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ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

Evolutionary/Incremental Acquisition

June 2018

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CPT Shane A. Kohtz, USA
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ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL

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ABSTRACT

The purpose of this project is to answer a Naval Postgraduate School (NPS) Acquisition Research Program–sponsored thesis' primary research question: How difficult is it to develop a successful incremental acquisition approach for defense acquisition programs (Acquisition Research Program, n.d.)? The research uses the Department of Defense's (DOD's) Joint Common Missile (JCM) program and the subsequent Joint Air-to-Ground Missile (JAGM) program as the basis for surveying acquisition professionals. This research prepares a preliminary survey to assess capabilities of future surveys and analysis of higher level acquisition scheduling and program planning.

The preliminary survey created for this thesis helps to enable future research on survey and questionnaire methods in the acquisition academic environment. Feedback on the preliminary survey from acquisition subject matter experts helps to revise the survey as needed to finalize a detailed and effective survey for future use. Results of the preliminary survey will help the DOD acquisition community in developing future questionnaires and training programs for acquisition professionals.

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ABOUT THE AUTHORS

Captain Patrick M. Gress, USA, graduated from the University of North Dakota with a Bachelor of Science in Aeronautics degree and received his commission as a United States Army Aviation second lieutenant in December 2008. CPT Gress served as an OH-58D Kiowa Warrior pilot-in-command & air-mission-commander, platoon leader, assistant operations officer, and troop commander in the 1-6 Cavalry Squadron at Fort Riley, KS from 2011 to 2016. From 2013-2014 he deployed to Kandahar, Afghanistan in support of Operation Enduring Freedom as a part. In 2016, CPT Gress attended the United States Army Maneuver Captain's Career Course and moved to Monterey, CA after to attend the Naval Postgraduate School. There he received his Master of Business Administration degree with specialization in Systems Acquisition Management. CPT Gress is married to Joanna Graf from Tustin, CA. Joanna holds a Bachelor of Arts in Criminology from Sonoma State University. They have two children; Callum, 3; Mackenna, 2. CPT Gress enjoys traveling, running, and spending quality time with his family. CPT Gress' next assignment is with the CENTCOM United States Military Training Mission in Riyadh, Saudi Arabia.

Captain Shane Kohtz, USA, is from Frankfort, Indiana. He graduated from the United States Military Academy and received a commission as a Second Lieutenant in the Infantry in May 2008. He then completed the Infantry Basic Officer Leader Course, Ranger School, Airborne School, and the Infantry Mortar Leader Course. CPT Kohtz served as a Rifle Platoon Leader, Mortar Platoon Leader, Assistant Operations Officer, and Company Executive Officer with 2nd Battalion, 506th Infantry Regiment at Fort Campbell, KY from 2009-2011. He deployed to Afghanistan with 2-506th IN in support of Operation Enduring Freedom 10-11. Following deployment, he completed the Maneuver Captains Career Course at Fort Benning, Georgia in May 2012. CPT Kohtz then served with 1st Battalion, 16th Infantry Regiment as the Assistant Operations Officer, Bravo Company Commander, and Headquarters and Headquarters Company at Fort Riley, KS from 2012-2015. As the Bravo Company Commander, CPT Kohtz deployed to Kuwait in support of Operation Enduring Freedom (Spartan Shield) and forward deployed to Operation Inherent Resolve (Iraq). CPT Kohtz served as an ROTC Instructor at University of Toledo, Ohio from November 2015 to December 2016. He then began his master's degree education in January 2017 at the Naval

Postgraduate School in Monterey, CA. CPT Kohtz received a Master in Business Administration from the Naval Postgraduate School in Systems Acquisition Management, and he completed the Naval War College JPME phase 1 while at NPS. CPT Kohtz is married to the former Alison McGeady of Atlanta, Georgia. They have two children; Aedan, 2.5 years; and Wyatt, 2 months. CPT Kohtz enjoys spending time with family, golfing, and in the outdoors. His next assignment is with PEO IEW&S at Aberdeen Proving Ground, Maryland.

Major Christopher Noll, USA, is from Queens, New York. He graduated from King's College in Wilkes-Barre, Pennsylvania and received a Bachelor's of Science in Biology and a commission as a Second Lieutenant in the Field Artillery in May 2007. He then completed the Field Artillery Officer Basic Course at Fort Sill, OK. MAJ Noll served as a Battery Fire Direction Officer, Platoon Leader, Battery Executive Officer, and Squadron Logistics Officer with 2nd Squadron, 3d Armored Cavalry Regiment at Fort Hood, Texas from 2008-2012. He to Iraq with the Regiment in support of Operation Iraqi Freedom (OIF) 07-09 and Operation New Dawn (OND) 10-11. Following deployment, he completed the Field Artillery Captains Career Course at Fort Sill, Oklahoma in December 2012. MAJ Noll then served with the 1st Battalion, 17th Field Artillery Regiment (FAR) as the Commander of Charlie Battery. Later, he would go on to serve as the Commander of Delta Battery, 1st Battalion, 31st Field Artillery (FA). After transitioning to the Army Acquisition Corps., MAJ Noll deployed with the 900th Contracting Battalion (CBN) out of Fort Bragg, North Carolina in support of Operation Inherent Resolve (OIR) from June 2015 to March 2016. Upon his return, he served as the 608th Contracting Team (CT) Team Leader. MAJ Noll began his master's degree education in January 2017 at the Naval Postgraduate School in Monterey, CA and would go on to earn a Master's of Business Administration in Systems Acquisition Management and complete JPME phase I requirements from the Naval War College.

Major Noll is married to the former Lauren Lienert of Honesdale, PA and they have two children, Hunter and Hailey. MAJ Noll enjoys spending time with family, traveling, and exercise. His next assignment is with DCMA Springfield at Picatinny Arsenal, New Jersey.

