Portfolio Influences on Air Force Capabilities-Based Assessment and Capabilities-Based Planning Activities

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Abstract – *Capability-Based Assessments (CBA) are the starting point in identifying, and recommending solutions for gaps and shortfalls in operational military capabilities. CBAs assess several key areas, and provide actionable decision-quality information to senior leadership. The Air Force (AF) Capabilities-Based Planning (CBP) process is aligned with joint CBA constructs, to better support AF corporate decisions regarding acquisition of warfighting capabilities. Both these rigorous processes require collection and analysis of significant amounts of disparate data. This paper discusses use of portfolios and portfolio frameworks to collect, aggregate, and manage this variety of information in support of investment decisions – acquiring new platforms, systems, and systems of systems (SoS) intended to deliver these future capabilities.*

Keywords: Capability need, Capability-Based Assessment (CBA), Capability-Based Planning (CBP), Development Planning (DP), portfolio, portfolio framework, system(s) of systems (SoS), system-of-systems engineering (SoSE), trade space

1 Introduction[1]

The *Joint Chiefs of Staff (JCS) J-8 Capability-Based Assessment (CBA) User's Guide* [1] (hereafter "CBA Guide") details the Department of Defense (DoD) planning process to address real or potential gaps and shortfalls (herein referred to as "needs") in current capabilities. Key CBA activities encompass mission definition; operational performance criteria for successful mission execution; how existing assets – platforms, systems, and systems of systems (SoS) – deliver needed capabilities; identification of operational risks; prioritization of needs; identification and assessment of potential non-materiel solutions to eliminate or mitigate needs; and, when appropriate, materiel solution recommendations for addressing needs.

The CBA Guide breaks these areas into detailed sets of activities. The final phase of these activities addresses "conducting overall solutions recommendations" and includes four tasks: generating alternatives, bounding alternatives by feasibility (*e.g.*, technical risk, affordability, or strategic responsiveness), identifying transformational capabilities, and generating portfolios (defined as "means to structure alternative solutions") and form-of-solution recommendations. This paper uses "portfolio" to mean a grouping of assets with like attributes that can be leveraged or reused.

Air Force (AF) Capabilities-Based Planning (CBP) is defined as "planning, under uncertainty, to provide capabilities suitable for a wide range of challenges and circumstances, all designed to achieve certain battlespace effects." Air Force Instruction (AFI) 10-604, *"Capabilities-Based Planning"* [2] addresses internal AF CBP processes.

AF capability planning processes continue to evolve. The essential point of this paper is that "portfolio thinking" can help in aggregating information about prospective new systems and SoS in support of resource investments.

The *2010 Quadrennial Defense Review (QDR) Report* [3] set a context for a "portfolio approach" to investment decisions. "*... to produce weapons systems efficiently, it is critical to have budget stability – but it is impossible to attain such stability* in DoD modernization budgets *if we continue to underestimate the cost* of such systems from the start. We must *demand cost, schedule, and performance realism* in our acquisition process... *We cannot afford everything* we might desire; therefore ... *must balance capability portfolios to better align with budget constraints and operational needs, based on priorities* assigned to warfighter capabilities."[2] (emphasis added).

[1] Approved for Public Release: MITRE Case # 11-2899; SAF/PA Case # 2011-0345, distribution unlimited.

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[2] Office of the Secretary of Defense, "Quadrennial Defense Review Report," (Washington, DC, 1 February 2010), p. 76

In the context of the QDR Report, "capability portfolio" means a set of related DOTMLPF (doctrine, organization, training, materiel, leadership and education, personnel, facilities) assets that collectively and individually deliver capability. DoD Directive 7045.20, *"Capability Portfolio Management,"* [4] directs Joint Capability Areas (JCA) and their associated programs, initiatives, and activities as the common DoD framework and lexicon for organizing capability portfolios. Integration, synchronization, and coordination of capability needs with current and planned investments in prospective solutions will provide a more substantive technical and analytical basis for decision support information associated with beginning future acquisition programs (Figure 1).

