NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

DEMONSTRATING THE REQUIREMENT FOR AMPHIBIOUS READY GROUP (ARG) REPLENISHMENT IN SEA-BASED LOGISTICS OPERATIONS

by

Max A. Willey

December, 1997

Thesis Advisor: David A. Schrady

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DEMONSTRATING THE REQUIREMENT FOR AMPHIBIOUS READY GROUP (ARG) REPLENISHMENT IN SEA-BASED LOGISTICS OPERATIONS

Max A. Willey - Lieutenant, United States Navy
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Operational Maneuver From the Sea (OMFTS) is a new concept under development by the Marine Corps. OMFTS is a warfighting concept that revises the way combat power is projected in littoral regions in that it uses the sea as a maneuver space and safe haven for logistics, while further adopting *ship to objective* operations. Sea-Based Logistics (SBL) uses the Amphibious Ready Group (ARG) ships to provide a sea-base from which combat forces ashore are directly sustained. To function in this new capacity, the ARG units need replenishment to maintain high stockage levels of fuel, ammunition, and stores. This thesis develops a computer simulation for modeling the logistical support needed for ARG units functioning in a sea-base role for supporting combat forces ashore.

Master of Science in Operations Research, December 1997

Thesis Advisor: David Schrady, Department of Operations Research
Second Reader: Arnold Buss, Department of Operations Research

Unclassified/A

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October, 1997	Master's Thesis

4. TITLE AND SUBTITLE DEMONSTRATING THE REQUIREMENT FOR AMPHIBIOUS READY GROUP (ARG) REPLENISHMENT IN SEA-BASED LOGISTICS OPERATIONS

5. FUNDING NUMBERS

6. AUTHOR(S)
Willey, Max A.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Surface Warfare Center, UNREP Department, Port Hueneme, CA

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
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.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

ABSTRACT *(maximum 200 words)*
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14. SUBJECT TERMS
Underway Replenishment (UNREP), Sea-Based Logistics (SBL), OMFTS, Amphibious Ready Group, MEU(SOC)

15. NUMBER OF PAGES
41

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500
98 (Rev. 2-89)

Standard Form

Presribed

by ANSI Std. 239-18

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Lieutenant, United States Navy
B.S., Old Dominion University, 1989

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
October 1997

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ABSTRACT

Operational Maneuver From the Sea (OMFTS) is a new concept under development by the Marine Corps. OMFTS is a warfighting concept that revises the way combat power is projected in littoral regions in that it uses the sea as a maneuver space and safe haven for logistics, while further adopting *ship to objective* operations. Sea-Based Logistics (SBL) uses the Amphibious Ready Group (ARG) ships to provide a sea-base from which combat forces ashore are directly sustained. To function in this new capacity, the ARG units need replenishment to maintain high stockage levels of fuel, ammunition, and stores. This thesis develops a computer simulation for modeling the logistical support needed for ARG units functioning in a sea-base role for supporting combat forces ashore.

THESIS DISCLAIMER

The reader is cautioned that the computer program developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the program is free from computational and logical errors, it cannot be considered validated. Any application of this program without additional verification is at the risk of the user.

ACKNOWLEDGMENT

The author wants to thank the Almighty God for giving him strength and wisdom to successfully complete the Operations Research curriculum. He wants to thank the following individuals for their patience and diligence while completing this thesis. For his loving wife, Rachel, for maintaining a balanced home and shoulder to lean on in time of need. For his son, Jordan, and his daughter, Victoria, who provided joy to his heart. For Professors David Schrady and Arnold Buss, who patiently guided him in the development and completion of this thesis. For Ray Chatten, Debbie Kreider, and Allisyn Rojas, who provided much help and technical expertise in resolving all computer related problems. And lastly, for his parents, brothers and sisters, for providing encouragement for him during the past two years.

DEDICATION

The author wishes to dedicate this thesis to the memory of his loving sister, Es ther Jaria Willey, whose 19 years of life has brought more love and joy to his life than any of his other brothers and sisters. May God bless and keep her!

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I. INTRODUCTION

A. BACKGROUND

...From the Sea and *Forward ...From the Sea* define a new approach to projecting Naval Power. This new approach is of strategic significance since it emphasizes littoral operations and provides a link between maneuver warfare and naval warfare. This approach further serves as the foundation for *Operational Maneuver From the Sea* (OMFTS), a concept being developed by the U.S. Marine Corps. The goal of OMFTS is to break from the traditional two-phase *ship to shore to objective* movement and transition to a one-phase *ship to objective* concept. [Ref. 1]

Converting the OMFTS strategic concept into an operational reality requires modification of current doctrinal and tactical practices. Decision makers must be capable of merging their warfighting knowledge with technologically advanced support systems to complete the combat equation. Once fully implemented, warfighters will soon benefit from the advantages of speed, mobility, and focused logistics that OMFTS has to offer.

A crucial part of OMFTS is the philosophy of "sea-basing" logistics. Sea-Based Logistics (SBL) uses Amphibious Ready Group (ARG) ships to provide a sea-base from which combat forces ashore are directly sustained. One clear advantage of SBL is the elimination of a costly, vulnerable, and manpower-intensive shore-based logistics infrastructure. Rather than incrementally building up a logistics stockpile ashore, SBL uses over-the-horizon delivery vehicles to provide a more adaptable and secure replenishment option to the landing force commander. With SBL, the landing force commander has the flexibility of taking to shore only those items that are critical during the first phases of the operation and replenishing as needed from an existing sea-base. If needed, the landing force commander can respond more rapidly as changing situations dictate the need to move or maneuver to a different objective area.

OMFTS and SBL are ideal for situations that lack modern port facilities or secured airfields, as well as navigable waters that allow for safe offload of Maritime Prepositioning Force (MPF) ships. For example, contrast the sealift operations at Mogadishu, Somalia in 1992 to those in Operation Desert Storm two years earlier. The

U.S. and other allied nations were allowed an unopposed six month buildup of forces during the Gulf War. Saudi Arabia provided substantial Host Nation Support (HNS) for coalition forces. Allies were able to offload and assemble war material at modern well-managed port facilities located significant distances away from hostilities. In contrast, Somalia lacked both suitable port facilities and civil authority. With no host nation assistance available, the MPF ships were relied upon to transport all requirements into theater in order to support the mission. Along with inadequate port facilities, military planners were confronted with extreme tidal conditions and inaccurate depth sounding data which further hampered the safe offload of critical MPF equipment. Though Restore Hope and Desert Storm are dissimilar in scale, Somalia appears to be the more likely template for events in the future. [Ref. 4] Somalia would have been a suitable scenario for SBL. The establishment of a sea-base for logistical sustainment of troops operating ashore would have compensated for the lack of port facilities and HNS.

With the uncertainty of the locations of future conflicts, deployed Marine units must remain flexible to changing threats and be capable of executing a variety of operations in areas providing little or no HNS. Current plans require U.S. military forces to support two near-simultaneous Major Theater Wars (MTW). The MTW scenarios are the focus of many planning efforts. However, there are still numerous third world nations whose instabilities have kept our military involved in Small Scale Conflict (SSC) operations. Some examples of SSC include: disaster relief, humanitarian assistance, peacekeeping, aid in assisting disaster victims, non-combatant evacuation operations, and other related operations short of war. [Ref. 2&3]

Most SSC operations will occur in the littoral regions of the world. Combat forces should assume that there will be no forward bases, little infrastructure and little or no HNS in the area of operations. Small mobile Marine forces that are part of an expeditionary force are likely candidates for most SSC operations and for utilizing sea-based assets for sustainment. Expeditionary operations will involve the Marine Air Ground Task Force (MAGTF). Perhaps the most likely size of MAGTF to implement OMFTS is the Marine Expeditionary Unit (Special Operations Capable) (MEU(SOC)). The MEU (SOC) embarked aboard the ships of an Amphibious Ready Group (ARG) are capable of rapidly responding to any crisis on short notice within their area of operation.

With OMFTS, the ARG will function as a sea-base, as well as a warehouse and distribution center for Marine logistics. A new secondary function for the ARG is to serve as an intermediate maintenance activity (IMA) for Marine ground equipment. Each ARG possesses organic capability to transport supplies from its inventory directly to the forces operating ashore. Platforms such as the CH-46, CH-53 and, eventually, the new MV-22 Osprey will transport supplies and field service assets from the ARG ships directly to the objective area ashore. Landing Craft Air Cushion (LCAC) vehicles will also play a role in SBL, but its movement is limited to the beach area ashore; air or ground lift assets must provide the additional transfer of supplies inland.

It takes substantial coordination with the units of the ARG to maneuver close enough to the objective area for the transport assets to deliver material to the shore. The ARG has an even more limited capability in transporting some commodities such as Supply Class III bulk fuel[1]. A recent thesis by LT Mark Beddoes [Ref. 5] determined the constraints on the distance between the ARG and the objective area. Figure 1 depicts the concept of SBL with the ARG serving as a sea-base for Marine forces ashore.

