2010-09

Team 8: Investigation of the Impact of Ship Loading Strategies on USMC MPF Arrival and Assembly

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INTRODUCTION

The U.S. Marine Corps' Maritime Prepositioning Force (MPF) enables the rapid deployment of Marine forces to permissive areas of operations. The MPF consists of more then a dozen ships divided between three squadrons. Each squadron supports a notional Marine Expeditionary Brigade (MEB) and is based in one of three locations: the Pacific Ocean, the Indian Ocean, or the Mediterranean.

MPF Operation

During an MPF operation, a Maritime Prepositioning Ship Squadron (MPSRON) or some portion or combination thereof, is deployed to a permissive area of operations where its equipment and supplies are offloaded. A fly-in echelon (FIE) compromising the bulk of personnel and additional equipment is flown into a nearby airport. The equipment and personnel are then integrated to form a functioning Marine Air Ground Task Force (MAGTF). This process is called Arrival and Assembly.

Motivation

The MPF concept of operations has historically been focused on the employment of a MEB. The equipment that a MEB requires (its table of equipment (TE)) exceeds the equipment that a MPSRON can provide. Therefore, a MPSRON's entire set of equipment is allocated to a MEB with the remainder of the MEB's TE being designated for the FIE. This operation employment concept results in ships being densely packed to maximize the amount of equipment that can be prepositioned, reducing the FIE.

Embark constraints to some degree determine how the prepositioning objective (portion of the MEB TE that is prepositioned on a MPSRON) is distributed across the ships in a MPSRON and where within a ship the items are placed. For example, tanks are spread across the ships due to weight and some items are placed in specific holds or decks due to height restrictions. With one exception, equipment is generally loaded by these constraints with little regard for operational employment since the entire set of equipment is needed to support the MEB and equipment is only designated down to the MAGTF element level (Command Element (CE), Ground Combat Element (GCE), Air Combat Element (ACE), and Logistics Combat Element (LCE)).

A subset of each MPSRON's equipment is designated for the Marine Expeditionary Unit (MEU). The "MEU slice" is loaded on two ships and in locations that enable the equipment to be offloaded with out having to offload much non-MEU equipment.

The MPF concept of employment may head towards supporting less than MEB sized units or capability sets (LTMUs). Currently, the equipment to support a LTMU may be spread across multiple ships within a squadron and may be embarked in inaccessible locations.

Workshop Goals

The goal of this work at IDFW 21 is to use data farming techniques and the MPF Arrival and Assembly model to explore the trade off between the size of an LTMU equipment set, the access of equipment on the MPSRON and the number of ships that the equipment is drawn from. Access is a combination of two factors; how much equipment that is not required must be offloaded to allow the offload of the required equipment and the relative ordering of the required and not required equipment.

ARRIVAL AND ASSEMBLY MODEL

The MPF Arrival and Assembly Model is a discrete event simulation implemented in ExtendSim7. The model has two main processes: the offload of equipment from a ship to a pier and the throughput of equipment from the pier to its using unit located some distance from the pier.

Offload

The offload process models the interaction between ships and docks, where a dock is required to conduct an offload. Multiple docks allow for the simultaneous offload of ships. There are two methods for offloading equipment from a ship:

1. Roll On Roll Off (RORO) is used for vehicles that can be driven off the ship via its stern ramp. RORO requires both a ramp (ship asset) and offload drivers.
2. Lift On Lift Off (LOLO) is used for offloading containers (and possible vehicles) by lifting them with either a ship crane (ship asset) or a gantry crane (dock asset).

Equipment is offloaded in a random order.

Throughput

The throughput process models the physical movement of equipment from the pier to the using unit and any maintenance or setup actions that must be completed to make equipment operational. The equipment is classified into four types; ammo containers (AMMO), non-ammo containers (ISO), vehicles that require a heavy equipment transporter (HET), and vehicles that can move themselves (RS).

Scenario

In this scenario, the throughput parameters are fixed. The quantity of equipment (both required and not required), the offload ordering, the number of ships, and the number of docks are explored using a full factorial design.

