MV-22 Supply Chain Refinement

Big data analysis supporting joint prepositioning

by Maj Jacob P. Jones

The Marine Corps prides itself on its ability to successfully operate within a dynamic environment in an expedient and expeditious manner. To achieve power projection requirements, high states of aircraft, vessel, equipment, and personnel readiness are required. No small accomplishment, this burden lies heavily on supply professionals and the agility of the supply network in support of the Operating Forces. Supply chain management (SCM) must cultivate dynamic supply chains as fluid as the maneuver units they support. Though military action is reactive at times, proactive preparations foster an ability to increase momentum and gain the initiative. SCM should also adopt a proactive mindset, forecasting readiness requirements through critical and balanced consideration.

As a Naval Postgraduate School student, the following study was completed as a master's thesis examining SCM. The purpose of this quantitative research was to assess the supply chain network of a deployed MV-22 Osprey squadron, discover inefficiencies, and make recommendations to increase supply chain productivity. Specifically, this study took advantage of Microsoft Excel and Big Data (BD) techniques to sort through structured and unstructured data. Collaboration with the Department of the Navy for requirements and attaining data sets permitted the application of Excel and Lexical Link Analysis, a text-mining, software to derive relationships between given data sets. Extraction of variables, such as response times and aircraft parts availability, measured SCM strengths and drew attention to deficiencies. Interpreted relationships helped determine opportunities, shortfalls, and both favorable and unfavorable conditions within the organizational and intermediate maintenance levels of the Osprey supply chain. The results observed formed the basis for supply chain improvement recommendations and assisted with enhancing the Department of the Navy's SCM productivity.

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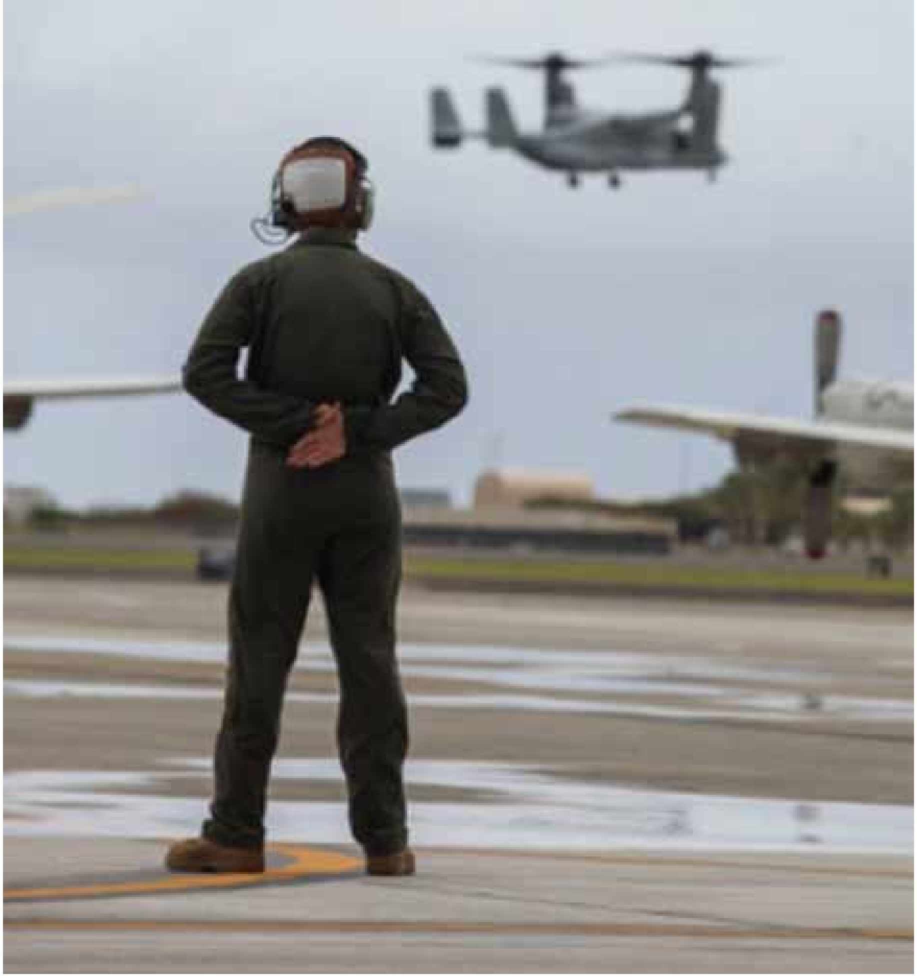
Background

The philosophy of SCM is one ap-



A Marine stands by to guide MV-22Bs assigned to VMM-363. *(Photo by Sgt Jesus Sepulveda Torres.)*

proach many organizations embrace as a force multiplier. When suppliers, manufacturers, distributors, and vendors form a cohesive partnership, benefits throughout the supply chain are recognized while minimizing unwanted consequences. SCM provides positive outcomes for the private sector, and so too can the government and DOD realize many of the same advantages.

