Studying Acquisition Strategy FORMULATION of INCREMENTAL DEVELOPMENT APPROACHES

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This is a study of the challenges that acquisition professionals confront in formulating the Department of Defense's preferred acquisition–incremental development. The research surveys acquisition professionals to recommend the components of an acquisition strategy associated with a typical acquisition program undergoing program/project milestone review and approval. This work provides insights into how program managers use typical programmatic decision inputs (requirements, technology maturity, risk, urgency, and funding) to formulate the components of an acquisition strategy. The results suggest that acquisition policy should perhaps require a justification for most programs of record if an incremental development approach is not planned. Adoption of the recommended acquisition policy changes would make the defense acquisition system more responsive to the warfighter by fielding improved capability as quickly as possible and reducing risk of the eventual delivery of the full required capability.

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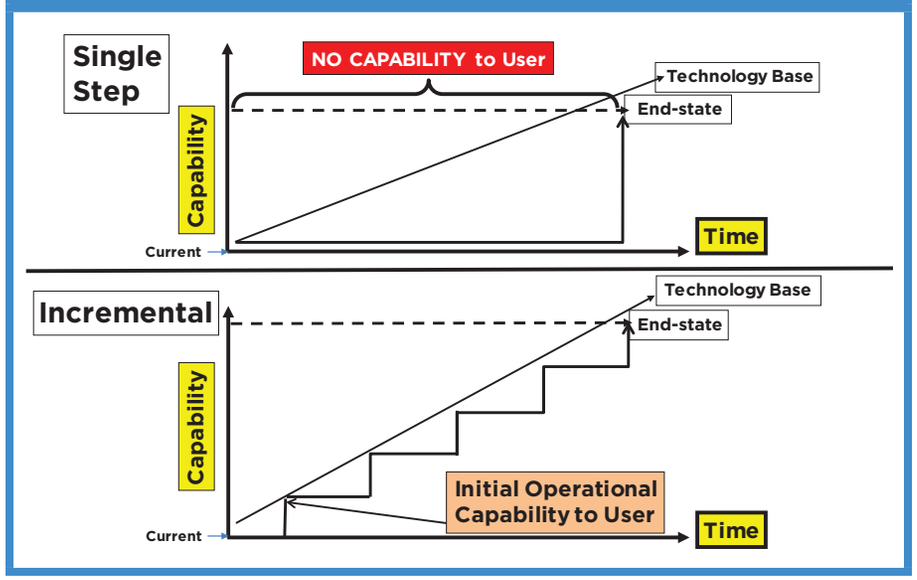
Image designed by Michael Bubar-Krukowski

Within U.S. defense acquisition, an evolutionary strategy with an incremental development (ID) approach is the preferred strategy for most programs, specifically major defense acquisition programs (MDAPs) involving technology development efforts (Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics [OUSD(AT&L)], 2007). The basic advantage over a single-step acquisition developmental approach is that the warfighter gets some capability sooner rather than waiting for full capability. Figure 1 outlines the basic advantage of the incremental approach versus a single-step approach, where the warfighter or user gets no capability until the end of a successful development. In contrast, using the incremental approach, the warfighter gets some improved capability (over their existing level) in a shorter time period.

FIGURE 1. SINGLE STEP VERSUS INCREMENTAL DEVELOPMENT APPROACH



Department of Defense Directive (DoDD) 5000.01, *The Defense Acquisition System* (OUSD[AT&L], 2007), provides guidance on the preference for ID approaches, but how difficult is it for program managers (PMs) to recommend, plan, and obtain approval of this approach? This research studies how challenging it is for a PM to formulate an evolutionary acquisition (EA) strategy with an ID approach for a specific program using a case study-based framework. The research also includes an analysis of the importance of typical program data—such as requirements, technology maturity, risk, and funding—as inputs to the PM decision-making process for determining a recommended acquisition strategy.

The goal is to provide insight into the unique challenges of formulating an incremental approach within defense acquisition and to suggest acquisition policy changes. The work aligns with general research in the areas of project management, defense acquisition reform, strategic leadership, and organizational behavior. This research supports the 2018 National Defense Strategy approach to reform the Department of Defense (DoD) for greater performance and affordability (DoD, 2018), and also addresses the challenges of "enabling effective acquisition and contract management" highlighted in a 2018 Office of the DoD Inspector General report (p. i).

"This research studies how challenging it is for a PM to formulate an evolutionary acquisition (EA) strategy with an ID approach for a specific program using a case study-based framework.

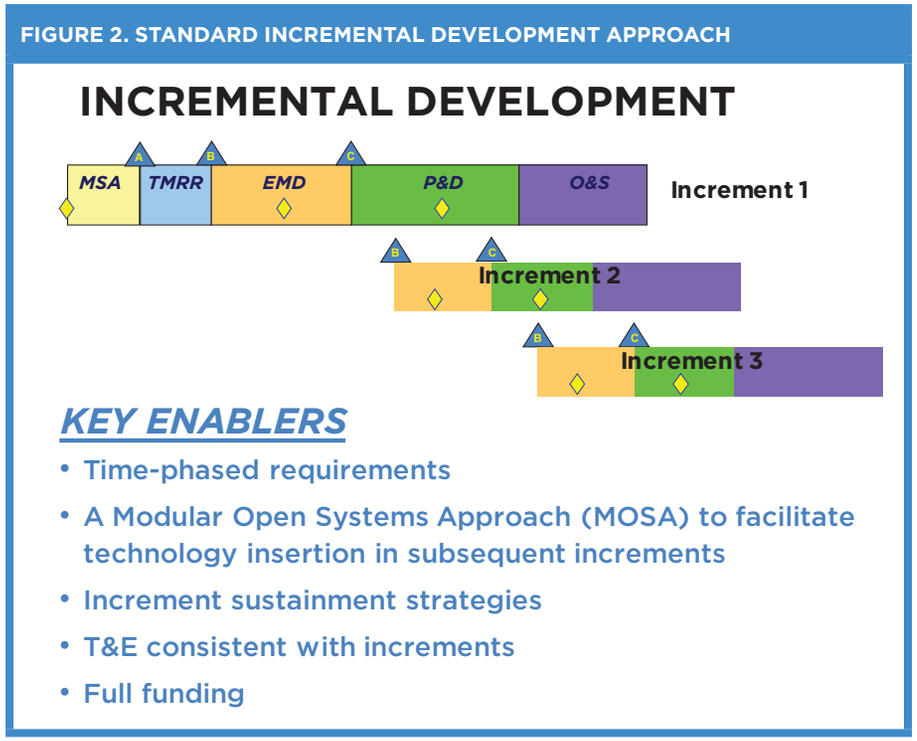
According to DoDD 5000.01, *The Defense Acquisition System*, responsiveness is one of five policies that governs the Defense Acquisition System. Specifically, DoDD 5000.01 defines responsiveness as follows:

> Advanced technology shall be integrated into producible systems and deployed in the shortest time practicable. Approved, time-phased capability needs matched with available technology and resources enable **evolutionary acquisition** strategies. Evolutionary acquisition strategies are the preferred approach to satisfying operational needs. **Incremental development** is the preferred process for executing such strategies. (OUSD[AT&L], 2007)

The accompanying DoD Instruction (DoDI) 5000.02 further expands on the use of ID strategies (OUSD[AT&L], 2017). In fact, the words *incremental* and/or *increment(s)* appear 52 times in the 110-page instruction. The DoDI 5000.02 recognizes the importance of a modular open systems approach (MOSA)—modular designs coupled with open business models—to successfully implement incremental development efforts. Figure 2 outlines a basic ID strategy across the five phases of the acquisition framework from materiel solution analysis (MSA) to technology maturation and risk reduction (TMRR) to engineering and manufacturing development (EMD) to production and deployment (P&D) to operations and support (O&S). Key enablers for a successful implementation of an ID approach include time-phased requirements, MOSA, integrated test & evaluation (T&E),

and sustainment strategies, as well as full funding for each increment. Recently, the Office of the Under Secretary of Defense for Acquisition and Sustainment (OUSD[A&S]) released DoDI 5000.80 (2019) and DoDI 5000.02 (2020), which both continue to emphasize the acquisition policy objectives of responsiveness, flexibility, and innovation facilitated through ID approaches. The *Defense Acquisition Guidebook* (DAG) reinforces the DoDD 5000.01 and DoDI 5000.02 by mentioning "increment(s)" or "incremental" hundreds of times in its 1,230 pages (Defense Acquisition University [DAU], 2012). The DAG defines an increment as "a militarily useful and supportable operational capability that can be developed, produced, deployed, and sustained" (DAU, 2012). Furthermore, Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 5123.01H, dated August 31, 2018, which replaces the CJCSI 3170.01 series, continues the theme on the importance of time-phased requirements for the success of EA strategies and ID efforts (CJCS, 2015, 2018).

FIGURE 2. STANDARD INCREMENTAL DEVELOPMENT APPROACH



Despite the emphasis on ID approaches in both DoD acquisition and requirements policy documents and regulations, many PMs struggle to develop and recommend the preferred approach at program approval milestones; and many programs are approved as single-step development efforts even when an ID approach may have been more appropriate and effective in delivering capability. The Government Accountability Office (GAO) continues to highlight the importance of EA and ID approaches as widely accepted best practices in commercial industry. For example, a 2010 GAO report titled *Defense Acquisitions—Strong Leadership Is the Key to Planning and Executing Stable Weapons Programs,* was a study on the stability of DoD MDAPs, and found that only 21% appeared to be stable. The GAO reported that stable MDAPs "pursued evolutionary or incremental acquisition strategies, leveraged mature technologies, and established realistic cost and schedule estimates that accounted for risk" (GAO, 2010, p. 2). In *Defense Acquisition Reform 1960–2009: An Elusive Goal*, J. Ronald Fox (2011) writes:

> **Evolutionary acquisition** is the preferred DoD strategy for rapid acquisition of mature technology for the user. An evolutionary approach delivers capability in **increments**, recognizing up front the need for future capability improvements. The objective is to balance needs and available capability with resources and to put capability into the hands of the user quickly. (p. 23)

This research narrowly focuses on programs that do not have time-phased requirements because it makes the development of an incremental approach more challenging. In this situation, PMs use a variety of inputs, such as requirements, technology maturity, risk, urgency, and funding to formulate the components of a strategy to meet the warfighters' needs and timelines, and to augment affordability for the Services.