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LIST OF ACRONYMS AND ABBREVIATIONS

AACOE	Army Acquisition Center of Excellence
ACAT	Acquisition Category
AMSAA	Army Materiel Systems Analysis Activity
AO	Acquisition Objective
AoA	Analysis of Alternatives
APB	Acquisition Program Baseline
ARH	Anti-Radiation Homing
ASA (ALT)	Assistant Secretary of the Army for Acquisition, Logistics and Technology
AS	Acquisition Strategy
ASR	Acquisition Strategy Report
AUPC	Average Unit Procurement Cost
C2	Command and Control
CAIG	Cost Analysis Improvement Group
CBA	Capabilities Based Assessment
CDD	Capability Development Document
COTS	Commercial-Off-the-Shelf
CPIF	Cost-Plus Incentive Fee
CTE	Critical Technology Elements
CTV	Control Test Vehicle
DAU	Defense Acquisition University
DOD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
EA	Evolutionary Acquisition
EMD	Engineering, Manufacturing and Development
FAR	Federal Acquisition Regulation
FFP	Firm-Fixed Price
FOC	Full Operational Capability
FPIF	Fixed-Price Incentive Fee
FY	Fiscal Year

FYDP	Future Years Defense Program
F&F	Fire and Forget
GAO	Government Accountability Office
GFE	Government Furnished Equipment
GS	Guidance Section
ICE	Independent Cost Estimate
ICD	Initial Capabilities Document
IOC	Initial Operational Capability
IPT	Integrated Product Team
IT	Information Technology
IR	Infrared
JAGM	Joint Air-to-Ground Missile
JAMS	Joint Attack Munition System
JCIDS	Joint Capabilities Integration and Development System
JCM	Joint Common Missile
JCP	Joint Cost Proposal
JLC	Joint Logistics Commanders
JROC	Joint Requirements Oversight Council
KPP	Key Performance Parameter
LRIP	Low Rate Initial Production
MDAP	Major Defense Acquisition Program
MMW	Millimeter Wavelength
MOSA	Modular and Open Systems Architecture
MOUT	Military Operations on Urban Terrain
MRL	Manufacturing Readiness Level
MS	Milestone
NPS	Naval Postgraduate School
NDAA	National Defense Authorization Act
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
PAUC	Program Acquisition Unit Cost
PBD	Program Budget Decision
P&D	Production and Development

PDR	Preliminary Design Review
PM	Program Manager
PMO	Program Management Office
PO	Project Office
POM	Program Objective Memorandum
PP	Precision Point
PPT	Precision Point Targeting
RA	Risk Assessment
RAND	Research and Development Corporation
RDECOM	Research Development and Engineering Command
RDT&E	Research, Development, Test, and Evaluation
SDB	Small Diameter Bomb
SDD	System Development and Demonstration
SECDEF	Secretary of Defense
SSC	Senior Service College
STO	Science and Technology Objective
TD	Technology Development
TMRR	Technology Maturation and Risk Reduction
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
USD(A)	Under Secretary of Defense for Acquisition
WBS	Work Breakdown Structure

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I. INTRODUCTION

A. DEFENSE ACQUISITION MANAGEMENT SYSTEM

In the current age of evolving threats, the need to expedite the development and procurement of systems with increased capability has become synonymous with national security. The most recent calls to "fix" the acquisition system by Secretary of Defense (SECDEF) Jim Mattis brings attention to ongoing budget instability and long procurement lead times on major defense acquisition programs suffered by the Department of Defense (DOD; Mattis, 2018). Now, more than ever, acquisition professionals are faced with increased trade-offs in attempts to manage a program's cost, schedule, and performance requirements, known in the acquisition community as a program's "triple constraint," and meet warfighter needs; development of a sound acquisition strategy is one way of doing this.

The 5000 series of government policies have governed the U.S. DOD Acquisition System since 1971. The DOD has made multiple updates to the series since that time. The current DOD Directive 5000.1 provides management principles and government acquisition policies and procedures for managing all the DOD's acquisition programs (Office of the Under Secretary of Defense for Acqusition, Technology, and Logisitcs [OUSD(AT&L)], 2007). DOD Instruction 5000.02 reflects the 5000.01 directives and provides the detailed procedures that help guide acquisition decision-makers throughout the life cycle of a DOD acquisition program (OUSD[AT&L], 2017a). The current version of the 5000.01 was last updated in 2007, and the 5000.02 is current as of 2017. Both documents outline the need for an appropriate acquisition strategy that addresses the technological risk to maturity and program performance goals, as well as schedule and budgetary constraints.

The current DOD Directive 5000.01, dated November 20, 2007, clearly states that an evolutionary acquisition (EA) strategy, with an incremental approach is the DOD's preferred approach to ensuring technology is mature enough to provide warfighters with needed equipment in a timely manner and within budget constraints (OUSD[AT&L], 2007). A leading reason for schedule delays and excessive budgetary expenditures in defense acquisition is the lack of technological maturation. Calendar-driven schedules apply pressure

on acquisition professionals to procure materiel that is not yet ready for the warfighter to use. An incremental approach allows a program's technology to mature while completed elements are delivered to bridge the time gap between a user's request and a program's final increment delivery.

A U.S. DOD program's acquisition strategy (AS) is the plan to achieve goals and execute the program in its entirety. The program manager (PM) uses the AS to describe the management approach and basis for planning and executing all programmatic goals throughout the life of the program while addressing and maintaining the program is within the boundaries of cost, schedule, and performance. The program schedule, processes required, major risks, funding, and business aspects are all summarized in the AS ("Acquisition Strategy [AS]," 2017). The AS allows senior leaders and decision-makers the ability to assess whether the PM's overall strategy reflects DOD priorities, follows proper business standards, and allows a program the best chances of becoming an operational asset for the end-user.

The 2003 National Defense Authorization Act (NDAA) defines evolutionary acquisition and incremental approaches by explaining that

> the term "evolutionary acquisition process" means 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. The term "increment," with respect to an evolutionary acquisition program, means one of the discrete phases or blocks of such program. (National Defense Authorization Act for Fiscal Year 2003, 2002, § 802(c) (1-2), p. 2603).

Organizations have used evolutionary acquisition practices since the early 1950s. The X-15 Hypersonic jet, developed by North American Aviation, used an evolutionary and incremental approach during its development. This strategy influenced the design of NASA spacecraft during the early stages of the Mercury space program and IBM's evolutionary software design (Larman & Vasili, 2003).

