NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

Repetitive Use of
Joint Theater Level Simulation (JTLS)
for Investigation of
Headquarters Effectiveness

by

Thomas Douglas Sloan

March 1988

Thesis Advisor: CDR Joseph S. Stewart, II

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Postgraduate School 6b OFFICE SYMBOL (If applicable) 39	7a NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c. ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000	7b. ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
Repetitive Use of Joint Theater Level Simulation (JTLS) for Investigation of Headquarters Effectiveness

12. PERSONAL AUTHOR(S)
Sloan, Thomas D.

13a. TYPE OF REPORT	13b TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Master's Thesis	FROM ____ TO ____	1988 March	95

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Simulation, Modeling, JTLS, Evaluation, Wargame HEAT

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This thesis is a discussion of the Headquarters Evaluation Assessment Tool (HEAT), Command, Control, and Communications (C3), and the Joint Theater Level Simulation (JTLS) wargame. The discussion is based upon a history of past experiments and present such as a series of experiments conducted by government contractors and NPS students. Using background material, research documents and analysis reports from government agencies and contractors, this thesis reports on one particular experiment focusing on a comprehensive review. By this, the author hopes to stimulate interest in experimentation and analysis of C3 processes as means of developing C3 principles.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a NAME OF RESPONSIBLE INDIVIDUAL Stewart, Joseph S.,II	22b TELEPHONE (Include Area Code) (408)646-2419	22c OFFICE SYMBOL 55St

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

☆ U.S. Government Printing Office: 1986—606-243

Approved for public release; distribution is unlimited.

Repetitive Use of Joint Theater Level Simulation (JTLS) for Investigation of Headquarters Effectiveness

by

Thomas Douglas Sloan
Lieutenant, United States Navy
B.S., United States Naval Academy, 1980

Submitted in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY
(COMMAND, CONTROL AND COMMUNICATIONS)

from the

NAVAL POSTGRADUATE SCHOOL
March 1988

Author: Thomas D. Sloan
Thomas Douglas Sloan

Approved by: Joseph S. Stewart II
Joseph S. Stewart, II
Thesis Advisor

Thomas J. Brown
Thomas J. Brown
Second Reader

Carl R. Jones
Carl R. Jones, Chairman
Command, Control, and Communications Academic Group

Kneale T. Marshall
Kneale T. Marshall
Acting Academic Dean

ABSTRACT

This thesis is a discussion of the Headquarters Evaluation Assessment Tool (HEAT), Command, Control and Communications (C3), and the Joint Theater Level Simulation (JTLS) wargame. The discussion is based upon a history of past experiments and present such as a series of experiments conducted at the Naval Postgraduate School in August and September 1987 and the experiment analysis conducted by government contractors and NPS students. Using background material, research documents and analysis reports from government agencies and contractors, this thesis reports on one particular experiment focusing on a comprehensive review. By this, the author hopes to stimulate interest in experimentation and analysis of C3 processes as a means of developing C3 principles.

TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION

The Defense Communications Agency (DCA) is continuing its direction of research in Command, Control and Communications (C3) with another in a series of experiments using the Headquarters Effectiveness Assessment Tool (HEAT). The vehicle for this experiment was the Joint Theater Level Simulation (JTLS). Previous research in this area has included the evaluation of Operations Plans using various wargaming systems including JTLS and an assessment of HEAT to quantify the command and control system effectiveness of simulated headquarters. This thesis will review the background of these systems and the vehicle for the present experiment and discuss the particular uniqueness of this experiment.

A. DCA/HEAT BACKGROUND

The Headquarters Effectiveness Assessment Tool (HEAT) development project was an initiative of the C3 Architecture and Mission Analysis in the Planning and Systems Integration Directorate of the Defense Communications Agency (DCA). The Defense Nuclear Agency supported the project due to the interest in the survival of an effective C3I system during nuclear combat. The goal was to size theater-level headquarters and make them survivable and effective. (Ref. 1, p. 39) The problem of determining what was effective had to be solved first. (Ref. 2, pp. p1-p3) The strategy was to first develop a method to recognize the difference between effective and ineffective headquarters performance, then find factors that could be used to explain, predict and eventually manipulate the level of performance. Defense Systems, Incorporated of McLean, Virginia was awarded the development contract and tasked with an initial goal of developing a methodology for measuring the effectiveness of theater level headquarters. (Ref. 1, pp. 39-40) Effective headquarters performance is strongly influenced by intangible qualities such a leadership, staff, commander instinct, morale and willpower. Even if a headquarters is structurally sound, it may not be effective just as the best commander and staff cannot make a structurally inadequate headquarters perform effectively. (Ref. 2, pp. p1-p3) One of the intended uses of HEAT was to be a tool that the commander would use to structure the headquarters configuration to provide the capabilities necessary to meet the military mission. (Ref. 3, pp. 1-9)

HEAT is an analysis tool that was designed to allow an objective and quantitative assessment of theater level headquarters performance and effectiveness by a team of internal or external observers. HEAT was to provide quantitative, objective, and reproducible numerical scores which would be descriptive of the effectiveness of the headquarters command organization. HEAT is designed for application to those headquarters organizations that are primarily responsible for the planning, supporting and coordination of fighting forces, not direct war fighting. (Ref. 2, pp. 1.1-1.2)

The commands that were referred to as "theater headquarters" during the HEAT development were the highest levels of the U.S. and NATO commands. The development team established the definition of a theater command to be the highest level of military command in a distinct geographic region, where the overall commander of military force is the theater commander. (Ref. 2, p. 2.10)

The development team had to determine what functions and roles that a theater command performed before they could measure its performance and effectiveness. The study of headquarters organization found that the theater commander's role had evolved from the battlefield commander toward the present day role as a planner and logistician. The theater command today is a layered structure with direct control of fighting forces handled at corps, fleet and major air command levels. The commander provides support for his subordinate commanders. He performs an interface function for the translation of political, economic and social guidance into military directives. The higher the command, the greater the interface function performed. (Ref. 1, pp. 41-42) The principal role of the theater commander is the assignment of military objectives and resources to his war fighting commands. (Ref. 2, pp. 2.11-2.15) The vehicle for assigning objectives and resources is via the military directive, the plan and it is a measurable entity. (Ref. 2, pp. 2.32-2.33)

The JCS Publication I definition of a Command and Control system is:

> "The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the mission assigned."

The HEAT development team expanded the definition and defined a theater level headquarters to be:

> "The set of personnel, equipment, communications facilities, and procedures for the execution of those command and control functions by which the commander plans for, directs, coordinates, and controls forces and operations pursuant to the missions assigned."

This definition included communications, computer equipment, and facilities that are within the physical space occupied by the headquarters personnel. Remote elements of the headquarters are also included that are linked directly to the headquarters via telephone, microwave, etc., and performs an internal function or process of the headquarters, regardless of the distance. (Ref. 2, p. 2.7)

The key concepts concerning headquarters effectiveness (Ref. 4, p. 1.5) that were formalized during the development of HEAT were:

- Effectiveness is the capacity to accomplish military missions.

- Effectiveness of a theater level headquarters is its capacity to operate as an adaptive control system such that it keeps crucial factors in its environment (enemy actions, losses of territory, casualties, etc.) within expected boundaries.

- The primary measure of effectiveness is the capacity of the headquarters to develop plans and use the resources available to bring those plans to fruition.

- When plans being used are not working, the effective headquarters is the one that can recognize that fact, develop alternative plans, and implement them in a timely fashion. The effective use of contingent options is an important issue, because of the uncertainty inherent in military operations.

- Effectiveness is always measured in terms of interactions with the environment.

- Timeliness, not speed, is essential for effectiveness.

- Speed and good quality decision making processes may be necessary conditions for successful performance, but they are not sufficient for success.

An effective headquarters is one that can survive, continue to perform its assigned mission, make its presence felt in its environment, that is, effectively produce the desired military impact, and efficiently use its time and resources. The concept of effectiveness is the ability to accomplish a military mission and is uncompromising. A headquarters may be large, complex and functionally divided into parts; some parts may work well, other parts may fail and the mission can still be accomplished. In some headquarters all of the functions may work well, as planned and the mission fails. Then the headquarters is NOT effective. (Ref. 2, pp. 2.20-2.22)

HEAT's purpose is to enable a team of internal or external observers to objectively assess and quantify headquarters performance and effectiveness. It was developed to provide quantitative, objective, and reproducible scores which would, in essence, be descriptive of the effectiveness of virtually any headquarters or command, control, communications and intelligence system. ~~(Ref. 5, p. 1)~~

For greater detail, refer to the manuals on the Headquarters Effectiveness Assessment Tool prepared by Defense Systems, Incorporated, References 2 and 5.

B. JILS BACKGROUND

From November 1980 through July 1982, a number of tests, exercises, studies and demonstrations were conducted using an enhanced version of the McClintic Theater Model (MTM). As a result of these efforts, the need for a new model with integrated Air, Land and Naval interactions was highlighted. The United States Readiness Command (REDCOM), in conjunction with the United States Army War College (USAWC) and the United States Army Concepts Analysis Agency (CAA), undertook the task of developing the Joint Theater Level Simulation (JTLS). The Jet Propulsion Laboratory (JPL), under the management and direction of REDCOM, was tasked with the initial development effort on JTLS.

The JTLS development effort was designed to meet three primary objectives:

(1) Provide a contingency planning analysis tool for REDCOM

(2) Provide an educational wargame capability for students at the USAWC and an analytic capability for the evaluation of doctrine for Echelon Above Corps (EAC)

(3) Provide an analytic tool aiding contingency plan evaluation for CAA

To meet these objectives, five specific design goals were established for the initial development effort:

(1) Develop a tool that can be used for warfare training, combat analysis, joint operational planning, and doctrinal analysis.

(2) Provide functional visibility in order to facilitate model validation.

(3) Incorporate specific user requirements.

(4) Provide an enhanced user-machine interface.

(5) Provide a baseline system that can be expanded to a graphics-assisted planning and analysis model.

In July 1982, General Vessey, as Chairman of the Joint Chiefs of Staff, identified the need to upgrade the analytic tools available to the unified Commanders-in-Chief (CINC's) for use in war planning. As a result of his concern, the Joint Analysis Directorate (JAD) of the Organization of the Joint Chiefs of Staff (OJCS) was tasked to begin formulating a program designed to address this deficiency. On 15 July 1985, the Modern Aids to Planning Program (MAPP) became an approved JCS program.

The JTLS model was selected as one of the models to be included in the MAPP set of analytic models. Following the selection of JTLS, responsibility of future JTLS development was transferred to JAD at the completion of version 1.5. (Ref. 6, pp. 1.1-1.3)

C. MOTIVATION FOR 1987 NPS EXPERIMENT

The master plan of the experiment called for the experiment to be conducted at the Naval Postgraduate School using the JTLS for HEAT. The need was for a series of basic experiments on C3 theory and architecture identifying the dependent and independent variables for each experiment. This last part presented the very uniqueness this experiment held over past work conducted at the Postgraduate School or anywhere else. Previous work consisted of running one "wargame" experiment and analyzing several predetermined measures of effectiveness (MOE). This would produce some evaluation of the headquarters effectiveness. This experiment analyzed several HEAT MOE's over a series of varying experiments to evaluate certain prescribed hypothesis. The repetitive use of a wargame for headquarters evaluation was a new direction in analyzing a C3 system. Dependent upon merits of several experiment sets conducted at the Naval Postgraduate School, the further use of this scenario as depicted on JTLS for future command and control experimentation and demonstration would be determined. A subgoal was the successful establishment of a baseline scenario available to corresponding researchers in the field.

