Discrete-Event Simulation of the Establishment of a Bare Beachhead for Long-Term Joint Logistics over the Shore (JLOTS) Operations

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Abstract: The United States military uses Joint Logistics Over-the-Shore (JLOTS) operations to move soldiers, vehicles, and equipment across the globe for military and humanitarian missions. These logistics operations can only be accomplished through cooperation between commanders in all services. The U.S. Army Engineer Research and Development Center is developing a tool to analyze a set of early entry alternatives to optimize mission effectives and efficiencies in order to facilitate assured mobility and freedom of movement. This program is currently being developed under the name Planning Logistics Analysis Network System (PLANS). PLANS comprehensively covers air, land, and sea transportation infrastructure, regions of avoidance, and more. This research addresses a gap in strategic and operational planning by modeling the establishment of JLOTS operations on bare beach environments. The West Point developed discrete event simulation will determine the amount of time it takes to prepare a beach to sustain JLOTS operations under varying environmental and operational conditions.

Keywords: JLOTS, bare beachhead, discrete-event simulation

1. Introduction

JLOTS is defined as the transportation of people and their resources from ship to shore for both military and humanitarian missions. JLOTS operations are critical links to the projection, deployment, and sustainment of United States military forces across the globe. The Army, Air Force, Coast Guard, and Navy all play an integral part in the successful execution of any JLOTS operation. These operations move everything required of the deployed force -- personnel, fuel, food, and vehicles. The military has the capability to use existing ports, improve degraded ports, or utilize bare beaches (Joint Pub 4-01.6, 1998). Operation OVERLORD, more commonly known as D-Day, is a historic and iconic example of a full-scale JLOTS operation. In this instance, all necessities of the operation and follow-on missions were landed on a bare beach. This landing site typically has no mechanical infrastructure beneficial to throughput operations. Due to its complex nature, the time, resources, and funding to conduct a full-scale JLOTS training exercise is rarely available. Simulating this type of operation can develop the capabilities and coordination between the branches without committing considerable resources.

The training exercises, doctrine, and history of logistical operations tends to focus on the operational aspect rather than the preparation (Thede, et al., 1995). This research will show that modeling JLOTS preparation in a bare beach scenario by incorporating doctrine, historical data, and information gleaned from interviews with current commanders will help develop an often overlooked component of a JLOTS operation, and simulating the preparation will help develop the capabilities and coordination between the branches without committing considerable resources.

2. Background

2.1 Project Scope

The United States Military Academy at West Point Department of Systems Engineering formed this capstone group project in conjunction with the U.S. Army's Engineer Research and Development Center's Information Technology Lab (ERDC ITL) to develop a model for JLOTS preparation. The simulation begins with all the ships successfully staged offshore. It continues through the process of setting up necessary infrastructure to allow throughput of materials. The simulation concludes when all the allotted equipment is positioned to accept throughput. The model analyzes the beach composition, weather data, and personnel available to determine if ships can operate. The beach data, weather data, equipment available can all be changed for different scenarios. The goal of the model is to determine, with given beach and weather data, the amount of time required to set up all the equipment. The primary source for model logic is Joint Pub 4-01.6 Joint Logistics Over-the-Shore Logistics. Additionally, interviews with subject matter experts provided current information regarding equipment availability and readiness. The simulation developed in this research specifically models the preparation required for a JLOTS operation. It does not analyze or optimize the throughput of JLOTS operations.

2.2 Application to Plans

ERDC ITL is developing the Planning Logistics Analysis Network System (PLANS) to analyze a set of early entry alternatives to optimize mission effectives and efficiencies in order to facilitate assured mobility and freedom of movement. PLANS focuses on three areas: land, air, and sea. The land portion determines possible routes for convoys, identifying choke points, average speed, convoy order, and more to help the commander analyze land movement. The air portion focuses on the ability to utilize air assets via available airfields or airports. Combined, these two sections can determine the value and utility of certain airports. If an airport is farther away but allows for higher throughput, the commander may decide to use that airport because there is a developed road network that mitigates the travel time. The sea portion analyzes movement time of ships and setup equipment, potential paths, and landing points. PLANS gives commanders a range of options, not just one "right" answer. The United States military needs the capability to move and deploy amphibiously because it allows for maximum throughput with limited existing infrastructure. In addition, it will examine the time to complete a full JLOTS operation (Bednar and Boler, 2016).

