft.
Maximum fraction task force attack aircraft attrition allowable for transition to second phase of carrier operation, 2nd condition.	Probability of kill of enemy attack aircraft by a fighter in a single attack when deck launched and able to engage enemy raid (including probability of detection and conversion).	Probability that airborne attack aircraft survives 30 minutes or more after being attacked by enemy local (ground) defenses.
Fraction of task force sorties to attack grounded enemy aircraft during first phase of carrier operation.	Minimum number desired for task force defense. No reassignment to escort or attack role when minimum is reached. May be zero.	Probability of no damage of kind that would cause a kill on landing attempt after attack by enemy local defenses.
Fraction of task force sorties to attack grounded enemy aircraft during second phase of carrier operation.		Probability that repair is required after returning from mission and landing safely.
Clock time of beginning of operational day.		Mean time to repair (hours).
Task force attack aircraft mission radius (nautical miles).		

different mixes of carrier aircraft. It never was intended to provide specific outcome estimates.

Some discussion of the C-BASE II drawbacks as an OC follow. First, it has no provision for changing weather throughout an engagement, and weather was identified as a key decision variable that forces changes to specified operation plans. Second, the ability to initially plan and subsequently change strike operations is limited and to a large extent not visible to a user. Each aircraft is given relative effectiveness factors such as:

- Fighter loaded as an escort fighter
- Fighter loaded as a fighter/bomber
- Bomber loaded as a bomber
- Bomber loaded as a fighter/bomber.

These factors are used in a fixed linear programming routine for strike aircraft role assignment. The objective function used in the linear program to maximize strike group effectiveness is certainly open to debate and allows a TFC little planning recourse.

Third, detailed probabilities and effectiveness data are required for each aircraft, as it relates to enemy aircraft, for computing air-to-air attrition. The following inputs indicate what this data is like; I denotes a task force aircraft and K, an anemy interceptor aircraft:

- Probability, p, that a task force escort fighter I makes all its attacks first in an air-to-air engagement with an enemy interceptor K. ($q = 1 - p$ is the probability that the enemy attacks first. The number of attacks made by the escort fighter is assumed to be a random variable whose probability distribution is the binomial distribution with parameter = probability of detecting and converting on target interceptor K by escort fighter I.).
- Maximum number of attacks by a task force escort fighter I when attacking enemy interceptor K.
- Maximum number of attacks by an enemy interceptor K when attacking task force escort fighter I.

- Maximum number of attacks by an enemy interceptor K when attacking task force attack aircraft I.
- (Probability of detecting and converting on a target enemy interceptor K by an escort fighter I) × [Probability of kill of a target interceptor K when attacked (i.e., given detection and conversion) by a task force escort fighter I].
- (Probability of detecting and converting on a target task force escort fighter I by an enemy interceptor K) × [Probability of kill of a target escort fighter when attacked (i.e., given detection and conversion) by an enemy interceptor K].
- (Probability of detecting and converting on a target task force attack aircraft I by an enemy interecptor K) × [Probability of kill of a target attack aircraft I when attacked (i.e., given detection and conversion) by an enemy interceptor K].

These types of data are subjected to a series of model computations, once again fixed and unseen by the TFC, for computing air-to-air attrition. Trying to model aerial combat in this detailed fashion, indeed in any fixed fashion, would appear unwise to a potential decision-maker.

D. The NWRC Strike Outcome Calculator (SOC)

1. Description

Since the paper, pencil, and pub, as well as off-the-shelf combat simulation methodologies appeared to fall short of the OC requirements (identified in the initial phase of the research), the Naval Warfare Research Center (NWRC) set out to design its own OC, specifically designed to meet the desired OC specifications. It is named the Strike Outcome Calculator (SOC). SOC is tailor-made for use as a component of a Naval task force decision-aiding system. In addition, SOC is a decision-aid in its own right and can be used independent of any structured decision problem solving methodology.

SOC is a decision aid that enables a TFC quickly and easily to estimate battle outcomes associated with alternative courses of action. SOC consists not only of a computational algorithm, but of an interactive medium to facilitate both the description of alternative courses of action and the display of the associated battle outcomes. It is envisioned that a decision aid such as SOC would be useful in decisions concerned with long-range planning, contingency planning, and short range tactical execution.

The overall SOC concept is illustrated in Figure 7. As indicated in this figure, the major parameters which enter into the choice among alternative courses of action are timing, use of assets, force position, threat action, and weather. A TFC generally describes a possible COA by prescribing values of these parameters in aggregate, often qualitative, terms. The emphasis in developing SOC was in providing the TFC with the flexibility to describe easily the alternative COAs in a wide range of values of these parameters, and yet maintaining a level of detail consistent with the needs of the TFC.

As shown in Figure 7, the SOC system contains three major components: the communicator/translator, the aggregate SOC data base, and the computational algorithm. The communicator/translator is the man-machine interface between the decision-maker and the computational algorithm and data base. The translator is a person who knows the decision problem well enough to be able to translate aggregate qualitative descriptions. The communicator is an interactive hardware/software system that permits the translator to communicate easily the description of the COAs to the computer and to obtain the desired outcome estimates. The communicator has been designed to enable the TFC to proceed through a series of alternative COAs efficiently. The communicator/translator facilitates the use of SOC as a component of an overall decision-aiding system for evaluating a set of alternative courses of action identified within a decision structuring component as well as for answering "what if" questions and planning for contingencies.

A second major component of SOC is the aggregate data base. This data base contains data of three types: background, scenario, and course of action data. All data in the SOC are at a level of aggregation consistent with that used by the TFC. The aggregate data base facilitates the translation of descriptions of the situations and alternative decisions into quantitative terms.

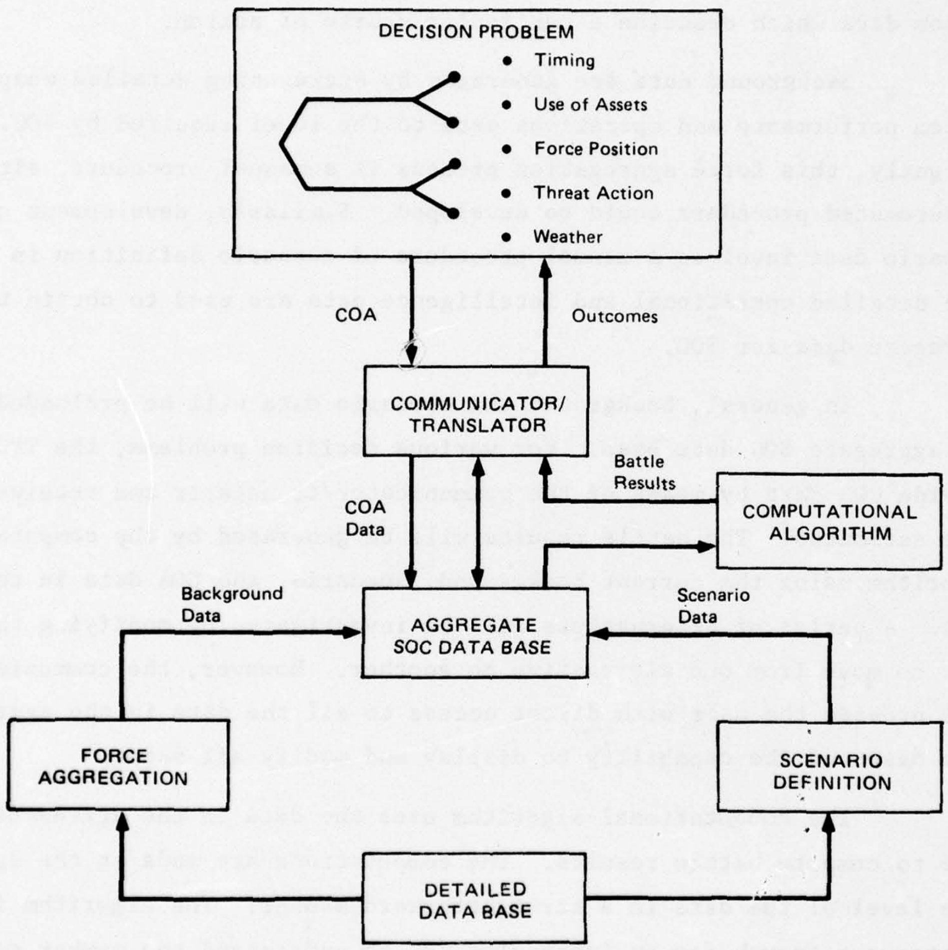


FIGURE 7 STRIKE OUTCOME CALCULATOR CONCEPT

Background data are generally constant over a wide range of scenarios. Such data include own and enemy force capability data (e.g., weapon system performance, availability, and effectiveness characteristics). Scenario data vary with the scenario under consideration, such as own and enemy resources, force concentration, and environment. COA data include the timing, use of assets, force position, weather, and threat action data which describe a particular course of action.

Background data are generated by aggregating detailed weapon system performance and operations data to the level required by SOC. Currently, this force aggregation process is a manual procedure, although an automated procedure could be developed. Similarly, development of scenario data involves a manual procedure of scenario definition in which more detailed operational and intelligence data are used to obtain the aggregate data for SOC.

In general, background and scenario data will be preloaded into the aggregate SOC data base. For various decision problems, the TFC will provide COA data by means of the communicator/translator and receive outcome estimates. The battle results will be generated by the computational algorithm using the current background, scenario, and COA data in the data base. A series of alternatives will be investigated by modifying the COA data to move from one alternative to another. However, the communicator will provide the user with direct access to all the data in the aggregate data base and the capability to display and modify all data.

The computational algorithm uses the data in the aggregate data base to compute battle results. The computations are made at the aggregate level of the data in a straightforward manner. The algorithm is transparent enough for an interested TFC to understand the number generating routines. The relative simplicity of the algorithm does not imply a lack of credibility. The algorithm is consistent with the level of detail of the data, and therefore, the integrity of the overall system is maintained. The absence of internal assumptions, so common in more detailed algorithms, tends to enhance the credibility of the SOC algorithm. In essence, the SOC computational algorithm provides a consistent, understandable, automated means of transforming a course of action as described by the TFC in terms of the data into the implications of the action in terms of attrition and battle accomplishment results.

The data is structured to a degree that permits model credit-ability without overburdening detail. In most battle simulations, as the inputs become more numerous or detailed (with a resultant increase in model sophistication), the user cannot rapidly and easily see the under-lying numerical routines, which reduces the user's ability to relate the causal effects of the input to the output. The aggregated data of SOC allows the user to avoid a loss of confidence associated with more de-tailed data inputs which are subjected to hidden and nonflexible assump-tions, doctrines, and numerical techniques within the model. Additionally, with SOC, a user can take advantage of personal judgment and experience to the extent necessary or desired.

Further details regarding SOC are provided in the following sections. First, the inputs and outputs of SOC are described in detail Such a description is valuable for communicating the level of detail at which SOC operates and the flexibility within the system for describing various scenarios and courses of action. Next, the man-machine inter-action of the system is described. Finally, a general description of the battle logic embodied in the strike outcome calculator is provided.

2. Inputs and Outputs

The input data to SOC falls into three categories: background, scenario, and COA. In this section, the specific input data required of each of these three types will be discussed. All data are input to the system in tabular form. The tables presented in this report as exhibits are the forms which must be filled out to provide data to the system. The outputs of the system, i.e., outcome results, are also provided in tabular form. These are also discussed in this section.

a. Background Data

Certain data required by SOC will remain generally fixed over a wide range of scenarios and decision problems. Such data are called background data. Although background data are accessible to the user for display and modification, it is expected that the data will be modified infrequently.

In the SOC concept, the friendly (Blue) and enemy (Red) forces are assumed to be composed of generic force elements. As shown in Exhibit 1 the Blue forces are composed of six elements: attack aircraft (ATTACK), all-weather attack aircraft (AW-ATTACK), low-performance fighter (VF-LO), high performance fighter (VF-HI), carrier (CV), and support ship. Red forces are composed of eight elements: low performance attack aircraft (BOMBER-LO), high performance attack aircraft (BOMBER-HI), fighter-bomber (VBF), interceptor fighter (VFI), surface-to-surface missile ship (SSM-SHIP), airbase, surface-to-air missile site (SAM-SITE), and supply line. Each of these elements are given a class designation: OA, DA, OS, DS, and LS denote offensive air, defensive air, offensive surface, defensive surface, and logistics support, respectively. The significance of the class of the element will be discussed later. The representative example of each element shown in Exhibit 1 is user specified as a reminder that performance and operational data, input subsequently for an element, is representative of a specific weapon system.

In performing offensive or defensive missions, certain combinations of the force elements are used. In the SOC concept, the user can define a variety of force units, that is, structural units to be utilized in performing missions. The magnitude of an action may be varied by assigning more than one unit to a mission.

Exhibit 2 shows a sample definition of Blue force units. Three major types of offensive units are chosen. ALPHA units are used to attack enemy air assets, WAS are used to attack enemy surface ships, and CAS units are used for close-air-support and interdiction missions. Defensive force units include fighter combat air patrol (VFCAP), surface combat air patrol (SUCAP), and deck launched interceptor (DLI) units. Several force units of a given type may be defined by designating unit subtypes.

