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Analysis of Alternatives: Keys to Success

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RAND Corporation

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Preface & Acknowledgements

Welcome to our Ninth Annual Acquisition Research Symposium! This event is the highlight of the year for the Acquisition Research Program (ARP) here at the Naval Postgraduate School (NPS) because it showcases the findings of recently completed research projects—and that research activity has been prolific! Since the ARP's founding in 2003, over 800 original research reports have been added to the acquisition body of knowledge. We continue to add to that library, located online at www.acquisitionresearch.net, at a rate of roughly 140 reports per year. This activity has engaged researchers at over 60 universities and other institutions, greatly enhancing the diversity of thought brought to bear on the business activities of the DoD.

We generate this level of activity in three ways. First, we solicit research topics from academia and other institutions through an annual Broad Agency Announcement, sponsored by the USD(AT&L). Second, we issue an annual internal call for proposals to seek NPS faculty research supporting the interests of our program sponsors. Finally, we serve as a "broker" to market specific research topics identified by our sponsors to NPS graduate students. This three-pronged approach provides for a rich and broad diversity of scholarly rigor mixed with a good blend of practitioner experience in the field of acquisition. We are grateful to those of you who have contributed to our research program in the past and hope this symposium will spark even more participation.

We encourage you to be active participants at the symposium. Indeed, active participation has been the hallmark of previous symposia. We purposely limit attendance to 350 people to encourage just that. In addition, this forum is unique in its effort to bring scholars and practitioners together around acquisition research that is both relevant in application and rigorous in method. Seldom will you get the opportunity to interact with so many top DoD acquisition officials and acquisition researchers. We encourage dialogue both in the formal panel sessions and in the many opportunities we make available at meals, breaks, and the day-ending socials. Many of our researchers use these occasions to establish new teaming arrangements for future research work. In the words of one senior government official, "I would not miss this symposium for the world as it is the best forum I've found for catching up on acquisition issues and learning from the great presenters."

We expect affordability to be a major focus at this year's event. It is a central tenet of the DoD's Better Buying Power initiatives, and budget projections indicate it will continue to be important as the nation works its way out of the recession. This suggests that research with a focus on affordability will be of great interest to the DoD leadership in the year to come. Whether you're a practitioner or scholar, we invite you to participate in that research.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the ARP:

- Office of the Under Secretary of Defense (Acquisition, Technology, & Logistics)
- Director, Acquisition Career Management, ASN (RD&A)
- Program Executive Officer, SHIPS
- Commander, Naval Sea Systems Command
- Program Executive Officer, Integrated Warfare Systems
- Army Contracting Command, U.S. Army Materiel Command
- Office of the Assistant Secretary of the Air Force (Acquisition)

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- Director of Open Architecture, DASN (RDT&E)
- Program Executive Officer, Littoral Combat Ships

We also thank the Naval Postgraduate School Foundation and acknowledge its generous contributions in support of this symposium.

James B. Greene Jr.
Rear Admiral, U.S. Navy (Ret.)

Keith F. Snider, PhD
Associate Professor

Panel 11. Getting the Front End Right in Major Defense Acquisition Programs

Wednesday, May 16, 2012	
3:30 p.m. – 5:00 p.m.	**Chair: Lorna B. Estep**, Deputy Director of Logistics, Air Force Materiel Command **Discussant: Katherine Schinasi,** Independent Consultant, former Managing Director, U.S. Government Accountability Office ***Basis for a Rational Defense: Acquiring the Right Capability*** J. David Patterson, *National Defense Business Institute, The University of Tennessee* ***Analysis of Alternatives: Keys to Success*** John F. Schank, *RAND Corporation*

Lorna B. Estep—Ms.Estep is the deputy director of logistics at the Directorate of Logistics and Sustainment, Headquarters Air Force Materiel Command, Wright-Patterson Air Force Base, OH. Ms. Estep is a member of the Senior Executive Service. She is responsible for the Materiel Support Division of the Supply Management Activity Group, a stock fund with annual sales of $7 billion. She directs a wide range of logistics services in support of Air Force managed spare parts, to include transformation programs, requirements determination, budgeting, acquisition, provisioning, cataloging, distribution and data management policy. She also provides supply chain management policy, guidance and direction in support of headquarters, air logistics centers, and U.S. Air Force worldwide customers.

