

2

AD-A208 480

NAVAL POSTGRADUATE SCHOOL

Monterey, California



DTIC
ELECTE
JUN 05 1989
S H D

THESIS

ANALYSIS OF RESUPPLY OPTIONS
FOR AN ARMOR BATTALION

by

Ronald G. McCandless

March 1989

Thesis Advisor: Samuel H. Parry

Approved for public release; distribution is unlimited.

89 6 05 048

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)	
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) 55	7a. NAME OF MONITORING ORGANIZATION NAVAL POSTGRADUATE SCHOOL	
6c. ADDRESS (City, State, and ZIP Code) MONTEREY, CA 93943-5000		7b. ADDRESS (City, State, and ZIP Code) MONTEREY, CA 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) ANALYSIS OF RESUPPLY OPTIONS FOR AN ARMOR BATTALION			
12. PERSONAL AUTHOR(S) McCANDLESS, RONALD G.			
13a. TYPE OF REPORT MASTER'S THESIS	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) 1989, MARCH	15. PAGE COUNT 64
16. SUPPLEMENTARY NOTATION THE VIEWS EXPRESSED IN THIS THESIS ARE THOSE OF THE AUTHOR AND DO NOT REFLECT THE OFFICIAL POLICY OR POSITION OF THE DEPARTMENT OF DEFENSE OR THE U.S. GOVERNMENT.			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP	
		HIGH RESOLUTION MODEL, JANUS, RESUPPLY, RESUPPLY VEHICLES, RESUPPLY DOCTRINE, BATTALION RESUPPLY	
19. ABSTRACT (Continue on reverse if necessary and identify by block number)			
<p>Forward area resupply of combat maneuver units is analyzed in this thesis by using the Janus(TRASANA)(T) high resolution combat model. The goal of this thesis is to analyze two different resupply vehicles and various doctrinal concepts for the deployment of these vehicles. Combat between a United States Army battalion task force and two Soviet tank regiments generates a need for the U.S. force to resupply. Using various doctrines the resupply vehicles will attempt to provide logistic support to the U.S. forces.</p>			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL SAMUEL H. PARRY		22b. TELEPHONE (Include Area Code) (408) 646-2779	22c. OFFICE SYMBOL 55Py

Approved for public release; distribution is unlimited.

ANALYSIS OF RESUPPLY OPTIONS FOR AN ARMOR BATTALION

by

Ronald G. McCandless
Captain, United States Army
B.S., United States Military Academy, 1977

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
March 1989

Author: Ronald G. McCandless
Ronald G. McCandless

Approved by: Samuel H. Parry
Samuel H. Parry, Thesis Advisor

Bard K. Mansager
LTC Bard Mansager, Second Reader

P. Purdue
Peter Purdue, Chairman, Department of
Operations Research

K. T. Marshall
Kneale T. Marshall, Dean of Information
and Policy Sciences

ABSTRACT

Forward area resupply of combat maneuver units is analyzed in this thesis by using the Janus(TRASANA)(T) high resolution combat model. The goal of this thesis is to analyze two different resupply vehicles and various doctrinal concepts for the deployment of these vehicles. Combat between a United States Army battalion task force and two Soviet tank regiments generates a need for the U.S. force to resupply. Using various doctrines the resupply vehicles will attempt to provide logistic support to the U.S. forces.



Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Avail and/or	
Dist	Special
A-1	

TABLE OF CONTENTS

I.	INTRODUCTION	1
A.	BACKGROUND	1
B.	PURPOSE AND GOAL	2
C.	METHODOLOGY	2
II.	MODEL DEVELOPMENT	4
A.	SCENARIO	4
1.	Force Structure	4
2.	Terrain	4
3.	Combat Scenario	6
4.	Assumptions	10
B.	MODEL PARAMETERS	10
1.	Janus(T)	10
2.	Direct Fire	11
3.	Indirect Fire	11
4.	Combat Vehicle Capabilities	12
a.	Ammunition	12
b.	Fuel	14
C.	RESUPPLY	15
1.	General	15
2.	Resupply Vehicle Capabilities	19
a.	HEMTT	19
b.	ARMS	20
3.	Resupply Doctrine	21

III. SIMULATION RESULTS 23

 A. OVERVIEW 23

 B. MEASURES OF EFFECTIVENESS (MOES) 25

 C. COMPARISON BETWEEN RESUPPLY FLEETS 26

 1. General 26

 2. Vehicle Type 26

 3. Resupply Doctrine 27

IV. STATISTICAL ANALYSIS 41

 A. TWO SAMPLE t-TEST 41

 1. Example 1 42

 2. Example 2 43

 B. REGRESSION ANALYSIS 45

V. CONCLUSIONS AND RECOMMENDED RESEARCH 49

 A. CONCLUSIONS 49

 B. RECOMMENDED RESEARCH 50

LIST OF REFERENCES 51

BIBLIOGRAPHY 52

INITIAL DISTRIBUTION LIST 53

LIST OF TABLES

1.	INITIAL BLUE COMBAT EQUIPMENT	5
2.	INITIAL RED EQUIPMENT	5
3.	AMMUNITION STORAGE CAPABILITY	12
4.	REDUCED BASIC LOAD	14
5.	BLUE FORCE FUEL USAGE RATES	15
6.	HEMTT AND ARMS OPERATING CHARACTERISTICS	21
7.	FIRST REGIMENT VEHICLE STATUS	24
8.	BLUE FORCE VEHICLE STATUS	24
9.	BLUE FORCE AMMUNITION STATUS	25
10.	T-TEST ON MEAN OF RED TANK LOSSES	44
11.	T-TEST ON MEAN OF BLUE TOTAL LOSSES	44
12.	REGRESSION RESULTS	48

LIST OF FIGURES

1. Map of Scenario Area 7

2. Soviet Formation 9

3. Fuel HEMTT 16

4. Cargo HEMTT 16

5. Trains Locations 18

6. ARMS 20

7. Red FST-2 Losses 29

8. Red BMP-2 Losses 30

9. Total Red Losses 32

10. Blue Abrams Losses 33

11. Blue Bradley Losses 35

12. Total Blue Losses 36

13. Vehicles Uploaded 38

14. Ammunition Uploaded 39

15. Regression of FST-2 Losses on Ammunition Uploaded .. 46

16. Plot of Residuals 47

ACKNOWLEDGEMENTS

I wish to express my thanks and sincere appreciation to my thesis advisor, Professor Samuel H. Parry. His tolerance, professional assistance, and expertise in combat modeling made this thesis possible. He was always available to listen and offer outstanding guidance and advice.

Special thanks to my second reader, LTC Bard Mansager. His encouragement and attention to detail in proof reading are greatly appreciated.

My sincere appreciation to everyone at TRAC-Monterey. MAJ Hirome Fujio for his instruction and expertise in Janus(T). CPT Jim Hoffman for assisting in making the production runs of the simulation. Especially for the runs which were made at 0500 hours or on the weekends.

Finally, my sincerest thanks to my wife, Trudy, for her proof reading, understanding, and encouragement.

I. INTRODUCTION

A. BACKGROUND

Since World War II, the United States Army has been fielding combat vehicles with greater mobility, firepower, and survivability. The tactics and doctrine of the Army have become more offensively oriented to improve the utilization of these new combat systems' capabilities. The Warsaw Pact forces have been making similar improvements in their equipment and doctrine. While these advances have been made in the areas of combat vehicles, the logistic vehicles tasked to provide the logistic support for the combat vehicles and the AirLand Battle doctrine have not changed since the 1940s. The modern Army is still supported by wheeled, soft-skinned vehicles similar to the vehicles which supported the Army in World War II. These logistic vehicles are lacking the mobility of modern fighting vehicles, and do not provide protection to the crew and cargo from artillery and small arms fire. The United States Army needs improved logistic vehicles if it is to be successful on the modern lethal battlefield. Based upon this concept, this thesis will analyze two different logistic vehicles and five doctrines for support of the modern Army.

B. PURPOSE AND GOAL

The purpose of this thesis is to analyze the logistic requirements of a United States Army armor battalion and recommend a logistic fleet and doctrine which can provide the logistic support required on the modern battle field. The Janus(T) combat model will be used to provide the combat scenario which will generate the logistic requirements for the resupply fleet to replenish.

The Janus(T) combat model is a high resolution combat model which can simulate the interaction of individual combat systems on the battlefield. Janus(T) is an approved and widely used combat model for combat simulations by the U.S. Army. It was chosen for this thesis because of its ease of use, terrain resolution, and its ability to be used as an analysis tool.

Specifically, the goal of this thesis is to analyze various resupply fleets and the doctrine for resupplying a combat battalion in a defensive scenario.

C. METHODOLOGY

To build a scenario, an area in the Federal Republic of Germany near the Fulda Gap was chosen. This area was selected because it resembles the terrain on which the Army will fight in a European combat scenario. A Soviet force (Red) will attack a defending U.S. Army force (Blue). The resulting combat will generate the need for the Blue force to

resupply ammunition and fuel. Three different types of ammunition, (120mm tank main gun, TOW missiles, and 25mm chain gun) and one type of fuel (diesel) will be resupplied by the Blue force's organic resupply fleet. This resupply fleet will be allowed to be attrited by Red artillery fire.

Based upon different configurations of the resupply fleet and different doctrines concerning the deployment of these fleets, various results will be achieved by the fleet in its attempt to resupply the Blue force. The result of the resupply effort to replace expended ammunition and fuel will be analyzed along with the outcome of the combat scenario to evaluate the different fleets and the various doctrines for their use.

II. MODEL DEVELOPMENT

A. SCENARIO

1. Force Structure

The Blue defending unit is a battalion task force consisting of two M1A1 Abrams Main Battle Tank (MBT) equipped Armor companies, two M2 Bradley Infantry Fighting Vehicle (IFV) equipped Infantry companies, and one M3 Cavalry Fighting Vehicle (CFV) equipped Scout platoon. The Blue forces are defending from prepared fighting positions. The Red attacking force consists of two tank regiments from a Soviet tank division equipped with the Future Soviet Tank-2 (FST-2), and BMP-2. The Red forces have the organic regimental artillery along with the higher-echelon artillery systems normally available at the regimental level. The Soviet force organization, equipment, and tactics were obtained from U.S. Army field manuals. [Refs. 1 and 2] Initial force structure of the Blue force is shown in Table 1, and the initial force structure of the Red force is shown in Table 2.

2. Terrain

The battle area in this scenario was chosen because it is the typical terrain on which the U.S. Army could be expected to fight in Europe. The Fulda Gap is an historical avenue of approach into Germany. It is one of the major

TABLE 1
INITIAL BLUE COMBAT EQUIPMENT

Weapon Class	Type	Weapon	Number
Direct Fire Weapons	MBT	M1A1	30
	IFV	M2	26
	CFV	M3	6
Indirect Fire Weapons	Mortar	4.2 in	6
	Howitzer	155 mm	24

TABLE 2
INITIAL RED EQUIPMENT

Weapon Class	Type	Weapon	Number
Direct-Fire Weapons	MBT	FST-2	180
	IFV	BMP-2	60
Organic Indirect-Fire Weapons	Mortar	82 mm	12
	Howitzer	122 mm SP	36
Higher-Echelon Indirect-Fire Weapons	Howitzer	122 mm SP	36
	Howitzer	152 mm SP	18
	MRL	BM-21	18
Helicopters	ATK	Hind D	8

avenues of approach that the Soviets are expected to use in an invasion of Europe. This area is characterized by gently rolling farmland with forested hillsides. The countryside is dispersed with small farming villages connected by secondary class roads. Numerous small streams and rivers do not pose significant obstacles to a mounted Red attack. A map of this terrain area with the Blue defensive battle positions and the Red avenues of attack is shown in Figure 1.