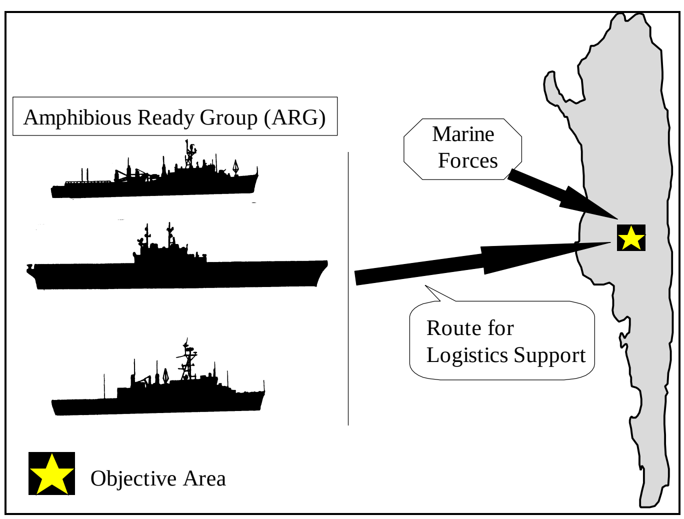

Figure 1. Concept of Sea-Based Logistics

[1] See Appendix A for an explanation of Supply Classes

The ARG normally deploys with enough supplies to sustain the MEU(SOC) for 15 days of operations with no external support. For the ARG to function as a logistics base, the ARG units need replenishment in order to maintain high levels of Marine specific supplies and services. Ships of the Combat Logistics Force (CLF) normally provide replenishment for Carrier Battle Groups (CVBG) and very limited support for ARG's. Currently there are no CLF assets earmarked for supporting an ARG in a sea-based logistics role.

B. OBJECTIVE OF THESIS

The objective of this thesis is to provide a better understanding of the ARG's role as a sea-base for Marines, monitor supply levels for Marine forces ashore and replenish as needed, and to quantify the requirement for CLF support to the ARG.

The remainder of this thesis is organized as follows: In Chapter II an overview of sea-based logistics is provided. In Chapter III, the *OMFTS Simulation Model* is described, followed by results in Chapter IV. Finally, Chapter V gives conclusions and recommendations.

II. OVERVIEW OF SEA-BASED LOGISTICS

The essence of flexibility is in the mind of the commander; the substance of flexibility is in logistics. (RADM Henry Eccles)

This chapter provides descriptions of a MEU(SOC) and an ARG. At the conclusion of this chapter, the reader will have gained an understanding of how each of these components must collaborate to provide logistical support for sea-based logistics.

A. MARINE EXPEDITIONARY UNIT (SPECIAL OPERATIONS CAPABLE) MEU(SOC))

> **The MEU is an expeditionary intervention force with the ability to move quickly on short notice, to wherever needed to accomplish conventional or special operations. The strength of the MEU (Special Operations Capable) resides in the inherent combined arms capability while operating from amphibious shipping, forward deployed. (U. S. Marine Corps, 11th MEU, 1997).**

The MEU serves as the "911" force for the National Command Authority in many situations, particularly SSC in the littorals as mentioned previously. There are seven standing MEU(SOC)s maintained by the USMC. Each embarks on an ARG with 15-days of sustainability across several classes of supply. A MEU(SOC) consists of a Command Element (CE), an Air Combat Element (ACE), a Ground Combat Element (GCE), and a Combat Service Support Element (CSSE). A detailed description of each component is given in Ref. 6. This thesis focuses on the GCE of the MEU(SOC), namely the Battalion Landing Team (BLT). The CE, ACE and CSSE all work cooperatively, oftentimes in support of the BLT.

The BLT contains approximately 1406 personnel composed of an infantry battalion and reinforced with an artillery battery, amphibious assault vehicle company, combat engineers detachment, light armored reconnaissance company, an M1A1 Main Battle Tank platoon, a reconnaissance platoon and other smaller attachments as required. This composition makes the BLT a highly mobile and combat ready assault force, capable of performing a variety of missions. For example, the BLT may be tasked with the seizure of an airfield in order to allow the establishment of a noncombat evacuation site for personnel. Other missions may include assistance to disaster relief victims. Due to its size and mission, the BLT is the dominating component of the MEU (SOC). [Ref. 19]

B. AMPHIBIOUS READY GROUP (ARG)

"Amphibious Warfare is a method of combat in which an attack is launched from the sea by naval and landing forces…special vessels are used to carry large numbers of troops and equipment to hostile shores." [Ref. 21]

Amphibious tactics of today require the use of high-speed lift assets that are capable of rapidly moving forces to an objective area. Modern amphibious shipping is capable of launching helicopters and discharging loaded landing craft from a flooded well deck.

The ARG provides the necessary transportation for the MEU(SOC)'s personnel and equipment from the point of embarkation to the designated operating area. The ARG usually consists of three ships, namely an amphibious assault ship (LHD) or (LHA), a dock landing ship (LSD), and a amphibious transport dock ship (LPD).

The LHD or LHA houses the CE for amphibious operations. It serves as the primary aviation platform for the ACE and is capable of launching Landing Craft Air Cushion (LCAC) vehicles, and conventional landing craft to move Marine forces ashore. The LPD is used to transport supplies to the objective area horizontally by embarked landing craft and vertically by air assets. The LSD has the largest LCAC capacity of all amphibious ships for troops and equipment transport. Its primary mission is to support horizontal insertion over the shore. All of the ships listed above will carry some component of the embarked MEU (SOC) and their supporting equipment.

It is also important to note that the LHD or LHA and the LSD carry the standard package of supply classes I, III, IV and V(W) for Landing Force Operational Reserve Material (LFORM). LFORM is a package of contingency supplies prepositioned on amphibious ships consisting of Class I (Rations), Class III (Trioxane), Class III (W), Petroleum, Oil and Lubricant (POL), Class IV (Field Fortification Material), and Class V (W) (Ground Ammunition). LFORM is part of the Marine Corps Prepositioned War Reserve Material Stocks (PWRMS). LFORM is used to enhance logistics response time and provide more timely support for embarked troops in contingencies. [Ref. 7]

With the reader introduced to the basic components and forces involved, the remaining sections of this chapter will discuss how the pieces must interact to provide SBL for the concept of OMFTS.

C. CONCEPT OF OPERATIONS

In traditional amphibious operations, ARG ships were used for a one time offload of Marine logistics. Once the ARG offloaded, ARG units maintained a safe distance offshore until the Marine forces returned from the assault. A logistics base ashore was constructed by the Landing Force Support Party (LFSP) to handle large amounts of fuel, ammunition, and other supplies received from the ARG. This base, also known as the Beach Support Area (BSA) provided a central point for both the distribution and management of logistic resupply materials for the forces operating ashore.

The BSA was maintained by members of the CSSE, and could be expanded to a much larger Combat Service Support Area (CSSA) to handle additional material. Establishing the BSA was time consuming and very labor intensive. Also, due to its immobile nature, the CSSA was susceptible to attack and had to be heavily defended.

Current OMFTS doctrine relies on SBL, thereby eliminating the need to establish a BSA or CSSA. The ultimate goal with SBL is to make amphibious operations seamless across the battlefield so that there is no interruption in force movement or sustainment from ship to objective area. Lift assets will transport resupply materials from the ARG directly to the forces ashore. With sea-based logistics, the commander ashore has the flexibility of taking only what he needs and then replenishing from the ARG ships as necessary. Here the advantages are increased mobility, less excess, and a reduced overall footprint. However, these types of operations may impose constraints on the lift assets and ships of the ARG and incur some risk. In addition, if the ARG is to serve as a sea-based warehouse to support forces ashore, the ARG units will need replenishment.

D. REPLENISHMENT AT SEA

In keeping with the Navy's tradition, fleet units must be capable of remaining at sea for prolonged periods of time. Logistics support for fleet units is received by means of underway replenishment (UNREP). The transfer of liquid and/or solid cargo between two ships underway is an UNREP. [Ref. 15] Ships of the combat logistics force (CLF) are equipped to replenish combatants underway for sustained periods of time.

Today, UNREP sustains a Carrier Battle Group (CVBG) anywhere, anytime for as long as needed. Figure 2 depicts a normal UNREP operation between ships of the CVBG and CLF.

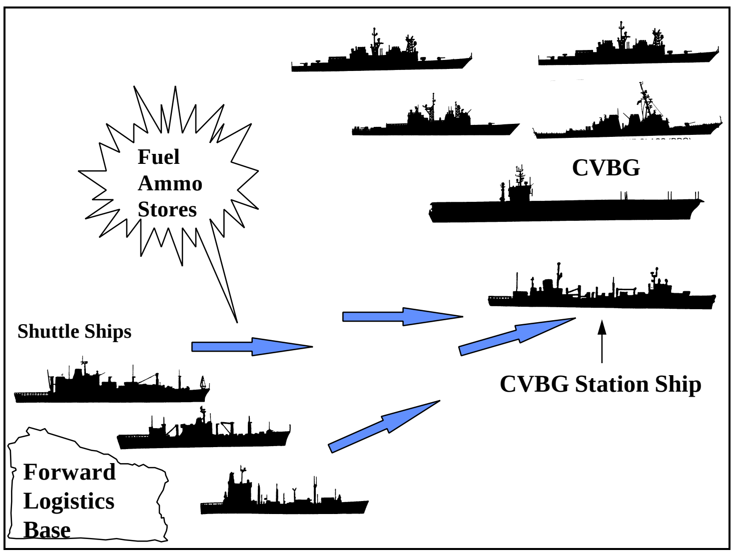

Figure 2. UNREP Sustains CVBG

A carrier battle group (CVBG) normally deploys with 4-5 escort ships for a six month duration. As part of the CVBG, a CLF multi-product replenishment ship keeps the carrier and escorts stocked with fuel, ammunition/ordnance, consumable stores, and spare parts. This CLF multi-product ship serves as a "station ship" for the CVBG. The CVBG station ship is capable of delivering ammunition and stores through vertical replenishment or by cargo transfer stations, while simultaneously transferring fuel.