II. EXPERIMENTAL DESIGN

A National Defense University (NDU) workshop on "Issues in CINC Command and Control" was developed for presentation to a practice work group of NDU students, then work groups of the Joint Chiefs of Staff and staff personnel of U.S. Central Command. The purpose of the workshop was to achieve better understanding of the issues faced by multiservice/multinational commanders in the field of command and control. The think piece used as the key feature of the workshops to focus attention on issues of CINC command and control was the same as that used for the basis of the JTLS experiment. (Ref. 7, p. 1)

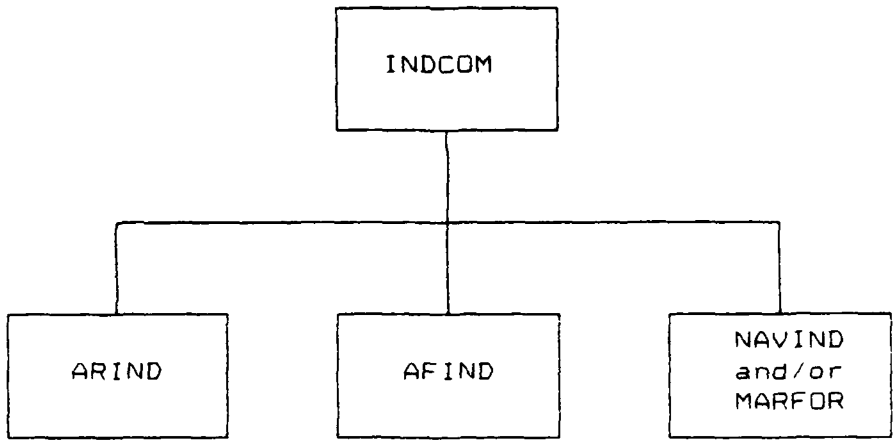
A. SCENARIO DEVELOPMENT

The basic description was the situation of the "U.S. Indian Ocean Command"--a fictitious yet plausible unified Commander-in-Chief (CINC) with assigned forces and area of operations which resembles those of the Central Command (CENTCOM) and the actions which the CINC and his staff and commanders decide to take with respect to the command and control systems of the command's forces top to bottom and throughout the force. The setting and scenario of this experiment have been adapted from material which has been used for unclassified instruction in Service colleges. The hypothetical CINC's situation and force employment should not be construed as reflecting any operational plans or the specific thinking of the Joint Chiefs of Staff or any unified command.

1. <u>The Fictional Indian Ocean Command (INDCOM)</u>

About 1988, the U.S. Department of Defense established a new unified command known as the U.S. Indian Ocean Command (USINDCOM).

Headquarters, USINDCOM, is on United States territory. An advance headquarters element is at Diego Garcia, in the Indian Ocean. A small communications staff is embarked on the command ship USS LASALLE, afloat in the Persian Gulf.



INDCOM's U.S. Army component (ARIND) is XXth Army, with two corps, each with three divisions and corps troops, and with army troops including an army support command. Its U.S. Air Force component (AFIND) is YYth Air Force, with six tactical fighter wings, a reconnaissance wing, an airlift wing, and other units. The forces of both ARIND and AFIND are all based in the United States and are assigned full time under INDCOM operational command.

INDCOM's U.S. Navy component (NAVIND) day-to-day consists only of a squadron in the Persian Gulf. ZZth Fleet and its naval forces are assigned, primarily from U.S. Pacific Command (PACOM), when required. ZZth Fleet is expected to include amphibious forces from U.S. Atlantic Command (LANTCOM).

2. CINCIND's Initiatives in Command and Control

The establishment of USINDCOM came as the Department of Defense and its components were adjusting to the implications of the Department of Defense Reorganization Act of 1986. That act increased the responsibility and authority of the Chairman, JCS; it created the position of Vice Chairman, JCS; it increased the role and independence of the Joint Staff by making it responsible directly to the Chairman; and it substantially increased the role and authority of unified command CINC's.

Shortly after taking command of USINDCOM, CINCIND concluded that one of his highest priority requirements was to insure an adequate command and control system for his forces in operations.

The chief of staff decided that in order to examine command and control system readiness top to bottom and throughout the force he needed a lifelike scenario for a typically demanding employment of INDCOM forces in an operational situation. It was necessary that the scenario be unclassified so that he could get the best effort of outsiders under the restrictions of JCS MOP 39.

3. <u>CINCIND's "C2 Systems Research Scenario"</u>

As a vehicle to assist their investigation and analysis of the command and control systems of INDCOM's forces when deployed and operating, top to bottom and throughout the force, under the lifelike conditions of combat, the INDCOM staff, working with the Joint Staff and INDCOM subordinate commands, developed a scenario.

The scenario was prepared to resemble a plausible INDCOM employment. It was designed as a means through which detailed investigation and analysis of command and control system performance could be conducted within the constraints of MOP 39. The forces and their employment were to be notional, but the forces' C2 systems were to be real-world.

The scenario laid out a hypothetical deployment/employment of a sizeable all-Service force in a situation which CINCIND and his staff considered reasonably true-to-life for the purpose intended--i.e., the investigation of command and control system performance.

It included a complete layout of the notional force in its operational setting, with deployment, mission, concept of operations, follow-on forces and logistics. It described the C2 systems of the force in detail, assuming the time to be 1992-1993 and current joint, Service, and national C2 system programs have been carried out.

The scenario also laid out an assumed 1992 opposing force--with its composition, deployment, mission, concept of operation, and logistics--and its notional capabilities both for command and control and for counter-C2.

4. The Scenario Outline

The Scenario, in outline, is as follows (all dates are 1992):

Dates		Events
1 Apr to 30 Apr	(D-66 to D-36)	Crisis in the Mideast and Southwest Asia; civil war in Iran; some INDCOM deployments; positioning of air and sea lift
1 May to 3 June	(D-35 to D-1)	Crisis deepens; deployment of major INDCOM forces into the region; Soviet-backed rebel Iranian forces threaten Bandar Abbas

31 May	(D-4)	INDCOM receives order to protect Bandar Abbas and the Persian Gulf
4 June	(D-day)	INDCOM forces seize Bandar Abbas
5 June	(D+1)	Soviet forces move into Iran from Afghanistan
5 June to 14 June	(D+1 to D+10)	Air warfare; air interdiction; some naval action; INDCOM develops its lodgment; Soviets drive toward Bandar-Abbas
15-16 June	(D+11 & 12)	The battle of Bam (Vignette One)
21 June	(D+16)	Soviets invade Azerbaijan
22 June	(D+17)	INDCOM inserts special operations forces vicinity Tabriz; air interdiction campaign
24-26 June	(D+21-22)	Delaying actions in northwest Iran (Vignette Two)
27 June to 31 July	(D+23 to D+57)	Soviets attack toward Bandar Abbas, Chah Bahar, Tehran, Kermanshah; Soviet and US-Japanese fleets clash in Persian Gulf and Indian Ocean; INDCOM builds a one corps force vicinity Khoramabad and another at Bandar Abbas, and a MAF at Chah Bahar
1 Aug to 20 Aug	(D+58 to D+77)	The battle for southern Iran and the Persian Gulf (Vignette Three)

5. Events of Early 1992

Any scenario's "road to war" is an exercise of the imagination.

In April, 1992, the 47th Air Assault Division, complete, is in Egypt on a scheduled exercise similar to the CENTCOM Bright Star exercises of the 1980s.

In April, 1992, civil war breaks out in Iran, rebel Iranian armed forces are supported by the Soviet Union. On 1 May the rebels threaten to close the Strait of Hormuz. The Government of Iran calls on the United States and other for help. Hardliner hawk types are in control in the Kremlin.

On 4 May, the U.S. begins deployment of air, land, and sea forces into Egypt, Oman, the United Arab Emirates, Qatar, the Persian Gulf, and the Indian Ocean.

On 10 May, the JCS issues a warning order to CINCIND and other commands, in anticipation of operations in defense of the Strait of Hormuz. CINCIND and his staff are at Abu Dhabi.

By late May, tensions have increased. The USSR has taken an implacable position. Attempts by the United Nations and other diplomatic efforts to resolve the crisis have failed. Soviet forces are poised to invade Iran and to support rebel Iranian forces in the seizure of Bandar Abbas. War seems imminent.

On 31 May, as a pre-emptive move, the President orders CINCIND, in conjunction with Loyalist Iranian Armed Forces (LIAF), to secure Bandar Abbas and protect the Strait of Hormuz.

On 1 June the JCS defined to CINCIND the rules of engagement:

> "No air or ground action on or over Soviet territory, except reconnaissance missions as approved by the JCS."

> "If Soviet forces attack into Iran by air or ground, engage them in and over Iran. If Soviet forces attack from Afghanistan, engage them in and over Afghanistan."

> "Air action over and south of the Persian Gulf is permitted in self-defense."

> "Action to locate and destroy the Soviet fleet at sea is permitted without restriction."

6. The Bandar Abbas Lodgment

As prepared by the staff and approved by CINCIND, Plan A called for the establishment of JTF 21, built around the 21st Airborne Corps, for the seizure of a lodgment at Bandar Abbas. At the end of the lodgment phase, JTF 21 would be terminated.

Plan A also called for the seizure by the 4th MAF of Chah Bahar as soon as amphibious shipping could be moved into position following its use in securing the beachhead at Bandar Abbas.

The composition of JTF 21:

21st Abn Corps[1]	10th AF[2]	MARFOR and NAVFOR elements (according to phase of opns)	
47th AASLT Div	1st TacFtrWg	42 MAU[3]	PHIBRON 2[4]
55th Mech Div	102 TFS A-10		42d MAU
102d Abn Div	103 TFS A-10	8 MAB	(BLT plus
21st Avn Bde	etc. for 2		avncbtelm
230th Sep Ar Bde	more TFS		& svcsptgp)
21st Corps Arty			3 amphib ship
61st FA Bde	2d TacFtrWg		7 frigates/
62d FA Bde	4 tac ftr		destroyers
63d FA Bde	sqdns		
Corps Troops			8th Fleet[5]
10th ADA Bde	3d TacFtrWg		CTF-80 (Battle
51st Engr Bde	4 tac ftr		Force) incl:
21st MI Gp	sqdns		USS AMERICA &
70th Sig Bde			7 combatants
21st CorpsSptCmd	10th TASS		USS ENTERPRISE
83d Med Gp			& 7 cmbtnts
16th Spt Gp	33d TacALWg		USS NEW JERSEY
17th Spt Gp	total of		& 5 cmbtnts
70th MedTrkGp	4 tac AL		USS LASALLE &
33d POLSupBn	sqdns		4 combatants
56th AmmoBn			CTF-82 (Patrol
	Recce units		Force) 12 a/c
			CTF-83 (Log Spt
Other units	Other units		Force) 27 log
			spt ships
			CTF-84 Submar-
			ine Force)
			CTF-86 (Amphib-
			ious Force) 23
			combatants

Note 1: Not all these ARIND troops will be under JTF 21, depending on the phase of the operation.

Note 2: Not all these AFIND unites will be under JTF 21, depending on the phase of the operation.

Note 3: The 42d MAU (BLT reinf) and 8th MAB (bde reinf) are the only USMC units that might be part of JTF 21.

<u>Note 4</u>: Amphibious Squadron 2 (PHIBRON 2) is opcon to JTF 21 only for Phase I (seizure of Bandar Abbas); it then reverts to NAVIND 8th Fleet control.

<u>Note 5</u>: 8th Fleet (NAVIND) is made up of elements of PACOM and LANTCOM, chopped to NAVIND, hence to USINDCOM. Except for PHIBRON 2 (see Note 4), 8th Fleet units are not part of JTF 21 but are "in support."

The 10th Air Force plan called for air reconnaissance but no air attack before D-day, and for on-call close air support to PHIBRON 2's assault of Bandar Abbas on D-day, to be employed only in the event of serious opposition. Likewise, the self-deployment of the 47th Air Assault Division and the airborne assault of the 102d Airborne Division were to be supported with on-call air, but only if opposing forces were identified in the area by intelligence or by pathfinders.

If such tactical air as the RIAF possessed should attack U.S. forces, their bases in Iran would be taken out and their air capability destroyed.

A major tactical air effort was held in readiness for execution as required upon the first crossing of the Iran-Afghanistan border by Soviet forces, whether air or land. If Soviet air forces crossed the border, all air bases in Afghanistan would be open to attack. If land forces crossed the border, they would be attacked both in Iran and in Afghanistan.

The sequence of events which followed was:

1-3 June	Soviet forces in Afghanistan prepare to move; Soviet actions indicate an intention to intervene in Iran.
4 June (D-day)	PHIBRON 2, under JTF 21, seizes Bandar Abbas.
5 June	Soviet forces cross Iran-Afghanistan border.
5-12 June	10th AF and Soviet air forces engage in air warfare: air-to-air combat; attack of each other's ground targets; action in and over Iran and Afghanistan only.
6 June	8th MAB secures the port and beachhead.
7 June	Elements of 21st COSCOM established at Bandar Abbas; COSCOM buildup begins.
8 June	Soviet 24th CAA headquarters is operational at Zahedan; units of 24th CAA are strung out on road from Zahedan some 200 km north and are moving south.
7 June (D+3)	47th Air Assault Division self-deploys into objective area 40 km NE of Bandar Abbas, prepares for movement to vicinity of Jiroft.
10 June (D+6)	102d Airborne Division deployed by airborne and airlanding operations into its objective area.
12 June	230th Separate Armor Brigade begins arriving at Bandar Abbas.
12 June	Soviet 24th CAA dispositions are... (TBD)
13 June	4th MAF seizes Chah Bahar, established beachhead; JTF 21 disestablished; CINCIND orders 8th MAB to remain under 21st Airborne Corps.
11-14 June	Air warfare continues.