This simulation will nest within the sea portion of PLANS and will help the commander determine which port or specific landing points to use when establishing a beachhead based on the amount of assets available and their vessel and cargo configurations. Similar to the air and land portion, the sea portion will display the value of increased throughput versus the proximity to the final destination. Using a bare beach may put the supplies closer to the final destination, but it does not necessarily allow for as maximal and efficient throughput as an improved port. With the additional of the preparation model, PLANS will empower a JLOTS commander to make these critical decisions while allowing for alternative solutions to be generated at very minimal cost in time and resources to the organization.

2.3 Problem Statement

The goal of this research is to develop a model to simulate necessary preparations for a JLOTS operation. Several Army and Navy officers were contacted to assist in understanding the time required to prepare for a JLOTS operation. ERDC provided the team with valuable data on the proposed beach locations. With the information and understanding acquired during the problem definition phase, the redefined problem statement is as follows: construct a model that simulates and determines the time requirements for the establishment of a beachhead for long-term JLOTS operations in a bare beach scenario.

3. Methodology

Discrete event simulation uses events that occur at specific points in time to initiate state changes. It calculates the time required for specific events and the simulation as a whole. Scheduled or conditional events may occur. A scheduled event occurs at a prescribed time and is coded into the model logic. A conditional event occurs when certain parameters meet pre-determined levels. Both types are used in the simulation to replicate the realistic decisions made in the establishment of a bare beachhead.

In the model, ships move to the Ship Lighterage Control Point (SLCP) as a scheduled event at the start of the simulation. Throughout the simulation the SLCP serves as the staging point for the rest of the operation for model simplicity.

Boats and vessels leaving the SLCP is a conditional event based on the availability of Beach Lighterage Control Point (BLCP). A discrete event simulation can determine the average time requirements for JLOTS operations given varying beach data.

Structurally, a Microsoft Excel™ data sheet organizes the beach characteristic and equipment specification variables, set-up, and movement times. The simulation in ProModel references this document when initializing the simulation.

3.1 Model Assumptions

The first assumption states that security at the beach is established and is maintained throughout the setup. Interviews with active duty military members indicated that safety during a JLOTS operation is vital before any soldiers work on the beach (Scrivo, 2016). If security fails, the entire operation could be discontinued. The assumption that security remains constant does not affect the validation or verification of the model.

The second assumption is that ships and lighterage are staged 1-5 miles off shore, dependent on the ocean depth. If there are not enough soldiers to set up the causeway ferry, operate a ship, or no open Beach Lighterage Control Points (BLCPs), then set up times will be delayed.

Third, all ships and boats are fully staged offshore in the holding area before preparation begins. Delays in movement associated with ships moving across the ocean to the area of operations prior to the SLCP are not examined. This assumption does not negatively influence validation because this model is designed to test combinations of lighterage at various beaches and then record the time to prepare the beach.

The final assumption is that information and times gathered from current officers working in military logistic operations are the most current and accurate available; however they are contextually sensitive. In certain cases, the information received from officers conflicted with joint publications. The information from branch or joint publications is given priority over the data received from stakeholders because it has normalized many of the sensitivities inherent in a stakeholder's anecdotal evidence. This assumption does not affect the validation or verification of our model because we annotated any variations from doctrine and where stakeholder insight was used.

All variations and assumptions are annotated in the model and supporting documents to provide traceability and accountability.

