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Evolutionary Acquisition

Implementation Challenges for Defense Space Programs

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Summary

Introduction and Research Approach

This monograph presents findings of a RAND Project AIR FORCE research project that documented the lessons learned by the U.S. Air Force and other Department of Defense (DoD) cost analysis and acquisition community members from the implementation of evolutionary acquisition (EA) strategies for major Air Force defense space acquisition programs. In May 2003, DoD promulgated revised 5000 series acquisition directives and instructions that mandated EA strategies relying on the spiral development process as the preferred approach to satisfying operational needs.[1] These same concepts were later incorporated into a new space acquisition policy document, the National Security Space Acquisition Policy (NSSAP) 03-01 (DoD, 2004).

The principal goal of EA strategies is to provide operationally useful capabilities to the warfighter much more quickly than traditional acquisition strategies. Instead of the old approach of "single step to full capability," evolutionary acquisition aims at achieving an overall objective end capability through the more rapid fielding of numerous operationally useful threshold capabilities by pursuing less demanding intermediary increments or steps. In theory, the initial spirals or increments provide a basic "threshold" capability relatively

[1] The DoD 5000 acquisition policy guidance documents have been the key DoD publications establishing the basic process and structure for developing and procuring U.S. weapon systems since July 1971 (Ferrara, 1996).

quickly, which is operationally useful to the user. Subsequent spirals or increments build on this to provide more capability, eventually resulting in a system that meets the full "objective" capability originally envisioned at the beginning of the program.[2]

Spiral development, the preferred process for implementing EA, suggests an even more radical departure from past approaches, because it envisions an ongoing process of evolutionary development of the system requirements, based on feedback loops from warfighters using field demonstrations, and from other stakeholders. As explained in the official DoD 5000 series guidance,

> In this process (Spiral Development), a desired capability is identified, *but the end-state requirements are not known at program initiation*. Those requirements are refined through demonstration and risk management; *there is continuous user feedback*; and each increment provides the user the best possible capability. *The requirements for future increments depend on feedback from users and technology maturation*.[3]

EA advocates claim many potential benefits from the adoption of the strategy, while skeptics raise numerous concerns about formidable barriers and challenges to implementing the policy effectively. Yet little documented objective experience and evidence exist to assess the policy and very little systematic analysis of what evidence does exist has yet been published. Nonetheless, almost all agreed at the time of its formal adoption that full implementation of EA using the

[2] The authors are aware of no authoritative official DoD definition of "objective" and "threshold" capabilities. However, based on the implied meaning of the words in common DoD usage, the authors provide the following definitions. Objective capabilities are the full end-state capabilities envisioned for a new weapon system at the beginning of an acquisition program. Objective capabilities may be attained through a single-step-to-capability traditional program, or through an EA program that goes through the fielding of several interim systems that meet useful but lower threshold capabilities. Threshold capabilities are the minimum capabilities thought necessary to justify development of a new system or a new variant of the system.

[3] DoD (2003c). Emphasis added. The other process identified for implementing evolutionary acquisition is called incremental development. With incremental development, the end-state requirements *are* known. This is an important conceptual distinction that is discussed at length in the body of this monograph.

spiral development process by DoD would necessitate a major overhaul of DoD acquisition procedures, particularly in the areas of requirements management, budgeting, cost analysis, and elsewhere.

The overarching objective of this RAND research effort is to assist cost analysts and other elements of the Air Force acquisition management community in formulating cost analysis and program management policies and procedures that anticipate and respond to the prospect of more widespread use of EA strategies.[4]

This research effort adopted a three-pronged approach. First, the project team carried out a comprehensive review of published and unpublished reports and other studies on the theory and implementation of evolutionary acquisition. Second, it conducted a wide-ranging series of interviews with senior DoD and Air Force acquisition management officials regarding their understanding of the meaning and implications of DoD's mandated EA policies. Finally, it carefully reviewed five major space acquisition programs that have been recently restructured in accordance with EA concepts, in order to gain lessons learned to date on the implementation of EA, particularly in areas of relevance for cost analysts. The information on these case studies was derived from open sources and from interviews with senior program officials.[5] These are the five case studies reviewed:

- Space-Based Space Surveillance (SBSS) System
- Rapid Attack Identification, Detection, and Reporting System (RAIDRS)
- Global Positioning Satellite (GPS) III
- Space-Based Radar (SBR)
- Kinetic Energy Interceptor (KEI)[6]

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[4] This study, however, focuses largely on the implications of EA for the cost analysis community.

[5] The interviews were conducted by the authors and took place primarily during the first nine months of 2004.

[6] KEI is, of course, a Missile Defense Agency program. However, it was widely recommended to us by DoD officials as an instructive example of one innovative approach to implementing EA.