The 21st Airborne Corps plan established a lodgment area some 300 kilometers deep. It assigned the 47th Air Assault Division a 250 kilometer front facing the 24th CAA, and gave the rest of the lodgment area line to the 102d Airborne Division, reinforced with corps aviation.

Taking into account the virtually trackless terrain highly unfavorable to mechanized forces in the eastern two-thirds of its sector, the 47th Air Assault Division plan assigned that sector to its 1st Brigade.

In the western third of its sector, one of the two roads potentially useful to the enemy led into the corps sector across the Jebal Barez to Sabsevaran and the other road went northwest to Kerman thence south toward Bandar Abbas. Here, the 47th Air Assault Division plan visualized establishing a killing zone in the vicinity of Darzin. (Ref. 7, pp. WP1-WP4, WP7-WP13, WP15-WP17)

B. JTLS MODEL

JTLS is a computer-based wargaming system. With such a system, war fighting processes are simulated, and the users make decisions about the allocation of resources assigned to accomplish a mission. The system also provides assessments of the result of combat, based on Measures of Effectiveness selected by the user(s).

JTLS is designed so that it may be used, without modification, as a planning analysis tool, as supporting material for education, and as a primary means to investigate the results of combat.

The distinctions that set the Joint Theater Level Simulation apart from almost all other wargaming models, including the McClintic Theater Model, become obvious from an examination of the total system as designed, developed, and delivered. In addition to including explicitly defined user requirements, the JTLS baseline design provides the following benefits:

- The primary software language, SIMSCRIPT II.5, was designed for creating simulations.
- User-machine interaction permits inputs and outputs to be available at independent terminals.
- A message-handling system and screen menuing capabilities are provided to the user.
- An expandable memory capability allows increased data base requirements to be accommodated.
- The design facilitates future product improvements.
- Configuration Management procedures provide for ongoing visibility and control of software and documentation.

C. JTLS SYSTEM DESIGN

1. Overview of Wargaming Phases

Wargaming may be conceptually divided into five operationally sequenced phases: Initialization, Preparation, Execution, Restart, and Analysis. A brief definition of each phase is provided.

- Initialization: those actions which must be accomplished in advance in order to set the stage or scenario for a wargame.

- Preparation: development of user-oriented items that directly affect succeeding phases of the game.

- Execution: a phase to assess the effects of the strategic and tactical plans developed in the two previous phases. Interaction within the combat simulation is accomplished by issuing orders to the available military forces.

- Restart: the capability to reset and restart the system following either a planned or an inadvertent interruption.

- Analysis: this phase provides insight into the issues under study and allows the refinement of study objectives.

a. Initialization

The wargaming operation commences with a statement of specific objectives. Identifying these objectives leads to the delineation of force lists, weapons effects, geographical and political considerations, logistical concerns, and threat analysis. With the assistance of the Scenario Preparation Program (SPP), these data are then entered into the JTLS data base. The SPP is designed to assist game planners in three areas-systemic data, environmental data, and modeling parameters.

- Systemic Data: includes military equipment, unit and ordnance data such as descriptors of performance, capabilities, and effectiveness relative to an established baseline.

- Environmental Data: items that influence the effectiveness of various war fighting systems (e.g., terrain, weather).

- Modeling Parameters: parameters or factors that affect the performance of the mathematical equations, or logical relationships that represent the real world in which systemic or environmental data operate (e.g., attrition coefficients).

Following data entry, the SPP verifies that individual entries in the data are within specified ranges, alerts the user as to any that are not in range, permits the user to change those entries, and then creates the Scenario Initialization File and the Terrain Data File.

A second program, the Scenario Verification Program (SVP), may then be used to examine the relationships between and among the items of data that have been entered. This program produces a listing of all noted errors, possible errors, and inconsistencies. The SPP can then be used to correct the noted discrepancies and the SVP to assess the new data. This process should continue until all errors and inconsistencies are eliminated. At that point, the SVP can be used to produce a listing of the data base, formatted for readability for the Controller(s) and for the Command, Air, Logistics, and Intelligence players.

Once the Scenario Initialization File and Terrain Data File have been created, the wargame is ready for use by the Controller(s) and players.

b. Preparation

Following the development of a strategic military mission to support stated objectives and issuance of a mission statement for the forces by the Commander, the component staff functions examine orders of battle, situations, and courses of action; analyze courses of action by opponents; and develop a concept of operations. The concept of operations must encompass deployment, employment, and sustainment.

Subsequentlv, specific tactical objectives are derived from the formulation of campaign plans for component forces (Air, Land, and Sea). Finally, selected parameters may be modified to reflect constraints or advantages created by the scenario. These plans and modifications are accomplished by the Model Interface Program.

c. Execution

During execution, campaign plans become tasking orders as the capabilities of air, ground, and naval forces are integrated into the battlefield scenario. When forces move and become detected, combat will occur and interactions dictate that the Commander's staff make day-to-day battle management decisions. During the execution phase, a continual assessment of decisions is essential to maintain effective utilization of available resources. Because JTLS is a machine-interactive, human-in-the-loop wargame, plans may be modified on a continuing basis.

d. Restart

In the Restart phase, the wargame is reinitiated following either a planned or an inadvertent process interruption. The wargame is reinitialized at or before the point of interruption. Reinitialization is accomplished by the Executive Program.

2. <u>JTLS PROGRAMS</u>

The top-level program in the JTLS system is the Executive program, which is actually a set of programs written in DEC Command Language (DCL) and SIMSCRIPT II.5. It is designed to eliminate the requirement that the Technical Coordinator be fluent in DCL and to automate as many steps and validity checks as possible in beginning the execution of the several JTLS programs. The Executive program is menu-driven and is documented in the Technical Coordinator Guide.

a. Technical Coordinator's Executive Program

A majority of the JTLS systems software is executed using this program throughout all wargaming phases.

(1) <u>Prepare or Alter a Scenario Data Base</u>

Preparation and alteration of scenario data bases and terrain data bases are accomplished with the Scenario Preparation Program (SPP). The interactive support function for data entry provided by the SPP assists the user in creating task organization and force structure, weapon systems, environment, modeling parameters, and checking that individual data items are appropriate.

The SPP was created to be operated independently of the main JTLS wargame. Since it may take many weeks to build a major wargame scenario, depending on the availability of data and the size of the support staff, this design feature is extremely important. Software independence permits using the SPP without all the computer and human resources necessary to operate the full JTLS game. Wargamers can also use the SPP to create and change scenario data bases while others are running the wargame.

(2) <u>Verify an Existing Scenario</u>

Verification of scenario and terrain data base is accomplished using the Scenario Verification Program (SVP), which is designed to verify the output from the SPP. The SVP checks the relationships between different data elements, while the SPP checks the validity of individual data entries. A listing of all errors and discrepancies detected by the SVP is provided. The user may then execute the SPP to make appropriate changes to the data, based on this error listing. The process of executing the SPP and SVP should be repeated until all necessary changes have been entered in the data. The SVP will also, as a user option, create Player Manuals for the data base.

(3) Print Out Player Manuals

A user can create Player Manuals for any scenario by running the Scenario Verification Program and requesting that the manuals be created. These manuals, which are formatted for easy reading, are useful for reviewing the data during the preparation phase. They may also be sued by the players during the execution of the game as a source for starting condition data and unit capabilities.

(4) Start/Restart the Combat Events Program

The Technical Coordinator initially starts the Combat Events Program (CEP) and, when necessary, restarts the model following a planned or an unplanned shutdown. The CEP is the warfare-simulation model around which JTLS is developed. The modules included in the CEP simulate the movement and interaction of land, air, and sea forces for two-sided combat. The modules produce a realistic, real-time warfare environment. This simulation model can be run faster than real time; hence, if a minimum of player intervention is required, the game speed can be set at a higher rate. Game speed is controlled by setting the ratio of game time to real time.

(5) <u>Backup/Restore a Scenario</u>

The Technical Coordinator is responsible for saving the output from the execution of the CEP. If executed, this portion of the Technical Coordinator's Executive Program saves all data needed to perform post game analysis or to restart the CEP.

(6) <u>Start the Graphics Processor</u>

The JTLS graphics processor is started by the Technical Coordinator via a separate terminal. The JTLS graphics system provides a visual representation of the battlefield and some of the events in the battle. The background, provided from a laser disc, is in the format of standard military maps. The game entity data are in the form of standard military symbols. The graphics process can execute only while the CEP is executing.

(7) <u>Run the Post-Processor</u>

The Post-Processor can be run from the Technical Coordinator's Executive Program if a data base for the program has been created. The Post-Processor uses the commercial relational data base program INGRES for its processing. More than one hundred preformatted queries are available as part of Version 1.5 of JTLS. Analysts familiar with INGRES can build other queries as required. The Post-Processor can also be run from the Players' Executive Program.

A new INGRES-formatted JTLS data base can be created only from the Player01 (Controller) Model Interface Program during game play. The Post-Processor was designed to be used immediately after a checkpoint, before game execution resumes, thus providing a near real-time analysis capability to the players, as well as in the stand-alone mode described above.

(8) <u>JTLS Tools Menu</u>

This menu option brings the user to a second menu, which permits execution of a series of software utility type tools designed to permit the Technical Coordinator to perform an assignment more efficiently and quickly.

(9) <u>Exit to the Operating System</u>

This option permits the Technical Coordinator to leave the Technical Coordinator's Executive Program and access the operating system directly.

b. Players' Executive Program

(1) <u>Run the Model Interface Program (MIP)</u>

The Model Interface Program is an interactive program used by all players to transmit their decision (in the form of orders) to the JTLS Combat Events Program. A player MIP provides continuous interaction between the CEP and the player. The number of stations and MIPs needed is a user variable and is dependent upon the exercise or system application. A minimum of four terminals (one each for the Red Commander, Blue Commander, Controller, and Technical Coordinator) to a maximum of 28 (two for the Technical Coordinator and 26 players) may be employed.

After one Controller and a Commander for each side have been assigned, the remaining MIPs can be assigned to any of the following functions:

Controller	
	(BLUE or RED)
Commander	Air & Logistics
Air	Air & Intelligence
Logistics	Logistics & Intelligence
Intelligence	Air, Logistics & Intelligence

The Model Interface Programs provide the following capabilities:

- Entering orders.
- Processing orders.
- Communication between players and Controllers.
- Communication between players and the combat simulation.
- Accessing and using support information.
- Saving directives in Archive Files.
- Analyzing Post-Processor Data.
- Controlling Graphics Output.
- Stopping or temporarily halting the game.

(2) Run the Post-Processor

This option allows individual players to run the Post-Processor in the stand-alone mode.

(3) Stand-Alone MIP

This option allows the individual player to build directives, including orders, routes, weapon loads, logistics loads, etc., while the game is not executing. It is worth noting that the Stand-Alone MIP cannot be started until the Scenario Initialization File has been created. Even the Stand-Alone MIP needs the Player Initialization Files to start itself.

(4) Logout

This option permits the player to log off the system, i.e., to terminate a session on the computer.

3. Future

The JTLS design provides for continued improvements that will enhance the capabilities of the system. These improvements include Naval Amphibious modeling and simulation technology advances.

- Naval and Amphibious Module. The Naval and Amphibious Module will provide the capability to model delivery of forces to various combat environment, subsurface warfare, and will enhance current naval modeling capability.

- Simulation Technology Advances. JTLS may draw on data base systems, distributed processing, and other software techniques to enhance the modeling environment.

