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Cost and Operational Evaluations of Centralized vs. Distributed Class IX Inventories

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MONTEREY, CALIFORNIA

COST AND OPERATIONAL EVALUATIONS OF CENTRALIZED VS. DISTRIBUTED CLASS IX INVENTORIES

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Abstract

The United States Marine Corps (USMC) seeks to improve its logistics operations for repair parts at the Division (Marine Expeditionary Force - MEF) level. USMC Installation & Logistics has partnered with the Defense Logistics Agency (DLA) to investigate whether increased collaboration with DLA could make the USMC supply depots more efficient and effective. Efficiency is measured by reduced inventory at the Divisional Supply Management Units (SMU) and effectiveness is measured by reduced customer wait time. The goal is to find the best efficiency-effectiveness balance. The dilemma is between distributed inventory at the SMUs and concentrated inventory at the DLA. Based on demand data collected at I MEF over a period of 20 months, we developed a simulation mimicking the requisition-supply cycle. The simulation, implemented on 6 repair parts, facilitates an analysis of the distribution-concentration balance regarding these items. The analysis produces plots visualizing efficiency-effectiveness tradeoffs, which can help decision-makers choose the right distribution-concentration balance. We comment about the results and offer some recommendations. For the analyzed repair parts, we show that the I MEF SMU can reduce the inventory levels of several parts, and relying on DLA support, while maintaining adequate customer wait time.

Keywords: *logistics, inventory, customer wait time, centralized vs. distributed*

I. INTRODUCTION

The United States Marine Corps (USMC) seeks to improve its logistics operations for repair parts. While current USMC inventory policies have proven quite adequate for supporting the warfighter, USMC Installation & Logistics partnered with the Defense Logistics Agency (DLA) to investigate whether increased collaboration with DLA could make the USMC supply depots more effective and efficient. If successful, the improvements to the USMC logistics system would result in reduced inventory costs and decreased customer wait time for parts. This report summarizes a study aimed at investigating the impact of such SMU-DLA collaboration.

A. PROBLEM STATEMENT

The USMC faces the critical issue of how to set their inventory policies to meet the Class IX repair-parts demands facing the USMC Supply Management Units (SMUs). Supporting the various requirements from Marine Expeditionary Force (MEF) customers, the SMUs play a key role in supporting the Marine Corps warfighter. Knowing when to reorder inventory, by having an accurate reorder point (RO), and how much to order, by setting a proper reorder up-to point (ROP), can make the difference between a shortage of an item, with all its operational ramifications, and a surplus of an item, which wastes funds and storage capacity. Historically, SMU forecasting miscalculations have periodically caused repair-parts to be ordered at the incorrect time and/or in the incorrect amount. These inaccuracies have led to various problems to include increased inventory costs and shortages for critically required parts. Moreover, customer wait times, the time from when the part is first ordered to final receipt to the customer, were adversely affected by incorrect parts forecasting. Having the correct inventory policy has been so important that the USMC and the Defense Logistics Agency (DLA) embarked on a series of trials to determine if increased USMC-DLA logistics integration can provide a solution.

Operating under an efficient inventory policy is important for the USMC. Shortages of critical parts when they are needed could mean the difference between mission success and mission failure. By setting an efficient inventory policy, decreased inventory costs and customer wait times would positively affect mission performance and cost. The status quo, however, could force the USMC and, more importantly, the warfighter to operate with an inefficient system. To provide insights on this problem and to make an attempt to remedy it, this project develops a modeling and simulation tool to analyze the USMC logistics system from the SMU perspective and its interaction with the regional DLA supply depots.

The project examines the advantages and disadvantages of possible modifications of the current system such as enhanced centralization at DLA or greater collaboration between the SMUs and DLA. By using SIMIO, a discrete-event simulation program, orders from I MEF and Second

MEF (II MEF) units will be simulated based on data provided by the I MEF SMU. Over a one-year simulated period, various experiments will determine the effects that changes in inventory posture will have on both customer wait time and on inventory costs. This project uses inventory cost as a proxy figure to show how much of a SMU's funds are held as inventory. Given similar customer wait times (CWT) between several inventory policies, lower inventory costs could signify that a given inventory policy might be more efficient than others with the same CWT. By using different levels of stocking and reordering points at the SMUs, this project examines if there are more efficient inventory policies that might improve the SMUs' performance.

In addition to developing a tailored simulation for the resupply cycle, the research examines the advantages and disadvantages of possible modifications of the current system such as enhanced decentralization or greater collaboration with DLA, which leads to centralization. The research also examines inventory management policies such as reorder frequency and amount.

Success can be determined if the model shows a feasible inventory policy where the SMUs experience decreased inventory costs and customer wait times. Decreased inventory costs lead to less time wasted inventorying excess material, less space required to store unneeded parts, and less budget wasted in over ordering parts. Budget saved by improving the ordering process can be used to order the parts the customers actually need, thereby improving customer wait times. Reduced customer wait times, not only for the customers, but also for the SMUs themselves, will lead to increased readiness overall for the Marines. The faster a critical part can be delivered to the customer, the faster that customer can deploy for its mission.

B. SMU AND DLA

USMC partnered with DLA to examine how DLA could improve the effectiveness of their current inventory system. With its massive logistics footprint worldwide, DLA can provide either a single centralized depot or a single centralized management entity to assist the USMC in its logistics requirements. Due to the prospect of a potential decrease in budgetary waste and of improving customer wait times, USMC and DLA established three integrated process teams (IPT), one for each MEF, to test various levels of integration with DLA.