The goal of this research is to examine the challenges in formulating an EA strategy with an ID approach. The objectives include the following:

- Develop insights into how acquisition professionals use typical programmatic decision inputs to formulate the components of an acquisition strategy with an ID approach.
- Recommend defense acquisition policy changes that better support the planning of successful ID acquisition strategies.

This article will show that acquisition professionals weigh typical programmatic decision inputs in various ways, resulting in a wide variety of recommended components of the acquisition strategy. It further reinforces the DoD acquisition policy of a preference for ID approaches and suggests that ID be the default strategy. Directly related to the research objectives is

the primary research question to be addressed: given programmatic decision inputs for a specific program, can we gain a better understanding of how PMs or acquisition professionals formulate the components of the acquisition strategy? The research will address the following secondary questions:

- What is the most important factor in determining the components of the recommended acquisition strategy?
- How can the decision input factors be changed to enable a PM or acquisition professional to recommend an ID strategy that more closely resembles the actual strategy later adopted by the Services?

The answers to these questions address the objectives outlined above within the research goal—studying the challenges in formulating an EA strategy with an ID approach. The research uses the Joint Common Missile (JCM) program and the subsequent Joint Air-to-Ground Missile (JAGM) program as a case study to survey acquisition professionals not previously associated with either program. A questionnaire asks acquisition professionals to recommend the components of an acquisition strategy for the JCM program based on approved requirements, technology maturity, a technology risk assessment, urgency, and funding levels. These recommended strategies are compared to the actual strategy approved for the JCM program at the time (a single-step development approach) and compared with the strategy (an incremental approach) later adopted by the subsequent JAGM program (a follow-on program from JCM).

The survey results address three hypotheses. The first hypothesis was that the JAGM strategy (an incremental approach) would not be recommended based on the pressures to maintain the constraints of performance, cost, and schedule within the proposed acquisition program baseline (APB). Based on the pressures for affordability and rapid acquisition, the second hypothesis was that acquisition professionals would maintain the cost and schedule constraints in the draft APB and reduce programmatic risk by recommending delaying performance capabilities (pushing some requirements to later increments). The third hypothesis was that acquisition professionals would choose to delay capabilities associated with technologies with low technology readiness level (TRL) ratings and/or high-risk ratings. For the purposes of this research approach, the JCM acquisition strategy is recognized as an unsuccessful/ineffective approach because the JCM program was cancelled 6 months after Milestone B (MS B) approval, and no capability was developed or delivered to the warfighter. Alternately, the JAGM acquisition strategy is recognized as a successful/effective approach because the strategy was adopted by the Services with approved MS B and C decisions; and the JAGM is on-track to deliver the first incremental capability to the warfighter.

Evolution of EA and ID Within Defense Acquisition

This section reviews the background of both EA and ID, and presents a historical review of how policy, regulations, and statutes have changed over time with respect to guidance on EA and ID for PMs. The seeds for significant acquisition reform were set in the 1980s. A 1986 RAND study titled *Improving the Military Acquisition Process* outlines broad recommendations to improve the acquisition process (Rich et al., 1986). Later that year, the Packard Commission also focused on acquisition reform. *A Quest for Excellence: Final Report to the President's Blue Ribbon Commission on Defense Management* (also known as The Packard Report) outlined significant acquisition reform recommendations, including the use of commercial-off-the-shelf (COTS) technologies (Packard, 1986). Ground-breaking legislation related to acquisition reform included the 1986 Goldwater–Nichols Department of Defense Reorganization Act, the 1990 Defense Acquisition Workforce Improvement Act (DAWIA), the 1994 Federal Acquisition Streamlining Act (FASA), and the 1996 Federal Acquisition Reform Act (FARA). These transformational acts laid the groundwork for significant congressional involvement in acquisition reform.

The annual National Defense Authorization Acts (NDAAs) have also had a significant impact on defense acquisition reform and on shaping EA and ID policy within defense acquisition. The Fiscal Year (FY) 1996 NDAA specifically calls for the incremental acquisition through "successive acquisitions of interoperable increments" (p. 506). Table 1 summarizes the NDAAs from 1996 to 2017 with a count of the number of times the words *evolutionary, increment,* or *block* are referenced with respect to defense acquisition (the terms block and increment are often used interchangeably in congressional language). Exceptionally, the NDAAs from 1997 to 2002 do not mention the words evolutionary, incremental, or blocks.

TABLE 1. NDAA SUMMARY OF EA AND ID WORD USE. DATA FROM NDAAs DATED 1996–2017

National Defense Authorization Act (NDAA)			
Fiscal Year	Total Page Count	Page Count of Title VIII—Acquisition Policy, Acquisition Management, & Related Matters	Uses of word "evolutionary" or "increment" or "block"
1996	519	10	40
1997	450	14	0
1998	450	22	0
1999	360	10	0
2000	466	16	0
2001	515	20	0
2002	384	18	0
2003	306	19	23
2004	436	20	1
2005	389	20	14
2006	423	32	16
2007	439	38	38
2008	602	70	48
2009	417	47	22
2010	656	23	16
2011	383	64	3
2012	566	45	49
2013	682	40	29
2014	494	13	14
2015	689	37	12
2016	585	80	52
2017	970	93	79

The consistent use of these terms by Congress in NDAAs provides an indication of Congressional intent. For example, the FY2003 NDAA defines *evolutionary acquisition* as "a process by which an acquisition program is conducted through discrete phases or blocks, with each phase or block consisting of the planned definition, development, production or acquisition, and fielding of hardware or software that provides operationally useful capability" (NDAA, 2003, p. 147). The term "increment ... means one of the discrete phases or blocks of a program" (NDAA, 2003, p. 147).

Subsequently, the 2009 Weapon Systems Acquisition Reform Act (WSARA) reiterates the importance of time-phased requirements to the success of EA and ID approaches and states that "the process for developing requirements is structured to enable incremental, evolutionary, or spiral acquisition approaches, including the deferral of technologies that are not yet mature and capabilities that are likely to significantly increase costs or delay production until later *increments* or *spirals*" (WSARA, 2009, p. 17). Note also that the terms increment and spiral are sometimes referred to synonymously. Congress again highlighted ID in the FY2017 NDAA, which states, "A major defense acquisition program ... to enable incremental development and enhance competition, innovation, and interoperability" (NDAA, 2017, p. 254).

Through NDAA language over the years, Congress has included consistent guidance on the application of EA and ID within DoD acquisition programs. In response to this congressional direction and in an attempt to capitalize on commercial industry best practices, the DoD acquisition community has transformed its acquisition regulations and policies to include guidance on the application of ID approaches. Starting in the mid-1980s, EA, using an ID approach, was recognized as the best way to develop and deliver capabilities specifically for information technology (IT), which involved software-intensive development efforts.

In 1987, the Defense Systems Management College (DSMC) published the *Joint Logistics Commander's Guidance for the Use of an Evolutionary Acquisition (EA) Strategy in Acquiring Command and Control (C2)* (A'Hearn et al., 1987). The guide encouraged "consideration and use of an Evolutionary Acquisition (EA) strategy by the Services in acquiring C2 systems," but emphasized applicability to other kinds of acquisition programs (A'Hearn et al., 1987, abstract). The guide defines an EA strategy as:

> of a character that the system is not required to have full capability when deployed, but will evolve to full capability through one or more incremental upgrades ... EA consists of first sequentially defining, funding, developing, testing, fielding, supporting, and evaluating increments of the system. (A'Hearn et al., 1987, p. v)

The guide defines EA as both "adaptive and incremental," and requiring a "core or baseline" capability necessary with an architectural framework upon which to build future increments for the delivery of the final desired full capability. The core or baseline element should "enhance the user's mission capability" and "be fielded quickly and sustained in its operational environment," and subsequent increments improve on the baseline capability (A'Hearn et al., 1987, p. 7).

The DoD 5000 series of regulations provides the basis for guidance to acquisition professionals and have evolved with the guidance from the NDAAs. In DoD's 5000 *Documents: Evolution and Change in Defense Acquisition Policy,* Ferrara (1996) summarizes the changes in the DoD 5000 series from 1971 to 1993—early versions of the documents laid the groundwork for later versions. Table 2 provides word counts of the key words (*evolutionary, incremental,* and *block*) within DoDD 5000.1 from 1971 through the still—valid 2007 version, and DoDI 5000.02 from 2000 to 2017. Use of the words gives an indication of DoD's emphasis of these concepts within defense acquisition. Uses of the words "evolutionary," "incremental," and "block" or "block upgrades" first appear in the 1980s versions and gradually increase in use through the 1990s versions, peaking in the early 2000s versions, consistent with NDAA references highlighted in Table 1.

In the 1985 and 1986 versions, the DoDD 5000.1 encouraged PMs to "consider evolutionary alternatives" to reduce programmatic risk (Office of the Under Secretary of Defense for Research & Engineering [OUSDRE], 1985a, 1986a, p. 2). The 1987 DoDD emphasizes that the evolutionary strategy is not limited to IT, command and control (C2) systems, or software development efforts (Office of the Under Secretary of Defense for Acquisition [OUSD(A)], 1987b). The 1991 DoDI defines EA as:

> an approach in which a core capability is fielded, and the system design has provisions for future upgrades ... With this approach, selected capabilities are deferred so that the system can be fielded while the deferred element is developed in a parallel or subsequent effort. (OUSD[A], 1991b, p. 5-A-5)

TABLE 2. DODD 5000.1 SUMMARY OF EA AND ID WORD USE DATA

Department of Defense Acquisition Regulations				Department of Defense Acquisition Regulations			
Revision Year	Total Page Count	Total Word Count	Uses of word "evolutionary" or "increment" or "block"	Revision Year	Total Page Count	Total Word Count	Uses of word "evolutionary" or "increment" or "block"
1971	7	1,897	0				
1975	8	2,308	0				
1977	15	3,623	0				
1980			*	1980	58	14,056	2
1982			*				
				1983	34	*	1
1985	16	4,808	1	1985	32	7,035	1
1986	15	5,133	1	1986	34	7,117	1
1987	15	4,425	2	1987	26	7,958	0
1991	35	14,000	2	1991	345	92,029	10
				1993	542	126,858	32
1996	14	5,734	4				
2000	15	4,117	14				
2001	12	4,220	14				
				2002	193	46,636	98
2003	8	3,075	2	2003	50	14,958	52
2007	10	3,210	3				
				2008	80	28,852	62
				2013	152	*	40
				2015	154	61,220	68
				2017	110	*	52

Note. Adapted from DoDD 5000.1 dated 1971, 1975, 1977, 1980, 1982, 1985, 1986, 1987, 1991, 1996, 2000, 2001, 2003, & 2007; and from DoDI 5000.2 dated 1980, 1983, 1985, 1986, 1987, 1991, 1993, 2002, 2003, 2008, 2013, 2015, & 2017. * = could not determine.