Estep started her career as a Navy logistics management intern. She has directed the Joint Center for Flexible Computer Integrated Manufacturing, was the first program manager for Rapid Acquisition of Manufactured Parts, and has served as technical director of Information Technology Initiatives at the Naval Supply Systems Command. In these positions, she has developed logistics programs for the Department of Defense, implemented one of the first integrated and agile data-driven manufacturing systems, and directed the development of complex technical data systems for the Navy.

Katherine Schinasi—Ms. Schinasi is currently an independent consultant. Until its sunset in 2011, Ms. Schinasi was a commissioner with the Commission on Wartime Contracting in Iraq and Afghanistan, a position she was appointed to by the Senate Majority Leader. The bipartisan Commission was established and charged with recommending contract-related improvements in contingency environments. Ms. Schinasi continues to provide advice and assistance to Congress on implementing the Commission's recommendations.

Beginning in 2009, Ms. Schinasi was a senior advisor to The Conference Board, a non-profit research firm in New York. As such she was responsible for conducting and commissioning academic-level research on 21st century information and communications networks and their impact on society and culture. She co-edited *The Linked World: How ICT is Transforming Societies, Cultures, and Economies* and continues to provide assistance to the business community on those issues.

From 1978 until March 2009, she was employed by the Government Accountability Office, serving the last six years as managing director for acquisition and sourcing management. Her portfolio included operations in the Departments of Defense, State, and Homeland Security, and cross-governmental acquisitions. In her position, Ms. Schinasi testified frequently before

congressional committees on topics of defense trade and investment, export controls, the acquisition of services and major developmental systems, and the relationship between government and private sector businesses.

She was a frequent lecturer at the Defense Acquisition University, the Industrial College of the Armed Forces, and the Naval Postgraduate School. Her team of 180 people, based in five U.S. locations, was responsible for recommendations that led to billions of dollars in savings and improved government operations, including those involving government-contractor relationships. She was appointed to the federal Senior Executive Service in 1998.

Ms. Schinasi received an MA in international relations from the School of International Service, American University, and a BA in government and politics from the University of Maryland.

Analysis of Alternatives: Keys to Success

John F. Schank—Schank (MS, Operations Research, University of Pennsylvania) joined RAND in 1972. He has been involved in a wide range of analysis that has included industrial base analyses, cost analyses, and studies of manpower, personnel, training, and logistics issues at both the Service and joint level. He has led or co-led numerous projects for the U.S. Navy, the U.S. Coast Guard, the Office of the Secretary of Defense, and the United Kingdom's Ministry of Defence. Among his larger, more influential studies were a project on sustaining the U.S. capability to design nuclear submarines, which resulted in the addition of more than $9 million to the Navy's submarine design budget to begin work on the next class early; an analysis of alternatives (AoA) on transit of special forces through littoral areas; and an AoA on the next-generation sea-based strategic deterrent. His other recent studies have dealt with increasing aircraft carrier forward presence, sustaining key skills in the UK naval industry, workload- and workforce-management practices in U.S. Navy shipyards, and relating littoral combat ship performance to mission package inventories, home ports, and installation sites. He has authored or coauthored close to 100 documents for RAND.

Abstract

An analysis of alternatives (AoA) is an important step in the acquisition process. It is one of the first places where the requirements community and the resource community must come together to identify a preferred material solution that can fill a shortfall in desired operational capability. AoAs inform Service, Office of the Secretary of Defense (OSD), and congressional decision-makers on the relative cost effectiveness of viable alternatives that meet the desired capabilities.

Based on conducting several AoAs for the various military Services, RAND has formed a set of important considerations when conducting an AoA:

- develop a thorough study plan that considers a range of alternatives and baselines,
- form effect relationships with oversight committees;
- conduct trade-off analyses and examine sensitivities;
- have a flexible analysis methodology;
- display results that are easily and quickly understood; and
- recognize and estimate technical, design, and production risks.

Introduction

An analysis of alternatives (AoA) is an important step in the acquisition process. It is one of the first places where the requirements community and the resource community must come together to identify a preferred materiel solution that can fill a shortfall in desired operational capability. AoAs inform Service, Office of the Secretary of Defense (OSD), and congressional decision-makers on the relative cost effectiveness of viable alternatives that meet the desired capabilities.