B. RESEARCH OBJECTIVE

The difficulty posed to DOD acquisition professionals in implementing an EA strategy with incremental approach on major defense acquisition programs (MDAPs) is the object of this research. This study compares the current Joint Air-to-Ground Missile (JAGM) program to its predecessor, the Joint Common Missile (JCM), to determine the issues involving the PM's responsibility in management of cost, performance, and schedule. The ultimate goal of this research is to develop a survey to be completed by DOD acquisition professionals that will facilitate the determination of difficulty these professionals face in the implementation of the DOD's preferred acquisition approach. This thesis provides a framework for subsequent students to design and distribute a follow-on survey and use their results to gain an understanding of which critical requirement factors are considered to develop program schedules.

1. Research Questions

a. Primary Question

- How difficult is it to develop a successful incremental acquisition approach for defense acquisition programs (Acquisition Research Program, n.d.)?

b. Secondary Questions

- What is the history of evolutionary acquisition and an incremental development approach?
- Currently, how effective is the Department of Defense at implementing an EA strategy with an incremental approach?
- What is an example of a successful implementation of an incremental approach?
- How did the Joint Common Missile evolve into the Joint Air-to-Ground Missile program?
- To what extent do acquisition professionals understand program risks and the necessity of using an incremental approach?

2. Scope, Limitations, and Assumptions

The research for this thesis is tied to existing acquisition policy and MDAPs. The scope of the research identifies how incremental development became the preferred approach

for defense acquisition programs. Acquisition professionals are the target population to gather information and understand how the workforce uses the preferred approach. However, the research is limited to developing a survey for future evaluation of acquisition professionals' implementation of an incremental approach, given critical program risks, requirements, and budgetary constraints. Program information from the JCM and JAGM provides data to develop the survey for understanding the level of acquisition professionals' implementation of an acquisition strategy with an incremental approach. Data from these two programs provide critical information for the survey without giving the target audience a solution.

An assumption in the research is the level of competence acquisition professionals have of the DOD 5000 series. The survey hinges on the notion that each member of the target audience has a basic understanding of EA with an incremental approach. Acquisition professionals should be able to assess basic risk and requirements data to build an acquisition strategy. Another assumption in building the survey relies on the absence of external factors and current budgetary environment. Administration of the survey is in a controlled environment, and the survey provides pertinent constraints and useful data to establish the planning setting.

3. Methodology (Survey)

The research methodology consists of three areas: a literature review, JCM and JAGM requirements documentation review, and the selection and development of a qualitative survey. The literature review follows the history of EA from being a consideration to its establishment as the preferred approach within the DOD's acquisition framework. Additionally, the literature review provides the reader with an overview of the merits of EA and justifies the DOD's position in establishing EA as the preferred acquisition approach.

The review of JCM and JAGM documentation follows the metamorphosis of program performance requirements without a change to user needs. An analysis of critical risk factors informs the reader of system complexity and provides an alternative view as to the proposed schedule. Finally, the development of a qualitative survey gives researchers the ability to gain an understanding of the difficulty presented to acquisition professionals in implementing

the DOD's preferred acquisition strategy. This study addresses expected results and provides a sample of the survey in the Appendix.

4. Benefits of Research

This thesis will benefit current and future DOD acquisition professionals who manage the cost, performance, and schedule of defense programs. Additionally, it will provide insight to defense policy-makers on the environmental pressures of implementing an EA strategy with incremental approach.

5. Organization of Study

Chapter I introduces the research objective, research questions, and data collection methods and sources used to collect and analyze data. Additionally, Chapter I provides assumptions, benefits, and limitations for the research topic.

Chapter II provides a history of EA. The chapter traces the DOD application of EA and incremental approaches from the mid-1980s to the present day and the policies and procedures that govern EA uses.

Chapter III provides an analysis of the JCM program and its eventual transformation into the JAGM program. A thorough examination of the initial requirements, eventual cancellation, and reinstatement of the program as the JAGM is critical to this research. In addition, the identification of the both programs' risk management, requirements, and budgetary considerations are pertinent data inputs. The information from these program documents provides critical details to use for survey development to gain an understanding of acquisition professionals' implementation of incremental development.

Chapter IV provides an explanation of the data collection methodology and survey development for use in future distribution to acquisition professionals. This section incorporates select background information on the JCM program and develops questions related to cost, schedule, and performance parameters that the PM would be responsible for. Additionally, this chapter provides an analysis of each section of the survey and describes the type of information that each section is designed to collect from survey participants.

Chapter V provides an analysis of results from a beta testing sample for improvements to the survey. Additionally, this chapter provides a conclusion and recommendation for future use of the survey.

II. LITERATURE REVIEW (EVOLUTIONARY ACQUISITION AND INCREMENTAL DEVELOPMENT)

A. PACKARD COMMISSION (1986)

In 1981, the Project on Government Oversight, a nonpartisan independent watchdog, reported on U.S. military acquisition mismanagement and gross overspending due to contractor overcharging, price distortion, and contract mismanagement. The report outlined such infamous items as a $435 hammer and, along with other reports, led President Ronald Reagan to appoint a commission to study defense acquisition spending and the problems surrounding defense management and acquisition organizations (Barron, 1983). David Packard, who co-founded the computer company Hewlett-Packard and who served as the U.S. deputy secretary of defense from 1969 to 1971 and chairman of the Business Council from 1973 to 1974, led the Blue Ribbon Commission of Defense Management, what is now known as the Packard Commission ("Obituary for David Packard," 2007). The report's recommendations for acquisition organization and procedures included the creation of the new positions under secretary of defense for acquisition, and separate service acquisition executive positions for the Army, Navy, and Air Force. The report also recommended the increased use of prototyping, testing, and commercial business practices to increase competition and lower procurement costs.

"Baselining" programs was the most important recommendation from the Packard Commission that affected PMs. The report recommended that the "DOD should fully institutionalize 'baselining' for major weapons systems at the initiation of full-scale engineering development. Establishment of a firm internal agreement or baseline on the requirements, design, production, and cost of weapon systems will enhance program stability" (Packard, 1986, p. xxvi). The recommendation helped establish the acquisition program baseline (APB), later codified by the 1987 NDAA. The Packard Commission did not create or implement any laws; however, some of its recommendations were addressed by the Goldwater–Nichols Act later in 1986.

B. GOLDWATER–NICHOLS (1986)

The Goldwater–Nichols Department of Defense Reorganization Act of 1986 implemented multiple laws to reorganize the DOD and outlined policies that enabled more efficient use of defense resources. The act gave the Office of the Secretary of Defense (OSD) more autonomy in the reorganization of the different staff positions and the interaction with the military service chiefs. Part of the OSD reorganization was the official creation of the under secretary of defense for acquisition (USD[A]) position. The Goldwater–Nichols Act provided the OSD a centralized figure that oversees and thoroughly manages MDAPs.