The 1996 DoDD further elaborates on the use of "nontraditional acquisition" referenced as incremental acquisition that involves the use "of nontraditional acquisition techniques, such as ... evolutionary and incremental acquisition, and flexible technology insertion" (Office of the Under Secretary of Defense for Acquisition and Technology [OUSD(A&T)], 1996, p. 5).

The 2000 and 2001 DoDD versions use the words *evolutionary, incremental,* and *blocks* extensively. The 2000 DoDD builds on the themes in the 1996 version, which linked evolutionary acquisition to technology maturity. For the first time, the DoDD clearly defined evolutionary acquisition in terms of "increments" or "blocks" of capability:

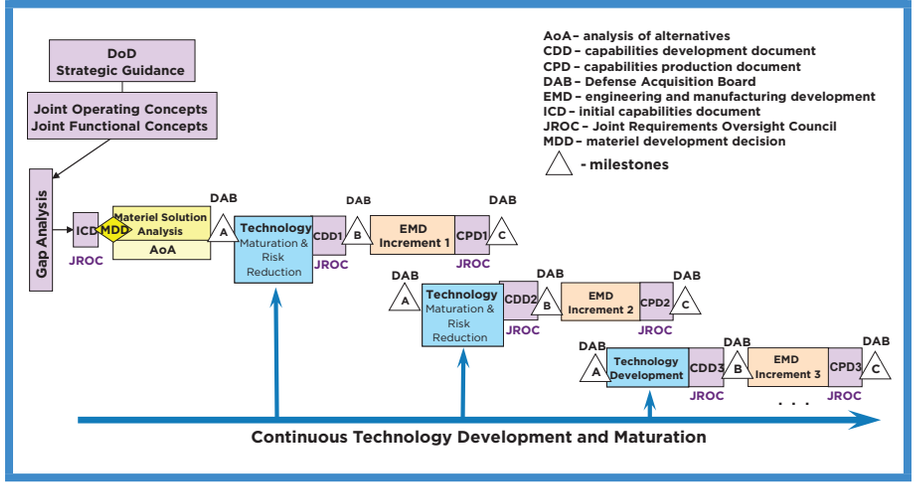
> Evolutionary Acquisition. To ensure that the Defense Acquisition System provides useful military capability to the operational user as rapidly as possible, evolutionary acquisition strategies shall be the preferred approach to satisfying operational needs. Evolutionary acquisition strategies define, develop, and produce/deploy an initial, militarily useful capability ("Block I") based on proven technology, time-phased requirements, projected threat assessments, and demonstrated manufacturing capabilities, and plan for subsequent development and production/deployment of increments beyond the initial capability over time (Blocks II, III, and beyond). In planning evolutionary acquisition strategies, program managers shall strike an appropriate balance among key factors, including the urgency of the operational requirement; the maturity of critical technologies; and the interoperability, supportability, and affordability. (OUSD[AT&L], 2000, p. 5)

The 2002 DoDI 5000.02 combined guidance for an MDAP with major automated information systems (MAIS), resulting in a spike in the use of the words evolutionary, increments, and blocks.

It is interesting that the 2003 version of the DoDD emphasizes evolutionary strategies as the preferred approach but introduces spiral development as the preferred process (OUSD[AT&L], 2003). The 2003 DoDI 5000.02 expands on this topic and explains the two options for EA development approaches: spiral or incremental. It defines *spiral development* as a process in which "a desired capability is identified, but the end-state requirements are not known at program initiation," and defines *incremental development* as a process in which "a desired capability is identified, an end-state requirement is known, and that requirement is met over time by developing several increments, each dependent on available mature technology" (OUSD[AT&L], 2003, p. 5).

The 2007 DoDD maintains nearly the same language as the 2003 version, with the important change of replacing the word "spiral" with "incremental," stating that "Evolutionary acquisition strategies are the preferred approach to satisfying operational needs. ***Incremental development*** is the preferred process for executing such strategies" (OUSD[AT&L], 2007, p. 3). Similar to the 2007 DoDD, the 2008 DoDI deletes references to spiral development and emphasizes ID, stating that each increment delivers a militarily useful capability to the warfighter, as depicted in Figure 3.

FIGURE 3. 2008 DODI 5000.02 EVOLUTIONARY STRATEGY WITH INCREMENTAL DEVELOPMENT



Note. Adapted from OUSD(AT&L), 2008.

The 2013, 2015, and 2017 versions of the DoDI 5000.02 continue to emphasize ID approaches but no longer use the word "evolutionary." The DoD acquisition directives and instructions, as well as the congressional guidance through NDAA language, have consistently recognized the benefits of ID over a period of several decades, and have called for their use and application in a variety of types of acquisition development programs. A continued emphasis on ID in DoD 5000 acquisition policy documents is expected and appropriate—directly tying to the relevance and long-term applicability of the research goal of studying the challenges in formulating an acquisition strategy with an ID approach. The next section provides a literature review related to EA and ID.

Literature Review of EA and ID Within Defense Acquisition

In 1998, a GAO report titled *Best Practices: Successful Application to Weapon Acquisitions Requires Changes in DOD's Environment* recommended that risk reduction within the DoD follow commercial practices of "using demonstrations of technology and incremental or evolutionary product developments" (p. 63). Furthermore, the 1998 GAO report referenced the Defense Science Board recommendation that "emphasizes incremental technology advancement, coupled with much shorter product development cycle times" (p. 8). The report also highlighted the National Center for Advanced Technologies' call for:

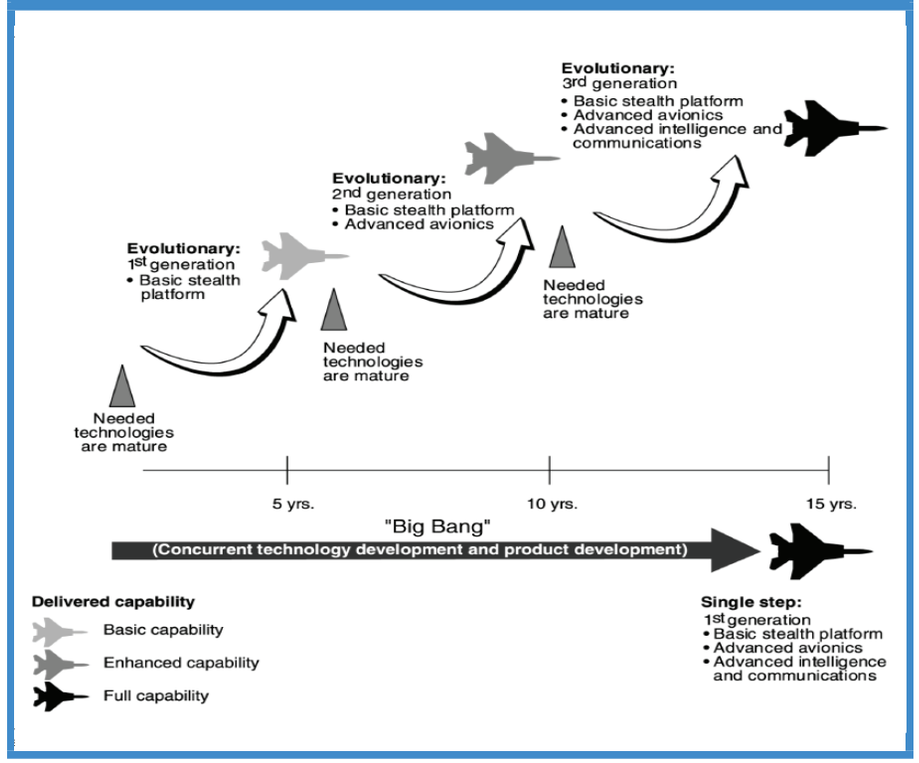
> a new culture that relies on an affordable, incremental approach that could reduce product development cycle times by 3 to 5 years. The new culture features an incremental approach to performance, with a threshold or minimum performance for the initial battle group with incremental upgrades and requirements that would be managed through cost tradeoffs to keep performance and cost in balance, avoid grand designs, and mitigate risk. (p. 71)

In a 2001 work, Williams studied the application of EA within the DoD. Williams found that despite several acquisition programs laying the groundwork for the application of EA, the use was not widespread, with further education and training required in the acquisition workforce. An *IEEE Computer Society* article by Larman and Basili (2003) titled *Iterative and Incremental Development: A Brief History* explained that even though some view agile methods or evolutionary development as relatively new concepts, the software development community had recognized the value of iterative and incremental development (IID) for decades. The authors noted that a great variety of EA and IID approaches exist, but they all avoid the "single-pass approach," often used in the DoD (Larman & Basili, 2003). Early practice of the IID approach in the 1970s, with IBM working on DoD space and avionics systems and the command and control (C2) system for the U.S. Trident submarine, successfully used an ID approach (Larman & Basili, 2003).

In 2003, the GAO reported to Congress on defense acquisitions in *DoD's Revised Policy Emphasizes Best Practices, but More Controls are Needed.* The GAO found that the DoD had tried to apply lessons learned from successful commercial companies by adopting a knowledge-based approach, specifically EA with time-phased ID in accordance with the requirements in the FY2003 NDAA (GAO, 2003b). Also in 2003, the GAO's *Best Practices: Better Acquisition Outcomes are Possible if DoD Can Apply Lessons from the F/A-22 Program* report used a case study approach with the F/A-22 program to illustrate "what can happen when a major acquisition program is not guided by the principles of evolutionary, knowledge-based acquisition" with ID—basically failing to deliver capability (GAO, 2003a, p. 2).