AoAs use an objective, systematic, and unbiased process to identify, evaluate, and document the costs and mission effectiveness of alternative systems. AoAs help establish critical mission characteristics and system performance requirements, and then identify potential alternative systems that can satisfy those requirements. An AoA develops an analytic framework and methodology to measure the operational performance and total costs of each alternative. It then develops appropriate cost-effectiveness measures and presents the findings and recommendations to the acquisition executives.

The objective of this paper is not to describe and define how to conduct an AoA. There are numerous sources for that information (e.g., Defense Acquisition University, n.d.; Office of Aerospace Studies, Air Force Materiel Command, 2008). Nor is the intent to present some new revelations on the conduct of AoAs. Rather, the objective is to coalesce a

number of important aspects of AoA execution that are self-evident to us all, but that often fall through the cracks during the complex and often time-constrained conduct of the analysis.

The paper describes several important principles that can help contribute to the success of an AoA. They are based on insights drawn from several AoAs conducted by RAND (Moore, 2004; Kennedy et al., 2006), including those examining the Joint High Speed Vessel (JHSV; Schank et al., 2006), Sea-Based Strategic Deterrent (SBSD; Schank et al. 2010), the Coast Guard's Offshore Patrol Cutter (OPC; Arena, 2011), and various assets under consideration by the Special Operations Command (USSOCOM; DeLuca et al., 2008, 2009). Success is measured not just by the acceptance of the AoA by the decision authorities, but by how thoroughly it identifies alternatives; evaluates the costs, effectiveness, and risks of those options; and presents the findings in a way that decision-makers can understand the trade-offs between operational requirements, system capability, and cost.

The paper is timely since the Government Accountability Office (GAO) recently criticized the conduct of previous AoAs (GAO, 2009). Based on reviewing over 20 completed AoAs, the GAO found that many AoAs did not consider a robust range of alternatives or adequately consider the cost, schedule, and performance trade-offs. Many AoAs did not fully understand the operational requirements and lacked sufficient knowledge of available and future technologies. Because knowledge of technologies, design risks, and production impacts was lacking, many AoAs based their performance, cost, and schedule estimates on optimistic assumptions. Also, the GAO criticized the OSD and the Services for not providing adequate guidance on the conduct of AoAs.

Three Fundamental Questions All AoAs Address

An AoA basically answers three questions:

- What are the desired operational capabilities (Do What?)
- What systems and technologies are or will be available to provide the desired capabilities (With What?)
- What are the costs and performance of the alternatives (How Well)?

These three questions can be answered through six high-level tasks as shown in Figure 1. The first task establishes how the systems will operate and scenarios for measuring operational performance. The second task identifies key performance parameters (KPPs) and the measures of effectiveness (MOEs) and performance (MOPs) that will help in the evaluation of the alternatives. In parallel to the first two tasks, Task 3 identifies viable alternatives that typically combine various platforms and systems, such as propulsion or sensors. Tasks 4 and 5 then use the scenarios, MOEs, and MOPs to estimate the effectiveness and total costs, respectively, of each alternative. Task 6 combines the cost and effectiveness analyses and presents the findings and recommendations to the Service and OSD decision authorities. Each basic task is decomposed into several subtasks.