The authors chose to focus on major space programs for two reasons. First, space programs have recently grown significantly in relative importance for the future of the Air Force, and are central to DoD's plans for transformation of the U.S. armed forces. Second, the Air Force has recently completed a thoroughgoing review and complete overhaul of space acquisition policy. The new National Security Space Acquisition Policy (NSSAP) 03-01 guidance mandates evolutionary acquisition as the preferred acquisition approach for space programs. Most major new Air Force space programs have been structured, at least initially, as evolutionary acquisition programs based on spiral development.[7]

The programs examined as case studies are all in the very earliest stages of the acquisition process. Therefore, the lessons learned derived from them must be considered tentative and treated as provisional. In addition, it is important to note that the programs varied in size and complexity, as well as in the interpretation, definition, and application of the rather general guidance on the evolutionary acquisition strategies and processes provided by the DoD 5000 series and NSSAP 03-01. The authors provide a taxonomy of the different general types of programs in the list of case studies. (See pp. 39–40, 45–46.)

The next section summarizes the EA implementation lessons derived from these case studies, as well as overall findings for acquisition managers and for cost analysts.

EA Implementation Lessons Learned from Case Studies

Many of the issues, findings, and recommendations mentioned in this section are applicable to all major DoD defense acquisition programs, not only those conducted according to the EA process.

[7] See Chapter One for organizations represented by interviewees. The applicability to nonspace programs of lessons learned derived from the use of EA on space programs is an area of some contention. The authors review the relevant evidence in the body of this study, and conclude that the EA lessons learned from space programs are largely applicable to other types of major DoD system acquisition programs.

However, there was a wide consensus among those interviewed that EA promotes certain program characteristics that make many of these issues and challenges more prominent.

EA programs require considerable additional up-front management planning and engineering workload and the budget sources to support them. (See below and Chapter Two, especially pp. 51, 88.) This situation arises from the necessity to map out the complex program structure implied by EA, which includes a series of separate, overlapping increments, each requiring the definition of operationally useful threshold and objective requirements, and each including formal milestone requirements mimicking a stand-alone program; and the additional system engineering and nonrecurring engineering to support the progression of upgrades and technology insertion that take place within and between increments. Also, additional up-front resources are required to support more extensive and continuously revised evolutionary costing efforts.

EA programs using the spiral development process should focus on capability mission objectives rather than traditional technical requirements. (See Chapter Two, especially pp. 46–48, 84–85.) With the spiral development process, the system requirements emerge and evolve over time. Therefore, the program focus, particularly at program inception, must be on capability objectives. This is a challenging approach, however, given the current acquisition regulatory and oversight environment; as a result, most programs examined while researching this monograph are tending to move away from spiral development and toward an incremental development process.[8]

After the initial formulation and stabilization of requirements at the beginning of a program or program increment (a process that does and should include significant feedback from the user communities), practical implementation of EA using the spiral development approach requires a more structured management of the user community feedback loop process. (See

[8] Unlike spiral development, the incremental development process assumes that the end-state requirements *are* known at the inception of the development process.

Chapter One, pp. 22–24, and Chapter Two, especially pp. 83–84.) Initial conceptual versions of EA strategies using spiral development envisioned constantly functioning feedback loops from the user community to fine-tune requirements and make sure that developers produce end products that meet real needs in the field. But actual experience in the early phases of the case study programs examined suggests that undisciplined feedback in the early concept development stages, particularly on programs with multiple user communities such as SBR, can lead to a counterproductive piling up of sometimes mutually inconsistent requirements, concepts, and technologies, and contributes to the challenge of controlling requirements creep.

Program managers believe that the use of EA on their programs will result in numerous different variants of the same system. This situation is expected to complicate logistics planning and implementation greatly. Plans will have to be made to update, retrofit, or dispose of earlier versions. (See Chapter Two, especially p. 84.) While none of the programs examined was nearly advanced enough to turn out operationally deployable hardware, it was the consensus view among program managers that the use of EA would produce multiple variants and greatly complicate support planning and implementation. Cost analysts also noted that this problem would make life-cycle cost (LCC) estimating more difficult.

The next section summarizes the broader overall findings from the review of the relevant published and unpublished literature, interviews with senior DoD acquisition managers, and case study analysis. The first subsection below summarizes general findings for acquisition management. The second subsection below summarizes the authors' overall findings for cost analysts.

Summary of Overarching Acquisition Management Findings

The new DoD guidance regarding EA (DoD 5000 series and NSSAP 03-01) permits great flexibility, but does not eliminate conceptual and definitional ambiguity. As a result, EA programs

vary considerably in their practical implementation approaches. (See Chapter Two, and Chapter Three, especially pp. 89–90.)[9] The persistence of definitional ambiguity and continuing lack of precise implementation guidelines have led to a range of differing interpretations of key terms and concepts in the structuring of EA programs. Such key EA concepts as feedback loops, and the difference between the spiral and incremental development processes, remain areas of debate and confusion in various sectors of the acquisition management community. Because of the serious implementation challenges posed by EA, especially using the preferred approach of spiral development, DoD should further clarify its guidance for implementing EA programs.

