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Posturing Spares for Great Power Competition

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POSTURING SPARES FOR GREAT POWER COMPETITION

EXECUTIVE SUMMARY

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Project Summary

Effectively posturing spares is essential to support forces for Great Power Competition. The purpose of this project was to study the effectiveness of spare-posturing strategies towards the improvement of operational availability by incorporating additive manufacturing (AM) into the supply chain. This study considered two situations. The first analyzed the naval aviation consumable spare part supply chains inclusive of AM as a supply source to fulfill orders within the United States Indo-Pacific Command (USINDOPACOM) sustainment network. These results would offer more definitive impacts that AM could have on naval aviation consumable repair parts lead time, especially for orders historically filled via contracts with longer lead times. This leads to the conclusion that the sooner we can operationalize AM to produce safe parts while running in parallel with traditional order fulfillment methodologies, the sooner we can see lead time improvements enterprise-wide even while AM-fulfillment only comprises a small fraction of orders. The second situation investigated how to better sustain the Phalanx Close-in-Weapon-System (CIWS) on guided missile destroyers (DDGs) in contested environments. This work found that the capabilities of 3D printing offer the Navy the opportunity to shorten sea lines of communication and provide critical repair parts to surface combatants engaged in near-peer combat in contested environments. In a time of fiscal constraints coupled with unreliable support provided by defense contractors, the reduced turnaround time of parts repaired utilizing 3D printing can offer increased sustainability of the CIWS found onboard DDGs. These studies provide motivation to pursue the technical skills needed within the Navy to produce critical components.

Keywords: *posturing spares, positioning spare parts, depot ship, additive manufacturing of spare parts, Close-In-Weapons System, CIWS, contested environment*

Background

DoD's strategic AM direction, put forth by the Joint Defense Manufacturing Council (2021) is driving towards a decentralized, downstream employment of AM throughout the spare parts supply chain, with smaller repair depots and end users primarily utilizing AM technology to produce critical repair parts. In this research, we imagine and simulate a Naval supply chain where the vast challenges regarding the implementation of AM have solutions, and AM productions sites are sources of supply similar to the role filled present day by DoD global distribution centers. Intellectual property, licensing, test and evaluation data, 3D computer-aided design (CAD) models, training of personnel, the safety of flight usage – the cavalcade of hurdles and challenges that all have been solved and put in place. In this world, when a user places an order for a part, the underlying supply system logic decides that if that part is not-in-stock, should that order be considered for printing? The primary research question in this part of the study is: how does the employment of a wide range of AM technologies impact the fulfillment of 9B cognizance code (COG) high-priority aviation consumables and affect the lead time for all 9B COG requisitions for deployed forces within the INDOPACOM area of responsibility (AOR) over a three-year time horizon? This study enhanced current tools for classifying the "printability" of individual national stock numbers (NSNs) and built a Monte-Carlo simulation based on historical fulfillment data to test assumptions about "printability" ratings based solely on an order's continuous characteristics, then attempted to stress a fictional but possible operational AM fulfillment network (Shields, 2023).

As the distribution of power evolves across the world and creates new threats, the DoD must continually seek ways to maintain a competitive advantage among dimensions of power that enable the US to advance its interests and values. America's competitors are becoming more assertive and technologically sound, meaning the Navy must improve readiness and adopt innovative capabilities. In the face of strategic challenges, it is important that there is a shift from legacy platforms to novel weapon system readiness. The purpose of this research was to evaluate the survivability of a primary defense weapon system onboard Arleigh Burke Class DDGs, the close-in weapon system (CIWS) under continuous operation in a contested environment based on current supply forecasting (Myles, Connell, and Loedeman, 2022). Currently, forecast supply models do not consider the increased demand in contested environments, nor additive manufacturing solution-based delivery. To extend the defense operational availability (Ao) time of primary defense systems, a selection methodology was used to identify the weapon components with the highest failure rates. Through simulation-based modeling, these components were evaluated for additive manufacturing capabilities and potential production onboard.