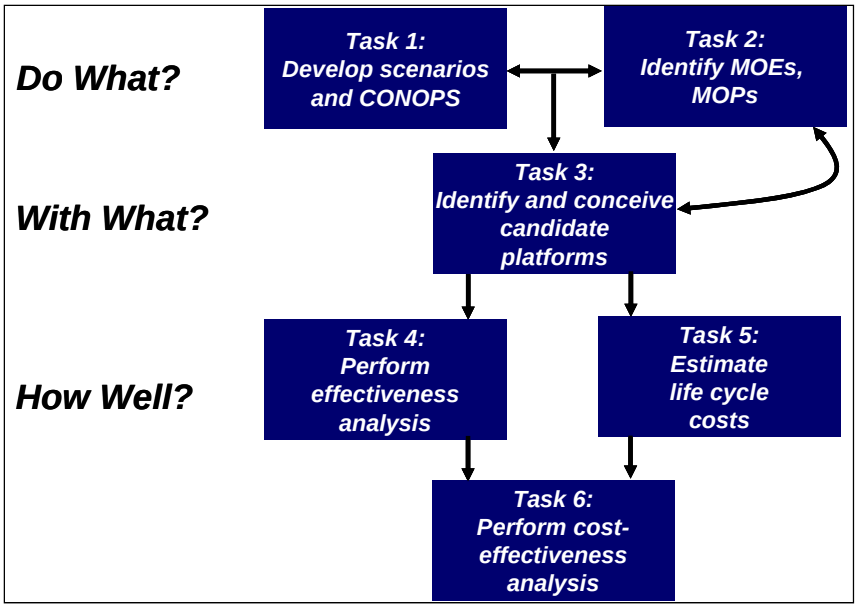

Figure 1. Six Tasks Help Address Three Basic Questions

Most AoAs are conducted in a teaming environment with a lead study director and study organizations supported by subject-matter experts in several key areas. For example, in the AoAs RAND has conducted, cost and engineering organizations from the Naval Sea System Command, other federally funded research and development centers (FFRDCs), and even private-sector organizations have been part of the AoA team.

The six basic tasks in Figure 1 seem straightforward enough, but there are underlying complexities that must be addressed for an AoA to be successful. These include the following:

- develop a thorough study plan that considers a range of alternatives and baselines;
- form effect relationships with oversight committees;
- conduct trade-off analyses and examine sensitivities;
- have a flexible analysis methodology;
- display results that are easily and quickly understood; and
- recognize and estimate technical, design, and production risks.

In the following sections, we discuss lessons that we have learned in discussing each of these complexities.

Develop a Thorough Study Plan

Figure 2 shows that an approved study plan is required before an AoA can start. An approved Initial Capabilities Document (ICD) defines the gap in operational capability and the requirement for a solution to fill that gap. The ICD may also suggest general alternatives that can provide the materiel solution based on functional studies conducted during the development of the ICD.

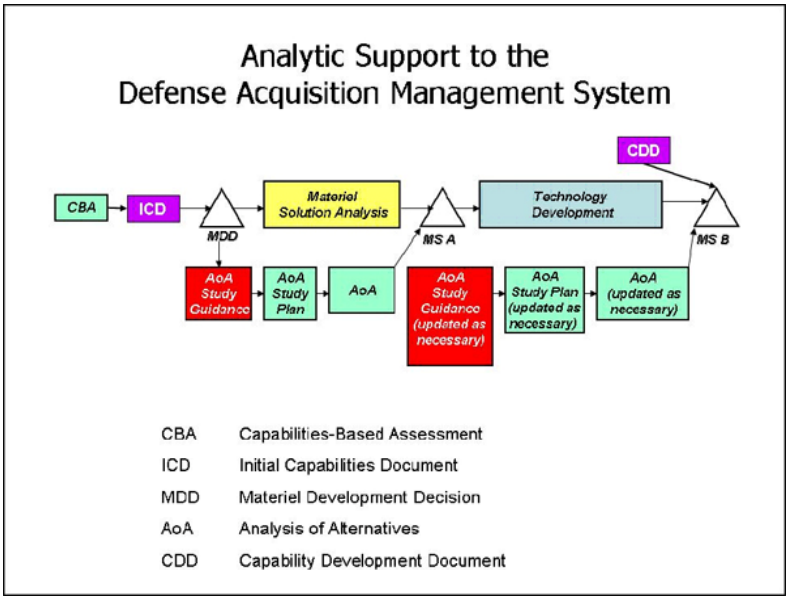

Figure 2. AoAs and the Defense Acquisition Process[1]
(DAU, n.d.)

The Director, Cost Assessment and Program Evaluation (CAPE) provides study guidance for the AoA. This guidance, along with the ICD, feeds into the development of the study plan.

The study plan provides guidance and objectives for the conduct of the AoA. It is the agreement between the AoA study director and the Service and OSD oversight organizations on what will be accomplished and how it will be done. The study plan identifies

- the scope of the analysis, the ground rules, and assumptions;
- the concepts of operation and the scenarios for evaluating mission effectiveness;
- an initial set of MOEs and MOPs for evaluating mission performance;
- the broad classes of alternatives and the system trade-offs within alternatives;
- the range of cost elements for estimating the total cost of each alternative;
- the roles and responsibilities of the organizations that make up the study team;
- the responsibilities of the oversight groups; and
- the schedule and deliverables during the conduct of the AoA.