Exhibit 1

BLUE AND RED FORCE ELEMENTS

BLUE FORCE ELEMENT

ELEMENT	EXAMPLE	CLASS
ATTACK	A-7E	OA
AW-ATTACK	A-6E	OA
VF-LO	F-4J	DA
VF-HI	F-14A	DA
CV	KITTY HAWK	OS
SUPPORT SHIP	DLG LEAHY	DS

RED FORCE ELEMENTS

ELEMENT	EXAMPLE	CLASS
BOMBER-LO	BADGER A	OA
BOMBER-HI	BADGER C	OA
VBF	SU-7B	DA
VFI	MIG-21	DA
SSM-SHIP	SS-N-3	OS
AIRBASE	ONRODA	OS
SAM SITE	SAM-3	DS
SUPPLY LINE	TRUCKS/AAA	LS

OA - OFFENSIVE AIR
DA - DEFENSIVE AIR
OS - OFFENSIVE SURFACE
DS - DEFENSIVE SURFACE
LS - LOGISTICS SUPPORT

Exhibit 2

BLUE FORCE UNITS

BLUE FORCE UNIT		ELEMENTS PER UNIT					UNIT CHARACTERISTICS					
TYPE	SUB-TYPE	ATTACK	AW-ATTACK	VF-LO	VF-HI	SUPPRESS	MAX RANGE	LONG RANGE DEFAULT	WORST WEATHER	BAD WEATHER DEFAULT	MAX DETECTION RANGE (NM)	SPEED (MACH #)
ALPHA	A	4		1	1	1	LONG			C	100	0.9
	B	4			4	2	LONG			C	100	0.9
	C		4				LONG		BAD		100	0.9
WAS	A											
	B											
	C											
CAS	A											
	B											
	C											
VFCAP												
SUCAP												
DLI												

For each Blue unit defined, the numbers of attack, all-weather attack, low and high performance fighter, and suppression aircraft* must be specified. In addition, several characteristics must be assigned each unit. These include the maximum range of the unit (LONG or SHORT), the long-range default force unit (i.e., the force unit that is to replace it in the event that its maximum range is "SHORT" and it is assigned a long-range mission), the worst weather conditions (GOOD or BAD) in which it can perform, the bad weather default unit (i.e., the force unit that is to replace it in the event that the worst weather conditions in which it can perform is GOOD and it is assigned a mission in BAD weather), maximum range at which it can be detected by the enemy, and the speed at which the unit operates. The default units differ only in subtype from the original unit. No default unit need be specified. If no range is specified, LONG is assumed. If no worst weather is specified, BAD is assumed.

Exhibit 3 shows a sample definition of Red force units. The types of Red units include anti-ship missile (ASM), freefall bombing (FREE), fighter-bomber attack (VBF), surface-to-surface missile (SSM), and strip launched interceptor (SLI) units. Each unit is composed of various numbers of low and high performance bombers, fighter bombers, interceptor fighters, and SSM ships. One unit cannot contain both SSM ships and other elements. As in the case for Blue units, each of the Red units is assigned several characteristics.

Having defined the force units, one must specify the battle engagement statistics which provide the basis for determining Blue and Red losses in combat. The engagement statistics for Blue attacking Red are shown in Exhibit 4, and for Red attacking Blue in Exhibit 5. As seen from these exhibits, the engagement statistics are fairly aggregate measures of the battle effectiveness of the force units previously defined. One of these measures is the number of attacking force units that can be killed by air-to-air and surface-to-air means per defensive element of the force under attack. A second set of statistics gives the number of the defending

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*Suppression aircraft are assumed to be specially-configured all-weather attack aircraft.

Exhibit 3

RED FORCE UNITS

RED FORCE UNIT		ELEMENTS PER UNIT					UNIT CHARACTERISTICS					
TYPE	SUB-TYPE	BOMBER-LO	BOMBER-HI	VBF	VFI	SSM-SHIP (8 LAUNCHERS)	MAX RANGE	LONG RANGE DEFAULT	WORST WEATHER	BAD WEATHER DEFAULT	MAX DETECTION RANGE (NM)	SPEED (MACH #)
ASM	A		4	4			SHORT	B	GOOD	B	300	1.5
	B		4				LONG		BAD		300	1.5
FREE	A											
	B											
	C											
VBF	A											
	B											
SSM												
SLI												

Exhibit 4

ENGAGEMENT STATISTICS FOR BLUE ATTACKING RED

BLUE FORCE UNIT		BLUE ATTACKING FORCE UNITS LOST PER RED DEFENSIVE ELEMENT				MAXIMUM RED FIGHTERS KILLED AIR-TO-AIR PER BLUE ATTACK UNIT		RED FORCE ELEMENTS KILLED AIR-TO-SURFACE PER UNIT OF PENETRATING BLUE ATTACK FORCE				
		AIR-TO-AIR		SURFACE-TO-AIR								
TYPE	SUB-TYPE	VBF	VFI	SAM	SUPPLY LINE	VBF	VFI	PARKED AIRCRAFT	SSM SHIP	AIRBASE	SAM SITE	SUPPLY LINE
ALPHA	A	0.11	0.22	0.67		3.0	1.5	3.0		.02	0.47	
	B											
	C											
WAS	A											
	B											
	C											
CAS	A											
	B											
	C											
SUCAP												

Exhibit 5

ENGAGEMENT STATISTICS FOR RED ATTACKING BLUE

RED FORCE UNIT		RED ATTACKING FORCE UNITS LOST PER BLUE DEFENSIVE ELEMENT				MAXIMUM BLUE FIGHTERS KILLED AIR-TO-AIR PER RED ATTACK UNIT		BLUE FORCE ELEMENTS KILLED AIR-TO-SURFACE PER UNIT OF PENETRATING RED ATTACK FORCE		
		AIR-TO-AIR		SURFACE-TO-AIR						
TYPE	SUB-TYPE	VF-LO	VF-HI	CV	SUPPORT SHIPS	VF-LO	VF-HI	PARKED AIRCRAFT	CV	SUPPORT SHIPS
ASM	A									
	B									
FREE	A									
	B									
	C									
VBF	A									
	B									
SSM										

fighters that can be killed air-to-air per unit of attacking force. The third set of statistics gives the number of the defending force elements that can be killed surface-to-air, per unit of attacking force that penetrates the defenses.

In specifying the effectiveness of an attacking force unit, the synergistic effects of the various assets in the unit (e.g., attack, fighter, and suppression aircraft) should be considered. The importance of such synergistic effects as well as the insertion of user judgment was a primary factor in the decision to treat force assets in terms of units.

The next type of background data required is weapon platform availability statistics. This form for the data is shown in Exhibit 6. For each of the force elements which make up force units, a normal and surge sortie rate and a refuel-rearm time must be specified. The normal sortie rate for a weapon platform is the average number of sorties that can be mounted per day on a sustained basis (usually thirty days). The surge sortie rate is the maximum number of sorties that can be mounted in a 24-hour period. The refuel-rearm time is the minimum time before a weapon platform returning from a mission can be ready to depart on another mission. In the computational algorithm, the battle is simulated in three-hour increments. Thus, the refuel-rearm time is specified in terms of the number of three-hour time periods.

The last of the background data is the operations and damage repair capabilities of the Blue carrier and Red airbase elements. The form of this data is shown in Exhibit 7. For various damage levels, the maximum number of operations per three-hour period and the maximum damage repair capability per period must be specified per element of Blue CV and Red airbase.

As an example of a rationale for determining the maximum number of operations for an undamaged Blue carrier, suppose a launch takes one minute and a recovery two minutes, on the average. Then, over a time period (180 minutes), one could specify the maximum number of operations

Exhibit 6

WEAPON PLATFORM AVAILABILITY

FORCE ELEMENT	NORMAL SORTIE RATE	SURGE SORTIE RATE	REFUEL REARM TIME
ATTACK			
AW-ATTACK			
VF-LO			
VF-HI			
VA-LO			
VA-HI			
VBF			
VFI			
SSM SHIP			

Exhibit 7

OPERATIONS AND DAMAGE REPAIR CAPABILITIES

DAMAGE LEVEL	MAXIMUM OPERATIONS PER PERIOD		MAXIMUM DAMAGE REPAIR PER PERIOD	
	BLUE CV	RED AIRBASE	BLUE CV	RED AIRBASE
0.0	180	150	.1	.05
0.1	150	140	.1	.05
0.2	100	120	.1	.05
0.3	50	100	.05	.05
0.4	25	70	.05	.05
0.5	0	50	0	.05
0.6				
0.7				
0.8				
0.9				
1.0				

to be 180, with a launch consuming one operation and a recovery consuming two operations.*

This concludes the background data inputs. These data are generally derived by aggregating more detailed data found in Navy data bases and publications. The present aggregation procedure is manual; however, an automated procedure could be devised for future use. As seen from the above description, these data are fairly static, depending on specific weapon systems and operating doctrine.

b. Scenario Data

A concept employed in defining scenario data is that of force complexes. Force complexes are groupings of Blue or Red force elements. The forms for the data used to define complexes are shown in Exhibits 8 and 9. As seen from these exhibits, a complex is defined by specifying the numbers of the various force elements associated with it. Resources for the defense of a complex are assumed to be drawn from the elements assigned to it. Similarly, resources for offensive actions are assumed to be drawn from the elements of a particular complex, with another complex being the target of the action.

In addition to physical location, one may define more than one Blue or Red complexes for a number of reasons. For example, Red or Blue may be composed of several allies who may act independently, or several groups of force elements may initiate or be the targets of attacks, independent of each other. For the purpose of illustration, assume that a Blue carrier task force undertakes a mission to interdict enemy supply lines. Assume also that there is an airfield in the vicinity of the interdiction targets. As shown in Exhibits 8 and 9, three complexes might be defined in this case. The sole Blue complex, called CTFORC, is composed of the assets in the carrier task force. The Red complexes, named AIRFLD and SUPLIN, are composed of the assets at the Red airfield and on

*The numbers of operations per launch and per recovery are part of the scenario data inputs.

Exhibit 8

BLUE FORCE COMPLEXES

BLUE COMPLEX	ELEMENTS AT COMPLEX						COMPLEX CHARACTERISTICS					
	ATTACK	AW-ATTACK	VF-LO	VF-HI	CV	SUP SHIP	DLI LAUNCH TIME (MIN)	SURV RANGE FACTOR	FRACTION AIRCRAFT SHELTERED	CYCLE TIME (DAYS)	REPL TIME (DAYS)	REPL OPS
CT FORC	20	10	20	20	1	9	2	1.0	0.20	5	1	50D

Exhibit 9

RED FORCE COMPLEXES

RED COMPLEX	ELEMENTS AT COMPLEX								COMPLEX CHARACTERISTICS					
	BMR LO	BMR HI	VBF	VFI	SSM SHIP	AIR BASE	SAM SITE	SUP LINE	DLI LAUNCH TIME	SURV RANGE FACTOR	FRAC AIR SHELT	CYCLE TIME	REPL TIME	REPL OPS
AIRFLD	20	20	20	10		2	5		1	1.0	0.25			
SUPLIN								2						

the Red supply lines, respectively. The user is free to name the complexes as he wishes.

In addition to the numbers of elements at a complex, several characteristics must be specified. These include the time between successive SLI or DLI launches at the complex, the surveillance range factor (i.e., the fraction of the maximum detection range* of incoming enemy forces expected at the complex), and the fraction of the sheltered aircraft assigned to the complex (i.e., not subject to air-to-surface attrition by enemy raids). If the complex operates in a replenishment cycle (such as a carrier), the length of the cycle (in days) is specified, as well as the number of days of the cycle during which replenishment is being conducted. Also, the maximum percentage of normal operations that can be conducted during replenishment is specified. Further, as shown in Exhibit 8, operations during replenishment can be restricted to defensive operations only by including a "D" with the percentage of normal operations.

In addition to the complex definition, scenario data include several miscellaneous inputs. These inputs, which are shown in Exhibit 10, are self explanatory.

c. COA Data

The course of action data are expected to be of major concern to the user in solving specific decision problems. These data provide the flexibility for describing various courses of action such as timing, use of assets, force position, weather, and threat action.

The timing, use of assets, and threat action are specified via the Blue and Red operations plan tables, shown in Exhibits 11 and 12. In the operations plan table, each offensive and defensive mission is defined by specifying a mission name, priority, origin complex, target complex, start, stop, mission times, type of unit, desired number of units, minimum number of units, and number of ready units.

*The maximum detection ranges were specified for each force unit in the background data (Exhibits 2 and 3).

Exhibit 10

MISCELLANEOUS INPUTS

MAXIMUM NUMBER OF DAYS THE BATTLE IS TO RUN (LESS THAN 31)	10
MISSION TIME FOR LONG RANGE MISSIONS (NO. OF 3HR TIME STEPS)	0
MISSION TIME FOR SHORT RANGE MISSIONS (NO. OF 3HR TIME STEPS)	0
NO. OF OPERATIONS PER AIRCRAFT LANDING	2
NO. OF OPERATIONS PER AIRCRAFT LAUNCH	1
FRACTION OF MAX UNIT DETECTION RANGE REALIZED IN BAD WEATHER	.5
DELAY IN MINUTES BEFORE FIRST SLI/DLI CAN BE LAUNCHED	5
DO YOU WANT LONG RANGE FORCE UNIT DEFAULT IN EFFECT (1=YES 0=NO)	1
DO YOU WANT BAD WEATHER FORCE UNIT DEFAULT IN EFFECT (1=YES 0=NO)	1

Exhibit 11

BLUE OPERATIONS PLAN

MISSION	PRIORITY	ORIGIN COMPLEX	TARGET COMPLEX	START	STOP	MISSION TIMES	TYPE OF UNIT	DESIRED UNITS	MIN UNITS	READY UNITS
HITAB	1	CTFORC	AIRFLD	DAY 1	DDA 50	14	ALPHA B	3	2	
INTER	2	CTFORC	SUPLIN	ENDHITAB	DLS 50	25	CAS B	2	1	
CAP1	1	CTFORC		DAY 1	ENDHITAB	12345678	VFCAP	2	1	1
CAP2	1	CTFORC		ENDHITAB		12345678	VFCAP	1	1	
DLI	1	CTFORC		DAY 1		12345678	DLI	2	1	

Exhibit 12

RED OPERATIONS PLAN

MISSION	PRIORITY	ORIGIN COMPLEX	TARGET COMPLEX	START	STOP	MISSION TIMES	TYPE OF UNIT	DESIRED UNITS	MIN UNITS	READY UNITS
HITCV	1	AIRFLD	CTFORC	DAY 1	DOS 90	26	ASM A	3	2	
HITDD	2	AIRFLD	CTFORC	DAY 1	DDS 90	26	FREE A	2	1	
SLI1	1	AIRFLD		DAY 1		12345678	SLI	3	1	

The mission name is arbitrarily assigned to identify each mission. The priority of the mission indicates the preferred order for assigning assets to perform missions, with priority 1 missions being allocated resources first. The origin complex is the name of the complex from which resource to perform the mission are to be drawn. The target complex is the name of the complex which is the target of an offensive strike mission. Defensive missions, except for those using SUCAP units, have no target complex. The complexes named as the origin and target complexes must be defined in the scenario data.