These three IPTs operated with the SMUs of the corresponding MEFs according to different levels of cooperation. The IPT at I MEF implemented a tailored version of DLA's inventory optimization system to recommend stock levels for the SMU based on demands, current wholesale performance, and distribution times from DLA. The team at II MEF positioned DLA-owned materiel in the SMU. DLA and SMU administratively managed their own materiel. However, all materiel, regardless of ownership, was physically managed by SMU Marines, who were trained to use DLA's Distribution Standard System. The Third MEF (III MEF) IPT leveraged SMU initiatives and a collaborative relationship with DLA Distribution Yokosuka Japan, Detachment Okinawa (DDOJ) for lateral support across a range of 10,000 NSNs. Here, emphasis was placed on combat critical spares supporting principal end use items (PEIs) on the MEF commander's top 25 list.

All three options tested by the IPTs showed that a more integrated approach with DLA could result in improvements to the USMC logistics system. In all cases, customer wait time and customer order fulfilment (or net effectiveness) increased while inventory size decreased. The question not answered by the IPTs was how much and what type of inventory SMUs could shift to DLA without increasing customer wait times. In this thesis, we attempt to answer this and related questions.

C. MARINE CORPS SUPPLY MANAGEMENT UNIT

The USMC's logistics hubs are its Supply Management Units (SMUs) which are present in every MEF and region where there is a significant Marine presence. The main SMUs are co-located with the MEFs so that the I MEF SMU supports Camp Pendleton on the West Coast and the II MEF SMU supports Camp Lejeune on the east. Camp Butler is supported by the III MEF SMU and there have been forward deployed SMUs supporting Marine operation abroad such as in

Afghanistan. The SMUs are primarily engaged in retail distribution of Class IX repair parts in support of the warfighter. Since stock outs of critically required parts can negatively impact the mission, SMUs must manage their 10,000+ line items of inventory worth millions of dollars very carefully. While forecasting errors can occur, a properly run SMU seeks to minimize these by ensuring their inventory policies for their repair parts are as accurate as possible. Knowing when to order and how much to order is key to their success.

D. DEFENSE LOGISTICS AGENCY DISTRIBUTION CENTERS

In contrast to the SMUs, DLA is a wholesale distributor of parts for the various logistics requirements in the Department of Defense. DLA through its distribution centers ensure that the SMUs are replenished with stock upon receipt of a reorder. The distribution centers also fill any customer requirements that the SMU passes to DLA, be it due to the SMU not carrying a part or the part in question being out of stock.

The distribution centers are located throughout the US, but for the purposes of this project, the main two centers studied will be DLA San Joaquin and DLA Susquehanna. Due to their proximity to the MEF SMUs, these distribution centers were chosen to cooperate with their local

SMUs when USMC partnered with DLA to test whether increased collaboration between the SMUs and DLA could decrease customer wait times and inventory held.

E. STUDY FOCUS

Supporting the various requirements from MEF customers, the SMUs play a key role in supporting the Marine Corps warfighter. A reorder policy by the SMU from DLA – its main wholesale source of repair-parts – is determined by two main parameters: RO and ROP. RO is the threshold level of inventory in the SMU that triggers a reorder. ROP is the "up-to-level" of a reorder. That is, a reorder size = ROP – current inventory – outstanding reorders. Another parameter that may affect the supply-chain effectiveness and efficiency is the frequency of inventory inspection, which is measured by the time between inspections (TBI). A reorder is only made at one of these inspection times. For example, the TBI might be one week to reduce the administrative overhead of making orders every day.

The values of a (RO, ROP) pair and the TBI may very well be the critical point between a shortage of an item, and unused surplus. Historically, SMU forecasting miscalculations have periodically caused parts to be ordered at the incorrect time and/or in the incorrect amount. These inaccuracies have led to various problems to include increased inventory costs and shortages for critically required parts. Moreover, customer wait times (CWT), the time from when the part is first ordered to final receipt by the customer, were adversely affected by incorrect demand forecasting. Having the correct inventory policy has been so important that the USMC and the Defense Logistics Agency (DLA) embarked on a series of trials to determine if increased USMC-DLA logistics integration provides a solution. Our study focuses on obtaining the best item-dependent values for RO, ROP and TBI.

F. BENEFITS OF THIS STUDY

The main benefit of this thesis is to verify if inventory policies more efficient than the ones currently in use by the SMUs exist. IPT I in Camp Pendleton produced improvements to customer wait time and reductions in inventory held without DLA's physical presence on site. Using SIMIO and simulating years of customer/SMU orders in the system could yield actual "sweet spots." These spots are where different combinations of current inventory, reorder point, and a maximum reorder up to level have either a similar customer wait times and/or similar inventory costs. These combinations could help the SMUs adjust their inventory to lower their inventory costs and their customer wait times.

If successful, this thesis could help the SMUs make tradeoffs between reducing their inventory and potentially increasing the customer wait time. Through a reduction of inventory, the SMUs are effectively shifting the risks to DLA to forecast future demand. Any reductions in customer wait times or in inventory costs will not only help the SMUs, but also fulfill USMC ILP's objective of finding more efficient ways to improve USMC logistics.

II. MODELING AND SIMULATION

This research develops modeling and simulation tools to analyze the USMC logistics system from the SMU perspective and its interaction with the regional DLA supply depots. In addition to developing a tailored simulation for the resupply cycle, the research examines the advantages and disadvantages of possible modifications of the current system, such as enhanced decentralization or greater collaboration with DLA, which leads to centralization. Inventory management policies such as reorder frequency and amount are also examined. Details are as follows:

The USMC resupply cycle comprises five main stages:

- **Identifying** shortage in the inventory of an item,
- **Generating** a requisition by a customer or SMU,
- **Processing a** requisition by routing it in a specified order to a potential supplier,
- **Handling** the requisition at the supplier, a stage that may take from few hours to a few days,
- **Shipping** the supply and receiving it by the customer or SMU.