The concept of SCM has grown over the past few decades, with organizations developing supply chain systems to increase competitive advantage. In a 2014 article in the *Journal of Supply ChainManagement*, authors Lisa Ellram and Martha Cooper defined SCM by stating:

> A supply chain is defined as a set of three or more entities (organizations or individuals) directly involved with the upstream and downstream flows of products, services, finances, and/or information from a source to a customer, (and return).[1]

Previous work written thirteen years earlier demonstrates that the fundamental principles of SCM have remained consistent.[2] Essentially, an organization must collaborate with its supply chain partners and develop aligned strategic policy to recognize the benefits of SCM. The same holds true today: managers must visualize the supply chain not as independent organizations but as a network of nodes facilitating a system of interaction—each impacting the function of the whole. With this perception, the integration of each supply chain member is vital to the success of the chain.

To optimize SCM, discover opportunities, and identify shortfalls, BD and business analytics can be applied to enhance supply chain processes.[3] For this research, we follow Helena Kosciejniak and Agnieska Puto's definition of BD:

> a vast amount of data generated very quickly and containing a large amount of content. The characteristics of BD is based on the rule of four: volume (a large amount of data), variety (any type of data), velocity (high changeability, dynamic of data), and value (assessment expressed by verification).[4]

Because of the challenges BD imposes, BD and business analytics and lyrics must employ complex methods to process and analyze data to discover valuable information relevant to the organization.[5] The end state of BD and business analytics and lyrics is to assist managers concerning decisions on all levels of an organization—strategic, operational, and tactical. By implementing BDBL, organizations can "improve visibility, flexibility, and integration of global supply chains and logistical processes, effectively manage demand volatility, and handle cost fluctuations."[5] Another article argues that organizations should employ data science, predictive analytics, and big data to improve supply chain effectiveness.[6]

Research Criteria

The emphasis of this research was to assess the supply vulnerabilities or opportunities that present themselves between MV-22 operational-level and intermediate-level maintenance activities deployed on a MEU. The squadron examined was Marine Medium Tiltrotor Squadron 264 (VMM-264), then assigned to the 22d MEU in 2016. VMM-264 embarked aboard the USS *Wasp* for six months and supported U.S. Africa Command, U.S. Central Command, Sixth Fleet, and Fifth Fleet operations.[7] During the deployment, VMM-264 participated in Operation ODYSSEY LIGHTNING and conducted operations in the Mediterranean and Red Sea areas of responsibility.

Findings

This project focused on two objectives: assessing how dynamic the supply chain was during a MV-22 MEU deployment and discovering potential opportunities to preposition MV-22 parts to maintain high aircraft readiness rates. To meet these goals, the study leveraged Aircraft Maintenance/Supply Readiness Report (AMSRR) documentation to assess organizational- and intermediate-level maintenance and supply activities.[8] Supply documents initially annotated on the AMSRR with status codes of "BA" (parts in inventory and ready to ship) and "AS" (parts that were shipping) were isolated for investigation. If supply documents possessed other status codes prior to being published on the AMSRR, they were not considered. Concentrating the research solely to these components allowed for the detailed scrutiny of supply chain efficiency and excluded times when specific component shortfalls were caused by other factors, such as contractual agreements or life expectancy inconsistences.

A limitation of this project is the accuracy of the data received. Results and potential recommendations to enhance SCM are based on the data provided. Prior to making recommendations and conclusions, the research methodology evaluated errors in the AMSRR documentation, such as erroneous estimated arrival times and invalid routing identification codes. Estimated arrival times of zero days and routing identification codes from Defense Logistics Agency (DLA), Fort Belvoir, VA, and Naval Supply Weapon System Support, Philadelphia, PA, were annotations that reduced the accuracy of the analysis.

