Maritime Prepositioning Force (MPF) Throughput Analysis of a Marine Expeditionary Unit (MEU) Slice Offload

by

Donald R. Bates

September 1994

Thesis Advisor: William G. Kemple

Approved for public release; distribution is unlimited
**Title and Subtitle**

Maritime Prepositioning Force (MPF) Throughput Analysis of A Marine Expeditionary Unit (MEU) Slice Offload

**Author(s)**

Bates, Donald R.

**Performing Organization Name(s) and Address(es)**

Naval Postgraduate School
Monterey CA 93943-5000

**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.

**Dissertation/Availability Statement**

Approved for public release; distribution is unlimited.

This thesis describes the design and employment of a general transportation and distribution simulation toolbox and an extension to that toolbox used to model the instream offload of a Marine Expeditionary Unit (MEU) Slice of a Maritime Prepositioning Force (MPF). The Simulated Mobility Modeling and Analysis Toolbox (SMMAT) is a toolbox of object oriented modules written in MODSIM II by faculty and students, including the author, of the Naval Postgraduate School for transportation and distribution modeling. The MEU Slice offload model is built as an extension to SMMAT, with itself being easily extendable to model other aspects of MPF operations. The objective of this thesis was twofold, (1) to build SMMAT and demonstrate its feasibility as a toolbox, and (2) to determine which of four asset distribution setups ashore, at varying levels of equipment reliability, will allow for the fastest offload and throughput of the MEU slice. This thesis successfully demonstrated SMMAT's usefulness as a transportation and distribution simulation toolbox, and the MEU Slice study indicates that no one distribution setup ashore is statistically faster than any other one.
Maritime Prepositioning Force (MPF) Throughput Analysis of A Marine Expeditionary Unit (MEU) Slice Offload

Donald R. Bates
Captain, United States Marine Corps
B.S., The United States Naval Academy, 1988

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 1994

Author: Donald R. Bates

Approved By: William G. Kemple, Thesis Advisor

Michael G. Bailey, Second Reader

Peter Purdue, Chairman
Department of Operations Analysis
ABSTRACT

This thesis describes the design and employment of a general transportation and distribution simulation toolbox and an extension to that toolbox used to model the instream offload of a Marine Expeditionary Unit (MEU) Slice of a Maritime Prepositioning Force (MPF). The Simulated Mobility Modeling and Analysis Toolbox (SMMAT) is a toolbox of object oriented modules written in MODSIM II® by faculty and students, including the author, of the Naval Postgraduate School for transportation and distribution modeling. The MEU Slice offload model is built as an extension to SMMAT, with itself being easily extendible to model other aspects of MPF operations. The objective of this thesis was twofold, (1) to build SMMAT and demonstrate its feasibility as a toolbox, and (2) to determine which of four asset distribution setups ashore, at varying levels of equipment reliability, will allow for the fastest offload and throughput of the MEU slice. This thesis successfully demonstrated SMMAT’s usefulness as a transportation and distribution simulation toolbox, and the MEU Slice study indicates that no one distribution setup ashore is statistically faster than any other one.
# TABLE OF CONTENTS

I. INTRODUCTION .................................................................................................................. 1
   A. MARITIME PREPOSITIONING FORCE (MPF) BACKGROUND ........................................ 1
   B. PROBLEM ...................................................................................................................... 3

II. MPF OPERATIONS .......................................................................................................... 5
   A. MPF OVERVIEW ........................................................................................................... 5
      1. The Phases of Operation ....................................................................................... 5
         a. Planning Phase .................................................................................................... 5
         b. Marshaling Phase ............................................................................................... 6
         c. Movement Phase ............................................................................................... 6
         d. Arrival and Assembly Phase ............................................................................. 6
      2. The Fly-In-Echelon (FIE) ...................................................................................... 7
         a. Survey, Liaison, and Reconnaissance Party (SLRP) ........................................... 7
         b. Offload Preparation Party (OPP) ...................................................................... 7
         c. Advance Party .................................................................................................... 7
         d. Main Body ......................................................................................................... 7
         e. Flight Ferry ......................................................................................................... 8
      3. Arrival and Assembly Organizations ...................................................................... 8
         a. Arrival and Assembly Operations Group (AAOG) ............................................ 8
         b. Landing Force Support Party (LFSP) ................................................................ 8
         c. Arrival and Assembly Operations Elements (AAOE's) ...................................... 9

B. THE MEU SLICE ........................................................................................................... 9
   1. Overview .................................................................................................................... 9
   2. Arrival and Assembly ............................................................................................... 9

III. METHODOLOGY ............................................................................................................ 11
   A. SIMULATION ............................................................................................................. 11
   B. SMMAT - THE TOOLBOX ....................................................................................... 11
      1. Description .......................................................................................................... 12
      2. Development ....................................................................................................... 13
   C. THE SCENARIO ....................................................................................................... 14
D. THE MODEL FORMULATION ........................................... 14
1. Junctions ......................................................... 14
   a. Ships ....................................................... 15
   b. Beach Areas ............................................... 15
   c. Container Operations Terminals (COT's) .................. 15
2. Transporters ..................................................... 15
   a. Lighterages ............................................... 15
   b. Logistics Vehicle Systems (LVS's) ......................... 16
3. Loaders ............................................................ 16
   a. Ship's Cranes ............................................. 16
   b. Rough Terrain Container Handlers (RTCH's) ............... 16
4. Cargo ............................................................... 17
5. Randomness ....................................................... 17
   a. Loading, Unloading, and Transit Times for the lighterages 18
   b. Loading, Unloading, and Transit Times for the LVS's .... 19
   c. Failure and Repair Times .................................. 20
6. Data instantiation ................................................. 21
IV. DATA COLLECTION AND ANALYSIS ................................. 23
   A. BACKGROUND ............................................... 23
   B. RELIABILITY LEVEL / SETUP OPTION ANALYSIS ............ 23
      1. Analysis of Variance (ANOVA) .......................... 23
      2. Graphical Analysis ....................................... 25
   C. SETUP OPTION ANALYSIS .................................. 26
   D. RELIABILITY LEVEL ANALYSIS .............................. 27
      1. Graphical Analysis ....................................... 27
      2. Differences in the Mean .................................. 29
V. CONCLUSIONS AND RECOMMENDATIONS .............................. 31
   A. CONCLUSIONS ............................................... 31
      1. SMMAT .................................................... 31
      2. The MEU Slice Model ..................................... 31
   B. RECOMMENDATIONS .......................................... 33
      1. SMMAT .................................................... 33
EXECUTIVE SUMMARY

A. BACKGROUND

Following the Iranian hostage crisis of 1979, the Department of Defense began exploring the concept of using prepositioned equipment to aid in contingency rapid response. The Marine Corps' long term answer to this initiative was the formation of today's Maritime Prepositioning Force (MPF). The MPF is the marriage of a Maritime Prepositioning Ship (MPS) Squadron (MPSRON) and a Marine Expeditionary Brigade (MEB). Three MPSRON's are afloat independently throughout the world awaiting the call to join with a Marine Air Ground Task Force (MAGTF) for rapid deployment in case of crisis prevention and intervention.

When the MPS's were first loaded (1984 - 1986), all ships were evenly loaded with equipment and supplies to reduce the impact of one or more ships being lost or unable to participate in an operation. This spreadloading forced the use of the entire MPSRON or none of it. The MPSRON could not effectively offload just the equipment and supplies needed to support a smaller MAGTF. In the mid to late 1980's, the following force modules were developed, and later implemented, for a more flexible employment of the MPF.

- the MEU Slice - all equipment comes from one MPS ship, capable of providing 2,700 Marines with 15 days of sustainment.

- the Low Intensity Conflict MEB [LIC MEB (1)] - all equipment comes from two MPS ships and an afloat MEU of four or five amphibious ships. It is capable of providing 12,500 Marines with 30 days of sustainment.

- the LIC MEB (2) - from three or four MPS ships (depending on which MPSRON is involved). It is capable of providing 12,500 Marines with 30 days of sustainment.

- the full MEB - the entire MPSRON. It is capable of providing 16,500 Marines with 30 days of sustainment.
B. MPF OPERATIONS

The MPF may be employed in many types of situations, from a humanitarian assistance effort utilizing a MEU Slice to the employment of an entire MEF with all three MPSRON's. Every MPF employment can be broken into four distinct phases: the planning phase, the marshaling phase, the movement phase, and the arrival and assembly phase. The first three phases can occur simultaneously or partially overlap in time; they constitute the most administrative aspects of the operation. Phase IV, the arrival and assembly phase, is the most crucial phase of an MPF operation. During the arrival and assembly, the equipment and supplies flow from the ships to the port and beach, and then from the port and beach to the Marine units inland. The arrival and assembly phase is the area of interest for this thesis.

C. METHODOLOGY

An MPF offload is not a serial process and cannot be easily modeled analytically. Many events occur simultaneously, such as crane operations aboard ship and Logistics Vehicle System (LVS) / Rough Terrain Container Handler (RTCH) operations ashore. Simulation was chosen as the modeling method, using the object oriented simulation language MODSIM II®, in that it easily allows parallel events to occur. Previous simulation models have looked at similar aspects of ship offloading, but for container-only and vehicle-only offloads. Because the MEU Slice offload takes much less time than a multiple ship offload, it is very sensitive to errors in assumptions. Therefore, this model has greater fidelity so that assumptions as to when the LVS's and RTCH's get ashore are unnecessary. Each specific piece of equipment is modeled, not just generic vehicles and containers. When an LVS or RTCH gets ashore in this model, it becomes available to move and load containers.

This simulation was written using the Simulated Mobility Modeling and Analysis Toolbox (SMMAT), of which the author was a co-developer. The need for this product was conceived by Professor Mike Bailey and Professor Bill Kemple of the Naval
Postgraduate School in January 1994, to allow students to conduct thesis research on logistics problems on a larger scale than previously possible. SMMAT is a collection of objects and processes designed to facilitate the modeling of materiel movement along a network. The primary components of SMMAT are junctions, transporters, loaders, and cargo. Within SMMAT, cargo is moved between junctions by transporters, and is transferred between junction and transporters with loaders. Delivery can be determined by the route of the transporters, or can be determined strictly on the basis of cargo destination, with SMMAT choosing the transporter based on availability and compatibility with cargo, junction, and loader. Once SMMAT was operational, it was used as the basis for the author's MEU Slice model.

D. DATA ANALYSIS / CONCLUSION

SMMAT proved to be extremely useful as the toolbox on which the author's MEU Slice Model was built. Once completed, it provided the author with a steady base on which to then produce a more specific model. This thesis demonstrated SMMAT's usefulness as a toolbox; with this powerful modeling toolbox now available, future students will now be able to study more difficult problems in much more detail.

The experiment for this thesis, which tested time to completion of the MEU Slice offload, was conducted as a 2 x 4 full factorial design, with the simulation model being used to generate data for each of the configurations that resulted from four setup options and two reliability levels. Each run produced 30 replications. The data collected was first analyzed with a two-factor Analysis of Variance (ANOVA), followed by graphical analysis and pairwise differences.

From the eight experiments run, it was determined that there was no significant differences between the setup options or reliability levels, or any significant interaction between the two. Future study is recommended as this is not what the author was anticipating. Additional analysis should include increasing fidelity between the RTCH's and LVS's, with a comparison against the original results to test for a significant difference.
I. INTRODUCTION

A. MARITIME PREPOSITIONING FORCE (MPF) BACKGROUND

Following the Iranian hostage crisis of 1979, the Department of Defense began exploring the concept of using prepositioned equipment to aid in contingency rapid response. The Marine Corps' answer to this initiative was the formation of the Near-Term Prepositioning Force (NTPF), the precursor of today's MPF. The NTPF, deployed in the Indian Ocean, was made up of seven ships containing equipment for the 7th Marine Expeditionary Brigade (MEB). The NTPF was designed to be a short term solution until the MPF was operational. This could not occur until the thirteen ships of the three Maritime Prepositioning Ship (MPS) Squadrons (MPSRON's) were completed. (CRM 89-339, pp. 3, 4).

These three MPSRON's are afloat independently throughout the world (in the Atlantic Ocean, the Pacific Ocean, and in the Indian Ocean) awaiting the call to marry up with a Marine Air Ground Task Force (MAGTF). This marriage of an MPSRON with the personnel of a MAGTF produces an MPF. The MPF concept follows that of the NTPF, to allow for the rapid deployment of a MEB for crisis prevention and intervention. The MPF's provide the United States with "... a balanced, sustainable, multi-role, middleweight, combined arms crisis response team." (Dalton, Kelso, and Mundy, April 1994, p. 20)

When the MPS's were first loaded (1984 - 1986), all ships were evenly loaded with Maritime Prepositioned equipment and supplies (MPE/S) to reduce the impact of one or more ships being lost or unable to participate in an operation. This spreadloading forced

---

1 A MEB is a specific type of Marine Air-Ground Task Force (MAGTF). A MAGTF is formed when headquarters, aviation, ground combat, and ground combat service support personnel are brought together under one command for a specific mission or objective. The three most common MAGTF's are, from largest to smallest, the Marine Expeditionary Force (MEF), the MEB, and the Marine Expeditionary Unit (MEU).
the use of the entire MPSRON or none of it. The MPSRON could not effectively offload just the MPE/S needed to support a smaller MAGTF. In the mid to late 1980's, discussions throughout Headquarters, Marine Corps (HQMC) centered around the possibility of restructuring the MPSRON's. Though the MPF had been extremely successful in past operations, it needed to be made more responsive and flexible for future contingencies (A.M. Gray, Speech, 1 Sept 1989). Due to these discussions, the Commanding Generals, Atlantic and Pacific Fleet Marine Forces (CGFMFLant and CGFMFPac) were tasked to study and develop a suite of varying MPF force modules for use by the Unified Commanders in case of contingencies and crises. Following this initial study, the Center for Naval Analysis (CNA) was asked to refine this concept of force modules. From CNA's study, the present Force Module Concept was born. This concept allows for more flexible MPF employment; each MPSRON can be unloaded in different ways to let it meet any one of the following four distinct threat levels:

- **the MEU Slice** - all equipment comes from one MPS ship, capable of providing 2,700 Marines with 15 days of sustainment.

- **the Low Intensity Conflict MEB [LIC MEB (1)]** - all equipment comes from two MPS ships and an afloat MEU of four or five amphibious ships. It is capable of providing 12,500 Marines with 30 days of sustainment.

- **the LIC MEB (2)** - from three or four MPS ships (depending on which MPSRON is involved). It is capable of providing 12,500 Marines with 30 days of sustainment.

- **the full MEB** - the entire MPSRON. It is capable of providing 16,500 Marines with 30 days of sustainment. (CNA CNR 190, March 1991, p. 3)

Desert Shield and Desert Storm provided the Marine Corps with the opportunity to reconfigure the MPSRON's with the force modules sooner than expected. When the MPSRON's were regenerated after Desert Storm, the ships could be loaded under with the new force modules in place.²

---
² Regeneration is the methodical approach to restore the MPSRON to its original strength and to attain full operational capability. In this case, it involved restructuring the types and quantities of MPE/S aboard the individual ships.
B. PROBLEM

During the Cold War, all MPF operational and logistical planning was completed assuming full employment of the force. In the Post Cold War era, using the force modules, it is no longer guaranteed that an MPF will be deployed in full. The MPF has "a capability of individual ship, squadron, or force employment to deliver on-scene humanitarian assistance or a fully combat-ready Marine Expeditionary Force." (Dalton, Kelso, and Mundy, April 1994, p. 20) A very likely scenario is the deployment of the MEU Slice, the smallest of the four levels, in a humanitarian assistance effort. This would be similar to OPERATION RESTORE HOPE, the humanitarian relief of Somalia, but on a smaller scale. Present MPF doctrine calls for the rapid deployment of a MAGTF and MPSRON to a secure environment where the offload and marrying up can occur (FMFM 1-5, p. 1-1). In the humanitarian assistance scenario, the offload environment may not be quite as secure as hoped. The total offload and throughput time becomes critical since the Marines supporting the operation are extremely vulnerable until their marriage with the MPE/S is complete.

In the worst case, the MEU Slice would have to be offloaded with MEU Slice equipment only. This would occur if no port facility was available; the offload would then proceed instream vice pierside.\(^3\) But, the MEU Slice includes only limited material handling equipment (three Rough Terrain Container Handlers [RTCH's]) and transportation assets (seven Logistic Vehicle Systems [LVS's]), so the allocation of these resources is believed critical to minimizing the throughput time. Also, since the force modules are relatively untried, the best setup of the Arival and Assembly Area (AAA) for a MEU Slice offload supporting a humanitarian assistance effort is not known.\(^4\) This thesis

\(^3\) An instream offload occurs when the ship anchors offshore and lighterages transport the equipment and supplies ashore.

\(^4\) The best setup is the one that allows for the quickest marriage of Marines and equipment.
will look at four possible setups of the AAA and determine which provides for the quickest offload and throughput.

The setup of the AAA is determined by the RTCH allocation. Each Container Operations Terminal (COT), designed to receive all containers for the associated Major Subordinate Element (MSE), will require at least one RTCH. The following describes the four candidate organizational options within the AAA for the setup of the COT's.