Note that there are two main resupply cycles: one that is initiated by and terminated at the customer (a USMC tactical unit), and another that is initiated by and terminated at the SMU when the inventory level of an item reaches its RO.

Our simulation follows the five stages described above, and the demand frequency and size are simulated based on real demand data collected from the SMU of I MEF . In addition to the RO and ROP, we also analyzed a third parameter— time between inspections (TBI). This parameter determines how often the inventory level of an item is inspected as excessive inspections may lead to unnecessary requisitions, while sparsely scheduled inspections may lead to undetected and severe shortages.

A. SIMULATION OF REPAIR PARTS ORDERS

Designing a model to simulate the lifecycle of a MEF customer order begun with defining what the major components of the model were. The customers, the SMUs, and the various parts of DLA are the major players in the model. In this section of the report, we define the model in terms of the corresponding supply network created and its underpinning assumptions. The model is a simulation mimicking USMC requisition process at the MEF. The process comprises several stages: requisition generation, processing, handling, shipping, and receipt of orders.

1. Requisition Generation

Since the processing, handling, and shipping of Marine Corps requisitions is the primary concern of this thesis, customer orders are critical to the model. The frequency and size of requisitions dependent on nature the type of the item being ordered. Some items in the I MEF SMU inventory are ordered quite frequently, but had low demand per order. Others are ordered less often, but sometimes have large demand. To simulate the requisitions, we use the empirical distribution of customer orders from the SMU. There are two components to the empirical distribution.

The first component is the order frequency. The simulation is time-driven. Each day, the model checks to see how many orders are made by various customers. The frequency was based on the requisition data from the I MEF SMU inventory. For example, an item might have 1,023 requisitions over a 570 day period. To form bootstrapping distribution for the likelihood of j orders occurring in a day, the number of days with j orders was calculated and then divided by the total number of days. If there are 57 days that had only 2 orders, then the model had a 10% chance of generating two requisitions in a given day.

The second component is the quantity of items demanded in each order. Demand was also based on the empirical data for the item being simulated. Again, using the setscrew distribution, if 50 requisitions out of 1,000 had a demand quantity of 3, then there would be a 5% chance of a requisition having a demand of 3. Using the empirical data avoids having to make parametric assumptions about the underlying distribution. This also bolsters the model's legitimacy as the data is real.

2. Processing

Once the model has generated a requisition with a demand quantity, the next step is for this order to go to the SMU for fulfillment if possible. USMC logistics policy mandates that the local SMU be the initial point of entry for requisitions. Since a SMU supports its regional MEF, USMC customers must send their parts orders to the SMU first for fulfillment. The model simulates this behavior by routing all orders to their respective SMU prior to any referral to DLA. As such, I MEF orders go to SMU1 and II MEF orders are sent to SMU2. Just as there is an inventory policy at the real-life SMUs, there is an inventory policy at the model SMUs. Inventory policy are a combination of starting inventory, reorder point (RO), and reorder up to point (ROP) that help a SMU manage its demand properly. An inventory policy with high ROs and ROPs could lead to low customer wait times, but also higher inventory costs. As such, the SMU has a vested interest in maintaining a tradeoff of having just enough inventory to satisfy demand while avoiding having too much of its funds tied up in inventory. Time between inspections (TBI) is another parameter that determines how frequently the SMU checks to determine whether it needs to replenish its inventory. A smaller TBI ensures replenishments are made close to when the inventory hits the RO. However, this increases the overall number of replenishments, which incurs a cost. Having a large TBI might result in running out of inventory.

3. Handling

Upon the arrival of an incoming requisition at a SMU, there are two actions that could take place. The SMU could fill the order from stock. If so, the requisition is filled and the amount demanded is deducted from the current SMU inventory. The requisition is then sent to the customer for removal from the system – the MEF customer receives its part. If the SMU does not have sufficient inventory to fulfill the requisition, the order is sent to a central DLA node that determines how to fulfil the order. This will occur if the SMU has less inventory when than is required by the arriving requisition. This also models an inventory policy where the RO and ROP are zero – the SMU does not stock the requested item. The special case of RO=ROP=0 corresponds to the situation where DLA centrally manages the inventory for a particular repair part.

Processing time at either the SMU or DLA central is considered negligible. The assumption is that other nodes/edges will mimic the time to process, handle, or ship a part. Also, the initial processing at these nodes is a simple stock check. Figure 1 illustrates the event graph of the order process.