The study plan must be thorough, clear, and concise. A good study plan is a prerequisite for a successful AoA. Adequate time and resources must be devoted to develop the study plan. Guidance and inputs from the subject-matter experts, as well as from the Service and OSD oversight organizations, are essential for the development of a study plan that will serve as the map—agreed to by all stakeholders—guiding the analysis.

Form Effective Relationships with Oversight Committees

Effective relationships with Service and OSD oversight groups are important for the AoA study director and study team. Ultimately, the oversight groups must approve the AoA.

[1] This is Figure 1 from the Defense Acquisition University website. The figure and a nice overview of the development and organization of an AoA study plan is at https://acc.dau.mil/CommunityBrowser.aspx?id=314769.

These groups will also provide guidance during the AoA and may require the evaluation of additional alternatives or trade-offs between system performance and operational requirements.

Critical to the interactions between the AoA study team and the oversight groups is the establishment of a steering group. The steering group should provide guidance as issues arise as well as access to subject-matter experts and various stakeholders. The steering group should work with the study director to approve decisions as analysis progresses.

The steering group should be comprised of representatives from research and development centers who can inform the study team of the status of various technologies. There should also be representatives from the program office, costs organizations, operational commands, and support and logistics groups. The group should have a chairperson appointed by the Service or OSD. The study director should meet with the steering committee on a monthly basis to discuss issues and potential solutions to those issues.

Again, effective interactions and relationships between the study director and the oversight groups are essential for a successful AoA.

Conduct Trade-Off Analyses

The primary purpose of an AoA is to evaluate the cost-effectiveness of the alternatives. However, the AoA should go beyond evaluating basic alternatives. It must examine trade-offs between various systems or subsystems and between operational requirements and the ultimate costs of meeting those requirements. For example, an AoA should address the following questions:

- How do operational requirements drive system performance?
- What is the operational impact of relaxing various system requirements?
- What new technologies (and associated risks) are needed to achieve operational goals?
- How does cost relate to desired mission performance?
- Which attributes drive costs and risks?

Figures 3 and 4 show a trade-off analysis that was conducted during the JHSV AoA. The alternatives evaluated during that AoA were basically different types of hulls, such as mono-hulls, multi-hulled designs, and surface effect ships. But the choice of the propulsion system also impacted cost and performance. Figure 3 shows how the choice of a propulsion system resulted in different force levels that would be required to deliver a combat force into a theater in a given number of days (a duration known as closure time). As shown in the figure, diesel propulsion systems needed more vessels for a given closure time compared to gas turbine (GT) or combined diesel and gas turbine systems (CODAG).

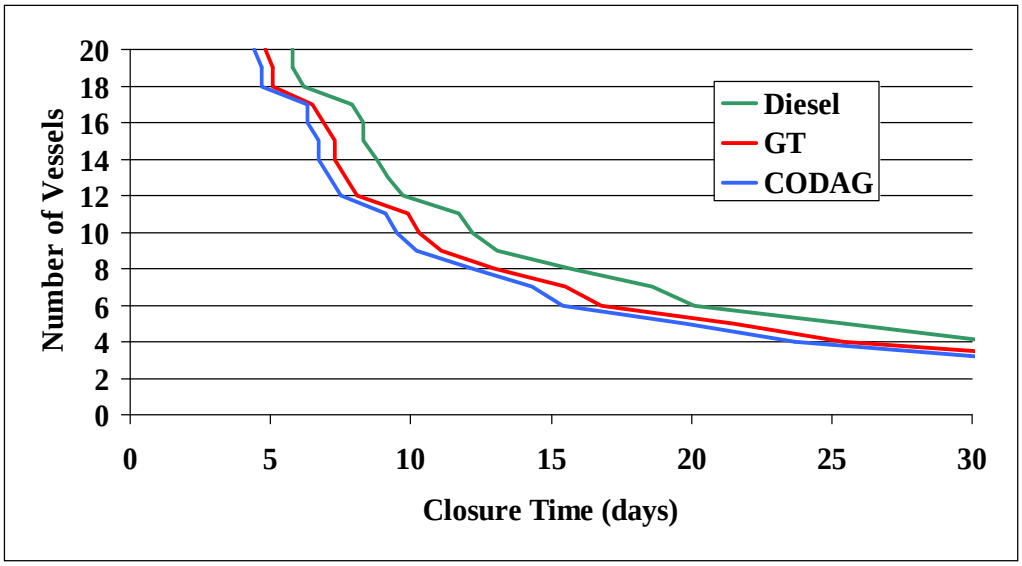

Figure 3. Propulsion System Trade-Off Between Closure Time and Number of Vessels

However, as shown in Figure 4, further analysis showed that the total acquisition costs for the force were largely the same across the three types of propulsion systems for a given closure time.