3. Combat Scenario

The combat scenario utilized in this thesis was designed to stress the forward area resupply capabilities of a defending Armor task force. The battle takes place several days into the war, and the Blue forces no longer have large enough ammunition supplies for full combat loads of ammunition. This assumption was made to force the combat units to resupply. Several trial runs of the scenario showed that the Blue forces, if given full basic loads of ammunition, could defeat the two Red regiments without a need for resupply.

The Blue force is defending from a battalion battle position with the four companies each fighting as a pure unit from a company battle position. Battalion scouts are screening in front of the battalion. Their mission is to detect the Red force and to deceive the Red force about the true battle positions of the Blue force.

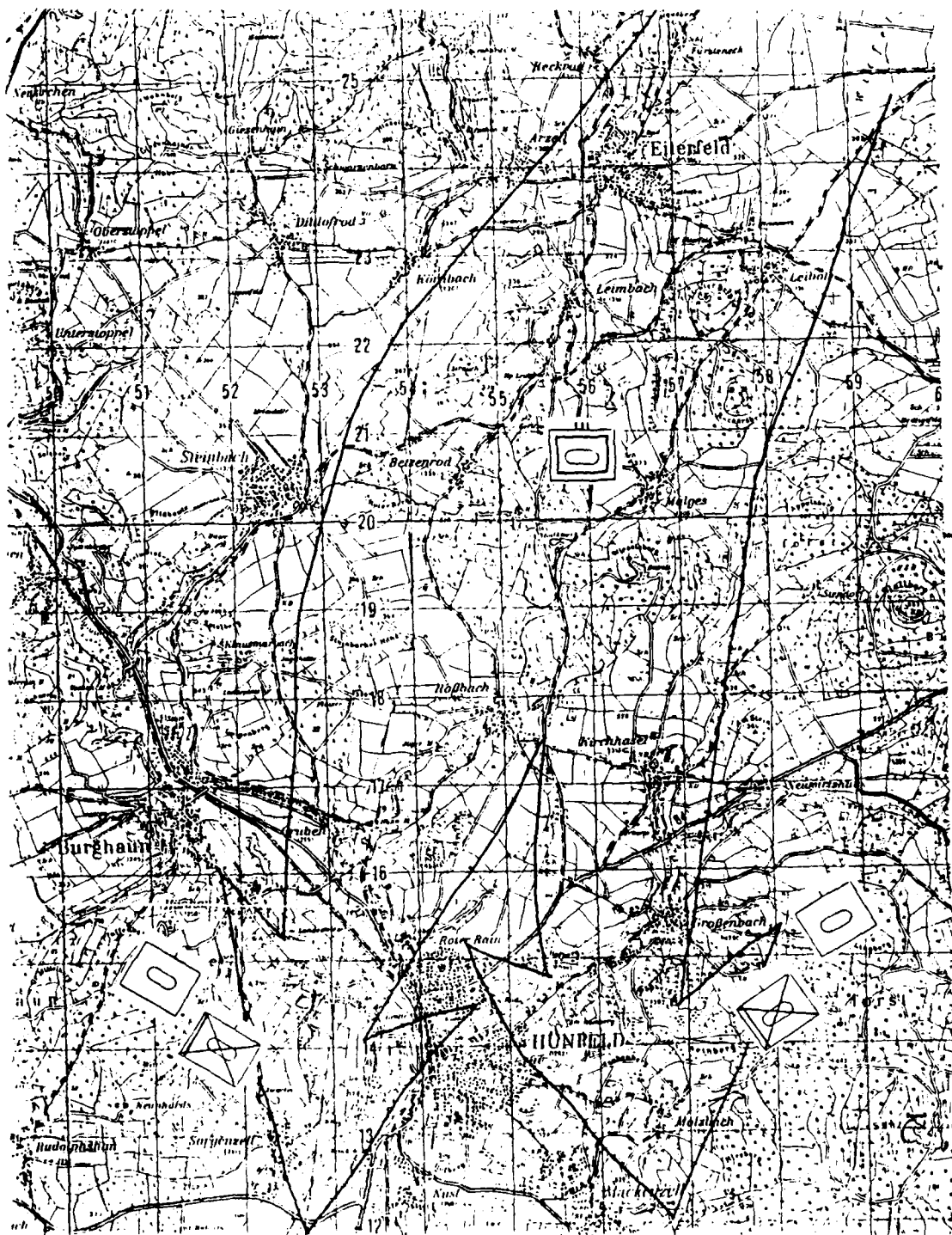


Figure 1. Map of Scenario Area

The attacking Red force is composed of two tank regiments from a Soviet tank division. Figure 2 shows the initial deployment of the leading Red regiment. There are three tank battalions in each of the regiments, each consisting of three tank companies and a reinforcing BMP company. Both regiments are attacking with two lead battalions abreast, and the third battalion is trailing behind the leading two. The second echelon regiment is trailing fifteen kilometers behind the leading regiment. All of the combat vehicles in the units are positioned to the norms of Soviet doctrine. Each combat vehicle has been assigned its own attack route which will keep it in formation with the other vehicles in the unit.

This combat scenario will be repeated for each of the resupply options. The actual ground combat will be held as constant as possible while the various resupply options are used to resupply the ammunition expended by the Blue force. For each of the resupply options the first 45 minutes of simulation will be held constant. This 45 minute period is the end of first regiment battle and the point from which the scenario continues for each of the resupply options. The first regiment will stop its advance, reorganize its remaining forces, and await the arrival of the second regiment. Upon arrival of the second regiment the Red force will continue its attack.

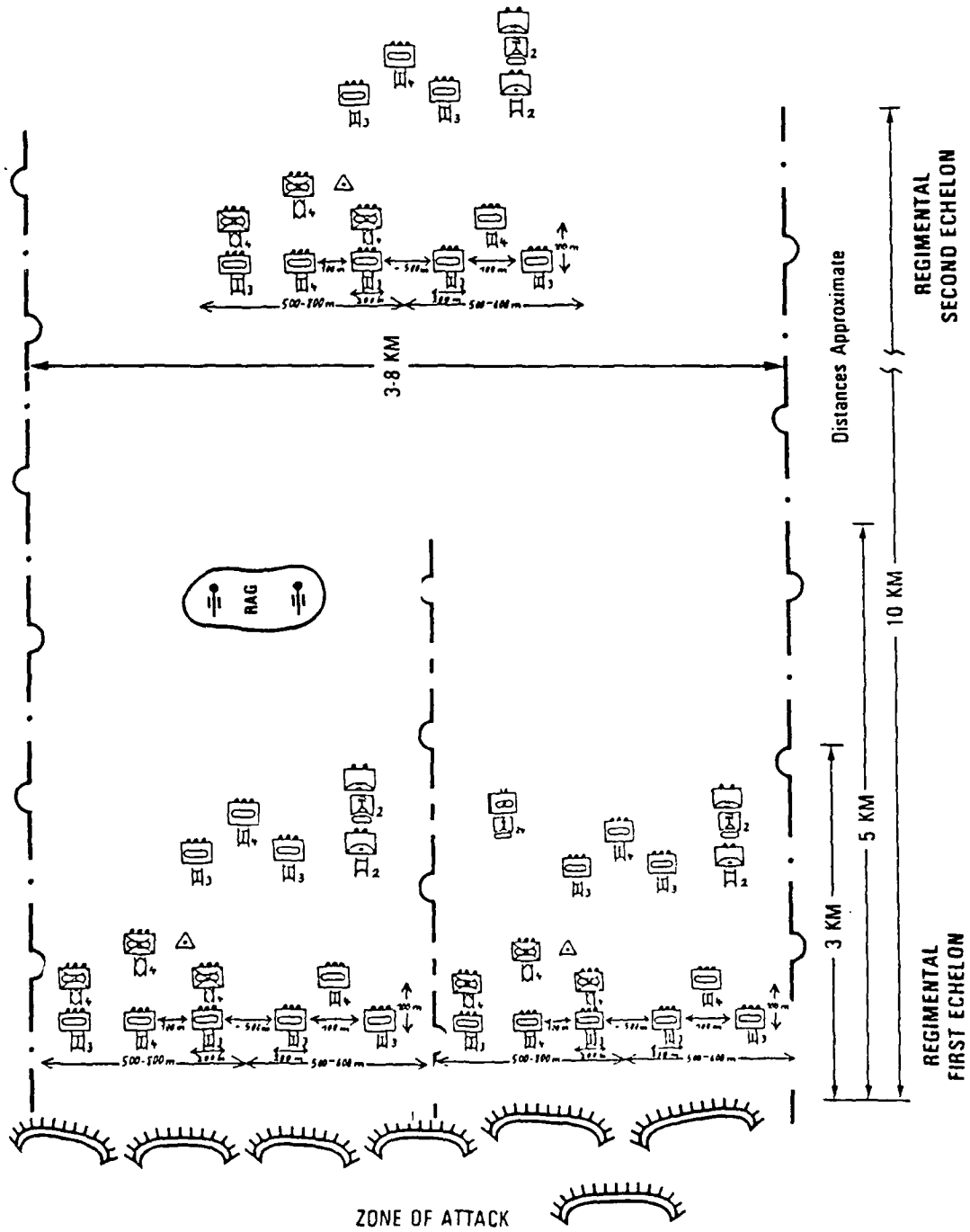


Figure 2. Soviet Formation

4. Assumptions

The assumptions and description of the scenario are as follows:

- The probability of hit and kill for each direct fire weapon system is valid.
- All other operating characteristics for the combat systems are valid.
- Only a conventional warfare environment is considered in this thesis.
- Estimates of the fuel consumption rates for the Blue forces are valid.
- HEMTT resupply vehicles will replace the current fleet of 5-ton trucks and trailers used in Infantry battalions.

B. MODEL PARAMETERS

1. Janus (T)

Janus(T) was developed primarily as an analysis tool to support Cost and Operational Effectiveness Analysis (COEA), tactics and doctrine analysis, and other Army studies. It was developed by the Army Training and Doctrine Analysis Command-White Sands Missile Range (TRAC-WSMR). Individual combat systems are modeled in Janus(T). The system functions represented are moving, searching, detecting, and firing on the ground or in the air. Primary focus is on the combat systems that participate in maneuver and artillery operations on land. Terrain used in the model is represented in three dimensions and is user-selected. The Janus(T) combat model is very flexible. It allows for the different operating characteristics of combat systems to be easily changed. The

data base for the Janus(T) model is provided by the Army Material Systems Analysis Activity (AMSAA) and accepted throughout the U.S. Army. Janus(T) is easily configured to allow for the answering of "what if" questions. The operating characteristics of combat systems and the deployment of these systems are easily modified in Janus(T). [Ref. 3]

2. Direct Fire

The direct fire engagements in the simulation occur between the Blue and Red units with as little interference by the players as possible. This is done to keep the scenario constant so the combat outcome will be a function of the Blue resupply effort rather than a change in tactics by the player. Some player interaction is required to maintain realistic fields of view for the Blue vehicles after they return to position from being resupplied. Often after a Blue vehicle returns from the resupply point to its battle position its field of view is not oriented in the correct direction.

3. Indirect Fire

The number of Red artillery pieces played represents the artillery weapons present in two Regimental Artillery Groups (RAG) and supporting artillery pieces from the Divisional Artillery Group (DAG) that are available to the forward regiments. A battalion of 155mm self propelled (SP) artillery is played for the Blue forces. Normally a Blue combat battalion would only expect the artillery fires of one battery. It was assumed the Armor task force had priority

of artillery fires and would receive the fire support of the entire artillery battalion.

4. Combat Vehicle Capabilities

a. Ammunition

The on-board capacities of ammunition for the Blue and Red forces are based upon design criteria for the Blue force and projected capabilities of the Red force. Usage rates by both forces depend on the initial input parameters and are a function of the combat between the forces. Only the major weapons on the combat vehicles are modeled in this thesis. This includes the 120mm main gun on the M1A1 and the TOW missiles and 25mm gun on the M2/M3. The on-board ammunition storage capability for the Blue forces is listed in Table 3.