The start and stop times for a mission can be specified in several ways. One way is to enter DAY, then the number of the day in the battle when the subject mission is to be initiated or terminated. A second way is to enter END, then the name of a previous mission. In this case, for start times, the subject mission will begin the day after the previous mission terminates. When used as a stop time the subject mission will be terminated the day the previous mission is terminated. A third way of designating start and stop times is to enter DOA, DDA, DOS, DDS, or DLS (meaning destroy offensive air, destroy defensive air, destroy offensive surface, destroy defensive surface, or destroy logistics support,* respectively); and then enter the level of destruction of the associated elements at the target complex desired before the mission is to be initiated or terminated. For example, the DDA 50 stop time for mission HITAB in Exhibit 11 means that mission HITAB is to be terminated when 50% of the defensive air elements (i.e., fighter bombers and interceptor fighters) at the target complex, AIRFLD, have been destroyed. A blank entry for a stop time indicates that the mission is to be continued indefinitely.

For computing battle results, the day is divided into eight, three-hour time periods. For the mission times, the user specifies time periods for each mission to be performed. The type of unit that is to perform each mission must also be specified by name. Enemy force unit names must have been defined in the background data. The desired units indicate the number of units the user wants to have assigned at each repetition of

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*See Exhibit 1 for the classes assigned to the various elements.

the mission. The minimum number of units designates the smallest number of force units to be assigned at each repetition of the mission, in the event that there are insufficient resources to assign the desired number of units. Ready units are specified if aircraft are to be saved for use to relieve engaged defensive units.

COA data that indicate force position and weather parameters are provided in tables of the form shown in Exhibits 13 and 14, respectively. The relative position (LONG or SHORT) between each pair of Red and Blue complexes must be specified. If no relative position is specified, LONG is assumed. The days of battle when weather changes occur are also specified. The weather remains the same between days of change.

d. Results

Two types of battle outcomes are generated by SOC: mission accomplishment results and battle attrition results. Blue and Red mission accomplishment results are shown in Exhibits 15 and 16. These results basically show the operations plans specified by the user. The start and stop times, which became activated because of the termination of missions or destruction of targets, are displayed by day of occurrence. The total number of units requested for each mission during the battle are shown, together with units actually engaged. Also, as in the case of mission INTER, if a default unit is activated, the number of units requested and engaged for the default unit is shown separately from the original type of unit requested.

Blue and Red battle attrition results are shown in Exhibits 17 and 18. For each complex, the number of elements of each type attrited, together with the total number of elements assigned are shown. The numbers of airbase and CV elements at a complex shown as lost do not include those damaged and subsequently repaired.

The results provided by SOC give a concise summary of the implications of a particular course of action. The results indicate the capability of the forces to carry out a given operations plan, provide information on the time, and force availability, and give an indication of the cost to both sides in terms of force losses.

Exhibit 13

FORCE POSITION

BLUE / RED	CTFORC
AIRFLD	LONG
SUPLIN	LONG

Exhibit 14

DAYS OF WEATHER CHANGE

DAY	1	8	10
WEATHER	GOOD	BAD	GOOD

Exhibit 15

BLUE MISSION ACCOMPLISHMENT RESULTS

BLUE MISSION	PRIORITY	ORIGIN COMPLEX	TARGET COMPLEX	START	STOP	MISSION TIMES	TYPE OF UNIT	DESIRED UNITS	TOTAL UNITS REQUESTED	TOTAL UNITS ENGAGED
HITAB	1	CTFORC	AIRFLD	DAY 1	DAY 3	14	ALPHA B	3	18	14
INTER	2	CTFORC	SUPLIN	DAY 4	DAY 10	25	CAS B CAS C	2 2	20 8	10 12
CAP1	1	CTFORC		DAY 1	DAY 3	12345678	VFCAP	2	72	72
CAP2	1	CTFORC		DAY 4		12345678	VFCAP	1	56	56
DLI	1	CTFORC		DAY 1	DAY 3	12345678	DLI	2	160	160

Exhibit 16

RED MISSION ACCOMPLISHMENT RESULTS

RED MISSION	PRIORITY	ORIGIN COMPLEX	TARGET COMPLEX	START	STOP	MISSION TIMES	TYPE OF UNIT	DESIRED UNITS	TOTAL UNITS REQUESTED	TOTAL UNITS ENGAGED
HITCV	1	AIRFLD	CT FORC	DAY 1	DOS 90	26	ASM A	3	60	25
HITDD	2	AIRFLD	CT FORC	DAY 1	DDS 90	26	FREE A	2	40	20
SLI1	1	AIRFLD	CT FORC	DAY 1		12345678	SLI	3	240	180

Exhibit 17

BLUE BATTLE ATTRITION RESULTS

BLUE	ELEMENTS ATTRITED/TOTAL ELEMENTS AT COMPLEX					
COMPLEX	ATTACK	AW-ATTACK	VF-LO	VF-HI	CV	SUPPORT SHIP
CT FORC	8 20	3 10	8 20	5 20	0.3 1.2	3 9

Exhibit 18

RED BATTLE ATTRITION RESULTS

RED	ELEMENTS ATTRITED/TOTAL ELEMENTS AT COMPLEX							
COMPLEX	BOMBER-LO	BOMBER-HI	VBF	VFI	SSM-SHIP	AIRBASE	SAM-SITE	SUPPLY LINE
AIRFLD	18 20	14 20	15 20	7 10		0.8 2.5	4 5	
SUPLIN								1.0 2.0

3. Man-Machine Interaction

The SOC data base is organized into 18 computer tables (previously shown as exhibits) listed in Table 4.

Table 4

STRIKE OUTCOME CALCULATOR (SOC) COMPUTER TABLES

Table	SOC Data-Base Exhibit Title	Type
1	BLUE AND RED FORCE ELEMENTS	Background Data
2	BLUE FORCE UNITS	
3	RED FORCE UNITS	
4	ENGAGEMENT STATISTICS, BLUE ATTACKING RED	
5	ENGAGEMENT STATISTICS, RED ATTACKING BLUE	
6	WEAPON PLATFORM AVAILABILITY	
7	OPERATIONS AND DAMAGE REPAIR CAPABILITIES	
8	BLUE FORCE COMPLEXES	Scenario Data
9	RED FORCE COMPLEXES	
10	MISCELLANEOUS INPUTS	
11	BLUE OPERATIONS PLANS	COA Data
12	RED OPERATIONS PLANS	
13	RELATIVE FORCE POSITIONS	
14	WEATHER DAYS	
15	BLUE MISSION ACCOMPLISHMENT RESULTS	Results (Computed Outcomes)
16	RED MISSION ACCOMPLISHMENT RESULTS	
17	BLUE BATTLE ATTRITION RESULTS	
18	RED BATTLE ATTRITION RESULTS	

The computer results tables 15 through 18 contain the computed outcomes from the last execution of the computational algorithm.

Given a computer terminal with a CRT and a printer, the communicator provides the user with the capability to display and modify all the data in the data base, exercise the computational algorithm, and obtain hard copy of any of the data and results. The communicator commands are as follows:

(1) LOAD INPUT

(2) SAVE INPUT

(3) DISPLAY/INPUT TABLE

(4) PRINT TABLE

(5) RUN

(6) STOP

(7) LIST TABLES

(8) EXPLAIN ABOVE FUNCTIONS.

A typical session for using SOC will begin by turning on the console and following a standard procedure for getting on-line to the computer.* If the user wishes to refresh his memory, he might issue the EXPLAIN ABOVE FUNCTIONS command and receive on the console a brief description of the SOC communicator functions. The user might then ask for a list of the aggregate data base computer tables by issuing the LIST TABLES command. If background, scenario, or COA data used in previous session are of interest, this data can be retrieved and placed in the aggregate data base by issuing the LOAD INPUT command.

With the functions explained and with data from previous sessions, the user is ready to evaluate the alternative courses of action associated with his decision problem. Any of the computer data tables can be displayed and modified by the user by issuing the DISPLAY/INPUT TABLE command. The user will generally be concerned with modifying the four COA computer data tables. When the data properly describe a course of action that the user wants to evaluate, the RUN command is issued. Upon executing this command, the computational algorithm computes the battle results using the data in the first 14 computer tables of the aggregate computer data base, and places the results in computer tables 15 through 18. Using the DISPLAY/INPUT TABLE command, the user can now have the results displayed on the console. Printouts (hard copy) of any of the data or results tables can be obtained using the PRINT TABLE command.

The user may evaluate a series of alternative courses of action by sequentially modifying data tables, running the computational algorithm,

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*SOC can also be exercised in a batch mode, although the interactive mode described here is preferred. When the user modifies data, SOC performs checks for various errors which may occur in the input. If such effors occur, the user is alerted.

and then displaying and/or printing the results. After all COAs have been evaluated, the user probably will issue the SAVE INPUT command. This will cause the current contents of the aggregate data base to be transferred to a computer storage device for use at some future time. The STOP command terminates the session.

From this brief description of a sample SOC session, it can be seen that the SOC interactive system is designed to be simple and fairly self-explanatory. A user need not be well-versed in computer science. With minimal training, a new user should be able to use the system efficiently.

4. SOC Battle Logic

The logic embodied within the computational algorithm of SOC is quite straightforward. The algorithm basically carries out the operations plans specified in the COA data, using the scenario and background data for information on force composition, effectiveness, and availability. The numerical computations are at the level of aggregation of the data in the aggregate data base. Thus, credible estimates of battle outcomes at the level of concern of the TFC are generated.

A macroflow chart of the SOC computational algorithm is shown in Figure 8. Each day of the battle is simulated successively. The dynamics of the battle within a day are assumed to occur in eight 3-hour time steps. At the beginning of each day a schedule is developed to reflect the Red and Blue missions that have been requested in each time step of the day. This schedule is based on the operations plans provided in the aggregate SOC data base. If the start time of a mission is later than the present day of the battle or the stop time is earlier than the present day of the battle, the mission is not scheduled. An offensive mission whose origin complex is under replenishment during the current day will not be scheduled if the user has indicated that only defensive missions are to be performed during replenishment. Missions that are given a priority zero in the operations plans will never be scheduled. This characteristic was incorporated to provide the user the facility

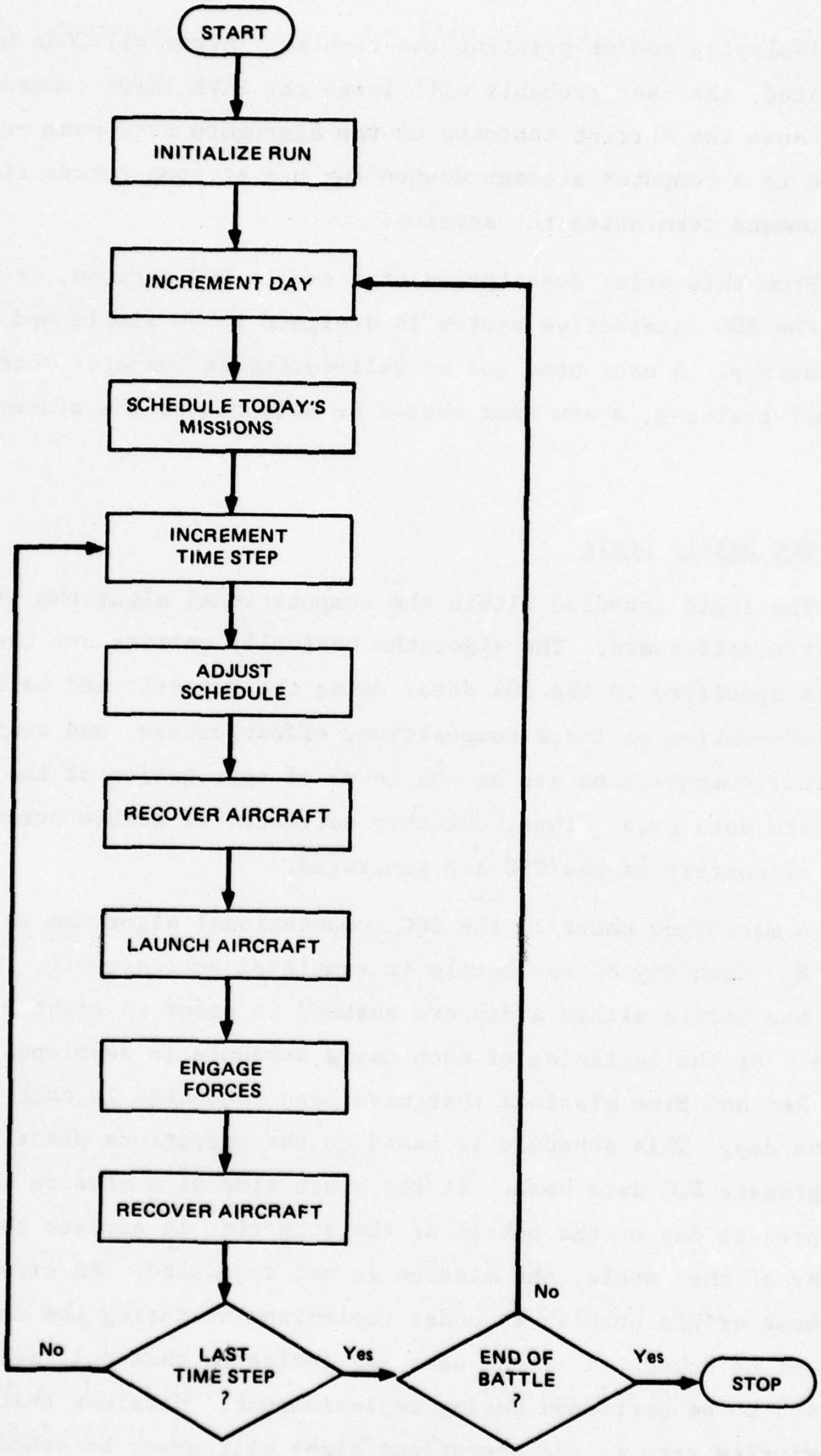

FIGURE 8 MACROFLOW CHART OF COMPUTATIONAL ALGORITHM

to easily activate and deactivate missions for testing alternative courses of action.

If the weather is bad on the day of battle and the force unit assigned to perform a mission cannot operate in bad weather, the mission will be scheduled using the bad weather default force unit, if the bad weather default force unit can operate at the range required. If no bad weather default has been designated for the originally requested unit, or if the user has chosen not to activate bad weather default options, the mission will not be scheduled. If the range between the origin and target complexes for a mission is LONG and that force unit requested to fill the mission can operate only at SHORT range, the mission will be scheduled using the long-range default unit specified for the original force unit. If no long range default unit has been designated, or the user has chosen not to activate long-range default options, or the default unit is not capable of operating in the current weather, the mission is not scheduled.