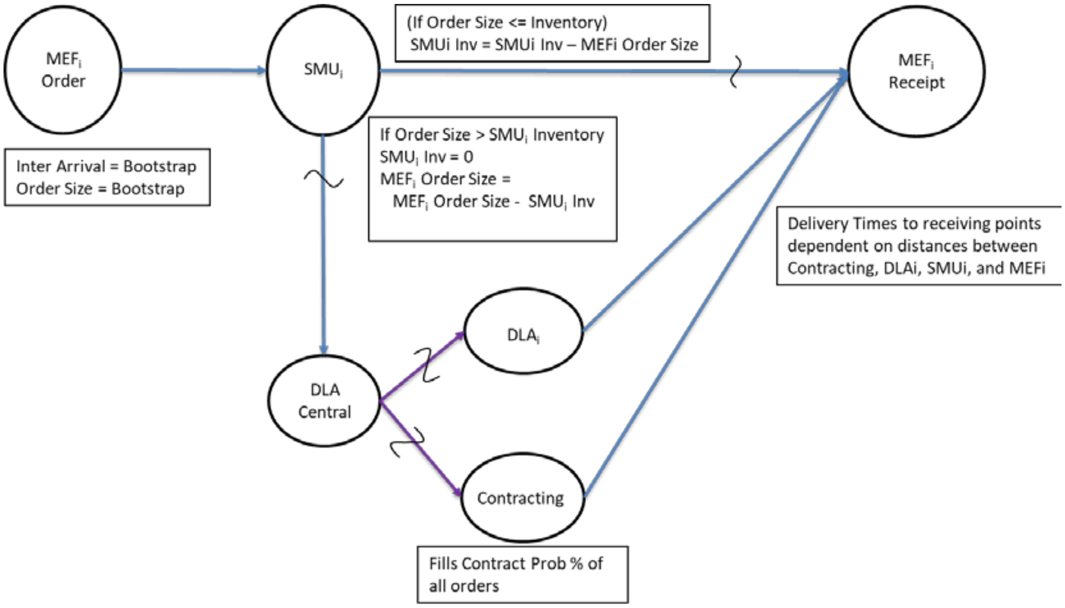

Figure 1. Event Graph of Customer Orders in the Model

If the requisition is forwarded to DLA, there is additional processing time. The first DLA node acts as an electronic clearinghouse for requisitions. Upon arrival, DLA routes the incoming requisitions to either the same coast DLA distribution center, the opposite coast DLA, or to contracting. Based on contacts with DLA, approximately 84% of requisitions are filled by the same coast DLA, 5% are filled by contracting and the remaining 11% by the opposite coast DLA. Since DLA is the wholesale distributor of Class IX parts, its policy is to always have enough stock on hand to fulfill customer orders.

In the model, if the order is sent to contracting (5%), this means that DLA does not have the particular part in stock and must contract a private vendor for procurement. The contracting, handling, and shipping portion is combined into a wait time for delivery to the SMU. As with frequency and demand, contracting lead time is dependent on the part being ordered. Some parts might have long procurement times which could detrimentally affect customer wait times. These lead times might influence the SMU to adjust its customer wait times accordingly. Based on experiments done with several parts from the I MEF SMU inventory, the difference in customer wait time and inventory costs is negligible for contracting percentages between 0% to 5%. To simplify the model and avoid tracking DLA wholesale reorders from a vendor, the order percentage of orders routed to contracting is set to 0%. As such, the model has DLA route requisitions in an 84%-16% to same/opposite coast distribution centers. The processing time at DLA can be seen as the time it takes for the workers to pull and package an item for shipment. After an order arrives to its distribution center, DLA's processing portion is over.

The DLA nodes play a critical role as these nodes process both SMU replenishments as well as any partially filled customer requisitions. Since contracting is set to 0%, it is assumed that the inventory at the DLA will always be sufficient to meet the customer demand. At the nodes, there are service times based on the time required to prepare a customer order for shipment. While DLA San Joaquin has multiple warehouses, getting a specific order from its respective warehouse to the loading point takes time. These service times can be considered the handling portion of the model. To simulate this process, the service times were given a triangular distribution 0.5 to 1.5 days, with a mean time of 1.0 days for processing orders. The assumptions are that DLA does not ship continuously and that there is a cut off time for the shipment of orders. This means that the DLA nodes can ship most customer orders within 24 hours of receipt. This service time can also account for orders that arrive in time to be processed the same day. Since DLA does not run 24 hours a day, the service times can also model those orders coming in "after hours" and must be processed the next day.

4. Shipping and Receipt of Orders

Once the parts have completed the handling phases, they are ready to ship in the model. Here there is another assumption that must be made regarding shipping time from the DLA nodes to the customers. While FEDEXed shipments are ignored for the purposes of this model, MEF orders filled by DLA San Joaquin or by DLA Susquehanna are assumed to be delivered by commercial truck. Per I MEF SMU, the average shipping time from DLA San Joaquin to Camp Pendleton is 2-4 days while parts received from DLA Susquehanna could take a week or more to arrive. As such, having parts fulfilled from the same coast is preferable. While DLA stated that at most off-coast parts could take 2-3 days more to arrive, based on the I MEF SMU's experiences, the longer time period was used. Another reason to use the longer time period is to use a worst scenario for receiving parts. A potential increase in customer wait time might have the SMUs consider inventory policies with higher ROs, ROPs, and ultimately inventory costs. The model enacts these parameters as triangularly distributed shipping times. Shipping from a same coast DLA to its corresponding SMU will have a triangularly distributed between 1 to 4 days, with a mean time of 2 days. Shipping opposite coast will be triangularly distributed from 7 to 14 with a mean time of 10 days.

The last step of the model is the receipt of parts at their destinations. This happens in three different ways. If the requisition was completely fulfilled by a SMU, then there is a combined handling/shipping time before the customer receives its parts. This wait time is assumed to be triangularly distributed between 0.5 to 1.5 days with a mean delivery time of 1.0 days. I MEF SMU personnel were observed to do daily deliveries to all, but their most distant customers (e.g. Yuma, AZ). If a customer order had a portion of its demand filled by DLA, the requisition is first shipped to its SMU and then follows the same path for delivery (0.5-1.5 days) as if the requisition were filled by the SMU. This is to simulate the SMU receiving the parts from DLA and then forwarding that requisition to the customer.