D. MODEL CAPABILITIES

1. Air

The air modules address those aspects of air operations that were identified by the United States Readiness Command, the United States Army War College, and the Concepts Analysis Agency users as required capabilities. An air tasking order (ATO) can be created for the players to plan and schedule missions well in advance of their desired launch and alert times. The ATO permits the building of mission "packages" that are composed of different types of aircraft, as well as directing individual, single-aircraft missions. A simple example of a mission package is one attack aircraft and one escort. A more complex grouping could consist of some attack aircraft, Wild Weasel, fighter escorts, and electronic countermeasure (ECM) aircraft. Using the various air directives available through JTLS, all of which are explained in detail in the JTLS Player Guide, the following types of missions can be tasked:

- Airborne Warning and Control System.
- Aerial Refueling.
- Combat Air Patrol.
- Defensive Counter Air (placed on alert at either home base or from forward-operating location).
- Offensive Air Support (close air support).
- Escort.
- Reconnaissance and Armed Reconnaissance.
- Electronic Combat.
- Air Interdiction and Offensive Counter Air.
- Air Defense Suppression (Wild Weasel).
- Airlift.
- Airdrop.

In addition to the mission capabilities enumerated above, there are two additional capabilities (listed below) that affect air operations:

- Accomplishment of airspace management.

- Weapons load directives that provide load configurations for various combat missions. These configurations represent preferred conventional loads.

Modeling the air assets includes both the aircraft and the weapons that they use. Aircraft are given mission orders that describe details such as the routes to fly, the type of mission to perform, targets to strike, and when to launch. For example, aircraft that are directed to perform combat air patrol missions are assigned an orbit location and will remain at that location until they must depart for fuel or lack of weapons or the mission runs out of crew time. Airlift and airdrop missions are checked within the model to determine the aircraft capacity needed for the requested mission. Finally, the air module logic will schedule the appropriate number of sorties.

Certain critical air weapon assets are also explicitly modeled in the air model portion of the CEP. Some air-to-air and air-to-ground weapons are loaded, flown, and expended in detail. Weapon characteristics such as the probability-of-kill (PK) are used. The model also precludes overloading the aircraft with too many weapons.

2. GROUND

The ground commander is responsible for the successful execution of the mission. The commander and staff develop a concept of operations and subsequently execute deployment, employment, and sustainment strategies and plans. To effect these plans, users have the following capabilities at their disposal for the ground forces:

- Establish new routes for ground movement.
- Perform administrative moves.
- Attack.
- Defend.
- Delay.
- Withdraw.
- Order indirect fire support (and the associated capability to cancel such orders).
- Emplace mines.
- Modify tactical thresholds-the point at which a unit will change its posture (e.g., from attack to defend).
- Clear mines.
- Repair targets.

The ground module of the CEP performs the basic ground combat functions of JTLS. Ground close combat is modeled by use of mixed, heterogeneous, time-stepped Lanchestrian difference equations. Ground movement follows a path of hexagons, with the moving unit "jumping" from hexagon to hexagon at appropriate time intervals. The paths that are followed may either be minimum time or minimum distance with the actual path optimized by the model.

A very large number of combat systems may be represented. Each system is characterized in terms of various characteristics, including maximum effective range, lethality, recoverability and repairability, type of fuel and ammunition required, etc. Combat systems are also characterized as direct or indirect fire systems, with the appropriate differences in attrition calculations.

Indirect fire may be employed explicitly and implicitly in the Lanchestrian attrition. All munitions are delivered to a set of coordinates on the terrain. All units, supply convoys, and targets in the vicinity of the fire are subject to attrition, regardless of who fired the munitions. Any ground combat unit may be directed to reinforce another ground combat unit with indirect fire resources. Any unit may be ordered to lay or clear mines and to repair targets.

3. NAVAL

Naval surface units have the ability to maneuver and engage targets with naval gunfire. Aircraft carriers may be included in a scenario. Carriers have the ability to simultaneously maneuver and conduct air operations. The JTLS model is capable of representing ship-to-shore, ship-to-ship, and anti-air warfare. Although the current naval modeling capability is limited, future planned enhancements for the naval modules include the simulation of subsurface and amphibious warfare and a more detailed modeling of naval surface operations.

4. LOGISTICS

The Commander's concept of the operation must consider a variety of combat support and combat service support activities. In addition to ground and air tactical plans, activities involving force sustainment are essential to mission accomplishment. The following logistics capabilities exist in JTLS:

- Cross-leveling of supplies between two units.
- Resupply of units.
- Creation of supply reserves (stockpiles).
- Creation of logistics loads for use in future orders.
- Modification of reorder thresholds for one or more categories of supplies for either a single unit, a group of units, or all units.
- Change of the depot or support unit from which a unit orders its supplies.
- Modification of stockage objectives for one or more categories of supplies for either a single unit, group of units, or all units.
- Airlift Operations (through the Air Model)--an aircraft squadron or helicopter company is capable of lifting either a unit or supply load from a loading location to an off-loading location.
- Airdrop Operations (through the Air Model)--an aircraft squadron or helicopter company is capable of airdropping a unit or supply load at a specified location or alternate location.

The foregoing list indicated the wide range of capabilities that are designed into the logistics module. As such JTLS provides a great deal of flexibility in addressing logistics requirements and problems. At one extreme, modeling zero consumption permits assessments of non-logistics-related results without the computer processing burden of the consumption calculations. The use of the unlimited supply capability permits assessment of both the logistics and combat results in an environment totally unconstrained by the availability of supplies. if desired, Red and Blue logistics may be gamed asymmetrically, so that the gamer may choose simulation of different logistic doctrines. At the other extreme, the very specific DIRECTED RESUPPLY, AIRLIFT, AIRDROP, SEALIFT, REORDER LEVEL, and STOCKAGE OBJECTIVE directives permit high-resolution micromanagment of the logistics situation. Between these two extreme conditions, modeling the normal constrained availability, automatic requisitioning, and automatic (player-initiated) PUSH shipments provides a medium-level, management-by-exception capability.

A very large number of different categories of supply can be represented. Categories of supply need not correspond to the standard military classes of supply. One unclassified data base for JTLS included the following categories:

- Personnel.
- Aviation Fuel.
- Ground Fuel.
- Major End Items.
- General Ammunition.
- Artillery Ammunition.
- Mines.
- Engineer Supplies.

This list is only an example. More or fewer categories of supplies may be used. It must be noted again that a major advantage of JTLS is that it is a data-driven model; the user is free to define into the data base whatever is desired with respect to the data, e.g., the supply classes and categories that are to be used.

Supplies are consumed in JTLS much as they are in real life. A data base input variable determines the normal periodic consumption rate for each category of supply by unit. In addition to this "normal" consumption, units that are in combat and/or moving will consume supplies at higher rates. Explicit expenditure of supplies occurs in JTLS by events such as ground or naval indirect fire missions, destroyed convoys, depots that have been attacked, air movement (airlift and airdrop), and air engagements.

The logistics module includes a maintenance function that simulates the repair of systems damaged in combat and their eventual return to operational status. Each combat system can have identifying attributes placed in the data base, which will indicate a percentage of casualties that can be recovered from combat and a percentage of those that will eventually return to their combat unit. This method is used to represent recovery and repair times of various combat systems. One aspect of this modeling approach is its extensible nature. For example, medical facilities are not normally included as a combat system. If there were a need to study the capability of a medical unit to function in a particular scenario, then be adding the appropriate data to the data base, such an excursion would be possible without changing the logic of the model itself.

5. INTELLIGENCE

The Commander and staff must possess information relative to their enemy in order to execute the military mission with adequate and timely tactical plans. JTLS provides the user with one capability pertaining to the effects of intelligence collection, namely Human Intelligence (HUMINT). Players are able to manage HUMINT teams by relocating them and changing the amounts of time that they spend on reconnaissance missions. Additional intelligence source material may be ascertained through variously available intelligence reports such as Situation Reports (SITREPs) and National, Strategic, and Tactical Intelligence Summaries.

6. REPORTS AND QUERIES

The capability to obtain information, either through periodically disseminated reports or responses to player queries, is essential to the successful planning and decision-making process. JTLS provides the user with a wide variety of reports and queries that enable him to stay abreast of the situation. These are incorporated into the four generic groups: Command (Ground and Naval), Air, Logistics, and Intelligence.

a. Command (Ground and Naval).

- Situation Report (SITREP): allows a player to request a current situation report for any unit or group of units in that player's reference data base.

- Operational Summary (OPSUM): provides the Commander with a current air and ground operations summary.

b. Air

- Air Status: provides a status summary of a squadron and the missions currently being flown.

- Route Status: provides a list of all air routes that have been developed.

- Load Information: provides a display of all preplanned weapon loads.

c. Logistics

- Logistics Report: available upon request for a particular force or a specific unit.

- Spread Sheet: provides summarized logistic statistics for elements on a side, using a tabular format.

d. Intelligence.

- National Intelligence: the Commander is provided with regularly scheduled National Intelligence Summaries.

- Strategic Intelligence: the Commander is provided with regularly scheduled Strategic Intelligence Summaries.

- Target Summary: provides the Commander with a current target list.

- Tactical Intelligence Summary: provides the Commander with limited information on unit names, activities, and location of hostile units and the identification, location, and capability of hostile and neutral targets within a specified range of friendly ground units.

- HUMINT Team Status: provides information on HUMINT teams that are currently collecting intelligence.

7. TERRAIN REPRESENTATION

The movement of forces within any combat environment is affected by the representation of the terrain. JTLS includes a data base that represents the geographic region of the planned scenario. The terrain is stored in the computer as sets of data points that describe a hexagonal "box" of terrain. Each hexagon in the data base is described in terms of its relative geographic location, the terrain interior to the hexagon boundaries, altitude, and the barriers on each of its sides. The size of the hexagons in the initial JTLS data base is approximately 16 kilometers from side to side. The number of hexagons used in any given data base and their size are user data entries.

JTLS uses the terrain values, interior and barrier, to determine how units proceed during the wargame. The interior values that represent desert, swamps, etc., are used to calculate the time or movement across that hexagonal area. Barrier values are similar but may also represent impassable or repairable obstacles such as destroyed bridges. In this situation the player (or model, in some instances) must decide to either expend the necessary resources and time to repair the obstacle or calculate a new route around it. The terrain values are also used to identify shorelines so that ground and naval units can be restricted to their appropriate parts of the world. In addition, the elevation values are used to determine if helicopters can traverse a given hexagon.

8. CONTROLLER

A JTLS game may be executed with as few as four terminals, as many as 28 terminals, or any intermediate number of terminals. In any of the configurations, at least one of the terminals is designated as a game Controller terminal. Data management functions are performed at this station. The control function permits the individual to do the following activities:

- Data base modification. At any time in the life of the game, the Controller has access and may alter the game data base.

- Game speed control. The control terminal is used to set and change the speed of the game.

- Post-Processor initiation. One of the Controllers can initiate the Post-Processor during a game pause. This Controller is called the Primary Controller, and is always designated as Player 1.

The primary purpose of the control function is to provide a single point for data base and game speed manipulations. This capability frees the players to concentrate on the strategies and tactics within the scenario itself, and they are relieved of administrative problems. A secondary purpose is to provide a focus for the Technical Coordinator to maintain control of the game progress and modulate the play as required through data base manipulations.

9. TECHNICAL COORDINATOR

The JTLS Technical Coordinator (TC) function is a role nominally staffed by someone who is well versed in operating the computer system used for the wargame. It is the TC who has the responsibility of determining that the system is performing properly. The TC starts the simulation, establishing the proper file structure, saving the necessary history files, and generally determining that the system is responding normally. He also decides whether output will be produced for the Post-Processor and assigns graphics stations to players. The TC usually represents, or is a member of, the computer operations or programming staff of the organization that is responsible for the computer system being used for the simulation. (Ref. 6, pp. 5.1-5.2, 3.1-3.14, 4.1-4.15)

E. STATISTICAL DESIGN

The specific goal for this experiment was to test the following two hypotheses:

- An operational plan (OPLAN) with multiple options or alternatives is superior to an OPLAN with a single option or alternative. That is, multiple option planning is better than single option planning.

- The value of a multiple option OPLAN over a single option OPLAN will increase as the pace, workload, or stress of battle increases. The degree to which multiple-option planning is better than single-option planning is positively related to the pace, workload, or stress of battle, and to the value of time lost during a battle due to the need to replan.

The overall experimental design was a two-factorial within-subjects analysis of variance. The two independent variables were:

- <u>Planning</u>, which manipulates the number of options or contingency plans within an OPLAN. There are two levels:

    1. Single-Option Planning is defined as an OPLAN that has one primary hypothesis of enemy intent, one primary course of action, and one primary estimate of battle outcome.