The schedule constructed with the constraints defined above is taken to be the "desired" mission schedule for the day. A running day-to-day total of the numbers of units requested for each of the missions in this desired schedule is maintained and provided in the mission accomplishment results tables (computer tables 15 and 16). The ready units associated with scheduled missions are included in the tally of total units requested.

The desired mission schedule is adjusted at the beginning of each of the eight time steps in the day. Priority 1 and 2 missions that were scheduled in the previous time step, but were not filled because of insufficient resources, are rescheduled in the current time step, unless the same mission has already been requested for the current time step. However, unfilled missions in one day will not be rescheduled for succeeding days. Also, at the beginning of each time step, the availability of resources to perform a mission is projected. Lower priority missions in the current time step will be cancelled if it is projected that using resources for such missions will result in insufficient resources for accomplishing higher priority missions scheduled for a future time step of the day.

The missions in the adjusted schedule are allocated resources in the order of high to low priority, subject to the availability of resources.* All resources for a mission are drawn from the origin complex. If there are insufficient resources to fill a mission with the desired number of force units, a lesser number of force units will be used, subject to the constraint that no fewer than the minimum number of units specified for the mission in the operations plan will be used. A cumulative total of the number of force units allocated to each mission, and subsequently engaged, is maintained and provided in the mission accomplishment results tables. Resources allocated to ready units are counted as engaged units.

The computational algorithm keeps track of the resources available at each of the Red and Blue complexes. The number of live force elements at each of the complexes is updated at the beginning of each time step. This update includes the repairs accomplished on damaged Blue carrier and Red airbase elements.

Resources to fill missions include aircraft (and SSM launchers) as well as the capability (in terms of number of operations) of Blue carriers and Red airbases to launch and recover aircraft. The aircraft can be in various states of availability. One state is that of returning from a mission with time of arrival in the current or some future time step. Antoher is that of being on the surface, undergoing maintenance or being refueled and rearmed.

When assigning aircraft to missions, only those aircraft that are on-the-deck (or ground), ready to perform a mission are assumed available. This constraint embodies several subordinate constraints. These include that, on a given day, the surge sortie rate for a given type of aircraft cannot be exceeded. The normal sortie rate can be exceeded only to fill priority 1 and 2 missions. Over a 30-day period, the cumulative sortie rate may not exceed that which would occur if the normal sortie rate were maintained for thirty days. Also, an aircraft which is recovered after

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*Missions with the same priority are allocated resources in the order in which they appear in the operations plan.

performing a mission cannot be ready to fly another mission in less than the number of time steps specified by the user as the refuel-rearm time for the aircraft. A zero rearm-refuel time means that the returning aircraft can be ready to perform another mission in the same time step in which it is recovered. Additionally, the aircraft must not only be available, but the carrier or airbase from which it is to be launched must have the capability to launch it. Thus, although there may be aircraft ready to fly on a carrier, they may not be able to perform missions because of excessive damage to the deck.

At the beginning of each time step, any aircraft returning from missions in a previous time step are recovered, subject to the constraint on the numbers of operations available at the carrier or the airbase. All the missions in the adjusted schedule for the current time step, for which resources are available, are assumed to be launched simultaneously. The attrition results for each of the missions is then computed.

The battle losses incurred when one side strikes the other are computed using the engagement statistics provided in the SOC aggregate data base. The aircraft or surface-to-surface missiles of an incoming strike are subject to attrition by air and surface defenses before they can inflict air-to-surface damage. The defending units are those associated with the target complex of the strike.

An incoming strike is first engaged by the airborne VF CAP at the target complex. Then, the DLI or SLI engage the strike. Ready units are used to refill the VF CAP and DLI or SLI positions vacated by the engaging defenders. The refilled VF CAP are then used to attack the incoming strike followed by the refilled DLI or SLI. This refilling and attacking sequence continues. There are, however, constraints on the use of the air defenders assigned to VF CAP, DLI, and SLI missions to attack incoming strikes. First of all, no more air defenders are engaged than necessary to completely annihilate an incoming raid. Secondly, based on the range at which the incoming strike force is detected, the speed of the incoming strike, the delay time until the first defender (on the deck or ground) can be launched, and the time between launches, a limit is placed on the number of defenders that can be engaged with the strike prior to its attack on the target complex.

The losses incurred by the incoming strike and the air defenders during the air-to-air combat is based on the engagement statistics supplied in computer tables 4 and 5. The losses are calculated assuming a simultaneous exchange between the forces. These losses are assumed to be a linear function of the number of force units in the strike and the number of defenders engaging the strike.

After the air-to-air battle, any surface-to-air defensive elements are assumed to have a shot at the remaining attackers. Surface-to-air capabilities may be specified by the user for carriers and support ships of Blue and SAM-sites and supply lines for Red.

The portion of strike force that penetrates the defenses inflicts air-to-surface losses on the elements at the target complex. Only a fraction of the parked aircraft that are not sheltered (as specified by the user in the scenario data) is subject to attrition. The number of parked aircraft of each type that is attrited is in proportion to the ratio of parked aircraft of each type to the total parked aircraft.

There is some logic peculiar to a Red SSM attack. If an SSM attack is imminent, the program assumes that any airborne SUCAP (associated with the Blue complex to be attacked) attack the SSM-ships from which the SSM attack is to be mounted. Only the portion of the ships that survive this attack are assumed to launch their missiles. Ready units associated with a SUCAP mission are launched and attack the remaining SSM-ships after the ship's missiles have been launched. All attacking SUCAP are subject to attrition by any air-to-air and surface-to-air defenses associated with the force complex to which the SSM-ships belong. The missiles launched are subject to air-to-air and surface-to-air attrition by the defenses of the Blue complex under attack. The sequencing of the engagements of the SUCAP and SSM missiles with air and ground defenses and the air-to-surface attacks are treated as previously described for offensive strikes.

The aircraft, both defensive and offensive, that survive are scheduled to land either in the current time step or some future time step. The scheduled landing at the home complex is based on the user-specified mission-times LONG and SHORT missions.* VF CAP, DLI, and SLI are scheduled to land at the end of the time step in which they were launched. Aircraft ready to land are recovered at the end of each time step, subject to the constraint on the available operations at carriers and airbases.

All attrition computations are assumed to be linear functions of the numbers of units of force elements engaging. The losses at each of the force elements at each of the force complexes are computed and used to maintain an updated inventory of Blue and Red assets. These results are needed to determine capability to perform future missions as well as for presentation to the user in the battle results tables.

After the eighth time step of a day has been completed, a new day of battle is initiated. The destruction level of each class of force elements at each of the force complexes is computed. These destruction levels are compared with the START and STOP criteria specified in the operations plans, then missions are initiated or terminated as appropriate. Also, START and STOP times that depend on the completion of other missions are checked and adjusted appropriately.† The weather for the new day is computed, the new day's schedule is developed, and the battle is resumed in the first time of the new day as described previously.

The battle may be terminated by meeting any of three criteria. The first is at the end of 30 days of battle, the second is at the end of the number of days of battle specified by the user, and the third is when Blue or Red has completed all of its offensive missions.

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*If aircraft are scheduled to land at the end of the time step in which they are launched, the mission time is specified as zero time steps.

†Because START and STOP times of a mission can depend on prior battle results, it may happen that the STOP criterion is met before the START criterion. In such a case, the mission would never be performed.

5. SOC Examples

SOC was specifically designed to meet the identified requirements and specifications for a Naval strike OC. Much of the comment and analysis regarding its utility has been presented in previous sections. The SRI research team did go one step beyond this analysis however. It formulated two experimental problems which required interactive data changes. The hard copy computer printouts that support these additional experimental analyses are shown in Appendix D. The printouts show resulting SOC tables for certain example situations that investigate weather and strike tactics changes. These two experiments support the flexibility and utility that was so carefully designed into the SOC.

The first experimental problem involved weather changes. Exhibits D-1 through D-14 show the initial data setup. Specifically, Exhibit D-14 indicates the weather for the problem as being "GOOD" for the entire initial problem. Exhibits D-15 through D-18 show the resultant outputs. By interactively inserting "BAD" under day 2, and "GOOD" under day 3, one day of poor weather is injected into the problem. Exhibit D-19 shows these changes, and Exhibits D-20 to D-23 show the changed results. Again, the weather table was entered and changed at the terminal as in Exhibit D-24. This change forced "BAD" weather into the problem from day 2 on. The results from that change are shown in Exhibits D-25 to D-28.

In the Blue Mission Accomplishment Results for the three cases, scheduled good weather strikes (ALPHA F, Exhibit D-11) default to all weather strikes (ALPHA H) as the weather worsens. The corresponding Blue Battle Attrition results show an improving situation in increasing poorer weather. These two notes are indicative of the types of information that can be available to a TFC for outcome estimation and comparison, from which he may make decisions.

The second problem the research team examined involved potential tactical changes. During the above analysis, Blue losses were found to be excessive. As a result, it was decided to change the planned strike tactics. A hypothetical TFC was assumed to reason that the Red SLI were taking more attrition on the attack elements of the Blue strike units than should be allowed. To correct this situation, the TFC decides to implement his escort fighters as an "ESCORT" unit, detaching them from the ALPHA F unit. He plans for the ESCORT unit to engage the Red SLI defense before the ALPHA F arrival, thus decreasing the attrition on ALPHA F. To simulate this tactic requires a change in the following computer tables:

- BLUE FORCE UNITS (Contrast Exhibit D-29 to Exhibit D-2)
- ENGAGEMENT STATISTICS FOR (Contrast Exhibit D-30 to Exhibit D-4) BLUE ATTACKING RED
- BLUE OPERATIONS PLANS (Contrast Exhibit D-31 to Exhibit D-11).

Every other input remains the same as in the original problem. The results are shown in Exhibits D-32 to D-35.

IV OUTCOME CALCULATOR ANALYSIS AND SUMMARY

A. Outcome Calculator Appraisal by Test Subject

To obtain expert unbiased opinion on the role of an OC in the task force decision environment, as well as compare OC alternatives presented earlier in this report, a test subject, simulating a staff officer, was indoctrinated in the use of each OC package. Rear Admiral A. H. Clancy, USN retired, of Los Altos, California was selected as the test subject. The indoctrination included a description of each system, the capabilities, the types of inputs required, and the results generated. Also included was a description of the simulated task force decision environment in the ONRODA scenario. Emphasis was directed on the TFC's decision problems for the task force during the four days of the ONRODA strikes. This indoctrination process took eight hours.

After the indoctrination and a demonstration of the SOC, Admiral Clancy submitted a paper with comparisons and comments on the OC concept. These comments are included as Appendix E to this report. In brief, Admiral Clancy forecasts efforts in the Navy to reduce the size of staffs, with a subsequent requirement to replace that resource with automated procedures. He agreed that flexible automation is desired over inflexible methods, but that older backup methods should not be abandoned. The interactive ability to change data was judged a very important feature. Other points of sophistication, training, and compatibility were commented upon by the Admiral. In general, he appears to be in total agreement with the following conclusions and recommendations. The conclusions will serve to summarize the conducted research.

B. Conclusions

(1) The general decision types that confront a TFC with regard to Naval strike warfare are:

- Positioning of forces
- Use of assets
- Planned timing of assets.

(2) The factors that effect the general decision types are:

- Task force composition
- Aircraft complement and capability
- Weapons capability and delivery accuracy
- Force mobility and endurance
- Weather
- Enemy offensive/defensive capabilities and deployment.

(3) Any strike OC used in the Fleet should satisfy the following criteria:

- The OC must accept, as input, alternatives for each of the general air strike decision types and assumptions based on factors affecting those decisions.
- The OC must translate the broad level of detail used by the TFC into sets of values and parameters that are required for computing battle outcomes, and the OC must allow the use of experience and judgment.
- The computational algorithm within the OC must be as simple as possible, consistent with credible results, allowing an interested TFC to understand the number generating procedures.
- The OC must allow maximum flexibility and effective communication with the user by means of an interactive capability.

(4) The role of an OC is not diminished if a formal decision structure, such as a decision tree, is not utilized by a TFC. The need for an efficient method of outcome determination still exists for use in contingency planning.

(5) Of the OC candidates examined, the NWRC SOC appears most qualified in meeting the criteria of conclusion 3.

C. Recommendations

(1) Currently, the SOC is a thoroughly studied research concept, a first step towards implementing such a decision aid in the Fleet. It is recommended that command reactions be elicited and recorded with regard to the use of SOC as a decision aid, for the purpose of eventually redesigning the SOC to take into account identified Fleet use improvements.

(2) It is recommended that a rational and consistent set of algorithms and techniques be designed and implemented for use by a TFC in aggregating raw performance data into engagement statistics for the SOC.

V REFERENCES

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Appendix A

NAVAL AIR STRIKE BACKGROUND

Appendix A

NAVAL AIR STRIKE BACKGROUND

1. Objectives

NWP-10 (B), NAVAL WARFARE, lists seven objectives for the Attack Carrier Strike Force:

- Destroy enemy naval air and ground forces, enemy shipping and other transport, and enemy industrial potential.
- Neutralize shore-based air power during a specific period.
- Interdict communications and transportation over a broad area.
- Carry out reconnaissance in force or support photographic reconnaissance.
- Soften and isolate the amphibious objective area.
- Defend strategically deployed forces.
- Provide air cover for an amphibious operation, important sea movement, lines of communication, airborne invasion, etc.

2. Missions

Traditionally, naval air strike missions have been directed against the following:

- Enemy air power and facilities (AntiAirWarfare--AAW)
- Enemy naval forces and shipping (War at Sea Strike--WAS)
- Close air support and interdiction targets (CAS).

These missions are also the essential strike objectives in the NWP-10 (B) list if the general cover, defense, and reconnaissance missions are not considered strikes.

AntiWarWarfare (AAW) or Counterair Operations

An aspect of the AAW mission of tactical aviation is to destroy or neutralize enemy air operations. The AAW mission includes the elimination of enemy threats to friendly air operations by destroying enemy aircraft air bases, AAA and SAM defense sites, and supporting systems such as radars, control towers, etc. Tasks for the AAW mission include non-GCI (ground controlled intercept) fighter sweeps in search of enemy aircraft; raids on enemy air bases, defense sites, and supporting systems; suppression of air defenses by use of ECM; and fighter escort for other missions.