When the CVBG station ship needs replenishment, CLF "shuttle ships", which are not organic parts of the CVBG, bring supplies from forward logistic bases (FLB's) to the

CVBG station ship. CLF shuttle ships are single product ships, such as fleet oilier ships (T-AO), ammunition ships (T-AE), and combat stores ships (T-AFS). In the event that a CLF multi-product station ship is not available for a CVBG, a T-AO and T-AE both will normally serve as station ships for the CVBG.

With the CVBG station ship providing logistic support for the CVBG, combatant escort ships can maintain station in a combat role, while minimizing time awaiting supplies. Similarly, UNREP of the ARG will allow the ARG ships to remain on station and continue to support Marine forces operating ashore. Even if operations ashore do not exceed 15 days, the ARG ships will need replenishment in certain classes of supply.

This thesis will examine the requirem ents to replenish the ARG ships from CLF shuttle ships. CLF shuttle ships that normally service a CVBG may need to reconfigure their cargo spaces to carry required levels of fuel, ammunition and stores needed for Marine units. Once shuttle ships replenish the ARG ships, the ARG ships can deliver fuel and cargo ashore with available transportation assets. CLF ships are not capable of delivering supplies ashore.

Having presented the basic concept of Sea-Based Logistics, the following chapter describes the simulation model developed to study it.

III. THE OMFTS SIMULATION MODEL

Many systems are highly complex, so that valid mathematical models of them are themselves complex, precluding any possibility of an analytical solution. In this case, the model must be studied by means of simulation (Law and Kelton, 1991).

A. THE PURPOSE OF THE MODEL

The *OMFTS Simulation Model* (OSM) models the logistical operations of an ARG functioning as a sea-based warehouse and distribution center for Marine forces ashore. The simulation was not intended to model combat operations ashore, but simply to examine the logistical operations necessary to support OMFTS. The model is implemented in Modular Simulation, Version II (MODSIM II), an object-oriented, modular, block-structured programming language that provides synchronous and asynchronous discrete event simulation. Appendix B discusses the controlling properties of each of the different modules developed for the OSM.

B. MEASURE OF EFFECTIVENESS

The main objective of Sea-Based Logistics is to support the forces on shore. Consequently, the primary Measures of Effectiveness (MOE's) for OSM are the average on-shore levels for each of the supply classes considered. The classes are considered separately because they are essentially incomparable. On the other hand, supplies are aggregated by class because there are too many distinct items. For example Supply Class V(W) contains approximately 100 different items with different characteristics such as usage rates and quantity. OSM allows the user to observe the characteristics of the supply class as a whole, vice analyzing observations of each supply item separately from the others.

The inventory levels are averaged over time (i.e. the mean values are time-averages) by dividing the cumulative area under the inventory level curve by the amount of time. For the sake of measurement, the inventory levels are assumed to be piecewise linear.

Thus, the primary MOEs capture the ability of Sea-Based Logistics to maintain average inventory levels on shore. There may be, however other factors that are important. For example, the minimum inventory level over the campaign may be an important consideration, since supplies that are short during a critical phase of the campaign may adversely affect the outcome regardless of the average levels.

Finally, the inventory levels at the ARG are also a consideration. To evaluate the ARG's ability to support the Marines, the average inventories of each supply class at the ARG is measured. Apart from high levels at the ARG supporting the Marines better, maintaining high ARG levels can also be a factor in case of unforeseen circumstances. An unanticipated battle or a campaign that is longer than anticipated may require greater inventory levels. Higher levels at the ARG help enable such contingencies. Each supply class's average level at the ARG is measured, with the time averages being computed in the same manner as the shore inventory levels.

C. MODEL ASSUMPTIONS

OSM makes the following modeling assumptions:

- The FLB has unlimited stockage of needed commodities. Since the focus of this thesis is about the ARG functioning as a sea-base, this assumption is reasonable. Modeling the FLB is beyond the scope of this thesis. However the simulation model is sufficiently flexible that the FLB could be readily incorporated.
- All CLF shuttle ships are multi-product with identical characteristics. Multi-product ships are able to replenish the ARG with fuel, ammunition and stores. Otherwise the ARG must wait for an available single-product shuttle ship for replenishment, while in the mean time she may be below safety stock levels in other commodities.
- Shuttle ships consider the ARG as one unit. The justification for this assumption is for model simplicity. In real-world situations, shuttle ships must replenish each ship in the unit of ships, except for units with a station ships.
- ARG lift Assets are allowed to travel "light", which means even if there are only a few items to be transferred ashore, the lift asset will detach. The model considers an average load to be 30% based on weight.

- Lift Assets travel unopposed between the ARG and Objective Area.

D. MODEL IMPLEMENTATION

This section provides a description of how OSM implements the concept of Sea-Based logistics. OSM considers an ARG and CVBG operating in close proximity to support an operation. When ships need replenishment, CLF shuttle ships deliver replenishment items from a Forward Logistics Base (FLB) directly to the ARG and the CVBG station ship. A general overview is provided in Figure 3.

The model consists of four components: Set-up and Initialization, Combat, Ship-to-Objective Logistics, and CLF Shuttle Ship Logistics.

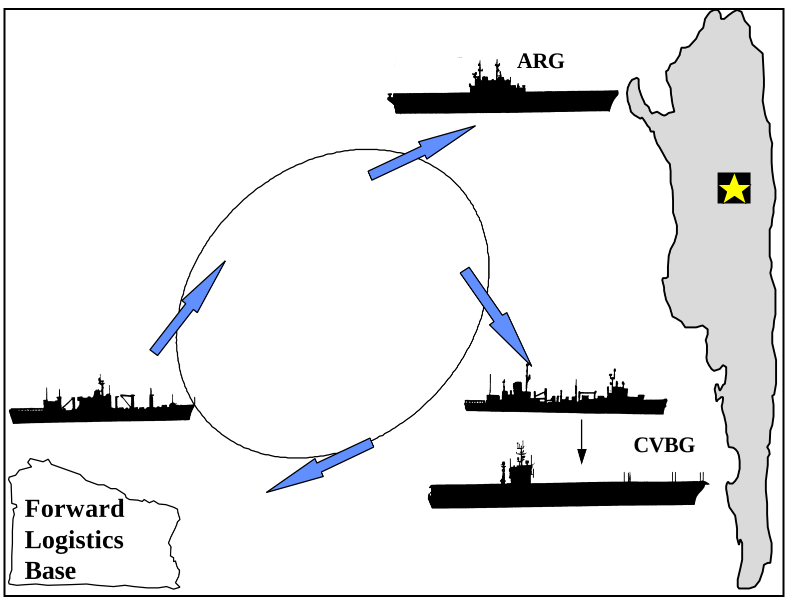

Figure 3. Overview of OSM

1. Set-Up And Initialization

The program begins by setting up a map structure that provides a coordinate system for all objects. An FLB is generated and given a location on the map. For modeling simplicity, CLF multi-product shuttle ships are used throughout, in the execution of the model. Once generated, these CLF ships are placed at the FLB. An area of potential hostilities is generated and placed on the map. An ARG and CVBG are located off the coast of the area of operations (AO). The ARG group contains a set of organic lift assets, that include a mix of helicopters, fixed wing aircraft, and landing craft as described in Chapter I. For modeling purposes, the ARG and CVBG remain in the same position or station during the entire operation. The CLF shuttle ships travel on a predetermined replenishment route as shown in Figure 3.

2. Combat

For the combat scenario, the Battalion Landing Team (BLT) is positioned deep in the objective area, and carrying a basic allowance of supplies for 1.5 to 2 days of operation. The Commander of the Landing Forces (LFC) [2] anticipates that ground forces will be involved in an assault for the first 3 days of the operation. Afterwards, ground forces must sustain and hold their positions until ordered otherwise. The combat phase commences at the start of the simulation clock.

3. Objective Logistics

The simulation begins and ground forces enter combat. Supplies are consumed based on the usage rates established for the scenario. At the end of each day of combat, the LFC directs Combat Service Support (CSS) personnel at the objective area to determine the amount of supplies used in each supply class. If the total amount of supplies for a particular item falls below 70% of the basic allowance, an order is placed so as to bring the amount of each item up to 100% of basic allowance. CSS personnel ashore compute total supplies as the amount currently on-hand plus the net amount of items already on order.

Supply requests from the LFC are passed to the CSS manager who shares a common office with the ARG Supply Manager on the LHD or LHA. Both supply managers perform similar tasks to ensure orders received from ground forces are

[2] Commander of the landing force is usually abbreviated as CLF. For this thesis LFC will be used to describe the Commander of the Landing Force, and CLF will be used to describe the Combat Logistics Force.

processed as quickly as possible. The ARG Supply Manager authorizes the removal of requisitioned items from the ARG ships. When an order is released for issue, available lift assets will transport the items directly to the ground forces ashore. Figure 4 describes the flow of information involved in Ship-to-Objective logistics.