Metrics

Figure 1 is a screen shot of the model outputs. The blue, green and red lines represent the counts of equipment over time at the pier, at the final destination, and in the throughput process respectively. We use days to complete throughput of the required equipment as our primary metric.

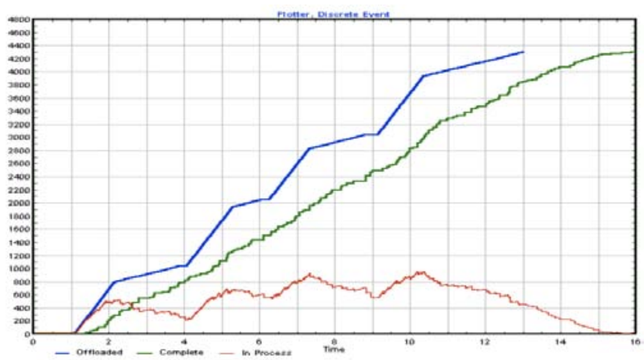

Figure 1. Simulation Output. The blue line identifies the count of equipment as it is offloaded at the pier. The green line is the count of equipment as it arrives at the final destination. The red line is the count of equipment in the throughput process.

DESIGN OF EXPERIMENTS

The equipment on the MPSRON is partitioned into three sets: offloaded required, offloaded not required, and not offloaded. The total amount of equipment is always fixed at 5000. The quantity of offloaded required equipment is a factor and varies from 100 to 2500 in increments of 200. The quantity of offloaded not required is a proportion of the not required equipment. The proportion is a factor and varies from 0.0 to 1.0 in increments of 0.1.

The number of ships varies from 1 to 4. The amount of required and not required equipment is equally distributed across the number of ships and the four equipment types in the scenario.

The number of docks in the scenario is either 1 or 4 representing the extremes of one ship offloaded at a time and all ships offloaded at the same time.

The offload ordering is determined by assigning each piece of offloaded equipment a random number between 0 and 1. The distribution that this number is drawn from varies for the required and not required equipment as depicted in Figure 2.

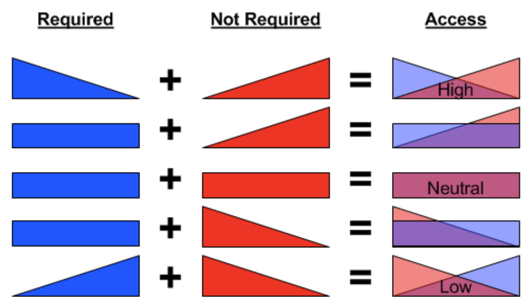

Figure 2. Offload ordering distributions. Each equipment item is assigned an ordering priority drawn from a random variable. The distributions used determine the relative access of the required equipment.

RESULTS

For each level of required equipment, a linear model with the time to throughput all required equipment to its destination versus the number of docks, the number of ships, the amount of equipment not required and the access ordering of the equipment and all two way interactions as factors, was fit and the significance of each factor calculated. The results are in Table 1. A plot of the effects of the most significant factors is shown in Figure 3.

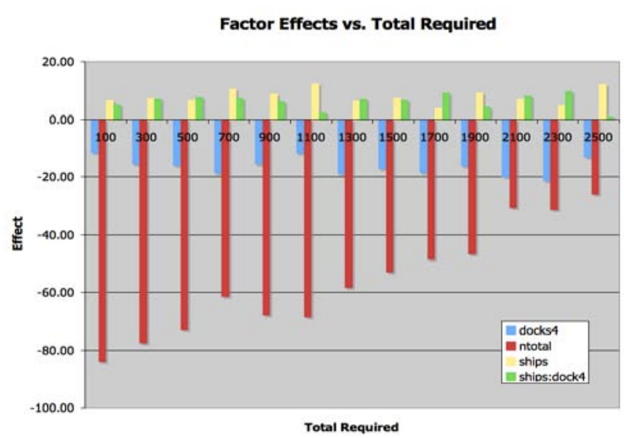

Figure 3. Factor effects. The amount of equipment not required has the largest effect on the response. However, its magnitude is decreasing as the size of the required equipment increases. The other factors have a relatively constant effect on the response.