Naval Strikes (WAS)

Carrier aircraft are the Navy's principal weapon against sea targets. Examples of these targets include (a) surface action groups such as SSM guided-missile cruisers with destroyers or a Moskva or Kiev aircraft platform with its escorts and (b) single-ship targets such as surfaced submarines, destroyer pickets, or intelligence-gathering ships. Utilizing bombs, rockets, or tactical air-to-surface missiles (ASM), the tactical aircraft have the mission of either sinking the target ships or rendering them unable to continue operations.

Close Air Support and Interdiction (CAS)

CAS and interdiction missions are considered to be the same type of strike because they are usually deployed in small units in low air threat areas. These missions differ only in that CAS is accomplished in close proximity to friendly forces and requires directed fire. Interdiction operations include support of ground and air forces by attacking targets in depth, relative to front lines, principally to disrupt and impede the enemy logistic forces.

While close air support is focused totally on the requirement of the ground commander, interdiction takes place along lines of communication and lines of supply of the enemy. Interdiction is designed to destroy and interrupt the flow of material and personnel to the enemy battlefield, and, in that sense, it generally requires an aircraft of a greater range than the close air support aircraft (especially if operated from sea bases).

3. Planning

The first step in raid development and planning is considering the target/objective complex assigned by the task force commander. First, the type of attack mission, type of target (materiel, personnel, fixed structure, etc.), and weather will determine the nature of the ordnance selected. The extent of the target and the estimated effectiveness of the ordnance chosen will indicate the appropriate size of the strike raid. The target areas defenses, weather, and terrain factors will indicate the requirement for strike support aircraft in fighter escort, ECM, pathfinder, laser designator, or command/control functions. The raid size and the range to the target will determine the appropriate numbers of refueling aircraft.

Once a carrier is on station with a strike mission, a daily air plan is developed to describe the sequence of aircraft operations. The strike and strike support sorties, combat air patrol (CAP) sorties, airborne early warning (AEW) sorties, and, if subject to a submarine threat, ASW sorties must be provided in the air plan for the defense of the carrier force. The air plan commonly calls either for cyclic operations with designated times between launch and recovery, or for major strike operations. Allowing for the respotting of aircraft on the deck between launch and recovery cycles, the air plan must indicate the availability of ready aircraft and aircrews, the time required to refuel and rearm between sorties for an individual aircraft, and the fatigue factor imposed upon flight operations personnel by prolonged flight quarters on a regular basis.

Typical raids (see Table A-1) during normal cyclic operations involve 20 aircraft during each cycle. Of these 20 aircraft, 10 to 15 would usually be attack aircraft, which typically would fly division-size (four aircraft) missions. The remaining 5 to 10 aircraft would be operating

Table A-1

TYPICAL RAID COMPOSITION

Raid Purposes	Cyclic Operations	Major Strikes
Strike	6 A-7s 4 A-6s	12 A-6s and A-7s
Flak suppression		4 A-6s and F-4s
Rescue CAP	2 A-7s	2 A-7s
SAM suppression	1 A-6	4 A-6s
ECM	1 EA-6 or EKA-3	2 EA-6s or EKA-3s
MIGCAP (escort)	4 F-4s/F-14	6 F-4s/F-14
Refueling	1 KA-6D	2 KA-6Ds
Communication links	1 E-2A	1 E-2A

individually or in small groups while flying support missions such as AEW, CAP, photographic reconnaissance, refueling, and ECM. Small strike raids can be conducted during CV cyclic operations. Typical raids of this type from large-deck carriers during the Vietnam conflict were comprised of the units listed in the first column of Table A-1.

Appendix B

PROBLEM EXAMPLE FOR THE PENCIL, PAPER, PUB METHOD

Appendix B

PROBLEM EXAMPLE FOR THE PENCIL, PAPER, PUB METHOD

A pencil, paper, pub example is shown best by using excerpts from "TFC DECISION STRUCTURING PROCESS" SRI/MSC-4030 report.* Table B-1 shows the estimated military outcomes for a Blue air strike for three contingency actions in the ONRODA scenario: no enemy attacks, Orange attacks, and Red and Orange attack. Four enemy postures were selected within each contingency: N--no action, R--reinforced force, T--threatening forces, and RT--reinforced and threatening. The category of outcomes were Blue aircraft losses during attack, Blue aircraft losses during defense, Blue ship losses during defense, and potential Orange sorties to Grey. The actual numbers that appear in Table B-1 under aircraft losses and ship losses show a conversion into A-7 aircraft equivalents and DLG ship equivalents in accordance with Table B-2. In this case, the equivalent numbers in Table B-2 are fictitious, but they represent the cost effective value of the weapon system to the TFC.

The computations for the losses and sortie potential of Table B-1 are shown in Table B-3. Table B-3 is divided into three sections. The first section presents basic data for Blue and Orange aircraft, which are used in the computations. These data are aircraft number, sortie rates, effectiveness, and attrition data. The second section presents the results of a normal four-day strike action by Blue aircraft. The third section presents the derivation of the numbers used in Table B-1; i.e., Cases I, II, and III each divided into four different ORANGE postures.

*Reference 3 in the body of this report.

Table B-1

MILITARY OUTCOMES FOR BLUE AIRSTRIKE*

Orange Posture	Orange Preemptive Action†	Blue Aircraft Losses, Attack	Blue Aircraft Losses, Defense	Blue Ship Losses, Defense	Potential Orange Sorties To Grey
Case I--No Enemy Attacks					
1	N	21.8	0	0	3750
2	R	45.8	0	0	6200
3	RT	45.8	0	0	6200
4	T	21.8	0	0	3750
Case II--Orange Attacks Blue Task Force					
1	N	21.8	18	2.75	3750
2	R	45.8	18	2.75	6200
3	RT	45.8	18	2.75	6200
4	T	21.8	18	2.75	3750
Case III--Red and Orange Attack Blue Task Force					
1	N	21.8	18	5.5	3750
2	R	45.8	18	5.5	6200
3	RT	45.8	18	5.5	6200
4	T	21.8	18	5.5	3750

*From Table 2.9 pp. 34
SRI Report MSC 4030
"TFC Decision Structuring"

†N--no action
R--reinforce
T--threaten
RT--reinforce and threaten.

Table B-2

SHIP VALUES AND AIRCRAFT VALUES IN A-7 AIRCRAFT EQUIVALENTS AND DLG SHIP EQUIVALENTS

Ship	Number of Ship (DLG) Equivalents	Aircraft	Number of Aircraft (A-7) Equivalents
DLG	1.0	A-7	1.0
DDG	1.5	F-14	6.0
CG	2.5	A-6	3.0
CLG	2	E-2C	10.0
CV	25	RA-5C	4.0
DE	.5	EA-6	4.0
DD	.7		

Table B-3

COMPUTATIONS FOR MILITARY OUTCOMES--ONRODA SCENARIO

Basic Data for Blue and Orange Forces

Blue Forces

Aircraft	Number on 2CVs	Sortie Rate
F-14	48	1.25
A-7	48	1.1
A-6	24	1.0

Effectiveness/Attrition

Air-to-air exchange ratio (ER) $\left\{ \frac{\text{MIG 21}}{\text{F-14}} = 4/1 \quad \frac{\text{Others}}{\text{F-14}} = 50/1 \right.$

Blue missiles required/kill = 4 (missiles per Blue aircraft, 6)

A7 kill rate = 0.5/sortie

Attrition rates:

		Aircraft Lost per Sortie
Attack planes, attacking airfield . . .	good weather	0.0015
	bad weather	0.005
Fighter escort, enroute		0.003
CAP or SUCAP over TF.		0.0002

Blue Strike Plan

Composition of 1 Strike	Schedule of Strikes	
18 A7	1st day	4
6 A6	2nd day	2
12 F14	3rd day	2
	4th day	2
	Total	10

Total Sorties in 4 Days

	Strike	Cap	Sam Suppress	Night Heckler
F-14	120	120		
A-7	180			
A-6			60	32

Orange Forces on ONRODA

Aircraft	Normal	Reinforce	Sortie Rate
MIG 21	48	96	1.2
SU-7	72	72	1.2
Bombers	24	24	1.0
Total	144	192	
Sorties/Day	168	226	
Sortie Potential, 90 days	15,100	20,400	

Table B-3 (Continued)

Computation of Losses (Normal Four Day Strike Action by Blue)

	Air to Air	Air to Surface
First Day		
Aircraft	48 Blue F-14 sorties	72 A7 sorties
Effectiveness	$\frac{48 \times 4 \text{ missiles shot}}{4 \text{ missiles/kill}} = 48$ kills	Target occurrence = 50% Kills = $\frac{72 \text{ sorties} \times 50\%}{2 \text{ sorties/kill}} = 18$
Attrition	Assume ER = $\frac{20}{1}$ Blue losses = $\frac{48}{20} = 2.4$	(See misc)
Second Day		
Aircraft	16 Blue F-14 sorties	36 A7 sorties
Effectiveness	$\frac{16 \times 2 \text{ missiles shot}}{4} = 8$ kills	Target occurrence = 40% Kills = $\frac{36}{2} \times 0.4 = 7.2$
Attrition	ER = $\frac{40}{1}$ Blue loss = $\frac{8}{40} = 0.2$	
Third Day		
Aircraft	16 Blue F-14 sorties	36 A7 sorties
Effectiveness	$\frac{16 \times 2 \text{ missiles shot}}{4} = 8$ kills	Target occurrence = 30% Kills = $\frac{36}{2} \times 0.3 = 5.4$
Attrition	ER = $\frac{40}{1}$ Blue loss = $\frac{8}{40} = 0.2$	
Fourth Day		
Aircraft	16 Blue F-14 sorties	36 A7 sorties
Effectiveness	$\frac{16 \times 2 \text{ missiles shot}}{4} = 8$ kills	Target occurrence = 20% Kills = $\frac{36}{2} \times 0.2 = 3.6$
Attrition	ER = $\frac{40}{1}$ Blue loss = $\frac{8}{40} = 0.2$	
Misc		
	Blue Fighter escort losses 120 sorties × 0.003 = 0.36 Blue CAP losses 120 sorties × 0.0002 = 0.024	Attack losses (4 days) 272 good weather sorties × 0.0015 = .41 272 bad weather sorties × 0.005 = 1.36 Assume 40% chance of bad weather Losses = 0.4(1.36) + 0.6(.41) = 0.8
Totals		
Kills	72	34.2
Losses (Blue VF)	3.4	0.8

Table B-3 (Continued)

CASE I NO ENEMY ATTACKS

1. N = No Orange Action

Results are the same as the Normal Four Day Strike Action:

Blue Aircraft	Losses	Equivalent Factor	A-7 Equivalents
F-14	3.4	6	20.4
A-7	0.5	1	0.5
A-6	0.3	3	0.9
Total			21.8

Blue Aircraft Losses, Defense = 0
Blue Ship Losses = 0
Orange Sortie Potential

74% aircraft lost
26% remain

0.26 x 120 x 1.2 = 37.4 (MIGS & SU-7)
0.26 x 24 x 1.0 = 6.2 (Bombers)

Sorties/day = 43.6

For 86 days = 3750 sorties

2. Orange Reinforced

96 MIG 21
96 Others

192

	Air to Air	Air to Surface
First Day		
Aircraft	48 Blue F-14 sorties	72 A7 sorties
Effectiveness	$\frac{48 \times 5 \text{ missiles shot}}{4 \text{ missiles/kill}} = 60$ kills	Target occurrence = 50% Kills = $\frac{72}{2} \times 0.5 = 18$
Attrition	ER = 1/13 Blue loss = $\frac{60}{13} = 4.6$	(Same as Normal Strike)
Other 3 Days (Each)		
Aircraft	16 Blue F-14 sorties	36 A7 sorties
Effectiveness	$\frac{16 \times 3 \text{ missiles shot}}{4} = 12$ kills	(Same as Normal Strike)
Attrition	ER = 1/13 Blue loss = $\frac{12}{13} = 0.925$	
Totals		
Kills	96	34.2
Losses	7.4	0.8

Blue Losses in Aircraft Equivalents

7.4 x 6 = 44.4
0.5 x 1 = 0.5
0.3 x 3 = 0.9

45.8

Table B-3 (Continued)

Computation of Losses (Normal Four Day Strike Action by Blue)

	Air to Air	Air to Surface
First Day		
Aircraft	48 Blue F-14 sorties	72 A7 sorties
Effectiveness	$\frac{48 \times 4 \text{ missiles shot}}{4 \text{ missiles/kill}} = 48$ kills	Target occurrence = 50% Kills = $\frac{72 \text{ sorties} \times 50\%}{2 \text{ sorties/kill}} = 18$
Attrition	Assume ER = $\frac{20}{1}$ Blue losses = $\frac{48}{20} = 2.4$	(See misc)
Second Day		
Aircraft	16 Blue F-14 sorties	36 A7 sorties
Effectiveness	$\frac{16 \times 2 \text{ missiles shot}}{4} = 8$ kills	Target occurrence = 40% Kills = $\frac{36}{2} \times 0.4 = 7.2$
Attrition	ER = $\frac{40}{1}$ Blue loss = $\frac{8}{40} = 0.2$	
Third Day		
Aircraft	16 Blue F-14 sorties	36 A7 sorties
Effectiveness	$\frac{16 \times 2 \text{ missiles shot}}{4} = 8$ kills	Target occurrence = 30% Kills = $\frac{36}{2} \times 0.3 = 5.4$
Attrition	ER = $\frac{40}{1}$ Blue loss = $\frac{8}{40} = 0.2$	
Fourth Day		
Aircraft	16 Blue F-14 sorties	36 A7 sorties
Effectiveness	$\frac{16 \times 2 \text{ missiles shot}}{4} = 8$ kills	Target occurrence = 20% Kills = $\frac{36}{2} \times 0.2 = 3.6$
Attrition	ER = $\frac{40}{1}$ Blue loss = $\frac{8}{40} = 0.2$	
Misc		
	Blue Fighter escort losses 120 sorties x 0.003 = 0.36 Blue CAP losses 120 sorties x 0.0002 = 0.024	Attack losses (4 days) 272 good weather sorties x 0.0015 = .41 272 bad weather sorties x 0.005 = 1.36 Assume 40% chance of bad weather Losses = 0.4(1.36) + 0.6(.41) = 0.8
Totals		
Kills	72	34.2
Losses (Blue VF)	3.4	0.8