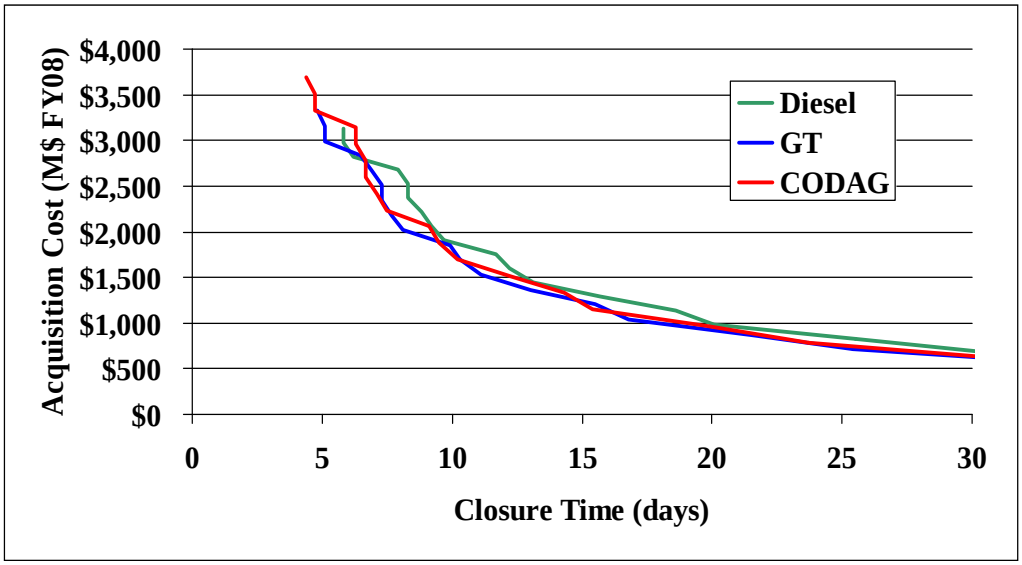

Figure 4. Propulsion System Trade-Off Between Closure Time and Acquisition Cost

Figure 5 shows another trade-off analysis that was informative during the SBSD AoA. That AoA had to address not only the type of platform but also the size and number of missile tubes. The analysis depicted in Figure 5 identified breakpoints for missile tube diameter. For example, for Tomahawk missiles there was no difference in the number of missiles that could fit into tubes between 94 and 103 inches in diameter. Since larger tube diameters meant bigger hull forms, this trade-off analysis helped define the cost-effective size of the platform under various missile payload assumptions.