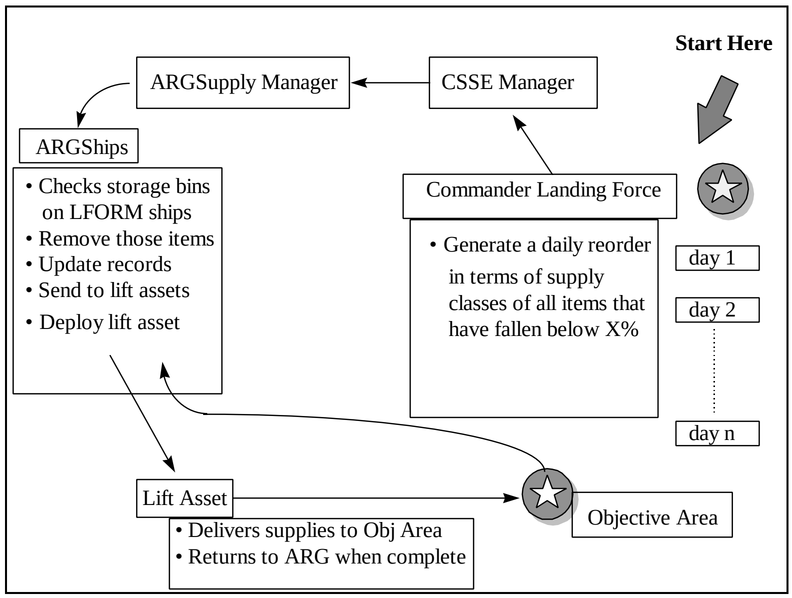

Figure 4. Ship to Objective Flow of Logistics

4. ARG Logistics

As this ship-to-objective replenishment proc ess continues, the LFORM stock levels aboard the ARG ships quickly diminish. The ARG Supply Manager monitors and reviews each of the LFORM inventory supply classes of all ARG ships to determine when to place a replenishment request. Similar to the LFC, when supply levels of a certain stock item fall below 70% of the stockage objective level, a re-order form is generated. The re-order form includes the supply line item and quantity of the item to return stock levels up to 100% of LFORM allowance. After a certain number re-order forms are generated, a replenishment request for these items is forwarded to the FLB. The FLB processes and loads the replenishment requests from the ARG on an available CLF shuttle ship at the FLB. Once loaded, the shuttle ship(s) proceed along the replenishment route. Note that these shuttle ships may also be required to service other underway units in the area. If no CLF assets are available for the ARG, filled orders wait at the FLB until a shuttle ship asset is available for loading.

When CLF shuttle ships arrive at the ARG, the shuttle ship services each unit of the ARG and replenishes fuel, ammo and stores. With the ARG ships replenished, the ARG is capable of maintaining a higher level proficiency in providing service to Marine forces ashore. Figure 5 displays the flow of CLF logistics to the ARG.

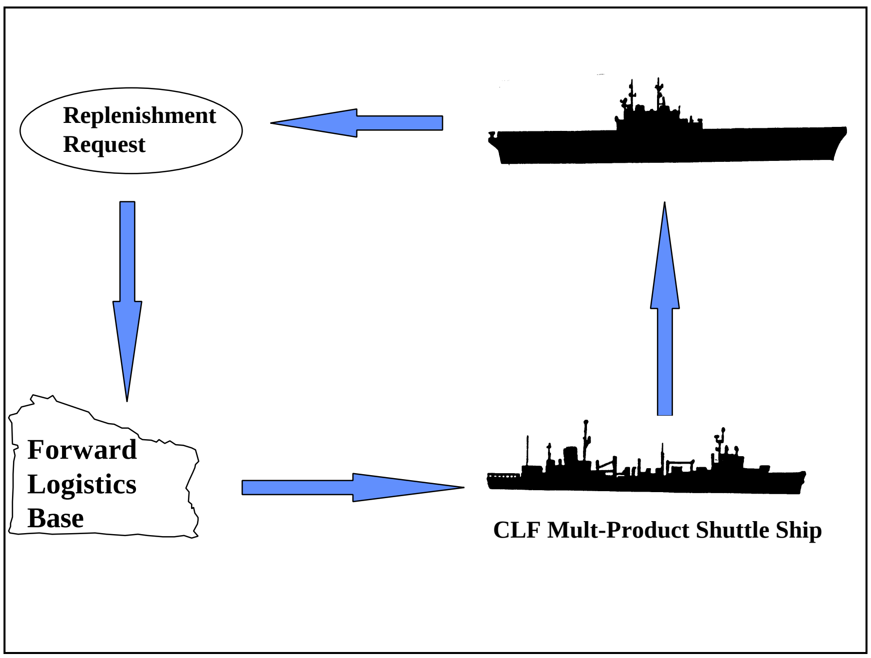

Figure 5. Flow of CLF Logistics

E. SUPPLY CLASS CONSUMPTION PLANNING FACTORS

Combat planning factors for daily supply usage rates of Class I, III, and V(W) are provided in Appendix C. These particular supply classes were selected because of their large quantity requirement and having the biggest impact on warfighting.

IV. RESULTS

Chapter II and III discussed the development of OSM and explained its implementation into MODSIM II. This chapter presents the results of OSM using two cases that exercise the features and functions of the model. The results of these cases will be discussed in terms of the logistical aspects of supporting Marine forces ashore from a sea-base.

A. COMMON SCENARIO

During the Set-Up and Initialization phase of the model, a map structure of 500 x 350 square nautical miles $(nm)^2$ was established for the placement of the FLB, CLF shuttle ships, ARG, CVBG, and area of operations. The FLB is located at the vertex of the map, and all distances to other areas are measured from this location. The following distances were used during each execution of the model:

FLB → **ARG** 443 nm

ARG → **Objective Area** 102 nm

CVBG → **Objective Area** 184 nm

A mixture of eight lift assets were used to transport supplies to the objective area. Determining the best mix of lift assets that would satisfy all supply requirements ashore proved difficult and tedious.

The problem of providing adequate fuel ashore is a recurring topic of discussion in SBL operations. Before the retirement of the tank landing ships (LSTs), these ships possessed the capabilities of transferring massive amount of fuel ashore directly to the Marines of the bulk fuel company. From here the fuel was pumped and stored at large fuel farms or transferred to motor transport platforms for distribution. Without the LSTs, the force service support group (FSSG) must provide some means of providing bulk fuel delivery ashore. Refs. 8 and 10 discuss some of the alternatives to overcome the shortfalls of depleting fuel stocks ashore in SBL operations.

From the model, fuel levels ashore reached less than 20% by day two of operations using CH-53 and VS-22 assets alone, and zero for the remaining days. Since the fuel requirement was so high, the lift assets were only able to load Class I and V(W), and only a small percentage of Class III.

For OSM to satisfy the fuel requirement ashore and maintain high levels of the other supply classes, the mix of lift assets used was modified to include a substantial number of LCAC's to allow for greater lift capacity. OSM made an additional assumption that once an LCAC reached the shore line, other vehicles will need to transport supplies further inland if the objective area is not at the beachhead.

The remainder of this chapter provides graphical analysis of two model cases. The first case involves the ARG supporting forces ashore without any external support. The second case examines the effect of routine replenishments of ARG ships. In each case, the ARG's ability to sustain forces ashore is discussed.

B. BASE CASE

Assuming that the ARG maintains supplies for 15 days, the Base Case was exercised for 25 days to estimate when all commodities reach zero levels. Figures 6 -11 on pages 22-24, show the ARG and BLT's current level of inventory for each of the supply classes modeled in this thesis. Note that in each supply class there is a continuous depletion of stocks from the ARG as these items are being consumed by the forces ashore. The oscillating behavior on graphs of the BLT represent the current level of supplies on a given day. Each peak represents the arrival of a lift asset replenishing the forces ashore. The vertical axis represents the ratio of the number of items currently onhand to the basic allowance. For example, for class I, this ratio represents the percentage of MRE's available. Thus with a basic allowance of 8,412 MRE's ashore (2 days of supply), the ARG is able to maintain Marine forces above 70% up to day 19. Similar results are obtained for the other supply classes. The sudden drop in BLT levels on day 16 for classes I and III is explained by the delay in the arrival of a lift asset. With the depletion of class V(W) supplies at day 15, the lift assets are waiting at the ARG until their cargo capacity has reached the average load of 30%. Once additional requests are processed from the BLT, the lift asset is loaded to capacity and sent to the beach. In practice the lift asset would have departed without waiting for additional loads.