B. SMU REPLENISHMENT

Replenishments are dictated by three parameters (RO, ROP,TBI). The SMU inspects it inventory according to TBI. If current inventory is above RO, then the SMU takes no action and waits until the next inspection time. If inventory is below RO, then the SMU immediately makes a replenishment request to DLA for the amount of ROP – current inventory. After the SMU makes the replenishment request to DLA the logic and dynamics of processing the replenishment at DLA are identical to the steps described in Section A for a customer order that routes to DLA. Once DLA finishes processing the replenishment, DLA ships the replenishment directly to the SMU that ordered it. Figure 2 illustrates the event graph of the SMU replenishment process and Figure 3 illustrates the combined customer order and SMU replenishment dynamics.

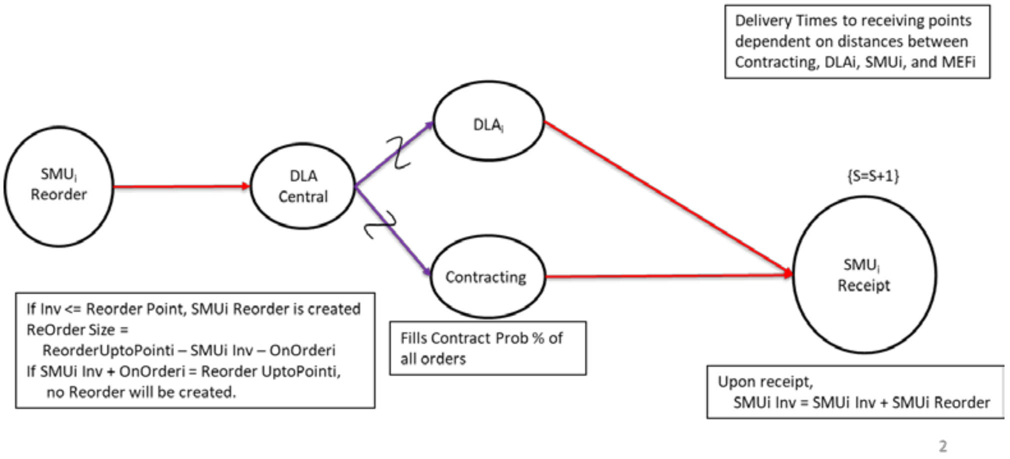

Figure 2. Event Graph of SMU Replenishments

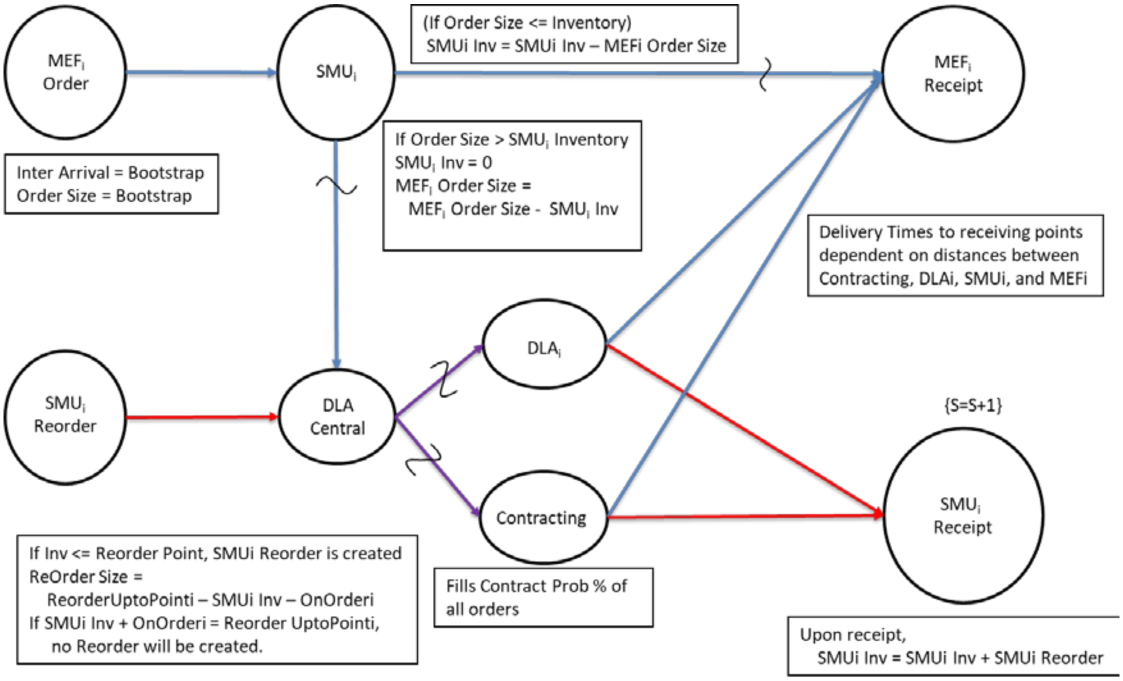

Figure 3. Combined Graph of Customer Orders and SMU Replenishments

C. LIMITATIONS TO THE MODEL

While this model simulates how a customer order is processed in the USMC-DLA logistics chain, there were several cases that were beyond the scope of this thesis. First, SMUs have visibility of each other's inventory and can transship parts to each other. This could have been modeled by having one SMU act as supply node for another SMU whenever that SMU had insufficient stock.

This was not implemented in the model. In practice, transshipments are seldom done due to the separation of the logistics and financial sides of the supply chain. This split requires not only the requesting SMU to arrange for the transfer from the supplying SMU, but also the SMU's financial admins to arrange for the payment of funds to the supplying SMU's financial team.