Table B-3 (Continued)

2. Orange Reinforced (continued)

Blue Defense Losses

Blue aircraft = 0
Blue ships = 0

Orange Losses		Orange Sorties
Blue attack =	34.2	32% remain
Blue VF =	96	0.32 x 168 x 1.2 = 64.5
	130.2	0.32 x 24 x 1.0 = 7.7
		Sorties/day = 72.2
		x 86 days = 6200

3. Orange Reinforces and Threatens

96 MIG 21 }
96 Others } 192 aircraft

(Same as 2, above)

4. Orange Basic Force and Threatens

(Sane as 1, above)

CASE II BLUE AIRSTRIKE ORANGE ATTACKS BLUE TASK FORCE

1 & 4 Basic Orange Force

No action or threatens

48 MIG 21 }
96 Others } 144 aircraft

Blue aircraft losses, attack	(Same as Case I 1.)	= 21.8
Orange Sortie Potential	(Same as Case I 1.)	= 3750
Orange Attacks Blue Task Force		

Orange Force	Blue Damage	Blue Ship Losses Defense
6 KOMAR Boats	0.1 damage CG	0.1 x 2.5 = .25
12 BADGER A's	0.1 damage CV	0.1 x 25 = 2.5
12 MIG 21	3 F-14's	2.75

Orange Losses		Blue A/C Losses Defense
10 F-14's engage and kill	10 BADGERS 12 MIG 21	3 x 6 = 18

2 & 3 Orange Reenforced

Reinforce or reinforce and threaten

96 MIG 21 }
96 Others } 192 aircraft

Blue aircraft losses, attack	(Same as Case I 2.)	= 36.2
Orange sortie potential	(Same as Case I 2.)	= 6200
Orange attacks Blue Task Force	(Same as Case II 1 & 4)	Blue Ship Losses Defense 2.75 Blue A/C Losses Defense 18

Table B-3 (Concluded)

CASE III RED AND ORANGE ATTACK BLUE TASK FORCE

1 through 4 Postures

Blue aircraft losses, attack Blue aircraft losses, defense Orange sortie potential	Same as CASE II

The difference in the Blue ship losses is due to Red ship SSM attacks, which damage more Blue ships. This threat does not affect Blue strike or Orange sortie potential.

Red SSM attack on Blue Task Force

0.1 damage on CG
0.1 damage on CV

Total damage on Blue ships increased to	Blue ship losses defense
0.2 damage on CG	0.2 x 2.5 = 0.5
0.2 damage on CV	0.2 x 25 = 5.0
	5.5

Appendix C

OFF-THE-SHELF COMBAT SIMULATION DESCRIPTIONS

Appendix C

OFF-THE-SHELF COMBAT SIMULATION DESCRIPTIONS

This appendix presents brief descriptions of candidate off-the-shelf computer simulation models, which were examined to see if they could perform the OC function. The material is either taken directly from or condensed from the noted reference.

1. C-BASE II

C-BASE II (Reference 7)* is a computer model of attack carrier operations against an enemy land-based air arm and target complex. The model was designed for investigations of the relative effectiveness of different mixes for the carriers' complement of combat aircraft. The mixed complement may be comprised of aircraft of one or more models in the mission categories, attack and fighter. (Fighter includes multipurpose aircraft also designed for ground support missions.) In the model, the aircraft may serve as CAP (combat air patrol), DLI (deck-launched interceptor), escort fighter or attack aircraft.

The model operations span only the several opening days of the engagement before either side can replace lost aircraft. Operations may begin with an air superiority phase and to this end, all or most of the carrier strikes may be initially directed against parked enemy aircraft. If air superiority is attained by the task force, operations may then be shifted to a second phase with increased allocation of strikes to close air support and interdiction. The enemy defends itself with fighter aircraft, SAM, and antiaircraft artillery. The carrier base, when attacked by enemy aircraft, is defended by the CAP's, DLI's, and supporting missile ships. Both sides suffer losses of aircraft, and damage to

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*References are listed numerically in Section V of the body of this report.

AD-A039 917 STANFORD RESEARCH INST MENLO PARK CALIF NAVAL WARFAR--ETC F/G 5/1
AUGMENTATION OF THE NAVAL TASK FORCE DECISION AIDING SYSTEM: TH--ETC(U)
APR 77 J V ROWNEY, R S GARNERO, J C BOBICK N00014-75-C-0742

UNCLASSIFIED NWRC-TR-14 NL

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6-77

carriers may compel a temporary suspension of flight activity or an early withdrawal of the task force. During both operation phases, as conditions warrant, carrier aircraft are allowed to change roles from a CAP or a DLI to an escort fighter or, if a multipurpose type, even to an attack role.

Inputs to the model may be broadly classified in the following areas: (1) enemy threat characteristics, (2) carrier survivability and supporting missile ship capability, and (3) carrier aircraft characteristics. The model outputs are running cumulative results after each carrier strike and enemy raid, in chronological order. The outputs include such items as number of sorties to weapon release, number and type of aircraft lost, and status of the carriers.

2. CFOAM

The Tactical Operations Module (Reference 12) functions as a simulation of tactical aircraft and missile operations (both offensive and defensive), Strike Warfare, ASM, and SSM operations. Both sides have equal offensive and defensive capabilities and wide discretion is allowed for the detail of the opposing forces for evaluation of equipment performance and doctrine change effects upon engagement outcomes.

The model is programmed in PL/1 for use in an IBM 360 compatible system of 500k or more working core.

Extensive employment of ECM, ASMs, and SSMs may be carried out during offensive phases. Defensive capabilities include jamming of guided missiles, surface-to-air missiles, gunnery, and interceptors. Airborne and surface early warning and aircraft control facilities are also provided. Features have also been incorporated to represent command and control saturation because of an excessive sum of both friendly and enemy units and actions, as well for providing means of avoiding irrationally aggressive or wasteful action on the part of either offensive or defensive forces.

Provisions are made for target repair and weapon replenishment and their resultant effects so that an extended period of action can be simulated.

Supporting software is specially designed to allow the execution of offensive and defensive action for an arbitrary length of time and freezing the action at a point so that the condition of both sides may then be investigated and changes made in doctrine and offensive and defensive deployments. The simulation may then be continued for another arbitrary time period. On-line printout of any and all data available is provided at desired time intervals during execution.

3. TACAV III

The TACAV III model (Reference 8) has been developed as an analytical tool to assist Navy planners in measuring operational effectiveness of tactical aircraft performing as a carrier air wing. It is a FORTRAN IV expected-value model that simulates an up-to-60-day war between a carrier task force composed of 1 to 6 carriers plus escort ships, against a land-based enemy.

The simulation starts with the task force located approximately 200 miles off the enemy shore. The enemy may launch an air strike against the ships of the task force, or the carrier aircraft may launch the first strike. The order in which the enemy and friendly attacks occur throughout the war are controlled by input. The simulation continues until one side wins (by killing all of the targets) or when the number of days for the simulation to continue is reached.

During a campaign, attacks are made against enemy targets in three weather conditions: visual, nonvisual, and marginal. A different aircraft assignment and tactic may be employed for each of the weather conditions. The effectiveness of alternative airwing compositions may be determined in terms of enemy targets killed, combat attrition, residual forces remaining at the end of the campaign and days to gain air superiority. Costs, which are applied externally from the model, can be introduced to determine the most cost-effective alternative. The model has a wide range of applications in the areas of weapon system planning, programming and budgeting, concept formulation, project management, development of carrier, aircraft and ordnance specifications, operations, tactics and force-level planning, and comparative cost-effectiveness studies.

Special input programs are available that use prototype offensive and defensive units so that large, complex aggregations of opposing forces can be increased with a minimum of effort.

4. ATACM

ATACM (Reference 11) is a computer model designed and built for the Arms Control and Disarmament Agency for use in analyzing the impact of various force mixes upon a tactical airwar in Europe between NATO and Warsaw Pact forces. ATACM models an air campaign as a zero-sum staged game and employs dynamic programming to solve this game for approximate, optimal MAXMIN/MINMAX aircraft allocation strategies for the opposing sides at each stage of the campaign. The model permits multiple aircraft types with user-assigned missions, numerical and fractional reinforcements as a function of stage, and user selection of the objective function used to generate the optimal strategies.

5. AIRCAM

The Air Campaign Model (AIRCAM) (Reference 10) is designed to simulate the flight-by-flight penetration of a defended environment and to provide visibility to the factors affecting this penetration. The model allows simulation of surface-to-air defense disposition and type, air-to-air combat between fighter escorts and enemy interceptors, and standoff capability of the prime strike weapon. There is an option for a "prior defense suppression" campaign to kill SAM sites before committing strike weapons. The expected-value model is coded in FORTRAN IV and is designed for use on the DIALCOM time-sharing system.

Appendix D

COMPUTER OUTPUT FOR NWRC SOC EXPERIMENTS

Appendix D

COMPUTER OUTPUT FOR NWRC SOC EXPERIMENTS

Exhibit D-1

BLUE FORCE ELEMENTS

ELEMENT	EXAMPLE	CLASS
ATTACK	A-7E	OA
AW-ATTACK	A-6E	OA
VF LO	F-4J	DA
VF HI	F-14A	DA
CV	KITTY HAWK	OS
SUPPORT SHIP	DLG LEAHY	DS

RED FORCE ELEMENTS

ELEMENT	EXAMPLE	CLASS
BOMBER-LO	BADGER A	OA
BOMBER-HI		OA
VBF	SU-7B	DA
VFI	MIG-21	DA
SSM-SHIP	SS-N-3	OS
AIRBASE	UNRODA	OS
SAM SITE	SAM-3	DS
SUPPLY LINE	AAA	LS

OA-OFFENSIVE AIR
DA DEFFENSIVE AIR
OS-OFFENSIVE SURFACE
DS-DEFENSIVE SURFACE
LS-LOGISTICS SUPPORT

Exhibit D-2

BLUE FORCE UNITS

B FRC UNIT		ELEMENTS PER UNIT					UNIT CHARACTERISTICS					
TYPE	SUB	VA	AW	VF LO	VF HI	SUP A/C	MAX RANGE	RANGE DEF SUB	WORST WX	WX DEF SUB	MAX DET (NM)	SPEED (MACH)
ALPHA	D	4			2	1	LONG		GOOD	H	100	.9
ALPHA	F	3			3	1	LONG		GOOD	H	100	.9
ALPHA	F	3			2	1	LONG		GOOD	H	100	.9
ALPHA	G	3			1	1	LONG		GOOD	H	100	.9
ALPHA	H		2		1		LONG		BAD		100	.9
WAS	A	1					LONG		GOOD	D	100	.9
WAS	B	1				1	LONG		GOOD	D	100	.9
WAS	C	4			2	1	LONG		GOOD	D	100	.9
WAS	D		2				LONG		BAD		100	.9
CAS	A	4		1		1	LONG		GOOD	C	100	.9
CAS	B	4				1	LONG		GOOD	C	100	.9
CAS	C		2				LONG		BAD		100	.9
SUCAP		1	1				LONG		BAD		100	.9
VFCAP					1		LONG		BAD		100	2.2
DLI				1			LONG		BAD		100	2.2

Exhibit D-3

RED FORCE UNITS

R FRC UNIT		ELEMENTS PER UNIT					UNIT CHARACTERISTICS					
TYPE	SUB	VA LO	VA HI	VBF	VFI	SSM SHP	MAX RANGE	RANGE DEF SUB	WORST WX	WX DEF SUB	MAX DET (NM)	SPEED (MACH)
FREE	A	4		4			LONG		GOOD	B	300	.9
FREE	B	4					LONG		BAD		300	.9
VBF	A			8			LONG		GOOD		300	.9
SSM						1	LONG		BAD		200	.9
SLI					1		SHORT					1.5

Exhibit D-4

ENGAGEMENT STATISTICS FOR BLUE ATTACKING RED

BLUE FORCE UNIT		BLUE UNITS LOST PER RED DEF ELEMENT				MAX RED AIR LOST PER BLUE UNIT		RED SURFACE ELEMENTS LOST PER BLUE UNIT				
TYPE	SUB	VBF	VFI	SAM	SPLY LINE	VBF	VFI	PKED A/C	SSM SHIP	AIR BASE	SAM	SPLY LINE
ALPHA	D	.11	.11	.067		13	11.3	2.8			1.1	
ALPHA	E	.08	.10	.052		16	14.7	2.1			1.1	
ALPHA	F	.12	.13	.052		12	10.7	2.1			1.1	
ALPHA	G	.16	.17	.052		8	6.7	3.0		.06	1.1	
ALPHA	H	.11	.12	.004		2	2	.8			0	
WAS	A	1.0	1.0	.003		1	.67		.6		0	
WAS	B	.5	.5	.006		2	1.3		.6		1.1	
WAS	C	.11	.11	.015		13	11.3		2.0		1.1	
WAS	D	.25	.25	.002		0	0		.4		0	
CAS	A	.16	.17	.023	.014	6	4.3				1.1	.41
CAS	B	.20	.20	.023	.014	5	3.4				1.1	.36
CAS	C	.25	.25	.002	.002	0	0				0	.22
SUCAP		.5	.5	.006		2	1.3		.6			

Exhibit D-5

ENGAGEMENT STATISTICS FOR RED ATTACKING BLUE

RED FORCE UNIT		RED UNITS LOST PER BLUE DEF ELEMENT				MAX BLUE AIR LOST PER RED UNIT		BLUE SURFACE ELEMENTS LOST PER RED UNIT		
TYPE	SUB	VF LO	VF HI	CV	SUP SHIP	VF LO	VF HI	PARKED A/C	CV	SUPPORT SHIPS
FREE	A	.22	.5		.37	4	1		.2	.5
FREE	B	.62	1		.75					.5
VBF	A	.12	.5	.12	.37	8	2	2		.2
SSM		.19	.37	.19	.28				.2	

Exhibit D-6

WEAPON PLATFORM AVAILABILITY

FORCE ELEMENT	NORMAL SR	SURGE SR	R/R TIME
BLUE			
VA	1	2	1
AW	1	2	1
VF LO	1	2	1
VF HI	1	2	1
RED			
VA LO	1	1.5	1
VA HI	1	2	1
VBF	1	2	1
VFI	1	2	1
SSMSHIP	1	2	4

