Site Selection for Joint Logistics over the Shore (JLOTS) Operations Using Multi-Objective Decision Analysis

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Abstract: As the U.S. military faces an increasing need to deploy across a range of military operations and environments, the ability to establish and sustain logistics support remains a major challenge. The Engineer Research and Development Center is currently developing the Planning Logistics Analysis Network System (PLANS), a decision support tool, to facilitate strategic and operational logistics planning. This paper describes a site selection protocol for logistics operations occurring without a suitable port, commonly referred to as Logistics over-the Shore (LOTS) operations. The model uses multi- objective decision analysis techniques to weight different operational criteria to determine the best overall site for logistics over the shore operations. This tool will enhance the time and accuracy in determining an optimal site that meets the decision maker's specific operational needs.

Keywords: Decision Analysis, JLOTS, Logistics, Decision-Focused Transformation

1. Introduction

The Army currently lacks a ubiquitous system to assist logistics planners in developing a complete sustainment concept from a point of origin to an operational location. Engineer Research and Development Center (ERDC) is creating Planning Logistics Analysis Network System (PLANS) to facilitate strategic and operational planning for the Army Logistics community (Bednar, 2015). PLANS will analyze a set of early-entry alternatives to optimize effectiveness in adapting to environmental conditions in support of JLOTS operations in austere entry environments. Figure 1 outlines JLOTS operations showing the potential complexity and variations of these operations.

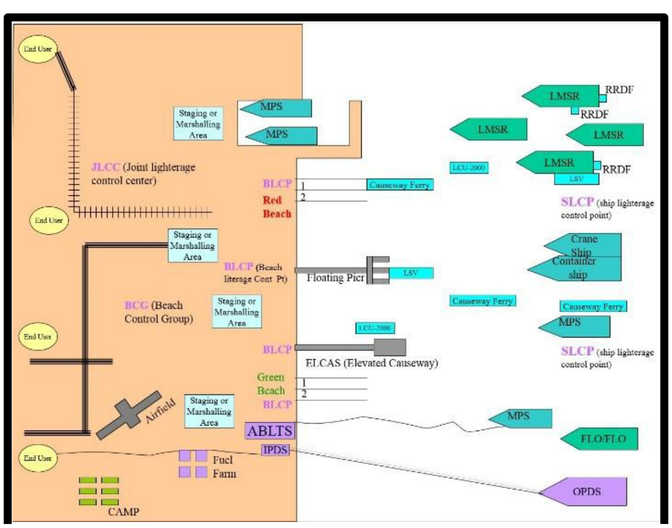


Figure 1. JLOTS Operation Visual Image

As a subset of PLANS, the JLOTS model analyzes the over-the-shore logistics operation from the Intermediate Staging Base (ISB) to the Central Receiving Shipping Point (CRSP). The ISB, located off the coast, is where vessels stage as they prepare for beach infiltration. The CRSP, located on the shore, is where supplies are organized and distributed in support of follow-on operations. The development of a decision support model will allow sustainment planners to conceptualize a JLOTS operation and optimize limited resources during the development of a deployment plan.

2. Background

From the invasion of Normandy to humanitarian operations in Haiti, U.S. forces have used JLOTS as a transportation technique to move personnel and equipment to locations without suitable ports. Specifically, the role of JLOTS is to conduct operations that facilitate the loading and unloading of ships through inadequate or damaged ports, or over a bare beach. JLOTS operations can last between 60 – 90 days and involve the integrations of many organizations. The main responsibility of JLOTS operations is to be an asset for commanders to support and sustain their forces in any environment (CJCS, 2013).

JLOTS requires extensive planning and precision execution in a timely and efficient manner. A successful JLOTS operation entails a comprehensive analysis of landing sites, operational considerations, and asset availability. Several operational considerations are communication plans, ship discharge plans, ship to shore movement plans, lighterage repair, weather, retrograde operations, and force protection. The success of JLOTS operations relies on the throughput of transporting cargo from ship to shore. Throughput is dependent on beach size, type of lighterage, transit system and marshalling yard capacity. Lighterage are vessels that transport cargo from deep-sea ships to the shore. JLOTS operations involve many types of transit systems to include the causeway ferry, floating causeways, and roll-on, roll off vessels (CJCS, 2013).