2. Multiple-Option Planning is defined as an OPLAN that has alternative hypotheses of enemy intent, alternative courses of action, and alternative estimates of battle outcome.

- Battle Workload, which varies a composite of four different attributes that affect time pressure, mental workload, or stress. The four attributes comprising this factor are: the number of air assaults that Orange lands in Blue's rear; the fighting strength of Orange's air-lifted units; the speed of advance of Blue and Orange's forces; and the frequency and accuracy of intelligence reports. There are two levels:

  1. Low Battle Workload is defined as two Orange air assault units to Blue's rear (and two to the front); a fighting strength equal to 600-650 troops and supplies for each of Orange's airlifted units; a speed of advance of 120 km per day; and one report per each simulated hour from National Technical and Theater Strategic Intelligence with 100 percent accuracy.

  2. High Battle Workload is defined as four Orange air assault units to Blue's rear; a fighting strength equal to 1200-1300 troops and supplies for each of Orange's airlifted units; a speed of advance of 160 km per day; and one report per each four simulated hours from National and Theater Strategic Intelligence with 60 percent accuracy.

The resulting design was therefore a 2x2, yielding four treatment conditions. Each team was assigned to one counterbalanced ordering of the four conditions. Counterbalancing of the treatment conditions would help in reducing learning and order effects. (See Figures 2-1 through 2-4.)

TEAM ALPHA			TEAM BETA	
PLANNING	BATTLE WORKLOAD		PLANNING	BATTLE WORKLOAD
SINGLE	LOW		MULTIPLE	HIGH
MULTIPLE	LOW		SINGLE	HIGH
MULTIPLE	HIGH		SINGLE	LOW
SINGLE	HIGH		MULTIPLE	LOW

Figure 2-1. Treatment Ordering

LABELS	FACTURS	LEVELS
A	PLANNING	SINGLE or MULTIPLE OPTION
B	BATTLE WORKLOAD	LOW or HIGH

Figure 2-2. Statistical Design

A		B: LOW	B: HIGH
	MULTIPLE	X_{21}	X_{22}
	SINGLE	X_{11}	X_{12}

Figure 2-3. Factorial Design.

TREATMENT NUMBER	TREATMENT CONDITIONS FACTORS	
	A	B
1	SINGLE	LOW
2	SINGLE	HIGH
3	MULTIPLE	LOW
4	MULTIPLE	HIGH

Figure 2-4. Experimental Design

1. Experimental Variables

Sometimes an experimental design requires a variable or set of variables to create or enhance the experimental milieu. Such variables are often referred to as random situation factors or experimental variables, and do not figure into the statistical analyses. The location and pattern of the Orange air assaults were two such variables. To disguise the multiple appearances of the same manipulation, as well as to foster external validity (applicability to the real world), the exact location of each of Orange's air assaults was varied. Different but comparable units in Blue's rear were attacked. Moreover, the exact look or pattern was also varied so that it sometimes appeared as one big air assault and at other times appeared as two separate air assaults. Another variable was the exact nature of the SITREPS that each headquarters receives at the beginning of an experimental trial. Once again, the SITREPS were varied to mask multiple appearances of the same experimental manipulation.

It was also necessary to inject some variation into the Orange scenario (i.e., script). These variations were necessary to respond to Blue's moves, establish Orange as an intelligent responsive adversary, and make the simulation a better analogue to the real world.

2. Experimental Constants

In addition to the independent and experimental variables, there were a number of experimental constants. These were parameters that were not manipulated but instead were fixed at some value. Some of the important experimental constants were:

- size, geographic location, and terrain of the battle zone: a 300 x 300 mile area in Iran encompassing deserts and mountains;

- Blue's force size and compliment;

- initial starting positions for Blue and Orange;

- primary mission: both Blue and Orange will be directed by their own unchanging primary mission;

- unsolicited intelligence (i.e., that Blue will receive and Orange order) will be set at a 10 percent probability.

- number of HUMINT Teams for Blue will be fixed at 36, once placed will move at 90 km per day, and report at an interval of one report every three hours of simulated time;

- threshold factors, i.e., the level of strength at which a unit changes posture (e.g., attack to defend, defend to delay, etc.)

- weather: good weather will be assumed throughout the entire length of the simulated times; and

- length of simulation: three hours.

3. Blue Task

The Blue team's task in all experimental treatments was to hold its assigned position (i.e., line Bastogne), trap, and annihilate a sizable enemy contingent outside Bam. It was also expected that Blue would thwart all enemy advances or attacks, set and accomplish subgoals to attain primary mission, accomplish goals with minimum self-attrition and maximum efficiency in the employment of communications, supplies, and troops.

4. Workload

The cognitive workload imposed by the experimental treatments, as well as other conditions throughout a trial, was expected to affect the subject's and team's performance. Workload was a construct employed to explain the inability of a human operator to copy with the performance requirements of a task. The literature described three approaches to the measurement of workload:

- Measures of demand, expressed in terms of the objective parameters of the task (e.g., signal quality and information rate).
- Measures of response (either behavioral or physiological).
- The performer's subjective appraisals of the load experienced during the task.

The third approach was employed in this experiment. To assess subjective workload, each subject filled out the Subjective Workload Evaluation Assessment Tool (SWEAT) once every half hour (plus or minus 5 minutes). SWEAT is a pencil and paper questionnaire that asks the subjects to evaluate the time pressure, mental effort, and stress they experienced during the past work period. Subjects make their ratings on a five-point scale, and it usually requires less than 30 seconds to complete the SWEAT measure. SWEAT was used by ALPHATECH on an earlier contract, and at that time, the measured reliability of the instrument (coefficient) was 0.90, indicating very high reliability. Scores on the measure also produced significant main effects and interactions indicating predictive validity.

Using SWEAT provided a validity check on the Battle Workload manipulations. The instrument was also used to track workload throughout an experimental trial, establish the perceived workload for each headquarters, assess perceived workload for each individual within a headquarters, and to reorder the experimental trials to reflect high or low perceived workload.

5. Dependent Measures

A number of dependent variables were assessed. The JTLS simulator produced "checkpoint" data. At any time, JTLS can be requested to output checkpoint data that indicates the latitude and longitude of each element (Blue and Orange) and the current value of each of 12 attributes describing a unit's fighting strength. These data were used to formulate three primary measures of effectiveness (MOE). The first MOE was based on Blue's Forward Line of Troops (FLOT). Blue's final FLOT was compared to its initial FLOT and the amount of advance or withdrawal calculated. The second MOE was the exchange ratio, i.e., Orange's attrition relative to Blue's attrition. The third MOE examined the percentage of Orange troops behind Blue's lines at the end of the game.

Just prior to each experimental trial, subjects were presented with an OPLAN. The OPLAN gave a brief description of the expected outcomes of the plan or plans. Subjects (or headquarters) were asked to examine the expected outcomes and then write their own version, based on their knowledge of the plan and situation. At the game's conclusion, a comparison was made between the initial expected outcome and the final disposition. This provided another MOE that related goals expected to goals achieved.

The JTLS simulator also records a time history of about 70 critical events (e.g., time an airlift began, time an airlift was concluded, time a ground-to-air missile was launched, time maintenance was scheduled, time maintenance was completed, time a logistic request was made, time a logistic request was responded to). A number of process and efficiency measures were constructed from these data, reflecting team performance.

In addition to these observational measures, information was collected and analyzed on the decision processes that occurred throughout the game. These measures allowed the assessment of how single- or multiple-option OPLANS and battle workload levels contributed to a team's meeting or not meeting its goals during a game.

Two major types of measures were planned: 1) measures of the speed with which a team took effective action in response to actions by Orange, and 2) measures of the number and quality of the hypotheses that were generated about the enemy's situation, objectives and possible actions. These measures were based on the HEAT data collection approach, but they concentrated on the subset of discussions and decisions that are most relevant to the hypotheses being tested in the experiment.

These measures were based on data collected by the observers who were assigned to each C^2 cell throughout the game. The observers had two types of observation sheets: a sheet for recording the actions taken by the Blue team, and a sheet for recording the team's hypotheses about the enemy's situation and possible actions.

The ACTION TAKEN observation sheet records the time of each action taken by a Blue team, and the nature of the action. Possible action types include probes for information, requests for assistance, and direct actions such as the movement of forces. For direct actions, the observer recorded his judgment of the effectiveness (quality) of the action on a five-point scale, based on his knowledge of ground truth and his knowledge of the Orange script.

The ACTIONS TAKEN sheet also records the time at which the Blue team first became aware of each Orange action, and the type of Orange action. This is necessary because of the variable lag (from 0 to 12 minutes) between the time that an action is taken by Orange, and the time it appears on the screen of the Blue team. The measure will compute the lag between the time that Blue becomes aware of an Orange action, and the time that an effective action is taken in response. The observer's evaluation of the effectiveness of the action was crucial. The aim was not simply to take some type of action quickly, but to take an effective action quickly. The hypothesis was that a multiple-option OPLAN would help a team to take effective action more quickly in response to an enemy action, especially under conditions of high workload.

The DISCUSSION OF UNCERTAINTIES observation sheet records the hypothesis generation that lies behind the actions taken by the Blue team. The sheet records two types of hypotheses: 1) speculations about where the enemy is currently located, strength and type of units, and 2) speculations about what the enemy may do in the future, based on possible objectives.

The Blue team had some information about the location and strength of Orange, but it was incomplete, and may have been supplemented by hypotheses. The observer recorded the hypotheses that were discussed, the time of the discussion, and the accuracy of the hypotheses. Because the observers had access to ground truth in the game, they knew whether Blue's speculations about the current enemy situation at any time were correct.

The Blue team may also have been expected to discuss the enemy's possible objectives and future actions. Again, the observer recorded the hypotheses discussed, the time of the discussion, and the accuracy of the hypotheses. Because the observers had access to the script being used by Orange, they were able to evaluate the accuracy of Blue's hypotheses.

The observer's record of the time of each hypothesis was used to link the discussions of uncertainty to the actions taken. For example, a discussion of possible enemy locations might lead to the decision to send an HUMINT team to a location to collect definite information. Discussion of possible enemy courses of action might lead to decisions about the allocation of Blue forces.

Discussion of uncertainty was strongly linked to the used of single- and multiple-option OPLANS in the experiment. The team using the multiple-option plan already had several alternative hypotheses about enemy intent laid out in the plan. The team may or may not have chosen to further elaborate these hypotheses. The team with the single-option plan may have chosen to generate some alternative hypotheses, which may or may not have agreed with those provided to the multiple-option team. Data from the DISCUSSION OF UNCERTAINTIES sheet allowed the assessment of the extent to which a multiple-option plan either facilitated the team's discussion of uncertainty or reduced their need to discuss uncertainties during the battle. For example, it was possible that under low stress conditions, a team with a single-option plan would have enough time to generate and evaluate hypotheses, and come up with a flexible, effective course of action, while under high-stress conditions they would not. (Ref. 8, pp. 5-17)

III. ANALYSIS

The design of the experiment was a two way, within subjects, factorial. The factors were Planning (two levels) and Battle Workload (two levels). Factorial experiments yield more complete information than single-factor designs because they permit observation of the interaction effects created by the combination of variables. Such effects are above and beyond those which can be predicted from each variable observed alone. Moreover, the results of a factorial experiment are more practically useful because the estimates of the effects are obtained by averaging over a relatively broad range of other relevant experimental variables. A within subjects design was used to make maximum use of the available teams, and to allow each team to serve as its own contrast.

The statistical analysis was a multivariate analysis of variance, employing the SPSS software package. The multivariate approach was less sensitive to failure to meet the assumptions of the analysis of variance, and thus provided a more robust analysis.

Care was taken to counterbalance experiment conditions and experimental variables. However, a vulnerable point in the design was the assignment of each team to an ordering where a multiple OPLAN condition is followed by a single

OPLAN condition. Concern that teams might apply the multiple options from the previous trial when faced with similar situations under a single option OPLAN was countered by introducing variations in experimental variables to disguise the basic similarity of the trial scenarios. (Ref. 8, pp. 21-22)

Several hypotheses used to form a basis for the trial observations were:

- Humans have limited information processing capacity.
- Humans tend to narrow their consideration of alternatives in high stress situations.
- Humans tend to rationalize following a decision.
- Humans tend to disbelieve information which is inconsistent with strong prior behavioral commitments and will seek out information to confirm the threatened view.
- There tends to be disproportionate amounts of communication directed toward an opinion deviate in a small group.
- Humans are more effective in all-channel communication networks when trying to solve a complex problem and more effective in a hierarchial net when trying to solve a less complex problem.