The GAO concluded that "an evolutionary environment for developing and delivering new products reduces risks ... While the customer may not receive an ultimate capability initially, the product is available sooner, with higher quality and reliability, and at lower, more predictable cost" (GAO, 2003a, p. 5). The GAO (2003a) recommended avoiding what they refer to as the "Big Bang" acquisition approach, or single-step acquisition, which is pictorially represented in Figure 4.

FIGURE 4. THE GAO COMPARISON OF EVOLUTIONARY AND BIG BANG APPROACHES



Note. (GAO, 2003a)

Following up on its earlier reports and at the height of military operations in Iraq and Afghanistan, in *DoD Acquisition Outcomes—A Case for Change,* the GAO reported to Congress that the DoD has been slow to fully adopt commercial industry's standard of knowledge-based acquisition that results "in evolutionary—that is, incremental, manageable, predictable—development" (GAO, 2005a).

The GAO studied the Joint Strike Fighter (JSF) program with a report in 2005 entitled *Opportunity to Reduce Risks in the Joint Strike Fighter Program With Different Acquisition Strategy,* concluding that the program's acquisition strategy failed to establish the commercially accepted best practice of ID (GAO, 2005b). In 2005, RAND published *Reexamining Military Acquisition Reform—Are We There Yet?* on behalf of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA[ALT]), which listed EA as a critical reform initiative within the acquisition enterprise (Hanks et al., 2005). The ASA(ALT) highlighted that the "move to greater use of 'evolutionary acquisition' (the initiative that encourages PMs to acquire systems in 'blocks' or 'increments' to reduce technical risk and meet delivery schedules) will be a good thing" (Hanks et al., 2005, pp. 35–36). In 2006, the GAO reported in *Defense Acquisitions—Major Weapon Systems Continue to Experience Cost and Schedule Problems under DoD Revised Policy* that DoD "continues to pursue revolutionary—rather than evolutionary or incremental—advances in capability" (p. 2).

In April 2009, Bussiere, Jester, and Sodhi presented a case study for the successful application of EA principles for management of the Navy's torpedo enterprise. The researchers highlighted the importance of MOSA design and stressed that "evolutionary updates via ID, modular design updates, technology refreshes, technology insertions" all come into play (Bussiere et al., 2009, p. 237). Dillard and Ford (2009) highlighted the risks of EA with an ID approach under certain instances. The authors studied two defense acquisition programs as case studies, and their conclusions were consistent with the fact that the principles of successful applications of EA and ID approaches had their roots in development efforts of software-intensive information systems.

In a 2014 RAND study titled *Prolonged Cycle Times and Schedule Growth in Defense Acquisition,* the authors comprehensively studied schedule growth within MDAPs and revealed that "the most commonly cited recommendations for reducing cycle time and controlling schedule growth are strategies that manage or reduce technical risk ... include using incremental fielding or evolutionary acquisition (EA) strategies, using mature or proven technology (i.e., commercial, off-the-shelf components)" (Riposo et al., 2014, p. xii). The authors opine that:

> incremental fielding and EA are acquisition strategies that have been employed as a way to speed fielding and control technical risks. They aim to provide some initial operationally useful capabilities more quickly than processes that use a single step to acquire a capability. EA achieves this goal through incremental improvements. (Riposo et al., 2014, p. 44)

The GAO continued to recommend more widespread acceptance of ID policies in a 2014 report titled *Agencies Need to Establish and Implement Incremental Development Policies,* and again in a 2016 report titled *Agencies Need to Increase Their Use of Incremental Practices.* In April 2015, the GAO issued a report entitled *Amphibious Combat Vehicle—Marine Corps Adopts an Incremental Approach* about the Marine Corps' effort following the cancellation of the Expeditionary Fighting Vehicle (EFV) program amid affordability concerns. The GAO (2015a) concluded that the Marine Corps' incremental approach for the ACV acquisition is consistent with best practices and can increase the likelihood of success.

As further evidence that the application of an ID approach is warranted across a wide spectrum of acquisition efforts, the GAO recommended in a 2015 report entitled *Evolved Expendable Launch Vehicle—The Air Force Needs to Adopt an Incremental Approach to Future Acquisition Planning to Enable Incorporation of Lessons Learned* that "when planning for the next phase of competition for launches, the Air Force use an incremental approach in the acquisition strategy" (GAO, 2015b, p. 2). A 2017 RAND study, *Program Characteristics That Contribute to Cost Growth,* compared Air

Force MDAPs. The study analyzed four programs with extreme cost growth and recommended that the Air Force "embrace incremental strategies with comprehensive and proven implementation strategies" (Lorell et al., 2017, p. xv).

Primarily through case studies of defense acquisition efforts, the literature review indicates that an ID approach continues to be highlighted as a key lesson learned for successful acquisition programs across a wide spectrum of efforts from software-intensive systems like IT and C2 systems and hardware-intensive development efforts like aircraft, tactical vehicles, launch systems, and missiles. The research in this article extends the body of knowledge in this field by also using a case study framework to study the challenges in formulating an ID approach for a typical MDAP involving technology development and facing a program approval milestone.

Acquisition Strategy Survey—Research Methodology and Data

Through case studies of past acquisition programs, EA with an ID approach is a well-documented commercial industry best practice for delivering customer products within performance, cost, and schedule constraints. With beginnings in software-intensive development efforts, the use of EA and ID spread to hardware-intensive development efforts. However, as discussed, the successful application to DoD acquisition efforts is spotty at best. Directives, regulations, and statutes have given guidance on the application of EA and ID over a period of three decades. This research examines how PMs decide on the components of an acquisition strategy for a development effort. It uses a case study framework of an actual acquisition program that went through an acquisition MS B approval to establish a program of record for a development effort.

Using the JCM program entering an MS B decision in 2004 as a case study, the research investigates how a PM can develop the key components of an acquisition strategy. The study surveys acquisition professionals and asks them to formulate the components of an acquisition strategy using the actual JCM program milestone decision input data. These proposed strategies are then compared to the approved original JCM acquisition strategy and the approved JAGM program strategy subsequently adopted by the Army and Navy over 10 years later. Insights into the importance of crucial decision inputs to PMs will provide policy recommendations for the DoD to consider to better support PMs in developing the Department's preferred strategy—an ID approach. This research is a study of the original JCM decision inputs (requirements, technology maturity, risk assessments, urgency, and funding) to see if the JAGM strategy that was subsequently adopted could have been envisioned using the original JCM milestone data, thus avoiding a "lost decade" of delivering no improved capability to the warfighter and possibly delivering capability sooner.

"Through case studies of past acquisition programs, EA with an ID approach is a well-documented commercial industry best practice for delivering customer products within performance, cost, and schedule constraints.

Problem Statement: Program managers and acquisition professionals struggle to formulate the preferred approach at program approval milestones, and many programs are approved as single-step development efforts whereas an incremental approach may be more appropriate and effective in delivering capability.

Primary Objective: To answer the following questions, by developing insights into how acquisition professionals use typical programmatic decision inputs to formulate the components of an acquisition:

Primary question: Given programmatic decision inputs for a specific program, can we gain a better understanding of how PMs or acquisition professionals formulate the components of the acquisition strategy?

- **Secondary questions:**
  - What is the most important factor in determining the recommended acquisition strategy?
  - How can the decision input factors be changed to enable a PM or acquisition professional to recommend an ID strategy that more closely resembles the actual strategy later adopted by the Services?

This research uses the JCM program as a case study in part because it did not have requirements that were time-phased. Therefore, the survey participants balanced the inputs of requirements, resources (approved funding), and technology maturity (TRLs and risk assessments) to try to develop the components of an acquisition strategy to meet the warfighter's required needs and timelines, and to augment affordability for the Services.

The JCM program was studied because the Services have maintained a consistent long-term need to replace existing capabilities, and because the program is well suited to the benefits of an ID approach. The JCM program was initiated in the late 1990s (Common Missile Project Office, 2003; JCM Program Office, 2004). It was a Joint (Army, Navy, Marine Corps) effort to replace Hellfire, Maverick, and aviation-launched, tube-launched, optically-tracked, wire-guided (TOW) missiles fired from both rotary wing (AH-64 Apaches, AH-1 Cobras, and MH-60 Seahawks) and fixed wing (F/A18 E/F Super Hornets) aircraft. The JCM program had a successful MS B in early 2004 with an approved capabilities development document (CDD) and subsequently awarded an Engineering and Manufacturing Development (EMD) contract for a planned 4-year EMD phase (Joint Requirements Oversight Council [JROC], 2004). The approved JCM acquisition strategy had a planned single-step development approach to meet all required capabilities. In late 2004 (approximately 6 months after program approval), the JCM program was cancelled primarily for affordability reasons (Wolfowitz, 2004). In 2015, the follow-on program, renamed the Joint Air to Ground Missile (JAGM), applied the key lesson learned from the failed JCM effort—adoption of an ID approach. The JAGM program emerged with a successful MS B and awarded the EMD contract 10 years after the original JCM program (JAGM Project Office, 2014, 2015, 2016).

The Army and Navy planned the JCM program for a decade prior to the MS B or official designation of the program of record and start of the EMD phase (Mortlock, 2005). The science and technology (S&T) communities matured the underlying missile technologies through S&T objectives and a technology maturation and risk reduction phase. A high-level government work breakdown structure (WBS) enabled a risk assessment for the JCM development effort as well as TRL determinations for the critical technology elements (CTE) of the missile for the MS B decision (U.S. Army Test & Evaluation Command [ATEC], 2003).