The lack of joint procurement and system interoperability between the services plagued DOD operations prior to the Goldwater–Nichols Act. Service chiefs led the different organizations, and joint efforts were strained by the lack of cross organization. The act gave greater authority to combatant commanders instead of service chiefs, which enabled joint service support when organizing, equipping, training, and executing specific regional missions. Shared procurement between services enabled interoperability of new technology and increased joint collaboration during program development (Goldwater–Nichols, 1986).

C. NATIONAL DEFENSE AUTHORIZATION ACT (1987)

In addition to the Goldwater–Nichols Act, the 1987 NDAA also codified recommendations from the Packard Commission. The NDAA details the duties and precedence of the USD(A) as well as the deputy undersecretary of defense for acquisition. The USD(A) is the senior procurement executive for the DOD. The act gives authority to the USD(A) over service secretaries regarding acquisition activities within the DOD. The NDAA made changes to enhance program stability and required the USD(A) to ensure that the service secretaries established a baseline description for MDAPs. The service secretaries established the baseline for their own jurisdiction and detailed the cost, schedule, and performance constraints placed upon the PM for each MDAP. Any deviation of the baseline required the PM to immediately submit a Program Deviation Report (PDR) to the specific service secretary for review and decision (National Defense Authorization Act for Fiscal Year 1987, 1986).

D. JOINT LOGISTICS CENTER GUIDANCE (1987)

In 1987, the Joint Logistics Commanders (JLCs) published guidance as it relates to the use of an EA strategy in the procurement of command and control (C2) systems. Supported by the Office of the Secretary of Defense (OSD), this guidance served as an endorsement by encouraging an EA strategy in the acquisition of C2 systems (A'Hearn, Bergmen, & Hirsch, 1988). The attraction to adopting an EA strategy was prevalent, as the results of two major C2 studies recently determined that conventional acquisition strategies led to suboptimal outcomes.

Furthermore, the merits of selecting an EA strategy came from the delivery of capability in increments, rather than in one step. This allowed for the system to achieve full capability through evolution, while still delivering increments of capability to the warfighter throughout the system life cycle. Ultimately, the JLC guidance served the purpose of expressing support to OSD guidance, decomposing OSD-level guidance into actionable joint guidance, providing an assessment on when to use EA, defining EA, and identifying several management techniques for successfully implementing an EA strategy (A'Hearn et al., 1988).

E. 5000.01 (1987)

The 1987 Department of Defense Directive (DODD) 5000.01 is the first to mention the implementation of a program baseline to codify program cost, performance, and schedule. As defined by the directive, the program baseline is

> a formal agreement between a PM and a PEO [Program Executive Officer], SAE [Service Acquisition Executive], or the DAE [Defense Acquisition Executive] that briefly summarizes factors critical to the success of a program, such as functional specifications, cost, and schedule objectives and requirements, against which the program will subsequently be evaluated. (OUSD[A], 1987, p. 3)

The implementation of a program baseline was intended to enhance program stability by providing governing metrics used to gauge program progress. It is here that full responsibility of the program was placed on the PM for management. As a result, PMs were given the appropriate authority and resources required to achieve the established baselines. The program baseline also served to minimize changes to funding and system requirements,

therefore allowing programs to exhibit increased stability. Following this theme, the 5000.01 also requires that PMs consider the use of evolutionary alternatives to properly balance system development and production risk. This is the first mention of EA in the series of acquisition directives.

F. 5000.02 (1991)

The 1991 Department of Defense Instruction (DODI) 5000.02 speaks to the primary goal of an acquisition strategy in minimizing program cost and schedule to field a desired capability. Of the various management strategies offered, the 5000.02 offers an EA strategy for consideration in programs where a high technology risk is present and refinements to requirements are anticipated (OUSD[AT&L],1991). The instruction defines EA as

> an approach in which a core capability is fielded, and the system design has a modular structure and provisions for future upgrades and changes as requirements are refined. An evolutionary acquisition strategy is well suited to high technology and software intensive programs where requirements beyond a core capability can generally, but not specifically, be defined. This approach is described in Joint Logistics Commanders Guidance, "Evolutionary Acquisition, An Alternative Strategy for Acquiring Command and Control (C2) Systems." (OUSD[AT&L], 1991, p. 5-A-2).

This EA strategy is still considered an alternative approach in this context; however, emphasis is heavily placed on consideration in the document.

G. 5000.01 (1996)

The 1996 DOD 5000.01 policy marked a shift in the adoption of EA strategies for defense programs. As noted in the 1991 DOD 5000 series, the instructions encouraged program managers to consider implementing nontraditional approaches for acquisition strategies and schedules. The 1996 DOD 5000.01 altered the language to state the acquisition community "shall" make use of nontraditional techniques as necessary. One of the highlighted techniques was evolutionary and incremental acquisition. Other techniques included rapid prototyping, advanced technology demonstrations, and flexible technology insertion. This transition placed a greater emphasis on program managers to utilize an evolutionary or incremental acquisition approach (OUSD[AT&L], 1996). This is the first

time incremental approaches are associated with the preferred EA strategy that was documented in the 1987 5000.01.

H. 5000.01 (2000)

In 2000, the DOD placed even greater emphasis on EA and incremental development. The language in the directive identified how the DOD wanted EA as the preferred approach for strategies and schedules, and not just utilization where appropriate, as outlined in the 1996 directive. The initiative to use EA relied on the necessity to provide capability to the warfighter as quickly as possible. In order to fulfill the operational needs of the services, the secretary of defense and acquisition community viewed EA with increments as the most capable approach. The directive also identified the use of blocks as increments to provide capability to the warfighter depending on the technology maturity, requirements based on time, and a plan for subsequent development over time past the initial capability. PMs needed to evaluate factors of the requirements urgency, critical technology maturity, and inoperability of the system. The idea of a modularity and open system designs were prevalent in the directive to enable the upgrades as the weapon system evolved over time. An incremental schedule was the proper method of phasing requirements and technology availability. In 2000, the DOD identified an overhaul and adoption of EA and use of increments to develop an acquisition strategy and schedule. These changes signaled a remarkable transition to evolve and build a system over time from previous acquisition development concepts (OUSD[AT&L], 2000). Figure 1 outlines three different steps with dedicated acquisition phases and milestones that are representative of a program with multiple increments.