Findings and Conclusions

The primary recommendation offered aligns directly with current DoD AM strategic objectives. The sooner we can operationalize AM to produce safe parts while running in parallel with traditional procurement and order fulfillment methodologies, the soonerlead time improvements can be presented enterprise-wide, even when only a tiny segment of orders are fulfilled via AM. This is not a new insight. However, the results illuminate the quantitative levels of lead-time benefit potentially gained with an operationalized AM fulfillment source for naval aviation consumable repair parts and orders.

Based on our findings, there are opportunities to improve the design of our current defense supply system. Instead of carrying a surplus of critical spares, the process for determining the number of critical components should consider continuous usage in contested environments. The Navy must shift its readiness focus from dispensable legacy systems to prioritize advancement in weapon system speed and agility. Tactically and strategically, our forces must prepare to operate our current weapon systems for longer periods of time to counter adversaries in contested environments. If the Navy continues to carry current levels of spares onboard without considering continuous operations, it will limit its CIWS operation capabilities in contested environments.

Our findings also suggested that the Navy should investigate the feasibility of using AM to supply critical components on DDGs. This would increase the firing time of the CIWS and decrease the number of total spares carried onboard. Understanding that making changes to the defense budget process is complicated, analyzing spaces onboard DDGs, such as those that contain test benches, could potentially make space for new AM machines.

With the reinvention of an old idea, depot repair ships that have AM capabilities could support longer operational firing of primary weapons onboard warships in contested environments. Much like the concept that depot repair ships supported during World War I and II, using AM to posture spares can nearly eliminate logistic downtime and increase the amount of operational time at sea for DDGs and naval warships alike.

Recommendations for Further Research

This research offers numerous opportunities for future work and exploration. Several limitations within the simulation model could be areas to refine the model's parameters. For example, we could incorporate machine downtime and consider the availability of additive manufacturing (AM) machines due to scheduling work shifts and/or off-days. Other useful extensions to the simulation model would be to include into the printability heuristic cost parameters associated with engineering design time, raw materials, transportation, and operating expenses. As aforementioned, building more flexibility into the Poisson demand generator within this simulation, which can also model different demand types, such as intermittent or seasonal demand, would be a valuable addition to this effort. Refining several heuristic evaluation parameters to include more engineering-specific information on part design would add a greater level of fidelity to this model.

The most promising extension of this study is in collaborating and providing this research to the Naval Supply Systems Command (NAVSUP) Price Fighter Services and Naval Air Systems Command (NAVAIR) innovation labs for consideration and utilization into existing ongoing AM research into evaluating part and order printability. The hope is that this research informs current and future AM stakeholders to a small degree on how to best deploy, integrate, and exploit AM technology to best support the warfighter and serve the nation's strategic objectives.

Spares modeling has only just recently begun exploring endurance logistics regarding contested environments as a weakness of the Navy's deployed supply network. The simulations ran within this study demonstrate the effect of targeted replenishment to critical components of the close-in weapons system (CIWS) onboard guided-missile destroyers (DDGs) and the effect that AM could produce if no logistical support existed during a heightened battle scenario. There are many factors that go into how the Navy orders, distributes, and stores these assets onboard warships, but with space and cost being the largest factors the future of expedient replenishment at sea could take many forms that the readiness-based sparing (RBS) model does not yet account for. The integration and utilization of these design and manufacturing advancements could singlehandedly change the conversation on parts constraints onboard warships and how sparing models are implemented.

Given the current state and algorithms that enable RBS systems and allow placement of spares onboard all Naval warships, a production capability at sea would ultimately change the relationship that warships in need of parts could have with the logistics network. Clean labs using stable power, distilled water, and dehumidified air would be ideal sterile conditions to continue research of high caliber AM. Recreating proven industry printing method results, but at sea, is the next step for the Navy to take to ensure AM success in ocean environments.

References

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Acronyms

AM	Additive Manufacturing
Ao	operational availability
AOR	area of responsibility
CAD	computer-aided design
CIWS	Close-In-Weapons-System
COG	cognizance code
DDG	Guided-Missile Destroyer
INDOPACOM	United States Indo-Pacific Command
NAVAIR	Naval Air Systems Command
NSNs	national stock numbers
RBS	readiness-based sparing