TABLE 3
AMMUNITION STORAGE CAPABILITY

VEHICLE	AMMUNITION	CAPACITY
M1A1	120MM	40
M2	25MM	900
	TOW	7
M3	25MM	1500
	TOW	12

It was found during test runs of the simulation that if the full basic loads of ammunition as listed in Table 3 were used, the resupply system would not be stressed. The

combat vehicles had sufficient on board ammunition to defeat both attacking regiments before expending their basic loads of ammunition. This situation caused it to be more efficient for the Blue force to not resupply than to replace expended ammunition. Greater numbers of Red forces were killed, and a larger number of Blue survived if no resupply was attempted. The reason is that once a Blue vehicle begins movement, it loses the protection of being in a defilade position and has a greater chance of being detected and killed by the Red force. Therefore, it was to the Blue force's advantage not to attempt resupply and fight using the remaining ammunition rather than suffer losses while attempting to resupply. This is an unrealistic scenario, as the surviving Blue force would be completely out of ammunition and unable to continue its defensive mission.

The amount of on-board ammunition available for each vehicle was reduced from the production storage capability listed in Table 3. This reduced load of ammunition represents the amount of ammunition which may be available due to limited supplies available after several days of combat. The reduced basic load for the Blue force vehicles is listed in Table 4.

TABLE 4
REDUCED BASIC LOAD

VEHICLE	AMMUNITION	AMOUNT
M1A1	120MM	20
M2	25MM	900
	TOW	5
M3	25MM	1500
	TOW	9

b. Fuel

Before this thesis, the monitoring of the fuel usage by vehicles had not been modeled in Janus(T). The vehicles operated on an unlimited supply of fuel, and in the unrealistic environment of no fuel usage constraints. Vehicles can now be limited to the design capabilities of their fuel tanks. Usage rates of fuel depend upon and correspond to the vehicle's status as either stationary or moving. Different rates of fuel usage, input as model parameters, can be assigned to vehicles for computing fuel consumption. The Red force in this simulation was given a very low fuel usage rate eliminating the requirement for the resupply of fuel by the Red forces. Blue forces were assigned fuel usage rates obtained from the Armor School at Fort Knox, Kentucky. The usage rates for the Blue forces are in Table 5.

TABLE 5
BLUE FORCE FUEL USAGE RATES

VEHICLE	STATIONARY	MOVING
M1A1	11.0 GAL/HR	50.00 GAL/HR
M2	1.4 GAL/HR	13.52 GAL/HR
M3	1.4 GAL/HR	13.52 GAL/HR

It was found during the test runs of the scenario that fuel usage by the Blue force was not very significant during the two hours of combat with the two Red regiments. Since the Blue force was defending and moving infrequently, it was consuming little fuel in the two hour period of the combat. So little fuel was used there was no need for fuel resupply to be performed during the combat scenario. For the average fuel use of 20 gallons per tank to cause a need for replacement, the amount of on-board fuel would require an artificially low setting of the fuel tank's 500 gallon capacity. The forward area resupply of fuel was not performed during the production runs of the scenario.

C. RESUPPLY

1. General

Currently an Armor battalion depends upon a fleet of 30 Heavy Expanded Mobility Tactical Trucks (HEMTT) configured to carry fuel or cargo to perform the logistic requirements of the battalion (Figure 3 and Figure 4). The majority of these vehicles are used to provide the hauling capability to supply the four tank companies with logistic

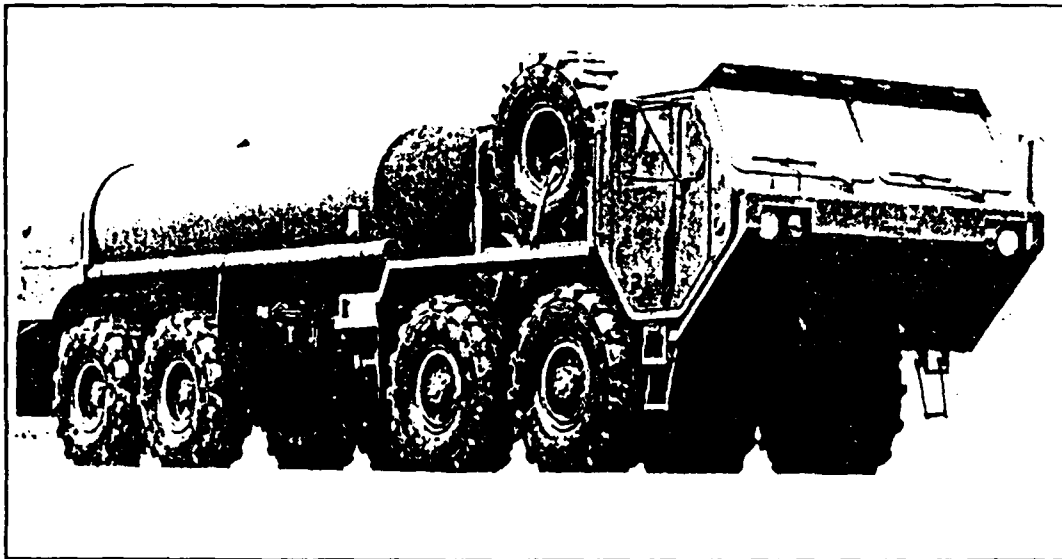


Figure 3. Fuel HEMTT

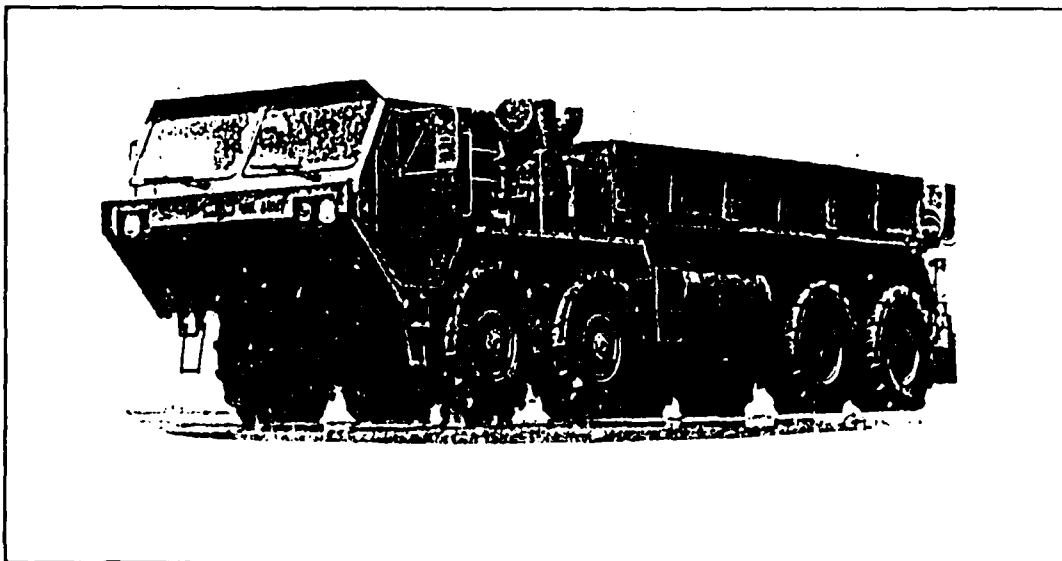


Figure 4. Cargo HEMTT

support for ammunition and fuel. Current doctrine has the battalion logistic support divided into three areas. Figure 5 shows the location of the different trains locations. These areas are the Battalion Field Trains (BFT), Battalion Combat Trains (BCT), and the Company Trains (CT). These trains areas are located approximately 30, 15, and 1 kilometer respectively, behind the Forward Edge of the Battle Area (FEBA) in a defensive scenario. The needed logistics are brought forward on HEMTTs from the BFT to the BCT as required by the companies to replace expended fuel and ammunition. The HEMTTs will travel as far forward as possible depending upon the tactical situation. During periods of combat the HEMTTs will resupply from positions out of danger from enemy direct fire but may still be subject to intense enemy artillery fire. If the tactical situation permits, the HEMTTs will move to the vehicle fighting positions and resupply from a defilade position near the combat vehicles. One ammunition and one fuel HEMTT per company are currently located at the BCT. These are for emergency resupply to the combat vehicles when the tactical situation does not allow time for the HEMTTs to come from the BFT.

Studies done by the Armor School at Fort Knox and by FMC of San Jose, California show that wheeled soft-skinned logistics vehicles lack the mobility and survivability to perform in the forward combat area. Logistic vehicles will spend considerable time off paved roads and may also be

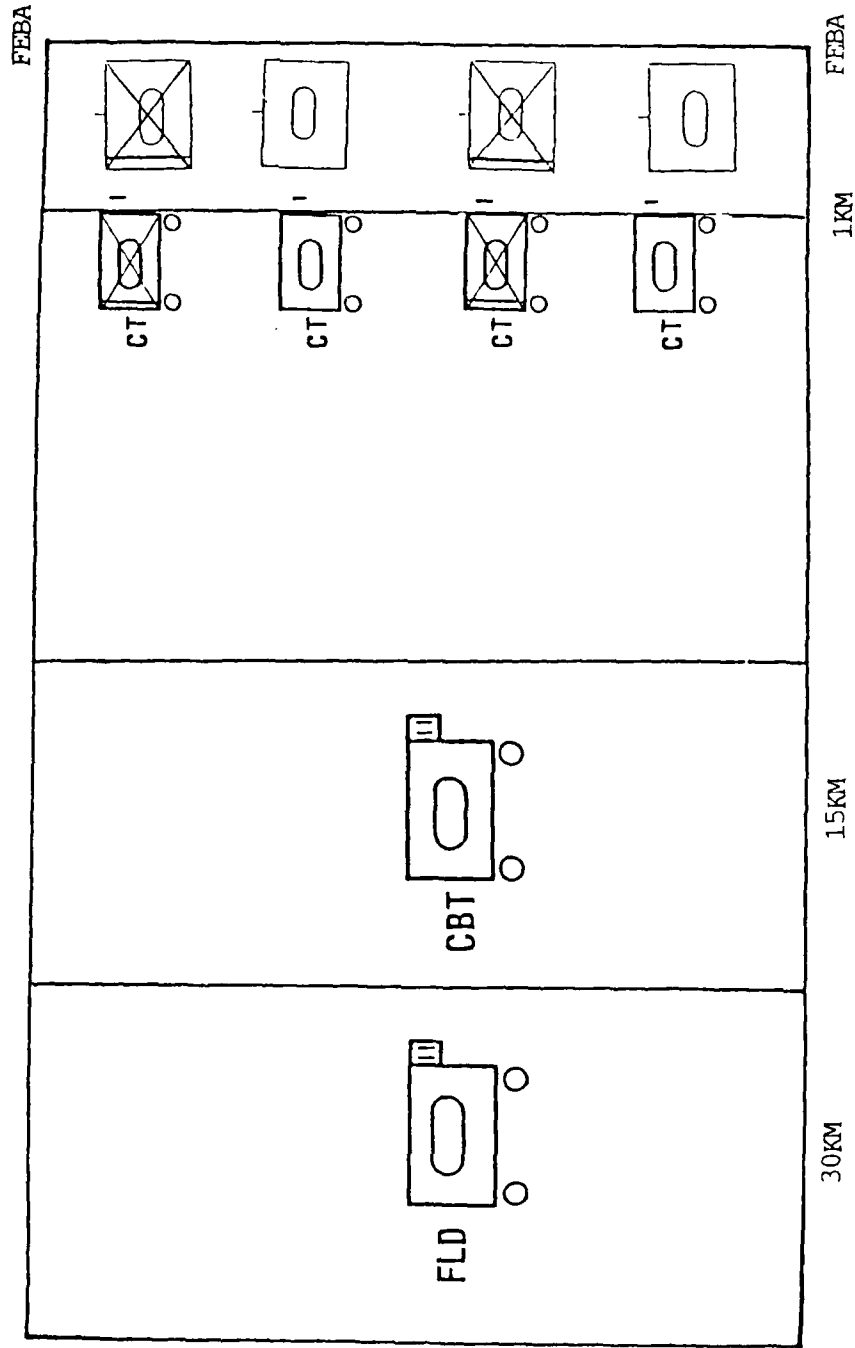


Figure 5. Trains Locations

subject to heavy artillery fire in the forward area. To counter these deficiencies it has been suggested that the Army augment the current HEMTT fleet with a tracked vehicle with armored protection for both the crew and cargo. The tracks will provide greater off-road mobility in the forward area matching the mobility of the combat vehicles that it is supporting. Armor will supply the crew and cargo protection against small arms and artillery fire. This tracked and armored resupply vehicle is called an Armored Resupply Multipurpose System (ARMS), Figure 6. The ARMS will be used to provide resupply in the forward combat area. This is the area from the BCT forward to the FEBA. HEMTTs will still be used to transport supplies from the BFT forward to the BCT. At this location the ARMS will be resupplied from the HEMTTs. The ARMS will carry the supplies forward to a position protected from direct fire or during a lull in combat to the fighting position.