- One COT, using two RTCH's at the beach and one RTCH at the COT.
- One COT, using one RTCH at the beach and two RTCH's at the COT.
- Two COT's, using one RTCH at the beach and one RTCH at each COT. The first COT will receive containers for the CE and the GCE; the second COT, for the CSSE and the ACE.
- Two COT's, using one RTCH at the beach and one RTCH at each COT. The first COT will receive containers for the CE, the GCE, and the CSSE; the second COT, for the ACE.

The setup which gives the quickest offload and throughput is not necessarily the setup that the MAGTF Commander should choose. The quickest setup may not be the most tactically sound. This model will provide him with one extra piece of information with which this decision can be made.

---

5 The MSE's are the Command Element (CE), the Ground Combat Element (GCE), the Combat Service Support Element (CSSE), and the Aviation Combat Element (ACE).
II. MPF OPERATIONS

A. MPF OVERVIEW

The MPF may be employed in many types of situations, from a humanitarian assistance effort utilizing a MEU Slice to the employment of an entire MEF with all three MPSRON's. Every MPF employment can be broken into four distinct phases: the planning phase, the marshalling phase, the movement phase, and the arrival and assembly phase (OH 1-5-1, pp. 1-5, 1-6). The first three phases can occur simultaneously or partially overlap in time. In addition, they constitute the most administrative aspects of the operation. Phase IV, the arrival and assembly phase, is the "final and most crucial phase of an MPF operation." (FMFM 1-5, p. 8-1) The first three phases are controlled by both the MAGTF Commander and the Commander, MPF (CMPF). The MAGTF Commander controls the ground and air side of planning, marshaling, and movement while the CMPF controls the sea aspects. They must also coordinate so that all issues are covered. The arrival and assembly phase is where most of the interaction takes place. The CMPF controls the flow of equipment and supplies from the ships to the port and beach, while the MAGTF Commander controls the flow from the port and beach through the AAA. The arrival and assembly phase is the area of interest for this thesis. Before the specifics of the arrival and assembly are discussed, a general understanding of the entire MPF operation is necessary.

1. The Phases of Operation

   a. Planning Phase

   The planning phase starts with the issuance of a warning order and continues throughout the entire operation (FMFM 1-5, p. 2-8). This phase encompasses both contingency and execution planning. Contingency planning takes place when only a hypothetical situation is known while execution planning occurs when the commitment of
a force is imminent. (FMFM 1-5, pp. 3-1, 3-2). The concepts for marshaling, movement, and arrival and assembly are developed during this phase. The MAGTF Commander and the CMPF must work together in this phase.

b. Marshaling Phase

The marshaling phase begins with the first Marines and Sailors arrive at a marshaling area and is complete when the final aircraft leaves the departure airfield. (FMFM 1-5, p. 2-10) The movement of Marines and equipment from their home base to the marshaling area falls within this phase. This is controlled by the MAGTF Commander.

c. Movement Phase

The movement phase begins when the first Marines or ships begin transiting toward the Area of Operations and ends with the last Marine or ship entering the AAA (FMFM 1-5, p. 2-12). During this phase, the Force is separated into elements that will deploy by air, the Fly in Echelon (FIE), and the elements that will deploy by sea, the MPSRON and associated support ships. The MAGTF Commander controls the FIE while the CMPF controls the movement by sea. A detailed breakdown of the FIE will appear later.

d. Arrival and Assembly Phase

The arrival and assembly phase begins with the arrival of the first Marine of the Main Body or ship of the MPSRON at the AAA and is complete when the MAGTF is combat capable. The CMPF decides when termination of the MPF operation is necessary, based on the recommendation of the MAGTF Commander. It is not necessarily when the final supply or piece of equipment is married with its designated unit. This phase includes the reception of all Marines and equipment and the distribution of equipment and supplies to the Marines (FMFM 1-5, p. 2-14). The MAGTF Commander controls operations ashore while the CMPF controls operations at sea. The MAGTF forms separate arrival and assembly organizations to execute the timely and thorough throughput of equipment and supplies.
2. The Fly-In-Echelon (FIE)

   a. Survey, Liaison, and Reconnaissance Party (SLRP)

      The purpose of the SLRP is to assess conditions, conduct initial
      reconnaissance, and make liaison with local authorities, if appropriate, and to report the
      findings to MAGTF Commander. Ideally it will deploy five to seven days prior to the
      MPSRON. (MPF Staff Planning Course [SPC], p. HO-315-1-2)

   b. Offload Preparation Party (OPP)

      The OPP is a temporary element comprised of maintenance personnel,
      embarkation personnel, and equipment operators; its purpose is to help the ships' crews
      prepare offload systems and equipment for debarkation once they arrive in port. The OPP
      ideally will meet the MPSRON no later than four days before it arrives at the AAA. The
      OPP will dis-establish on arrival at the AAA, and its members will become the skeleton of
      the debark crew. (MPF SPC, pp. HO-314-1-2 - HO-314-1-4)

   c. Advance Party

      The Advance Party is the next element of the FIE to arrive at the AAA; it
      is made up of representatives from all MSE's. They link up with the SLRP to organize
      offload control agencies and to ready the AAA for the Main Body arrival. They also
      augment the OPP to form the remainder of the debarkation crew.

   d. Main Body

      The Main Body is comprised of the rest of the FIE Marines not
      mentioned in one of the previous elements. It also includes equipment necessary for the
      operation. For a full MEB offload, it should not exceed 250 sorties aboard Air Force
      transports. The Main Body arrival at the AAA must be coordinated in such a way as to
      mirror the offload of the ships.
e. **Flight Ferry**

The Flight Ferry involves the aircraft from the ACE that can self-deploy to the AAA with support of aerial refueling (FMFM 1-5, p. 7-4).

3. **Arrival and Assembly Organizations**

a. **Arrival and Assembly Operations Group (AAOG)**

The AAOG, whose nucleus is from the SLRP, is comprised of personnel from all MSE's of the MAGTF, and it is responsible for coordination of the arrival and assembly operations. This includes both the flow of personnel and equipment from the arrival airfield to the AAA and the flow of equipment and supplies from the port and beach to the MSE's. They work closely with the NSE's Primary Control Officer (PCO), who controls the flow of equipment and supplies from the MPSRON to the port and beach.

b. **Landing Force Support Party (LFSP)**

The LFSP is an element of the CSSE and is responsible to the AAOG for the throughput of personnel, equipment, and supplies at the arrival airfield, beach, and port. The LFSP is made up of the following elements.

1. Beach Operations Group (BOG). During an instream offload, the BOG must work closely with the NSE's Beach Party Group, who controls the landing of lighterages at the beach.

2. Port Operations Group (POG). During a pierside offload, the POG must work directly with the ship's debarkation officer to ensure the timely offload of each ship.

3. Arrival Airfield Control Group (AACG). The AACG must coordinate with the Air Force to ensure the timely arrival of personnel and equipment.
c. **Arrival and Assembly Operations Elements (AAOE's)**

An AAOE is formed for each MSE, and its purpose is to receive equipment and supplies from the LFSP, depreserve and perform maintenance when necessary, and pass on usable equipment and supplies to the using units.

**B. THE MEU SLICE**

1. **Overview**

   The differences between a normal MPF operation and a MEU Slice specific operation occur during the arrival and assembly phase. The planning, marshaling, and movement phases are extremely similar independent of which module is being implemented. When a MEU Slice is employed, it involves only one ship from the MPSRON, normally the flagship. A secondary ship is designated backup and will be ready if the flagship is not available. The MEU Slice ship is loaded so that the necessary MPE/S can be offloaded with the minimal offload of other MPE/S. The equipment required for the MEU Slice is approximately 120 vehicles, as opposed to the entire load of 384 vehicles. It requires approximately 150 containers, as compared with the entire MPSRON's approximately 2,000 containers. (CRM 91-38, pp. D-6, E-2)

2. **Arrival and Assembly**

   This is the phase where the full MEB MPF Operation and the MEU Slice MPF Operation differ mostly. For the full MEB Operation, the full MPSRON would be offloaded in a benign port with much of the material handling equipment provided by the Host Nation. The offload would most likely be pierside, with the added possibility of some MPE/S offloaded instream. For a MEU Slice offload, only part of one ship, normally the MPSRON flagship, will be offloaded. Additionally, Host Nation support can not be expected, so the entire offload must be accomplished using organic assets only. Organic assets include the ship's material handling equipment as well as the MEU Slice equipment. Additionally, as mentioned previously, the offload of a full MEB MPF will occur, by
doctrine, in a secure port. Experience has shown, as with OPERATION RESTORE HOPE in Somalia, that the port chosen for offload and throughput may not be totally secure. The MEU Slice offload and throughput will more likely be similar to OPERATION RESTORE HOPE than the totally secure port of OPERATION DESERT SHIELD that doctrine stipulates.
III. METHODOLOGY

A. SIMULATION

An MPF offload is not a serial process and cannot be easily modeled analytically. Many events occur simultaneously, such as crane operations aboard ship and LVS / RTCH operations ashore. Simulation was chosen as the modeling method, using the object oriented simulation language MODSIM II, in that it easily allows parallel events to occur.

Previous simulation models have looked at similar aspects of ship offloading. For example, one previous NPS thesis (Sumner, 1991) modeled container offload while another (Noel, 1993) considered only vehicles. While these theses were also concerned with total offload time, they were not strictly dependent on the organic offload assets. Noel's model did not consider containers, so the availability of RTCH's and LVS's was irrelevant, and Sumner's model examined a larger offload of two ships instream. Because the MEU Slice offload takes much less time than a multiple ship offload, it is much more sensitive to errors in assumptions. Therefore, this model has greater fidelity so that assumptions as to when the LVS's and RTCH's get ashore are unnecessary. Each specific piece of equipment is modeled, not just generic vehicles and containers. When an LVS or RTCH get ashore in this model, they become available to move and load containers.

In addition, to eliminate the requirement to develop a new model to study each aspect of MPF operations (or other similar transportation and mobility problems), the author, and others, developed a general transportation and logistics mobility modeling and analysis toolbox (discussed below) and the author developed a MEU Slice offload model as an extension to it. This extension provides the building blocks for unlimited future MPF modeling.

B. SMMAT - THE TOOLBOX
1. Description

The Simulated Mobility Modeling and Analysis Toolbox (SMMAT) is a collection of objects and processes designed to facilitate the modeling of a transportation and distribution network. Designed originally to handle problems as diverse as battle group vertical replenishment, maritime prepositioned ship offload, amphibious (LCAC) offload, and strategic sealift, it has the flexibility to handle large or small scale problems. The primary components of SMMAT are junctions, transporters, loaders, and cargo, and the functions provided to allow them to interact. Within SMMAT, cargo is moved between junctions by transporters, and is transferred between junction and transporters with loaders. Delivery can be determined by the route of the transporters, or can be determined strictly on the basis of cargo destination, with SMMAT choosing the transporter based on availability and compatibility with cargo, junction, and loader.

Additionally, all junctions have the ability to act as transporters and all transporters can act as junctions. This allows a transporter to receive and deliver cargo as it is transiting. For example, a ship transiting the ocean in a carrier battle group can resupply with helicopters from the supply ship. The ship is a transporter from port to port, but it is also a junction of the helicopter. This ability is accomplished through inheritance. In MODSIM II, when an object inherits another object, it receives all the capabilities of the inherited object. Specifically for SMMAT, junctions inherit transporters, so the junction receives all the capabilities of the transporter, plus the additional capabilities added for itself. Within SMMAT, all transporters are actually junctions functioning as transporters. This allows junctions to move from junction to junction with the ability to have other junctions moving between them.

SMMAT provides several convenient ways to introduce variability into each problem, both during the creation of the scenario, and during the simulation itself. During the creation of the scenario, the number of pieces of cargo at each junction can be varied according to any number of statistical distributions. Additionally, any appropriate characteristic of the cargo (e.g., weight, size, volume, height) can be varied for each
individual piece using the same distributions. During the execution of the simulation, additional variability is possible by using distributions for load times for each piece of cargo, as well as by introducing reliability into the loaders and transporters, allowing them to break at random and be out of action for a variable repair time.

SMMAT also provides the capability to run replications of the scenario as specified by the user, collecting statistics on any parameter the user is interested in measuring. Upon completion of the replications, SMMAT also provides tools for statistical analysis of the total results.

2. Development

The need for a product like SMMAT was conceived by Professor Mike Bailey and Professor Bill Kemple of the Naval Postgraduate School in January 1994, in order to provide a product that would allow students to conduct thesis research on logistics problems on a larger scale than previously possible. SMMAT was developed under their guidance over a nine month period by LT Tim Wilson, USN, LT Ed Kearns, USN, LT Bill Roberts, USN, and the author. SMMAT was developed using MODSIM II® (CACI Products, 1993) on the UNIX workstations.

The development process followed a strict protocol prescribed by Prof. Bailey. First, each component had to meet the common requirements of the diverse applications being modeled by the developers. Additionally, each object and process was thoroughly tested prior to integration into the toolbox.

In order to create a framework allowing the creation of vastly different objects, a common data file structure was used, with special data handlers tailored to put the information contained in the data files into the proper fields of the object being created. Once a basic object has been instanciated, it inherits other attributes as is applicable to turn it into a final object capable of performing the required functions independently.

Interest in SMMAT resulted in an invitation to present at the 1994 CACI SummerSim Simulation Conference in Washington, D.C. in August, 1994, in which Professor Bailey and the four developers attended.
C. THE SCENARIO

For this simulation, a scenario was chosen in which a MEU Slice of the MPF would offload in support of a humanitarian assistance mission. A MAERSK class ship would offload instream and anchor approximately five miles from the beach. The setup ashore would vary as described in the Chapter I. Each COT ashore would be about five miles inland from the beach. The determination of which elements unload at each COT is a function of the setup options. All setup options are the same from the ship to the beach, with the differences becoming evident once ashore. The four options, as described earlier, are

- Option 1 - 1 COT with 2 RTCH's at the Beach.
- Option 2 - 1 COT with 2 RTCH's at the COT.
- Option 3 - 2 COT's with 1 RTCH at each COT and one at the Beach; the CE and GCE unload at COT1 and the CSSE and the ACE unload at COT2.
- Option 4 - 2 COT's with 1 RTCH at each COT and one at the Beach; the CE, GCE, and the CSSE unload at COT1 and the ACE unloads at COT2.

Specifics such as quantities, capacities, and sizes of transporters, loaders, and cargo will be discussed in detail in the following section.

D. THE MODEL FORMULATION

1. Junctions

Junctions are the center building blocks of SMMAT. The junctions contain other objects and allow them to interact. Each junction may contain numerous loading and unloading spots as well as lists of transporters, loaders, and cargo. The main mission of the junction is to control the flow of the transporters docked at it. Once the junction docks the transporter, it tells the transporter to unload, load, and depart.
a. Ships

One ship, from the MAERSK Class, forms the initial junction within this model. The ship has three unloading spots, one for each crane.

b. Beach Areas

The beach areas form the middle junction within this model. This is where control shifts from the Navy to the Marine Corps. Within this model, the beach will be modeled as one junction with one unloading spot.

c. Container Operations Terminals (COT’s)

A COT is where all of the containers may be stored; within each COT, the containers are stored by MSE. Each COT will be modeled as an individual junction with one or two offload spots per COT, depending on the option being modeled.

2. Transporters

The transporters perform the bulk of the work once they are accepted by the junction. The transporter controls docking, unloading, loading, departing the junction, and transiting to the next junction. The next destination may be determined by either the transporter itself or the cargo it has loaded. Each transporter has a list of legal destinations to prevent the cargo from taking it to an illegal junction. This prevents, for example, lighterages from the sea from delivering cargo inland from the beach. Each transporter has a list of cargo that makes up that load as well as a field for average speed used to determine transit time.

a. Lighterages

The lighterages used in this model are organic to the one ship that is being offloaded. They will transport the cargo from the ship to the beach. The ship has eight causeways, three causeway sections, powered (CSP’s) and five causeway sections, nonpowered (CSNP’s). The causeways can be connected in various ways depending on loads to be carried, but every lighter must contain at least one CSP. The number of CSNP’s is not limited. A combination of one CSP and two CSNP’s would be called a 2+1
lighter, the "2" signifying the two CSNP's and the "1" signifying one CSP. For this model, the ships eight causeways will be formed into two 2+1 lighterages and one 1+1 lighterage. This configuration was chosen due to previous studies, which have found that making all causeway combinations as alike as possible reduces offload time (CRM 89-339, p. 40).

b. **Logistics Vehicle Systems (LVS's)**

The LVS's will initially be cargo until they arrive at the beach; once there they become transporters. The LVS's will transport the cargo from the beach to the COT's. With only seven LVS's being offloaded within this model, this is expected to cause chokepoints within the offload.

3. **Loaders**

The loaders are responsible for moving the cargo from the junction to the transporter. Each junction has a list of loader types and gives out loaders as the transporters ask for them. No cargo can be unloaded or loaded without first having a dedicated loader. Each type of loader has specific characteristics that make it unique, such as maximum load and average cycle time. In addition, each transporter and piece of cargo have lists of allowable loader types. These lists prevent, for example, forklifts from trying to load trucks and tanks onto lighterages.

a. **Ship's Cranes**

Since this model is of an instream offload, the ship's cranes will move all of the cargo from the ship to the lighterages. Each crane on the ship has a capacity of 30 Tons, which never was a factor in this model because it exceeded any cargo offloaded.

b. **Rough Terrain Container Handlers (RTCH's)**

The RTCH's will initially act as cargo until they reach the beach or specified COT, then they will be able to act as loaders. The RTCH's will move cargo from the lighterages to the beach, from the lighterages directly to awaiting LVS's, from the beach to the LVS's, and from the LVS's to the COT's. Since only the three RTCH's being
offloaded will be used, this is also expected to be a chokepoint and area of concern. The RTCH allocation is the driving force between the different setup options.