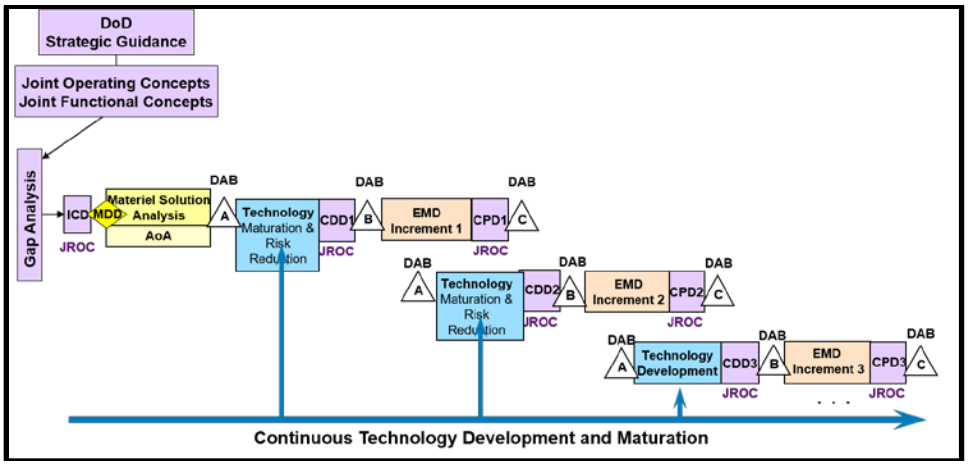


Figure 1. Incremental Approach. Source: Mortlock (2017).

I. 5000.01 (2003)

The updated 5000.01 directive was released in May 2003 and specifically identifies EA within the policy objectives of the 2003 NDAA. "Flexibility, responsiveness, innovation, discipline, and streamlined and effective management" (OUSD[AT&L], 2003, p. 1-2) were the policies identified in the 2003 5000.01 that governed the defense acquisition system. The directive places an emphasis on responsiveness by identifying the need to match user requirements with available technologies. "Approved, time-phased capability needs matched with available technology and resources enable EA strategies. EA strategies are the preferred approach to satisfying operational needs. Spiral development is the preferred process for executing such strategies" (OUSD[AT&L], 2003, p. 2).

The spiral development model has two distinguishing features: "One is a cyclic approach for incrementally growing a system's degree of definition and implementation while decreasing its degree of risk. The other is a set of anchor point milestones for ensuring stakeholder commitment to feasible and mutually satisfactory system solutions" (Boehm & Hansen, 2001, p. 2). Spiral development does not clearly define requirements and objectives for a program's end goal. The lack of planning for a program's finality necessitated another update to 5000.01 in 2007.

J. 5000.01 (2007)

The 2007 5000.01 made a slight but important update to policies describing the responsiveness of MDAPs. The policy implemented the change from spiral development to incremental development as the preferred process for executing EA strategies (OUSD[AT&L], 2007). Incremental approaches provide clear requirements for each increment and an end-state for a specific acquisition program. The incremental approach falls in line with the goal of program stability outlined in the 5000.01 when referring to the development of "realistic program schedules, long-range investment plans, and affordability assessments, and shall strive to ensure stable program funding" (OUSD[AT&L], 2007, p. 9).

K. GOVERNMENT ACCOUNTABILITY OFFICE REPORTS (2014 & 2016)

The Government Accountability Office (GAO) analyzed and reported on the use of an incremental approach on Information Technology (IT) centric systems in recent years. The report from 2014 focused on the need to implement an incremental approach for government agencies. The report from 2016 evaluated how agencies implemented an incremental approach since 2014.

The GAO report from 2014 outlines the need to utilize an incremental approach due to significant cost overruns and schedule delays quantified in years (Government Accountability Office, 2014). Focused on IT intensive programs, the report assesses two areas: Whether agencies have established policies utilizing an incremental approach on IT intensive programs and if they are using an incremental approach on those programs (Government Accountability Office, 2014). The report found that few DOD programs delivered functionality indicative of an incremental approach.

The GAO report from 2016 focuses on government reporting of what programs are using an incremental approach. The report identified that DOD exhibited lower rates of utilizing incremental approaches. However, insufficient DOD reporting led to GAOs inability to analyze the DODs ability to implement the preferred acquisition strategy (Government Accountability Office, 2016).

L. SMALL DIAMETER BOMB

A success story of implementing an EA strategy with an incremental approach is the Air Force's Small Diameter Bomb (SDB). In 2017, the Research and Development (RAND) Corporation published a study of Air Force MDAPs. RAND identified four major programs that experienced a low cost growth, and the SDB was one of the four examples of a successful program (Lorell, Payne, & Mehta, 2017). The SDB used two increments to deliver capability to the warfighter while maturing high-risk technology, which is a common practice when using an incremental approach for schedule development.

The study identified two characteristics for a successful program. The first was a realistic cost estimate prior to Milestone (MS) B. The second characteristic highlighted the importance of an incremental strategy as an imperative for success (Lorell et al., 2017). Six programs with extreme cost growth had immature technology, ambiguous requirements, or insufficient cost estimates before MS B. The same programs possessed inadequate strategies and schedules without an incremental approach and combined MS B and C under the assumption of little need for research, development, test, and evaluation (RDT&E; Lorell et al., 2017). These metrics established the RAND study's foundation for the evaluation of Air Force MDAPs and correlation to cost growth and program performance. SDB divided the program into two increments with distinct differences between mission and capability.

SDB I increment is an example of achieving feasible requirements with more high-risk technology maturation for the later increments. The mission of the SDB I was to provide a GPS-guided smart munition capable of targeting stationary targets in extreme weather conditions both day and night. The threshold aircraft for the first increment was the F-15E with objective aircraft of F-22, F-35, and Air Force bombers (Department of Defense, 2007). The program office focused the two non-tradeable requirements of weapon load capacity and GPS interoperability, which was the intent to provide the warfighter an "80% solution" (Lorell et al., 2017, p. 43). The eventual program results of the SDB indicated a reduction of 16% cost growth of the Program Acquisition Unit Cost (PAUC; Lorell et al., 2017). These program characteristics identify how the program office managed the successful increment and reduced cost growth. Thus, the well-defined requirements and mature technology

enabled SDB I increment's success of maintaining cost, schedule (illustrated in Figure 2), and performance.