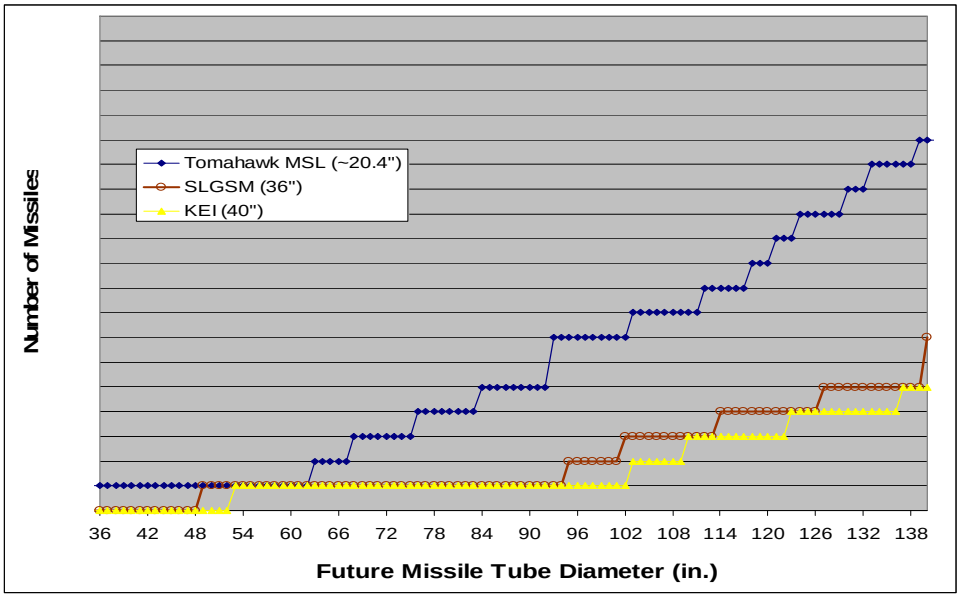

Figure 5. Number of Missiles in Different Diameter Tubes

Have a Flexible Analysis Methodology

Things will change during an AoA. New alternatives will be defined. Additional MOEs and MOPs will be identified. New scenarios or mission requirements will be added or modified. New questions will arise. The original study plan will morph as the AoA progresses. Because of these inevitable changes, the AoA must develop a flexible and transparent methodology for evaluating effectiveness and estimating costs that can adapt as changes arise. This methodology must be understood and approved by the steering and oversight groups. Typically, several simple, easily understood models are better than a single large, complex model that clouds the relationships between variables.

Display Results in a Way That is Easily Understandable

AoAs typically deal with complex issues. Multiple factors and variables surrounding operational requirements, system performance, and cost are often interrelated. The AoA must capture this complexity yet clearly show the impact of different decisions and choices. The charts, graphs, and tables that display results of the analyses are the mechanisms the AoA uses to transmit the findings and recommendations. These displays must be easy to understand and decipher.

Figure 6 shows a display that we used in one AoA to show the effectiveness of various alternatives in several mission areas. Although no single alternative proved most effect in all mission areas, the operational value of alternatives A and B clearly stood out when considering the range of missions.

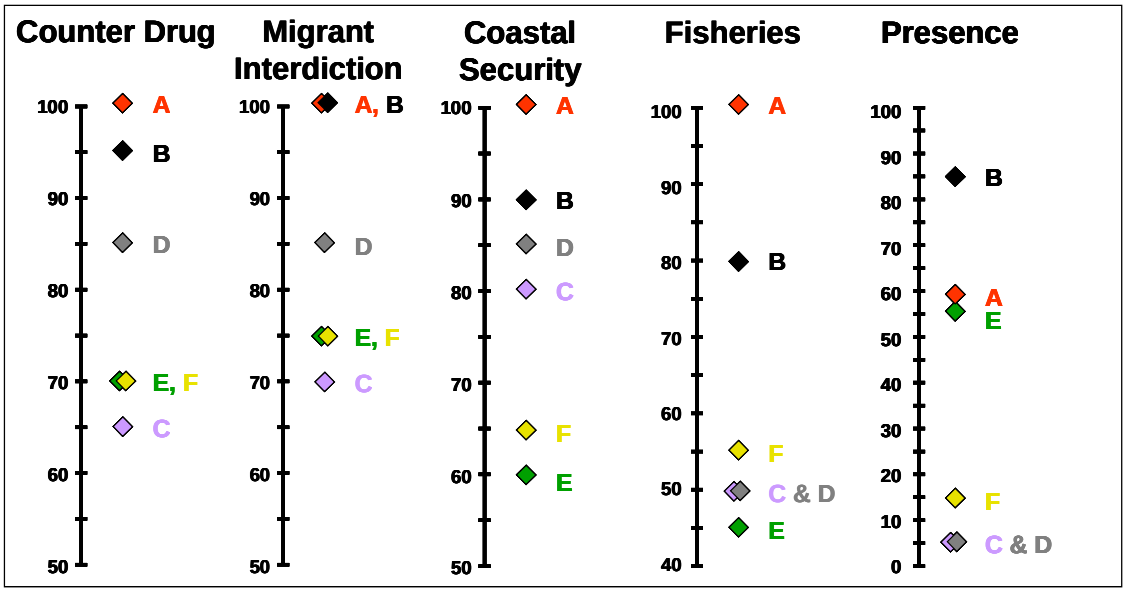

Figure 6. Comparing the Effectiveness of Platforms Across Missions

Table 1 shows another display that related various MOEs and MOPs across the various alternatives. Here, alternatives A, E, and G all performed equally well. Finally, Figure 7 shows a display used to relate life-cycle cost to mission effectiveness for various alternatives. In this example, alternatives K and L were shown to be very costly for the capability they provided.