Logisticians must understand the specific mission requirements and operational considerations in order to determine an optimal site for a JLOTS operation. Site selection criteria must include both land and sea considerations. The current site selection process uses a qualitative checklist available on the Joint Publication on JLOTS planning (CJCS, 2013). This process involves a thorough map and imagery analysis, site reconnaissance, and risk mitigation by the planning team.

3. Methodology

Multi-Objective Decision Analysis (MODA) is the foundation of the decision model. This type of model translates qualitative input of experts into a numeric scoring system used to show utility for each specific site landing (Parnell, 2013). After conducting research and extracting expert opinion from stakeholders, a qualitative value model translates the information gathered from stakeholders into a usable diagram that identifies the functions, objectives and value measures of site selection (Parnell, 2008). Objectives represent a statement of preference, usually in the form of maximize, minimize or optimize. Value measures identify the scale to assess how well the objective is achieved (Parnell, 2008). There are two types of value measures: discrete and continuous.

The objectives and value measures assist in developing a swing weight matrix and value functions. The swing weight matrix assesses the level of importance to the operation against the variation in the measure ranges of the value functions. The relative importance represents the impact the stakeholder believes it will have on the decision. The variation of the measure ranges represents the impact that the measure would have on the decision if it varied across its entire range (Parnell, 2008). Value measures in the swing weight matrix with the highest importance and variation receive the largest swing weights, while low importance and variation receive the lowest swing weights. Swing weights vary between one and one-hundred. After the assignment of the swing weights, the individual measure weight is obtained by dividing the value measure swing weight by the sum of all the swing weights of the value measures (Parnell, 2008). Value measures can be a direct or proxy measure, or a natural or constructed scale. Direct and natural value measures are preferred over proxy and constructed when available.

Value functions return a unit-less value score based on the desirability of the raw data. The value functions identify threshold values that serve as feasibility screening criteria for alternatives. The objective of the value measures, as identified by the qualitative value model, determines the shape of the graph (Belton, 2002).

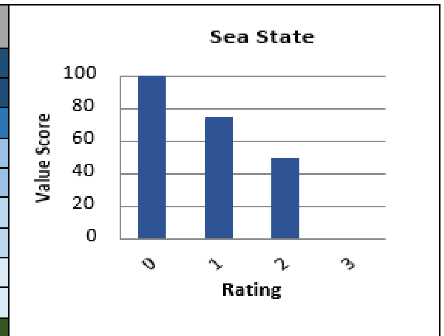
The overall model is additive and uses the measure weights and raw data from each site to arrive at a value score. In the model, $VVV_{V}V$ represents the value of the *j*th alternative, V_{V} represents n scores for the *j*th alternative, V_{V} represents the measure weight for the *i*th value measure, and $VVV_{VV}V$ represents the value of the *j*th alternative on the *i*th value measure (Parnell, 2008).

Decision-focused transformation (DFT) provides further analysis to the decision-maker. Decision focused transformation rescales the value attained from each site in the model by eliminating all unattainable and common value between the sites. Additionally, it rescales the swing weights based on the earned value for each site and redistributes the weights amongst the value measures. The output of the transformation shows where each site derives most of its value, which allows the decision maker to choose the site that offers the most value in a particular area (Dees, 2010). DFT will automatically account for a lack of data at a particular site. If data is not available for a specific measure, then the value is unattainable and redistributed to other measures.

4. Analysis

The critical first step in developing the model was engaging stakeholders and experts about site selection. We engaged stakeholders through surveys and interviews to gain knowledge on the factors and complexities of JLOTS operations. The stakeholders include the Center for Army Analysis (CAA), 7th Transportation Brigade (Expeditionary), Beach Naval Group- Pacific, TRANSCOM, and U.S Expeditionary Warfare Training Group Pacific. We gathered information on the relative importance of value measures, which is crucial to assigning swing weights and creating the value functions. Our iterative engagement with these stakeholders led to the development of nineteen value measures and corresponding functions and three feasibility screening criteria that are crucial to the viability and accuracy of our model (Figure 2). Differentiating between land and water factors prevents diluting the importance of each factor. The additive model generates a score for land and water factors that sums both for an overall site score. The breakdown of water and land considerations allows the weighting of the considerations separately and more clearly demonstrates the tradeoffs for each. This allows the decision maker to conduct his own analysis on which of the two considerations are most important in his decision (Kirkwood, 1997). The graphs to the right of Figure 2 are two of our value functions for the model. Each value measure has a function that returns a score based on raw data input.