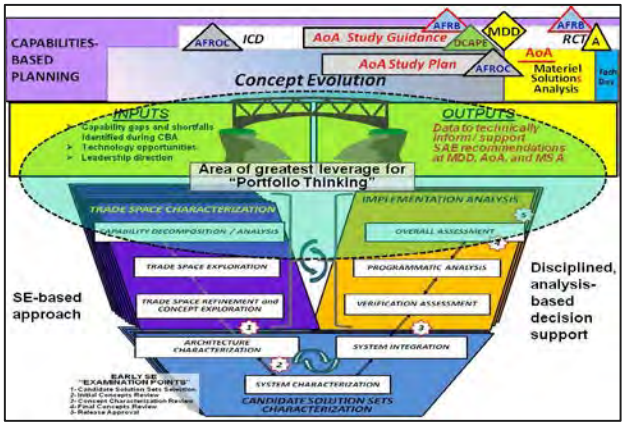

Figure 1. Technical Underpinning of Pre-Acquisition CBP.

2 Conducting CBA and CBP with Portfolios

Pre-acquisition investment decisions must be focused on timely development and fielding of affordable and sustainable operational assets. Both the JCS CBA and AF CBP processes utilize portfolio constructs to assist developers and analysts in organizing and assessing various options to address capability needs. Increasing dependence on networked and interoperable systems means that SoS perspectives and implications must be standard elements of the information sets presented to support these decisions.

CBAs are often exercises in accumulating large sets of distinct pieces of information that can be difficult to manage. The need to group a set of options coherently is a primary concern. This paper attempts to identify the use of portfolio frameworks (*i.e.*, basic conceptual structures; a way to view the disparate pieces of information) to group the content of portfolios defined by the Joint Staff as "mutually supporting sets of recommendations that are related by a common theme."[3]

In building a portfolio, analysts must account for major components of existing capabilities, as well as expected attributes of possible solutions in areas such as technical risk, affordability, mission effectiveness, and strategic responsiveness. The selected framework dictates how these components are used in constructing the portfolio. Choosing one or more frameworks should make it less daunting to aggregate sets of options associated with overarching themes; given a framework, the initial choice of how to select and group the actual portfolio options will significantly influence critical acquisition decisions.

The Air Force Materiel Command (AFMC) *Development Planning (DP) Guide* [5] and the AF *Early Systems Engineering Guide* [6] identify Trade Space Characterization as the first set of activities associated with generating materiel concepts to address an identified capability need. These activities should be grounded in initial quantifiable measures of military utility, such as casualties, cost, or time saved in a military engagement. Use of these or similar attributes helps eliminate solutions of little or no military value from further analysis; it can also help establish frameworks. AF CBP activities use the JCA framework as a means to collect concepts according to similar capabilities such that "like" gets packaged with "like." The remainder of this paper will discuss a few of the numerous portfolio frameworks that can be considered, as well as some approaches for employing the results of portfolio analysis.

As part of the initial study definition phase of a CBA, analysts develop sets of measures to judge the value of a particular Concept of Operation (CONOPS). A similar approach should be used to assess the mission effectiveness of a portfolio. Sometimes the measures will be at odds with each other, but trade studies can be used to assess how various operational goals impact each other. The ultimate goal of a CBA/CBP effort is to provide linkage from capability needs to estimated operational outcomes for each scenario in terms of measures of effectiveness (MOE). This information allows decision makers to consider both the likelihood of the scenario occurring and any consequences of failure. It additionally permits calculations in terms of tradeoffs among MOEs (*e.g.*, accuracy vs. collateral damage vs. probability of kill with one weapon).

2.1 AF Construct for Portfolio Organization and Management

The AF has established twelve Service Core Functions (SCF), each with an associated Core Function Master Plan (CFMP). The SCFs can be generally mapped to the nine Tier 1 JCAs (Figure 2). Each SCF has an appointed Core Function Lead Integrator (CFLI) charged to optimize SCFs in terms of strategy, capability, capacity, modernization, and sustainment. CFLIs establish 20-year horizon Planning Force Proposals to feed CFMP integration. The CFMPs evaluate the overall mix of SCF missions and personnel to align strategy, operating concepts, and capability development. They can also help prioritize AF Science and Technology (S&T) efforts based on long-term strategy.