The study director must be creative in putting together the displays that show the results of the AoA. Typically, it is better to have several simple charts that build on each other rather than a single, complex chart where relationships are not obvious.

Table 1. Comparing Effectiveness of Various Alternatives

Alternative	Measures of Effectiveness		Measures of Performance		
	%of TOI Prosecuted	% of Traffic Detected	Small Boats	Advanced C4I	Aviation
A	20%	31%	3	Yes	HH60/VUAV
B	15%	27%	2	No*	HH65
C	14%	24%	?	No	HH60/VUAV
D	17%	27%	?	No	HH60/VUAV
E	20%	31%	2	Yes	HH60/VUAV
F	15%	26%	2	No	HH65
G	20%	31%	2	SWAP	HH60/VUAV
H	18%	29%	2	No	HH60
I	18%	29%	2	No	HH60
J	18%	29%	2	No	HH60
K	18%	29%	3	No	HH60
L	18%	29%	2	No	HH60

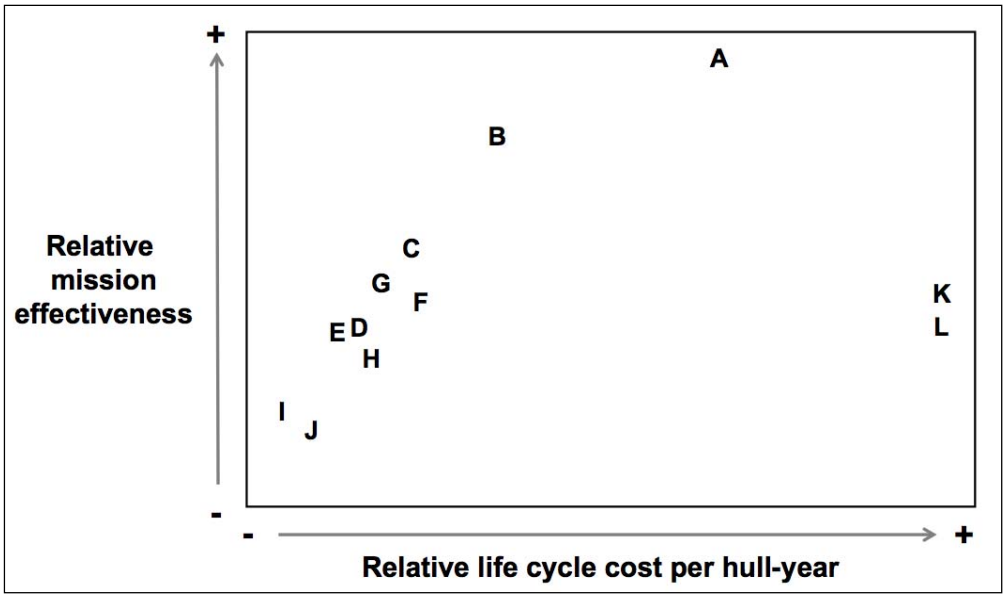

Figure 7. Comparing Life Cycle Cost to Mission Effectiveness

Recognize and Estimate Risks

One of the GAO's criticisms of previous AoAs was their lack of appreciation for, and consideration of, the various risks involved with different alternatives or system solutions. Ignoring or underestimating risks can lead to incorrect decisions that result in future cost and schedule growth. The AoA must clearly understand and convey the state of various technologies, which often requires that the studies be informed by subject-matter experts in various fields. While typically associated with technologies, risks can also arise from inadequacies in the industrial base, especially in the second-tier vendor base. Risks may also arise from other programs the AoA system is dependent upon. For example, although the Future Combat System (FCS) for the Army made heroic assumptions on the readiness of key technologies needed for program success, it was also dependent on the technologies from other programs and made assumptions about the availability of these technologies that were not realized.

Summary Comments

AoAs are not easy to conduct. There are numerous factors to consider and numerous organizations to please. Factors other than those mentioned above that must be considered that complicate the analysis include the following:

- alternatives with unequal service lives,
- systems of systems, and
- alternatives with greatly different expenditure profiles.

In addition to the lessons described above, the AoA must realize there are numerous organizations in the approval chain, each with its own ideas and preferences. It is important to involve these organizations early in the AoA. It also is important to be prepared for the changes and questions that will inevitably arise.

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