Exhibit D-7

CAPABILITIES OF A/C RELATED ELEMENTS

DAMAGE LEVEL	MAX OPERATIONS PER PERIOD		MAX DMGE REPAIR PER PERIOD	
	BLUE CV	RED AIRBASE	BLUE CV	RED AIRBASE
0.0	250	300	0	0
.1	225	260	.07	.07
.2	200	230	.12	.12
.3	125	200	.15	.15
.4	100	175	.16	.16
.5	75	150	.15	.15
.6	24	24	.12	.12
.7	24	24	.07	.07
.8	0	0	0	0
.9	0	0	0	0
1.0	0	0	0	0

Exhibit D-8

BLUE FORCE COMPLEXES

BLUE COMPLEX	ELEMENTS: VA	AW	VF LO	VF HI	CV	SUP SHIPS	CHARACTERISTICS: DLI LNCH TIME (MIN)	SURV RANGE FACT	FRACT A/C SHELT	CYCL TIME DAYS	REPL TIME DAYS	REPL OPS
CTFRC	48	24	0	48	2	12	.5	1	.3	4	1	50

Exhibit D-9

RED FORCE COMPLEXES

RED COMPLEX	ELEMENTS								CHARACTERISTICS					
	VA LO	VA HI	VBF	VFI	SSM SHP	AIR BSE	SAM STE	SLY LNE	DLI LNCH TIME (MIN)	SURV RANGE FACT	FRACT A/C SHELT	CYCL TIME DAYS	REPL TIME DAYS	REPL OPS
AIRFD	48	0	72	96		2	18	0	.5	1	0	0	0	
REDCA					1					1	0	4	1	

Exhibit D-10

```
                          MISCELLANEOUS INPUTS
*************************************************************************
*MAXIMUM NUMBER OF DAYS THE BATTLE IS TO RUN(LESS THAN 31)        *   10*
*MISSION TIME FOR LONG  RANGE MISSIONS(NO. OF 3HR TIME STEPS)     *    0*
*MISSION TIME FOR SHORT RANGE MISSIONS(NO. OF 3HR TIME STEPS)     *    0*
*NO. OF OPERATIONS PER AIRCRAFT LANDING                           *    2*
*NO. OF OPERATIONS PER AIRCRAFT LAUNCH                            *    1*
*FRACTION OF MAX UNIT DETECTION RANGE REALIZED IN BAD WEATHER     *   .5*
*DELAY IN MINUTES BEFORE FIRST SLI/DLI CAN BE LAUNCHED            *    3*
*DO YOU WANT LONG RANGE FORCE UNIT DEFAULT IN EFFECT(1=YES 0=NO )*    1*
*DO YOU WANT BAD WEATHER FORCE UNIT DEFAULT IN EFFECT(1=YES 0=NO)*    1*
*************************************************************************
```

Exhibit D-11

BLUE OPERATIONS PLANS

MISSION	P	ORIGIN COMPLX	TARGET COMPLX	START	STOP	MISSION TIMES	UNIT TYPE	SUB	DES UNT	MIN UNT	RDY UNT
STRK1	2	CTFRC	AIRFD	DAY 1	DAY 1	1234	ALPHA	F	6	4	
STRK2	2	CTFRC	AIRFD	DAY 1	DOA 75	6	ALPHA	H	2	1	
STRK3	2	CTFRC	AIRFD	DAY 2	DDA 75	13	ALPHA	F	6	4	
CLEAN	2	CTFRC	AIRFD	DDA 50	DOA 75	13	ALPHA	G	6	4	
CAP1	1	CTFRC		DAY 1	ENDSTRK3	12345678	VFCAP		3	1	0
CAP2	1	CTFRC		ENDSTRK3	FNDCLEAN	12345678	VFCAP		1	1	0
SUCAP	0	CTFRC	REDCA	DAY 1	DOS 100	1234	SUCAP		1	1	1

Exhibit D-12

RED OPERATIONS PLANS

MISSION	P	ORIGIN COMPLX	TARGET COMPLX	START	STOP	MISSION TIMES	UNIT TYPE	UNIT SUB	DES UNT	MIN UNT	RDY UNT
VBFHT	1	AIRFD	CTFRC	DAY 2	DOA 50	23	VBF	A	2	1	
FREE	2	AIRFD	CTFRC	DAY 1	DOA 50	23	FREE	A	3	2	
SLI1	1	AIRFD		DAY 1		12345678	SLI		16	1	
SSMHT	0	HEDCA	CTFRC	DAY 2	DOA 50	23	SSM		2	1	

Exhibit D-13

```
******************************************************
***BLUE*                                             *
*  *   *           RELATIVE COMPLEX POSITIONS        *
*   *  *                                             *
*    * ***********************************************
*RED  **CTFRC *     *     *     *     *     *     *  *
******************************************************
*AIRFD *LONG  *     *     *     *     *     *     *  *
*REDCA *SHORT *     *     *     *     *     *     *  *
*      *      *     *     *     *     *     *     *  *
*      *      *     *     *     *     *     *     *  *
*      *      *     *     *     *     *     *     *  *
*      *      *     *     *     *     *     *     *  *
*      *      *     *     *     *     *     *     *  *
*      *      *     *     *     *     *     *     *  *
*      *      *     *     *     *     *     *     *  *
******************************************************
```

Exhibit D-14

INITIATING WX DAYS

```
*******************************************************
*DAY*    1*    *    *    *    *    *    *    *    *
*WX *GOOD *    *    *    *    *    *    *    *    *
*******************************************************
```

Exhibit D-15

```
              BLUE MISSION ACCOMPLISHMENT RESULTS
*****************************************************************
*       * *ORIGIN*TARGET*         *          *MISSION *   UNIT   *DES*UNT*UNT*
*MISSION*P*COMPLX*COMPLX* START   *   STOP   * TIMES  * TYPE SUB*UNT*REQ*ENG*
*****************************************************************
**STRK1**2*CTFRC *AIRFD *DAY     1*DAY     1*      1234*ALPHA*F  *  6* 24* 18*
**STRK2**2*CTFRC *AIRFD *DAY     1*DAY     2*         6*ALPHA*H  *  2*  4*  2*
**STRK3**2*CTFRC *AIRFD *DAY     2*DAY     2*        13*ALPHA*F  *  6* 12*  6*
**CLEAN**2*CTFRC *AIRFD *DAY     2*DAY     2*        13*ALPHA*G  *  6* 12*  6*
**CAP1 **1*CTFRC *       *DAY    1*DAY     2*12345678*VFCAP*     *  3* 48* 46*
**CAP2 **1*CTFRC *       *DAY    3*DAY     2*12345678*VFCAP*     *  1*  0*  0*
**SUCAP**0*CTFRC *REDCA *DAY     1*DOS   100*      1234*SUCAP*     *  1*  0*  0*
*****************************************************************
```

Exhibit D-16

```
              RED MISSION ACCOMPLISHMENT RESULTS
*****************************************************************
*       * *ORIGIN*TARGET*         *          *MISSION *   UNIT   *DES*UNT*UNT*
*MISSION*P*COMPLX*COMPLX* START   *   STOP   * TIMES  * TYPE SUB*UNT*REQ*ENG*
*****************************************************************
**VBFHT**1*AIRFD *CTFRC *DAY     2*DAY     2*        23*VBF   *A  *  2*  4*  2*
**FREE **2*AIRFD *CTFRC *DAY     1*DAY     2*        23*FREE  *A  *  3* 12*  9*
**SLI1 **1*AIRFD *       *DAY    1*          *12345678*SLI   *   * 16*256*153*
**SSMHT**0*REDCA *CTFRC *DAY     2*DAY     2*        23*SSM   *   *  2*  0*  0*
*****************************************************************
```

Exhibit D-17

BLUE COMPLEX BATTLE ATTRITION RESULTS

BLUE COMPLEX	VA	AW	VF LO	VF HI	CV	SUPSHIP
	ELEMENTS ATTRITED / TOTAL ELEMENTS AT COMPLEX					
CTFRC	35.	15.	0.	31.	0.0	0.0
	46.	24.	0.	48.	2.0	12.0

Exhibit D-18

RED COMPLEX BATTLE ATTRITION RESULTS

RED COMPLEX	VA LO	VA HI	VBF	VFI	SSMSHIP	AIRBASE	SAM	SUPLINE
	ELEMENTS ATTRITED / TOTAL ELEMENTS AT COMPLEX							
AIRFD	45.	0.	67.	87.	0.0	0.0	18.0	0.0
	46.	0.	72.	96.	-0.0	2.0	18.0	0.0
REDCA	0.	0.	0.	0.	0.0	0.0	0.0	0.0
	-0.	-0.	-0.	-0.	1.0	-0.0	-0.0	-0.0

Exhibit D-19

INITIATING WX DAYS

```
*************************************************************
*DAY*    1*     2*     3*     *     *     *     *     *     *     *
*WX  *GOOD *BAD   *GOOD *     *     *     *     *     *     *     *
*************************************************************
```

Exhibit D-20

BLUE MISSION ACCOMPLISHMENT RESULTS

```
**********************************************************************
*        * *ORIGIN*TARGET*        *           *MISSION *    UNIT   *DES*UNT*UNT*
*MISSION*P*COMPLX*COMPLX* START   *   STOP    * TIMES  *  TYPE SUB*UNT*REQ*ENG*
**********************************************************************
**STRK1**2*CTFRC *AIRFD *DAY     1*DAY      1*     1234*ALPHA*F  *  6* 24* 18*
**STRK2**2*CTFRC *AIRFD *DAY     1*DAY      2*        6*ALPHA*H  *  2*  4*  2*
**STRK3**2*CTFRC *AIRFD *DAY     2*DAY      3*       13*ALPHA*F  *  6* 12*  6*
**       ** *      *      *       *          *          *    *H  *  6* 12*  6*
**CLEAN**2*CTFRC *AIRFD *DAY     2*DAY      2*       13*ALPHA*G  *  6*  0*  0*
**       ** *      *      *       *          *          *    *H  *  6* 12*  6*
**CAP1  **1*CTFRC *      *DAY     1*DAY      3*12345678*VFCAP*   *  3* 72* 72*
**CAP2  **1*CTFRC *      *DAY     4*DAY      2*12345678*VFCAP*   *  1*  0*  0*
**SUCAP**0*CTFRC *REDCA *DAY     1*DOS    100*     1234*SUCAP*   *  1*  0*  0*
**********************************************************************
```

Exhibit D-21

RED MISSION ACCOMPLISHMENT RESULTS

MISSION	P	ORIGIN COMPLX	TARGET COMPLX	START	STOP	MISSION TIMES	UNIT TYPE	SUB	DES UNT	UNT RFQ	UNT ENG
VBFHT	1	AIRFD	CTFRC	DAY 2	DAY 3	23	VBF	A	2	4	3
FREE	2	AIRFD	CTFRC	DAY 1	DAY 3	23	FREE	A	3	12	6
								B	3	6	3
SLI1	1	AIRFD		DAY 1		12345678	SLI		16	384	221
SSMHT	0	HELCA	CTFRC	DAY 2	DAY 3	23	SSM		2	0	0

Exhibit D-22

BLUE COMPLEX BATTLE ATTRITION RESULTS

BLUE COMPLEX	ELEMENTS ATTRITED / TOTAL ELEMENTS AT COMPLEX					
	VA	AW	VF LO	VF HI	CV	SUPSHIP
CTFRC	26.	14.	0.	32.	0.0	0.0
	48.	24.	0.	48.	2.0	12.0

Exhibit D-23

RED COMPLEX BATTLE ATTRITION RESULTS

ELEMENTS ATTRITED / TOTAL ELEMENTS AT COMPLEX

RED COMPLEX	VA LO	VA HI	VBF	VFI	SSMSHIP	AIRBASE	SAM	SUPLINE
AIRFD	43.	0.	65.	80.	0.0	0.0	16.2	0.0
	48.	0.	72.	96.	-0.0	2.0	18.0	0.0
REDCA	0.	0.	0.	0.	0.0	0.0	0.0	0.0
	-0.	-0.	-0.	-0.	1.0	-0.0	-0.0	-0.0

Exhibit D-24

INITIATING WX DAYS

DAY	1	2								
WX	GOOD	BAD								

Exhibit D-25

```
                 BLUE MISSION ACCOMPLISHMENT RESULTS
*************************************************************************
*        * *ORIGIN*TARGET*          *          *MISSION *   UNIT   *DES*UNT*UNT*
*MISSION*P*COMPLX*COMPLX* START    *   STOP   * TIMES   * TYPE SUB*UNT*REQ*ENG*
*************************************************************************
**STRK1**2*CTFRC *AIRFD *DAY     1*DAY      1*      1234*ALPHA*F  *  6* 24* 18*
**STRK2**2*CTFRC *AIRFD *DAY     1*DAY      2*         6*ALPHA*H  *  2*  4*  2*
**STRK3**2*CTFRC *AIRFD *DAY     2*DDA     75*        13*ALPHA*F  *  6*  0*  0*
**      ** *      *      *        *          *          *     *H  *  6* 48* 16*
**CLEAN**2*CTFRC *AIRFD *DAY     2*DAY      2*        13*ALPHA*G  *  6*  0*  0*
**      ** *      *      *        *          *          *     *H  *  6* 12*  6*
**CAP1 **1*CTFRC *       *DAY     1*ENDSTRK3*12345678*VFCAP*     *  3*120* 96*
**CAP2 **1*CTFRC *       *ENDSTRK3*DAY      2*12345678*VFCAP*     *  1*  0*  0*
**SUCAP**0*CTFRC *RFDCA *DAY     1*DOS    100*      1234*SUCAP*     *  1*  0*  0*
*************************************************************************
```