All of the case studies point to the conclusion that the capabilities and requirements definition and management processes are major challenges in all EA programs. Appropriate structuring of EA phases with operationally useful threshold requirements and mapping the path to overall objective capability are demanding tasks on most EA programs. (See Chapter Two, especially pp. 46–48, pp. 84–85.) This is particularly the case in large, complex hardware procurement programs using the spiral development process, where the objective end requirements are not known at the inception of the program. Areas of particular concern include the issues of structuring specific spirals or increments, defining operationally useful threshold requirements for specific spirals or increments, and mapping out the specific path to the objective end requirements. Preventing requirements creep is perceived as a significant challenge.

The use of the officially preferred spiral development process for implementing EA on major hardware acquisition programs greatly increases the level of program uncertainties, raising serious challenges for program managers in the current acquisition environment. (See Chapter Two, and Chapter Three, pp. 91–93.)

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[9] Definitional ambiguity and lack of precise guidance have permitted not only significantly different approaches to be used on EA programs, but have also permitted certain policies that run counter to the original intent of EA advocates. Chapters Two and Three expound on this.

The very uncertainties that provide acquisition managers with valuable flexibility necessary to gain the expected benefits from EA through spiral development also raise considerable challenges for managers in the existing acquisition environment. Acquisition managers of large, complex hardware acquisition programs report that they are subjected to very strong pressures from political authorities, as well as from the requirements and cost analysis communities, to provide far more detail about the end stages of the program than they believe is feasible under the spiral development approach. As a result, many programs that started with the spiral development approach have been evolving toward an incremental acquisition approach, or something more akin to a traditional single-step-to-capability program with planned upgrades.

Therefore, the authors believe that evolutionary acquisition using the preferred approach of spiral development, as laid out in the most recent DoD 5000 and NSSAP 03-01 guidance, cannot likely be realistically implemented in the current political and acquisition environment on major DoD space programs, and even perhaps on other large-scale DoD hardware acquisition programs. At best, EA using spiral development may be one useful tool that can be used in some limited circumstances on software programs, on smaller-scale hardware programs, or perhaps on programs such as KEI that operate outside the traditional acquisition framework.

Summary of Cost Management Findings

EA programs require an evolutionary costing approach. By necessity, EA using the spiral development approach generally tends to lead to a heavy focus of the cost analysis effort on the initial spiral or increment, at the expense of other phases of the program. (See Chapter Two, especially pp. 49–50, 86–87.) Program managers and other acquisition managers interviewed noted that evolutionary costing is the only feasible and realistic approach to use on EA programs, especially those that employ the spiral development process. Evolutionary costing requires that the cost analysts work closely with government engineers for independent assessment of technological risk and schedule of the program. In addition, they need to work closely with the contractors to track the design and the technologies, and thus the costs, as they evolve. Cost models jointly developed by the Program Office and the prime contractor are often used. However, the inputs and the underlying assumptions to the cost model may be different. The authors found virtual unanimity among the cost analysts interviewed on all levels that evolutionary costing is feasible and that it works well, when government and contractor cost analysts work closely together in a nonpoliticized environment, and where general agreement has been reached among user communities on system requirements and the associated level of technological risk.

Overall, most cost analysts interviewed expressed generally positive views about EA. Nonetheless, lingering concerns did surface during the interviews regarding a variety of cost issues associated with EA. (See Chapter Two, especially pp. 48–51, 86–87.) Some of those concerns are listed below.

1. Committing the U.S. Air Force (USAF) to large, costly programs before the full cost implications of the program are well understood
2. Accurately assessing total program LCC, support costs, and retrofit costs based on sound and independent technical assessment of the program baseline
3. Adequately budgeting for the potentially high variability of cost outcomes arising from the high degree of uncertainty surrounding inputs to cost models
4. Accurately accounting for the potential cost implications of requirements creep arising from multiple users and planned insertion of technologies of uncertain future maturity.

A strong consensus emerged from the interviews with cost analysts that EA is an important and useful tool providing program managers with useful flexibility, and that the cost community can accommodate it adequately through the use of evolutionary costing. Nonetheless, there was recognition at least among some of those interviewed that EA would increase the cost analyst's workload and require substantial interface with the engineers and the contractor.

EA as currently defined inherently results in increased uncertainties regarding technology development timelines and program schedule during the early phases of a program. If handled with care, these increased uncertainties can provide opportunities for greater program flexibility and program realism. At the same time, increased program uncertainties can pose difficult political and budgetary challenges for program managers within the current acquisition environment.