	Importance	Variation	Swing Weight	Value Measure	Units
Water C[illegible]ations	Very High	Very High	90	Distance to Beach from ISB	kilometers
		High	85	Sea State	rating
	High	Medium	70	Distance to Safe Haven	kilometers
	Medium	High	60	Ocean Floor Rating	rating
		Low	40	Wind Speed - Water	knots
	Low	Low	20	Cross Current	knots
		Very Low	10	Precipitation - Water	avg. in per month
	Very Low	High	30	Tidal Range	feet
		Medium	20	Visibility - Water	miles
LandCo[illegible]	Very High	High	90	Distance to Road From Beach	kilometers
		Medium	80	Beach Length	kilometers
		Medium	70	Beach Depth	kilometers
	High	Very High	90	Number of Supply Routes	number
		Low	65	Area for Marshalling Yards	sq. km
	Medium	Low	55	Trafficability Rating	rating
	Low	Medium	40	Population Size	people
		Very Low	15	Slope of Beach	slope
	Very Low	Medium	25	Wind Speed	knots
		Low	10	Precipitation -Land	avg. in per month
			Feasibility Screening Criteria		
			Water Depth - Ships	Water Depth - Lighterage	Beach Capacity



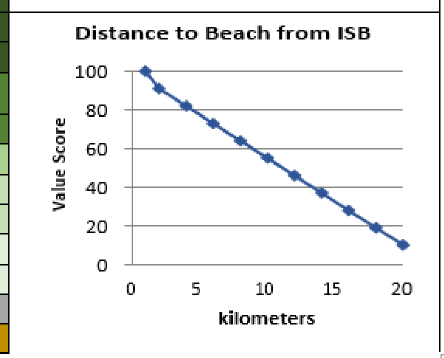


Figure 2. Complete List of Nineteen Value Measures and Three Screening Criteria

The outputs of the model are a land score, a water score and a total score. For further analysis, the model produces a Land vs. Water Value Chart (Figure 3), a Comparison of Value Breakdown and a DFT Analysis (Figure 4). The tradeoffs between the water and land scores of each site (Figure 3) show what the user will see by selecting a control on the Graphic User Interface. This is useful because it allows the decision maker to compare all the sites simultaneously. The visual representation of the sites makes it easier to comprehend the value and analyze land versus water scores. This chart also displays deterministic dominance when one site has both a higher land and water score than the other alternatives. Sites below the efficient frontier are deterministically dominated and can be eliminated from consideration (Keeney, 1993).