The total amount of not required equipment that must be offloaded plays a significant role across all of the levels of required items. The number of docks and ships are significant in some levels of required items. The relative ordering of equipment does not play a significant role in all but one level of required items.

The effects plot shows that the not required equipment has the largest effect. However, its effect decreases as the amount of required equipment increases. The other factors have a relatively constant effect on the response.

Figure 4 is a plot of the design points where the average day to complete the throughput all of the required equipment was day five. The plot is faceted by the total required equipment versus the total not required equipment with number of ships on the x-axis and access ordering on the y-axis. The number of docks is indicated by the color of the points. This plot reveals that having multiple docks enables the offload of much more equipment in a particular time frame. It also reveals that there is little correlation between the number of ships and the access order.

Inspection of these plots across the set of days required to complete the throughput of required equipment (2 days to 23 days) shows that the time required is highly dependent upon the size of the equipment sets.

The access of LTMU sized equipment sets will be an important consideration in the load planning of the MPF ships in the future. The ships have limited high access locations and there are many different LTMUs that could be sourced from a MPSRON (e.g., Humanitarian Assistance, Disaster Relief, Security Cooperation MAGTF, fuel, water or life support equipment sets).

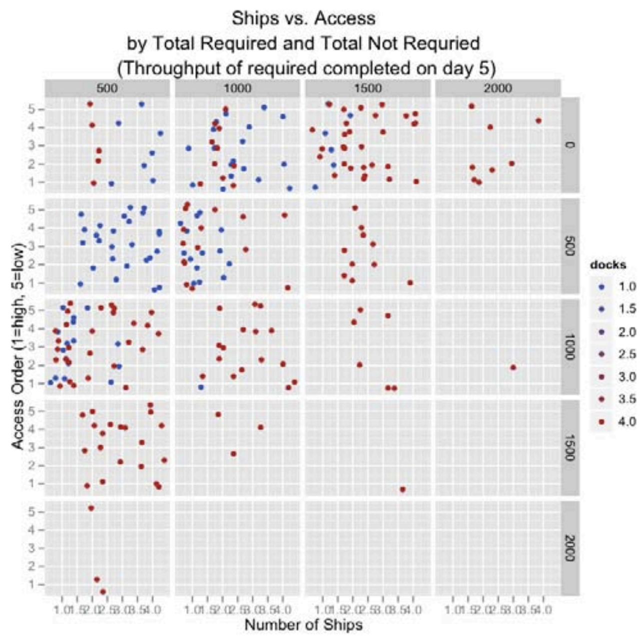

Figure 4. Plot of the design points where the mean days to complete throughput of the required equipment was on day five. The plot is faceted by the total required and not required equipment with the number of ships on the x-axis and the access ordering on the y-access. The number of docks is indicated by the color of the points.

The next step will be to explore specific scenario offloads. This will require the specification of the required equipment set and an offload plan derived from the actual load plans to

include the deterministic offload order vice a random order and the not required equipment set to be offloaded.

SUMMARY AND WAY AHEAD

The access of equipment plays a significant role when offloading a LTMU equipment set during an MPF supported operation. The access of the equipment has two components, the size of the equipment set that is not required but must be offloaded and the relative ordering of the not required and required sets. We found that the size of the not required equipment set is the most significant factor and that it has the most effect on the time to throughput the required equipment. However, this effect decreases as the size of the required set of equipment increases. The two are related because the total amount of equipment on a MPSRON is finite and fixed.

The relative ordering of the equipment sets is not significant and has a relatively small effect on the time to throughput the required equipment. However, the true effect may be masked by the choice of metric. The time to throughput all of the required equipment to its final destination is tied to the last piece of equipment. The shape of the accumulation curve at the final destination (green line in Figure 1) is not considered. The majority of equipment could arrive relatively quickly while a few items are delayed at the end thus skewing the final time to complete the throughput. The impact of this choice of metric must be further explored.