2. Resupply Vehicle Capabilities

a. HEMTT

The HEMTT is the primary resupply vehicle found in Armor battalions today. It is configured to carry either fuel or cargo. The HEMTT is a soft-skinned, wheeled vehicle that provides little protection to its crew or cargo from battlefield damage. Its performance is excellent on paved roads and hard-packed trails, and it also performs well moving supplies over long distances.

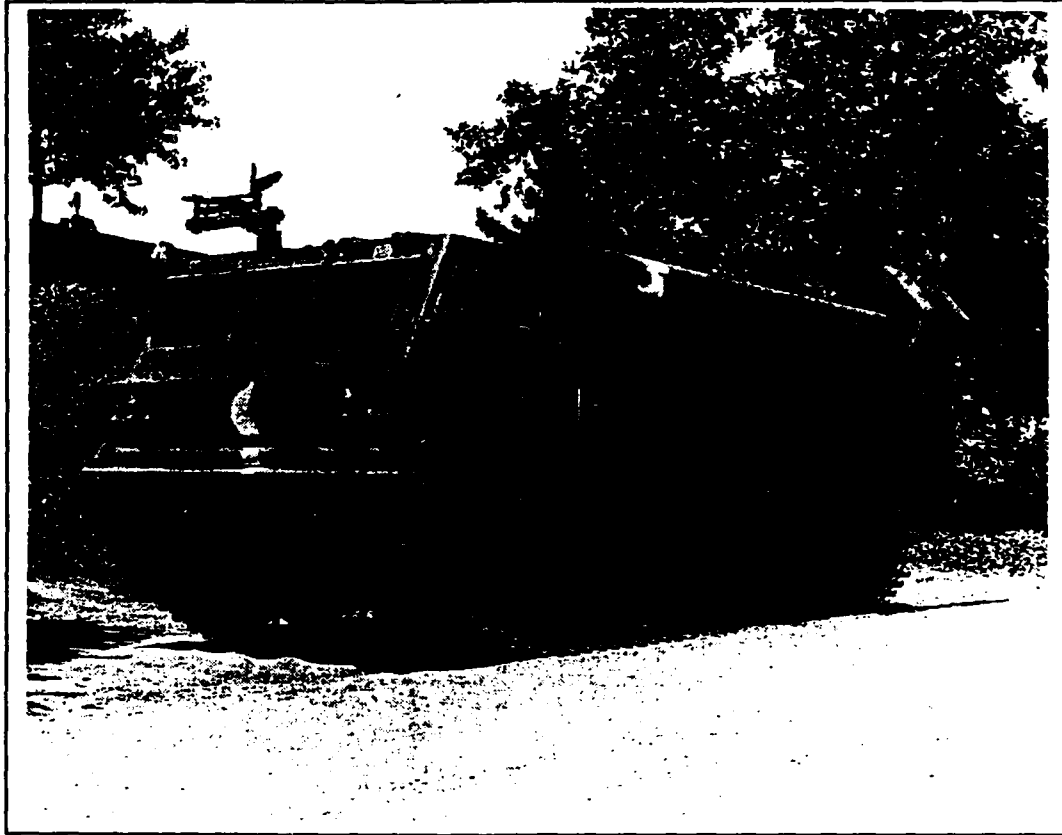


Figure 6. ARMS

b. ARMS

The ARMS modeled in this simulation is based upon the armored resupply vehicle designed by the FMC Corporation of San Jose. This vehicle can be configured to carry either ammunition or fuel. The cargo carried by this tracked vehicle is protected from artillery fire and small arms fire in an armored cargo bay. Because it is tracked, the ARMS will perform well during off-road travel. This will give it mobility that is comparable to the combat vehicles for which

it is providing resupply of ammunition and fuel. The operating characteristics for the HEMTT and ARMS are listed in Table 6.

TABLE 6
HEMTT AND ARMS OPERATING CHARACTERISTICS

VEHICLE	TANK ROUNDS	TOW MISSILES	25mm	FUEL
HEMTT	240	50	5000	2500 GAL
ARMS	180	35	5000	1800 GAL

3. Resupply Doctrine

Today's Soviet forces field a large, highly modern and mobile force of armored vehicles. This force is trained and organized to conduct a violent, fast-paced, offensive action. The defending force against such an attack must be able to rearm quickly to sustain its combat power. Defending forces no longer have the luxury of displacing far behind the FEBA to rearm. The defending force must be able to rearm quickly, maintaining the maximum amount of combat power as far forward as possible.

Five different resupply options will be used in this thesis to resupply the Blue force with forward area resupply.

- ARMS-1: ARMS from 500 meters behind battle positions
- ARMS-2: ARMS starting from the Battalion Combat Trains
- HEMTT-1: HEMTTs from 1000 meters behind battle positions

- HEMTT-2: HEMTTs starting from the Battalion Combat Trains
- HEMTT-3: HEMTTs starting from the Battalion Field Trains

Two resupply options will use the ARMS as its resupply vehicle and HEMTTs will be used in the other three. The HEMTTs will be positioned at the BFT, BCT, or 1000 meters behind the combat vehicles. The ARMS vehicles will be positioned at the BCT or at a position 500 meters behind the combat vehicles. Each resupply fleet will consist of four resupply vehicles. Two vehicles in each fleet will carry 120mm tank ammunition for the two Armor companies, and two vehicles will carry TOW missiles and 25mm ammunition for the two Infantry companies. When the HEMTTs deploy from the BFT or from the BCT, they will resupply from 1000 meters behind the combat vehicles' fighting positions. This location will provide the HEMTTs with some safety from the intense Soviet artillery that the combat vehicles can be expected to be receiving in their battle positions.

III. SIMULATION RESULTS

A. OVERVIEW

The purpose of this thesis, as stated in Chapter I, is to analyze two different resupply vehicles that are deployed using various resupply doctrines. This chapter focuses on the analysis of the simulation output.

The combat and events which take place in this simulation can be analyzed by following a time line as the various events in the battle take place. Each replication is run for a total of 120 minutes. At this time the Blue force had been attrited to ten percent of its starting size, was out of ammunition, or the Red force had bypassed its position with at least a company plus size force. After 45 minutes of simulation the Blue force had attrited the first Red regiment down to one-third of its starting combat vehicle strength, and the Blue force had lost approximately one company of combat vehicles. The status of the first regiment of the Red force and the Blue force after 45 minutes of combat are shown in Tables 7 and 8, respectively.

The first regiment has halted and is waiting for the arrival of the second regiment. There are approximately 3000 to 3500 meters distance between the tree lines of the stopped Red force and the defending Blue force. The stopped first regiment would hold in this position until the arrival of the

TABLE 7

FIRST REGIMENT VEHICLE STATUS

VEHICLE	REMAINING	LOSSES
FST-2	27	63
BMP-2	9	21

TABLE 8

BLUE FORCE VEHICLE STATUS

VEHICLE	REMAINING	LOSSES
M1A1	21	7
M2	20	6

second regiment which was following about 15 kilometers behind. Resupply operations are started by the Blue force at the 45 minute point in the scenario. This represents the Blue commander's understanding that he has stopped the first regiment and there is a time window for resupply to be accomplished before the arrival of the second regiment. Resupply is conducted by resupplying one platoon at a time from each of the four companies. When the resupplied platoon returns to its battle position, another platoon from the company is sent for resupply. As many platoons as possible are resupplied from each company before the arrival of the second regiment. After arrival of the second regiment, vehicles are sent to be resupplied individually as their ammunition supply is depleted to zero. At approximately the 95 minute point the forces of the second regiment begin to

come into TOW missile and tank main gun range. The remaining forces of the first regiment join the attack of the second regiment forces, and the simulation is allowed to run until 120 minutes of simulation has passed. Table 9 shows the status of the Blue force ammunition after the first 45 minutes of battle.

TABLE 9
BLUE FORCE AMMUNITION STATUS

TYPE	CAPACITY	REMAINING	REQUIRED
120MM	420	266	154
TOW	80	10	70

B. MEASURES OF EFFECTIVENESS (MOES)

Five different MOEs were selected to evaluate the different resupply vehicles and doctrines. The five MOEs are as follows:

- MOE-1: number of Red casualties
- MOE-2: number of Blue casualties
- MOE-3: number of resupply vehicle casualties
- MOE-4: number of Blue vehicles uploaded
- MOE-5: number of rounds uploaded

MOE-1 and MOE-2 measure the number of Red and Blue casualties. By measuring the number of Red casualties, the effectiveness of the resupply fleet delivering ammunition may be monitored. In theory, the greater the efficiency of

resupply, the greater the expected number of Red casualties will be. Also, the greater the efficiency of a resupply fleet, the smaller the expected number of Blue casualties will be. The more ammunition a combat unit has, the better it should be able to survive and the better it can destroy the enemy. MOE-3 measures the ability of the resupply vehicle to survive on the battlefield. The greater the number of resupply vehicles surviving, the better the resupply fleet can perform its mission of resupplying the combat vehicles. MOE-4 and MOE-5 measure how many vehicles and how much ammunition are resupplied by the resupply vehicles. The greater the quantity of ammunition resupplied and the more vehicles resupplied indicate a better resupply system.

C. COMPARISON BETWEEN RESUPPLY FLEETS

1. General

Each of the five MOEs will be analyzed. Particular attention will be paid to the differences between the resupply ability of the HEMTT and the ARMS. Also, the four different doctrines for employing the resupply vehicles will be analyzed using the five listed MOEs.

2. Vehicle Type

The resupply capabilities of the two different vehicle types will be analyzed. As mentioned, the ARMS is an armored tracked vehicle and the HEMTT is a soft-skinned, wheeled vehicle. The armor protection of the ARMS, in theory, should

make it less vulnerable to the Red artillery fire than the HEMTT. MOE-3 measures the number of resupply vehicles destroyed by artillery. The results of the simulation are inconclusive in determining the survivability difference between the two vehicles. The ARMS is destroyed twice during 48 runs when it was used for resupply. The HEMTT is destroyed three times out of 72 runs. This gives the HEMTT a higher survivor rate than the ARMS. If the HEMTT option that delivers ammunition from the BFT is excluded from the data, both the ARMS and the HEMTT using similar doctrine lose two vehicles in 48 runs. The resupplying HEMTTs in the BFT runs are out of artillery range during most of the simulation. Two HEMTTs are in range for 20 minutes of the simulation, and the other two resupplying HEMTTs do not move into artillery range during the simulation. This is a function of the BCT's location 25 kilometers behind the battle positions.

3. Resupply Doctrine

The resupply vehicles are employed using four different doctrines. The ARMS resupplies the combat vehicles from a position 500 meters behind the combat vehicles. It is either prepositioned at that location or it arrives there after traveling from the BCT. The HEMTT resupplies from a position 1000 meters behind the combat vehicles. It is prepositioned at that location or it arrives there after traveling from the BCT or the BFT.