[3] JCS J-8 CBA User's Guide, p. 61

Integration produces SCF/portfolio trades, provides recommendations on current and future capability needs and investment, and balances capabilities and capacity among SCFs. It connects the CFMPs to the AF long-term investment plan; balances current and future priorities; and orients program phasing, requirements generation, CONOPS development, and organization and training.

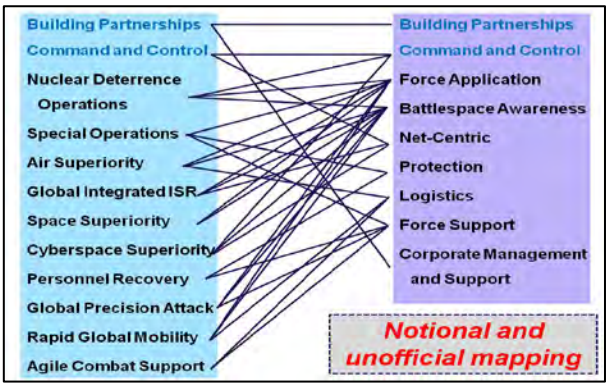

Figure 2. Twelve AF SCFs and Nine Tier 1 JCAs.

2.2 Assembling/Analyzing Portfolio Options

Decisions as to which framework(s) to use in aggregating portfolio options should be made during the up-front planning for CBA/CBP efforts. Requirements sponsors must identify key "value elements" – those things most critical to operational success; to the greatest extent possible, they should state needs in quantitative terms. This clarity should enable analysts to find the best mix of options across hopefully known MOEs, while considering affordability, responsiveness, risk, and similar criteria.

In all cases, one framework that should be considered is the temporal construct to determine "when" a solution is needed: Does it address a near-term, mid-term, or long-term capability gap or shortfall?[4] While a portfolio construct can facilitate the use of computational analysis and optimization techniques, some common-sense filtering is still needed. Recognizing how prospective solutions can be "special-purpose" or "general-purpose" can help determine if the portfolio is too heavily weighted toward solutions optimized only for a particular situation, as opposed to containing a reasonable number of generic solutions that have not been developed to solve specific problems.[5] Appropriate balance is essential.

The CBA Guide advances the perspective of an economic construct to characterize the spectrum of investment options and operational payoffs. By considering total life cycle cost as a primary determinant, such a framework can present various options for consideration, *e.g.*, a "best unconstrained cost" solution, one that neither appreciably increases or decreases total cost, and one that identifies a decrease in total cost. Another framework could address the uncertainty of a critical enabling capability (*e.g.*, spectrum) outside the immediate scope of the instant CBA: the analysis can consider a solution that assumes availability of the enabler, one hedging toward it being unavailable, and another assuming its unavailability.

By examining the effects of differing priorities on portfolio recommendations, a CBA focused on a specific scenario might recommend an entirely different approach based on the disparity between measures. This anomaly is mentioned here since measures in and of themselves can also provide a framework for portfolio options.[6] For example, analysts could present sets of options within space-based, air-based, and ground-based portfolios. An approach of this nature addresses the issue of conflicting operational goals: as measures change, it may or may not be possible to assess how any particular solution choice influences the complete set of options. Other frameworks might consider strategic risk guidance across future security challenges (*i.e.*, accept risk in one area in order to improve performance in another area), domain (land, sea, air, space, cyberspace), or force-basing posture (*e.g.*, use of overseas vs. continental United States bases).[7]

An often-overlooked common-sense consideration is the need to acknowledge non-materiel solutions. A fully comprehensive assessment examines DOT_LPF (*i.e.*, non-materiel) alternatives as well as materiel ones to address operational capability needs. Developers and analysts should show at least one portfolio that does not recommend a new materiel solution for decision makers to take into account: identifying DOT_LPF options (*e.g.*, changes to tactics/techniques/procedures) as well as materiel options more limited in scope (*e.g.*, modifications or enhancements to current systems or SoS) can help put realistic bounds on how much improvement can be attained without new materiel assets. A complete investment picture requires that developers, analysts, and operators (requirements sponsors) understand the DOT_LPF implications of the materiel alternatives. These efforts may also satisfy any requirement to analyze against alternative CONOPS,[8] although that step provides confidence that all doctrinal approaches can satisfactorily employ the same resources.