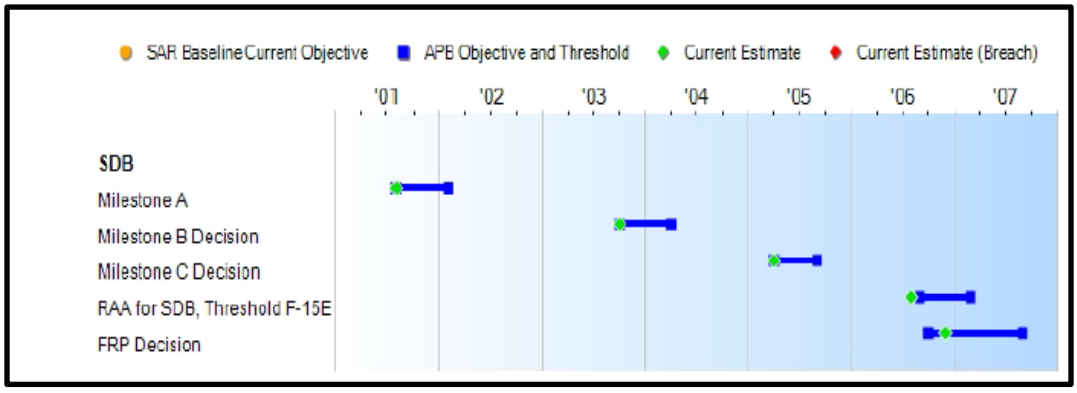


Figure 2. SDB Increment I Schedule. Source: Department of Defense (2007).

SDB II increment was a separate program due to complexity and size, which is a common practice for most MDAPs. SDB II began the technology development phase while the SDB I was in full-rate production (Department of Defense, 2007). The mission for SDB II is to provide the warfighter the capability to attack mobile targets in adverse weather conditions in day and night. In addition, the threshold aircraft for the SDB II increased to include the F-15E, F-35B, and F-35C (Department of Defense, 2017). An increase in the SDB II's ability to attack mobile targets and the option to use SDB II on additional platforms are improvements from SDB I. The program is moving toward operational testing with issues in the government confidence testing and F-35 program delays. However, the program does not have any Nunn-McCurdy or APB breaches at this time (Department of Defense, 2017). The SDB II schedule (illustrated in Figure 3) utilized the mature technology and lessons learned from SDB I to maintain cost and schedule even as the program moves through issues with new platform integration.

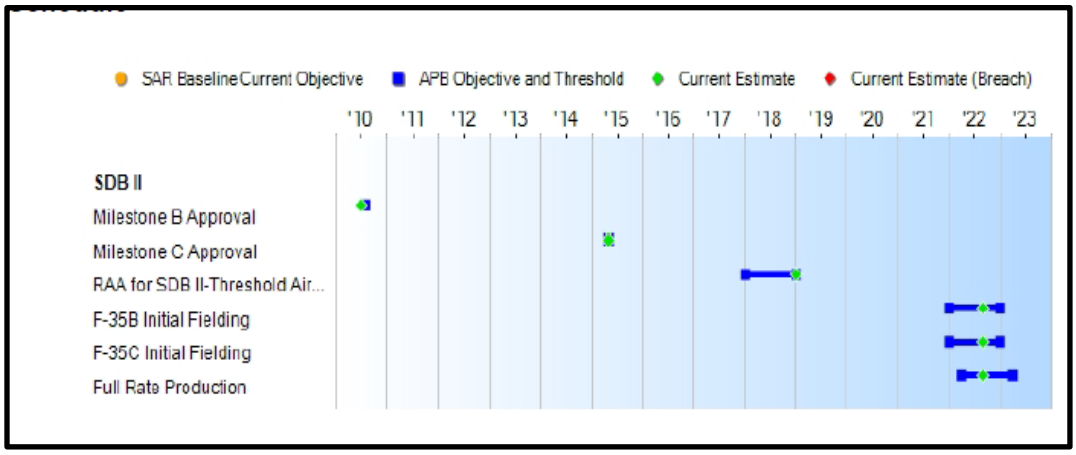


Figure 3. SDB Increment II Schedule. Source: Department of Defense (2017).

The success of the SDB demonstrates how the use of an incremental approach assists in management of cost, schedule, and performance. The RAND Corporation's analysis on Air Force MDAPs with extreme cost growth provided critical insights into their two characteristics for program execution. Realistic cost estimates prior to MS B and incremental strategies enable programs to avoid Nunn-McCurdy and APB breaches. The Small Diameter Bomb increments are examples of how an EA strategy with an incremental approach can assist program offices with adhering to cost, schedule, and performance constraints.

III. JOINT MISSILE SYSTEMS CASE STUDY

The intent of Chapter III is to examine an existing MDAP and identify critical system inputs that guide the development of an acquisition strategy. The chapter outlines specific components of the Joint Common Missile (JCM) program. Critical inputs include a description of the need and purpose of the JCM, user requirements for the weapon system, technology risks, schedule considerations, and budget inputs. In addition, this chapter highlights the transition of the JCM to the Joint Air-to-Ground Missile (JAGM). An analysis of the JAGM's critical inputs of purpose, requirements, risks, schedule, and budget inputs was necessary to understand how the weapons system evolved over time. Analysis in Chapter III assists the researchers in understanding how acquisition professionals may utilize critical program inputs to develop an acquisition strategy that employs EA with an incremental approach.

A. JCM

The Army and Navy conducted a capabilities-based assessment to identify numerous capability gaps where the year 2000 assets could not achieve an overmatch. An in-depth analysis of alternatives (AoA) scrutinized the eight different capability gaps (Sleevi & Mount, 2003):

1. Destroy targets that were either time-sensitive or mobile in urban or complex terrain.
2. Destroy covered targets at extended ranges with minimal collateral damage.
3. Effectively counter battlefield effects of typical obscurants such as smoke or fires.
4. Communicate and designate weapons systems effectively in complex or mountainous terrain.
5. Avoid susceptibility to enemy counterattack due to long exposure time of effective shots on target.
6. Attain logistics simplicity in using a single missile with different seeker types and targeting capabilities instead of using multiple missiles.
7. Target high-speed water craft and other non-traditional targets with the array of legacy air-to-ground missions.
8. Overcome low cloud ceilings and adverse weather (Sleevi & Mount, 2003).