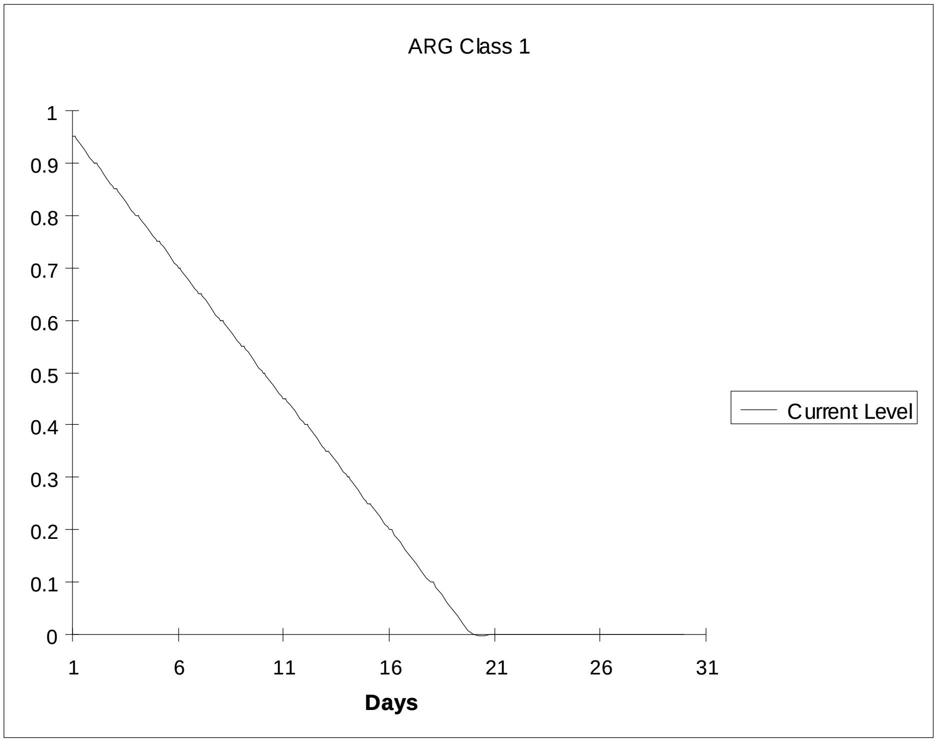

Figure 6. ARG Class 1 Levels (Base Case)

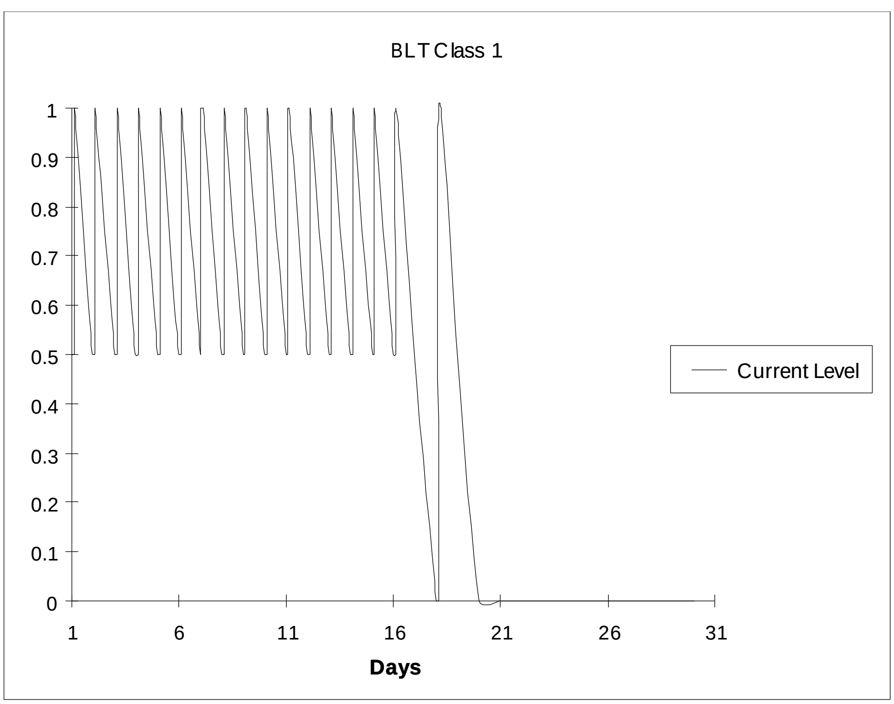

Figure 7. BLT Class 1 Levels (Base Case)

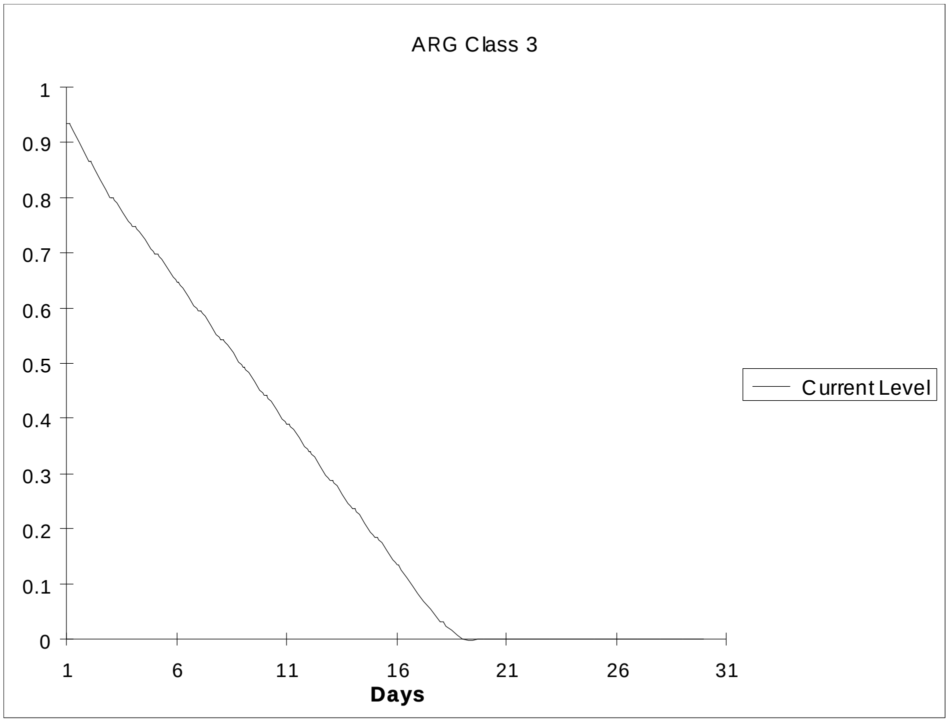

Figure 8. ARG Class 3 Levels (Base Case)

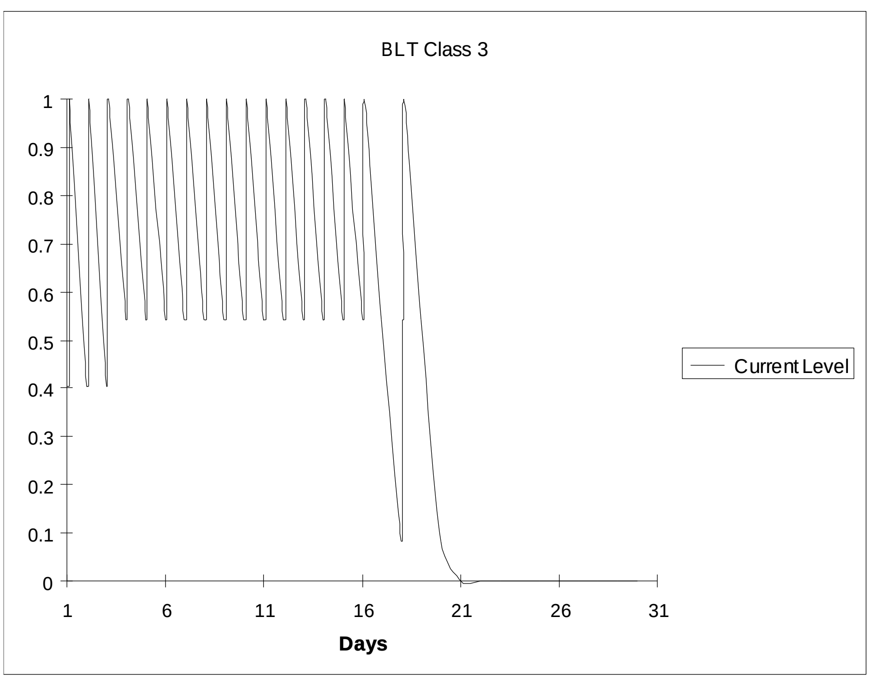

Figure 9. BLT Class 3 Levels (Base Case)

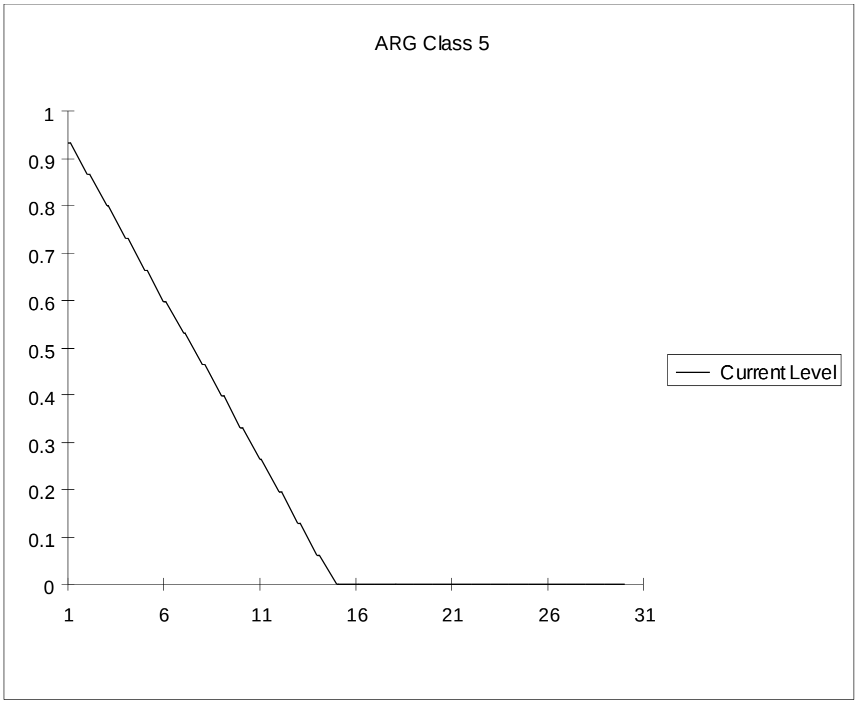

Figure 10. ARG Class 5 Levels (Base Case)