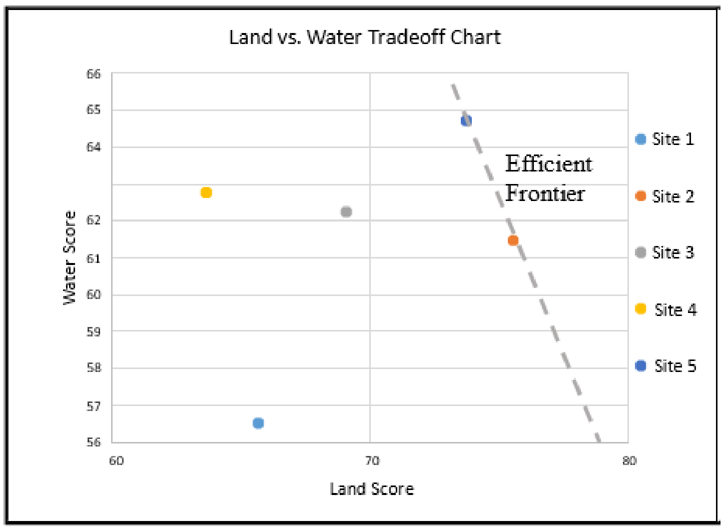


Figure 3. Example of a Land vs. Water Value Chart

The second graph is a comparison of the value breakdown for each site. This allows the user to observe which value measures contribute the most value to the site (Figure 4). The third graph displays the individual breakdown of each total value score according to the value from each measure after DFT (Figure 4). This allows the decision maker to perform his own tradeoff analysis by comparing the specific value breakdown of the sites to gain insights into which sites have superior scores for each of the measures (Kirkwood, 1997). The DFT provides valuable insight by showing the additional value gained for each value measure in choosing one site over another.

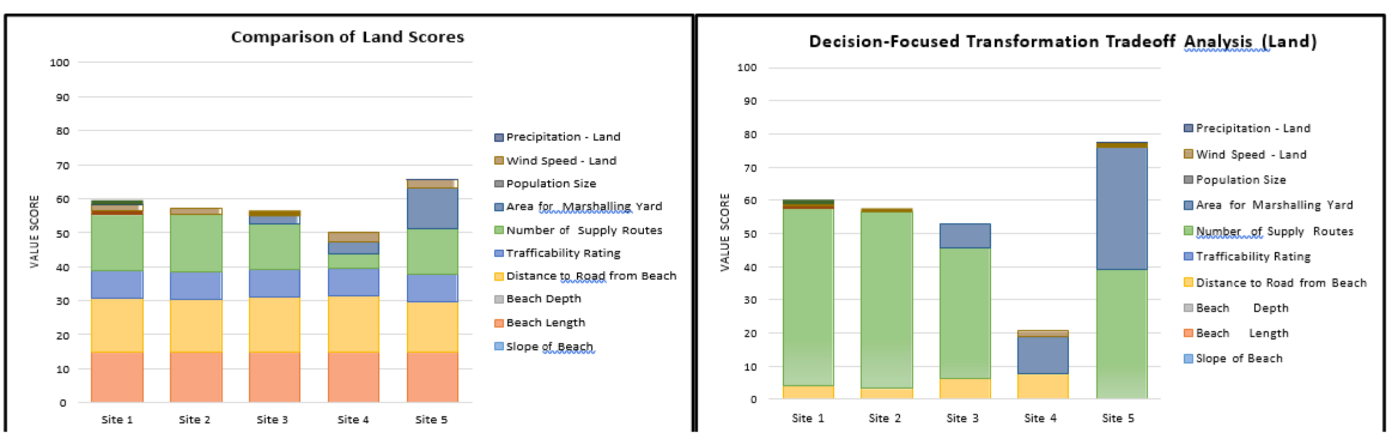


Figure 4. Example of a Regular Stacked Value Graph vs. DFT Analysis

5. Results, Discussion, and Future Plans

In order to validate the model, the team conducted a case study with two different scenarios. The first is an operational scenario, landing on the Mid-Atlantic coast of the United States. This scenario intends to model landing on foreign soil for sustainment support of combat operations. The second is a humanitarian effort that would land in Florida in case of flooding due to a natural disaster such as a hurricane. Each scenario models five sites in both the winter and summer. All sites are in the Unites States due to availability of data. Modeling at different times of year takes into account the changes in weather that occur in different seasons. The reason for two different scenarios is the type of cargo transported in different missions. In a humanitarian effort, combat vehicles and ammunition are not required. We acquired data for the case studies from multiple sources including geospatial imagery, the National Oceanic and Atmospheric Administration (NOAA), and several other historical weather data sources.

Figure 5. Scenario 2 Site Locations

According to Figure 6, Miami receives the best water score of 82.17 and the best overall score of 139.55. However, the best site in terms of land objectives is Naples. On the comparative value chart, Pompano Beach, Jupiter and Cape Coral are below the efficient frontier and can be removed from consideration because they are dominated (Figure 6).