4. Cargo

The cargo is what drives the entire model, yet it is the simplest of all modules. When all of the containers have been delivered to the COT's, the simulation is complete. All cargo determined to be necessary for the MEU is initially loaded onto the ship before the simulation begins. To model the conflict between vehicles and containers for lighterage space, all vehicles and containers are delivered from the ship to the beach. Once at the beach, the delivery of containers to the COT's is considered independent of, and more time critical than, the delivery of the vehicles to the AAOE's. Therefore, the delivery of vehicles to the AAOE's is assumed to be not necessary and is not modeled in this simulation. Once the vehicles arrive at the beach, they are removed from the beach's cargo list and are not considered for delivery inland.

The cargo is being brought into the model with the help of the Computer Aided Embarkation Management System (CAEMS), a sub-system of MAGTF II Logistics Automated Information System (LOG AIS). The notional cargo list, with offload priorities and cargo characteristics, used in this thesis was determined from the analysis of the 1stLt Jack Lunnus load plans (a MAERSK-Class ship from MPSRON-3), and from the recommended changes provided in CMR 91-38, Reconfiguration of MPSRon-3 To Support The Priority Force Modules. See Appendix A, the listing of the data files used in the simulation, for the detailed cargo data used; it is provided in the files simstart.dat and cargo.dat.

5. Randomness

Randomness enters into simulations when the attempt is made to model the real world. In this model, all processes that could be realistically modeled with distributions were so modeled, others were modeled deterministically with the best data available.
a. **Loading, Unloading, and Transit Times for the lighterages**

The Center for Naval Analyses (CNA) has analyzed MPF operations extensively from the beginning. They have determined through analysis of previous operational results, that the loading, unloading, and transiting of lighterages follow lognormal distribution with varying parameters, dependent upon ship class and distances from the beach (CRM 91-3, p. 26). For this model, the distributions provided for the loading and unloading of the lighterages were used, with slight modifications, but the transit distribution was not. The only drawback to using the distributions for loading and unloading is that they aggregate the individual cargo into one large piece of cargo per lighterage. The entire lighterage cargo list is loaded or unloaded at the exact same time. This is not to the level of detail initially planned for this model. This proved to not be a problem for the loading of the lighterages at the ship, because the lighterage could not leave the ship until it is full anyway. No realism is lost by aggregating at this point.

Realism would be lost, however, by offloading at the beach in aggregate. If aggregation was used, numerous pieces of cargo would arrive at the beach simultaneously for dispersion rather than serially as each lighterage offloaded. It was decided that a separate unload time for each piece of cargo was needed. In order to have the lighterage offload times follow the lognormal distribution provided, and still unload each of n pieces of cargo in a distinct, random length of time, random offload times were generated as follows:

First, a total lighterage offload time, X, was generated from the lognormal distribution.

Next, n U[0, 1] random variables, U_1, U_2, ..., U_n, were generated. These were rescaled to form Z_1, Z_2, ..., Z_n by letting

\[ U = \sum_{i=1}^{n} U_i \text{ and } Z_i = \frac{U_i}{U} \text{ so } \sum_{i=1}^{n} Z_i = 1. \]

Finally, the individual offload times were formed as

\[ X_i = Z_i \times X, \]

so
\[ \sum_{i=1}^{n} X_i = X. \]

Once the offload time of each individual piece of cargo was found, these new times were used to determine when each individual piece of cargo was offloaded. This allowed the RTCH access to the cargo sooner than would otherwise have been possible, and added a measure of increased realism to the model.

The parameters of the lognormal distribution for transit time were based upon the specific exercise being modeled. The scenario used in this model was not close enough to any of the observed exercises for the author to comfortably use the associated distributions. It was determined that it would be better to model the transit time deterministically, with different parameters for full and empty loads.

\textit{b. Loading, Unloading, and Transit Times for the LVS's}

The loading, unloading, and transiting times of the LVS's were not as easily accessible as the lighterage data.

The loading and unloading of the LVS's were determined by the author to be factors of the RTCH, and not of the LVS itself. These were both modeled with the same distribution, \( U \sim \text{Uniform} \ [4, 12] \), where the parameters are in minutes. This distribution is based on the authors experience and on Sumner's thesis (1991), and it seems to satisfy common sense. Firstly, one would expect the loading of the LVS to take a minimum amount of time, no matter where the container is located in the staging area. Secondly, one would expect that the loading would take no longer than a certain time, no matter where the container was located in the staging area. Thirdly, one would expect the containers to be uniformly distributed throughout the staging area. Therefore, a uniform distribution is called for. One could possibly dispute the parameters, but by no more than a minute or so either way, and the author does not feel that this would alter the simulation results significantly.

Since no recently published data was available for the transiting of LVS's, it was modeled deterministically with the same parameter for full and empty loads.
c. Failure and Repair Times

It is necessary to model failure and repair times because they occur in the real world. Not modeling them will most likely give overly optimistic results from the simulation. For the simulation to reveal meaningful results, the reliability input into the model needs to be accurate. Determining the reliability for the different parts of this simulation was difficult. Since most models of MPF operations have stopped at the beach, the author could not find trustworthy reliability data for the LVS and the RTCH from MPF operations, the reliability data used would have to come from a different source.

The Marine Corps keeps detailed maintenance records of all its equipment, but it does not provide accurate reliability data. Even though fields exist on the Equipment Record Orders (ERO's) for mileage, hours, or rounds at the time of breakdown, no requirement exists that this field be filled in accurately. Therefore, it normally is filled with "dummy" numbers, such as 00000 or 99999. Trying to use this information would yield nonsense at best.

The next best solution for reliability information for the LVS and RTCH was to use the results from the systems' operational test (OT) performed before procurement of the items. These numbers show how well the systems performed under various conditions and levels of duress. The disadvantages of this solution are twofold: (1) very few samples were used for the initial OT's and (2) this reliability represents a new system, not a system that has been in operation for a number of miles or hours.

Another possibility is to use availability data from OPERATION DESERT STORM. The advantages of using this data is that it represents units that were deployed in an actual operation. Additionally, the data is available for all the units that took part in Desert Storm, a very large sample to get data from. The disadvantages are that this information is provided in availability form only and it does not represent equipment that has been in storage, as the MPF equipment has been. Even with these disadvantages, it was determined that this information was the best available. In order to
use this availability data, assumptions about Mean Time to Repair (MTTR) would have to be made.

The worst LVS availability in OPERATION DESERT STORM was 93% while the worst RTCH availability was 64% (CRM 91-206, pp. 8, 18, and 36). Using the basic Availability formula of

\[ A = \frac{MTBF}{MTBF + MTTR}, \]

the MTBF of the LVS is 13.29 times its MTTR and the MTBF of the RTCH is 1.78 times its MTTR. The RTCH availability from OPERATION DESERT STORM is not consistent with previous studies, so RTCH reliability was not treated within this thesis (Sumner, p. 39, 1991). This decision will most likely give optimistic results, but should still allow for the accurate comparison of times among different options. One day was estimated by the author as the MTTR for the RTCH. Both 93% and 100% availability were looked at within the model; 100% was used as a baseline with 93% being a lower bound as to what to expect. Both MTTR and MTBF were modeled using the exponential distribution with 1 day as the parameter for MTTR and 13.29 days as the parameter for MTBF.

6. Data instantiation

The tools used to instantiate the initial data within this model are part of SMMAT. Six data files are necessary for this toolbox to work. One file is written for the junctions, `junct.dat`, one for the transporters, `trans.dat`, one for the cargo, `cargo.dat`, and one for the loaders, `load.dat`. These files contain the static information about each module. Additionally, another file, `simstart.dat`, is written that explains the dynamic relationships of the modules. It lists each junction with its associated lists of transporters, cargo, and loaders. The final data file needed is a list of primary junctions, `pjname.dat`. A primary junction is a junction which does not belong to a larger junction. In the case of this model, the primary junctions are the ship, the beach, and the CO's. These primary junctions are listed in both the primary junction file and in the junction data file. The Lighterages and LVS's are listed in the transporter data file, the cranes and RTCH's are listed in the loader data file, and all of the cargo in its detail is listed in the cargo.dat file. The dynamic data
file includes the ship with its associated transporters, cargo, and loaders. See Appendix A to view the actual files used for this model.
IV. DATA COLLECTION AND ANALYSIS

A. BACKGROUND

The experiment for this thesis was conducted as a 2 x 4 full factorial design. Thus, the simulation model was used to generate data for each of the eight configurations that resulted from four setup options and two reliability levels. Each run produced 30 replications. The data collected from these runs is included in Appendix B. Table 1 is a listing of the mean values from the eight design settings, along with the column means, row means, and the grand mean.

<table>
<thead>
<tr>
<th></th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Option 4</th>
<th>Row Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 % Rel</td>
<td>5,125.32</td>
<td>5,117.36</td>
<td>5,151.04</td>
<td>5,154.11</td>
<td>5,139.96</td>
</tr>
<tr>
<td>93 % Rel</td>
<td>5,155.37</td>
<td>5,159.8</td>
<td>5,224.23</td>
<td>5,109.7</td>
<td>5,162.28</td>
</tr>
<tr>
<td>Column Means</td>
<td>5,140.34</td>
<td>5,138.58</td>
<td>5,187.64</td>
<td>5,131.91</td>
<td>5149.62</td>
</tr>
</tbody>
</table>

The data will first be analyzed with a two-factor Analysis of Variance (ANOVA). If factor effects are found to be significant, further study will be done to identify those differences. If no significant factor effects can be found, further analysis will be conducted to look for trends that may indicate possible effects or areas for further study.

B. RELIABILITY LEVEL / SETUP OPTION ANALYSIS

1. Analysis of Variance (ANOVA)

ANOVA was used as to test the significance of reliability level and setup option. A two-way ANOVA was conducted with the reliability at two levels, 100% and 93%, the setup options at four levels, one for each candidate setup previously mentioned,
and each cell containing 30 values, one per replication. ANOVA is an especially useful technique that attempts to attribute the variance in the observations by the level of the factors. A basic assumption in order to use ANOVA is that each observation can be expressed as

$$X_{ijk} = \mu + R_i + SO_j + I_{ij} + \varepsilon_{ijk},$$

for $i = 1, 2; j = 1, 2, 3, 4; \text{and } k = 1, 2, ..., 30$.

$X_{ijk}$ is the $k^{th}$ observation in cell $ij$,
$\mu$ is the overall mean,
$R_i$ is the effect due to Reliability,
$SO_j$ is the effect due to the Setup Option,
$I_{ij}$ is the effect due to the interaction of $R_i$ and $SO_j$, and
$\varepsilon_{ijk}$ is the random error of the $k^{th}$ observation in cell $ij$.

$\varepsilon_{ijk}$ is normally distributed with mean equal 0 and variance equal $\sigma^2$. Additionally, it is usually assumed that

$$\sum_{i=1}^{2} R_i = 0, \sum_{j=1}^{4} SO_j = 0, \sum_{j=1}^{4} I_{ij} = 0 \text{ for } i = 1, 2, \text{ and } \sum_{i=1}^{2} I_{ij} = 0 \text{ for } j = 1, 2, 3, 4.$$

The hypothesis for the existence of a reliability effect is

$H_0: R_i = 0 \; \forall \; i$ (there is no reliability effect)

$H_a: R_i \neq 0$ for some $i$ (there is a reliability effect),

for the setup option effect it is

$H_0: SO_j = 0 \; \forall \; j$ (there is no setup option effect)

$H_a: SO_j \neq 0$ for some $j$ (there is a setup option effect),

and for the interaction effect it is
\[ H_0: I_{ij} = 0 \text{ for } i \text{ and } j \text{ (there is no interaction effect)} \]
\[ H_a: I_{ij} \neq 0 \text{ for some } i \text{ and } j \text{ (there is an interaction effect)}. \]

Table 2 contains the results of the ANOVA. When using ANOVA, one should test for the interaction effect first; if the interaction effect is significant, no other tests should be done. Since the F-Statistic of the interaction, 0.2841, is less than the critical \( F_{3, 232} = 2.08 \), the null hypothesis for the interaction cannot be rejected. Infinite denominator degrees of freedom were used for the preceding critical F due to constraints in the F-Table. If a statistic cannot be rejected with infinite degrees of freedom, it will not be rejected for any degree of freedom selected for that parameter. Therefore, no interaction effect exists. Now, testing for reliability and the setup options effects can occur. Since the residual had 232 degrees of freedom, pooling with the interaction to gain fidelity was not necessary. The F-Statistic of the reliability, 0.3226, and the F-Statistic of the setup options, 0.3598, are both less than their respective F critical values, 2.17 and 2.08, so neither null hypothesis can be rejected. It cannot be shown that an effect due to the reliability or setup options exists.

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F - Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>1</td>
<td>38,429</td>
<td>38,429</td>
<td>0.3226</td>
</tr>
<tr>
<td>Setup Options</td>
<td>3</td>
<td>128,562</td>
<td>42,854</td>
<td>0.3598</td>
</tr>
<tr>
<td>Interaction</td>
<td>3</td>
<td>101,516</td>
<td>33,839</td>
<td>0.2841</td>
</tr>
<tr>
<td>Residual</td>
<td>232</td>
<td>27,635,664</td>
<td>119,119</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>239</td>
<td>27,904172</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. **Graphical Analysis**

Boxplots provide another method to see if a factor is different from the rest, as well as determining certain attributes about the data. These attributes include the median of the data, the upper and lower interquartiles of the data, the outliers, and symmetry to name a few. The boxplot allows multiple runs to be compared simultaneously, from all
eight, to four when the data is pooled by setup option, to two when the data is pooled by reliability level. (Chambers, and others, 1983, pp. 21-24)

The full boxplot for this experiment, Figure 1, contains eight separate plots, one for each setup option at each reliability level. From this plot, one can see that no significant difference exists between any of the eight samples. The confidence intervals, the inner box within each larger box, overlap so that all eight groups contain similar points. This is another way of showing no difference between groups. Additionally, a few of the groups are slightly skewed, but not so as to provide any useful information about the data.

![Comparison of Unload and Throughput Times by Reliability Level and Setup Option]

Figure 1. Boxplot of the Individual Simulation Runs

C. SETUP OPTION ANALYSIS

The setup option graphical analysis was conducted using a pooled boxplot, Figure 2, with four plots. This allows for the comparison of setup options without reliability, assuming reliability is not significant. From the ANOVA, since it cannot be shown that reliability is a significant factor, this was a valid assumption. Nothing on this boxplot seems to be meaningful. As noted above, the confidence intervals all contain similar points.
so no significant differences in times can be found. The pooling by setup option did not show any relationships previously hidden by the data.

![Comparison of Unload and Throughput Times by Setup Option](image)

Figure 2. Boxplot of the Simulation Runs, Pooled by Setup Option

D. RELIABILITY LEVEL ANALYSIS

1. Graphical Analysis

The graphical analysis of the reliability levels was conducted using a pooled boxplot, Figure 3, with two plots. This allows for the comparison of reliability only with setup option assumed to be not significant. As with the previous plot, the ANOVA conducted earlier verifies the assumption that setup option is not significant. Again the confidence intervals overlap so no significant differences can be found between the two reliabilities. This result is somewhat surprising given the MTTR and MTBF used in the model.
Figure 3. Boxplot Results of the Simulation Runs, Pooled by Reliability Level

Using the assumed MTBF of 13.29 days (or 19,137.6 minutes) and the assumed exponential failure and repair times, the probability that a specific LVS survives past the grand mean without failure is approximately equal to

\[ P(X > \text{Grand Mean}) = P(X > 5149.62) = \left( e^{-\frac{5149.62}{19137.60}} \right) = 0.764. \]

Therefore, the probability that all seven LVS's survive past the grand mean is equal to

\[ P(\text{all 7 LVS's survive}) = [P(\text{a specific LVS survives})]^7 = (0.764)^7 = 0.152. \]

Assuming that the operation length is equal to the grand mean mentioned above, 0.152 also equals the probability that all seven LVS's survive an operation. Theoretically, this shows that the simulation runs the same at 100% and 93% reliability only 15.2% of the time. Almost 85% of the time, the simulation at 93% reliability was running with less LVS's than the 100% reliability simulation. Analysis of the simulation output shows the LVS's were indeed breaking down when set at 93% reliability with about one of the seven
reaching its failure time before the simulation ended. One could possibly conclude from these results that the LVS's are not taxed enough in this scenario. The loss of one or two LVS's for a short time does not seem to slow the system down as expected.

