Emerging Requirements for Optimization of Military Asset Management

STRATEGIC, TACTICAL, AND OPERATIONAL ASPECTS IN MILITARY ASSET MANAGEMENT

The greatest point of leverage in future asset management will come from coordinating decisions at strategic, tactical, and operational levels across organizational boundaries. This coordination results from an integrated view of overarching mission requirements as opposed to a functional view of requirements.

For example, optimizing the use of transportation assets may in fact diminish capabilities to achieve the overarching mission’s objectives. Additionally, decisions at the strategic, tactical, and operational levels are made by different organizations on different time scales. The types of decisions typically associated with asset management are illustrated in Figure 1. The connectedness of these decisions cannot be overlooked. The arrows in Figure 1 suggest that strategic decisions need to be made with the understanding of their impact on operational effectiveness. While this fact has been long understood, the tools used to measure these impacts are lacking in scope.

Figure 1. Supply Chain Decision Making
The tools present in AIO for example fall into the tactical decision making sphere. The tactical uses of this model are fundamentally two-fold: first, to create budgets and second to guide procurement actions. Both the budgeting and the procurement decisions are made at headquarters levels at a point in time that often precedes the time of asset deployment by years. Although its focus is tactical, AIO can also play a role in shaping strategic plans by providing rapid feedback to senior management on the stocking implications of supply chain design and configuration. For example, changing the types of repair that will be performed at a given echelon in the supply chain and changing the transportation times to move assets among locations dramatically impact the stocking requirements. AIO permits measurement of these impacts.

The modeling framework of AIO along with its probabilistic viewpoint, data requirements, output measures of effectiveness, and solution techniques are geared to address questions that are fundamentally tactical in nature. This framework limits the range of decisions that can be effectively addressed. To effectively integrate strategy, tactics, and operations in a coordinated manner, a new framework is required. This new framework should be based on the evolving trends in military asset management.

**Dynamic collaboration**

The emerging doctrine for Air Force operations, for example, calls for warfighting with interdependent joint forces, multiple rapidly-changing scenarios and courses of action (COA), and decentralized command. [Department of Defense (DoD). 2005. Command and Control Joint Integrating Concept Final Version 1.0] This implies that units must dynamically collaborate in mission planning, preparation, and execution. This is a marked departure from earlier doctrine in which units operated in a more self-sufficient manner and commanders had control over their local assets. Dynamic collaboration changes this situation dramatically. All elements of the DoD must become capable of functioning in a more collaborative manner, both within and across branches.

**Resource sharing**

In the Air Force, the original doctrine of self-sufficiency, in which a base is supplied with and assigned control over an array of dedicated assets to support its activities for an extended period of time, has been giving way to a doctrine of resource sharing, in which resources are pooled, perhaps centrally, and allocated or transshipped as needed to balance availability with need. Centralization of service parts and supplier commitments to performance-based logistics are key features of this trend. Furthermore, repair activity will increasingly be allocated across many locations based on available capacity and skills. Where repair will be done will not necessarily coincide with the location at which the need has arisen.

**Asset visibility**

Enterprise-wide information systems are being developed and deployed that capture transactions and status reports at the serial number level and will enable the visibility of assets and asset state throughout the enterprise from multiple perspectives (e.g. the Expeditionary Combat Support System, or ECSS). Less significant, but still worth noting, is the advent of sensor-based data on asset health.
Demand blurring

The causal factors underlying usage rates for service parts are becoming more complex and difficult to trace. In the past, aircraft were often deployed as squadrons or wings to a single location. The unit would also deploy maintenance and supply resources to support the mission of the deployed aircraft. Increasingly, aircraft are being deployed in a more opportunistic fashion, with maintenance and repair occurring at multiple locations, and often not at the operating location for many types of required repair actions. Each aircraft may experience unique and diverse missions that may change over time. In addition, aircraft such as the C-5, the C-17, and now unmanned air vehicles (UAVs), do not necessarily operate on a single base concept, but instead require network support even in peacetime operations. Correlating the demand for a service part at a particular base with traditional metrics such as base flying hours is becoming increasingly difficult and irrelevant.