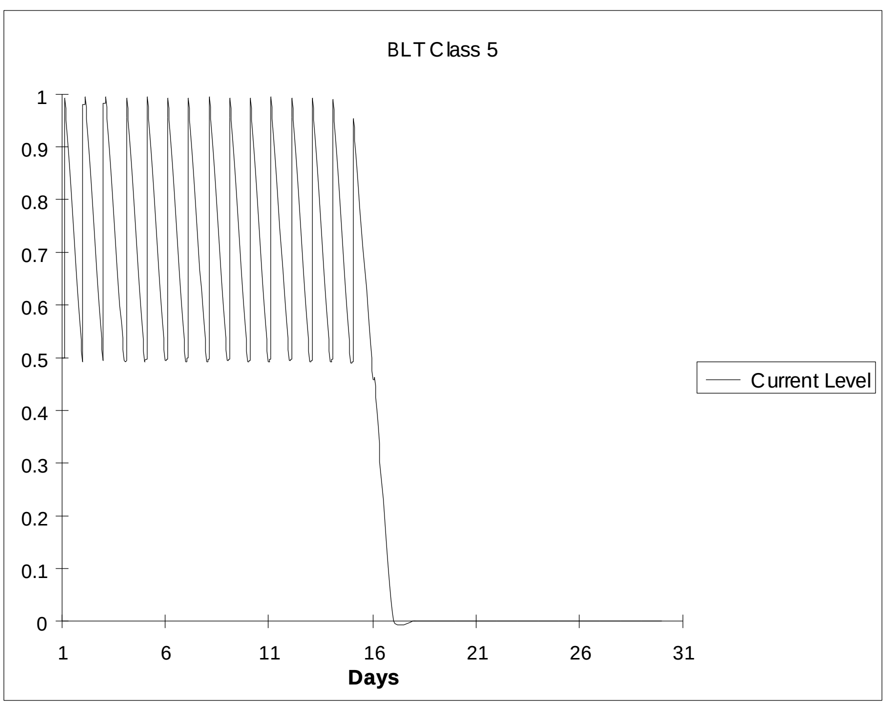

Figure 11. BLT Class 5 Levels (Base Case)

When comparing all six graphs together, it can be concluded that the ARG by itself is no longer capable of providing any level of support to the forces ashore after 20 days. Knowing that contingencies never last an exact amount of time, replenishing the ARG will assist in planning for uncertainties during the campaign. This leads to the next case, in which CLF shuttle ships are providing periodic replenishments to the ARG.

C. UNREP FOR THE ARG

As mentioned previously, both the ARG Supply Manager and the LFC desire to maintain a minimum inventory of 70% at all times in each of the supply classes. To try to keep the ARG stock levels at or above 70%, a CLF shuttle ship will need to provide a complete replenishment of needed items for the ARG by day five but not later than day seven. This determination was made by observing when the class stock levels on the ARG reach 70%, as clearly seen in Figure 6. Otherwise, the level of support provided by the ARG to the forces ashore could be jeopardized if the level of combat intensity rapidly changes.

Applying the replenishment procedures discussed in Chapter II and depicted in Figure 5, the FLB is able to provide periodic shuttle ship service to the ARG commencing on day five. Presently, only one CLF multi-product shuttle ship is available to support the ARG and CVBG, therefore the FLB will load the shuttle ship with items for the ARG only after all items for the CVBG have been loaded. Once fully loaded, the CLF ship proceeds along the replenishment route as shown in Figure 3. The results of the replenishments is given on the following pages in Figures 12-13.

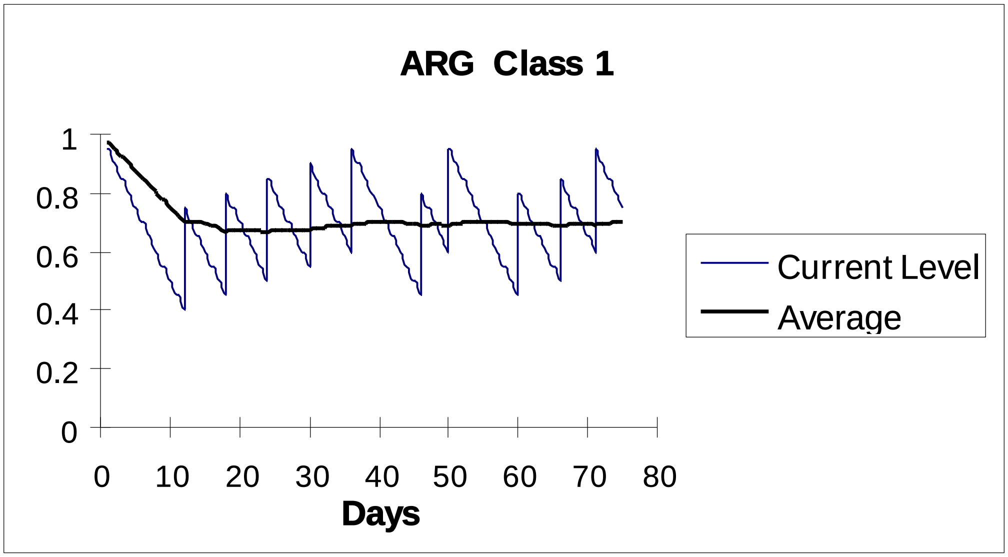

Figure 12. ARG Class 1 Levels (With CLF Replenishment)

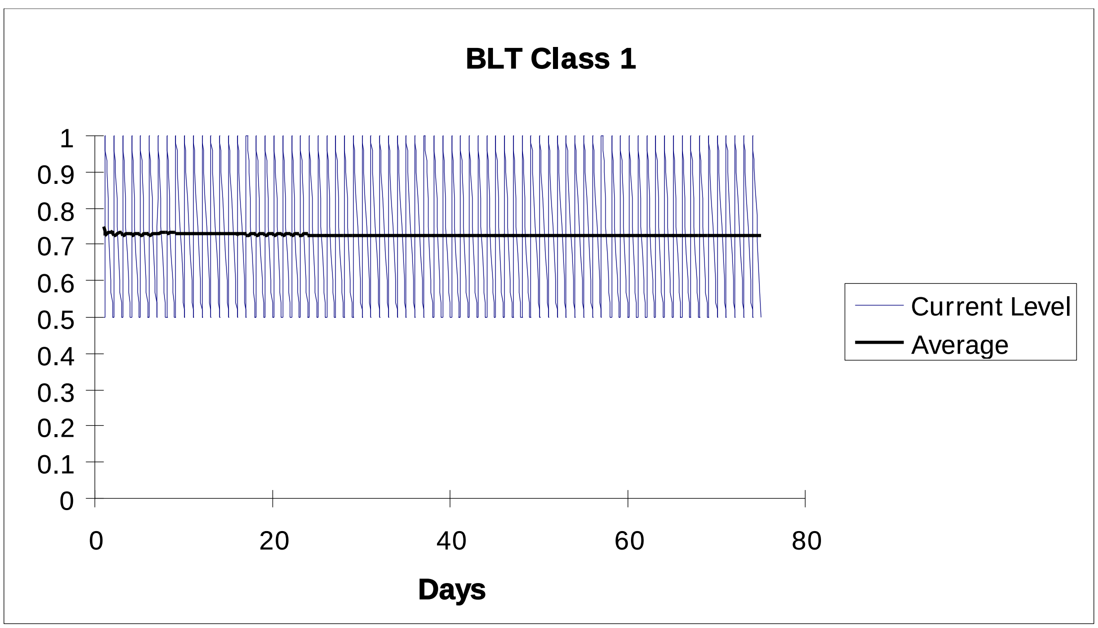

Figure 13. BLT Class 1 Levels (With CLF Replenishment)

