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Logistic Network Model for Distributed Lethality

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EXECUTIVE SUMMARY

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Project Summary
In this study we evaluate a Gas Station resupply method for Distributed Lethality (DL) scenarios, and obtain some insights about the interplay among spatial, temporal and capacity parameters related to this mode of resupply. Our motivating questions are: What is the effect of the ratio between supply ship capacity and combat ship on-board capacity on logistic responsiveness? How does the location of the Gas Station affect that responsiveness? What is the impact of the number of Adaptive Force Packages (AFPs) served by the Gas Station? Shall the Gas Station be a shuttle (i.e., a ship that goes back and forth to port to replenish) or a delivery ship that is being resupplied by a separate shuttle? Our results do not necessarily establish a specific blueprint for logistic planning, but rather point out at key factors and considerations

Background
Changes in the global political and strategic environments have resulted in some modifications in US defense strategies. In particular, these changes have led to the emergence of a new naval operational concept: Distributed Lethality (DL) [1]. From the force-employment point of view, the DL concept calls for fragmenting the traditional naval battle/strike groups into smaller, more agile and lethal Surface Action Groups (SAGs) or Adaptive Force Packages (AFP) comprising a small number of surface vessels. The SAGs and AFPs operate in a distributed manner over a relatively large area of operations. Tactical implications of the DL concept have been studied by the Commander, Naval Surface Forces, Surface and Mine War-fighting Development Center Command, and Naval War College (NWC). The studies are based on a Distributed Lethality Task Force and war games conducted at the NWC. The DL concept brings about a serious logistic challenge: how to effectively and efficiently satisfy logistic demands at different times and many locations dispersed over a large area. A fundamental dilemma in this context is choosing between two logistic principles: flexibility, derived from concentrating resources, and attainability obtained from distributing them [2]. Concentrating resources at the operational level, either on land or afloat, enhances logistic flexibility by directing resources only to areas of need. This principle has two important benefits. First, similarly to the inventory-pooling principle in commercial supply chain management [3], operational flexibility saves resources and enhances efficiency. Second, holding resources in a central location at the back of the AOI minimizes the logistic tail of the forward deployed AFPs, and thus reduces the AFPs' signature as targets, and make them more tactically agile. Third, keeping the inventories afloat in the relatively safe communication zone, beyond the threat area, enhances the survivability of the supplies. However, these positive features of concentrating logistics at the communication zone come at the cost of timeliness; the lead time required for shipping supplies from a central theater source at the back of the theater to the DL tactical units may be long.

SAGs or AFPs are small and agile; they may find it difficult to "drag" a logistic tail and protect it. Thus, the DL concept implies the transition from the traditional shuttle ship/ delivery ship setup, typical to CVN battle groups, where a delivery ship is attached to the battle group and a shuttle ship resupplies it with resources pulled from the theater logistic base, to a new approach that we denote the *Gas Station* setup. In the Gas Station approach, the AFPs need to travel back from the combat zone to meet a resupply source, e.g., an AOE or T-AO ship, in the communication zone. The objective of this study is to evaluate the Gas Station resupply method for DL scenarios and obtain some insights regarding the interplay among spatial, temporal and capacity parameters related to this mode of resupply.

Findings and Conclusions

Distributed lethality is an operational concept that embodies significant logistic implications. The existing logistic system supporting carrier battle group, where the logistic tail is an integral part of the tactical force – the shuttle-delivery ship setup – will clearly be inappropriate when the force structure is fragmented into small AFPs. Attaching a logistic tail to each such AFP is neither economically viable nor operationally feasible. A new logistic structure is required that adequately responds to the new naval force layout.

In this report we model and analyze the Gas Station setup where an AOE is deployed at a certain resupply point in the communication zone and AFPs travel from their stations to that point to be resupplied. We define the utilization rate - the fraction of time the AFP is on station - as a measure of effectiveness. From a relatively simple model, with only one AFP, we see that for resupply points relatively far away from the AFP stations, the utilization rate is insensitive to the capacity of the AOE; the dominant factor is the travel time of the AFP to the resupply point. If the AOE is deployed closer to the combat area we see some differences in utilization rates for different capacities; for high capacities the utility is monotone increasing as the AOE gets closer to the combat zone but for low capacities there is an optimal resupply point closer to port. In the more realistic, and relevant, case when there are multiple AFPs we see that the utilization rate, as well as the probability an AFP has to wait for the AOE, are sensitive to the size of the operating force in the theater, but only when the force is relatively large. For any distance of the resupply point a, the utilization rate is very similar when the force size is between 1 and 4 AFPs.

Recommendations for Further Research

The work in this project can be extended in several directions. The linear situation described in this report (optimizing the value of the resupply point on a line) can be extended to a two-dimensional situation, taking into account spatial considerations, as well as variable demand scenarios. Also, the underlying queuing problem may be addressed with more rigorous mathematical tools. Finally, while our research did address attritional aspects embedding the logistic model in a combat one may produce additional insights.

References

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