	Miami	Pompano Beach	Jupiter	Cape Coral	Naples
Water Score	82.17	67.67	65.90	57.84	50.25
Land Score	57.39	57.20	56.39	50.16	65.65
Total Score	139.55	124.87	122.29	108.00	115.90

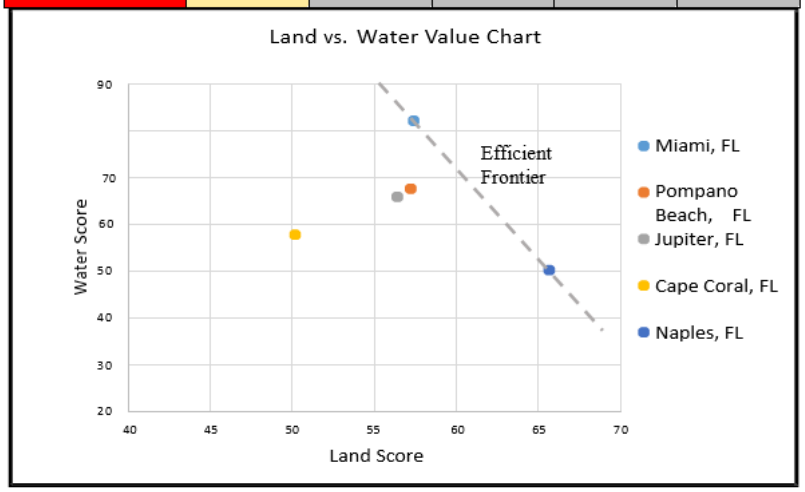


Figure 6. Scenario 2 Land vs. Water Chart

The tradeoff analysis for water considerations displays that the distance to the safe haven and distance to beach from ISB value measures yield significant value over the other alternatives. Figure 7 shows the reason why Miami is better than Naples for water considerations. Miami possesses more value from distance to safe haven and distance to beach from ISB. This type of analysis gives the decision-maker the tools necessary to make an educated decision while weighing the positives and negatives of the best available sites. Additionally, by eliminating all common and unattainable values, Naples is the worst site for water considerations.

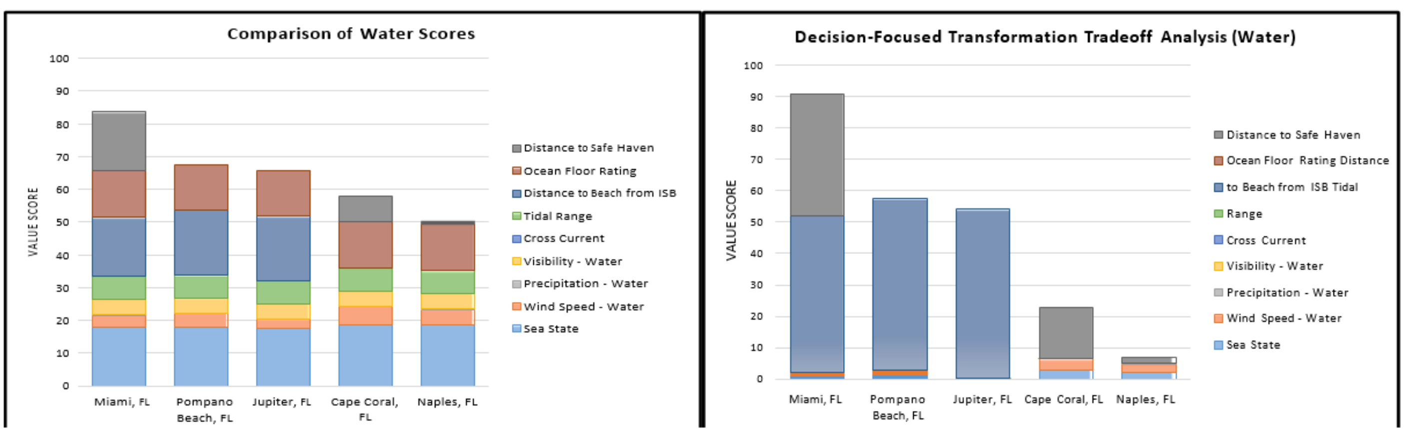


Figure 7. Water Score Comparison and Breakdown and DFT Analysis

To verify the model, our team conducted sensitivity analysis on all of the value measures for each scenario of the case study. Area for Marshalling Yards is the only value measure that is sensitive. The value measure is sensitive between the values of 45 and 80. Between these two values, site 1 has a greater value. Otherwise, site 5 is the best site for this value measure. The sensitivity analysis of the value measures supports the model. Due to only one of the swing weights being sensitive, the model does not over-rate or under-rate a specific measure.