2. Differences in the Mean

In addition to the graphical analysis just discussed, the method of pairwise differences can be used to test for significant differences due to reliability. This method is useful because it exploits dependence in the data (e.g. due to setup option effect) to reduce variance, thus gaining precision. See Appendix C for a listing of differences in time by reliability level for each setup option. Assuming the difference are normally distributed, the following hypothesis test can be used:

\[ H_0: \mu_{R(100)} - \mu_{R(93)} = \mu_d = 0 \]

\[ H_a: \mu_{R(100)} - \mu_{R(93)} = \mu_d \neq 0, \]

where

- \( \mu_{R(100)} \) is the mean value of time at 100% reliability,
- \( \mu_{R(93)} \) is the mean value of time at 93% reliability, and
- \( \mu_d \) is the difference between them.

The test statistic used for this test is Student's \( t \) statistic,

\[ t = \frac{\bar{d}}{s_d / \sqrt{n}} , \]

where the null hypothesis will be rejected if \( |t| \) is greater than the critical \( t \) from the tables. (Mendenhall, Wackerly, and Scheaffer, 1990, pp. 573-575) For this problem,

- \( \bar{d} \), the sample average of the differences, equals -25.26,
- \( s_d \), the sample standard deviation of the differences, equals 475.223, and
- \( n \), the number of samples, equals 120.

This gives \( t = -0.58227 \), which results in a two-sided p-value of 0.5687, and leads to a failure to reject the null hypothesis. Therefore, it cannot be shown that a difference exists.
between $\mu_{R(100)}$ and $\mu_{R(93)}$. If no difference exists between the means, then it cannot be shown that reliability tested here has an effect on total offload time.
V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. SMMAT

The Simulated Mobility Modeling and Analysis Toolbox (SMMAT) was developed and built by faculty and students of the Naval Postgraduate School, including the author. It is designed to provide students interested in modeling transportation and distribution problems with a basic toolbox of object oriented computer modules on which more specific thesis related simulations could be built.

SMMAT proved to be extremely useful as the toolbox on which the author's MEU Slice Model was built. Once completed, it provided the author with a steady base on which to then produce a more specific model. SMMAT's overall usefulness was not taken advantage of within this thesis. As much as 90% of the time spent writing computer code for this thesis was spent on SMMAT. Future users of SMMAT will not have that burden. They will be able to take SMMAT and use it from the start. With this powerful modeling toolbox now available, they will then be able to study more difficult problems in much more detail.

2. The MEU Slice Model

An MPF employment is a very delicately balanced operation including elements of many organizations. The operation can go awry at any time, from the initial planning phase through the marshaling and movement phases to the arrival and assembly phase. At no time during this extremely busy operation, is it more hectic than during its final phase, the arrival and assembly. It is during this phase that the marriage of Marines and their equipment must occur.

Of all MPF employments, the one most critical to time is the MEU Slice force module. The MEU Slice allows for the offload of a partial ship in order to support a MEU
ashore. For this force module, the equipment and supplies must be ashore as rapidly as possible, but it must be accomplished with only organic lighterages afloat and minimal RTCH's and LVS's ashore.

The most crucial phase, the arrival and assembly, of this most time sensitive force module, was looked at in this thesis. Specifically, the instream offload, was examined as the worst case possible. Different setups ashore were examined in order to determine if these setup options affected the offload and throughput process. Additionally, two levels of LVS reliability were examined to see if that too was a factor.

From the eight experiments run, four setup options at two reliability levels each, using the assumptions and parameters previously listed., it was determined that there were no significant differences between the setup options or reliability levels, or any significant interaction between the two. This is not what the author was anticipating. The model did not bring out the expected difference. There are four possible explanations for this.

- The model is not doing what it is supposed to do.

- The assumptions and parameters are incorrect.

- The model does not have enough fidelity to capture the effects between the RTCH's and the LVS's.

- The author could be wrong.

A detailed analysis of the simulation output has verified that the model does indeed do what it is supposed to do. This eliminates the first alternative from above as a possibility. It is not as straight forward a process to reach a conclusion on the second and third alternatives. After rechecking the assumptions and parameters used within the model, the author has concluded that 100% RTCH reliability may not be a valid assumption. Other assumptions, however, such as lighterage reliability and transit times, do seem valid. Although they play a part in the overall simulation results, they are relatively constant for all setup options, and do not effect which setup option produces the quickest offload.
Another possibility, that not enough fidelity exists within the model, can only be confirmed by actually increasing the fidelity and comparing the results. The fourth alternative, that the author's intuition was incorrect, is a definitely possibility. This can be determined after the first three alternatives are eliminated. The following recommendations for further study are offered so that the final three alternatives can be examined more closely.

B. RECOMMENDATIONS

1. SMMAT

In the process of utilizing SMMAT to develop the MEU Slice Model, a few areas for future refinement were determined. As mentioned earlier, within SMMAT, junctions inherit transporters. Using this same concept, the author recommends the inheritance structure shown in Figure 4.

![Figure 4. Recommended SMMAT Inheritance Structure](image)

This structure puts the cargo as the lowest entity within SMMAT. Every loader will inherit cargo, so they have the capability to be carried as well as to carry. All transporters
will inherit loaders, so each transporter has the capability to load and unload itself, as well as to transit. Each junction will continue to inherit a transporter, so it can receive cargo as well as deliver it. Without the use of this structure, the author was forced to create an LVS cargo for the ship and then create a new LVS transporter once the LVS cargo reached the beach, and then dispose of the LVS cargo. This new structure will allow an LVS to be carried on a ship as a piece of cargo and then seamlessly act as a transporter once it hits the beach.

2. The MEU Slice Model

Additional RTCH's could be added to the model and new, untried setups could be modeled. This would be quite beneficial, since there is presently debate within the Marines Corps as to whether there are adequate RTCH's within each MSPRON (Pleis, January 1993, pp. 19 - 21).

Within the MEU Slice model, fidelity could be increased with the results of both models being compared to see if a difference exists. If the new SMMAT structure is adopted, it would be quite easy to model the RTCH as a transporter with loader capabilities. This would give much more fidelity to the beach operations. It would allow the RTCH to transit, and load and unload at junctions. A whole sub-system could be modeled at the beach at a level of fidelity greater than the rest of the model. This would be useful because the beach is where the critical interaction occurs and crucial decisions are made.

RTCH reliability should be taken into account once more reliable figures are determined. Additionally, the following could be included to reduce the assumptions in the model and to add more realism to the scenario.

- RTCH loading and unloading also needs to monitored closely so that they can better be modeled in future simulations. Experience is always useful, but not always available.

- Crane and lighterage reliability; the cranes and lighterages were assumed to never break down, but this was overly optimistic.
• Lastly, LVS transit distributions could add additional realism if accurate distributions could be determined.

The results of this new model should also be compared to the original results to see if a difference exists. If the results, after increased fidelity and fewer assumptions, show a difference between setup options, then the author's intuition was correct. If no difference occurs, then the fourth alternative listed previously must be correct, that the author was wrong in his intuition and there is no difference between setup options.
APPENDIX A - INPUT DATA FILES

PJNAME.DAT

1 # number of records in this file
# This is the MASTER data file that contains the
# names of the Primary Juncitons,
# Names should agree with the JUNCT.DAT
Master ->
LUMMUS # junction 1
BEACH  # junction 2
COT1   # junction 3
COT2   # junction 4
COTNSE  # junction 5

JUNCT.DAT

11 # number of records in this file
# This is the junction data file,
# names should agree with PJNAME.DAT
LUMMUS ->
LUMMUS  # Name : STRING;
# { Location : LocationReType;}
0      # {X coordinate}
0      # {Y coordinate}
3      # NumSpots : INTEGER;

BEACH ->
BEACH   # Name : STRING;
# { Location : LocationReType;}
5.0    # {X coordinate}
0.0    # {Y coordinate}
1      # NumSpots : INTEGER;

COT1 ->
COT1    # Name : STRING;
# { Location : LocationReType;}
10     # {X coordinate}
2      # {Y coordinate}
2 # (1 or 2) # NumSpots : INTEGER;

COT2 ->
COT2    # Name : STRING;
# { Location : LocationReType;}
10     # {X coordinate}
-2     # {Y coordinate}
1 # (or 2) # NumSpots : INTEGER;

COTNSE ->
COTNSE  # Name : STRING;
# { Location : LocationReType;}
10     # {X coordinate}
0      # {Y coordinate}
1      # NumSpots : INTEGER;

TRANS.DAT

3 # number of records in this file
# This is transporter data file.
LIGHTER(1+1) ->
# ------- Capacity of the transporter -------
3523.0 # Sq Ft
# Sq Ft Tall
340000.0 # Weight
10000000000.00 # Volume
8 # Number
# ------------------------------------------------------------------------#

LIGHTER(1+2) ->
# ------- Capacity of the transporter -------
5224.0 # Sq Ft
# Sq Ft Tall
540000.0 # Weight
10000000000.00 # Volume
13 # Number
# ------------------------------------------------------------------------#

*LVSLONG ->
# ------- Capacity of the transporter -------
100000000.0 # Sq Ft
# Sq Ft Tall
100000000.0 # Weight
100000000.0 # Volume
3 # Number
# ------------------------------------------------------------------------#
CARGO.DAT

25 # number of records in this file
# This is the cargo "type" fixed data file
CONTAINER ->
# Size : CapRecType;
33 # SqFt   # SqFtTall
8980 # Weight
279 # Volume
1 # Number
\/

HMMWV ->
# HIGH MOBILITY MULTI-WHEELED VEHICLE
# (D1158, D1159, D1180, A1930, A1935, A1955)
# Size : CapRecType;
110 # SqFt   # SqFtTall
6104 # Weight
632 # Volume
1 # Number
\/

HMMWVLONG ->
# HMMWV W/ TRAILER (D0085)
# Size : CapRecType;
166 # SqFt   # SqFtTall
8304 # Weight
195 # Volume
1 # Number
\/

LINECHARGE ->
# LINECHARGE LAUNCHER (B1298)
# Size : CapRecType;
47 # SqFt   # SqFtTall
3800 # Weight
284 # Volume
1 # Number
\/

LVSLONG -> # (D0877, D0878, D0879, D0881)
# LVS (D0209) W/ TRAILER
# Size : CapRecType;
320 # SqFt   # SqFtTall
43400 # Weight
2165 # Volume
1 # Number
\/

LVS (D0209) W/ TRAILER (D0876)
# This is the Container Hauler!!!
# Size : CapRecType;
320 # SqFt   # SqFtTall
43400 # Weight
2165 # Volume
1 # Number
\/

LVSLWBED ->
# LVS (D0209) W/ LOW BED TRAILER (D0235)
# Size : CapRecType;
596 # SqFt   # SqFtTall
62987 # Weight
3280 # Volume
1 # Number
\/

FIVETON ->
# 5-TON TRUCK (D1059, D1134)
# Size : CapRecType;
209 # SqFt   # SqFtTall
23700 # Weight
1811 # Volume
1 # Number
\/

FIVETONLONG ->
# 5-TON TRUCK (D1059, D1134) W/ TRAILER
# Size : CapRecType;
334 # SqFt   # SqFtTall
29580 # Weight
2310 # Volume
1 # Number
\/

REFUELER ->
# SEMI-TRAILER REFUELER (D0215)
# Size : CapRecType;
244 # SqFt   # SqFtTall
16190 # Weight
2135 # Volume
1 # Number
\/

AAV -> # (E0846, E0856)
# AMPHIBIOUS ASSAULT VEHICLE
# Size : CapRecType;
311 # SqFt   # SqFtTall
46720 # Weight
3264 # Volume
\/

*LVSLONG ->
1  # Number
\`
SHOP_EQUIP ->
# SHOP EQUIPMENT, CONTACT (B1945)
# Size : CapRecType;
  127  # SqFt   # SqFtTall
  9360  # Weight
  872  # Volume
  1  # Number
\`

SCRAPER ->
# SCRAPER-TRACTOR, WHEELED (B1922)
# Size : CapRecType;
  472  # SqFt   # SqFtTall
  63900  # Weight
  5538  # Volume
  1  # Number
\`

COMPRESSOR ->
# AIR COMPRESSOR (B0395)
# Size : CapRecType;
  134  # SqFt   # SqFtTall
  7480  # Weight
  867  # Volume
  1  # Number
\`

TRACTOR ->
# TRACTOR, RT, ARTICUL (B2567)
# Size : CapRecType;
  2122  # Volume
  1  # Number
\`

FIRETRUCK -> # (D1082)
# Size : CapRecType;
  121  # SqFt   # SqFtTall
  8160  # Weight
  764  # Volume
  1  # Number
\`

31140  # Weight
2284  # Volume
1  # Number
\`

RTCH -> # B0391
# CONTAINER HANDLER, ROUGH TERRAIN
# Size : CapRecType;
  403  # SqFt   # SqFtTall
  106660  # Weight
  5568  # Volume
  1  # Number
\`

FORK_EXT ->
# TRUCK, FORKLIFT, EXT (B2561)
# Size : CapRecType;
  224  # SqFt   # SqFtTall
  27360  # Weight 1878  # Volume
  1  # Number
\`

FORK_RT -> # (B2566)
# TRUCK, FORKLIFT, ROUGH TERRAIN
# Size : CapRecType;
  107  # SqFt   # SqFtTall
  11180  # Weight
  699  # Volume
  1  # Number
\`

LAV ->
# LIGHT ARMORED VEHICLE (E0942)
# Size : CapRecType;
  171  # SqFt   # SqFtTall
  25440  # Weight
  1757  # Volume
  1  # Number
\`

WELDER ->
# WELDING MACHINE, ARC (B2685)
# Size : CapRecType;
  124  # SqFt   # SqFtTall
  7140  # Weight
  910  # Volume
  1  # Number
\`

HOWITZER ->
# HOWITZER, MEDIUM (E0665)
WATER_DIST ->
# TACTICAL WATER DISTRIBUTOR (B2391)
# Size : CapRecType;
141  # SqFt        # SqFtToAll
4540  # Weight
1010  # Volume
1     # Number
\`

EMI_SHELTER ->
# SHELTER, 10 FT, EMI (A2335)
# Size : CapRecType;
80    # SqFt        # SqFtToAll
5600  # Weight
640   # Volume
1     # Number
\`

LOAD.DAT

2  # number of records in this file
# This is the loader data file
CRANE ->
CRANE  # Name     : STRING;
# Capacity : CapRecType;
1000000.0  # SqFt    # SqFtToAll
10000000.0  # Weight
10000000.0  # Volume
1     # Number
# Size of loader : CapRecType;
1     # SqFt    # SqFtToAll
1     # Weight
1     # Volume
1     # Number
\`

RTCH ->
RTCH  # Name     : STRING;
# Capacity : CapRecType;
1000000.0  # SqFt    # SqFtToAll
1000000.0  # Weight
1000000.0  # Volume
1     # Number
SIMSTART.DAT

8 # number of records in this file
# This is the DYNAMIC data file
LUMMUS ->
28 # Number of Cargo "Types"
# {The cargo type must be defined in cargo.dat.}
2 # Number of Trans "Types"
# {The trans type must be defined in trans.dat.}
1 # Number of Load "Types"
# {The load type must be defined in load.dat.}
# **************************************
# ***CARGO LIST STUFF***
# ******************************