Analysis of the results for MOE-1, MOE-2, MOE-4, and MOE-5 shows that the doctrine used by the resupply vehicles is the determining factor for the results of the simulation. Values for the data in MOE-1, and MOE-2 are obtained from the mean of the six separate runs for each of the five resupply options. The values used for MOE-4 and MOE-5 are selected from the single run for each resupply doctrine that most closely match the mean amount of ammunition and number of vehicles uploaded for each doctrine.

MOE-1 is analyzed by viewing the FST-2 losses and BMP-2 losses independently versus simulation time, and then together versus time. Figure 7 shows that the number of Red FST-2 losses depends on the doctrine of the resupply fleet. At 75 minutes, before the arrival of the second regiment, the number of FST-2 losses is approximately equal for the different methods of resupply. The HEMTT fleet from the BFT has the greatest number of FST-2 kills at 90 minutes because all the Blue combat vehicles are still in position until this time. When this option is used, because the distance from the BFT to the resupply point is so great, the Blue vehicles have not departed their battle positions to resupply. This allows the Blue force to kill a greater number of Red vehicles initially using this option as compared with use of other options. By 105 minutes the combat vehicles that have been resupplied by the two ARMS fleets begin to destroy more vehicles than with the other resupply options. From 105

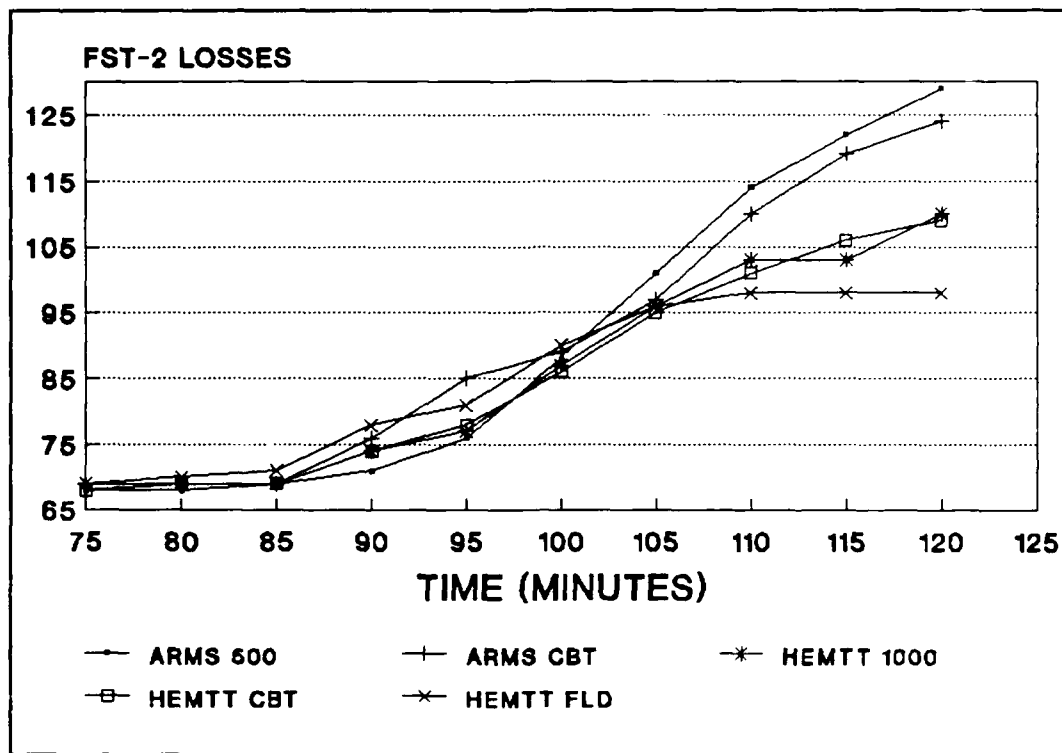


Figure 7. Red FST-2 Losses

through 120 minutes the two options using the ARMS for resupply are able to continue engaging the FST-2s, while the other options are out or almost out of ammunition. This is a result of the quick turnaround time from the battle positions to the resupply vehicles located 500 meters from the battle positions. The ARMS options that locate resupply vehicles 500 meters from the front are able to provide faster resupply of ammunition to the combat vehicles than the other doctrines.

Figure 8 is a plot of the Red BMP-2 losses versus time. Since the BMP-2 is engaged by the 25mm gun of the

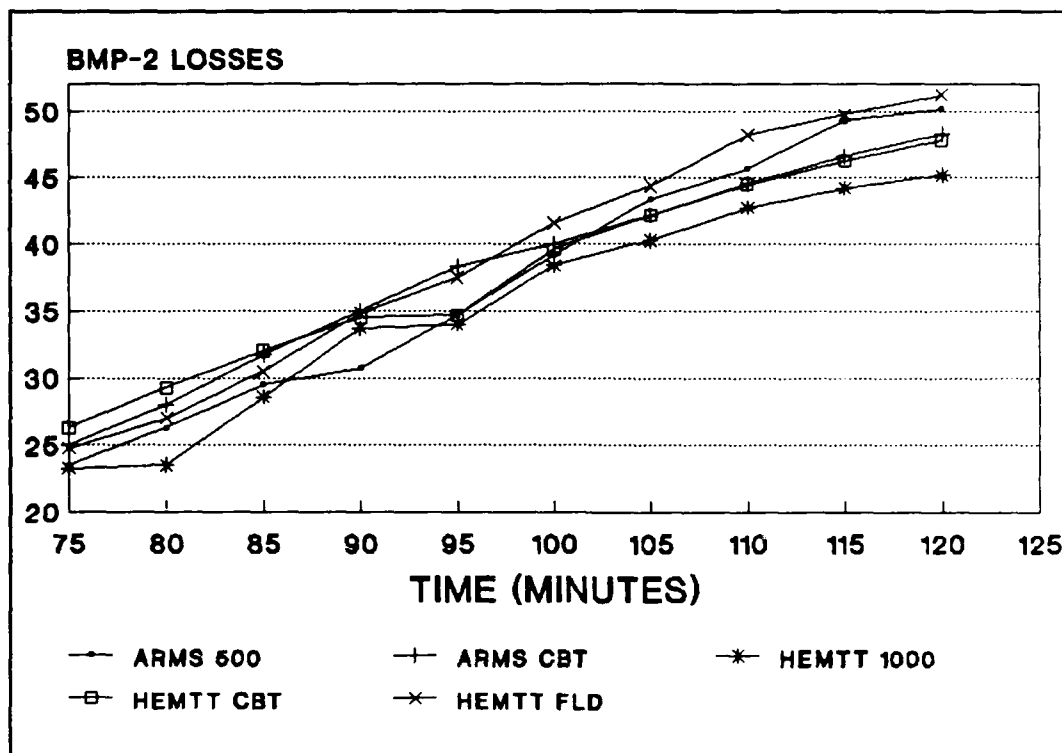


Figure 8. Red BMP-2 Losses

Bradley, the losses do not fluctuate greatly. The Bradleys do not deplete their supply of 25mm ammunition, and the engaging of BMP-2s depends upon engagement opportunities. The two resupply options that provide the Blue combat vehicles with the most time in their battle positions kill the most BMP-2s. These are options number one and number five. Option number one, ARMS prepositioned at 500 meters, allows the Bradleys to quickly rearm with TOW missiles and return to their battle positions. These Bradleys are spending little time out of their battle positions and, consequently, have increased opportunities to engage BMP-2s. Option number five,

HEMTTs from BFT, provides the Bradleys with the opportunities to kill BMP-2s because they are not spending time out of their battle positions resupplying. One HEMTT from the BFT never reaches its assigned company during the 120 minutes of simulation. This allows the Bradleys from this company to engage the BMP-2s for the entire 120 minutes.

The total Red losses of FST-2s and BMP-2s are shown in Figure 9. The results are similar to the results of the FST-2 losses. The two ARMS options provide the best resupply of ammunition. Therefore, when these two options are used, the total Red losses is the highest.

MOE-2 shows the number of Blue vehicle losses related to time. Blue casualties occur as a result of the combat between the two forces and the Blue forces attempts to resupply. The Blue forces have the advantage of being in prepared defilade positions. Movement or firing by a Blue vehicle increases the chance of being detected and fired upon by a Red vehicle. White phosphorous smoke is fired by the Blue artillery in an attempt to screen the Blue vehicles while resupplying. A Blue vehicle that depletes its ammunition can increase its chance of survival by not attempting to resupply.

The number of Blue Abrams losses is shown in Figure 10. The Blue vehicle losses that occur between 45 minutes (when the first regiment stops) and 95 minutes (when the second regiment arrives) occur because the Blue vehicles attempting to resupply are moving out of defilade positions.

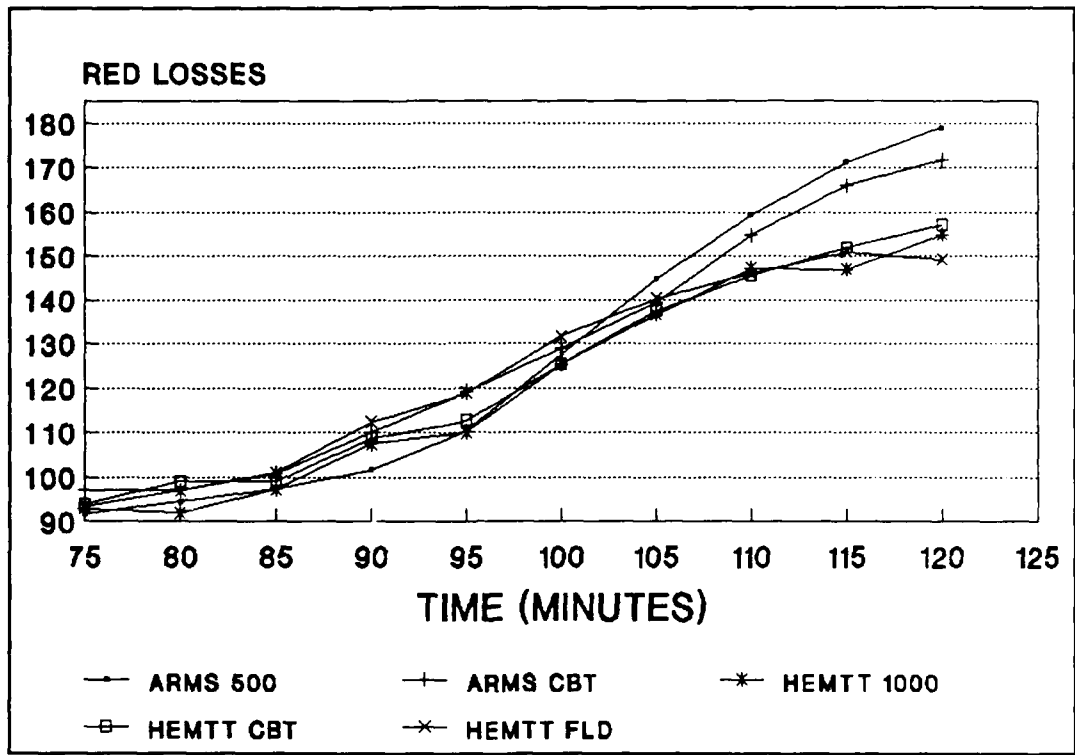


Figure 9. Total Red Losses

This causes the resupply doctrines of ARMS at 500 meters and HEMTTs at 1000 meters to have a greater number of casualties than the other doctrines during this period. Between 95 minutes and 110 minutes (when they are attempting to resupply) the rate of Blue casualties increases for the other resupply doctrines. This is shown by the increase in the slope of the line for Blue losses. After 110 minutes the loss rate increases for the option when the ARMS are located 500 meters behind the combat units. This is a result of having resupplied earlier and therefore depleting ammunition at an earlier point in time than occurs in the other options. The