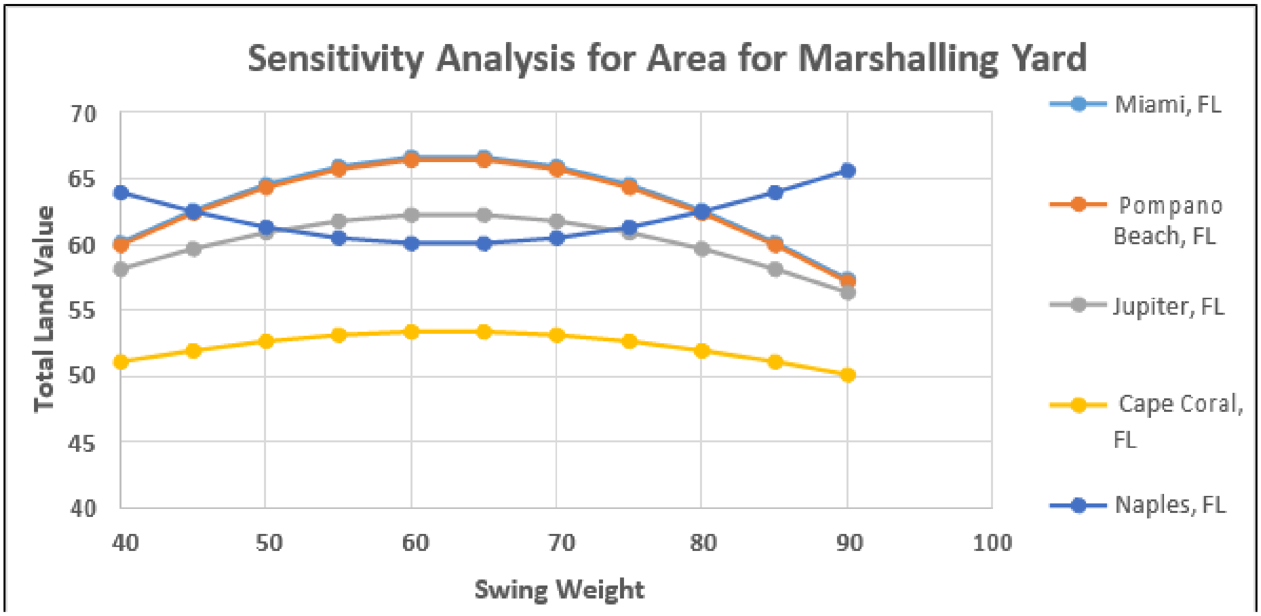


Figure 8. Sensitivity Analysis of Area for Marshalling Yard Value Measure

The model proves the MODA methodology is applicable to JLOTS site selection. Future work would include applying to worldwide sites and expanding to use equipment not in APS. We can also expand our model to differentiate between combat and non-combat operations by accounting for different factors that are organic to each. Some of these considerations are additional space and transportation for combat vehicles, ammunition, and greater fuel requirements. Accounting for port operations would be valuable to decision makers if that opportunity is available to them. Choosing a port site, damaged or otherwise, would be useful to compare the capability, it has on a LOTS operation.

6. Conclusion

The MODA methodology with decision-focused transformation is an appropriate technique to apply to site selection for JLOTS operations. The model provides a normative framework with decision support tools to assist the operational planner in selecting the optimal JLOTS site. Although there is still work to do on this project, it will be possible to integrate our site selection model into PLANS in development by the Engineer Research and Development Center. The initial groundwork, stakeholder analysis, and analytical decision platform is completed. Synthesizing our model with a data collection platform will increase the usability of the tool. Simplifying the process of collecting data would increase the ease of use and ultimately the utility of the model by making it applicable worldwide.

7. Acknowledgement

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