$\\$\\$ 1st Cargo Stuff $\\$
$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\\$\n
# NAME PRIORITY
CONTMRE1 2 # # MGC\r
CONTMRE2 4 # # MGC\r
CONTMRE3 8 # # MGC\r
CONTMRE4 6 # # MGC\r
CONTMRE5 18 # # MGC\r
CONTMRE6 1 # # MGC\r
CONTMRE7 17 # # MGC\r
CONTMRE2 16 # MCE\r
CONTMRE23 8 # MCE\r
CONTMRE24 21 # MCE\r
CONTMRE25 17 # MCE\r
CONTGENL41 10 # # MGC\r
CONTGENL42 35 # # MGC\r
CONTGENL43 25 # # MGC\r
CONTGENL44 36 # # MGC\r
CONTGENL45 31 # # MGC\r
CONTGENL46 26 # # MGC\r
CONTGENL47 26 # # MGC\r
CONTGENL48 10 # # MGC\r
CONTGENL49 35 # # MGC\r
CONTGENL50 25 # # MGC\r
3 # Number of Junctions in JunctPath
LUMMUS # 1st Junction in Junction Path
BEACH # STAGINGAREA # ...
# NAME PRIORITY
*LVSLONG # 2nd kind of cargo in cargo list
7 # Number of 2nd kind
*LVSLON 1 # 1st Name, Priority of 1st Cargo
*LVSLON 2 # Nth Name, Priority of Nth Cargo
*LVSLON 3
*LVSLON 4
*LVSLON 5
*LVSLON 6
*LVSLON 7
2 # Number of Junctions in JunctPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
#$$$$ 3rd Cargo Stuff $$$$$
#$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
RTCH # 2nd kind of cargo in cargo list
3 # Number of 2nd kind
# NAME PRIORITY
RTCH1 1 # # MEU
RTCH2 2 # # MEU
RTCH3 3 # # MEU
2 # Number of Junctions in JunctPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
#$$$$ 4th Cargo Stuff $$$$$
#$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
HMMWV # 2nd kind of cargo in cargo list
103 # Number of 2nd kind
# NAME PRIORITY
HMMWV19 1 # MEU
HMMWV20 5 # MEU
HMMWV21 23 # MEU
HMMWV22 43 # MEU
HMMWV23 49 # MEU
HMMWV24 54 # MEU
HMMWV25 58 # MEU
HMMWV26 60 # MEU
HMMWV27 84 # MEU
HMMWV28 86 # MEU 10
HMMWV29 87 # MEU
HMMWV30 88 # MEU
HMMWV35 20 # MEU
HMMWV36 25 # MEU
HMMWV37 26 # MEU
HMMWV38 76 # MEU
HMMWV39 107 # MEU
HMMWV40 125 # MEU
HMMWV41 130 # MEU
HMMWV42 133 # MEU 20
HMMWV43 134 # MEU
HMMWV44 135 # MEU
HMMWV45 137 # MEU
HMMWV46 138 # MEU
HMMWV47 139 # MEU
HMMWV48 141 # MEU
HMMWV49 142 # MEU
HMMWV50 143 # MEU
HMMWV51 145 # MEU
HMMWV52 146 # MEU 30
HMMWV53 147 # MEU
HMMWV54 148 # MEU
HMMWV55 149 # MEU
HMMWV56 150 # MEU
HMMWV57 3 # MGCE
HMMWV58 14 # MGCE
HMMWV59 18 # MGCE
HMMWV60 18 # MGCE {ON PURPOSE}
HMMWV61 19 # MGCE
HMMWV62 21 # MGCE 40
HMMWV63 22 # MGCE
HMMWV64 24 # MGCE
HMMWV65 25 # MGCE
HMMWV66 27 # MGCE
HMMWV67 28 # MGCE
HMMWV68 29 # MGCE
HMMWV69 31 # MGCE
HMMWV70 33 # MGCE
HMMWV71 33 # MGCE
HMMWV72 33 # MGCE 50
HMMWV73 34 # MGCE
HMMWV74 37 # MGCE
HMMWV75 37 # MGCE {ON PURPOSE}
HMMWV76 38 # MGCE
HMMWV77 38 # MGCE
HMMWV78 39 # MGCE
HMMWV79 40 # MGCE
HMMWV80 42 # MGCE
HMMWV81 50 # MGCE
HMMWV82 52 # MGCE 60
HMMWV83 53 # MGCE
HMMWV84 55 # MGCE
HMMWV85 64 # MGCE
HMMWV86 66 # MGCE
HMMWV87 67 # MGCE
HMMWV88 68 # MGCE
HMMWV89 69 # MGCE
HMMWV90 70 # MGCE
HMMWV91 71 # MGCE
HMMWV92 72 # MGCE 70
HMMWV93 73 # MGCE
HMMWV94 82 # MGCE
HMMWV95 85 # MGCE
HMMWV96 89 # MGCE
HMMWV97 90 # MGCE
HMMWV98 91 # MGCE
HMMWV99 92 # MGCE
HMMWV100 92 # MGCE
HMMWV101 93 # MGCE
HMMWV102 95 # MGCE 80
HMMWV103 95 # MGCE
HMMWV104 98 # MGCE
HMMWV105 100 # MGCE
HMMWV106 102 # MGCE
HMMWV107 105 # MGCE
HMMWV108 106 # MGCE
HMMWV109 108 # MGCE
HMMWV110 109 # MGCE
HMMWV111 110 # MGCE
HMMWV112 111 # MGCE 90
HMMWV113 112 # MGCE
HMMWV114 113 # MGCE
HMMWV115 114 # MGCE
HMMWV116 115 # MGCE
HMMWV117 116 # MGCE
HMMWV118 117 # MGCE
HMMWV119 118 # MGCE
HMMWV120 121 # MGCE
HMMWV121 129 # MGCE
HMMWV122 131 # MGCE 100
HMMWV123 132 # MGCE
HMMWV124 136 # MGCE
HMMWV125 144 # MGCE 103

LUMMUS  # 1st Junction in Junction Path
BEACH  # ...

# Nth Junction in Junction Path
#$555 5th Cargo Stuff $555
#$5555555555555555555555555555555
HMMWV1ONG # 2nd kind of cargo in cargo list
9  # Number of 2nd kind
# NAME PRIORITY
HMMWV1ONG8 4 # # MGCE
HMMWV1ONG9 6 # # MGCE
HMMWV1ONG10 8 # # MGCE
HMMWV1ONG11 10 # # MGCE
HMMWV1ONG12 16 # # MGCE
HMMWV1ONG13 35 # # MGCE
HMMWV1ONG14 56 # # MGCE
HMMWV1ONG15 61 # # MGCE
HMMWV1ONG16 75 # # MGCE
2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in Junction Path
BEACH  # ...

# Nth Junction in Junction Path
#$555 6th Cargo Stuff $555
LVS LONG  # 2nd kind of cargo in cargo list
16 # Number of 2nd kind
# NAME PRIORITY
LVS LONG 7 2 # MEU
LVS LONG 8 3 # MEU
LVS LONG 9 6 # MEU
LVS LONG 10 15 # MEU
LVS LONG 11 17 # MEU
LVS LONG 12 19 # MEU
LVS LONG 13 20 # MEU
LVS LONG 14 21 # MEU
LVS LONG 15 22 # MEU
LVS LONG 16 34 # MEU
LVS LONG 17 39 # MEU
LVS LONG 18 44 # MEU
LVS LONG 19 45 # MEU
LVS LONG 20 46 # MEU
LVS LONG 21 47 # MEU
LVS LONG 22 79 # MEU
2 # Number of Junctions in JunctPath

LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 7th Cargo Stuff $$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$$$$ 8th Cargo Stuff $$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
FIVETON # 2nd kind of cargo in cargo list
19 # Number of 2nd kind
# NAME PRIORITY
FIVETON 8 73 # MEU
FIVETON 9 91 # MEU
FIVETON 32 13 # MGCE
FIVETON 33 20 # MGCE
FIVETON 34 23 # MGCE
FIVETON 35 29 # MGCE
FIVETON 36 49 # MGCE
FIVETON 37 51 # MGCE
FIVETON 38 52 # MGCE
FIVETON 39 52 # MGCE (ON PURPOSE)
FIVETON 40 54 # MGCE
FIVETON 41 55 # MGCE
FIVETON 42 58 # MGCE
FIVETON 43 60 # MGCE
FIVETON 44 61 # MGCE
FIVETON 45 79 # MGCE
FIVETON 46 81 # MGCE
FIVETON 47 82 # MGCE
FIVETON 48 94 # MGCE
2 # Number of Junctions in JunctPath

1 # Number of 2nd kind
# NAME PRIORITY
FIVETON 5 33 # MEU
2 # Number of Junctions in JunctPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 10th Cargo Stuff $$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
COMPRESSOR # 2nd kind of cargo in cargo list
2 # Number of 2nd kind
# NAME PRIORITY
COMPRESSOR 1 8 # MEU
COMPRESSOR 2 54 # MEU
2 # Number of Junctions in JunctPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 11th Cargo Stuff $$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
TRACTOR # 2nd kind of cargo in cargo list
11 # Number of 2nd kind
# NAME PRIORITY
TRACTOR 1 8 # MEU
TRACTOR 2 13 # MEU
TRACTOR 3 16 # MEU
TRACTOR 4 18 # MEU
TRACTOR 5 23 # MEU
TRACTOR 6 28 # MEU
TRACTOR 7 37 # MEU
TRACTOR 8 38 # MEU
TRACTOR 9 40 # MEU
TRACTOR 10 43 # MEU
TRACTOR 11 44 # MEU
2 # Number of Junctions in JunctPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 12th Cargo Stuff $$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
GRADER # 2nd kind of cargo in cargo list
1 # Number of 2nd kind
# NAME PRIORITY
GRADER 1 9 # MEU
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 13th Cargo Stuff $$$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
FORK_EXT # 2nd kind of cargo in cargo list
7   # Number of 2nd kind
# NAME PRIORITY
FORK_EXT1 11  # # MEU
FORK_EXT2 31  # # MEU
FORK_EXT3 34  # # MEU
FORK_EXT4 38  # # MEU
FORK_EXT5 44  # # MEU
FORK_EXT6 53  # # MEU
FORK_EXT7 70  # # MEU
2   # Number of Junctions in JuncPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 14th Cargo Stuff $$$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
FORK_RT # 2nd kind of cargo in cargo list
4   # Number of 2nd kind
# NAME PRIORITY
FORK_RT1 93  # # MEU
FORK_RT2 101  # # MEU
FORK_RT3 103  # # MEU
FORK_RT4 35  # MGCE
2   # Number of Junctions in JuncPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 15th Cargo Stuff $$$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
LAV # 2nd kind of cargo in cargo list
9   # Number of 2nd kind
# NAME PRIORITY
LAV1 49  # # MEU
LAV2 50  # # MEU
LAV3 30  # MGCE
LAV4 31  # MGCE
LAV5 32  # MGCE
LAV6 33  # MGCE
LAV7 45  # MGCE
LAV8 46  # MGCE
LAV9 47  # MGCE
2   # Number of Junctions in JuncPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 16th Cargo Stuff $$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
WELDER # 2nd kind of cargo in cargo list
2   # Number of 2nd kind
# NAME PRIORITY
WELDER1 32  # # MEU
WELDER2 54  # # MEU  2
# Number of Junctions in JuncPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 17th Cargo Stuff $$$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
HOWITZER # 2nd kind of cargo in cargo list
6   # Number of 2nd kind
# NAME PRIORITY
HOWITZER1 43  # # MGCE
HOWITZER2 44  # # MGCE
HOWITZER3 45  # # MGCE
HOWITZER4 46  # # MGCE
HOWITZER5 47  # # MGCE
HOWITZER6 48  # # MGCE
2   # Number of Junctions in JuncPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 18th Cargo Stuff $$$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
WATER_DIST # 2nd kind of cargo in cargo list
1   # Number of 2nd kind
# NAME PRIORITY
WATER_DIST1 54  # # MEU
2   # Number of Junctions in JuncPath
LUMMUS # 1st Junction in Junction Path
BEACH # ...
# Nth Junction in Junction Path
$$$$ 19th Cargo Stuff $$$$$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
CONTAINER # 1st kind of cargo in cargo list
95   # Number of 1st kind
# NAME PRIORITY
CONTWATER1 3  # # MCSSE
CONTWATER2 4  # # MCSSE
CONTWATER3 5  # # MCSSE
CONTWATER4 6  # # MCSSE
CONTWATER5 8  # # MCSSE
CONTWATER6 10  # # MCSSE
CONTMED1 8  # # MCSSE
CONTMED2 16  # # MCSSE
CONTMED3 20  # # MCSSE
CONTMED4 34  # # MCSSE

44
CONTMED5 38 ## MCSSE
CONTMED6 45 ## MCSSE
CONTMED7 37 ## MCSSE
CONTMED8 41 ## MCSSE
CONTMED9 27 ## MCSSE
CONTMED10 13 ## MCSSE
CONTMRE8 3 ## MCSSE
CONTMRE9 11 ## MCSSE
CONTMRE10 23 ## MCSSE
CONTMRE11 9 ## MCSSE
CONTMRE12 1 ## MCSSE
CONTMRE13 3 ## MCSSE
CONTMRE14 24 ## MCSSE
CONTMRE15 19 # MACE
CONTMRE16 19 # MACE
CONTMRE17 25 # MACE
CONTMRE18 15 # MACE
CONTMRE19 7 # MACE
CONTMRE20 1 # MACE
CONTMRE21 9 # MACE
CONTFUEL1 41 ## MCSSE
CONTFUEL2 2 ## MCSSE
CONTFUEL3 35 ## MCSSE
CONTFUEL4 44 ## MCSSE
CONTFUEL5 15 ## MCSSE
CONTFUEL6 30 # MCSSE
CONTFUEL7 10 # MCSSE
CONTFUEL8 4 # MCSSE
CONTFUEL9 15 ## MCSSE
CONTFUEL10 6 # MCSSE
CONTFUEL11 16 # MCSSE
CONTFUEL12 46 # MCSSE
CONTFUEL13 14 # MCSSE
CONTFUEL14 43 # MCSSE
CONTFUEL15 42 # MCSSE
CONTFUEL16 16 # MCSSE
CONTFUEL17 18 # MCSSE
CONTFUEL18 51 # MCSSE
CONTFUEL19 45 # MCSSE
CONTFUEL20 43 # MCSSE
CONTHERS1 41 # MACE
CONTHERS2 41 # MACE
CONTHERS3 27 # MACE
CONTHERS4 27 # MACE
CONTHERS5 41 # MACE
CONTGENL1 8 ## MCSSE
CONTGENL2 16 # MCSSE
CONTGENL3 20 # MCSSE
CONTGENL4 34 # MCSSE
CONTGENL5 38 ## MCSSE
CONTGENL6 45 ## MCSSE
CONTGENL7 13 ## MCSSE
CONTGENL8 3 ## MCSSE
CONTGENL9 29 ## MCSSE
CONTGENL10 52 ## MCSSE
CONTGENL11 14 ## MCSSE
CONTGENL12 37 ## MCSSE
CONTGENL13 41 ## MCSSE
CONTGENL14 27 ## MCSSE
CONTGENL15 8 ## MCSSE
CONTGENL16 16 # MCSSE
CONTGENL17 20 # MCSSE
CONTGENL18 34 ## MCSSE
CONTGENL19 38 ## MCSSE
CONTGENL20 45 ## MCSSE
CONTGENL21 15 # MACE
CONTGENL22 11 # MACE
CONTGENL23 36 # MACE
CONTGENL24 32 # MACE
CONTGENL25 7 # MACE
CONTGENL26 9 # MACE
CONTGENL27 46 # MACE
CONTGENL28 28 # MACE
CONTGENL29 23 # MACE
CONTGENL30 12 # MACE
CONTGENL31 16 # MACE
CONTGENL32 25 # MACE
CONTGENL33 7 # MACE
CONTGENL34 15 # MACE
CONTGENL35 11 # MACE
CONTGENL36 36 # MACE
CONTGENL37 32 # MACE
CONTGENL38 7 # MACE
CONTGENL39 9 # MACE
CONTGENL40 46 # MACE

3   # Number of Junctions in JunctPath
LUMMUS   # 1st Junction in Junction Path
BEACH
COT2   # Nth Junction in Junction Path
#$$$ 20th Cargo Stuff $$$$
#$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
CONTAINER # 1st kind of cargo in cargo list
19   # Number of 1st kind
# NAME   PRIORITY
CONTNSE1 2 # NSE
CONTNSE2 27 # NSE
CONTNSE3 30 # NSE
CONTNSE4 23 # NSE
CONTNSE5 25 # NSE
CONTNSE6 9 # NSE
CONTNSE7 17 # NSE
CONTNSE8 19 # NSE
CONTNSE9 13 # NSE
CONTNSE10 32 # NSE
CONTNSE11 10 # NSE
CONTNSE12 28 # NSE
CONTNSE13 31 # NSE
CONTNSE14 21 # NSE
CONTNSE15 6 # NSE
CONTNSE16 20 # NSE
CONTNSE17 18 # NSE
CONTNSE18 22 # NSE
CONTNSE19 14 # NSE
3  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
#$$ 21st Cargo Stuff $$
#$$$$$$$$$$$$$$$$$$$$$$$$$@@@@@@$
HMMWV  # 2nd kind of cargo in cargo list
33  # Number of 2nd kind
# NAME PRIORITY
HMMWV31 35 # MCSS
HMMWV32 40 # MCSS
HMMWV33 49 # MCSS
HMMWV34 56 # MCSS
HMMWV35 59 # MCSS
HMMWV36 62 # MCSS
HMMWV27 62 # MCSS {SAME ON PURPOSE}
HMMWV28 69 # MCSS
HMMWV29 74 # MCSS
HMMWV30 76 # MCSS 10
HMMWV31 81 # MCSS
HMMWV32 83 # MCSS
HMMWV33 97 # MCSS
HMMWV33 99 # MCSS
HMMWV34 128 # MCSS
HMMWV1 4 # MACE
HMMWV2 32 # MACE
HMMWV3 41 # MACE
HMMWV4 43 # MACE
HMMWV5 45 # MACE 20
HMMWV6 47 # MACE
HMMWV7 50 # MACE
HMMWV8 77 # MACE
HMMWV9 78 # MACE
HMMWV10 81 # MACE
HMMWV11 93 # MACE
HMMWV12 94 # MACE
HMMWV13 96 # MACE
HMMWV14 96 # MACE
HMMWV15 105 # MACE 30
HMMWV16 107 # MACE
HMMWV17 119 # MACE
HMMWV18 120 # MACE 33
2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
#$$ 22nd Cargo Stuff $$
#$$$$$$$$$$$$$$$$$$$$$$$$$@@@@@@$
HMMWVLONG  # 2nd kind of cargo in cargo list
7  # Number of 2nd kind
# NAME PRIORITY
HMMWVLONG1 36 # MACE
HMMWVLONG2 39 # MACE
HMMWVLONG3 41 # MACE
HMMWVLONG4 51 # MACE
HMMWVLONG5 79 # MACE
HMMWVLONG6 26 # MCSS
HMMWVLONG7 73 # MCSS
2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
#$$ 23rd Cargo Stuff $$
#$$$$$$$$$$$$$$$$$$$$$$$$$@@@@@@$
LVSLONG  # 2nd kind of cargo in cargo list
6  # Number of 2nd kind
# NAME PRIORITY
LVSLONG1 80 # MACE
LVSLONG2 1 # MCSS
LVSLONG3 3 # MCSS
LVSLONG4 4 # MCSS
LVSLONG5 41 # MCSS
LVSLONG6 200 # MCSS
2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
#$$ 24th Cargo Stuff $$
#$$$$$$$$$$$$$$$$$$$$$$$$$@@@@@@$
FIVETON  # 2nd kind of cargo in cargo list
29  # Number of 2nd kind
# NAME PRIORITY
FIVETON1 30 # MACE
FIVETON2 35 # MACE
FIVETON3 48 # MACE
FIVETON4 62 # MACE
FIVETON5 65 # MACE
FIVETON6 72 # MACE
FIVETON7 83 # MACE
FIVETON10 2 # MCSS
FIVETON11 32 # MCSS