3.2 Stakeholder Interviews and Data Collection

The model's logic relies heavily on data from previous exercises and doctrine of JLOTS Operations. This required contacting multiple subject matter experts who were directly involved in either the planning of previous or current JLOTS operations. Due to how specialized these operations are, past data collection was limited and not a priority at the time (Scrivo, 2016). All information necessary for completing the mission is localized to those units who conduct JLOTS operations. Officers and enlisted personnel assigned to these units were the subject matter experts. Ken Davis, a Senior ProModel Consultant and Project Manager, assisted the capstone team in organizing and building the JLOTS preparation model.

The model uses four beach locations: Anmyeon Beach, Korea, Coronado, California, Sand Beach, Maine, and Fort Story, Virginia. Collectively, the beaches represent a wide variety of potential landing locations.

3.3 Model Development

First, the model runs initialization logic which assigns values to each of the attributes; such as beach length, beach gradient, ocean sea state, etc. Depending on the scenario, the allotted number of ships then arrive at the SLCP. There is no specific arrival rate because ships and vessels arrive at the JLOTS site as they are manned and resourced in their home port. After the vessels arrive at the SLCP, they assess the ocean sea state. The sea state is a uniformly distributed random variable ranging from 1 to 6 on the Pierson-Moskowitz sea spectrum. The respective sea state ranges are limited on this spectrum by historic weather conditions at each of the studied beaches. Once the sea state is deemed operable, the boats and vessels move to the vessel queue, which is set up as a first in, first out sequence system with no prioritization. The vessels then move to the Beach Lighterage Control Point (BLCP) that is available. Each location has a status indicator which indicates whether the BLCP is in use or empty. The vessels occupy the BLCP for a specified time before they move out of the system.

4. Analysis and Results

4.1 Verification and Validation

Verification is the confirmation of the methodology and logical assumptions made in the model to ensure that the output generated by the input parameters are dimensionally and proportionally consistent. This process enables us to identify any logic errors in the model as well as behavior not previously accounted for. Validation refers to the level of the model's acceptability of its usefulness based on comparisons between simulated data generated by the model and actual data collected from previous exercises and operations. Structurally, the model will be assessed according to the criteria phases of "concept, design, implementation, integration, data, final product, and documentation" (Rabe, Spieckermann, and Wenzel 2009). CPT Michael Weidner, a current planner in the 7th Transportation Brigade out of Ft. Story, VA, will review the simulation and validate its structure. However, further validation should be conducted by other members from the joint community involved in the beginning phases of a JLOTS operation. Combing through and debugging the logic verifies that the simulation works as intended. Due to the lack of catalogued data on beach establishment and ship movement times, it was impossible to compare our simulated results to actions in reality.

4.2 Analysis of Results

The overarching purpose of this simulation is to track entities, time, and inherent variability in preparing for a JLOTS operation. We ran 50 replications of 52 unique scenarios. Further broken down, we analyzed four different beaches each with 13 scenarios. The scenarios varied in number and type of ships but always contained 5 BLCPs. Figure 1 shows the percentage of total time that each BLCP was occupied, broken down by beach location. On average, Korea and Maine had slightly longer BLCP occupation percentages, but not by a statistically significant amount. Both have a weak slope resulting in an overall lower gradient. When the slope is lower, it takes longer for boats and vessels to approach and land on the shore.