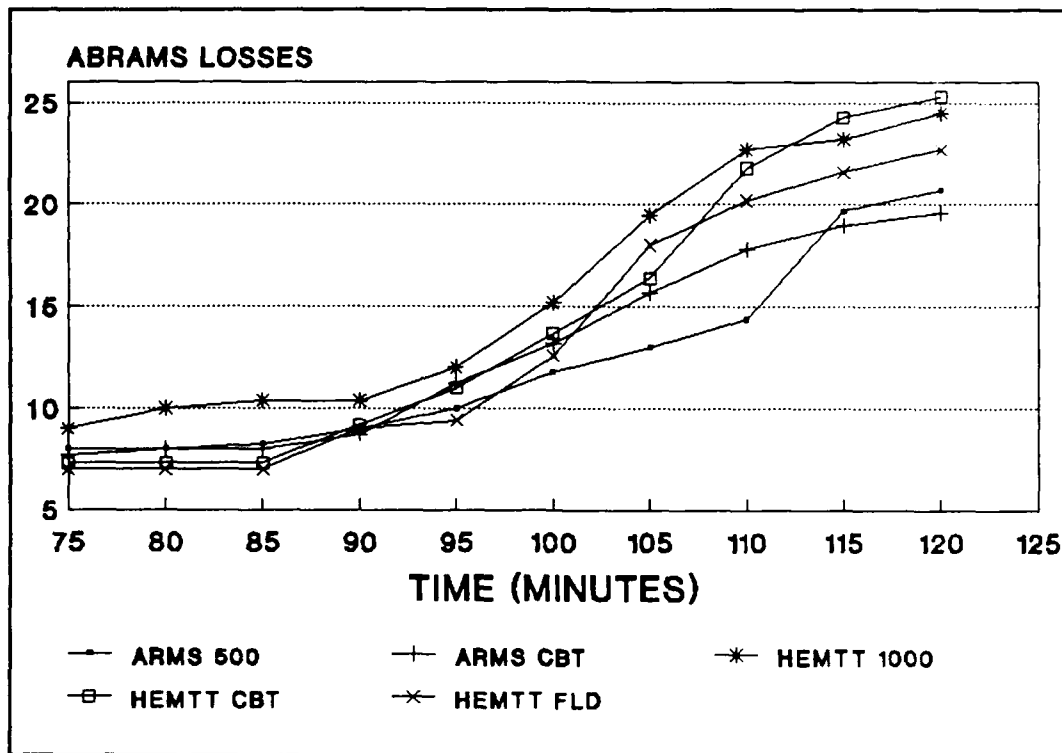


Figure 10. Blue Abrams Losses

vehicles using resupply option ARMS-1 are able to perform their initial resupply before the other options, and therefore can attempt resupply again.

The total Blue tank losses is the greatest for HEMTT-1 and HEMTT-2 options. This is a result of the HEMTTs being positioned 1000 meters behind the battle positions. The longer travel time causes the tanks to be engaged by the second regiment as they are returning to their battle positions. HEMTT-3 is the third most effective option for reducing Blue losses, because the Blue tanks do not have the opportunity to resupply and, therefore are not moving out of

the protection of the battle positions. ARMS-1 and ARMS-2 have the lowest Blue tank losses. The tanks are able to resupply and return to their battle positions before the second regiment arrives because of the short travel distance of 500 meters from the resupply vehicles to the battle positions.

Figure 11 shows the number of Blue Bradleys that were destroyed. The losses vary with time as they resupply using the different resupply options. When the Bradleys have resupplied once with TOW missiles they do not attempt another resupply when this resupply of TOWs is fired. Instead, the Bradleys remain in their battle positions and engage the BMP-2s with their chain guns. As a result the Bradley losses are almost the same for options ARMS-1, ARMS-2, HEMTT-1, and HEMTT-2. HEMTT-3 has the lowest Bradley losses because the Bradleys did not have an opportunity to resupply and, therefore, did not suffer losses while out of their battle positions.

Total Blue losses of Abrams and Bradleys together are shown in Figure 12. HEMTT-1 and HEMTT-2 had the highest number of Blue losses. The longer travel time to the resupply location 1000 meters behind the battle position causes more Blue vehicles using these options to be exposed to the Red direct fire. The remaining three options had similar numbers of Blue losses.

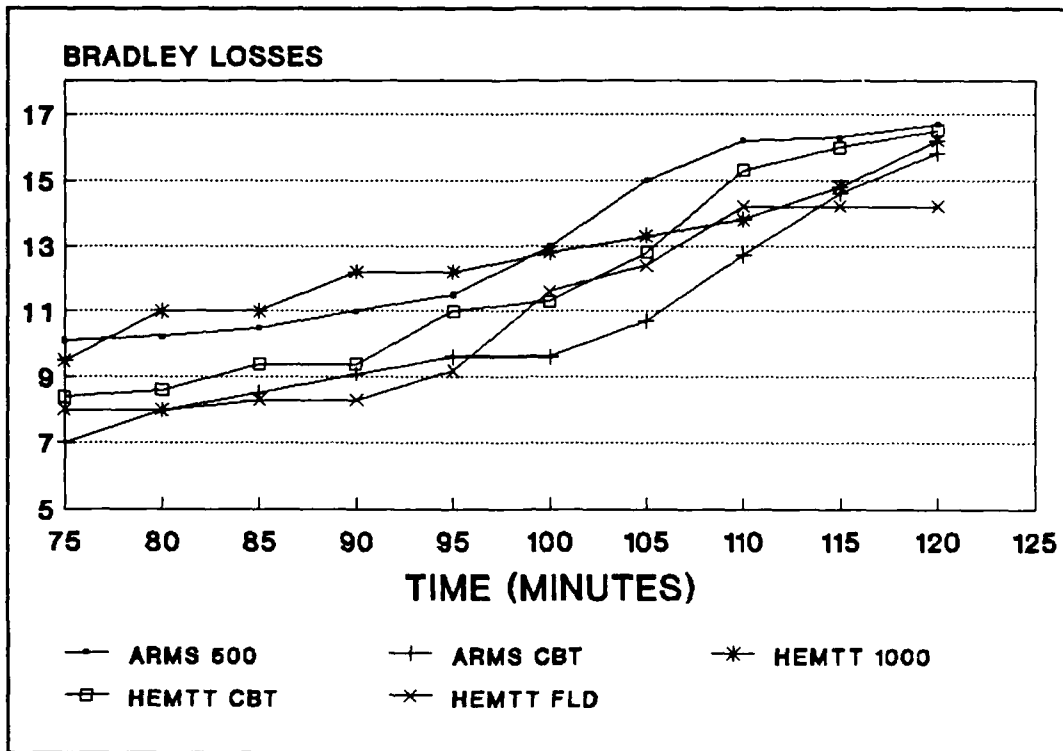


Figure 11. Blue Bradley Losses

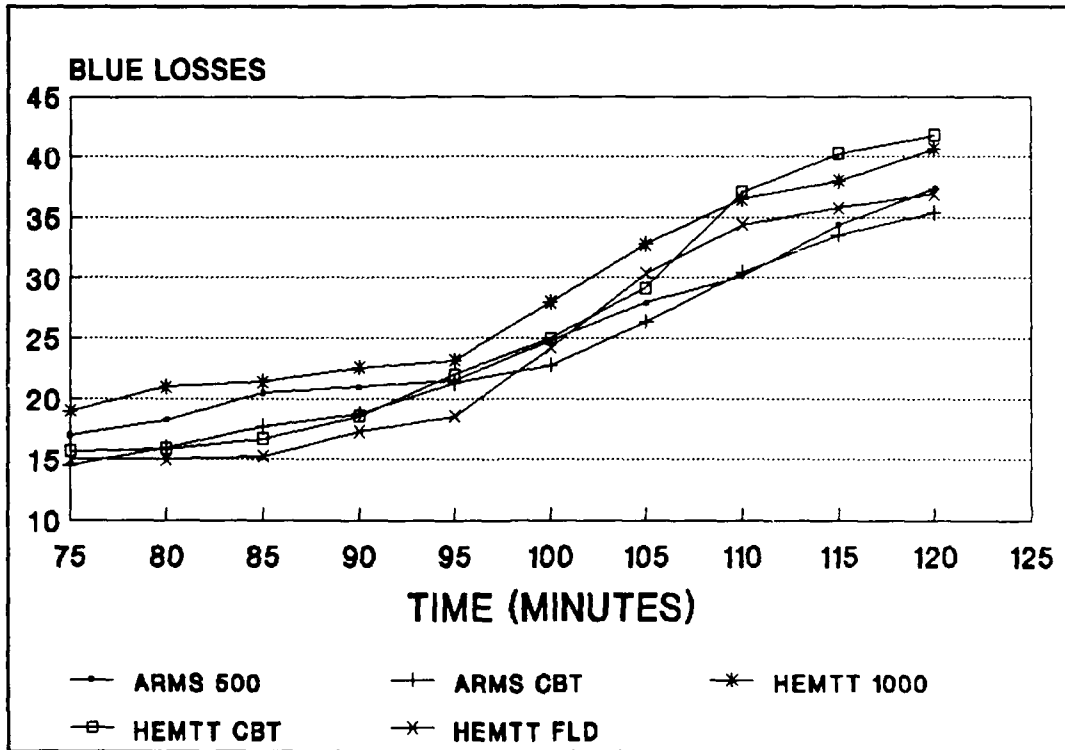


Figure 12. Total Blue Losses

MOE-4 shows the number of vehicles that were uploaded using each of the resupply options. A graph of this data is shown in Figure 13. The ARMS-1 option allowed resupply to begin more quickly after the first regiment was stopped and also resupplied the most vehicles. Although HEMTT-1 was third in total number of vehicles uploaded, it was second in speed of resupply. ARMS-2 was able to resupply more vehicles than HEMTT-1 because of the faster turnaround time due to the shorter distance traveled between the battle positions and the resupply location. HEMTT-3 did not upload many vehicles because it was delayed by the 25 kilometer distance from the BFT to the resupply location.

MOE-5 shows that the amount of ammunition uploaded is related to the location of the resupply vehicle. This is shown in Figure 14. ARMS-1 located at 500 meters and HEMTT-1 at 1000 meters are able to provide the quickest resupply because they are the closest to the combat vehicles. Resupply for the ARMS can start at 50 minutes and at 62 minutes for the HEMTTs. The difference in starting times is caused by the longer time it takes the combat vehicles to travel the 1000 meters to the HEMTTs, rather than the 500 meters to the ARMS. The resupply vehicles traveling from the BCT provide resupply later than the vehicles near the front, but sooner than the HEMTTs coming from the BFT. HEMTTs coming from the BCT arrive at the front sooner than the ARMS because of their greater speed on roads. At approximately the 95 minute mark, the ARMS