Second, there are three major MC SMUs – Camp Pendleton in San Diego, Camp Lejeune in North Carolina, and Camp Butler in Okinawa. The Marine Corps also can and has established forward deployed SMUs when required (e.g. Afghanistan). Additionally, the III MEF in Okinawa is considered a forward deployed Marine Air Ground – Task Force (MAG-TF). As such, the III MEF SMU is considered supporting forward deployed units and has a status different from the CONUS SMUs which support both deployed and non-deployed units. Any SMU with a forward deployed status would have complications with supplying CONUS units with parts. Lastly, since the CONUS SMUs account for most of the inventory filled, adding a deployed SMU to the model would not have provided much more additional information. While the III MEF SMU could have been modeled, doing so would have increased the number of nodes and paths and slowed the model's performance.

Third, similar to the SMUs, there are more than two DLA distribution centers than just DLA San Joaquin and DLA Susquehanna. Although modeling these distribution centers could provide more detail to the model, this would also increase the number of parameters and data required to produce a working model. Making assumptions about the delivery time from DLA San Joaquin to the I MEF SMU easier than trying to calculate the same for a delivery from a sub-unit of DLA San Joaquin to the I MEF SMU. The model avoids this unnecessary complexity by having such deliveries from DLA sub-distribution centers to the customers be simulated under the handling phase of the DLA model. Any deliveries from a sub-distribution center are assumed to be headed to the main DLA distribution center (DLA San Joaquin or DLA Susquehanna) for ultimate delivery to the customer.

Another limitation is that DLA's wholesale activities are only broadly simulated. To avoid modeling and obtaining information from DLA regarding certain Class IX parts, DLA is assumed to be out of stock of an item at a set parameter. DLA maintains a vigorous stocking policy such that on average items are only out of stock and are in the middle of being reordered 4.5-5.9% of the time. While further information could be obtaining regarding DLA stocks, it is much easier to assume a set NIS rate for DLA. Moreover, the 5% is an average of not-in-stocks across DLA's vast inventory. It is perfectly plausible that many frequently ordered items with high demand are never out of stock when a customer order arrives. Just as the SMU have a safety level determined by their RO, DLA does too.

The last limitation to the model is that the SMU budget for ordering Class IX parts could not be implemented. All SMUs reorder their parts whenever they receive funds from ordering customers. These reorders happen periodically both in the model and in real life, on different intervals: weekly, monthly, quarterly, etc. A real SMU would balance and forecast their purchases not just per line item, but across the whole of the SMU's inventory and with future requirements in mind. The model, in contrast, only examines parts one at a time. This limitation is partially mitigated by the inventory cost variable to represent the amount of time/money a part ties up when on the SMU's shelf. The higher the inventory cost, the less likely a SMU is to increase that part's inventory. Still, to accurately implement a reorder budget might require representing customer orders for different parts in the same simulation. This would add more complexity as a SMU's inventory could be in excess of 35,000 parts and result in longer simulation times for each run of the model.

III. RESULTS AND ANALYSIS

While the simulation is implemented on the data of six repairable stock items that vary in their frequency of demand and the size of requisitions, the analysis described below only focuses on one item: setscrew, which is a repair part frequently ordered at the SMU. The complete analysis for all six items will be presented in a thesis to be published soon. The analysis examines the tradeoff between the ROP, which is used as a proxy for inventory cost, and CWT, which measures the effectiveness of the supply chain. Higher ROP implies larger inventories that occupy storage space and lock in purchase funds. CWT is a measure of service quality: how long a customer waits to receive its order. This tradeoff is analyzed while varying the TBI, which is a control parameter, and the value of the RO, as a percentage of the ROP. As mentioned above, this analysis framework will be further expanded to the five other parts studied.

Some relations between the parameters are obvious. For example, large ROP and RO, and small TBI will lead to higher average inventory and thus lower average CWT. Conversely, Low ROP and RO values and large TBI will result in lower average inventories, which imply higher probability of stock-out and thus referral of requisitions to DLA. Such a situation will increase CWT.

The parameters chosen for the simulation of the setscrews supply chain are as follows:

ROP: Taking the current practice at the SMU of MEF I as the base-line, we range the values of ROP between a very risky value of 200 items (20% of current practice) and a conservative value of 1200 (120% of current practice).

RO: The reorder point – the inventory level that triggers a reorder – is taken as a percentage of the ROP and it ranges between a risky percentage of 10% and a conservative value of 70%.

TBI: The model has the SMU mimic in part how orders are done in a shipboard supply department. Since ships generally reorder on three intervals: daily, weekly, and bi-weekly. In addition, to check for sensitivity, we also examined a TBI of 4 and 12 weeks. The initial inventory level for all simulations is the current inventory in the SMU database. There are 385 different combinations of ROP, RO and TBI values, and each combination was simulated for 100 years. Total run time was 6.25 hours for 38,500 runs of the model.

Figures 1 and 2 below present the average CWT and the 90-percentile CWT, respectively. Each figure contains five blocks – corresponding to the five values of TBI – each includes seven curves – corresponding to the seven RO percentages. As one would expect, increasing the TBI shifts the graphs of CWT vs. ROP steadily upwards. Also, for any given value of RO and TBI, CWT decreases as ROP increases, but that decrease only can go so far; it stabilizes as ROP increases beyond a certain value. Finally, CWT decreases as RO increases. The difference is most apparent between the extremes.

The plots clearly display the tradeoffs among the decision parameters RO, ROP and TBI. Moreover, they reveal a potential “sweet-spot” for optimal policy. First we notice that the plots get closely clustered together as the RO increases. In other words, small to medium RO values are good enough – beyond, say, 30% the additional reduction in CWT becomes less significant.