In summary, the emerging doctrine demands highly collaborative interdependent systems. Effective collaboration depends on resource sharing. Effective resource sharing requires a high degree of asset visibility. Unfortunately, visibility does not imply predictability. Unpredictability will increase risk in tightly interdependent systems. Hence to mitigate these risks, the emerging business processes, information infrastructure, and decision support systems must be robust with respect to the presence of fundamental uncertainties. To address the operational requirements within this complex, real-time, and data driven environment, a fundamentally new class of optimization-based decision support tools is needed to manage assets effectively.

Implications and challenges for asset management, repair, and logistics

The four trends of increasing dynamic collaboration, resource sharing, asset visibility, and demand blurring have a number of implications and challenges for asset management, repair and logistics in general.

Dynamic collaboration requires real-time decision support

Like the transition from mass production to mass customization taking place in manufacturing systems, the transition to dynamic collaboration in warfighting and peacetime operations will require an investment in real-time enterprise-wide decision support systems for asset allocation and capacity management. Presently, the Air Force is committed to making such investments. To make asset management decisions effectively, they must be made quickly, they must recognize the real-time status of resources, they must consider the impact on and tradeoffs in operational capability, and they must address the uncertain nature of future demand. For example, the decision to use capacity at one location to repair an asset that fails at a different location can be best effected with real-time knowledge of the status of the overall system, an exploration of alternative uses for that capacity, and an assessment of the risks of using or not using that capacity for the proposed repair.

Asset visibility is not enough: planning visibility is required

Transaction capture systems, such as envisioned in the ECSS, are a necessary first step toward real-time asset allocation and capacity management systems; but, they are insufficient to meet the demands of dynamic collaboration. For the vision of dynamic collaboration to be realized, the plans must be as visible as the assets. That is, scenarios and courses of action must be visible within the system and these COA’s must be translated into projected resource requirements. This requirement raises numerous challenges. Chief among them are the information system challenges of representing the larger, more amorphous space of COA’s and the fact that COA’s can and must change at a much faster rate than the actual rate at which assets can change in state or deployment.
Resource sharing involves risk

Two major sources of risk need to be considered in light of the trend towards increased resource sharing. The first is network risk: the transition from dedicated stocks to centralized or pooled inventories increases the reliance of the system on transportation links and information transfers. This translates into making the system vulnerable to attacks or failures of transportation and information links.

The second is collaboration risk: collaboration requires trust, discipline, and incentive alignment. If these break down, as we have observed in other contexts, then centralized systems are subject to information hiding and status disguising. Informal networks and black markets coexist with centralized systems and flourish when the collaborative systems fail to provide basic levels of service. Care must be taken in defining resource pools and supply channels to capitalize on the benefits of centralization while ensuring that levels of service are sufficient to discourage anti-collaborative behavior.

Asset allocation and capacity management takes place under conditions of uncertainty

Assets in motion, whether in transit or repair, have momentum. We have noted above that COA’s change much more rapidly than the asset rate of change. Automated planning systems often exhibit a high degree of nervousness: small changes in inputs can ripple out into dramatic shifts in schedules that are output from these systems. These shifts can cause serious losses in efficiency as repair and logistics jobs are interrupted and reprioritized. Even if the nervousness of automated systems can be dampened, planning volatility can be expected to increase with the requirements for dynamic collaboration. The volatility of plans combined with the trend of demand blurring translates into high degrees of fundamental demand uncertainty for materiel management.

To a lesser extent, another trend contributes to the uncertainty. Historically, aircraft and engines have been subjected to periodic maintenance schedules. With the advent of sensor-based equipment health systems, we can expect to see these repair cycles evolve to a more dynamic health-driven frequency. Whatever the cost advantages of this trend from a reduction in maintenance frequency, it is clear that the unpredictability of maintenance activity will increase. This will translate into queueing effects in repair facilities and increased uncertainty in the timing of demands for service parts.