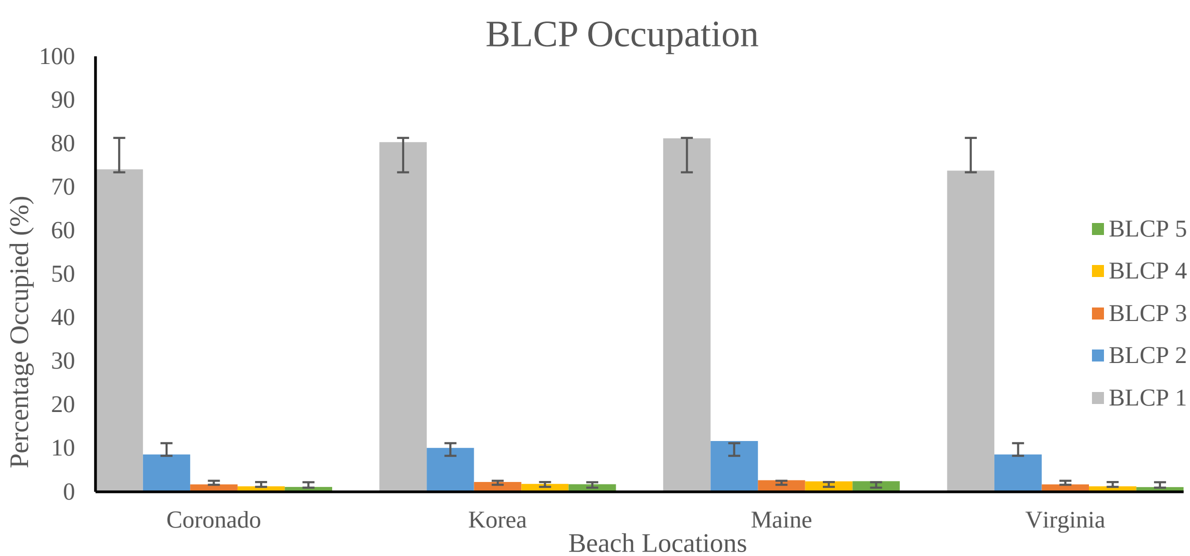

Figure 1. Percentage of BLCP Occupation across Beach Locations.

Figure 2 highlights that the boats and vessels in the Coronado and Virginia scenarios have a higher average time in the system. Coronado and Virginia have sandy beaches, good landings, and are often used for training exercises and were expected to produce lower than average time in the system. However, Coronado and Virginia have a higher likelihood that the sea state will be inoperable (> 3). When the sea state is greater than three, the vessels are unable to function safely, and they wait and reassess the conditions. The overall longer time in system is predominately caused by vessels waiting at the SLCP or Vessel Queue rather than the time spent at the BLCPs.

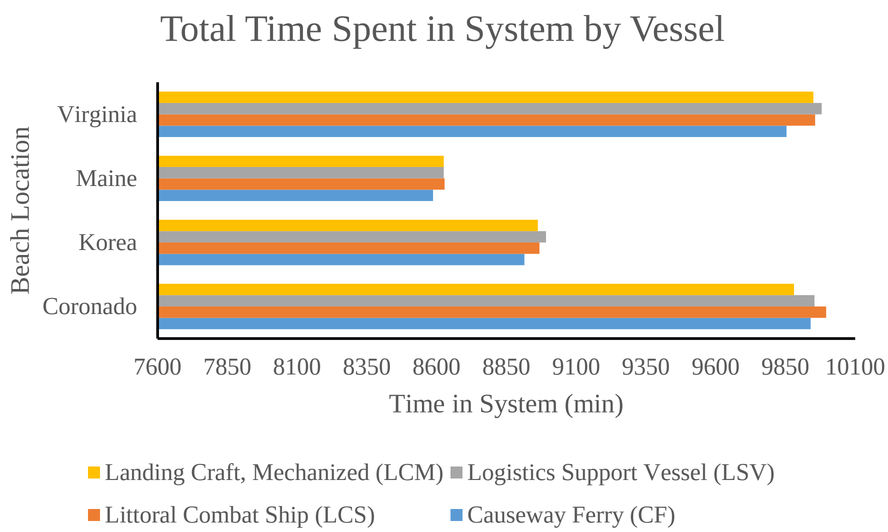

Figure 2. Average Time Spent in System by Vessel and Beach Location.