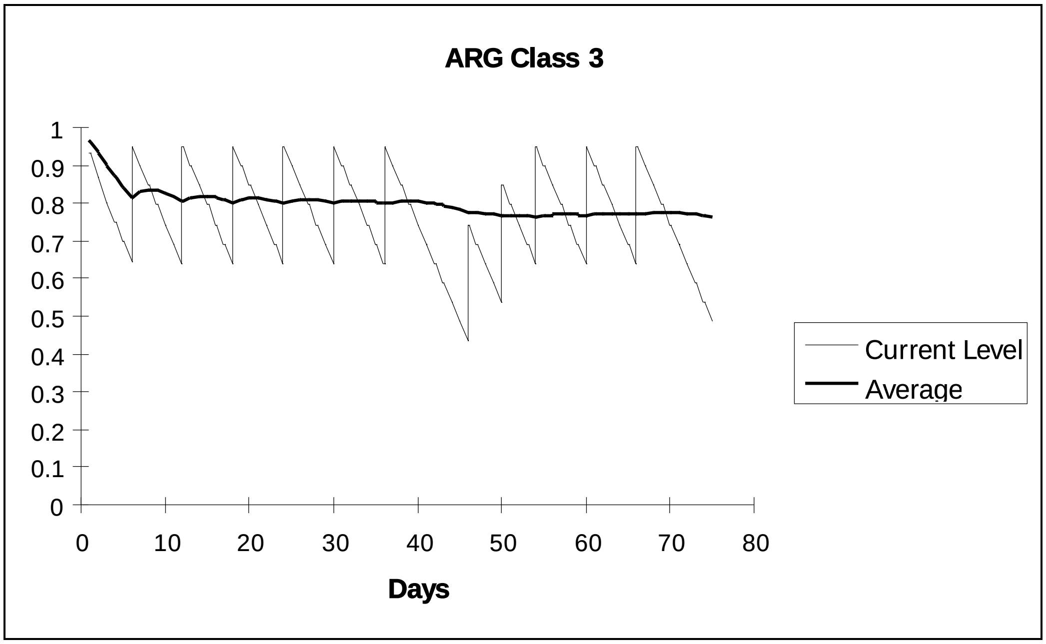

Figure 14. ARG Class 3 Levels (With CLF Replenishment)

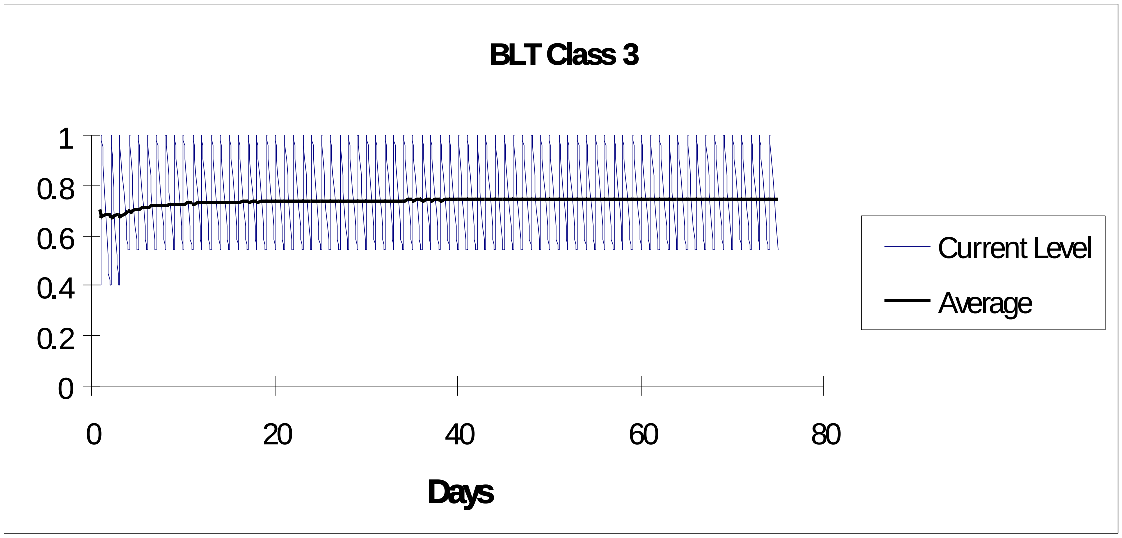

Figure 15. BLT Class 3 Levels (With CLF Replenishment)

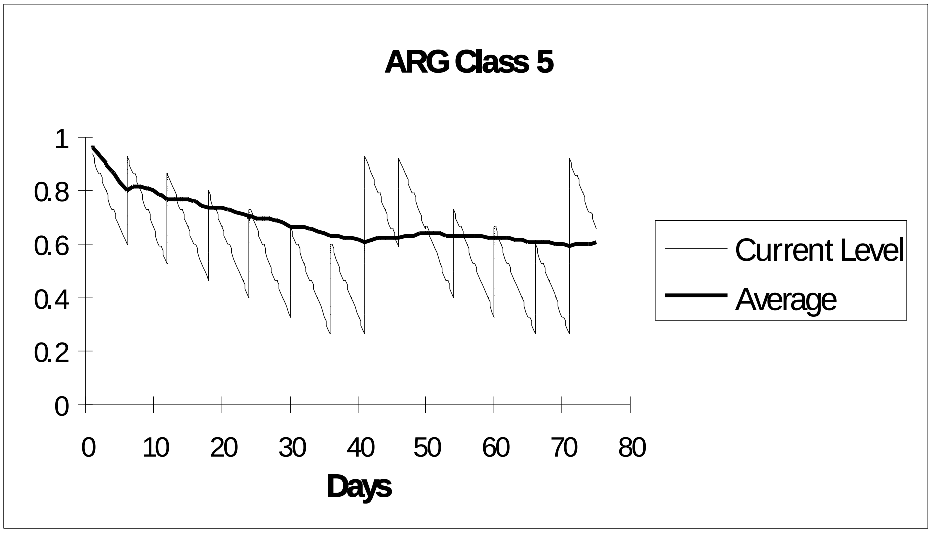

Figure 16. ARG Class 5 Levels (With CLF Replenishment)

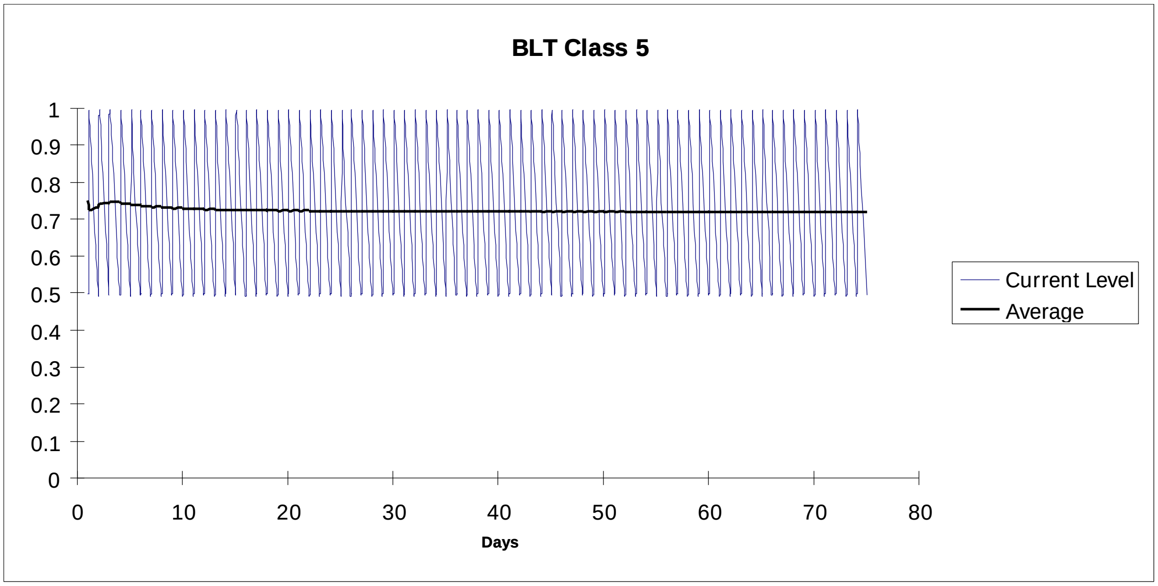

Figure 17. BLT Class 5 Levels (With CLF Replenishment)

The " saw-toothed" behavior on the graphs for the ARG represent the arrival of a shuttle ship. The heavy line is the average inventory level of the supply class and represents the MOE value to be measured. Several observations may be made about the graphs. OSM provided the UNREP days for the ARG and CVBG, as well as the times shuttle ships arrived and departed the FLB. On the average, the ARG received an UNREP about every 5 to 6 days and the time for the shuttle ship to complete the replenishment route is about 3 to 3.67 days.

When comparing Figures 12, 14, and 16, the ARG's current level for class 1 fell below the desired 70% level, even though the other classes received replenishment at day five. The reason for this occurrence is that the reorder points for classes 3 and 5 occurred on day 4. Therefore, the FLB loaded the shuttle ship with supplies from these classes only. The shuttle ship departed from the FLB on day five and completed an UNREP of the ARG on day six. While the shuttle ship was in route to the CVBG, the reorder point for class 1 occurred on day seven. When the FLB received the class 1 order from the ARG, there was not a shuttle ship asset available for loading. As a result class 1 levels fell to 40%. The next UNREP did not occur until day twelve, bringing class 1 levels up to 70%.

With the shuttle ship maintaining this schedule, given the distances needed to travel, the ARG is able to maintain the desired 70% of inventory in all supply classes with the exception of class 1 in the first twelve days. As a result, the ARG can sustain the BLT for an indefinite amount of time as long as the FLB maintains stock items needed for the ARG.

V. CONCLUSIONS

A. OVERVIEW

OSM is a deterministic modularly designed objected-oriented program that provided a preliminary look at the logistical implications of OMFTS, and provided a better understanding of the relationship between SBL and UNREP. The analysis show that supporting Marine forces from a sea-base can be achieved with periodic replenishments of the ARG ships. Specifically it was found that replenishments to the ARG every five to six days enabled the ARG to meet the demanding supply needs ashore.

B. SUGGESTED MODEL IMPROVEMENTS

OSM can be modified for additional features. Some recommended improvements are as follows:

- Modify the program that will allow supporting multiple objective areas. This will allow for studies into the effect of providing lift assets to support multiple campaigns at different geographical locations.