Exhibit D-26

```
                 RED MISSION ACCOMPLISHMENT RESULTS
*************************************************************************
*        * *ORIGIN*TARGET*          *          *MISSION *   UNIT   *DES*UNT*UNT*
*MISSION*P*COMPLX*COMPLX* START    *   STOP   * TIMES   * TYPE SUB*UNT*REQ*ENG*
*************************************************************************
**VBFHT**1*AIRFD *CTFRC *DAY     2*DAY      5*        23*VBF  *A  *  2*  0*  0*
**FREE **2*AIRFD *CTFRC *DAY     1*DAY      5*        23*FREE *A  *  3*  6*  6*
**      ** *      *      *        *          *          *     *B  *  3* 24*  3*
**SLI1 **1*AIRFD *       *DAY     1*          *12345678*SLI  *   * 16*640*334*
**SSMHT**0*REDCA *CTFRC *DAY     2*DAY      5*        23*SSM  *   *  2*  0*  0*
*************************************************************************
```

Exhibit D-27

BLUE COMPLEX BATTLE ATTRITION RESULTS

BLUE COMPLEX	VA	AW	VF LO	VF HI	CV	SUPSHIP
	ELEMENTS ATTRITED / TOTAL ELEMENTS AT COMPLEX					
CTFRC	22.	14.	0.	24.	0.0	0.0
	46.	24.	0.	48.	2.0	12.0

Exhibit D-28

RED COMPLEX BATTLE ATTRITION RESULTS

RED COMPLEX	VA LO	VA HI	VBF	VFI	SSMSHIP	AIRBASE	SAM	SUPLINE
	ELEMENTS ATTRITED / TOTAL ELEMENTS AT COMPLEX							
AIRFD	43.	0.	40.	75.	0.0	0.0	11.8	0.0
	46.	0.	72.	96.	-0.0	2.0	18.0	0.0
REDCA	0.	0.	0.	0.	0.0	0.0	0.0	0.0
	-0.	-0.	-0.	-0.	1.0	-0.0	-0.0	-0.0

Exhibit D-29

BLUE FORCE UNITS

R FRC UNIT TYPE	SUB	ELEMENTS PER UNIT VA	AW	VF LO	VF HI	SUP A/C	UNIT CHARACTERISTICS MAX RANGE	RANGE DEF SUB	WORST WX	WX DEF SUB	MAX DET (NM)	SPEED (MACH)
ESCOR	F	0			2	0	LONG		GOOD	H	100	2.2
ALPHA	E	3			3	1	LONG		GOOD	H	100	.9
ALPHA	F	3			0	1	LONG		GOOD	H	100	.9
ALPHA	G	3			1	1	LONG		GOOD	H	100	.9
ALPHA	H		2		1		LONG		BAD		100	.9
WAS	A	1					LONG		GOOD	D	100	.9
WAS	B	1				1	LONG		GOOD	D	100	.9
WAS	C	4			2	1	LONG		GOOD	D	100	.9
WAS	D		2				LONG		BAD		100	.9
CAS	A	4		1		1	LONG		GOOD	C	100	.9
CAS	B	4				1	LONG		GOOD	C	100	.9
CAS	C		2				LONG		BAD		100	.9
SUCAP		1	1				LONG		BAD		100	.9
VFCAP					1		LONG		BAD		100	2.2
DLI				1			LONG		BAD		100	2.2

Exhibit D-30

ENGAGEMENT STATISTICS FOR BLUE ATTACKING RED

BLUE FORCE UNIT		BLUE UNITS LOST PER RED DEF ELEMENT				MAX RED AIR LOST PER BLUE UNIT		RED SURFACE ELEMENTS LOST PER BLUE UNIT				
TYPE	SUB	VBF	VFI	SAM	SPLY LINE	VBF	VFI	PKED A/C	SSM SHIP	AIR BASE	SAM	SPLY LINE
ESCOR	F	.05	.25	0		8	8	0			0	
ALPHA	E	.08	.10	.052		16	14.7	2.1			1.1	
ALPHA	F	0	0	.052		0	0	2.1			1.1	
ALPHA	G	.16	.17	.052		8	6.7	3[illegible]0		.06	1.1	
ALPHA	H	.11	.12	.004		2	2	.8			0	
WAS	A	1.0	1.0	.003		1	.67		.6		0	
WAS	B	.5	.5	.006		2	1.3		.6		1.1	
WAS	C	.11	.11	.015		13	11.3		2.0		1.1	
WAS	D	.25	.25	.002		0	0		.4		0	
CAS	A	.16	.17	.023	.014	6	4.3				1.1	.41
CAS	B	.20	.20	.023	.014	5	3.4				1.1	.36
CAS	C	.25	.25	.002	.002	0	0				0	.22
SUCAP		.5	.5	.006		2	1.3		.6			

Exhibit D-31

BLUE OPERATIONS PLANS

MISSION	P	ORIGIN COMPLX	TARGET COMPLX	START	STOP	MISSION TIMES	UNIT TYPE	SUB	DES UNT	MIN UNT	RDY UNT
STRK1	2	CTFRC	AIRFD	DAY 1	DAY 1	1234	ALPHA	F	6	4	
STRK2	2	CTFRC	AIRFD	DAY 1	DDA 75	6	ALPHA	H	2	1	
STRK3	2	CTFRC	AIRFD	DAY 2	DDA 75	13	ALPHA	F	6	4	
CLEAN	2	CTFRC	AIRFD	DDA 50	DDA 75	13	ALPHA	G	6	4	
CAP1	1	CTFRC		DAY 1	ENDSTRK3	12345678	VFCAP		3	1	0
CAP2	1	CTFRC		ENDSTRK3	ENDCLEAN	12345678	VFCAP		1	1	0
SUCAP	0	CTFRC	REDCA	DAY 1	DOS 100	1234	SUCAP		1	1	1
ESCR1	2	CTFRC	AIRFD	DAY 1	DAY 1	1234	ESCOR	F	6	4	
ESCR3	2	CTFRC	AIRFD	DAY 2	DDA 75	13	ESCOR	F	6	4	

Exhibit D-32

BLUE MISSION ACCOMPLISHMENT RESULTS

MISSION	P	ORIGIN COMPLX	TARGET COMPLX	START	STOP	MISSION TIMES	UNIT TYPE	SUB	DES UNT	UNT REQ	UNT ENG
STRK1	2	CTFRC	AIRFD	DAY 1	DAY 1	1234	ALPHA	F	5	24	24
STRK2	2	CTFRC	AIRFD	DAY 1	DAY 2	6	ALPHA	H	2	4	4
STRK3	2	CTFRC	AIRFD	DAY 2	DAY 2	13	ALPHA	F	6	12	12
CLEAN	2	CTFRC	AIRFD	DAY 3	DAY 2	13	ALPHA	G	6	0	0
CAP1	1	CTFRC		DAY 1	DAY 2	12345678	VFCAP		3	48	48
CAP2	1	CTFRC		DAY 3	DAY 2	12345678	VFCAP		1	0	0
SUCAP	0	CTFRC	REDCA	DAY 1	DOS 100	1234	SUCAP		1	0	0
ESCR1	2	CTFRC	AIRFD	DAY 1	DAY 1	1234	ESCOR	F	6	24	24
ESCR3	2	CTFRC	AIRFD	DAY 2	DAY 2	13	ESCOR	F	6	12	12

Exhibit D-33

RED MISSION ACCOMPLISHMENT RESULTS

MISSION	P	ORIGIN COMPLX	TARGET COMPLX	START	STOP	MISSION TIMES	UNIT TYPE	SUB	DES UNT	UNT REQ	UNT ENG
VBFHT	1	AIRFD	CTFRC	DAY 2	DOA 50	23	VBF	A	2	4	2
FREE	2	AIRFD	CTFRC	DAY 1	DOA 50	23	FREE	A	3	12	9
SLI1	1	AIRFD		DAY 1	DAY 10	12345678	SLI		16	256	216
SSMHT	0	REDCA	CTFRC	DAY 2	DOA 50	23	SSM		2	0	0

Exhibit D-34

BLUE COMPLEX BATTLE ATTRITION RESULTS

BLUE COMPLEX	ELEMENTS ATTRITED / TOTAL ELEMENTS AT COMPLEX					
	VA	AW	VF LO	VF HI	CV	SUPSHIP
CTFRC	6.	7.	0.	18.	0.0	0.0
	48.	24.	0.	48.	2.0	12.0

Exhibit D-35

RED COMPLEX BATTLE ATTRITION RESULTS

ELEMENTS ATTRITED / TOTAL ELEMENTS AT COMPLEX

RED COMPLEX	VA LO	VA HI	VBF	VFI	SSMSHIP	AIRBASE	SAM	SUPLINE
AIRFD	46.	0.	71.	64.	0.0	0.0	18.0	0.0
	48.	0.	72.	96.	-0.0	2.0	18.0	0.0
REDCA	0.	0.	0.	0.	0.0	0.0	0.0	0.0
	-0.	-0.	-0.	-0.	1.0	-0.0	-0.0	-0.0

Appendix E

TEST SUBJECT'S COMMENTS ON THE OUTCOME CALCULATOR APPROACH IN DECISION AIDING IN STRIKE WARFARE

Appendix E

TEST SUBJECT'S COMMENTS ON THE OUTCOME CALCULATOR APPROACH IN DECISION AIDING IN STRIKE WARFARE

A. H. Clancy, Jr.
9 March 1977

I don't believe that I have to belabor the fact that today's world is exceedingly complicated. The number of nations that now exist-the so called Third World countries-the changing sponsorship-the improvement in communications, surveillance and intelligence-all clamor for a multitude of contingency plans-all of which must be routinely up-dated. I believe it is also obvious that the cost of personnel is taking such a large percentage of the Defense Budget that there will be continuing efforts to reduce people numbers. If the trend of the last five years continues, the first target will be "staffs" or what is considered overhead. The result is that there will be insufficient personnel to give more than lip service to the planning that must be done. This suggests that there must be some innovative thinking done to cut out or shorten the massive amount of paper work that confronts the planners. This very short rationale would seem to support some type of machine assisted decision aiding system.

After reviewing the NWRC triad of choices, I have concluded that I need not worry about your specific choice of systems for comparison purposes. The choices were really generic; i.e., non-automated, automated with an inflexible program and automated with a flexible program. It is almost axiomatic that one would choose the third choice, if it were manageable.

Pencil, Paper and Pub Method

I don't want to discount this method for it appears to me we should never lose this capability. Some ships may not have the applicable computer, computers fail, ships incur battle damage with power failures, unique situations occur-all these demand some back-up capability to "continue the battle". Nevertheless, under normal operating conditions this method is archaic and slow in developing the initial plan. It is almost impossible to introduce a change and produce an immediate reaction. In an era of rapidly changing world events, supersonic aircraft and cruise missiles, this slow reaction time is unacceptable.

Combat Simulation Model and MWRC OC Model (SOC)

The obvious deduction, if you accept the comments about the Pencil, Paper, Pub method, is to develop a computer assisted method. I'm going to lump my comments on the C Base II method and the SOC method together since, in general principle, they are similar. Both serve to provide a computer analysis of the outcome of a defined battle problem. The significant differences lie in the purpose for which they were constructed, the detail, the flexibility and the ingenuity of the analyst.

The Combat Simulation Mode, I suspect, is used to compare US aircraft against foreign aircraft under relatively fixed conditions, so that continuing comparisons will be valid. It's much like correcting all your data to standard conditions. As illustrated, there are many inputs, and the model suffers from too much detail and too little flexibility. If a model is to be used, it must be broad enough to cover many situations, accepting perhaps other compromises, so that the TFC can use it frequently. If it is too narrow, it will remain in the file.

If one accepts the need for the machine assisted aid-and the requirement for flexibility-then the SOC design appears to be a first step. Withoug referring to your outline, I'm going to list the things that I can think of that a TF should be able to do on offense and defense, regardless of scenario.

OFFENSE

Attack

Submarine and submarine launched missiles (latter perhaps defensive)

Surface ships

Aircraft

Land targets (which can be attacked under the purpose of air superiority, interdiction, amphibious support)

SAM and AAA sites-listed separately because of special nature

DEFENSE

Defend against

Sub launched missiles and torpedos

Surface guns and surface launched missiles/torpedos

Air launched bombs, missiles and torpedos

There are other specialized missions like photo and EW collection which may be simple enough to be handled manually.

It appears to me that if the above elements are included in a Model, then the scenario could be anything since you have covered all the capabilities of the TF in the program.

My point in going through this mental exercise is to convince myself that this approach is flexible enough that it would have utility whether in the Eastern Mediterranean, Indian Ocean or China Sea. It appears to me that the approach is valid.

I'm not going to dwell on detail. If the Fleet is interested, the inputs and outputs will be driven by their suggestions. I will comment on some other aspects we have touched upon-no particular order of priority.

Flexibility

I like the flexibility of the SOC-the ability to test the "what ifs". The system simply can't be hard wired. The flexibility feature can be used all the way from deciding a deck-loading for a deployment to planning an individual strike. It immediately simplifies the development and updating of contingency plans. I can envision a "short form" contingency plan which will simply show a brief scenario and then a computer runout of various options with outcomes. This would be very easy to update if the situation changed.

Sophistication

I will echo that the SOC should not strive to provide results that are more accurate than the inputs. There are too many non-quantifiable factors like, training, fear and luck that make the outcome approximate at best. What is required is an order of choices and a knowledge of to what degree a change in one factor changes the outcome. I emphasize your statement that the routine must be transparent enough for the TFC to understand the number generating procedures. The Interactive feature is also a must. If the TFC has to wait very long for an answer, I believe he will revert to a judgment decision, in times of emergency. The on-line feature is very appealing.

Training

To use this system to best advantage requires that it be woven into the pattern of operations. It can't be something you play with during peacetime and then forget when things get hot. I would recommend that the Ops and Plans officers plus two junior officers have detailed training. This would include a detailed knowledge of the program and several hours of operation of the system under various scenarios. The TFC and the COS should have the "Executive" training course in order to understand the program capabilities and limitations. This course would provide some "hands on" training to see results and gain confidence.

Electronic Warfare

I believe the next conflict will see EW play a much larger part than it has in the past. As I see the SOC, the effect can be an input as a modifier to the various effectiveness factors. Nevertheless, when the program is presented, this should be mentioned (if true) to show that it has been taken into account.

Compatibility

The concept of the SOC is certainly compatible with the concept of the Task Force Command Center. As a matter of fact, I would suspect that the data base already exists. The Recon and Intelligence data base already has the capability of being up-dated for the theatre of operations in which the Task Force is steaming. It certainly would be no problem to store whatever effectiveness tables are necessary (assuming there is enough storage!). The program should be made compatible with the standard shipboard computer.

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