46
FIVETON12 32 # MCSS {SAME ON PURPOSE}
FIVETON13 34 # MCSS
FIVETON14 36 # MCSS
FIVETON15 37 # MCSS
FIVETON16 40 # MCSS
FIVETON17 41 # MCSS
FIVETON18 42 # MCSS
FIVETON19 59 # MCSS
FIVETON20 66 # MCSS
FIVETON21 66 # MCSS {SAME ON PURPOSE}
FIVETON22 67 # MCSS
FIVETON23 68 # MCSS
FIVETON24 70 # MCSS
FIVETON25 71 # MCSS
FIVETON26 72 # MCSS
FIVETON27 76 # MCSS
FIVETON28 78 # MCSS {WRECKER}
FIVETON29 80 # MCSS
FIVETON30 87 # MCSS
FIVETON31 90 # MCSS

2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
### 25th Cargo Stuff $$

###$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
FIVETONLONG  # 2nd kind of cargo in cargo list
4  # Number of 2nd kind

# NAME PRIORITY
FIVETONLONG1 19  # MACE
FIVETONLONG2 31  # MACE
FIVETONLONG3 33  # MACE
FIVETONLONG4 54  # MACE

2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
### 26th Cargo Stuff $$

###$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
FIRETRUCK  # 2nd kind of cargo in cargo list
1  # Number of 2nd kind

# NAME PRIORITY
FIRETRUCK1 9  # MCSS

2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
### 27th Cargo Stuff $$

###$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
EMI_SHELTER  # 2nd kind of cargo in cargo list
1  # Number of 2nd kind

# NAME PRIORITY
EMI_SHELTER1 100  # MACE

2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
### 28th Cargo Stuff $$

###$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
REFUELER  # 2nd kind of cargo in cargo list
1  # Number of 2nd kind

# NAME PRIORITY
REFUELER1 48  # MACE

2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath
### 29th Cargo Stuff $$

###$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
SCRAPER  # 2nd kind of cargo in cargo list
1  # Number of 2nd kind

# NAME PRIORITY
SCRAPER1 7  # MCSS

2  # Number of Junctions in JunctPath
LUMMUS  # 1st Junction in JunctPath
BEACH  # ...
# Nth Junction in JunctPath

###$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
# ***TRANSPORTER LIST STUFF***

###$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
LIGHTER(1+1)  # 1st kind of trans in trans list
1  # Number of 1st kind

# list with names / locations of trans at this junct
LIGHTER(1+1)1  # Name {1st kind}
0 0  # Location.x Location.y
# ... nth Name {1st kind}
# ... Nth Location.x Location.y
# number of Junct in LEGALDESTA and names
2  # Number in Legal Dest A List

LUMMUS  # 1st in A list
BEACH  # 2nd in A list
# number of Junct in LEGALDESTB and names
2  # Number in B list
LUMMUS  # 1st in B list
BEACH  # 2nd in B list
LUMMUS  # Orig Junct
###$$$$$ 2nd Transporter Stuff $$

###$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
LIGHTER(1+2)  # 1st kind of trans in trans list
2  # Number of 1st kind
# list with names / locations of trans at this junct
LIGHTER(1+2)1 # Name {1st kind}
0 0 # Location.x Location.y
LIGHTER(1+2)2 # Name {1st kind}
0 0 # Location.x Location.y
    # ... nth Name {1st kind}
    # ... Nth Location.x Location.y
# number of Junct in LEGALDESTA and names
2 # Number in Legal Dest A List
LUMMUS # 1st in A list
BEACH # 2nd in A list
# number of Junct in LEGALDESTB and names
2 # Number in B list
LUMMUS # 1st in B list
BEACH # 2nd in B list
LUMMUS # Orig Junct

# ***********************
# **LOADER LIST STUFF**
# ***********************
CRANE # 1st kind of loader in load list
3 # Number of 1st kind

BEACH ->
0 # Number of Cargo "Types"
0 # Number of Trans "Types"
0 # Number of Load "Types"

COT1 ->
0 # Number of Cargo "Types"
0 # Number of Trans "Types"
0 # Number of Load "Types"

COT2 ->
0 # Number of Cargo "Types"
0 # Number of Trans "Types"
0 # Number of Load "Types"

COTNSE ->
0 # Number of Cargo "Types"
0 # Number of Trans "Types"
0 # Number of Load "Types"

LIGHTER(1+1)1 ->
0 # Number of Cargo "Types"
0 # Number of Trans "Types"
0 # Number of Load "Types"
## APPENDIX B - OUTPUT DATA FILES

### 1 COT WITH 2 RTCH'S AT THE BEACH - 100% R

<table>
<thead>
<tr>
<th>REP #</th>
<th>MEAN</th>
<th>VAR</th>
<th>SAMPLE</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00000</td>
<td>5329.362496</td>
<td>0.000000</td>
<td>5329.362496</td>
<td>0.000000</td>
</tr>
<tr>
<td>2.00000</td>
<td>5458.239135</td>
<td>33218.376613</td>
<td>5587.115775</td>
<td>505.196428</td>
</tr>
<tr>
<td>3.00000</td>
<td>5235.002887</td>
<td>166112.455523</td>
<td>4788.530392</td>
<td>922.415387</td>
</tr>
<tr>
<td>4.00000</td>
<td>5171.324163</td>
<td>126961.556720</td>
<td>4980.287990</td>
<td>698.380639</td>
</tr>
<tr>
<td>5.00000</td>
<td>5196.643234</td>
<td>98426.444399</td>
<td>5297.919520</td>
<td>549.992748</td>
</tr>
<tr>
<td>6.00000</td>
<td>5133.205623</td>
<td>102887.139167</td>
<td>4816.017563</td>
<td>513.323312</td>
</tr>
<tr>
<td>7.00000</td>
<td>5086.650396</td>
<td>100911.006430</td>
<td>4807.319037</td>
<td>470.658944</td>
</tr>
<tr>
<td>8.00000</td>
<td>5110.469244</td>
<td>91033.848658</td>
<td>5277.201183</td>
<td>418.160037</td>
</tr>
<tr>
<td>9.00000</td>
<td>5120.587685</td>
<td>80576.063189</td>
<td>5201.535212</td>
<td>370.909396</td>
</tr>
<tr>
<td>10.00000</td>
<td>5126.802151</td>
<td>72009.363182</td>
<td>5182.732347</td>
<td>332.644657</td>
</tr>
<tr>
<td>11.00000</td>
<td>5102.891692</td>
<td>71097.237615</td>
<td>4863.787098</td>
<td>315.149112</td>
</tr>
<tr>
<td>12.00000</td>
<td>5129.628400</td>
<td>73212.070686</td>
<td>5423.732182</td>
<td>306.187029</td>
</tr>
<tr>
<td>13.00000</td>
<td>5129.067643</td>
<td>67115.152620</td>
<td>5122.338563</td>
<td>281.659680</td>
</tr>
<tr>
<td>14.00000</td>
<td>5137.412818</td>
<td>62927.435765</td>
<td>5245.900090</td>
<td>262.810109</td>
</tr>
<tr>
<td>15.00000</td>
<td>5129.424482</td>
<td>59389.821539</td>
<td>5017.587782</td>
<td>246.658705</td>
</tr>
<tr>
<td>16.00000</td>
<td>5135.125931</td>
<td>55950.604448</td>
<td>5220.647667</td>
<td>231.808025</td>
</tr>
<tr>
<td>17.00000</td>
<td>5120.344006</td>
<td>56168.281671</td>
<td>4883.833213</td>
<td>225.323856</td>
</tr>
<tr>
<td>18.00000</td>
<td>5107.337590</td>
<td>55909.268878</td>
<td>4886.228505</td>
<td>218.469956</td>
</tr>
<tr>
<td>19.00000</td>
<td>5133.586680</td>
<td>65894.478917</td>
<td>5606.070314</td>
<td>230.852074</td>
</tr>
<tr>
<td>20.00000</td>
<td>5112.307134</td>
<td>71482.730057</td>
<td>4707.995759</td>
<td>234.353603</td>
</tr>
<tr>
<td>21.00000</td>
<td>5099.105583</td>
<td>71568.493507</td>
<td>4835.074562</td>
<td>228.842855</td>
</tr>
<tr>
<td>22.00000</td>
<td>5118.860004</td>
<td>76745.683786</td>
<td>5533.702833</td>
<td>231.527038</td>
</tr>
<tr>
<td>23.00000</td>
<td>5124.695971</td>
<td>74040.592191</td>
<td>5253.087242</td>
<td>222.411424</td>
</tr>
<tr>
<td>24.00000</td>
<td>5125.912561</td>
<td>70856.958235</td>
<td>5153.894146</td>
<td>212.996123</td>
</tr>
<tr>
<td>25.00000</td>
<td>5115.717307</td>
<td>70503.165345</td>
<td>4871.031198</td>
<td>208.171068</td>
</tr>
<tr>
<td>26.00000</td>
<td>5127.235375</td>
<td>71132.351787</td>
<td>5415.187071</td>
<td>205.037348</td>
</tr>
<tr>
<td>27.00000</td>
<td>5129.154945</td>
<td>68495.980367</td>
<td>5179.063775</td>
<td>197.440721</td>
</tr>
<tr>
<td>28.00000</td>
<td>5139.532444</td>
<td>68974.482007</td>
<td>5419.724927</td>
<td>194.558977</td>
</tr>
<tr>
<td>29.00000</td>
<td>5124.960449</td>
<td>72669.055844</td>
<td>4716.945886</td>
<td>196.228384</td>
</tr>
<tr>
<td>30.00000</td>
<td>5125.324621</td>
<td>70167.204974</td>
<td>5135.885615</td>
<td>189.580004</td>
</tr>
<tr>
<td>REP #</td>
<td>MEAN</td>
<td>VAR</td>
<td>SAMPLE</td>
<td>CI</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>----------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>1.00000</td>
<td>5308.937786</td>
<td>0.000000</td>
<td>5308.937786</td>
<td>0.000000</td>
</tr>
<tr>
<td>2.00000</td>
<td>5132.692073</td>
<td>62125.102567</td>
<td>4956.446360</td>
<td>690.883194</td>
</tr>
<tr>
<td>3.00000</td>
<td>5151.126495</td>
<td>32082.035017</td>
<td>5187.995339</td>
<td>405.374470</td>
</tr>
<tr>
<td>4.00000</td>
<td>5166.197599</td>
<td>22296.575993</td>
<td>5211.410909</td>
<td>292.667946</td>
</tr>
<tr>
<td>5.00000</td>
<td>5149.017230</td>
<td>18198.257284</td>
<td>5080.295757</td>
<td>236.491734</td>
</tr>
<tr>
<td>6.00000</td>
<td>5164.110312</td>
<td>15925.412615</td>
<td>5239.575724</td>
<td>201.955548</td>
</tr>
<tr>
<td>7.00000</td>
<td>5109.298511</td>
<td>34301.512302</td>
<td>4780.427702</td>
<td>274.406049</td>
</tr>
<tr>
<td>8.00000</td>
<td>5098.402003</td>
<td>30351.167301</td>
<td>5022.126449</td>
<td>241.450869</td>
</tr>
<tr>
<td>9.00000</td>
<td>5083.874933</td>
<td>28456.593306</td>
<td>4967.658371</td>
<td>220.422674</td>
</tr>
<tr>
<td>10.00000</td>
<td>5100.051496</td>
<td>27911.561407</td>
<td>5245.640560</td>
<td>207.099063</td>
</tr>
<tr>
<td>11.00000</td>
<td>5091.552351</td>
<td>25914.995404</td>
<td>5006.560900</td>
<td>190.267798</td>
</tr>
<tr>
<td>12.00000</td>
<td>5101.869426</td>
<td>24836.391241</td>
<td>5215.357254</td>
<td>178.336275</td>
</tr>
<tr>
<td>13.00000</td>
<td>5073.567067</td>
<td>33179.997417</td>
<td>4733.938766</td>
<td>198.039839</td>
</tr>
<tr>
<td>14.00000</td>
<td>5079.805861</td>
<td>31172.605625</td>
<td>5160.910183</td>
<td>184.973111</td>
</tr>
<tr>
<td>15.00000</td>
<td>5146.065586</td>
<td>94801.257365</td>
<td>6073.701729</td>
<td>311.635903</td>
</tr>
<tr>
<td>16.00000</td>
<td>5151.032678</td>
<td>88875.925632</td>
<td>5225.539062</td>
<td>292.158243</td>
</tr>
<tr>
<td>17.00000</td>
<td>5146.834197</td>
<td>83620.843364</td>
<td>5079.658506</td>
<td>274.927940</td>
</tr>
<tr>
<td>18.00000</td>
<td>5128.558388</td>
<td>84714.064059</td>
<td>4817.869626</td>
<td>268.922768</td>
</tr>
<tr>
<td>19.00000</td>
<td>5138.392258</td>
<td>81845.346520</td>
<td>5315.413310</td>
<td>257.280139</td>
</tr>
<tr>
<td>20.00000</td>
<td>5155.778688</td>
<td>83583.038692</td>
<td>5486.109474</td>
<td>253.413733</td>
</tr>
<tr>
<td>21.00000</td>
<td>5140.893371</td>
<td>84056.912931</td>
<td>4843.187022</td>
<td>248.006542</td>
</tr>
<tr>
<td>22.00000</td>
<td>5199.021912</td>
<td>154390.603158</td>
<td>6419.721275</td>
<td>328.386397</td>
</tr>
<tr>
<td>23.00000</td>
<td>5218.436853</td>
<td>156042.467053</td>
<td>5645.565558</td>
<td>322.881791</td>
</tr>
<tr>
<td>24.00000</td>
<td>5203.996836</td>
<td>154262.350283</td>
<td>4871.876440</td>
<td>314.275422</td>
</tr>
<tr>
<td>25.00000</td>
<td>5190.956368</td>
<td>152086.097282</td>
<td>4877.985144</td>
<td>305.746026</td>
</tr>
<tr>
<td>26.00000</td>
<td>5175.448178</td>
<td>152255.756910</td>
<td>4787.743408</td>
<td>299.975824</td>
</tr>
<tr>
<td>27.00000</td>
<td>5176.532918</td>
<td>146431.536137</td>
<td>5204.736173</td>
<td>288.683189</td>
</tr>
<tr>
<td>28.00000</td>
<td>5184.023014</td>
<td>142578.988840</td>
<td>5386.255597</td>
<td>279.727276</td>
</tr>
<tr>
<td>29.00000</td>
<td>5164.001257</td>
<td>149112.133628</td>
<td>4603.392069</td>
<td>281.888812</td>
</tr>
<tr>
<td>30.00000</td>
<td>5155.373242</td>
<td>146203.615353</td>
<td>4905.160798</td>
<td>273.655698</td>
</tr>
<tr>
<td>REP #</td>
<td>MEAN</td>
<td>VAR</td>
<td>SAMPLE</td>
<td>CI</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>1.000000</td>
<td>5426.406027</td>
<td>0.00000000000</td>
<td>5426.406027</td>
<td>0.000000</td>
</tr>
<tr>
<td>2.000000</td>
<td>5355.025255</td>
<td>10190.429163</td>
<td>5283.644483</td>
<td>279.812625</td>
</tr>
<tr>
<td>3.000000</td>
<td>5317.794934</td>
<td>9253.5051370</td>
<td>5243.334290</td>
<td>217.710099</td>
</tr>
<tr>
<td>4.000000</td>
<td>5243.328684</td>
<td>28349.892888</td>
<td>5019.929934</td>
<td>330.013558</td>
</tr>
<tr>
<td>5.000000</td>
<td>5206.424221</td>
<td>28072.116504</td>
<td>5058.806370</td>
<td>293.723466</td>
</tr>
<tr>
<td>6.000000</td>
<td>5142.511688</td>
<td>46966.564693</td>
<td>4822.949021</td>
<td>346.820564</td>
</tr>
<tr>
<td>7.000000</td>
<td>5183.577569</td>
<td>50943.649942</td>
<td>5429.972854</td>
<td>334.412171</td>
</tr>
<tr>
<td>8.000000</td>
<td>5157.082605</td>
<td>49281.850557</td>
<td>4971.617857</td>
<td>307.669593</td>
</tr>
<tr>
<td>9.000000</td>
<td>5102.901128</td>
<td>69542.310745</td>
<td>4669.449317</td>
<td>344.579448</td>
</tr>
<tr>
<td>10.000000</td>
<td>5062.388105</td>
<td>78228.437837</td>
<td>4697.770896</td>
<td>346.711619</td>
</tr>
<tr>
<td>11.000000</td>
<td>5021.033052</td>
<td>89218.238169</td>
<td>4607.482527</td>
<td>353.034010</td>
</tr>
<tr>
<td>12.000000</td>
<td>5045.796075</td>
<td>88465.976501</td>
<td>5318.189320</td>
<td>336.576339</td>
</tr>
<tr>
<td>13.000000</td>
<td>5039.962243</td>
<td>81536.248565</td>
<td>4969.956256</td>
<td>310.448634</td>
</tr>
<tr>
<td>14.000000</td>
<td>5052.937370</td>
<td>77621.184338</td>
<td>5221.614021</td>
<td>291.885272</td>
</tr>
<tr>
<td>15.000000</td>
<td>5072.990819</td>
<td>78108.926798</td>
<td>5353.739117</td>
<td>282.872529</td>
</tr>
<tr>
<td>16.000000</td>
<td>5138.653230</td>
<td>141886.499342</td>
<td>6123.589387</td>
<td>369.144679</td>
</tr>
<tr>
<td>17.000000</td>
<td>5136.302523</td>
<td>133112.532110</td>
<td>5098.691215</td>
<td>346.873465</td>
</tr>
<tr>
<td>18.000000</td>
<td>5125.923693</td>
<td>127221.345314</td>
<td>4949.483577</td>
<td>329.556443</td>
</tr>
<tr>
<td>19.000000</td>
<td>5139.803787</td>
<td>123813.976063</td>
<td>5389.645482</td>
<td>316.441986</td>
</tr>
<tr>
<td>20.000000</td>
<td>5140.594566</td>
<td>117309.957623</td>
<td>5155.619359</td>
<td>300.219231</td>
</tr>
<tr>
<td>21.000000</td>
<td>5134.036764</td>
<td>112347.559801</td>
<td>5002.880727</td>
<td>286.720167</td>
</tr>
<tr>
<td>22.000000</td>
<td>5122.865662</td>
<td>109743.133288</td>
<td>4888.272526</td>
<td>276.862034</td>
</tr>
<tr>
<td>23.000000</td>
<td>5105.759247</td>
<td>111485.285774</td>
<td>4729.418125</td>
<td>272.917211</td>
</tr>
<tr>
<td>24.000000</td>
<td>5098.875904</td>
<td>107775.229513</td>
<td>4940.559000</td>
<td>262.687813</td>
</tr>
<tr>
<td>25.000000</td>
<td>5088.357249</td>
<td>106050.647140</td>
<td>4835.909547</td>
<td>255.312880</td>
</tr>
<tr>
<td>26.000000</td>
<td>5071.033854</td>
<td>109611.221828</td>
<td>4637.948974</td>
<td>254.522923</td>
</tr>
<tr>
<td>27.000000</td>
<td>5074.951775</td>
<td>105809.858303</td>
<td>5176.817704</td>
<td>245.395871</td>
</tr>
<tr>
<td>28.000000</td>
<td>5088.586692</td>
<td>107096.481733</td>
<td>5456.729456</td>
<td>242.434629</td>
</tr>
<tr>
<td>29.000000</td>
<td>5085.008529</td>
<td>103642.901611</td>
<td>4984.819970</td>
<td>234.345625</td>
</tr>
<tr>
<td>30.000000</td>
<td>5117.361276</td>
<td>131470.014913</td>
<td>6055.590928</td>
<td>259.500857</td>
</tr>
</tbody>
</table>
1 COT WITH 2 RTCH'S AT THE COT - 93 % R