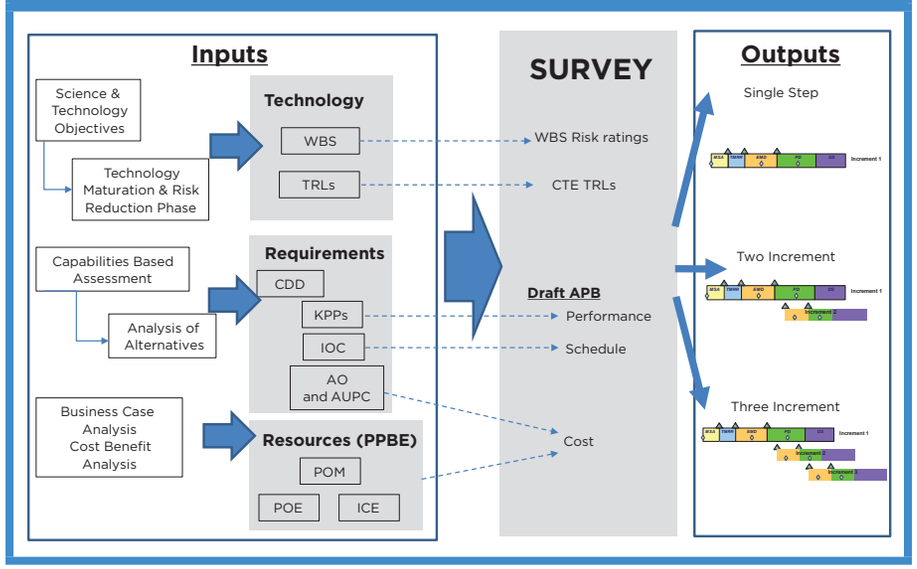
At the same time as the missile technologies were being matured, the requirements generation system, formally named the Joint Capabilities, Development, and Integration System (JCIDS), completed both a capabilities-based assessment (CBA) and analysis of alternatives (AoA) (Sleevi, 2003). The CBA and AoA supported the JROC approval of the JCM capability development document (CDD), which contained key performance parameters (KPP), initial operational capability (IOC) dates, acquisition objective (AO), and an average unit procurement cost (AUPC) (JROC, 2004). Simultaneous with the technology maturation and requirements solidification, the resourcing plan for a JCM program was being worked in the planning, programming, budgeting, and execution (PPBE) system. The JCM business case analysis supported the JCM program office estimate (POE), the Army and Navy program objective memorandum (POM) submissions, and an independent cost estimate (ICE) (R. P. Burke, personal communication, April 16, 2004; E. J. Gregory, personal communication, May 7, 2004).

The acquisition strategy survey puts the participant in the shoes of PMs as they prepare for the approval of the JCM program of record to start EMD, and asks for a recommendation of the components of an appropriate strategy—single step or incremental—based on program requirements and constraints. The survey participants decide whether to maintain the planned single-step development strategy or develop an alternate, incremental strategy. The baseline survey provides acquisition professionals with the actual JCM MS B data used by the PM, program management office (PMO), program executive offices (PEO), Service Acquisition Executives, and Milestone Decision Authority (MDA) (the Defense Acquisition Executive [DAE] who, at the time, was the USD[AT&L]). The survey data are consolidated into the important program information, including background program data, the draft APB, the Service's affordability determinations, the independent cost estimate, the risk assessment, and TRLs of CTEs based on the JCM WBS.

Figure 5 outlines the general survey approach. The inputs to the survey include three main areas: technology, requirements, and resources. The technology portion of the survey was presented to the participant in the form of a high-level missile design WBS, which included missile component risk ratings and TRLs for each of the missile CTEs. The requirements section summarized the KPPs, IOC, AO, and AUPC from the approved CDD,

and the resources section summarized the approved POE and ICE. Both the requirement and resources sections of the survey were presented to the participants in the form of a draft APB with performance, schedule, and cost sections. The survey was developed based on the work of Gress, Kohtz, and Noll (2018) in the Naval Postgraduate School (NPS) thesis entitled, "Evolutionary Acquisition with an Incremental Approach."

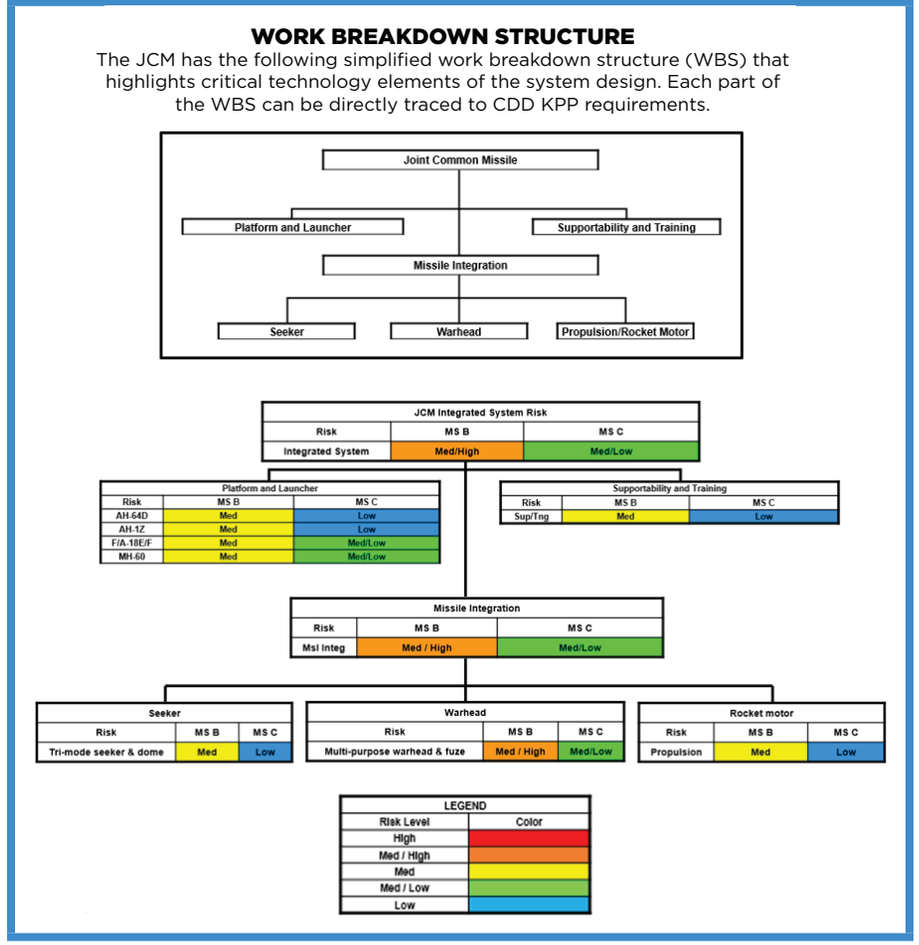
FIGURE 5. ACQUISITION STRATEGY SURVEY APPROACH



The survey provides each individual with sufficient data to make an informed recommendation on the components of the most appropriate acquisition strategy. Further, it provides a situation and the background information for the JCM program outlined in Appendix A and described previously.

The performance section of the APB contains the approved CDD KPPs. The schedule section of the APB came from the approved IOC date found in the CDD, and the cost section of the APB came from the approved AO and AUPC—also found in the CDD (JROC, 2004). Appendix B presents the draft APB, and Figure 6 presents the WBS and risk ratings presented in the survey as data for the survey participants. The risk assessment in Figure 6 presents the risk ratings for the critical development efforts associated with the missile (based on the WBS) at MS B and projected at MS C. The overall risk rating for the missile at the milestones is taken as the highest risk rating on any of the WBS subcomponent areas. For example, at MS B, the multipurpose warhead was rated as medium/high risk, which made the missile integration risk medium/high and the overall JCM integrated system risk medium/high at MS B.

FIGURE 6. ACQUISITION STRATEGY SURVEY JCM WBS AND RISK RATINGS



Survey participants were then asked to define the capabilities, cost, and schedule components for their recommended acquisition strategy. Specifically, they decided on whether to recommend a single-step development approach, a two-increment development approach, or a three-increment development approach based on the following programmatic data: the draft MS B APB, the WBS risk rating, and a CTE TRL for the three missile areas (seeker, warhead, and motor). The survey constrained the options with respect to performance, cost, and schedule. For example, with respect to performance, acquisition professionals only decided whether the

desired KPP requirements were developed in an increment or delayed to a later increment. With respect to schedule and cost, the participants decided only whether to recommend the Services' POE or ICE AUPC estimates and EMD phase duration for each increment.

As stated previously, the baseline survey used the following actual JCM MS B data for eight risk ratings and three TRL ratings (ATEC, 2004; JCM Program Office, 2004):

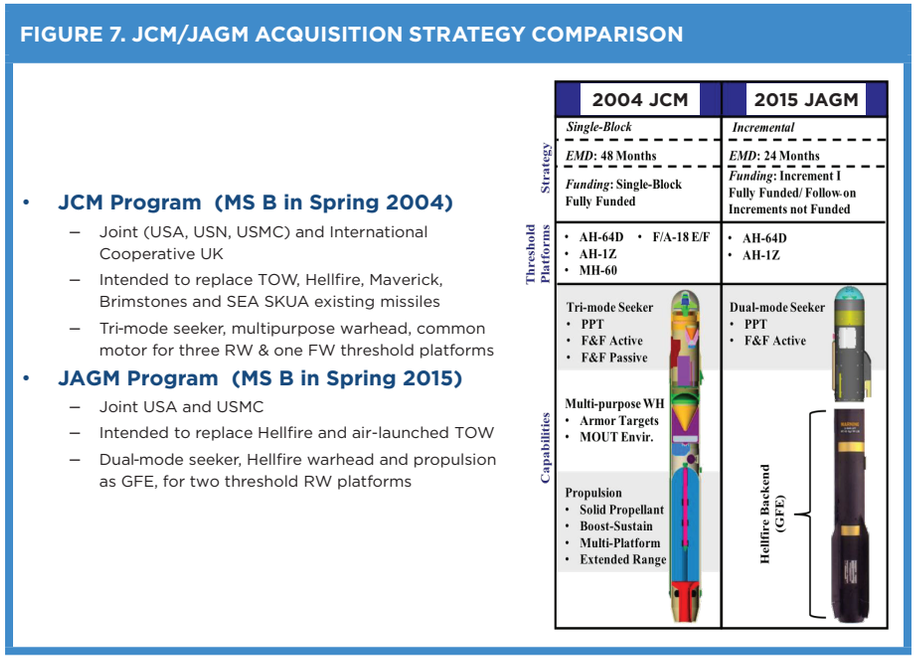
- Critical Technology Element (CTE) TRLs:
  - Tri-mode seeker (s): 6
  - Multipurpose warhead (w): 6
  - Common motor (m): 6
- Risk ratings (RR) based on JCM WBS:
  - Tri-mode seeker (s): medium (m)
  - Multipurpose warhead (w): medium/high (m/h)
  - Common motor (m): medium (m)
  - Missile integration (i): medium/high (m/h)
  - AH-64 Apache platform integration (64): medium (m)
  - AH-1 Cobra platform integration (1): medium (m)
  - MH-60 Seahawk platform integration (60): medium (m)
  - F/A18E/F Super Hornet platform integration (18): medium (m)

[Note that the risk ratings had a range from low (l), low/medium (l/m), medium (m), medium/high (m/h) to high (h).]