Overwhelmingly, the supply chain did not behave as an agile network, adjusting and adapting to the needs of VMM-264. After analyzing a 92-day period, the supply documents reported on the AMSRR conveyed a supply network that was heavily reliant on supply nodes located within the continental United States. For parts with the AMSRR status code BA Not Mission Capable Supply (NMCS), the study found that 71.3 percent of the requisitions were sourced from the continental United States, while DLA Europe—located in Germany—sourced only 0.19 percent of the requests. BA Partial Mission Capable Supply (PMCS) displayed similar sourcing rates from the United States, accounting for 73.6 percent of the components while none of the PMCS parts were sourced from DLA Europe or other European distribution centers. AS coded parts shared comparable results. AS NMCS and PMCS sourcing activities accounted for 83.4 percent and 72 percent of the components forwarded from the United States. None of the parts initially given a status code of AS were sourced within the European theater of operation. Faster response times might have been achieved if critical parts were

Criticality	Status Code	Average Estimated Response Time (Days)	Median Estimated Response Time (Days)	Mode Estimated Response Time (Days)
NMCS	BA	20	8	6
	AS	11.3	10	10
PMCS	BA	12.8	8.5	7
	AS	15	10.5	6

Table 1. Estimated response times of less than 15 days for critical parts.

prepositioned in European distribution centers and supply points.

Though identifying the sourcing activities of critical components was important to understand supply chain efficiency, this research also assessed expected delivery date data to ascertain an estimated response time from order date to potential arrival of the component. Estimated response times of 15 days or less for BA NMCS and PMCS components were 83.6 percent and 78.8 percent, respectively. However, the average NMCS time was twenty days, with a median of eight days, and a mode of six days. Though the median and mode were found to be roughly a week in time, the high average demonstrates outliers that experienced much longer estimated response times. Of the 483 NMCS BA parts examined, 62 experienced an estimated response time greater than 15 days. On the extreme, 5 were found to have estimated response time greater than 90 days. The average PMCS time was much less, at 12.8 days yet with a similar median of 8.5 days and a mode of 7 days. Estimated response times of 15 days or less for NMCS and PMCS AS identified parts were discovered to be 83.2 percent and 75.0 percent, respectively. The average NMCS time was 11.3 days with a median and mode of 10 days. Likewise, the average PMCS time was 15 days, with a median of 10.5 days, and a mode of 6 days. Thus, the majority of parts initially labeled BA and AS arrived within two weeks from the order date with one exception. Sourcing activity MALS-26 Support Element, Djibouti, tended to have longer response times, greater than two to three weeks. Table 1 describes the estimated response time findings.

The significance behind these findings is that aircraft readiness suffers because of response times associated with shipping critical aircraft components from locations within the continental United States. Using descriptive analytics, this study describes the behavior of the supply chain. It was beyond the scope of this project to use predictive analytics to forecast decreased response times from prepositioning parts within the squadron's area of operation. However, it is presumed that if critical parts were staged at European supply locations, response times would reduce and readiness would improve. Further research must be conducted to determine the validity of part prepositioning.

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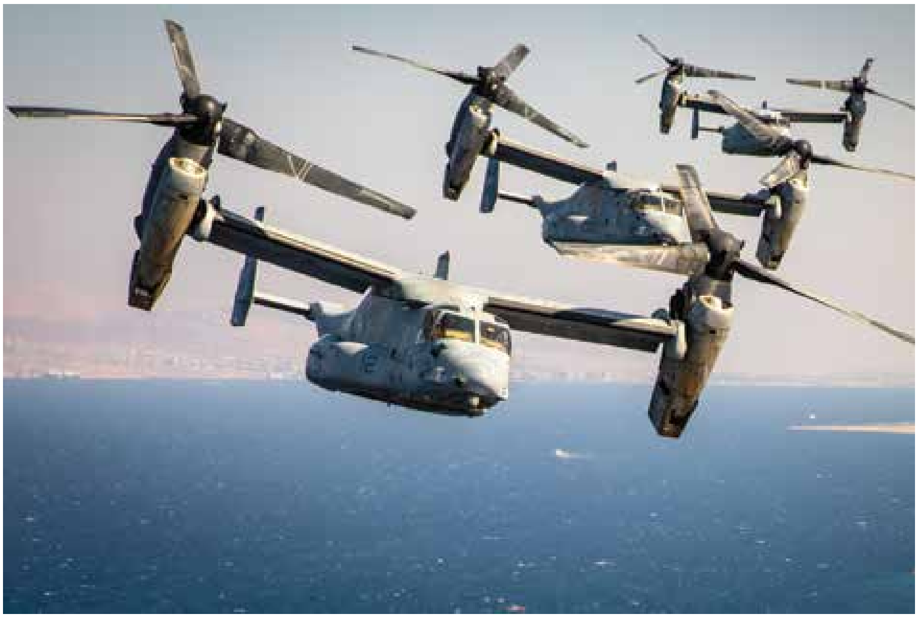
The second requirement was to identify and recommend parts to preposition. This project discovered nine outlier parts that were ordered at a higher frequency than the preponderance of the components demanded. Emphasizing parts that were originally categorized as BA and AS when first appeared on the AMSRR, as well as being critical to aircraft readiness, the research indicates those nine parts were likely maintained in the supply system—with the opportunity to be pushed to optimal supply chain locations based on mission requirements.