- Design an attrition routine that determines the probability of lift assets arriving at their destination. One suggestion is to use a Probabilistic Circulation Model. Wayne Hughes, CAPT,USN(Ret) of the Operations Research Department at the Naval Postgraduate School is a good source for researching this topic. See Ref. 22.

- Allow the program to distinguish between single product and multi-product CLF ships. This can assist planners in determining the CLF requirements for future operations.

- Combine the Marine forces supply demand with the supply demand for ships in the ARG. This can be used to determine additional levels of CLF support is needed to sustain underway units.

C. POTENTIAL MODEL APPLICATIONS

The disadvantage of using deterministic models in combat is their inability to capture the intensity of combat. Most tactical combat models provide a greater level a detail in the attrition of troops and supplies. These daily attrition of supplies can be used as inputs to OSM. Future researchers may find it useful to merge the characteristics of OSM with a tactical combat model. These results could provide a more realistic evaluation of the constraints imposed by SBL and could lead to further studies in the determination of the level of CLF support needed for a campaign.

APPENDIX A. EXPLANATION OF SUPPLY CLASSES

APPENDIX B. SIMULATION COMMAND AND CONTROL

The *OMFTS Simulation Model* consists of 14 distinct object classes. A detailed description is provided below for each of the object modules generated in the model in the order in which they are created.

1. MShuttle. Main module. Controls simulation time and execution. Creates the Map Object and starts the simulation clock after all other modules have been created.
2. MovingObj and PointObj. A MovingObj provides a basic structure for all objects that move. It contains an instance variable of a PointObj that allows objects to move from one location to another. The user can input the desired speed of an object, or of no speed is given, MovingObj will set the initial speed to zero.
3. MapObj. Establishes a map structure and coordinate control for all objects. Provides routines for reading input data files. Creates the FLB, Ships, and Amphibious Objective Area (AOA)/ Combat Service Support(CSS) Area.
4. BaseObj. Contains a PointObj instance variable and characterizes the establishment of a Forward Logistics Base (FLB) for CLF ships to be consoled. Processes replenishment requests from the ARG, loads the CLF multi-product shuttle ships and sets them to sail along the replenishment route.
5. InventoryObj. Uses a record to manage the inventory of supplies for underway ship units . Handles bookkeeping for the supply stock items, and determines reorder points.
6. SupplyClassObj. Models any of the 10 supply classes[3]. Has similar characteristics as InventoryObj, but with a greater level of detail. Computes daily consumption and determines reorder points. Communicates directly with the CSSEManager on supply shortages.

[3] Only supply classes I, III, and V(W) are modeled in this thesis.

7. CSSAreaObj. Represents the operating area of Marine landing forces. Manages a queue of SupplyClassObj's to allows CSS personnel ashore to monitor supply inventories.
8. CSSEManagerObj. On a daily basis, queries each of the supply class requisitions from the shore forces and passes the order request to the ArgSupplyManager.
9. ArgSupplyManager. Manages LFORM for the entire ARG, maintains control over all logistic lift assets, and processes orders received from the CSSEManagerObj. The ArgSupplyManager also has the responsibility of monitoring inventory levels for the ARG and generating and forwarding replenishment requests to BaseObj for UNREP.
10. ShipObj. Inherits all the attributes of MovingObj and PointObj. Contains routines for shipboard operations, such as move to another destination, unload and receive cargo, etc.
11. UnrepGroupObj. A queue of ShipObj's that contain CLF shuttle ship units.
12. ARGroupObj. A queue of ShipObj's that contain Amphibious ship units. Contains the master inventory of LFORM. Provides all routines for the ArgSupplyManager in the performance of his duties
13. CVBGroupObj. A queue of ShipObj's that contain Carrier Battle Group units.
14. LiftAssetObj. A moving object that is created and owned by the ARGroupObj. This object provides the transportation of supplies from the ARG ships to the Objective Area.

APPENDIX C. SUPPLY REQUIREMENTS BY CLASS

This appendix provides the daily supply requirements for an entire Battalion Landing Team (BLT) modeled in this thesis. Sustainment is determined by supply classes I, III and V(W).

A. Class I Subsistence

Planning factors for Class I is based on a BLT with 1406 personnel. The requirements for food is based on three meal-ready-to-eat (MRE) packages per man per day, each weighing 1.47 pounds.

Planning factors for water is 2.5 gallons per man per day based climate and other tropical conditions. This rate does not include medical and sanitary usage which increases the daily rate to 10 gallons per man per day. The ARG is usually capable of providing enough water to forces ashore. Depending on the distance from shore to the objective area, ground forces can provide themselves with 600 gallons per hour using portable reverse-osmosis water purification units (ROWPU's). Due to the difficulty of modeling water replenishment from more than one source to the forces ashore, water consumption was not modeled in OSM.

B. Class III Bulk Fuel

Based on the components of the BLT listed in Chapter 2, a table of equipment (T/E) was provided by Ref. 8. This information was then passed to I Marine Expeditionary Force (MEF) bulk fuels officer (REF. 9) who provided the daily fuel usage for the BLT. The T/E is given in Table 1. These quantities of vehicles times the gallons per day planning factors yields the total daily fuel usage.

Equipment	Quantity
M 923 5 TON TRUCK	8
LAV-25	4
LAV-A7	2
LAV-R	1
M998 HMMWV	20
AAV-P 7A1*	13
AAV-R 7A1*	1
AAV-C7A1*	1
M1A1*	4
M88A1E 1*	2
MK-138	2
MEP 16	2
BULL DOZER	2
FOR KLIFTS	2

Table 1. Table of Equipment

Equipment description can be found in Ref. 20. The preponderance of the BLT's fuel is for tracked vehicles, these are denoted by asterisk. F-44 (JP-5) and MOGAS are the two types of fuels used by the BLT. MOGAS is gradually being phased out of service due to its highly flammable nature and handling requirements. Since the tracked vehicles, which use JP-5, have the highest usage, only JP-5 is used in determining Class III requirements. The assault and sustainment rates are 4772.3 and 3671.0 gallons per day respectfully.

C. Class V(W) Ground Ammunition

The combat planning factors (CPF's) are based on the required LFORM stock levels for 15 days of operations listed in Ref. 7. The daily consumption rates for ground ammunition were determined by dividing the LFORM stock amount for a particular ammunition type by 15 days. This number was then doubled to determine the 2 day amount of supplies carried ashore by the BLT.

LIST OF REFERENCES

1. Headquarters, U.S. Marine Corps, *Operational Maneuver From The Sea (OMFTS) Concept*. (Washington: U.S. Marine Corps, 1 December 1995).

2. Shaklikashvili, John M. *Focused Logistics*: A Joint Logistics Roadmap. Chairman of the Joint Chiefs of Staff, 1995.

3. Clinton, William J . *A National Security Strategy of Engagement and Enlargement*. Office Of The President Of The United States, February 1996.

4. McGraft, John, J. *History of Sealift Force Sustainment Operations During the Somalia Intervention* (1992-1994) Masters Thesis. March 1996 , Naval Postgraduate School, Monterey, CA.

5. Beddoes, Mark W. *Logistical Implications of Operational Maneuver From the Sea.* Masters Thesis, March, 1997 Naval Postgraduate School, Monterey, CA.

6. 26th MEU (SOC) Organization (http://www.usmc.mil).

7. Prepositioning Of Landing Force Operational Reserve Material (LFORM) / Mission Load Allowance (MLA) And Other Contingency Material Aboard Amphibious Warfare Ships Of The U.S. Pacific Fleet. Commander, Naval Surface Forces Pacific Instruction 4080.1B and Fleet Marine Force Pacific Order 4080.2B, 1991.

8. Over, Richard C, Chief Warrant Officer Three, USMC. Bulk Fuels Officer, G-4 Engineers, Camp Pendleton, CA.

9. Class V(W) Planning Factors For Fleet Marine Force Combat Operations. Marine Corps Order (MCO) 8010.1E.

10. Skipper, Charles 0, Colonel, USMC. *Can We Fuel OMFTS?.* Marine Corps Gazette, January 1997.

11. Clancy, Tom. *MARINE: A Guided Tour of a Marine Expeditionary Unit*, November 1996, Berkley Books, New York.

12. *Logistical Support of Operational Maneuvers From the Sea*. Naval Studies Board, July 1995.

13. Bancroft, Bruce K, USMC. *Sea Based Logistics in Operational Maneuver from the Sea*. June 1996. Naval War College, Newport, RI.

14. Naval Doctrine Command, *Sea Based Logistics,* Draft Feb. 1997.

15. Naval Warfare Publication. *Underway Replenishment NWP 4-01.4.* August 1996. Department of the Navy, Office of the Chief of Naval Operations.

16. Fuquea, David USMC, R*iding the Dragon.* Proceeding, July 1997. Naval Institute Press.

17. Polmar, Norman, *The Ships and Aircraft of the U.S. Fleet*, Fourteenth Edition, 1987 Naval Institute Press.

18. The United States Navy Fact File (http: //www.navy.mil).

19. Von Hussell, Agostine, *Strike Force*, 1991, Howell Press.

20. The United States Marine Corps Fact File (http: //www.usmc.mil).

21. Encarta Encyclopedia, 1997, Microsoft Publishing.

22. OA4202, *Campaign Analysis*, 1997, Lecture Notes.

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