The CBA Guide also stresses the need to understand how a proposed portfolio aligns with current investment trends.[9] If a candidate solution demands significantly more funding in a specific mission area that has not yet demonstrated actual operational shortfalls in capability, chances are senior leadership will be reluctant to provide necessary fiscal backing when evaluating future investment

[4] *Ibid.*, p. 61
[5] *Ibid.*, p. 63
[6] *Ibid.*, p. 64
[7] *Ibid.*, pp. 61-63
[8] *Ibid.*, p. 63
[8] *Ibid.*, p. 63

decisions. Executing the analysis portion of the process requires scenarios and doctrinal approaches that can be evaluated for several different time frames of incremental and full availability of the anticipated capability.

Once analysts have assembled a set of portfolio options (Figure 3), they must balance scope, technique, and level of detail in their considerations. They may employ methods based on expert judgment when important considerations lack quantifiable attributes; however, it is always better to document the analysis results in measurable terms. The output should be an assessment of how well the task(s) can be accomplished, and an accounting of why mission success can or cannot be achieved at an acceptable level of risk.

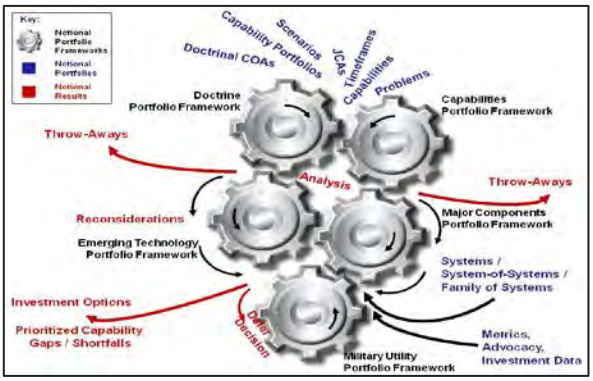

Figure 3. Notional Aggregation of Portfolio Options.

The analysis should present a spectrum of alternatives: a list with at most three courses of action (*e.g.*, a baseline that is essentially "do nothing and accept the risk"; one approach that explicitly addresses the stated or implied interests of a specific senior leader or influential group; and perhaps one that, on the basis of cost or technology maturity, is obviously a throwaway) is clearly incomplete. This is not to imply that these opinions should be categorically ignored; rather, they should not be seen as artificial limits or constraints to considering a larger number of options (or combinations of options) that more thoroughly cover the prospective solution space.

2.3 Opportunity-Based CBA

S&T efforts can present emergent or transformational capabilities that no one has yet envisioned employing. Some technologies are being developed in support of perceived future capability needs, but due to their immaturity these cannot be directly linked to either a JCA or similar artifacts of strategic planning. In other cases, the S&T community conducts research on their own, perhaps based on tangential findings of past efforts. A portfolio framework structured along emerging technology areas can help collect potential solutions for future consideration.

Once a sponsor (user) determines that a concept emerging from the S&T domain could address, either directly or partially, an existing validated need, they must ascertain if a non-materiel approach is already being pursued to solve the problem, or if any analysis is under way in support of a forthcoming Materiel Development Decision (MDD). If no link to a validated capability need exists, an S&T solution approach could still provide an opportunity for a transformational technology.[10]

This scenario triggers what is called an "opportunity-based CBA": the study structuring phase would resemble a conventional CBA, including selecting a strategic framework, identifying scenarios, collecting doctrinal COAs, and establishing appropriate metrics. The needs assessment phase should examine doctrinal approaches and estimate outcomes to evaluate candidate solutions, noting that a CONOPS for a future S&T solution might radically differ from any currently being employed. Analysts should examine options against current capabilities in strategically relevant situations, including in conjunction with various doctrinal concepts. They should endeavor to discover "where" and "when" the potential solution is worthwhile, and the degree of improvement; they should also identify scenarios in which the potential solution is not useful.[11]

2.4 CBP Portfolio Usage

In support of strategic planning, concept developers within acquiring communities conduct CBP and analysis efforts. The results can provide value-added information to the sponsors/users as well as the acquirers. Generally, analysis conducted for AF CBP focuses on capability needs within a Product Center portfolio. The framework may be broken down into various mission areas that closely align themselves to JCAs and product center business areas.