<table>
<thead>
<tr>
<th>REP #</th>
<th>MEAN</th>
<th>VAR</th>
<th>SAMPLE</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000000</td>
<td>5476.088090</td>
<td>0.0000000000000</td>
<td>5476.088090</td>
<td>0.0000000</td>
</tr>
<tr>
<td>2.000000</td>
<td>5738.406481</td>
<td>137621.877193</td>
<td>6000.724873</td>
<td>1028.288095</td>
</tr>
<tr>
<td>3.000000</td>
<td>5547.562480</td>
<td>178075.237248</td>
<td>5165.874477</td>
<td>955.052411</td>
</tr>
<tr>
<td>4.000000</td>
<td>5433.871450</td>
<td>170419.425569</td>
<td>5092.798362</td>
<td>809.125000</td>
</tr>
<tr>
<td>5.000000</td>
<td>5386.584441</td>
<td>138994.875346</td>
<td>5197.436405</td>
<td>653.582566</td>
</tr>
<tr>
<td>6.000000</td>
<td>5252.968436</td>
<td>218315.322220</td>
<td>4584.884070</td>
<td>747.743335</td>
</tr>
<tr>
<td>7.000000</td>
<td>5215.523122</td>
<td>191744.495706</td>
<td>4990.851241</td>
<td>648.781563</td>
</tr>
<tr>
<td>8.000000</td>
<td>5232.272329</td>
<td>166596.712372</td>
<td>5349.516778</td>
<td>565.684510</td>
</tr>
<tr>
<td>9.000000</td>
<td>5240.127963</td>
<td>146327.522126</td>
<td>5302.970301</td>
<td>499.836333</td>
</tr>
<tr>
<td>10.000000</td>
<td>5194.691723</td>
<td>150713.426828</td>
<td>4785.765571</td>
<td>481.240356</td>
</tr>
<tr>
<td>11.000000</td>
<td>5216.377521</td>
<td>140815.096232</td>
<td>5433.235499</td>
<td>443.521148</td>
</tr>
<tr>
<td>12.000000</td>
<td>5190.999441</td>
<td>135742.286985</td>
<td>4911.840565</td>
<td>416.920284</td>
</tr>
<tr>
<td>13.000000</td>
<td>5163.805112</td>
<td>134044.339991</td>
<td>4837.473158</td>
<td>398.050919</td>
</tr>
<tr>
<td>14.000000</td>
<td>5137.745621</td>
<td>133240.595704</td>
<td>4798.972242</td>
<td>382.419767</td>
</tr>
<tr>
<td>15.000000</td>
<td>5129.933119</td>
<td>124638.938232</td>
<td>5020.558083</td>
<td>357.328213</td>
</tr>
<tr>
<td>16.000000</td>
<td>5130.135230</td>
<td>116330.329268</td>
<td>5133.166901</td>
<td>334.250876</td>
</tr>
<tr>
<td>17.000000</td>
<td>5132.562067</td>
<td>109159.805843</td>
<td>5171.391462</td>
<td>314.118116</td>
</tr>
<tr>
<td>18.000000</td>
<td>5142.601160</td>
<td>104552.741764</td>
<td>5313.265740</td>
<td>298.756613</td>
</tr>
<tr>
<td>19.000000</td>
<td>5162.209595</td>
<td>106049.579845</td>
<td>5515.161425</td>
<td>292.862485</td>
</tr>
<tr>
<td>20.000000</td>
<td>5141.255294</td>
<td>109249.677726</td>
<td>4743.123573</td>
<td>289.721784</td>
</tr>
<tr>
<td>21.000000</td>
<td>5160.766954</td>
<td>111781.996052</td>
<td>5551.000149</td>
<td>285.997574</td>
</tr>
<tr>
<td>22.000000</td>
<td>5156.638231</td>
<td>106834.063635</td>
<td>5069.935048</td>
<td>273.167860</td>
</tr>
<tr>
<td>23.000000</td>
<td>5147.511494</td>
<td>103893.808365</td>
<td>4946.723281</td>
<td>263.461392</td>
</tr>
<tr>
<td>24.000000</td>
<td>5135.182677</td>
<td>103024.679926</td>
<td>4851.619879</td>
<td>256.833153</td>
</tr>
<tr>
<td>25.000000</td>
<td>5159.574994</td>
<td>113606.613770</td>
<td>5744.990614</td>
<td>264.251749</td>
</tr>
<tr>
<td>26.000000</td>
<td>5158.686425</td>
<td>109082.877638</td>
<td>5136.472205</td>
<td>253.908761</td>
</tr>
<tr>
<td>27.000000</td>
<td>5152.823733</td>
<td>105815.403684</td>
<td>5000.393734</td>
<td>245.402302</td>
</tr>
<tr>
<td>28.000000</td>
<td>5149.912021</td>
<td>102133.700561</td>
<td>5071.295791</td>
<td>236.750871</td>
</tr>
<tr>
<td>29.000000</td>
<td>5169.324762</td>
<td>109414.849166</td>
<td>5712.881507</td>
<td>240.782656</td>
</tr>
<tr>
<td>30.000000</td>
<td>5159.785067</td>
<td>108372.096568</td>
<td>4883.133921</td>
<td>235.604823</td>
</tr>
<tr>
<td>REP #</td>
<td>MEAN</td>
<td>VAR</td>
<td>SAMPLE</td>
<td>CI</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>1.000000</td>
<td>5231.935490</td>
<td>0.000000000000</td>
<td>5231.935490</td>
<td>0.000000</td>
</tr>
<tr>
<td>2.000000</td>
<td>5090.742461</td>
<td>39870.9426290</td>
<td>4949.549432</td>
<td>553.476672</td>
</tr>
<tr>
<td>3.000000</td>
<td>5341.915028</td>
<td>209198.446505</td>
<td>5844.260162</td>
<td>1035.153291</td>
</tr>
<tr>
<td>4.000000</td>
<td>5381.881880</td>
<td>145855.028129</td>
<td>5501.782437</td>
<td>748.543036</td>
</tr>
<tr>
<td>5.000000</td>
<td>5281.085967</td>
<td>160190.351438</td>
<td>4877.902316</td>
<td>701.647920</td>
</tr>
<tr>
<td>6.000000</td>
<td>5132.038862</td>
<td>261442.518929</td>
<td>4386.803335</td>
<td>818.273622</td>
</tr>
<tr>
<td>7.000000</td>
<td>5047.940476</td>
<td>267376.535289</td>
<td>4543.350161</td>
<td>766.123339</td>
</tr>
<tr>
<td>8.000000</td>
<td>5057.833115</td>
<td>229962.801871</td>
<td>5127.081590</td>
<td>664.614587</td>
</tr>
<tr>
<td>9.000000</td>
<td>5128.419716</td>
<td>246059.665158</td>
<td>5693.112520</td>
<td>648.164180</td>
</tr>
<tr>
<td>10.000000</td>
<td>5136.964117</td>
<td>219449.770276</td>
<td>5213.863727</td>
<td>580.702415</td>
</tr>
<tr>
<td>11.000000</td>
<td>5142.235429</td>
<td>197810.447250</td>
<td>5194.948546</td>
<td>525.671385</td>
</tr>
<tr>
<td>12.000000</td>
<td>5186.285064</td>
<td>203112.123295</td>
<td>5670.831047</td>
<td>509.992004</td>
</tr>
<tr>
<td>13.000000</td>
<td>5177.226492</td>
<td>187252.863389</td>
<td>5068.523632</td>
<td>470.466413</td>
</tr>
<tr>
<td>14.000000</td>
<td>5167.010104</td>
<td>174310.041128</td>
<td>5034.197061</td>
<td>437.404505</td>
</tr>
<tr>
<td>15.000000</td>
<td>5168.429150</td>
<td>161889.529279</td>
<td>5188.295794</td>
<td>407.239427</td>
</tr>
<tr>
<td>16.000000</td>
<td>5162.384017</td>
<td>151681.592186</td>
<td>5071.707017</td>
<td>381.673946</td>
</tr>
<tr>
<td>17.000000</td>
<td>5177.547405</td>
<td>146110.274496</td>
<td>5420.161166</td>
<td>363.414277</td>
</tr>
<tr>
<td>18.000000</td>
<td>5161.607920</td>
<td>142088.761911</td>
<td>4890.636670</td>
<td>348.280917</td>
</tr>
<tr>
<td>19.000000</td>
<td>5179.917405</td>
<td>140564.449964</td>
<td>5509.488150</td>
<td>337.168517</td>
</tr>
<tr>
<td>20.000000</td>
<td>5182.129601</td>
<td>133264.197196</td>
<td>5224.161315</td>
<td>319.983668</td>
</tr>
<tr>
<td>21.000000</td>
<td>5188.632054</td>
<td>127488.907139</td>
<td>5318.681114</td>
<td>305.430652</td>
</tr>
<tr>
<td>22.000000</td>
<td>5176.279759</td>
<td>124774.748921</td>
<td>4916.881568</td>
<td>295.214768</td>
</tr>
<tr>
<td>23.000000</td>
<td>5167.136219</td>
<td>121026.069052</td>
<td>4965.978329</td>
<td>284.355487</td>
</tr>
<tr>
<td>24.000000</td>
<td>5168.376202</td>
<td>115800.967473</td>
<td>5196.895825</td>
<td>272.293040</td>
</tr>
<tr>
<td>25.000000</td>
<td>5157.067467</td>
<td>114173.114279</td>
<td>4885.657830</td>
<td>264.909777</td>
</tr>
<tr>
<td>26.000000</td>
<td>5154.247958</td>
<td>109812.880199</td>
<td>5083.760218</td>
<td>254.756946</td>
</tr>
<tr>
<td>27.000000</td>
<td>5153.267799</td>
<td>105615.247100</td>
<td>5127.783664</td>
<td>245.170095</td>
</tr>
<tr>
<td>28.000000</td>
<td>5152.652063</td>
<td>101714.186922</td>
<td>5136.027209</td>
<td>236.264144</td>
</tr>
<tr>
<td>29.000000</td>
<td>5147.673543</td>
<td>98800.3217010</td>
<td>5008.274970</td>
<td>228.805388</td>
</tr>
<tr>
<td>30.000000</td>
<td>5154.112086</td>
<td>96637.0589700</td>
<td>5340.829820</td>
<td>222.483236</td>
</tr>
<tr>
<td>REP #</td>
<td>MEAN</td>
<td>VAR</td>
<td>SAMPLE</td>
<td>CI</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>1.000000</td>
<td>5579.028687</td>
<td>0.000000000000</td>
<td>5579.028687</td>
<td>0.000000</td>
</tr>
<tr>
<td>2.000000</td>
<td>5270.136099</td>
<td>190829.262237</td>
<td>4961.243510</td>
<td>1210.858946</td>
</tr>
<tr>
<td>3.000000</td>
<td>5167.536435</td>
<td>126994.703961</td>
<td>4962.337108</td>
<td>806.525763</td>
</tr>
<tr>
<td>4.000000</td>
<td>5097.814001</td>
<td>104108.007431</td>
<td>4888.646697</td>
<td>632.409141</td>
</tr>
<tr>
<td>5.000000</td>
<td>5006.900751</td>
<td>119407.100377</td>
<td>4643.247753</td>
<td>605.781688</td>
</tr>
<tr>
<td>6.000000</td>
<td>4992.371744</td>
<td>96792.2325990</td>
<td>4919.726708</td>
<td>497.886895</td>
</tr>
<tr>
<td>7.000000</td>
<td>5050.290743</td>
<td>104142.467163</td>
<td>5397.804739</td>
<td>478.135487</td>
</tr>
<tr>
<td>8.000000</td>
<td>5003.818846</td>
<td>106542.069609</td>
<td>4678.515566</td>
<td>452.378168</td>
</tr>
<tr>
<td>9.000000</td>
<td>5063.401547</td>
<td>125175.195152</td>
<td>5540.063154</td>
<td>462.300061</td>
</tr>
<tr>
<td>10.00000</td>
<td>5038.716051</td>
<td>117360.577502</td>
<td>4816.546582</td>
<td>424.665701</td>
</tr>
<tr>
<td>11.00000</td>
<td>5067.844698</td>
<td>114957.778588</td>
<td>5359.131168</td>
<td>400.736505</td>
</tr>
<tr>
<td>12.00000</td>
<td>5059.478973</td>
<td>105346.895642</td>
<td>4967.456001</td>
<td>367.287641</td>
</tr>
<tr>
<td>13.00000</td>
<td>5085.559720</td>
<td>105410.657282</td>
<td>5398.528681</td>
<td>352.985326</td>
</tr>
<tr>
<td>14.00000</td>
<td>5099.776058</td>
<td>100131.604909</td>
<td>5284.588452</td>
<td>331.518400</td>
</tr>
<tr>
<td>15.00000</td>
<td>5122.514052</td>
<td>100734.593110</td>
<td>5440.845970</td>
<td>321.240102</td>
</tr>
<tr>
<td>16.00000</td>
<td>5125.658798</td>
<td>94177.1844570</td>
<td>5172.829996</td>
<td>300.745354</td>
</tr>
<tr>
<td>17.00000</td>
<td>5105.553755</td>
<td>95162.7274190</td>
<td>4783.873063</td>
<td>293.288508</td>
</tr>
<tr>
<td>18.00000</td>
<td>5124.494963</td>
<td>95991.7799880</td>
<td>5445.676499</td>
<td>286.264067</td>
</tr>
<tr>
<td>19.00000</td>
<td>5138.092468</td>
<td>94195.4033210</td>
<td>5383.666554</td>
<td>276.009558</td>
</tr>
<tr>
<td>20.00000</td>
<td>5185.518335</td>
<td>134222.007886</td>
<td>6086.609809</td>
<td>321.131520</td>
</tr>
<tr>
<td>21.00000</td>
<td>5211.538743</td>
<td>141188.023070</td>
<td>5721.446900</td>
<td>321.421814</td>
</tr>
<tr>
<td>22.00000</td>
<td>5242.994263</td>
<td>156930.199460</td>
<td>5914.060181</td>
<td>331.076221</td>
</tr>
<tr>
<td>23.00000</td>
<td>5243.657574</td>
<td>149807.128165</td>
<td>5258.250427</td>
<td>316.364969</td>
</tr>
<tr>
<td>24.00000</td>
<td>5278.819943</td>
<td>172967.187159</td>
<td>6087.554427</td>
<td>332.783900</td>
</tr>
<tr>
<td>25.00000</td>
<td>5286.144682</td>
<td>167101.516033</td>
<td>5461.938416</td>
<td>320.483930</td>
</tr>
<tr>
<td>26.00000</td>
<td>5277.463835</td>
<td>162376.739993</td>
<td>5060.442667</td>
<td>309.785654</td>
</tr>
<tr>
<td>27.00000</td>
<td>5272.038253</td>
<td>156926.278228</td>
<td>5130.973113</td>
<td>298.849148</td>
</tr>
<tr>
<td>28.00000</td>
<td>5249.519965</td>
<td>165312.245736</td>
<td>4641.526197</td>
<td>301.203188</td>
</tr>
<tr>
<td>29.00000</td>
<td>5242.251616</td>
<td>160940.275250</td>
<td>5038.737826</td>
<td>292.024600</td>
</tr>
<tr>
<td>30.00000</td>
<td>5224.230372</td>
<td>165133.567465</td>
<td>4701.614301</td>
<td>290.832624</td>
</tr>
</tbody>
</table>
2 COT'S (CE, GCE, & CSSE AT COT1; ACE AT COT2) - 100 % R