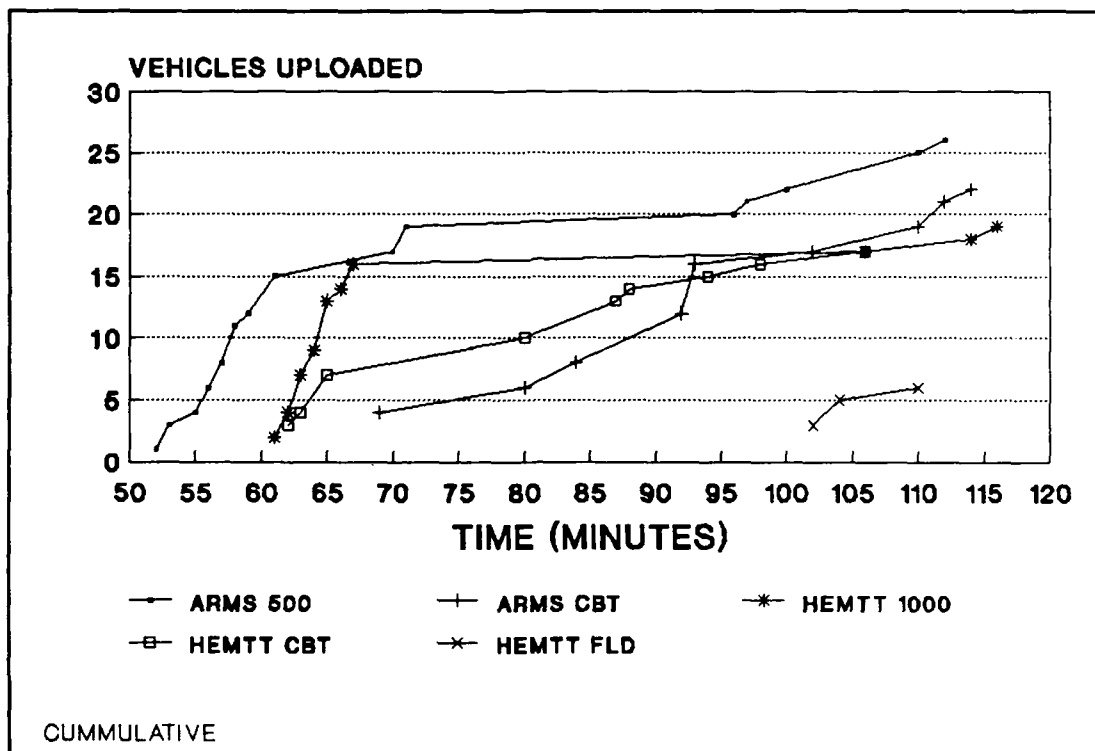


Figure 13. Vehicles Uploaded

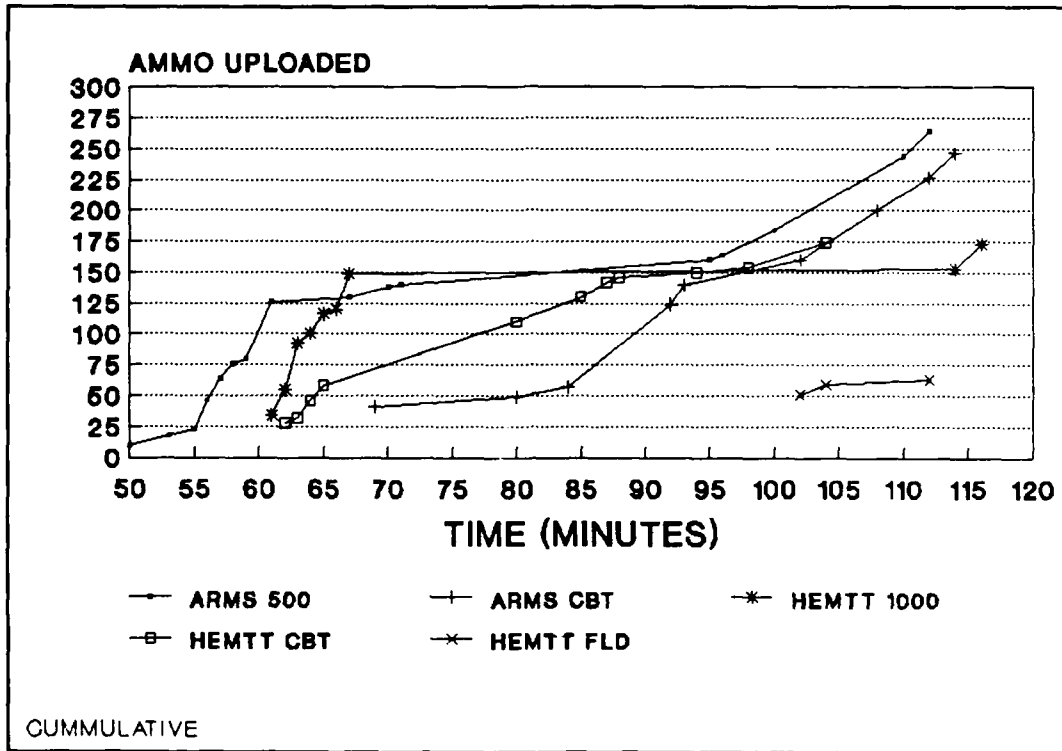


Figure 14. Ammunition Uploaded

from the BCT begins to provide more resupply than the HEMTTs from the BCT because they are located closer to the combat vehicles. The HEMTTs that travel the 25 kilometers from the BFT to the front are not able to provide effective resupply to the combat vehicles. Resupply does not begin until 100 minutes of simulation time, and often two of the resupply vehicles do not arrive at the front in time to begin resupply before the simulation ends at 120 minutes.

From the analysis of the different MOEs several conclusions can be made about the resupply doctrines. The resupply vehicle should be placed as close to the combat vehicles as possible while avoiding danger of direct fire from the enemy. This allows resupply to be quickly accomplished and completed before arrival of the second regiment. Smoke is needed to cover vehicle movement from battle positions while conducting resupply operations. Vehicles attempting resupply during contact with the enemy will suffer high rates of attrition.

IV. STATISTICAL ANALYSIS

A. TWO SAMPLE t-TEST

The Two Sample t-Test will be used to determine whether or not there is a statistical difference between any two population means of the Red tank losses or the Blue total losses for each of the five different resupply options [Ref. 4]. Only the Red tank losses will be analyzed. The quantity of tank ammunition and number of TOW missiles resupplied will affect the number of Red tanks destroyed. The Red BMP-2s are killed by the 25mm gun on the M2 or the M3. This ammunition on the Blue vehicles never reaches a level low enough to reduce the number of BMP-2s killed.

In situations where the combined sample size of the two samples (n, m) is small, ($n + m < 30$), the Student t-table is preferred for testing the differences between two means over the Normal table. Three assumptions are made when this test is used. The populations from which the samples come are normal, variances of the populations are equal, and the two samples are independent. Examples of two cases of the two sample t-test with the null hypothesis stating the population means (μ_x, μ_y), are equal, and the alternate hypothesis stating the two population means are not equal are given below.

1. Example 1

Let \bar{X} be the sample mean of Red losses from six replications, and μ_x be the population mean of Red losses from the scenario using the ARMS resupplying from 500 meters behind the combat vehicles.

Let \bar{Y} be the sample mean of Red losses from six replications, and μ_y be the population mean of Red losses from the scenario using the ARMS starting from the BCT and stopping 500 meters behind the combat vehicles to resupply.

The hypothesis will be tested at a 0.05 level of significance.

$$H_0: \mu_x = \mu_y$$

$$H_1: \mu_x \neq \mu_y$$

Let S_x^2 and S_y^2 be the sums of squares as follows:

$$S_x^2 = \sum_{i=0}^m (X_i - \bar{X})^2 \qquad S_y^2 = \sum_{i=0}^n (Y_i - \bar{Y})^2$$

The test statistic T is defined by the following equation:

$$T = \frac{(n + m - 2)^{1/2} (\bar{X} - \bar{Y})}{(1/m + 1/n)^{1/2} (S_x^2 + S_y^2)^{1/2}}$$

Because the alternate hypothesis is two-sided, the test procedure is to reject H_0 if either $T < c_1$ or $T > c_2$. The constants c_1 and c_2 are chosen so that when H_0 is true, $\Pr(T < c_1) + \Pr(T > c_2) = 0.05$

For this example and the remaining tests of the means of Red losses, the sample size for m and n will be six,

corresponding to the number of replications performed for each resupply option. The value of T in this example is 1.697. Using a table of the t distribution with 10 degrees of freedom, $(m + n - 2)$, c_1 and c_2 are -2.228 and 2.228, respectively. The value of T is not greater than 2.228 or less than -2.228. Therefore, the null hypothesis that the mean number of Red losses for resupply by the two ARMS options is equal can not be rejected.

2. Example 2

Let \bar{X} be the sample mean of Red losses from six replications, and μ_x be the population mean of Red losses from the scenario using the ARMS resupplying from 500 meters behind the combat vehicles.

Let \bar{Y} be the sample mean of Red losses from six replications, and μ_y be the population mean of Red losses from the scenario using the HEMTT resupplying from 1000 meters behind the combat vehicles.

The sample size is 6 for both m and n . Testing will still be done at a 0.05 level of significance. Since T is equal to 3.346, and this is greater than 2.228, the null hypothesis is rejected at the 0.05 level. Table 10 summarizes the results of two sample t -tests on the mean of Red tank losses for each of the five different resupply options.

The results in Table 10 confirm the results determined in the analysis of the MOEs. There is a difference between the number of Red tanks that were killed when the ARMS was

TABLE 10

T-TEST ON THE MEAN OF RED TANK LOSSES

TEST	MEANS		T	RESULT
ARMS1 & ARMS2	128.8	123.5	1.697	DO NOT REJECT
ARMS1 & HEMTT1	128.8	109.7	3.346	REJECT
ARMS1 & HEMTT2	128.8	109.3	3.795	REJECT
ARMS1 & HEMTT3	128.3	98.3	7.656	REJECT
ARMS2 & HEMTT1	123.5	109.7	2.432	REJECT
ARMS2 & HEMTT2	123.5	109.3	2.780	REJECT
ARMS2 & HEMTT3	123.5	98.3	6.407	REJECT
HEMTT1 & HEMTT2	109.7	109.3	0.0477	DO NOT REJECT
HEMTT1 & HEMTT3	109.7	98.3	0.0972	DO NOT REJECT
HEMTT2 & HEMTT3	109.3	98.3	1.946	DO NOT REJECT

providing the resupply and when the HEMTTs were providing the resupply. ARMS was better able to provide resupply to the combat vehicles than the HEMTTs, because it could move closer to the positions of the combat vehicles than could the HEMTTs.

Table 11 summarizes the results of two sample t-tests on the means of the total Blue vehicle losses for each of the five different resupply options.

TABLE 11

T-TEST ON THE MEAN OF BLUE TOTAL LOSSES

TEST	MEANS		T	RESULT
ARMS1 & ARMS2	37.3	35.3	0.697	DO NOT REJECT
ARMS1 & HEMTT1	37.3	40.7	-1.043	DO NOT REJECT
ARMS1 & HEMTT2	37.3	41.8	-1.797	DO NOT REJECT
ARMS1 & HEMTT3	37.3	36.8	0.209	DO NOT REJECT
ARMS2 & HEMTT1	35.3	40.7	-1.776	DO NOT REJECT
ARMS2 & HEMTT2	35.3	41.8	-2.886	REJECT
ARMS2 & HEMTT3	35.3	36.8	-0.704	DO NOT REJECT
HEMTT1 & HEMTT2	40.7	41.8	-0.439	DO NOT REJECT
HEMTT1 & HEMTT3	40.7	36.8	1.499	DO NOT REJECT
HEMTT2 & HEMTT3	41.8	36.8	3.108	REJECT

There is a difference in the mean number of Blue losses in two of the cases. The difference does not appear to be caused as a result of resupply vehicles or the doctrine used for resupplying. In the cases where the t-test rejects, only a difference of one additional vehicle separated the means. This is a statistical difference, but may not be a significant difference on the battlefield.

B. REGRESSION ANALYSIS

Regression analysis is performed to determine if a relationship exists between the total amount of ammunition uploaded and the number of Red tanks destroyed. Only the Red tank losses were considered because, as mentioned, the Red BMP-2 losses are not caused by one of the ammunitions being resupplied. A plot of ammunition uploaded versus Red tanks killed and the fitted simple linear regression are shown in Figure 15. The fitted line has a positive slope as expected. As the number of uploaded rounds is increased the Blue force has additional ammunition for engaging and killing increasing numbers of Red FST-2s.