Recognition of the fact that assets in motion have momentum leads to a recognition that cycles, cutoffs and frozen periods will still be required in asset allocation and capacity management systems in order to buffer the transportation and repair systems from the inherent volatility in planning systems. To be sure, these cycles, cutoffs, and frozen periods will trend downwards but only as fast as the underlying physical systems can be re-engineered to respond.

One of the great challenges in this field will be to make repair and logistics decisions within the frozen windows that take into account the uncertainties that exist beyond the frozen period. The ability to hedge decisions, such as holding stock or capacity in reserve for the unforeseen, and to bet on priorities, such as which competing need to satisfy, will have a major impact on the effectiveness of the system in a complex world.
Priorities for asset management, repair, and logistics support systems

This analysis of trends and their implications leads us to the following agenda for asset management, repair and logistics.

1. **Establish dynamic reserve requirements, allocation thresholds, and repair priorities based on uncertainty and mission priorities**

Based on probabilistic resource requirements and a detailed knowledge of the evolving logistics network, optimization tools are needed to search out a set of dynamic reserve, allocation, and priority rules to transship, repair, stage, and deploy assets for maximum effectiveness in both the near and medium term. These networks may evolve slowly or abruptly. For example, a large number of aircraft may be deployed over a short period of time to operating locations distant from their home bases. A repair and logistics plan will be developed to support the deployment and must be tested. By measuring the effect of employing dynamically optimized decisions, the scenario of resource requirements can be evaluated to assess the ability to meet mission objectives.

2. **Allocate critical assets in real-time**

There are only limited decision support tools presently available to implement the policies established for real-time asset allocation for critical resources. What is needed is an integrated view of stock availability, transportation assets and schedules, mission requirements, and repair capability. This integrated viewpoint must consider the inherent uncertainties in operational and logistics environments, and must be capable of rapid reconfiguration. As a consequence, these models must be stochastic in nature. Their formulation will differ dramatically from the stationary perspective of AIO-type planning tools. Correspondingly, the methods for suggesting operational actions will likely be radically different. It is also likely that parallel computing will play a significant role in supporting real-time asset allocation.

3. **Compare scenario serviceability rapidly**

The overall cycle of scenario formulation, course of action generation, translation into probabilistic requirements, support decision optimization, and serviceability simulation must be completed sufficiently quickly to provide actionable feedback to appropriate command staff.

4. **Optimize repair schedules**

There are some long-standing asset management problems that have not been effectively thought through even today. In particular, the problem of coordinating life-limited components is a missed opportunity of great significance. Modular engines have life-limited components. When a component nears the end of its current life, the engine must be removed, and the component replaced, with the removed component being placed in the reverse logistics repair and refurbish system. Unless the remaining lives of life-limited components on an engine are closely matched, engine removals from an airframe are too frequent. However, matching the ages of components to use in maintenance and repair demands centralized control of these components, efficient mechanisms to share these components, and a high degree of asset visibility. These are precisely the trends now taking place. Thus, this long-standing problem in engine repair management is within reach of a solution through the Reliability Centered Maintenance Program. Developing optimization-based approaches to enhance the matching problem, under all the conditions of uncertainty described above, is potentially of significant importance.

5. **Define asset pools and supply chain channels**

As noted above, care must be taken in defining asset pools and supply chain channels to take advantage of resource sharing but also to minimize collaboration risk by ensuring that the most commonly needed service parts are readily available. Optimization tools can be developed to balance these tradeoffs automatically.
6. **Optimize stock levels and asset acquisition schedules**

Taking into consideration the dynamic and probabilistic nature of the demand, the definition of asset pools, the choice of supply chain channels, and the reverse logistics of reparable parts, optimization tools are needed to plan and schedule the acquisition of new parts.

7. **Optimize budget allocations for weapons system support**

Taking into account all of the above, for given capital appropriations, optimization tools are needed to determine the composition of the service parts budget that maximizes the ability of to meet operational targets.

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