Second, while there is a dramatic decrease in CWT as ROP is increased from its minimum level of 200, this decrease subsides when ROP reaches the level of around 500. Third, TBI has relatively little effect on TBI in the range 0-2. TBI of 4 or 12 weeks can increase TBI substantially.

Taking 40 hours as a reasonable goal for average CWT (yellow line in figures 1 and 2), we see that, for setscrews, the SMU can reach this goal with a much lower ROP than the current level of 1000. Specifically, If TBI is one week, then ROP of 600 items (40% less than the current practice) and RO=120 items will achieve that goal. Even the 90th percentile CWT of that policy is less than 45 hours (see Figure 2). If inventory inspections are daily (TBI=1) then this goal of 40 hours average CWT is obtained with ROP of only 400 items (and RO of 80 items).

Notice that if the SMU relies entirely on DLA supply, that is, RO = ROP = 0, then the average CWT is 95.04 hours and the 90th percentile is 102.16 hours, more than twice the stated goal of 40 hours. We also observe that no policy can reach a CWT average value lower than 36 hours.

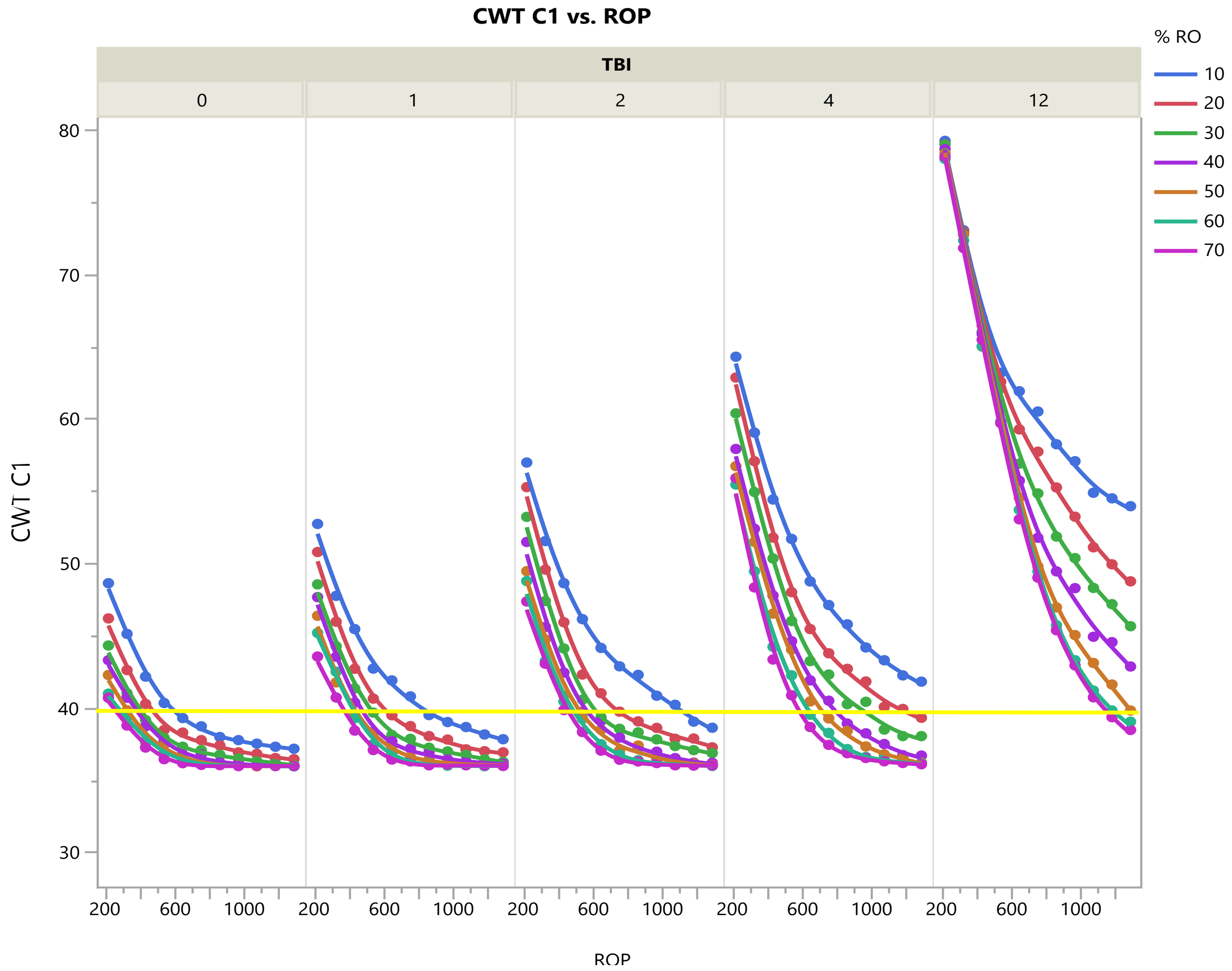

Figure 4. CWT vs. ROP per Inspection Period and by Percentage of ROP

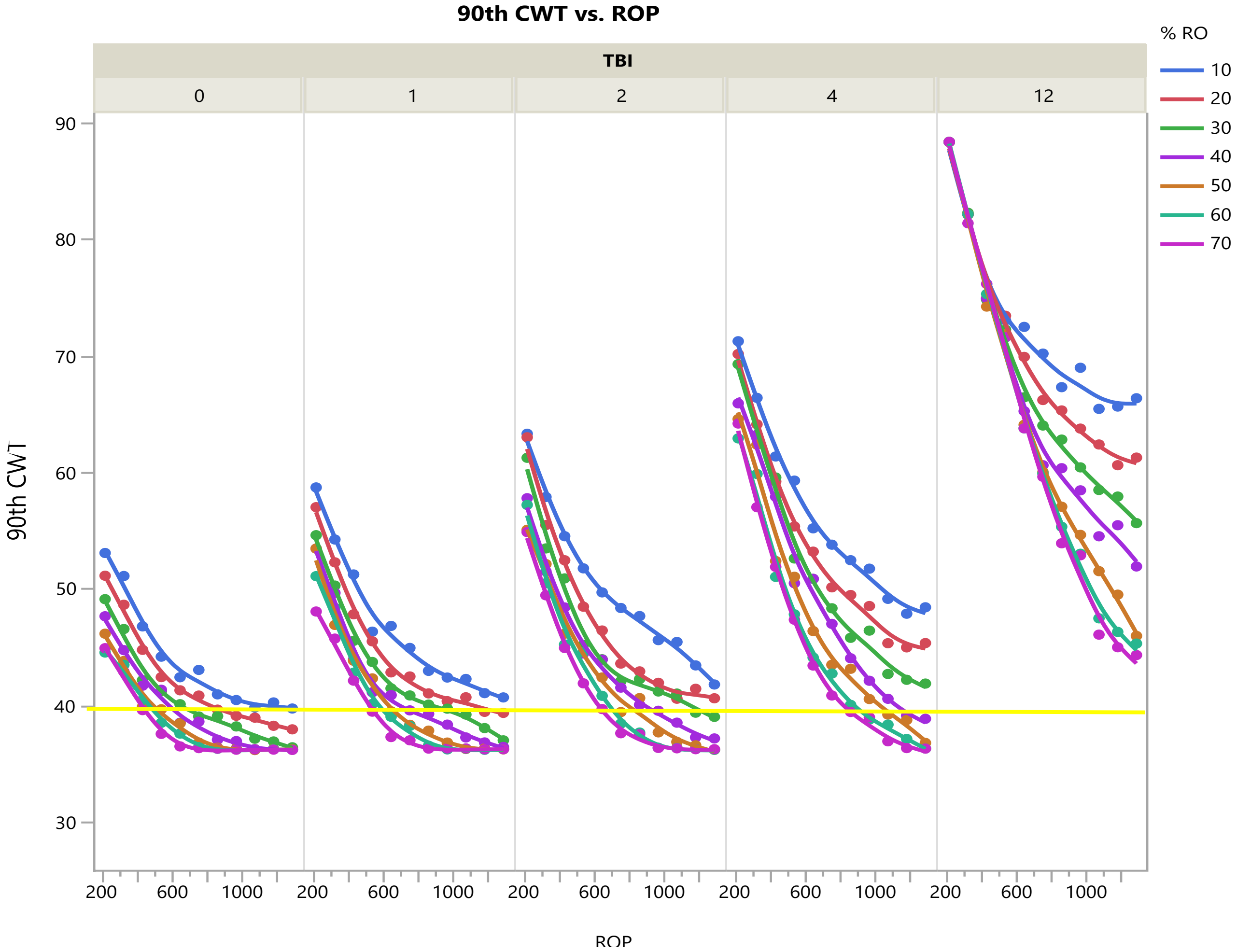

Figure 5. 90th Percentile of CWT vs. ROP per Inspection Period and by Percentage of ROP

IV. CONCLUSIONS

Reordering policy at the SMU – setting the RO, ROP and TBI values - has a great effect on CWT. This parameter is sensitive to the ROP; CWT experiences a sharp decline when one moves from very low ROP to moderate values. This effect is mollified as one moves from moderate values of ROP to large values. We also note that while shorter TBI leads to shorter CWT, for realistic values of TBI – 0,1,2 – the CWT is not very sensitive to TBI. CWT increases when TBI are unrealistically high (12 weeks).