These capability gaps highlighted the importance of a solution capable of effectively operating in complex terrain and targeting a multitude of targets. A new air-to-ground missile provided a materiel solution to counter each of these capability gaps. A joint missile provided an overall reduction in the logistic footprint for the services, and the missile required a multipurpose seeker and warhead with a propulsion system to provide the capability over a large range.

As a result of these capability gaps, in October 2001 the JCM program began to provide a joint missile for rotary and fixed-wing platforms of the Army, Navy, and Marine Corps, and the target sets ranged from tanks and watercraft to bunkers and buildings (Joint Attack Munition Systems Project Office, 2016). The overarching goal of the JCM program was to use a modular open system for upgrades, obtain missile commonality, and reduce the logistic requirements to decrease life-cycle costs (Common Missile Project Office, 2003). These armed services identified a need for "an extended range, precision guided, air-to-surface weapon providing both precision point target and fire-and-forget capability to be employed against targets in day, night, obscured battlefield, and adverse weather conditions" (Common Missile Project Office, 2003, p. iv). The operational need required a materiel solution that employed multiple advanced technologies. The significant capability gaps provided the reason to develop an advanced weapons system such as the JCM.

1. Capabilities Development Document

The JCM program was the first to become a program of record within the DOD's new capabilities-driven Joint Capabilities and Integration and Development System (JCIDS) process in early 2003. The U.S. Army was the lead service and program participant for the JCM, alongside the U.S. Navy, U.S. Marine Corps, and the British Army Air Corps. The JCM Program Management Office (PMO) personnel assisted the Army and Navy requirement lead offices to develop the Initial Capabilities Document (ICD), analysis of alternatives (AoA), and Capabilities Development Document (CDD). The Joint Requirements Oversight Council (JROC) approved pursuing a materiel solution to the capabilities gap outlined in the JCM ICD. The AoA quantified performance measures and requirements for the CDD, later validated by the JROC (Mortlock, 2005).

2. Requirements

Five key performance parameters (KPPs) outlined the critical requirements that the users developed for the missile system. The KPPs listed in the CDD were targeting capability, combat effectiveness/reliability, missile range, interoperability, and carrier/shipboard operability (Joint Requirements Oversight Council [JROC], 2004). The requirements were critical during all contractor design, development, fabrication, testing, and qualifying of the JCM (Joint Requirements Oversight Council [JROC], 2004).

The users required that the JCM contain three separate targeting methods. Precision Point Targeting (PPT), Fire and Forget (F&F) (Passive), and F&F (Active) were the three targeting methods. The targeting capability requirement quantifies hit probabilities for each of the targeting methods within a threshold and objective range. The PPT targeting method utilizes the JCM's seeker to identify, track, and guide the missile toward a friendly designated laser spot. This method enables multiple targeting platforms to use appropriate laser guidance for a single JCM missile to target. The F&F (Passive) targeting method uses infrared (IR) identification and tracking capabilities within the seeker. A target's IR signature is used to help guide the missile towards the intended hit point. This targeting method allows for JCM use during low ceiling and adverse weather conditions. F&F (Active) targeting method uses radar guidance from hardware affixed to the launch platform. The launching platform's radar identifies, tracks, and guides the single JCM missile to the intended target (JROC, 2004).

The combat effectiveness/reliability KPP quantifies requirements for specific types of single-shot kill probabilities and defines different walled target types. The single-shot kill probabilities are broken into objective and threshold levels for T90 variant tank targets and Military Operations on Urban Terrain (MOUT)–type walls. The KPP requirement separated the MOUT wall targets into two types of material based on objective and threshold requirements. "Brick over Block" was designated as the threshold criteria, and "Triple Brick" material was designated as the objective criteria (JROC, 2004).

The missile range KPP outlined the minimum and maximum ranges required by the missile. The requirement separates both the minimum and maximum ranges into fixed-wing and rotor-wing launch platform categories. Minimum range requirements help to support

targeting and firing on close in targets likely found in an urban environment. Maximum range requirement allows fixed-wing launch platforms, specifically fighter aircraft, to engage targets at higher speeds.

Interoperability encompassed the last two KPPs. The interoperability requirement identifies specific aircraft type at the threshold and objective levels. The threshold platforms were American rotor and fixed-wing type aircraft. The AH-64D Apache, AH-1Z Cobra, F/A-18 E/D Hornet, and MH-60R Seahawk made up the list of threshold aircraft. The objective platforms included more American rotor/fixed-wing aircraft as well as U.K. platforms. The final KPP ensures the JCM is compatible and capable of carrier/shipboard operations without detracting from other surrounding naval operations.

3. Work Breakdown Structure

Systems engineers develop work breakdown structures (WBSs) to link work required on each subcomponent to produce the final product. Shown in Figure 4, the JCM PMO developed the WBS into three levels (Army Test and Evaluation Command, 2003). The JCM's first level encompasses the JCM Integrated System, which branches off into the missile Platform & Launcher, and Supportability & Training. The second level of the WBS breaks out the major elements of the defense materiel item. The JCM's second level centers around Missile Integration and is tied directly to the JCM Integrated System. Integrated Flight Simulation branches off Missile Integration. The third level of the WBS identifies major subordinate elements of each second level major element. The JCM's third level breaks down the missile subsystems into Seeker Integration and its separate components, Warhead, Propulsion, and Guidance & Control.