The order of play was as follows:

	GAME 1	GAME 2	GAME 3	GAME 4
TEAM A				
PLAN	SINGLE	MULTIPLE	MULTIPLE	SINGLE
WORKLOAD	HIGH	HIGH	LOW	LOW
TEAM B				
PLAN	SINGLE	MULTIPLE	MULTIPLE	SINGLE
WORKLOAD	LOW	LOW	HIGH	HIGH

The measurement of command and control effectiveness in the experiment had two components: the outcomes of the wargame and the process by which outcomes were achieved. Outcome measures indicate the degree to which the Blue teams in the experiment achieved their objectives in the game; process measures provide more detail on how they went about achieving those goals.

Outcome measures were determined by the goals that were set for the Blue team at the beginning of the game. These goals were to defend the Line Bastogne and to prevent any significant enemy penetration of the Line. This was to be achieved with the minimum attrition of Blue forces. Achievement of these goals was measured through two major factors: movement and troop losses. The JTLS program provided location and strenth data for all units at the beginning and the end of the game, as well as periodic reports, which might be used to compute outcome measures.

Figures 3-1 through 3-5 show some of these results.

	SINGLE PLAN	MULTIPLE PLAN		
HIGH WORKLOAD	10.0	8.5	9.2	NS
LOW WORKLOAD	9.6	12.2	10.9	
	9.8	10.4		

$p < .05$

INTERACTION NS

Figure 3-1. Average Time Elapsed (in Minutes) Before First Definitive Action After Enemy Air Assault (From Observations)

	GAME 1	GAME 2	GAME 3	GAME
TEAM A	HIGH WORKLOAD SINGLE OPTION 15.0 ACTION: ATTACK HELOS	HIGH WORKLOAD MULTIPLE OPTIONS 6.0 ACTION: ATTACK HELOS AND ARTILLERY	HIGH WORKLOAD MULTIPLE OPTIONS 3.0 ACTION: AIR LIFT	HIGH WORKLOAD SINGLE OPTION 3.0 ACTION: MOVE TO AVOID CALL FOR GAS
TEAM B	LOW WORKLOAD SINGLE OPTION 16.3 ACTION: ATTACK HELOS AIR LIFT MOVE TROOPS	LOW WORKLOAD MULTIPLE OPTIONS 21.5 ACTION: ATTACK HELOS	HIGH WORKLOAD MULTIPLE OPTIONS 11.0 ACTION: ATTACK HELOS	HIGH WORKLOAD SINGLE OPTION 5.0 ACTION: MOVE TROOPS

Figure 3-2. Average Time Elapsed (in Minutes) Before First Definitive Action After Enemy Air Assault (From Observations)

	SINGLE PLAN	MULTIPLE PLAN	
HIGH WORKLOAD	2.51	2.32	2.42
LOW WORKLOAD	2.35	2.13	2.24
	2.43	2.22	

Figure 3-3. Average Subjective Workload Score During Period in Which Air Assault Occurred

	SINGLE PLAN	MULTIPLE PLAN	
HIGH WORKLOAD	2.55	2.53	2.54
LOW WORKLOAD	2.29	2.48	2.38
	2.42	2.50	

NO SIGNIFICANT EFFECTS

Figure 3-4. Average Subjective Workload Score Throughout Game

	SINGLE PLAN	MULTIPLE PLAN	
HIGH WORKLOAD	53.5	76.5	65.0
			$p < .06$
LOW WORKLOAD	69.5	91.5	80.5
	61.5	84.0	
	$p < .02$		

INTERACTION NS

Figure 3-5. End-of-Game Effectiveness Measure: Computed As A Function of Planned Versus Actual Enemy Advance, Weighted by Enemy Attrition

Figures 3-6 and 3-7 show a pattern of increasing subjective workload as the game progressed for the multiple-option conditions, and decreasing or constant perceived workload for the single-option conditions. This result is puzzling, and suggests that the presence of the multiple-option plan may have had effects on perceived workload that go beyond the effort associated with early reactions to the air assault. Perhaps the multiple-option plan allowed subjects to deal with the early air attack without high stress or high workload, and they were therefore able to increase their effort level or workload and take more initiative during the last part of the game.

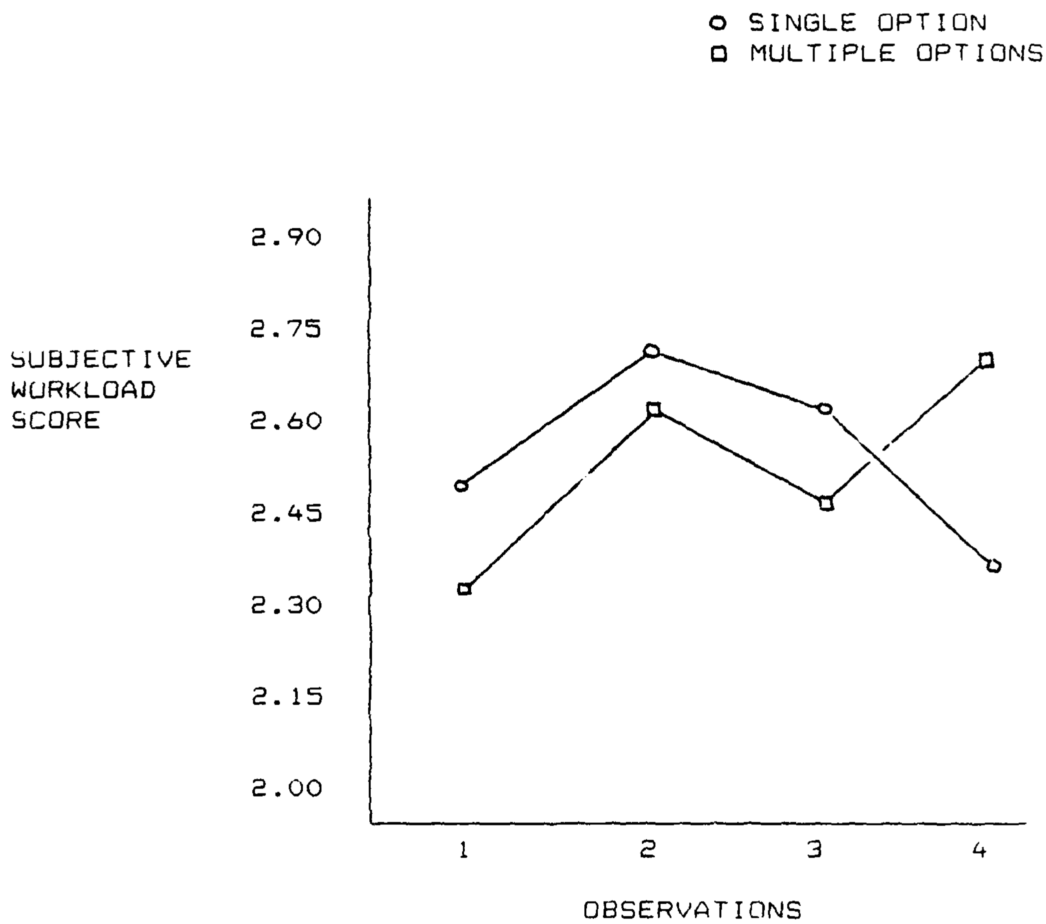


Figure 3-6. Subjective Workload (High Stress)

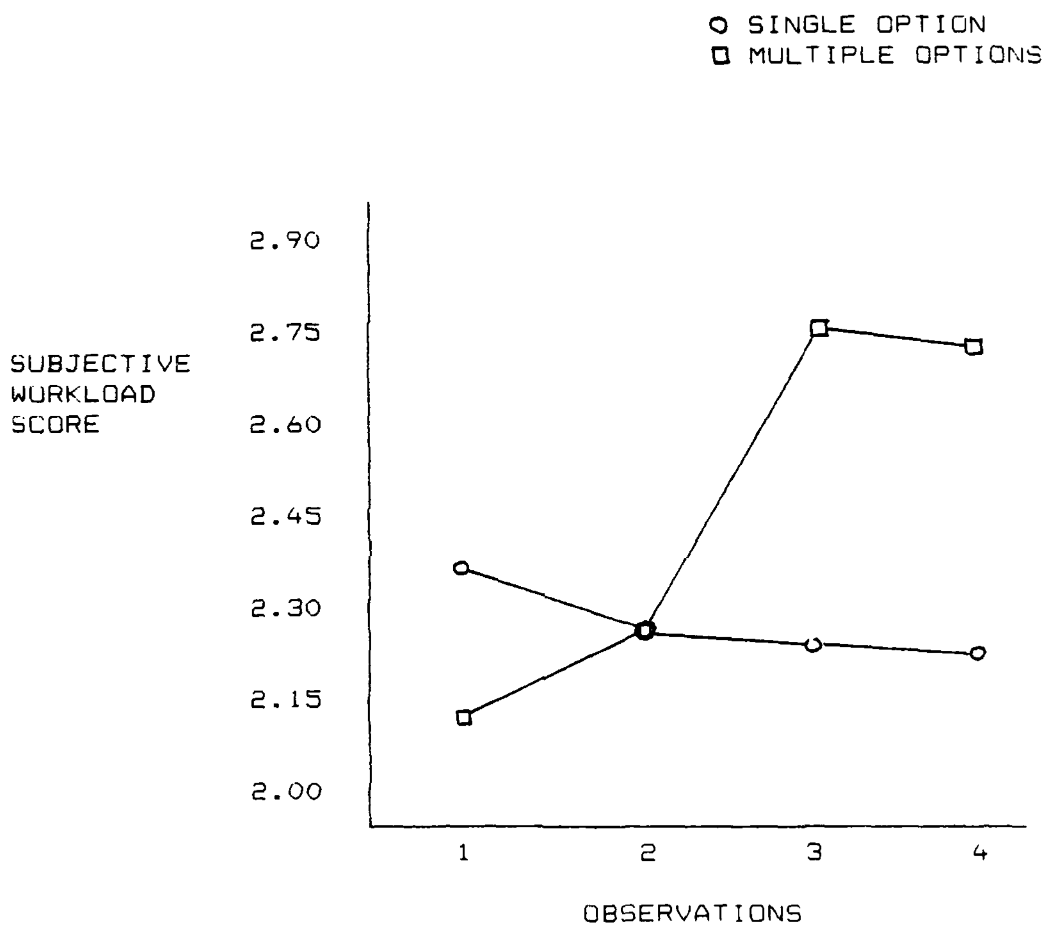


Figure 3-7. Subjective Workload (Low Stress)

The outcome measures used in the experiment do not reveal an increase in Blue effectiveness during the last part of the game under a multiple-option plan. However, Blue troop losses increased during the last part of the game under the multiple-option, while decreasing under the single-option plan. This suggests that the players using the multiple-option plan may have been taking more aggressive action toward the end of the game, and the outcome measures may not be sensitive enough to detect the effects of this action. (Figure 3-8 through Figure 3-11.)

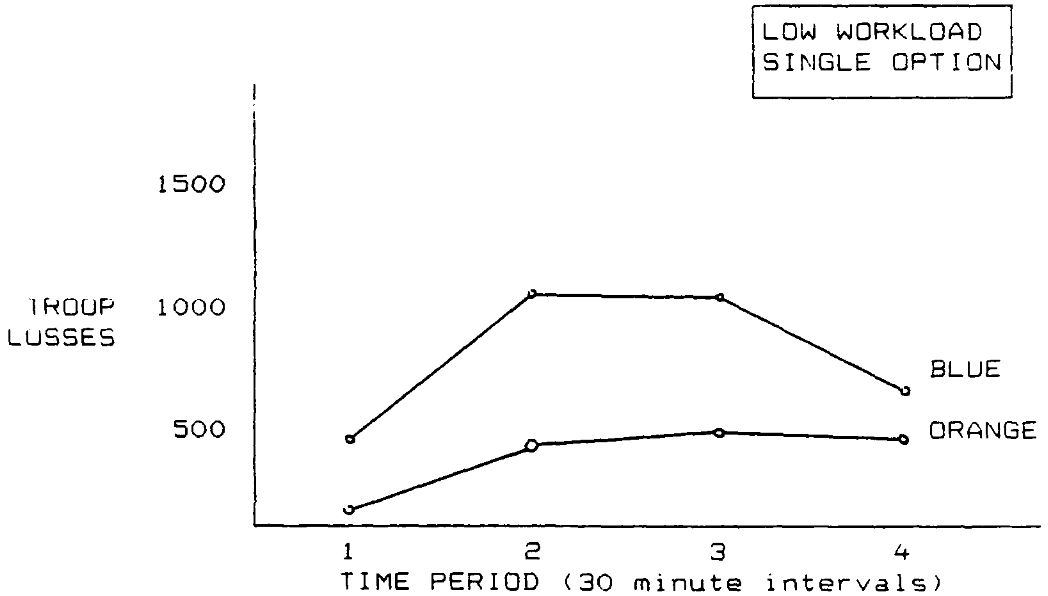


Figure 3-8. Total Troop Losses Over Time (L.W./S.O.)

