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AoA Paradigm for Early Visibility of Logistics and Cost in the Acquisition Process

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NPS NRP Executive Summary
Program Wholeness in Acquisition System
Report Date: 12/10/19 Project Number (IREF ID): NPS-19-N176-A
Naval Postgraduate School Graduate School of Operational and Information Sciences
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EXECUTIVE SUMMARY

Project Summary
Analysis of Alternatives (AoA) is a study comprising a crucial part in the process of acquiring a new system for the DoD. AoA is a multi-dimensional decision process that involves several criteria and stakeholders. There are three sets of criteria according to which alternatives are evaluated in an AoA. In most studies, typically, two of the three sets— effectiveness criteria (what can the system do and how its capabilities fit the operational requirements) and cost criteria (acquisition and lifecycle cost)—draw most of the attention. The third set, usually given less attention in an AoA, is concerned with long-term readiness and sustainment implications.

Our research focuses on this third set of criteria, and has two goals: (a) study the set of criteria related to readiness and sustainment, and define measures of effectiveness (MOEs) that help evaluate these criteria, and (b) develop an aggregation process that transforms the MOEs values of the alternatives into a single relative value. In this report we study in detail the criteria that affect the long-term viability and usefulness of an alternative, which determine readiness and sustainment, and propose an analytic framework for evaluating the relative merit of alternatives with respect to those criteria.

Keywords: *Analysis of Alternatives AoA, readiness, sustainment, Data Envelopment Analysis, DEA*

Background
The DoD Acquisition System comprises three interconnected stages that start with specifying requirements: a procedure called Joint Capabilities Integration and Development System. The second stage, called the acquisition process, determines appropriate materiel solutions for the requirements. The third stage is concerned with funding and financial-controlling activities contained in the planning, programming, and budgeting execution process. Most of the decisions that have long-term sustainment, readiness and logistics implications are taken at the second stage, where materiel choices are made. The overarching process dominating this stage is the AoA, which in general, trades off the effectiveness of a materiel solution with its risks and costs. The AoA in the acquisition process is essentially a large-scale multi-criteria decision analysis (MCDA) problem that involves multiple stakeholders and many uncertainties. The set of criteria used in evaluating alternatives, and their weights or importance, depend, among other factors, on the availability of the aforementioned alternatives. For example, the risk associated with acquiring an off-the-shelf system is considerably lower than the risk in developing a new system. Thus, the "risk" criterion, with all its derivatives, is less prominent for the former than the latter.

In this study, we focus on systems that are still in various stages of development, which means that the AoA process is typically not a "one-shot" decision event, but rather a sequence of decisions marked by milestones. In these settings, the AoA starts off with a set of potential alternatives being developed as

prototypes. As time passes, data is collected and information is gained with respect to each contending alternative. Each milestone in the research and development (R&D) phase involves solving a MCDA problem that determines which alternatives continue to be relevant, and therefore continue in the R&D phase, and which alternatives are dominated, and therefore deleted from further consideration. The process culminates in a winning alternative.

The purpose of this research is to define the criteria relating to readiness and sustainment, and develop a model that aggregates evaluations regarding these criteria. The new paradigm may facilitate better (and earlier) awareness to sustainment considerations, readiness implications, and total ownership cost during the acquisition process.

Findings and Conclusions

The readiness of a system has three different aspects: technological, technical and functional. Technological readiness describes the state of a system while still being developed, while technical and functional readiness relate to a system when it is fully operational and already deployed. Our study focuses on the latter two aspects of readiness. A system is technically ready if all its components are in a perfect working condition, and functionally ready when its supporting resources, such as infrastructure, energy, communication and personnel, are available and functioning.

We find seven MOEs for evaluating an alternative with respect to readiness and sustainment:

Mean Time Between Downs is a combination of the mean time between failures and the mean time between regular services. The former is a probabilistic parameter and the latter is typically a deterministic parameter specified by the manufacturer; we propose a formula for estimating this parameter.

Mean Down Time is calculated as a combination of down time following a failure, and regular scheduled service time. In the study we propose a formula that combines the deterministic (scheduled service) and probabilistic (failure repair) time parameters.

Maintenance Cost is comprised of fixed costs of infrastructure (e.g., shops, storage facilities, labs, equipment, personnel) and variable cost (e.g., replaceable parts, energy); we develop a formula for estimating this cost.

Operational Cost covers the actions needed for operating the system. Such a set is typically well defined as it establishes the foundation for functional readiness. This cost is measured by the number of operators and controllers, broken down by required skills, cost of operating facility (when applicable) and the amount and type of energy and supplies needed for the operation.

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Interdependency is a crucial, yet elusive, characteristics. The more a system depends on other systems, the more it is vulnerable to possible breakdowns and failures of those peripheral systems. We develop a new MOE for measuring the impact of interdependency.

Personnel is mentioned in the Operational Cost mentioned above; however, we also need to take into consideration the sensitivity of the alternative system to staffing. The latter includes the number of personnel and their skill set. we propose a new measure for this factor.

Supply chain (SC) is affected by many factors, which can impact its robustness and how it supports a system. However, the literature has not reached a consensus on how to measure its impact. We propose using an ordinal scale for ranking the alternatives according to the impact of the SC.

Next, we develop an aggregation process based on data envelopment analysis (DEA). DEA has been applied to hundreds of application areas including several DoD-related applications such as evaluating the efficiency of air-force maintenance units and US Army recruitment centers. DEA is a non-parametric methodology for comparing multiple entities, which use several inputs to produce several outputs. In the report we give more details about the methodology and demonstrate its effectiveness on an example.

Recommendations for Further Research

The methodology described above could be applied at any stage of the AoA, and expansion of this work is worthwhile. Obviously, as the development process of an alternative progresses, more information and data are available, and thus the evaluations become more robust and significant. However, we recommend initially implementing our methodology as an ongoing AoA study; after some feedback, the number of MOEs could be expanded by breaking down the factors to sub-factors, creating a hierarchical structure similar to the Analytic Hierarchy Process. Further research could also take data from an implementation and analyze its impact.

Acronyms

Analysis of Alternatives	AoA
Department of Defense	DoD
data envelopment analysis	DEA
multi-criteria decision analysis	MCDA
measure of effectiveness	MOE
research and development	R&D
supply chain	SC