Given sufficient resources, results of these analyses help build capability-based roadmaps that inform strategic planning. New S&T plans and potential solutions can be inserted into these roadmaps where appropriate. It may be possible to structure a portfolio on S&T community solutions (both available and potential) that intersect Product Center business areas. In contrast, some CBP efforts are more narrowly focused on development planning (DP) efforts relating to work on a prospective program approaching MDD. In this case, the attributes of the DP efforts can characterize a portfolio framework for capturing information according to the AF *Concept Characterization and Technical Description (CCTD) Guide* [7].

AF directive guidance [8] requires Program Executive Officers (PEO) and Designated Acquisition Officials (DAO) to ensure collaboration across the integrated life cycle management framework. These offices have their own systems/SoS portfolios, some of which include

[10] *Ibid*., pp. 65-66
[11] *Ibid*., pp. 65-66

roadmaps, comprising the breadth of their management responsibilities. Merging PEO/DAO portfolios with portfolio frameworks used as tools in CBA/CBP efforts provides an integrated view of capability needs across established program offices and weapon systems. This allows for in-depth analyses that collectively represent elements of System-of-Systems Engineering (SoSE). These analyses can identify transition opportunities for new technologies, candidate approaches to address capability needs, inputs to strategic planning for acquiring and using communities, and collaborative opportunities (*e.g.*, integrated systems/SoS risk assessment).

3 Challenges

Both DoD and the AF have established functional Capability Portfolio Managers (CPM) as a first step toward institutionalizing this aspect of planning for acquiring future platforms, systems, and SoS. While CPM responsibilities are generally aligned to the JCAs, the actual implementation across AF Product Center business areas is less clear: many broad capability areas such as Intelligence, Surveillance, and Reconnaissance (ISR) do not fall neatly into a single domain such as aeronautical systems or space systems.

Prior to initial acquisition decisions, acquirers and operational users must collaboratively identify future assets needed to perform the missions and tasks identified in overarching strategic direction. SoS considerations in terms of aggregating both legacy assets in inventory and those yet to be acquired include defining performance (as well as appropriate measures/metrics) in a "plug-and-fight" interoperability context; discovering and understanding interactions and emergent behavior, especially in ad hoc operational configurations; and identifying potentially inconsistent configuration and data management approaches across the various systems and platforms that comprise the SoS. This latter point also applies to less obvious elements of the SoS architectures such as adapters and middleware. Collaboration must also address critical areas of senior leadership interest (*e.g.*, open architectures, security constraints in supply chain risk management, etc.).

A major challenge of SoSE is defining architectures to link fielded platforms and systems. Loren [9] reiterates significant governance issues: each of the constituent systems of the SoS is generally at a different point in its life cycle; each has generally been developed under unique sponsorship, management, and acquisition paradigms; and each generally has its own distinct approach to capability evolution. Phasing and resourcing modification/integration activities across dozens – and potentially hundreds or even thousands – of fielded assets is a substantial and complex effort; a seemingly small perturbation that may initially appear to impact only one part of one subsystem on one platform can upset the delicate balance of the entire effort. SoSE sensitivity analyses can help mitigate this issue.

Another great challenge, with implications far beyond the scope of this paper, is that instantiation of portfolio management is largely constrained by the long-established budgeting paradigm that principally funds discretely-managed acquisition *programs*, and largely overlooks so-called "cross-cutting" *capabilities* such as ISR that apply to multiple platforms and benefit multiple organizations, users, etc. Senior decision makers must examine the entire budget with respect to affordability issues when deciding whether to initiate new acquisition programs, and how to pay for those they actually elect to begin. An often-overlooked aspect in the debates is how, and for how long, to sustain existing platforms and systems while the desired future capabilities are being developed, integrated, tested, and phased into the operational inventory. In these cases, divestiture and divestment decisions are as important as investment decisions, and must be given a commensurate degree of weight in overall portfolio management.