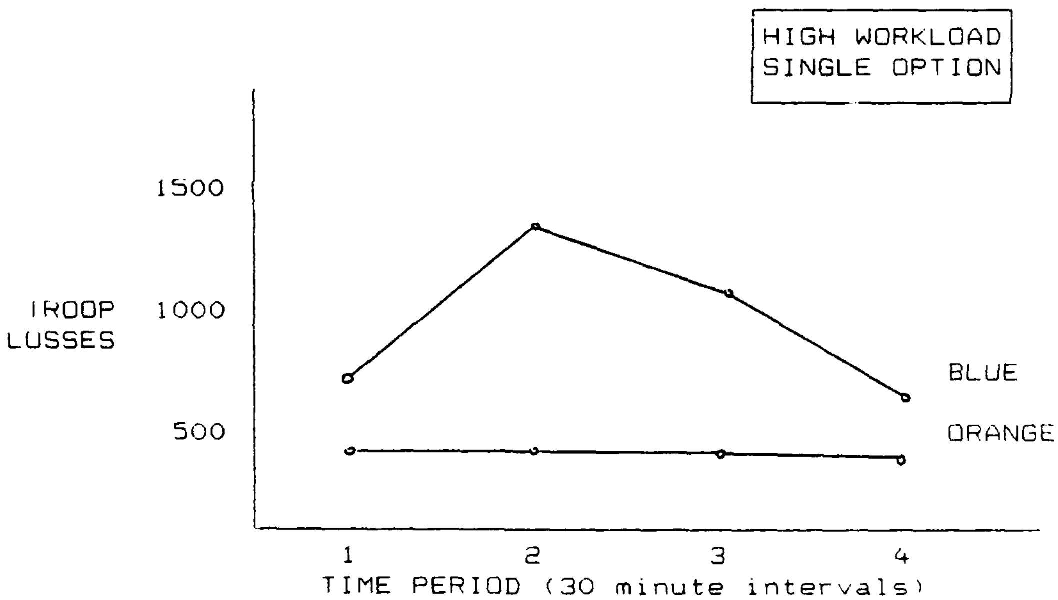


Figure 3-9. Total Troop Losses Over Time (H.W./S.O.)

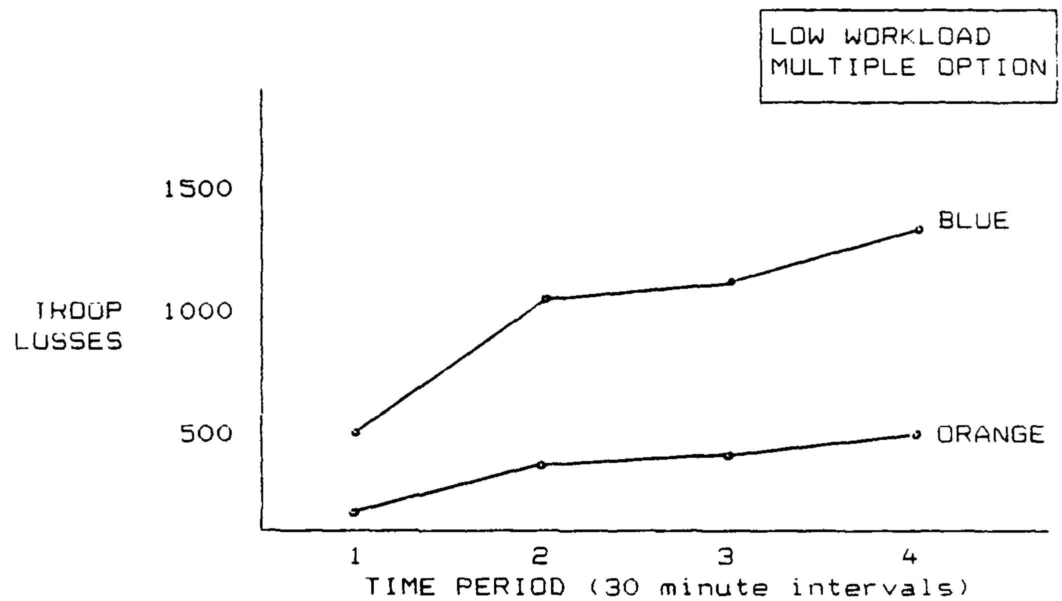


Figure 3-10. Total Troop Losses Over Time (L.W./S.O.)

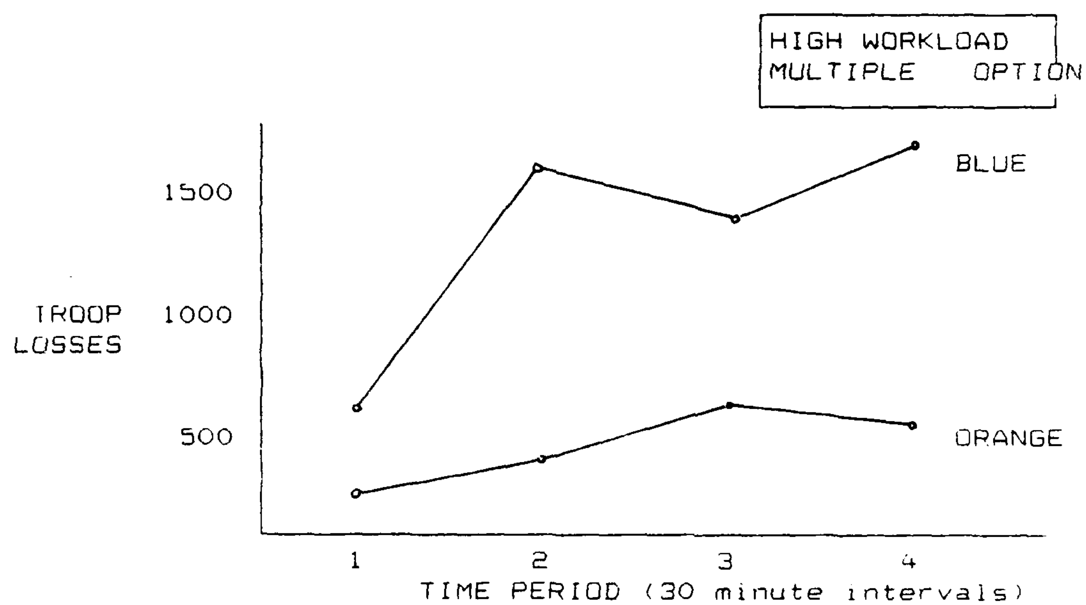


Figure 3-11. Total Troop Losses Over Time (H.W./S.O.)

Players rated their subjective workload during the experiment. Every 30 minutes, each player was asked to complete a Subjective Workload Evaluation Assessment Tool (SWEAT) questionnaire. This was a brief questionnaire that asked subjects to make three ratings on a five-point scale to evaluate the stress, mental effort, and time pressure they had experienced during the previous half hour. (Figures 3-12 through 3-15.)

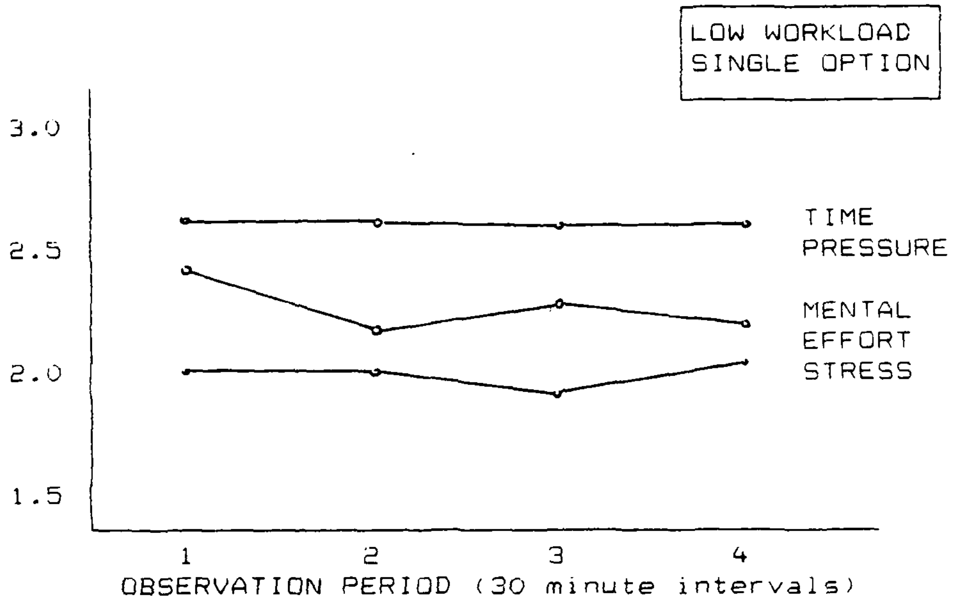


Figure 3-12. Subjective Workload Evaluation Assessment (L.W./S.O.)

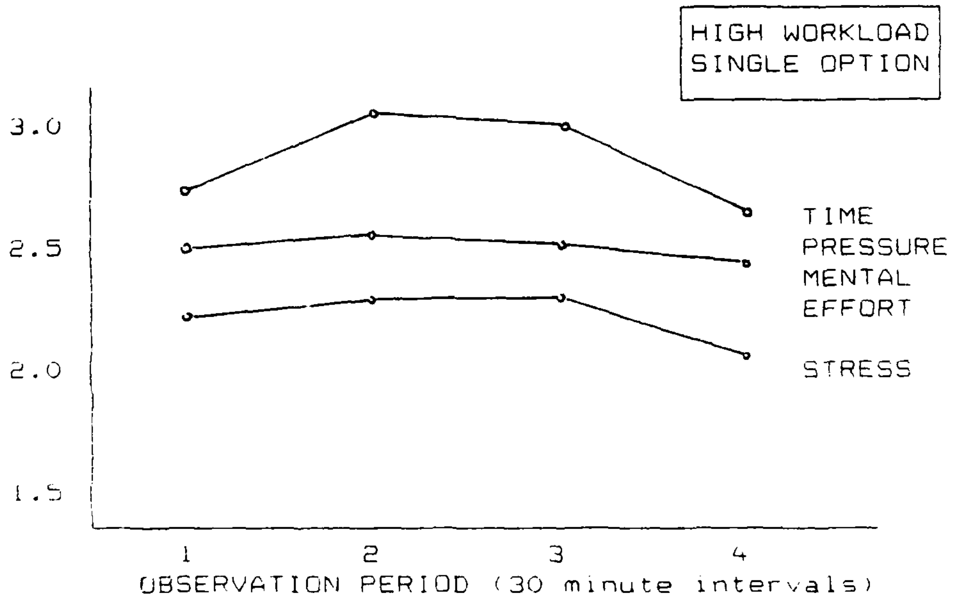


Figure 3-13. Subjective Workload Evaluation Assessment (H.W./S.O.)