The original JCM acquisition strategy recommended by the Army and Navy, supported by the warfighters, and approved by the DAE in the spring of 2004 after a successful MS B was a single-step development effort that met all the KPPs. The JCM program was later cancelled as a program of record by the Office of the Secretary of Defense (OSD), and re-designated as a technology base effort (Wolfowitz, 2004). Eventually, the effort was renamed as the JAGM program.

The JAGM program was approved as a program of record and successfully awarded an EMD contract after an MS B approval in 2015 (11 years after the JCM attempt for an EMD program of record). However, the capabilities to be delivered under the JAGM program were greatly reduced from the capabilities desired in the JCM program. Figure 7 displays the differences between the JCM and JAGM programs. The documented lessons learned emphasized the avoidance of extensive unprioritized requirements, multiple threshold platforms, and the fixed-wing F18 platform in particular. The Army and Navy lessons applied to the JAGM effort emphasized an ID effort of the warfighter's highest priorities, reduced the threshold platforms, and leveraged the existing Hellfire missile warhead and motor to reduce risk, cost, and schedule.

FIGURE 7. JCM/JAGM ACQUISITION STRATEGY COMPARISON



Note. Adapted from Gress, Kohtz, & Noll, 2018.

Survey Participants

The survey participants included 31 acquisition professionals representing a broad spectrum across the DoD, including active duty officers and government civilians from the Army, Navy, and Air Force. All the respondents were members of the acquisition workforce with various Defense Acquisition Workforce Improvement Act (DAWIA) acquisition certifications. The survey was intended to be taken by acquisition professionals in the DoD acquisition workforce. "The acquisition workforce

is generally defined as uniformed and civilian government personnel, who are responsible for identifying, developing, buying, and managing goods and services to support the military" (Schwartz, et al., 2016). The size of the acquisition workforce has stabilized to approximately 150,000 total personnel (about 90% civilian and 10% uniformed personnel) across 14 distinct career fields that include engineering, contracting, life cycle logistics, program management, production & quality management, test & evaluation, facilities engineering, business–financial management, IT, auditing, S&T manager, business–cost estimating, purchasing, and property (Schwartz et al., 2016). The survey research protocol was reviewed by the Naval Postgraduate School Institutional Review Board and found to meet exemption category 2 in accordance with 32 CFR 219.101(b). Although not required, best practices of informed consent were followed. Additionally, the volunteer nature of the survey participation was emphasized, and no personably identifiable information (such as names, organizations, job titles, etc.) was recorded or could ever be traced to specific individual answers. The survey participants had no prior experience within either JCM or JAGM programs. They took the survey as part of leader development seminars sponsored by PEOs or as students in a master of science in program management or master of business administration in systems acquisition management. Prior to taking the survey, the respondents participated in discussions on critical thinking, risk and knowledge-based decision making, and the benefits of ID approaches.

Research Survey Data

The baseline survey uses the actual JCM MS B data, presents the draft JCM acquisition strategy, and asks survey participants to develop an appropriate acquisition strategy based on this data. The survey results are presented in Table 3. Table 3 tallies the responses of each participant for their recommended components of the strategy in terms of capabilities developed, schedule, and AUPC costs for each increment. Of the 31 participants, seven recommended a single-step strategy, 13 recommended a two-increment strategy, and 11 recommended a three-increment strategy. Within each strategy type, read across the row to follow the tally of how many respondents recommended a specific strategy with respect to seeker, warhead, propulsion, platforms, schedule, and costs. The survey asked the participants to decide the following for each increment based on the given data:

- Seeker: development of dual or tri-mode seeker (laser, millimeter wave, and infrared) or use of a nondevelopmental (NDI) single mode seeker.
- Warhead: development of multipurpose warhead or use of an NDI single warhead.
- Propulsion: development of a common motor or use of an NDI single motor.
- Platforms: rotary wing (AH-64, AH-1, or MH-60) or fixed wing (F/A-18E/F)
- Schedule: (length of EMD phase)
- AUPC costs: (POE or ICE)

To address the research questions and help analyze the data, three hypotheses were studied. The first hypothesis was that the JAGM strategy would not be recommended based on the pressures to deliver all KPPs by the required IOC within the cost and schedule constraints of the Service-approved POE. The JAGM strategy was an incremental approach with the first increment developing a dual mode seeker and using an NDI warhead and NDI motor, while only being incorporated on the AH64 and AH1 platforms. The second hypothesis was based on the nearly constant emphasis on affordability and rapid acquisition, articulated by senior leaders

and Congress over many years. It proposed that acquisition professionals would reduce programmatic risk by maintaining the cost and schedule constraints in the draft APB and recommending delaying performance capabilities (pushing some KPPs to later increments). Given that an incremental strategy was recommended, the third hypothesis was that acquisition professionals would choose to delay capabilities associated with technologies with low TRL ratings and/or high-risk ratings (for example, only the multipurpose warhead had medium/high risk rating and would be delayed to later increments).

TABLE 3. SURVEY DATA RESULTS

		Seeker			Warhead		Propulsion		Platform				Schedule (EMD length)		Cost (AUPC)	
	Respondents (n)	Single Mode (NDI) TRL 9	Dual Mode	Tri-mode APB KPP TRL 6 Med Risk	Single (NDI) TRL 9	Multipurpose APB KPP TRL 6 Med/High Risk	Single motor (NDI) TRL 9	Common APB KPP TRL 6 Med Risk	AH64 APB KPP	AH1 APB KPP	MH60 APB KPP	F18 APB KPP	48 months APB POE	72 or 144 months ICE	$108K or $120K APB POE	$153K ICE
	31															
Single Step	7		1	6	1	6	1	6	6	6	6	7	1	6	2	5
Two-Increment Approach								**Two-Increment Approach**								
Increment I	13		8	5	7	6	3	10	12	11	10	5	7	5	8	4
Increment II				13		13		13	13	13	13	13	3	8	5	8
Three-Increment Approach								**Three-Increment Approach**								
Increment I		4	5	2	8	3	10	1	10	8	6	5	9	2	7	4
Increment II	11		4	7	5	6	8	3	10	9	9	8	7	4	6	5
Increment III				11		11	1	10	10	9	9	10	7	4	6	5

Hypothesis No. 1: Acquisition professionals would not recommend the JAGM acquisition strategy from the JCM MS B data. For a sample size of 31, 7 of 31 (23%) recommended a single-step approach, 13 of 31 (42%) recommended two increments, and 11 of 31 (35%) recommended three increments. None (0 of 31, or 0.0%) of the respondents recommended an acquisition strategy resembling the JAGM strategy (dual mode seeker, NDI warhead, NDI motor, and integration of only AH64 and AH1 in first increment)—providing evidence that supports hypothesis No. 1 that acquisition professionals did not recommend the JAGM ID strategy based on the actual JCM MS B programmatic data.

Hypothesis No. 2: Most acquisition professionals would maintain the approved Service cost and schedule constraints and choose to delay capability, given the JCM MS B data. For single-step acquisition, 5 of 7 respondents (71%) chose the ICE-recommended 6-year schedule and $153,000 AUPC with no capability increments; and 2 of 7 (29%) of the respondents chose a 4-year or 12-year schedule and $120,000 AUPC with no capability increments. For the first increment in two-increment strategies, 5 of 13 (38%) recommended delaying some capability with a first-increment schedule of 6 or 12 years, with ICE-recommended $153,000 AUPC; and 7 of 13 (54%) recommended delaying some capability with a first increment

schedule of 4 years and $120,000 AUPC. For the first increment in three increment strategies, 7 of 11 (64%) recommended delaying some capability but maintaining the Service-approved 4-year schedule and $108,000 AUPC. In summary, only 14 in 31 respondents (45%) decided to maintain the approved Service cost and schedule constraints and incrementalize capability—indicating evidence counter to hypothesis No. 2.

Hypothesis No. 3: For those acquisition professionals that recommended an incremental approach, they would recommend delaying capabilities linked to technologies with low TRLs and/or high-risk ratings. For the baseline survey, 24 of 31 (77%) recommended an incremental approach, with 13 recommending two increments, and 11 recommending three increments. Of the 13 recommending a two-increment approach, 8 of 13 delayed seeker capability, 7 of 13 delayed warhead capability, 3 of 13 delayed motor capability, and 11 of 13 delayed a platform to increment two. Of the 11 recommending a three-increment approach, 9 of 11 delayed seeker capability, 8 of 11 delayed warhead capability, 10 of 11 delayed motor capability, and 8 of 11 delayed a platform to later increments. For the baseline survey, the three CTEs had a TRL of 6, six risk areas were ranked as medium risk, and the warhead and integration were ranked as medium/high. These results neither confirm nor deny hypothesis No. 3 because the warhead was highlighted as higher risk, and 15 of 24 (63%) respondents pushed the multipurpose warhead to a later increment. However, 17 of 24 (71%) respondents pushed the seeker to a later increment despite the tri-mode seeker having the same TRL rating as the multipurpose warhead and a lower risk rating. The recommended approaches do not appear to be entirely data-driven based on the CTE, TRL, and risk ratings.

Research Limitations

The following observations acknowledge the limitations of this research framework and data.

- A small sample size of 31 participants representing a diverse acquisition workforce.
- The research case study framework leverages only one effort—the evolution of the JCM program to the JAGM program—as a typical acquisition effort representing a great variety of defense acquisition efforts.
- The assumption that the components of an acquisition strategy can be developed from milestone decision data of requirements (KPPs), technology risks (TRLs and CTE risk ratings), costs (AUPC predictions from POE and ICE), and schedule (required IOC).
- The assumption that the acquisition strategy can be summarized by describing the components of capability desired (planned KPPs to be achieved), the schedule (length of development effort), and costs (AUPC) for each increment within the strategy.
- The research assumptions that the JCM acquisition strategy was ineffective because the program was cancelled, resulting in no warfighter capability, and that the JAGM acquisition strategy was effective because the program was not cancelled, resulting in improved warfighter capability.