<table>
<thead>
<tr>
<th>REP #</th>
<th>MEAN</th>
<th>VAR</th>
<th>SAMPLE</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000000</td>
<td>5772.735190</td>
<td>0.000000000000</td>
<td>5772.735190</td>
<td>0.000000</td>
</tr>
<tr>
<td>2.000000</td>
<td>5427.742407</td>
<td>238040.040961</td>
<td>5082.749624</td>
<td>1352.37110</td>
</tr>
<tr>
<td>3.000000</td>
<td>5280.547015</td>
<td>184019.470877</td>
<td>4986.156231</td>
<td>970.861610</td>
</tr>
<tr>
<td>4.000000</td>
<td>5279.036155</td>
<td>122688.778045</td>
<td>5274.503574</td>
<td>686.528375</td>
</tr>
<tr>
<td>5.000000</td>
<td>5271.155864</td>
<td>92327.078406</td>
<td>5239.634703</td>
<td>532.679044</td>
</tr>
<tr>
<td>6.000000</td>
<td>5279.650479</td>
<td>74294.613554</td>
<td>5322.123550</td>
<td>436.203460</td>
</tr>
<tr>
<td>7.000000</td>
<td>5251.707507</td>
<td>67377.845529</td>
<td>5084.049679</td>
<td>384.587892</td>
</tr>
<tr>
<td>8.000000</td>
<td>5243.175010</td>
<td>58334.867028</td>
<td>5183.447533</td>
<td>334.738125</td>
</tr>
<tr>
<td>9.000000</td>
<td>5203.952699</td>
<td>64888.516034</td>
<td>4890.174208</td>
<td>332.850132</td>
</tr>
<tr>
<td>10.000000</td>
<td>5166.177289</td>
<td>71948.496735</td>
<td>4826.198602</td>
<td>332.504042</td>
</tr>
<tr>
<td>11.000000</td>
<td>5211.817889</td>
<td>87667.355144</td>
<td>5668.223890</td>
<td>349.952159</td>
</tr>
<tr>
<td>12.000000</td>
<td>5191.778900</td>
<td>84516.328645</td>
<td>4971.350019</td>
<td>328.977166</td>
</tr>
<tr>
<td>13.000000</td>
<td>5165.045798</td>
<td>86763.865002</td>
<td>4844.248572</td>
<td>320.246090</td>
</tr>
<tr>
<td>14.000000</td>
<td>5173.093396</td>
<td>80996.415132</td>
<td>5277.712165</td>
<td>298.163823</td>
</tr>
<tr>
<td>15.000000</td>
<td>5131.858048</td>
<td>100716.264846</td>
<td>4554.563187</td>
<td>321.210877</td>
</tr>
<tr>
<td>16.000000</td>
<td>5136.227892</td>
<td>94307.375702</td>
<td>5201.775544</td>
<td>300.953159</td>
</tr>
<tr>
<td>17.000000</td>
<td>5123.965956</td>
<td>90969.201129</td>
<td>4927.774974</td>
<td>286.753546</td>
</tr>
<tr>
<td>18.000000</td>
<td>5088.602533</td>
<td>108128.361984</td>
<td>4487.424342</td>
<td>303.822286</td>
</tr>
<tr>
<td>19.000000</td>
<td>5147.514171</td>
<td>168062.272649</td>
<td>6207.923664</td>
<td>368.675589</td>
</tr>
<tr>
<td>20.000000</td>
<td>5151.715767</td>
<td>159569.958050</td>
<td>5231.546090</td>
<td>350.143956</td>
</tr>
<tr>
<td>21.000000</td>
<td>5142.184814</td>
<td>153499.080686</td>
<td>4951.565745</td>
<td>335.142349</td>
</tr>
<tr>
<td>22.000000</td>
<td>5134.865385</td>
<td>147368.229540</td>
<td>4981.157377</td>
<td>320.831247</td>
</tr>
<tr>
<td>23.000000</td>
<td>5153.798658</td>
<td>148914.457322</td>
<td>5570.330681</td>
<td>315.420983</td>
</tr>
<tr>
<td>24.000000</td>
<td>5169.931741</td>
<td>148686.547870</td>
<td>5540.992631</td>
<td>308.543417</td>
</tr>
<tr>
<td>25.000000</td>
<td>5165.028279</td>
<td>143092.373334</td>
<td>5047.345211</td>
<td>296.568012</td>
</tr>
<tr>
<td>26.000000</td>
<td>5150.254705</td>
<td>143043.399514</td>
<td>4780.915342</td>
<td>290.759092</td>
</tr>
<tr>
<td>27.000000</td>
<td>5128.509605</td>
<td>150308.663790</td>
<td>4563.136996</td>
<td>292.480012</td>
</tr>
<tr>
<td>28.000000</td>
<td>5147.488472</td>
<td>154827.204061</td>
<td>5659.917902</td>
<td>291.494716</td>
</tr>
<tr>
<td>29.000000</td>
<td>5149.680117</td>
<td>149436.956907</td>
<td>5211.046160</td>
<td>281.394805</td>
</tr>
<tr>
<td>30.000000</td>
<td>5151.044729</td>
<td>144339.823425</td>
<td>5190.618497</td>
<td>271.905833</td>
</tr>
</tbody>
</table>
### 2 COT'S (CE, GCE, & CSSE AT COT1; ACE AT COT2) - 93 % R

<table>
<thead>
<tr>
<th>REP #</th>
<th>MEAN</th>
<th>VAR</th>
<th>SAMPLE</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000000</td>
<td>5600.629744</td>
<td>0.000000000000</td>
<td>5600.629744</td>
<td>0.000000</td>
</tr>
<tr>
<td>2.000000</td>
<td>5416.817727</td>
<td>67573.7157010</td>
<td>5233.005709</td>
<td>720.543109</td>
</tr>
<tr>
<td>3.000000</td>
<td>5290.703665</td>
<td>81501.1274480</td>
<td>5038.475542</td>
<td>646.111168</td>
</tr>
<tr>
<td>4.000000</td>
<td>5385.696968</td>
<td>90428.9952500</td>
<td>5670.676876</td>
<td>589.399718</td>
</tr>
<tr>
<td>5.000000</td>
<td>5363.926520</td>
<td>70191.5083307</td>
<td>5276.844731</td>
<td>464.454690</td>
</tr>
<tr>
<td>6.000000</td>
<td>5310.984526</td>
<td>72970.3350460</td>
<td>5046.274556</td>
<td>432.298384</td>
</tr>
<tr>
<td>7.000000</td>
<td>5260.021144</td>
<td>78989.4766580</td>
<td>4954.240852</td>
<td>416.410494</td>
</tr>
<tr>
<td>8.000000</td>
<td>5236.649260</td>
<td>72075.2256580</td>
<td>5073.046067</td>
<td>372.078074</td>
</tr>
<tr>
<td>9.000000</td>
<td>5240.998103</td>
<td>63236.0344210</td>
<td>5275.788853</td>
<td>328.584540</td>
</tr>
<tr>
<td>10.00000</td>
<td>5187.627470</td>
<td>84694.0532780</td>
<td>4707.291771</td>
<td>360.755139</td>
</tr>
<tr>
<td>11.00000</td>
<td>5208.969710</td>
<td>81235.0510140</td>
<td>5422.392105</td>
<td>336.869315</td>
</tr>
<tr>
<td>12.00000</td>
<td>5164.781440</td>
<td>97281.2840870</td>
<td>4678.710478</td>
<td>352.947485</td>
</tr>
<tr>
<td>13.00000</td>
<td>5200.398089</td>
<td>105665.604312</td>
<td>5627.797877</td>
<td>353.411935</td>
</tr>
<tr>
<td>14.00000</td>
<td>5164.399733</td>
<td>115679.823989</td>
<td>4696.421103</td>
<td>356.328745</td>
</tr>
<tr>
<td>15.00000</td>
<td>5173.503476</td>
<td>108660.151503</td>
<td>5300.955880</td>
<td>333.638063</td>
</tr>
<tr>
<td>16.00000</td>
<td>5166.273080</td>
<td>102252.599476</td>
<td>5057.817137</td>
<td>313.374212</td>
</tr>
<tr>
<td>17.00000</td>
<td>5162.460952</td>
<td>96108.861400</td>
<td>5101.466910</td>
<td>294.742880</td>
</tr>
<tr>
<td>18.00000</td>
<td>5155.267840</td>
<td>91386.734442</td>
<td>5032.984937</td>
<td>279.313157</td>
</tr>
<tr>
<td>19.00000</td>
<td>5147.325917</td>
<td>87508.102539</td>
<td>5004.371289</td>
<td>266.031706</td>
</tr>
<tr>
<td>20.00000</td>
<td>5156.936771</td>
<td>84749.783380</td>
<td>5339.543005</td>
<td>255.176319</td>
</tr>
<tr>
<td>21.00000</td>
<td>5166.545437</td>
<td>82451.149936</td>
<td>5358.718758</td>
<td>245.626250</td>
</tr>
<tr>
<td>22.00000</td>
<td>5145.979577</td>
<td>87829.905744</td>
<td>4714.096520</td>
<td>247.682849</td>
</tr>
<tr>
<td>23.00000</td>
<td>5130.355053</td>
<td>89452.529518</td>
<td>4786.615526</td>
<td>244.465997</td>
</tr>
<tr>
<td>24.00000</td>
<td>5116.785759</td>
<td>89982.306826</td>
<td>4804.691998</td>
<td>240.026398</td>
</tr>
<tr>
<td>25.00000</td>
<td>5107.131253</td>
<td>88563.281576</td>
<td>4875.423090</td>
<td>233.315135</td>
</tr>
<tr>
<td>26.00000</td>
<td>5105.981294</td>
<td>85055.132839</td>
<td>5077.232328</td>
<td>224.207252</td>
</tr>
<tr>
<td>27.00000</td>
<td>5117.598732</td>
<td>85427.832687</td>
<td>5419.652109</td>
<td>220.497606</td>
</tr>
<tr>
<td>28.00000</td>
<td>5112.478931</td>
<td>82997.784956</td>
<td>4974.244311</td>
<td>213.422549</td>
</tr>
<tr>
<td>29.00000</td>
<td>5095.929686</td>
<td>87976.025539</td>
<td>4632.550844</td>
<td>215.908250</td>
</tr>
<tr>
<td>30.00000</td>
<td>5109.697355</td>
<td>90628.830191</td>
<td>5508.959735</td>
<td>215.456017</td>
</tr>
</tbody>
</table>
APPENDIX C - PAIRWISE DIFFERENCES

<table>
<thead>
<tr>
<th>option 1</th>
<th>option 2</th>
<th>option 3</th>
<th>option 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.42</td>
<td>-49.68</td>
<td>-347.09</td>
<td>172.11</td>
</tr>
<tr>
<td>630.67</td>
<td>-717.08</td>
<td>-11.69</td>
<td>-150.25</td>
</tr>
<tr>
<td>-399.46</td>
<td>77.46</td>
<td>881.92</td>
<td>-52.31</td>
</tr>
<tr>
<td>-231.12</td>
<td>-72.87</td>
<td>613.13</td>
<td>-396.18</td>
</tr>
<tr>
<td>217.62</td>
<td>-138.62</td>
<td>234.65</td>
<td>-36.91</td>
</tr>
<tr>
<td>-423.56</td>
<td>238.06</td>
<td>-532.93</td>
<td>275.85</td>
</tr>
<tr>
<td>26.89</td>
<td>439.12</td>
<td>-854.45</td>
<td>129.81</td>
</tr>
<tr>
<td>255.08</td>
<td>-377.9</td>
<td>448.56</td>
<td>110.4</td>
</tr>
<tr>
<td>233.88</td>
<td>-633.52</td>
<td>153.05</td>
<td>-385.62</td>
</tr>
<tr>
<td>-62.91</td>
<td>-88</td>
<td>397.31</td>
<td>118.91</td>
</tr>
<tr>
<td>-142.77</td>
<td>-825.75</td>
<td>-164.18</td>
<td>245.83</td>
</tr>
<tr>
<td>208.38</td>
<td>406.35</td>
<td>703.37</td>
<td>292.64</td>
</tr>
<tr>
<td>388.4</td>
<td>132.49</td>
<td>-330.01</td>
<td>-783.55</td>
</tr>
<tr>
<td>84.99</td>
<td>422.64</td>
<td>-250.39</td>
<td>581.29</td>
</tr>
<tr>
<td>-1,056.11</td>
<td>333.18</td>
<td>-252.55</td>
<td>-746.4</td>
</tr>
<tr>
<td>-4.89</td>
<td>990.42</td>
<td>-101.12</td>
<td>143.95</td>
</tr>
<tr>
<td>-195.82</td>
<td>-72.7</td>
<td>636.29</td>
<td>-173.7</td>
</tr>
<tr>
<td>68.35</td>
<td>-363.78</td>
<td>-555.03</td>
<td>-545.56</td>
</tr>
</tbody>
</table>

57
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>290.66</td>
<td>-125.52</td>
<td>125.82</td>
<td>1,203.55</td>
</tr>
<tr>
<td>-778.12</td>
<td>412.5</td>
<td>-862.45</td>
<td>-107.99</td>
</tr>
<tr>
<td>-8.11</td>
<td>-548.12</td>
<td>-402.78</td>
<td>-407.15</td>
</tr>
<tr>
<td>-886.02</td>
<td>-181.66</td>
<td>-997.18</td>
<td>267.07</td>
</tr>
<tr>
<td>-392.47</td>
<td>-217.3</td>
<td>-292.27</td>
<td>783.71</td>
</tr>
<tr>
<td>282.02</td>
<td>88.94</td>
<td>-890.65</td>
<td>736.3</td>
</tr>
<tr>
<td>-6.96</td>
<td>-990.08</td>
<td>-576.28</td>
<td>171.93</td>
</tr>
<tr>
<td>627.45</td>
<td>-498.52</td>
<td>23.32</td>
<td>-296.32</td>
</tr>
<tr>
<td>-25.67</td>
<td>176.43</td>
<td>-3.19</td>
<td>-856.51</td>
</tr>
<tr>
<td>33.46</td>
<td>385.44</td>
<td>494.5</td>
<td>685.68</td>
</tr>
<tr>
<td>113.55</td>
<td>-728.06</td>
<td>-30.47</td>
<td>578.49</td>
</tr>
<tr>
<td>230.73</td>
<td>1,172.46</td>
<td>639.22</td>
<td>-318.34</td>
</tr>
</tbody>
</table>

Mean Difference: -30.048  -42.4223  -70.119  41.3577

Standard Deviation: 475.223  T  -0.5834
LIST OF REFERENCES


BIBLIOGRAPHY


INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center .................................. 2
   Cameron Station
   Alexandria, Virginia 22304-6145

2. Defense Logistics Studies Information Exchange ....................... 1
   U.S. Army Logistics Management Center
   Fort Lee, Virginia 23801

3. Library, Code 52 .................................................................. 2
   Naval Postgraduate School
   Monterey, California 93943-5002

4. William Kemple, Assistant Professor ................................. 2
   Code OR/KE
   Naval Postgraduate School
   Monterey, CA 93943

5. Michael Bailey, Associate Professor ................................. 2
   Code OR/BA
   Naval Postgraduate School
   Monterey, CA 93943

6. Director, Training and Education .......................................... 1
   Marine Corps Combat Development Center
   1019 Elliot Road
   Quantico, Virginia 22134-5027

7. Commandant of the Marine Corps ....................................... 2
   I & L Department, Code LPM-3
   HQMC
   3033 Wilson Blvd.
   Arlington, VA 22201-3803

8. Studies and Analysis Division (C45) ..................................... 1
   MCCDC
   3093 Upshur Ave
   Quantico, VA 22134-5130
101 Stoney Brook Court
Stafford, VA 22554