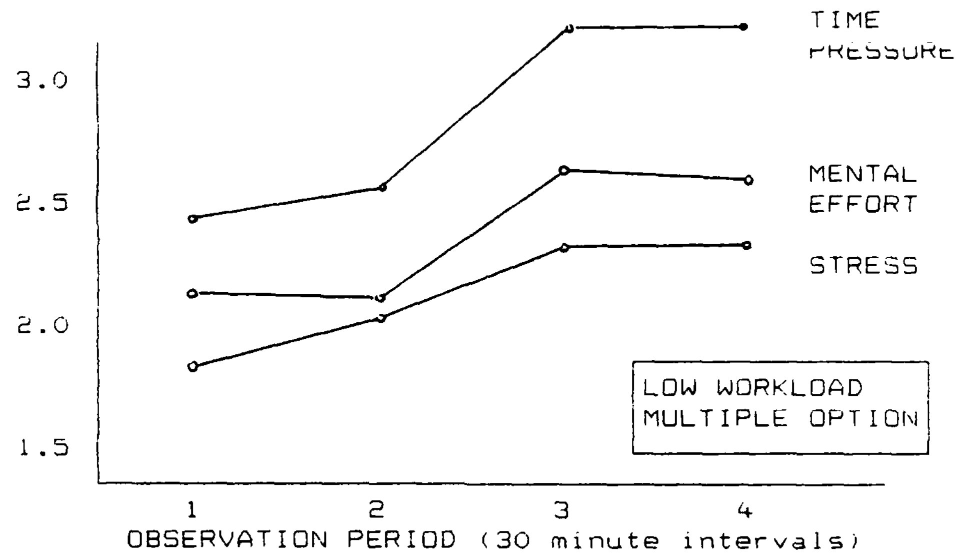


Figure 3-14. Subjective Workload Evaluation Assessment (L.W./M.O.)

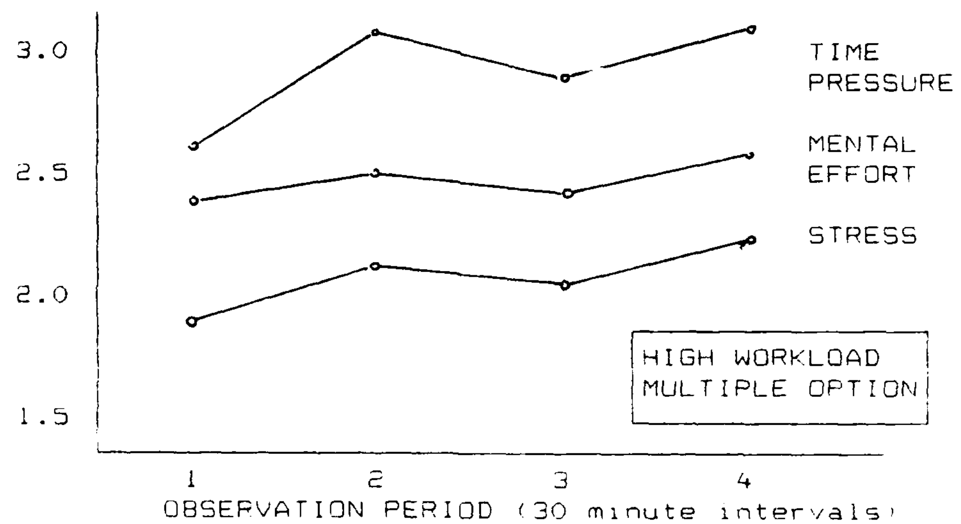


Figure 3-15. Subjective Workload Evaluation Assessment (H.W./M.O.)

IV. DISCUSSION AND OBSERVATIONS

The positive results of the experiment should not be overshadowed by individually evaluating the preliminary goals. The unique attempt of the experiment was the repetitive use of a model that provided the opportunity for insight into the relative merits of alternative courses of action, force structures, and procedures during joint force combat operations. The lessons learned show some minor drawbacks to repetition but they are things that can be overcome by modifying the experimental design execution. The repetitive use of JTLS or any other game, like the current experiment utilizing JANUS, is helpful in identifying trends during execution. The specific outcome is not the purpose. (Ref. 9, p. 95) CINC's will not exercise in the manner of this experiment. They play only one game. The designs, architectures, etc. learned from these analytical series of experiments provide plausible scenarios.

Several lessons were learned from this experiment.

- Outcome measures are dependent on the characteristics of the software used for the simulation.
- Limits on game time may lead to artificial behavior.
- Formal training of observers is essential.
- Subjects may act to keep their overall subjective workload constant.

- Strong learning effects should be expected with game repetitions.

Observed features in the JTLS model include:

- The terrain over which the battle was conducted is overlayed with hexagons (hex). The model prohibits a Blue Force and Orange Force from occupying the same hex, regardless of unit size.

- The attrition of fixed wing air missions was reported to be stochastic. It was noted that Blue air, which was extensively used, suffered high losses. Orange air was seldom used and suffered only one loss. This suggests the need for in-depth investigation into the underlying game mechanism and the statistical analysis of game data to verify the stochastic nature of attrition.

The direction this experiment had at the beginning was to meet certain needs.

- Provide a quantitative framework to describe the operation of real headquarters.

- Provide analytical tools for use in that framework to go from data to design.

- Provide empirical tools to collect data in a form consistent with the framework.

- Provide opportunities to apply those tools to gather operational data.

The goals established for this experiment were:

- For operational commands:

  * a method for extracting more insight from exercises

  * a method to identify trends through a series of exercises

  * develop more effective deployed headquarters architectures

- For systems commands:

  * a tool to objectively and accurately assess program alternatives

  * a tool to verify and validate headquarters performance

- For systems engineers:

  * high level guidelines for better headquarters design

- For design guidance:

  * establish some general design principles

  * provide historical data for comparison

  * provide analytical tool for sensitivity analysis

- For data collection:

  * provide a well structured set of measures to guide data collection

  * be an analyst's toolkit to recover information from raw data

- For theory:

  * provide a unified framework for the study of command and control

  * provide specific theoretical and analytical results

V. CONCLUSIONS AND RECOMMENDATIONS

Multiple-option planning does appear to have some effect on headquarters effectiveness. However, the effects were limited in scope. When effectiveness is measured by the success of the Orange enemy in meeting its goals, the first major hypothesis of the experiment is confirmed: Headquarters effectiveness was higher when a multiple-option plan was used. The expected interaction was not observed, however. The difference between single- and multiple-option planning was not affected by workload as implemented in this experiment. It is possible that the differences induced by the low and high workload manipulations in the experiment were not great enough to create the expected interaction between the plans and workload. Such an interaction might be observed under higher workload conditions.

A more focused analysis of the outcome of the rear area battle also showed an effect of multiple-option planning. The Blue team was most effective in the rear area conflict, as measured by troop exchange ratios, under a multiple-option plan and low-workload conditions. This conclusion applies only to the rear area battle, however. There were no differences in the overall exchange ratio by experimental condition.

Multiple-option planning had several different effects on the processes that went on within each headquarters during the experiment. The presence of a multiple-option led to a better reaction to the enemy air assault under conditions of low workload. The multiple-option plan also led to lower subjective workload assessments immediately following the assault. Commanders were less certain about enemy intent at the beginning of the game if they were given a multiple-option plan, and division headquarters seems to have pursued a more active role, as measured by their delay in reading their electronic mail. The higher workload in division headquarters under a multiple-option plan is supported by the analysis of subjective workload throughout the experiment. As the game progressed, players in the multiple-option plan condition showed an increase in their subjective workload, while players in the single-option condition did not.

Overall, the multiple-option plan seems to have resulted in a better reaction to the air assault, at a lower cost in terms of workload early in the game. Players became more active later in the game when they had a multiple-option plan, and showed more active communications with division headquarters.

A correlation analysis suggests that the two independent variables in the experiment, planning and workload, affected headquarters processes during the experiment, and that these processes, in turn, affected wargame outcomes. Both plans and externally imposed workload were correlated with end-of-game effectiveness in the expected direction. The presence of a multiple-option plan had a substantial positive correlation with rear exchange ratios (.71) and with end-of-game effectiveness. (.80) The correlation patterns suggest that both subjective workload and false certainty about enemy intent may have mediated the effects of planning on effectiveness. The multiple-option plan led to a lower workload following the assault, but to less certainty about the enemy's objectives. Both of these factors may have contributed to higher effectiveness.

Externally imposed workload was negatively related to end-of-game effectiveness (-.55). The major mediating factors identified for this relationship are communications volume and false certainty about intent. Higher workload conditions were associated with more communication, which was negatively related to end-of-game effectiveness. External workload was also positively related to certainty, which had a negative relationship to effectiveness measures.

The results of the experiment support the hypothesis that multiple-option planning has a positive effect on headquarters effectiveness. Blue teams performed better in frustrating enemy objectives when they were provided with a multiple-option plan. The interaction expected between planning and workload was not observed, however. The positive effect of multiple-option planning on overall outcomes was about equal under conditions of low and high workload.

Planning had several interesting effects on the headquarters processes observed during the experiment. First, the presence of multiple-option plan for dealing with an enemy air assault led to a lower subjective workload in the period immediately following the assault, and subjective workload had a negative relationship to outcomes. The multiple-option plan also seems to have made commanders less certain about the enemy's intent. Perhaps it introduced an element of doubt into their minds about possible enemy actions. This uncertainty had a positive effect on the outcomes of the battle. These findings suggest a multiple-option plan may improve effectiveness by decreasing workload, and by discouraging a false sense of certainty about what the enemy will do. Experimentally-induced workload was negatively related to overall effectiveness, as expected. One of the effects of higher workload was to increase communications volume, which had a negative relationship to outcome measures.

The Joint C3 simulator project will address the future simulator needs of individual services and the future simulator needs when performing joint operations. The simulator will be made up of geographically dispersed, interconnected command centers. It will provide the means to experiment with and test the functioning of total systems.

The use of JTLS as a tool for repetitive use in evaluating headquarters effectiveness has a promising future. A government contractor is currently conducting extensive improvements to the JTLS software to "fix" some of the problems discovered during previous play. The "game" provides a great deal of data to be used by HEAT/WHITE. Better game preparation by subjects is highly recommended. This would remove the learning curve on "game play" and allow the subjects attention to be fully devoted to option planning and headquarters "play".

The results of the experiment suggest two promising paths for future work. First, it seems possible to establish links between measures of headquarters processes and measures of headquarters effectiveness that are based on battle outcomes. The two outcome measures used in the experiment were highly correlated with each other, supporting the idea that both are related to an underlying concept of effectiveness. Meaningful correlations were observed between process measures and outcome measures, especially subjective workload and false certainty about enemy intent. (Ref. 10, pp. 17, 29-30, 34-35, 54-55)

LIST OF REFERENCES

1. Hardee, N.E., An Assessment of the Ability of the Headquarters Effectiveness Assessment Tool (HEAT) to Quantify the C2 System Effectiveness of a Simulated U.S. Navy Tactical-Level Headquarters Under Periods of Communications Stress, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1985.

2. Defense Systems, Inc., Measures of Effectiveness and the Headquarters Effectiveness Assessment Tool, Volume I, 31 March 1983.

3. Defense Systems, Inc., The HEAT User's Manual, Draft, 26 July 1984.

4. Defense Systems, Inc., Design Considerations and Guidelines for Theater Headquarters Effectiveness, 31 March 1983.

5. Hoffman, P.J., Preliminary Analysis and Review of HEAT (Headquarters Effectiveness Assessment Tool), Draft, Naval Postgraduate School, Monterey, California, 30 April 1985.

6. Jet Propulsion Laboratory, California Institute of Technology, Joint Theater Level Simulation Manuals, Executive Overview, May 1986.

7. Cushman, J.H., Think Piece for NDU's CCRP Workshop, Draft, 18 June 1987.

8. Entin, Elliot E., Lentz, Paul, and MacMillan, Jean, The Effects of Option Planning and Battle Workload on Command and Control Effectiveness, August-September 1987.

9. Barrowman, M.A.M., Evaluation of Operation Plans Using the Joint Theater Level Simulation, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1987.

10. Entin, Elliot E., Lentz, Paul, and MacMillan, Jean, Experiment Report: The Effects of Option Planning and Battle Workload on Command and Control Effectiveness, January 1988.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Library Code 0142 Naval Postgraduate School Monterey, California 93943-5002	2
2.	Curricular Office, Code 39 Naval Postgraduate School Monterey, California 93943-5000	2
3.	Superintendent, Code 74 ATTN: Professor C.R. Jones Naval Postgraduate School Monterey, California 94943-5000	1
4.	Superintendent, Code 55st ATTN: Cdr. J.S. Stewart, II, USN Naval Postgraduate School Monterey, California 93943-5000	2
5.	Superintendent, Code 62Bb ATTN: Maj. T.J. Brown, USAF Naval Postgraduate School Monterey, California 93943-5000	1
6.	Lt. Thomas D. Sloan, USN 4916 Petersburg Road Knoxville, Tennessee 37921	1
7.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22304-6145	2