Analysis of Results

This section presents the results detailed earlier to address the research questions.

Primary Research Question

Given programmatic decision inputs for a specific program, can we gain a better understanding of how PMs or acquisition professionals formulate the components of the acquisition strategy? The survey results indicated that acquisition professionals used knowledge of TRLs and risk ratings to recommend the components of an acquisition strategy in terms of performance, cost, and schedule. To reduce programmatic risk, most participants chose to recommend an incremental approach rather a single-step acquisition as originally planned.

Additionally, most participants chose to relax performance constraints by delaying requirements to later increments, relax schedule constraints by extending the EMD length, and relax cost constraints by recommending the higher ICE AUPC. This result directly addresses the primary research question by providing evidence that acquisition professionals have difficulty in prioritizing the triple constraint of cost, schedule, and performance; therefore, they tended to relax all three rather than choose just one element to reduce programmatic risk.

These results provide data to support a recent GAO (2015c) conclusion, in *Joint Action Needed by DOD and Congress to Improve Outcomes,* that defense acquisition provided incentives for PMs to promote successful acquisition strategies (defined as approved and leading to successful milestones) rather than sound acquisition strategies (defined as executed within cost, schedule, and performance constraints, and leading to fielding capability). This research suggests that acquisition policy needs to provide more guidance to assist PMs in developing acquisition strategies like ID

approaches to optimally balance near-term program milestone approval and long-term program executability in terms of maintaining cost, schedule, and performance baselines and delivering capability.

Secondary Research Question

What is the most important factor in determining the recommended acquisition strategy? The survey results indicated that when acquisition professionals recommended an incremental approach, neither a low-component TRL nor high-risk rating was more important in recommending that a capability be delayed to a later increment. Acquisition professionals were equally likely to recommend a delay, to a later increment, of the seeker capability and the warhead capability, despite the latter technologies being rated at a higher risk level. The research results suggest that acquisition professionals used other than the provided data on TRLs and risk ratings. The results also indicate that acquisition professionals did not link the KPPs to the TRLs and risk ratings. For example, the development of the common motor was directly linked to the requirement for delivery from both rotary wing and fixed wing (F/A-18E/F). However, acquisition professionals recognized this connection in their recommended acquisition strategy less than 50% of the time, and recommended delaying the common motor development and the F/A-18E/F platform to later increments.

PMs basically have two choices to reduce programmatic risk when formulating acquisition strategy—either request more time and money for the effort as defined or request a reduction in scope for the time and money planned. Requesting more money or additional schedule is unrealistic for a development program that has been in the TMRR phase with a planned EMD phase, and it risks program approval with Service leaders who already approved the funding and the schedule to go along with that funding. The more likely choice to reduce programmatic risk would be to maintain cost and schedule constraints and recommend a reduction in scope or performance capability.

This is difficult for the PM to recommend because the warfighter wants all the required capability. This is where the benefits of an ID approach can help alleviate some concerns by delivering improved capability (albeit not full desired capability) in increments while the full capability is developed simultaneously. In this research, 71% recommended an ID approach, indicating good training and education of the acquisition workforce on the benefits of ID. Even though most acquisition professionals recommended an ID approach, only 41% maintained the cost and schedule constraints. The participants believed that they not only had to reduce performance by delaying requirements, but had to recommend a longer schedule and request more funding.

This puts the PMs in the difficult position of not being able to deliver on cost, schedule, or performance requirements, and it increases the risk that the program will not get approved as a program of record at the milestone. This pressure to get program approval must be balanced with the PM's risk of trying to execute a program with a high probability of encountering cost over-runs, schedule slips, and underperformance in delivering the proposed capabilities.

The results indicate what many experienced acquisition professionals intuitively know: at program initiation for a complex defense research and development effort, it is extremely hard to plan the components of an acquisition strategy that does not need to be later adjusted by fact-of-life changes in the acquisition environment. The problem is that these acquisition strategy adjustments usually require APB changes that put the program at risk for cancellation due to schedule slips, cost increases, and/or inability to deliver required performance capability. The inputs to the acquisition strategy survey here typify the data that would be provided to the MDAs to approve planned acquisition strategies. Some might argue that more data and time are needed to make a truly informed decision; however, in reality, less data and time are normally available. It is also noted that acquisition strategies are usually developed through integrated product teams (IPTs) leveraging the concepts of integrated product and process development. In the end, however, the PM makes recommendations through the chain of command to the MDA for decisions; IPTs don't make decisions—they enable a more informed recommendation from the PM and a more informed decision by the MDA.

In this case for the JCM program, the requirements were well established and supported by years of analysis with a set capability need date. The technologies needed to turn those requirements into capabilities for the warfighter had matured to the point that they were deemed mature (TRL 6) and ready for integration and development work. Additionally, the funding to support the JCM program of record for a development and engineering work and procurement of missiles was aligned to the required need date (IOC). The PM triple constant of cost, schedule, and performance was all synchronized and set within the planned APB. However, for the JCM program, a single-step acquisition strategy to deliver all required capabilities was eventually cancelled and the warfighter received no capability. Had an ID approach similar to the subsequent JAGM acquisition strategy been adopted initially, the warfighter would have received improved capability more than a decade sooner.

Future Research

This research could not address the secondary research question—how can the decision input factors be changed to enable a PM or acquisition professional to recommend an ID strategy that more closely resembles the actual strategy later adopted by the Services? To address this research question, the input variables in the survey would need to be changed from the original JCM data in different versions of the survey. The results of the modified surveys could be compared to one another to study which survey input variables resulted in a higher percentage of acquisition professionals recommending a JAGM incremental acquisition strategy. Future work investigating the relative importance of CTE TRL ratings versus CTE risk ratings in determining the recommended components of the strategy would shed light on the importance of these ratings in decision making. Table 4 represents a proposed design-of-experiments approach showing how the eight risk ratings and TRL ratings could vary in different survey versions.

A comparison of the results between surveys No. 1 through No. 4 could be undertaken to see whether acquisition professionals recommend an incremental approach to the development of the tri-mode seeker in situations with a low seeker TRL and/or high seeker risk rating. Surveys No. 5–7 would support the results of surveys No. 1–4 by varying the warhead data, rather than the seeker data.

Similarly, surveys No. 8–12 would study the missile motor as well as the platforms that would accept the missile. For example, the results of survey No. 9 would study the question, "Did a higher percentage of acquisition professionals recommend delaying integration of the missile onto the F18 platform if the risk rating was high rather than medium?"

Survey No. 13 would study the importance of the integration risk rating in relation to the CTE TRLs or CTE risk ratings. The results of this survey may indicate that an integration readiness level (IRL) has the same level of acceptance as TRLs and manufacturing readiness levels (MRLs) within acquisition policy.

The results of survey No. 14 would reveal whether acquisition professionals do indeed recommend an incremental approach at higher percentages when the TRLs are low and risk ratings are high. Survey No. 14 data input is set up to determine whether respondents recommended a JAGM strategy more often than the baseline data in survey No. 1.

TABLE 4. PROPOSED FUTURE SURVEY DESCRIPTIONS

	Technology Readiness Level (TRL)			Risk Ratings (RR)							
Survey Number	**Seeker (s)**	**Warhead (w)**	**Motor (m)**	**Seeker (s)**	**Warhead (w)**	**Motor (m)**	**Integration (i)**	**AH-64 Apache (64)**	**AH-1 Cobra (1)**	**MH-60 Seahawk**	**F/A18E/F (18)**
Survey #1 - baseline	6	6	6	m	mh	m	mh	m	m	m	m
Survey #2 - seeker TRL	4	6	6	m	mh	m	mh	m	m	m	m
Survey #3 - seeker RR	6	6	6	h	mh	m	h	m	m	m	m
Survey #4 - seeker TRL & RR	4	6	6	h	mh	m	h	m	m	m	m
Survey #5 - warhead TRL	6	4	6	m	mh	m	mh	m	m	m	m
Survey #6 - warhead RR	6	6	6	m	h	m	h	m	m	m	m
Survey #7 - warhead TRL & RR	6	4	6	m	h	m	h	m	m	m	m
Survey #8 - motor TRL & RR	6	6	4	m	mh	h	h	m	m	m	m
Survey #9 - F18 platform RR	6	6	6	m	mh	m	mh	m	m	m	h
Survey #10 - MH60 platform RR	6	6	6	m	mh	m	mh	m	m	h	m
Survey #11 - motor TRL & RR and F18 RR	6	6	4	m	mh	h	h	m	m	m	h
Survey #12 - motor TRL/RR and F18/MH60 RRs	6	6	4	m	mh	h	h	m	m	h	h
Survey #13 - integration RR	6	6	6	m	mh	m	h	m	m	m	m
Survey #14 - JAGM	4	4	4	h	h	h	h	m	m	h	h

Conclusions and Recommendations

The results highlight the importance of the Service affordability constraints in establishing the acquisition program's cost and schedule parameters in the APB. After cost and schedule constraints are set, the senior leaders, acquisition professionals, and warfighters must come together and agree on an incremental approach to deliver some capability as soon as possible to the warfighter and delay the full capability to later increments. If this struggle does not happen initially for a complex development program, then the program may never deliver capability because of the high risk of cancellation due to schedule slips and cost overruns.

Once the program's cost and schedule parameters are planned, programmed, and budgeted in the Service POM, the importance of considering alternate acquisition strategies, such as to delay desired capability to later increments, is evident. PMs must coordinate and balance the inputs from the S&T, testing, and warfighter communities to recommend the integration of the least risky technologies for inclusion in the first increment of a new warfighting capability. The use of both TRLs and risk ratings for the development of CTEs and integration risk ratings may help increase the chance of program success (defined in terms of improved fielded capability to warfighters).

In the case of the JCM program, the cost and schedule constraints indicated the need to recommend an ID approach and delay some capability to later increments. The JCM program was cancelled after a successful MS B, and it took more than 10 years for the new JAGM program to pass an MS B—this time with an incremental approach that leveraged existing government furnished equipment (GFE) and NDI components. Meanwhile, during this "lost decade," the warfighter got none of the desired capabilities required.