Recommendations for Further Research

Follow-on research to assess and increase SCM efficiency can be broken down into three subject areas: parts, locations, and inventory management. Focusing efforts to understand shortfalls and limitations with demanded components, supply warehouse locations, and methods of managing inventories will position supply chain professionals to cultivate supply chain agility. Fostering agile SCM strategies will create a proactive rather than reactive supply chain response, resulting in improved readiness and increased combat capability.

Because of the robust nature of naval aircraft and equipment, an intimate knowledge of component lifespans and proper diagnosis of faulty parts and subsystems is a critical element to any supply system. Studies concerning failure rates of parts and engineering expectations may uncover additional supply chain vulnerabilities. Parts that are not identified or perceived as challenges will put undue burden on the supply chain and decrease SCM effectiveness. This research could also consider maintenance actions repairing and diagnosing inoperative components. Assessing personnel habits and techniques to repair aircraft may unearth training deficiencies that negatively impact supply systems. Parts can also be grouped into subcomponents and subsystems to assess categories of parts and find inconsistencies or obstacles that may be occurring because of a specific subsystem rather than discrete components.

Measuring the efficiencies of each supply node would also be conducive to research. Analyzing each supply warehouse location and routing identification code could provide additional insight to evaluate efficient locations. Through comparisons, research could



Ospreys operating in support of SPMAGTF-Crisis Response-Central Command. ***(Photo by Sgt Branden Bourque.)***

uncover valuable information about location productivity, available space for stock, and shipping/transportation responsiveness. This could unearth reasons for the use of supply distribution originating from the continental United States. Furthermore, information regarding host-nation requirements, such as customs obligations, must be considered to ensure impediments are mitigated and do not add to supply chain delays. Making informed decisions regarding supply nodes and locations, supply chain professionals could optimize the supply network depending on mission requirements in realtime.

Lastly, researching inventory management techniques and tools for supply warehouses and stockpiles could be beneficial to enhancing SCM effectiveness. Whether information technology systems are implemented to track and manage inventories, or locations manually account for inventories, various approaches to accountability could be assessed to determine the most resourceful. Again, supply professionals could modify inventory management methods to best fit each supply location benefiting the entire supply network.

Recommendations

Given operational tasks and dynamic changes in location, SCM recommendations are to levy sourcing activities within a squadron's and MEU's area of operation. Pushing inventories of readily available parts to theater DLA facilities or U.S. Navy supply points may be beneficial in reducing the response times of components critical to aircraft readiness. In this situation, DLA Sigonella, Italy, or DLA Sigonella at Rota, Spain, may have been more advantageous. An end user evaluating these results would have based his operational decisions on a one-to-two-week impairment in combat capability for specific components. A reduction in response time and strengthening of aircraft readiness may be achieved by prepositioning critical, frequently demanded, and low quantity components. The study uncovered an opportunity for supply professionals to proactively engage supply chains and confirmed SCM vulnerabilities. Not tethered to the MV-22 Osprey, this research and methodology could be used to assess supply chain agility across numerous platforms within the DOD.

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Notes

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8. Department of the Navy, *NAVMC 3500.11B, MV-22B, Training &Requirements Manual,* (Washington, DC: 2010).

>Author's Note: Keywords: supply chain management, Department of Defense supply chain management, big data, data mining, text mining, big data and supply chain management, MV-22 Osprey, MV-22 Osprey supply chain, Lexical Link Analysis.