Comparing the results of the setscrew analysis with current practices at the I MEF SMU, we conclude that the SMU can maintain an acceptable average CWT with a substantially smaller inventory. Specifically, the SMU can reduce its ROP for setscrews by as much as 40%, thus saving inventory costs. While this reduction in inventory might lead to an increase in administrative work due to the increased number of reorder requisitions, the more frequent the reorder period, the greater the decrease in CWT. If the SMU is constrained in adjusting its reorder policy due to financial or operational reasons, the SMU can still consider decreasing the ROP while increasing its RO.

This analysis is expanded to five other repairable items in a follow-up thesis. It would be interesting to verify if other Class IX items behave the same way in the model as the setscrews. Changes in the demand patterns in other items might lead to different efficient and effective values of ROP, RO, and TBI. For now, we recommend, for items with similar demand characteristics to the setscrews, new ROP and RO values of 600 and 120, respectively, with TBI of one week or two weeks.

Future research will relax the assumption regarding vertical flow of supplies where repair parts move along the hierarchy: DLA (wholesale) to SMU (retail) to customer. While still more of an exception than a rule, lateral flow between SMUs are possible, and perhaps even desirable. As this flow is not captured in our model, it could be part of a model extension. A second model extension would be to expand the scope of the model to include third SMU (MEF III), other forward deployed logistic units at the operational level, as well as modeling in detail the DLA operations with all its relevant installations. Finally, the current model touches on budgetary considerations only thorough the ROP proxy. Further research would involve estimations of inventory, handling and shipping cost so that the tradeoff between effectiveness (CWT) and efficiency (cost) will be more realistic.

Acronyms

Customer Wait Time – CWT

Defense Logistics Agency – DLA

Marine Expeditionary Force – MEF

Reorder Point – RO

Reorder Up-To Point – ROP

Supply Management Unit – SMU

Time Between Inspections – TBI

US Marine Corps – USMC