This research suggests that the guidance in DoDD 5000.1 should encourage PMs to plan acquisition strategies for programs of record with an ID approach using set affordability parameters with respect to cost and schedule for development efforts. Further, allow the Services the ability to fit what is affordable from a performance (requirements) perspective into the first increment of the program of record by delaying the achievement of some requirements (even KPPs) to subsequent increments to allow more time for technology maturation. Warfighters would benefit from some capability increase, and acquisition programs would be less likely to fail due to cost overruns and/or schedule slips.

Results of this research suggest that the defense acquisition system should break the concept of the PM's triple constraint of cost, schedule, and performance. The triple constraint ties the hands of the PMs and may contribute to high program failure and no delivered capability. The bottom line is that if all three—cost, schedule, and performance—are set, then the program may have an unnecessarily high risk of failure. If affordability sets the constraints of cost and schedule, which must be done in a government/defense industry domain like defense acquisition, then flexibility in determining which requirements to pursue by allowing ID approaches would loosen the triple constraint stranglehold. In the end, the warfighter must determine whether the first capability increment offers enough capability improvement over the current systems to warrant the investment of time and money. The current defense acquisition system incentivizes PMs to get through an improved milestone—often with a program that cannot be executed in terms of cost, schedule, and performance and has a high risk of cancellation and failure. A better approach would incentivize fielded and delivered warfighter capability by allowing PMs to develop acquisition strategies that balance gaining program approval and maintaining acquisition baselines.

"Results of this research suggest that the defense acquisition system should break the concept of the PM's triple constraint of cost, schedule, and performance. The triple constraint ties the hands of the PMs and may contribute to high program failure and no delivered capability.

The following recommendations, specific to defense acquisition policy, result from this study:

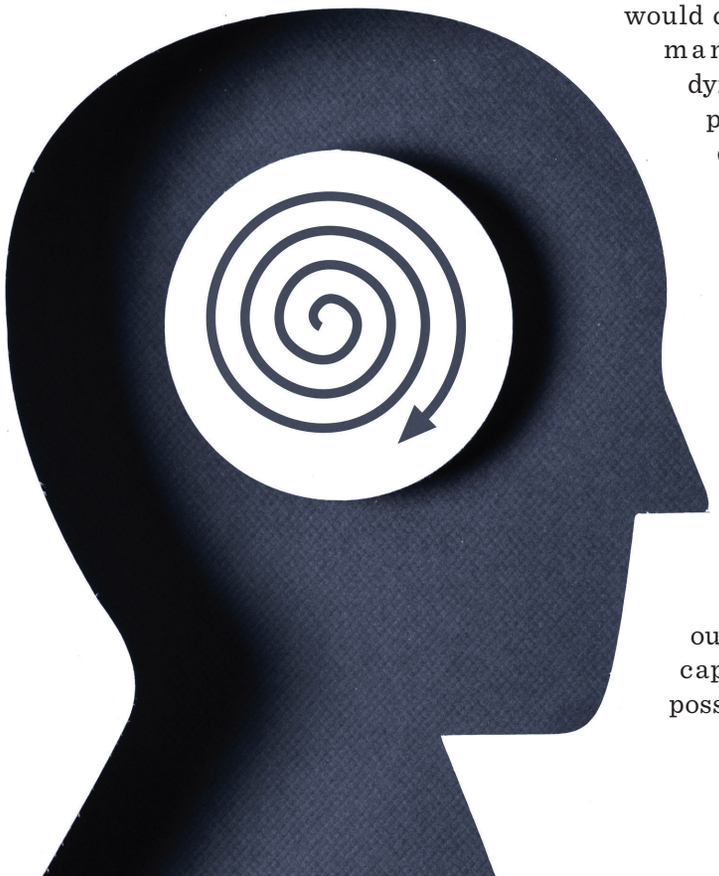
- For major defense acquisition programs, especially technology development efforts, the DoDD 5000.01 should continue to state the preferred approach as ID. Although the sample size is relatively small, this work suggests that DoD should consider modifying acquisition policy to make ID the default strategy, requiring MDAs to justify any single-step acquisition.
- The use of TRLs for specific component technologies is well entrenched in defense acquisition training for PMs, specifically the requirement for all component technologies to achieve TRL 6 for an MS B or entry to the EMD phase. However, TRLs

alone do not provide sufficient information for PMs and MDAs to make well-informed choices on appropriate incremental strategies. Component technology TRLs should be augmented with risk ratings. Specifically, risk ratings should be medium or lower for all program-identified risks before proceeding into the EMD phase of the first increment.

- The integration risk should be specifically addressed at all milestone reviews, either through the program risk assessment or the introduction of an IRL, similar to the TRL and MRL levels.

This study focused on the challenges PMs have in formulating the DoD's preferred approach—an ID strategy. The conclusions and recommendations focus on acquisition policy changes to optimize the implementation of ID strategies. The goal is to make the defense acquisition system more responsive to the warfighter by fielding improved capability as quickly as possible and reducing risk to the eventual delivery of the full required capability.

A proposed extension of this research is a "new" area of research called "behavioral acquisition." Similar to behavioral finance that studies both economics and psychology within finance decision making, behavioral acquisition would combine the study of program management, organizational dynamics, defense acquisition, and psychology within acquisition decision making. A paradigm shift may be required within defense acquisition to realize the importance of research in behavioral acquisition. A solid understanding of how acquisition professionals think critically and make decisions or recommendations in the complex defense acquisition environment would lead to improved acquisition strategy planning and better acquisition program outcomes—specifically, warfighter capability delivered as soon as possible.



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APPENDIX A

ACQUISITION STRATEGY SURVEY SITUATION AND BACKGROUND

SITUATION

You are preparing for a Milestone (MS) B decision to enter engineering and manufacturing development (EMD) and award competitive EMD contracts. The joint common missile (JCM) program is an Acquisition Category-1D (ACAT-1D) program with planned MS B in 6 months.

BACKGROUND

The JCM program just finished a very successful 3-year technology maturation and risk reduction (TMRR) phase, which met all exit criteria in which all critical technology elements (CTE) were assessed at technology readiness level (TRL) 6. Successful science and technology objectives (STO) efforts by Research Development and Engineering Command (RDECOM) preceded the TMRR phase. Comprehensive analysis during the TMRR phase underpinned the requirements for the JCM program. The capabilities based assessment (CBA) documented the need for JCM, along with an approved initial capabilities document (ICD). An approved analysis of alternatives (AoA) solidified the Joint Requirements Oversight Council (JROC)-approved capability development document (CDD) requirements, including the key performance parameter (KPP) thresholds/objectives.

The user has an operational and logistical need for development of the JCM to replace the Hellfire, Maverick, and aviation-launched TOW missiles for the Army and Navy. The Services desire increased range, capability, force protection, and a decreased logistics footprint. The current platforms and accompanied missiles are as follows:

- Army AH-64 Apache fires multiple versions of the Hellfire missile with either precision point (PP) targeting using laser designation or fire and forget (active) targeting using millimeter wavelength (MMW) radar and separate warheads for different target sets. The Hellfire Average Unit Procurement Cost (AUPC) averages $58.2K - $115.6K.
- USMC AH-1Z Cobra fires all versions of the Hellfire missiles and TOW missiles with wire guided targeting. The TOW AUPC averages $63.7K–$92.5K.
- Navy MH-60 Seahawk fires all versions of the Hellfire missiles and TOW missiles.
- Navy F/A-18 E/F Super Hornet fires Maverick missiles with either PP or fire and forget (passive) targeting using Infrared (IR) with separate warheads for different target sets. The Maverick AUPC averages $179K.

All current missiles have single-mode seeking capability only, with separate warheads. A single JCM is capable of replacing more than a dozen variants of Hellfire, Maverick, and TOW missiles.

The current draft JCM acquisition strategy (AS) outlines a 4 year EMD phase that meets the warfighter required initial operational capability (IOC) dates. The single step, 4 year EMD has support from the warfighting community, the Services' requirements communities, the Service Chiefs, and Service Acquisition Executives.

APPENDIX B

ACQUISITION STRATEGY SURVEY DRAFT JCM APB

DRAFT ACQUISITION PROGRAM BASLINE (APB)

The following performance, schedule, and cost data outline the constraints applied to the joint common missile (JCM) program

PERFORMANCE

CDD Performance Requirements			
#	**KPP**	**Threshold/ Objective**	**Performance**
1	Targeting	T=O	Precision Point (Laser Designated / Guided)
			Fire & Forget – Active (Radar Designated / Guided)
			Fire & Forget – Passive (IR Designated / Guided)
2	Combat Effectiveness	T=O	Anti-Tank (T90)
			MOUT (Personnel behind Triple Brick & Concrete Walls)
3	Range	T=O	Rotary Wing (RW): 16 KM
			Fixed Wing (FW): 28 KM
4	Interoperability (Platform)	Threshold	AH-64D (Apache), AH-1Z (Cobra), F/A-18 (E/F), MH-60R (Seahawk)
		Objective	UAVs, JSF, UK airframes
#	**Additional Attributes**	**Threshold/ Objective**	**Performance**
1	Physical Dimensions	Threshold	Weight:108 lbs.
		Objective	Weight: 90 lbs.
		T=O	Length: 70 Inches

(Acronyms: JSF = Joint Strike Fighter, MOUT = military operations in urban terrain, UAVs = unmanned aerial vehicles, UK = United Kingdom)

SCHEDULE

The current program is constructed to support a single-step acquisition strategy and will deliver full capability desired. The CDD documented an initial operational capability (IOC) for the JCM at MS B +5 years (60 months) based on the urgency of the need, the capabilities based assessment (CBA), and the analysis of alternatives (AoA) results. The engineering, manufacturing, and development (EMD) phase has been planned for 48 months. The schedule part of the APB has the following significant events: critical design review (CDR) at MS B + 2 years (24 months), MS C at MS B + 4 years (48 months), and IOC at MS B + 5 years (60 months).

COST

The acquisition objective (AO) for the JCM is 63,978 missiles to be procured for the Army and Navy. Cost estimates from Service affordability leads have determined an AUPC of $108K (with multiyear contract vehicle) and $120K (without multiyear contract vehicle). The program has been incorporated into the approved Services' POM positions and Services have certified that JCM is fully funded. The JCM joint cost proposal (JCP) has been approved and the Army and Navy fully funded a 48-month EMD with research, development, test and evaluation (RDT&E) funding and a 10-year production and deployment (P&D) with procurement funding.

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