Figure 16 shows a plot of the residuals from the regression against the number of uploaded rounds. The residuals are the difference between what is actually observed, and what is predicted by the regression equation. The plot indicates there is not an abnormality which the regression equation has not explained. There is an impression

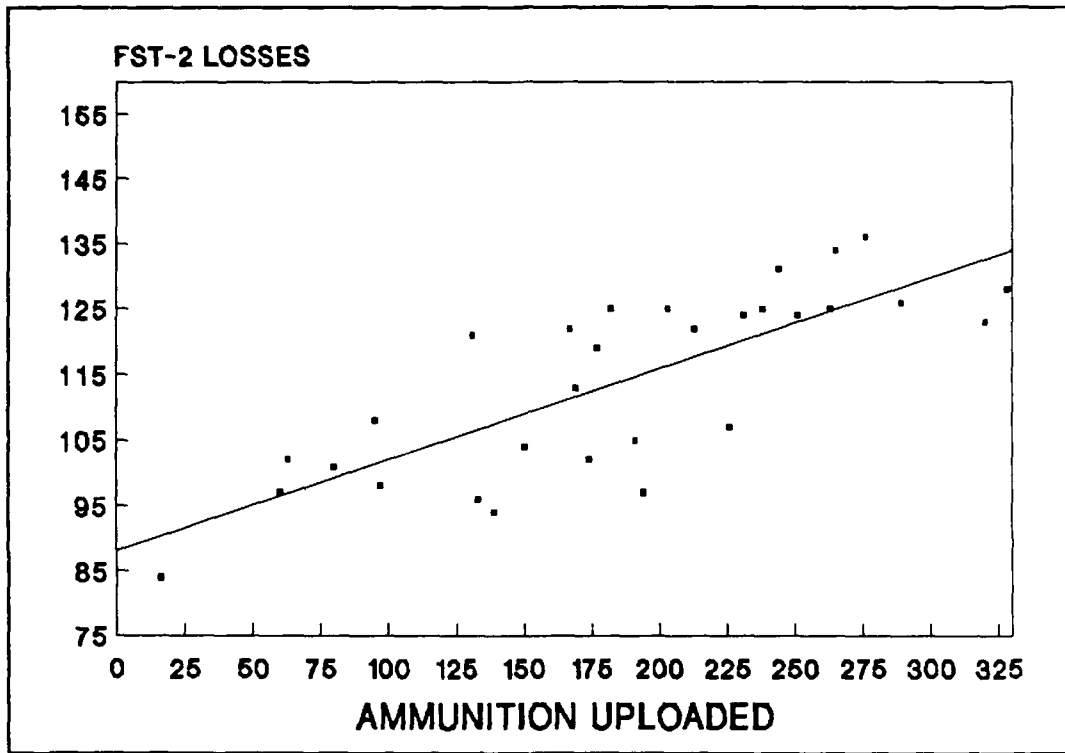


Figure 15. Regression of FST-2 Losses on Ammunition Uploaded

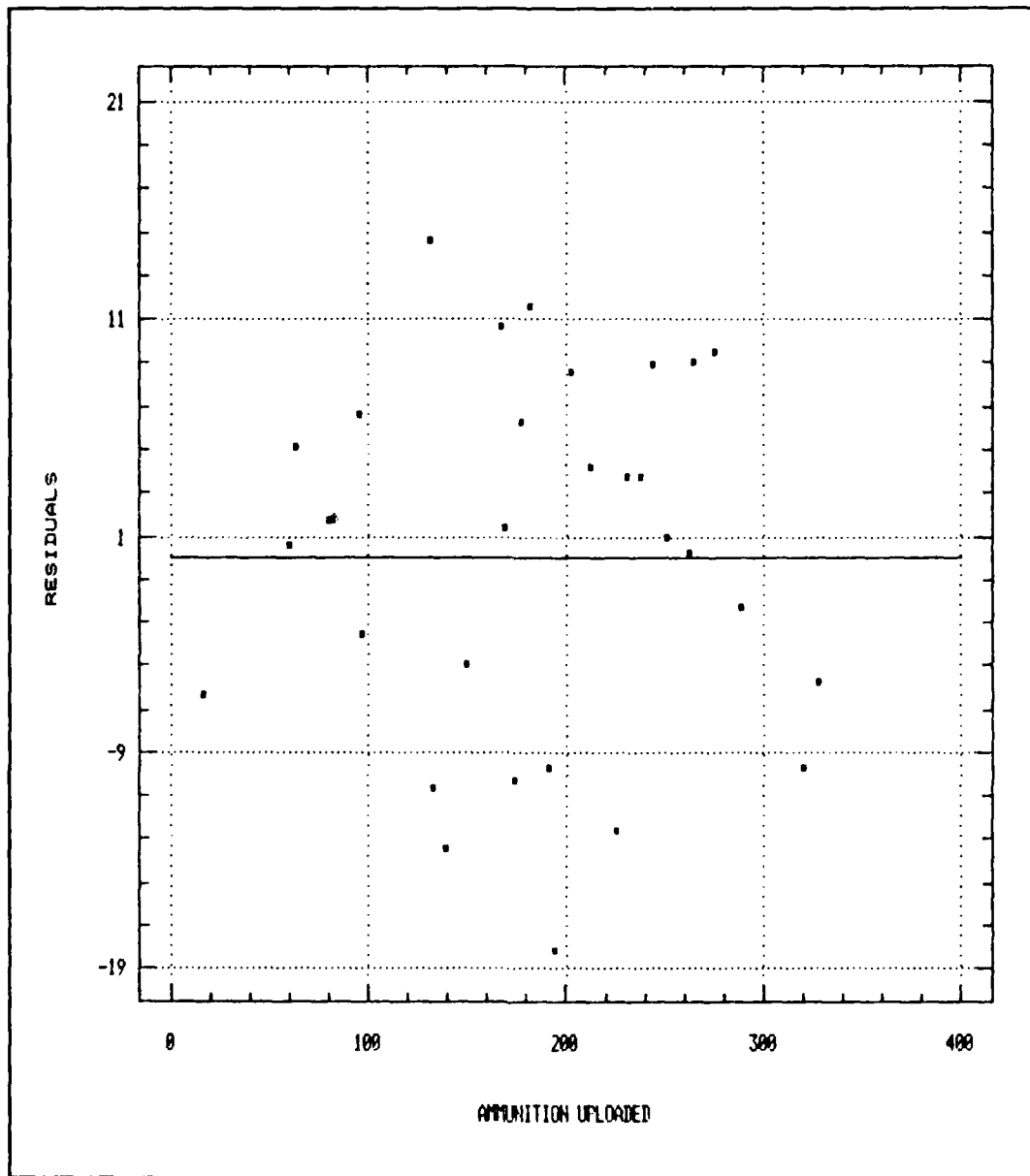


Figure 16. Plot of Residuals

of a horizontal "band" of residuals which indicates no unaccounted for abnormality. [Ref. 5]

Each of the six replications from the five different resupply options are used in the regression. Table 12 shows the results of the regression. Since the R^2 value is 62.08 percent, it can be said that approximately 62 percent of the variation in the number of Red tanks killed can be accounted for by a linear relationship with the amount of ammunition uploaded.

TABLE 12
REGRESSION RESULTS

Equation	$Y = 88.01 + .14X$
Correlation Coefficient	0.7879
$R^2 = 62.08$ percent	
Number of Observations	30
Degrees of Freedom	28

V. CONCLUSIONS AND RECOMMENDED RESEARCH

A. CONCLUSIONS

This thesis conducts a study of resupply for an armor battalion using the Janus(T) combat model. The scenario is based upon a U.S. armor battalion defending against two Soviet tank regiments. Terrain in the Fulda Gap area of the Federal Republic of Germany is utilized. The Blue force combat vehicles in the model are resupplied with two different resupply vehicles using four different resupply doctrines. Depending upon which resupply option is used, different results occur in the simulation. The Red forces suffer higher casualties when the two ARMS options are used as the resupply doctrines. This is a function of the ARMS being positioned closer to the battle positions of the Blue forces. The combat vehicles are able to resupply and then return to their battle position faster than when the HEMTT resupply options are used. The greater amount of ammunition uploaded allows the Blue force to kill a larger number of Red vehicles. Blue forces suffer less casualties when the two ARMS options and the HEMTT option with the HEMTTs prepositioned at 1000 meters are used. These options allow the Blue force to resupply during the lull in combat that occurs before the second Soviet regiment arrives. This reduces the number of Blue vehicles that are destroyed while attempting to resupply.

The most efficient resupply option for the Army will be one which places the resupply vehicles close to the battle positions. This will allow for resupply to be accomplished quickly and during lulls in combat. The current Army doctrine of resupplying from the Battalion Field Trains clearly does not meet these requirements.

B. RECOMMENDED RESEARCH

The offensive logistic support of the AirLand Battle Doctrine has not been addressed in this thesis. The heart of the AirLand Battle Doctrine is the Deep Attack. It is during such an operation that the support of a logistic system will be tested to its limits. Offensive action will consume larger amounts of both ammunition and fuel. Resupply for such offensive operations must accompany the combat vehicles. This will require a resupply vehicle that can not only keep up with the combat vehicles, but be able to survive in a more lethal environment.

Janus(T) may be used to model such an offensive operation. The length of simulation time required to stress the fuel resupply option may be prohibitive. Such an offensive scenario may have to be started at a time well into the operation.

LIST OF REFERENCES

1. Headquarters, Department of the Army, The Soviet Army Troops, Organization, and Equipment, 16 July 1984.
2. Headquarters, Department of the Army, The Soviet Army Operations, and Tactics, 16 July 1984.
3. Department of the Army, JANUS (T) Documentation, United States Army TRADOC Analysis Center White Sands Missile Range, New Mexico, October 1986.
4. DeGroot, M. H., Probability and Statistics, 2d ed., pp. 506-510, Addison-Wesley Publishing Company, Inc., 1968.
5. Draper, N., and Smith, H., Applied Regression Analysis, pp. 86-91, John Wiley & Sons, Inc., 1966.

BIBLIOGRAPHY

DeGroot, M. H., Probability and Statistics, 2d ed., Addison-Wesley Publishing Company, Inc., 1968.

Department of the Army, JANUS (T) Documentation, United States Army TRADOC Analysis Center White Sands Missile Range, New Mexico, October 1986.

Erickson, J., Hansen, L., and Schneider, W., Soviet Ground Forces, Boulder, Colorado, Westview Press Inc., 1986.

Headquarters, Department of the Army, The Soviet Army Troops, Organization, and Equipment, 16 July 1984.

Headquarters, Department of the Army, The Soviet Army Operations, and Tactics, 16 July 1984.

Huber, R. K., Modeling and Analysis of Conventional Defense in Europe, New York, New York, Plenum Press, 1986.

U.S. Army Command and General Staff College, Soviet Commander's Tactical Planning Worksheet, Fort Leavenworth, Kansas, 1983.

INITIAL DISTRIBUTION LIST

	No. Copies
1. Defense Technical Information Center Cameron Station Alexandria, VA 22304-6145	2
2. Library, Code 0142 Naval Postgraduate School Monterey, CA 93943-5002	2
3. Department Chairman, Code 55 Department of Operations Research Naval Postgraduate School Monterey, CA 93943-5000	1
4. Professor Samuel H. Parry, Code 55PY Department of Operations Research Naval Postgraduate School Monterey, CA 93943-5000	3
5. Instructor LTC Bard Mansager, Code 55MA Department of Operations Research Naval Postgraduate School Monterey, CA 93943-5000	1
6. TRAC-Monterey MAJ Hirome Fujio Naval Postgraduate School Monterey, CA 93943-5000	2
7. CPT Ronald G. McCandless U.S. Army Armor Center ATTN: ATSB-CD-SD Fort Knox, KY 40121-5215	2
8. Chief, TRAC-Monterey LTC V. Bettencourt Naval Postgraduate School Monterey, CA 93943-5000	1
9. Commander TRADOC Analysis Command ATTN: ATRC-FA Fort Leavenworth, KS 66027-5200	1

10. Chief of Naval Operations (OP-0403) 1
Department of the Navy
Washington, DC 20350
11. Chief of Naval Operations (OP-09BC) 1
Department of the Navy
Washington, DC 20350