MDD (or Concept Decision, as the initial acquisition milestone was previously known) has long been regarded as the opportunity to answer the question "What new platform or system are we going to acquire?" Loren [10] and others have suggested that the question is better phrased in terms of "Do we even need a capital investment in a materiel solution to address the instant need?" Given an affirmative answer, the Analysis of Alternatives (AoA) report presents a set of options that the sponsor could realistically and affordably think about acquiring. Continuing collaboration between the acquirer and user on prospective Courses of Action (COA) results in the sponsor coming forward to the Milestone A decision with a "This is actually what we want to start down the path to acquire" position. The upper portion of Figure 4 depicts an expanding technical and analytical knowledge base on a limited number of prospective materiel solutions.

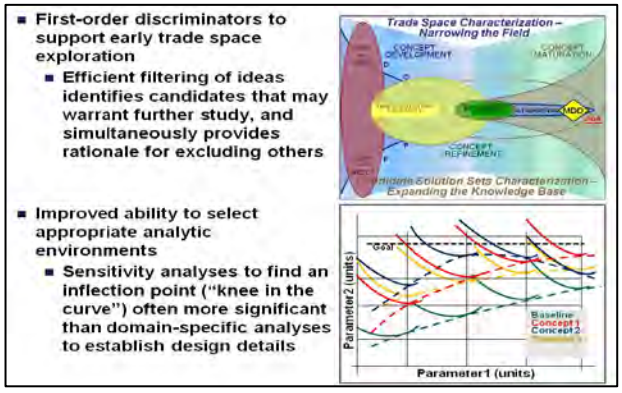

Figure 4. Concept Evolution; General Sensitivity Analysis.

Up-front SoS-level portfolio analysis and management efforts must reconcile conflicts among these strategies. It is essential to begin trade studies and analyses that form the core of concept and architecture development efforts *before* detailed product, system, or SoS solutions are advanced. Loren and Bullard [11] identify that developers of constituent systems must ensure system-level technical

planning reflects how their systems and subsystems interact as elements of the greater SoS. Understanding, or even acknowledging, the myriad of SoS implications will help all stakeholders – operators, planners, technologists, analysts, and others – better understand the "realm of the possible" across the entire trade space before moving into the AoA, and again before beginning COA discussions. The lower portion of Figure 4 depicts a generalized approach to sensitivity analyses.

4 Conclusion

In order to conduct CBA/CBP efforts, practitioners must capture and manage a host of data points: materiel versus non-material approaches; possible transformational capabilities; resource demands for each capability; future availability of current platforms, systems, and SoS; technical risks; contributions to MOEs; associated CONOPS and alternative CONOPS; specific versus general-purpose; cost-benefit factors; and more.

From the SoSE perspective, portfolios and portfolio frameworks provide useful ways to collect and manage the immense amount of disparate data needed to conduct CBA and CBP activities. They can provide additional constructs to logically group sets of options; these can enhance sponsor-acquirer collaboration in addressing common themes across key elements of operational architectures – interconnections as well as disconnects – an essential element of effective SoSE practices.

Considerable efforts to shift the thinking behind the pre-acquisition investment decision paradigm are under way, both within AF leadership as well as upward in DoD. The CCTD, as the main artifact of DP and early Systems Engineering (including SoSE), captures the technical and analytical knowledge base needed to inform these critical investment decisions, and thereby set future acquisition efforts on a high-confidence path to programmatic success.

Operational capability planners, technologists, and others must bring open minds to discussions about the next generations of materiel and non-materiel military assets. Capability portfolios give concept developers, requirements sponsors, and stakeholder analysts a set of mechanisms to more comprehensively organize, assess, and present options; in so doing, they serve a key role in developing essential information to support pre-acquisition decisions on future capability needs.

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AF/A8X	AFNWC/XR	ASC/XR	ESC/XR	SMC/XR

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