Stakeholders made it clear that the deciding factor in most JLOTS operation is the environment (Paquette, 2016). The variability in the ocean and beach selection was an important source of complexity in the simulation. The ocean sea state, gradient of the beach, and other factors hinder a fluid JLOTS preparation of a bare beach. Figure 3 demonstrates that, within the scenarios and replications performed on one beach location, there are noticeable variations the time required for set up. JLOTS commanders and planners should consider environmental factors when planning for and resourcing an operation.

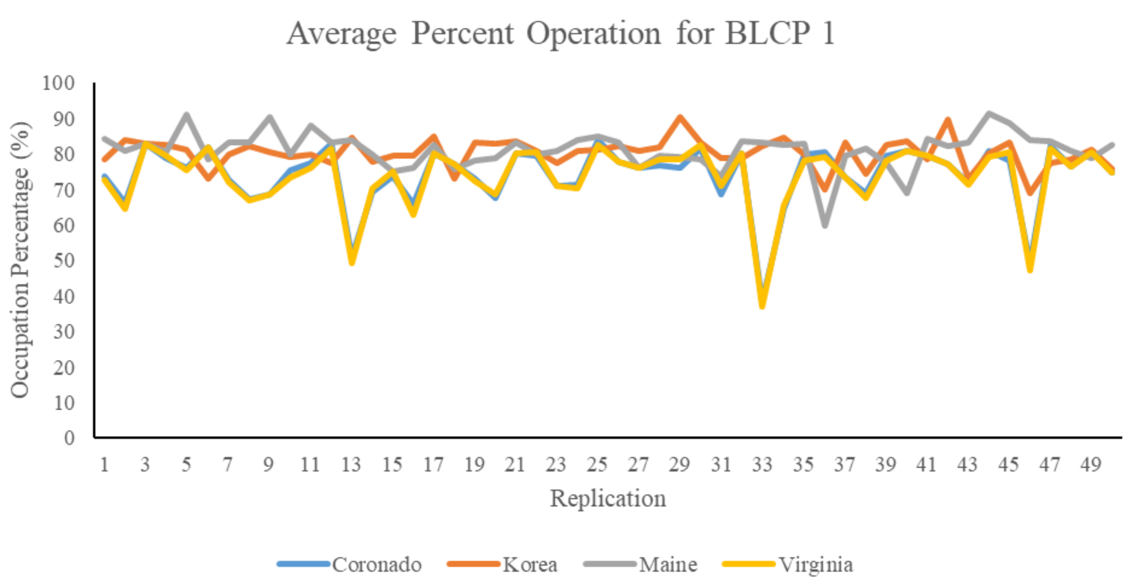

Figure 3. Variability in Percent Operational for BLCP 1 in the Coronado Scenario.

5. Conclusion

JLOTS operations are an important capability for our military in combat and humanitarian missions. PLANS will enable commanders to coordinate operations and assess different scenarios. Aside from its obvious logistical value, these operations prove that the United States and its allies can project force anytime, to anyone, and anywhere. Any model requires past data to simulate future results. Even though JLOTS exercises are conducted every year, the method and times associated with conducting the operation are mainly institutional knowledge rather than codified into official doctrine. This decreases the availability of accurate information and contributes to the difficulty in modeling all aspects of a JLOTS operation.

A simulation can quickly and cheaply assess various scenarios that may take weeks and millions of dollars to achieve the same results in real life. This model seeks to simulate the establishment of a bare beach, arguably the most difficult scenario for this type of operation. The results prove that although there is not a significant difference in the set-up times between four distinct beaches, the environmental conditions caused considerable variability between replications. Therefore, the environment should be the main focus of JLOTS commanders when assessing when and where to conduct an operation.

Future work on this topic could focus on incorporating more environmental complexity into the simulation. The weather, beach, and land data is available, but its effect on each vessel's operation is not. More research into times for every aspect of the operation would strengthen the model and make it more realistic.

6. Acknowledgement

This paper was previously published and presented in the Donald R. Keith Memorial Capstone Conference at USMA in May of 2017.

7. References

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