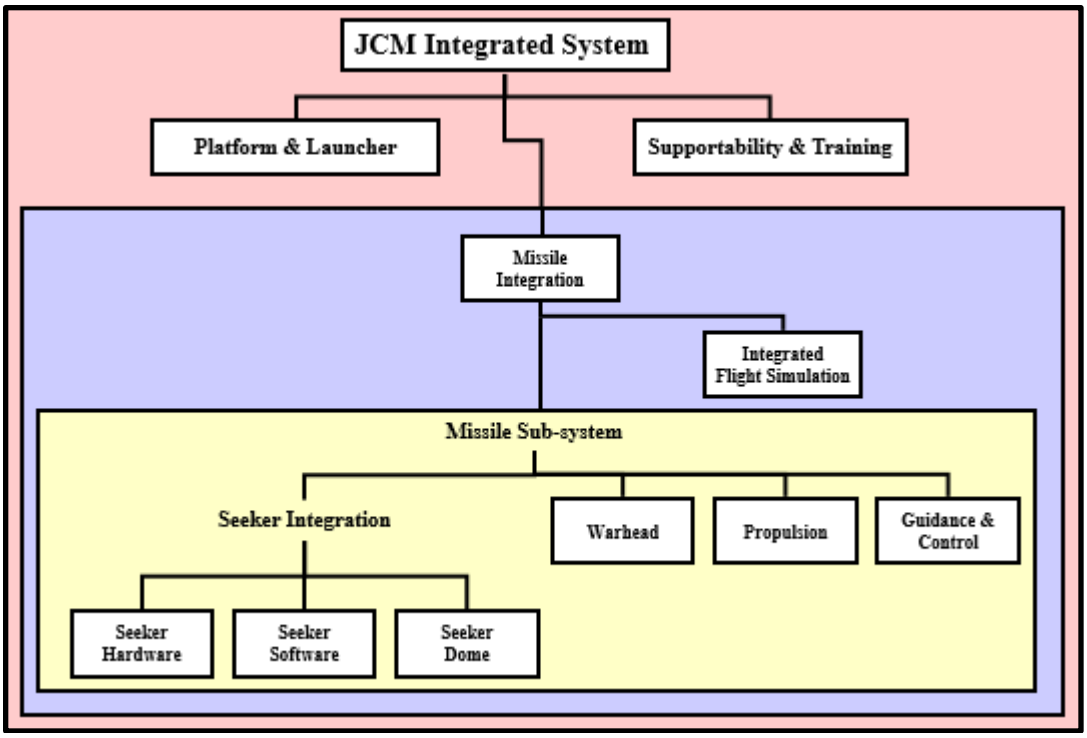


Figure 4. JCM Work Breakdown Structure

4. Risk Assessment

The JCM program office conducted a thorough risk assessment to determine the program's high-risk technologies in June 2003. The PMO used the WBS to determine the most critical JCM components with the highest risk. The initial risk assessment illustrates the WBS traceability of requirements to the risk level of each critical technology element (Figure 5; Army Test and Evaluation Command, 2003). Since the main components of the weapon system were the seeker, warhead, and propulsion system, the most critical technologies of the program aligned with those areas. The three most critical technology elements were the seeker integration, propulsion turn down ratios, and the multipurpose warhead's low length/diameter (Common Missile Project Office, 2003).

Figure 5 highlights the outcome of the 2003 in-depth risk assessment. A collection of nearly 70 technical experts, acquisition professionals, and users conducted a four-day risk assessment lockdown at Aberdeen Proving Ground to assess the JCM risk (Army Test and Evaluation Command, 2003). Prior to the lockdown meeting, the risk assessment participants conducted internal assessments from each stakeholder's perspective. The intent of the

assessments prior to the lockdown was to enable consensus building at lockdown, begin work risk assessment issues beforehand, and establish conditions for the risk assessment at Aberdeen Proving Ground.

The risk assessment focused on each component and subcomponent areas of the JCM, and the structure of the overall risk assessment aligned with the WBS levels. The first level was the JCM integrated system risk; the second level focused on platform and launcher interoperability, supportability and training, and missile integration; and the third level provided an analysis of each missile subsystem and integrated flight simulation. Risk assessments on each component and subcomponent identified the change in expected risk levels over the course of the program. The lockdown participants utilized the Army Materiel Systems Analysis Activity (AMSAA) methodology to determine the likelihood of a component's or subcomponent's technology's ability to mature (Army Test and Evaluation Command, 2003). For example, if the component or subcomponent technology is developed and mature, then the rating for the risk likelihood of occurrence would be low. The consequence rating of a component's and subcomponent's risk follows the DOD methodology of determining the impact on cost, schedule, and performance. A low rating has a minimal impact while a high rating has an unacceptable impact on the program's cost, schedule, and performance. The intersection of these two ratings gives the integrated rating for each component or subcomponent's risk level according to the Risk Assessment Guide shown in Figure 5.

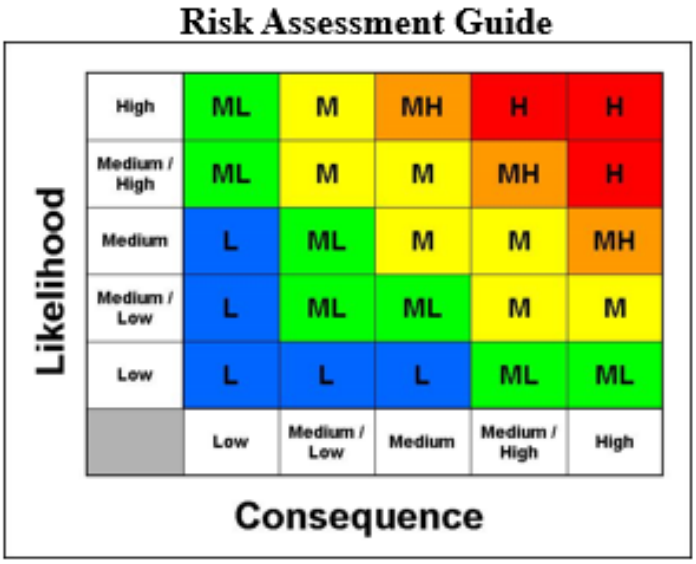


Figure 5. Risk Assessment Guide Matrix. Source: Army Test and Evaluation Command (2003).

As a result, the ratings ranged from low to high at critical milestones throughout the program. The lockdown participants determined how the component and subcomponent risk would burn down during the program's life through events such as test and evaluation and modeling and simulation. The lockdown output follows the initial risk determination in 2003 through MS C and reflects the overall JCM WBS structure by component and subcomponent (see Figure 6). Initial assessments identified the warhead and missile integration as having the highest impact on the overall system integration risk. This in-depth risk assessment provided a useful illustration of the risk assessment by component and subcomponent. As a result, all stakeholders obtained a shared understanding, and the assessment remained a critical input for building the JCM's acquisition strategy.

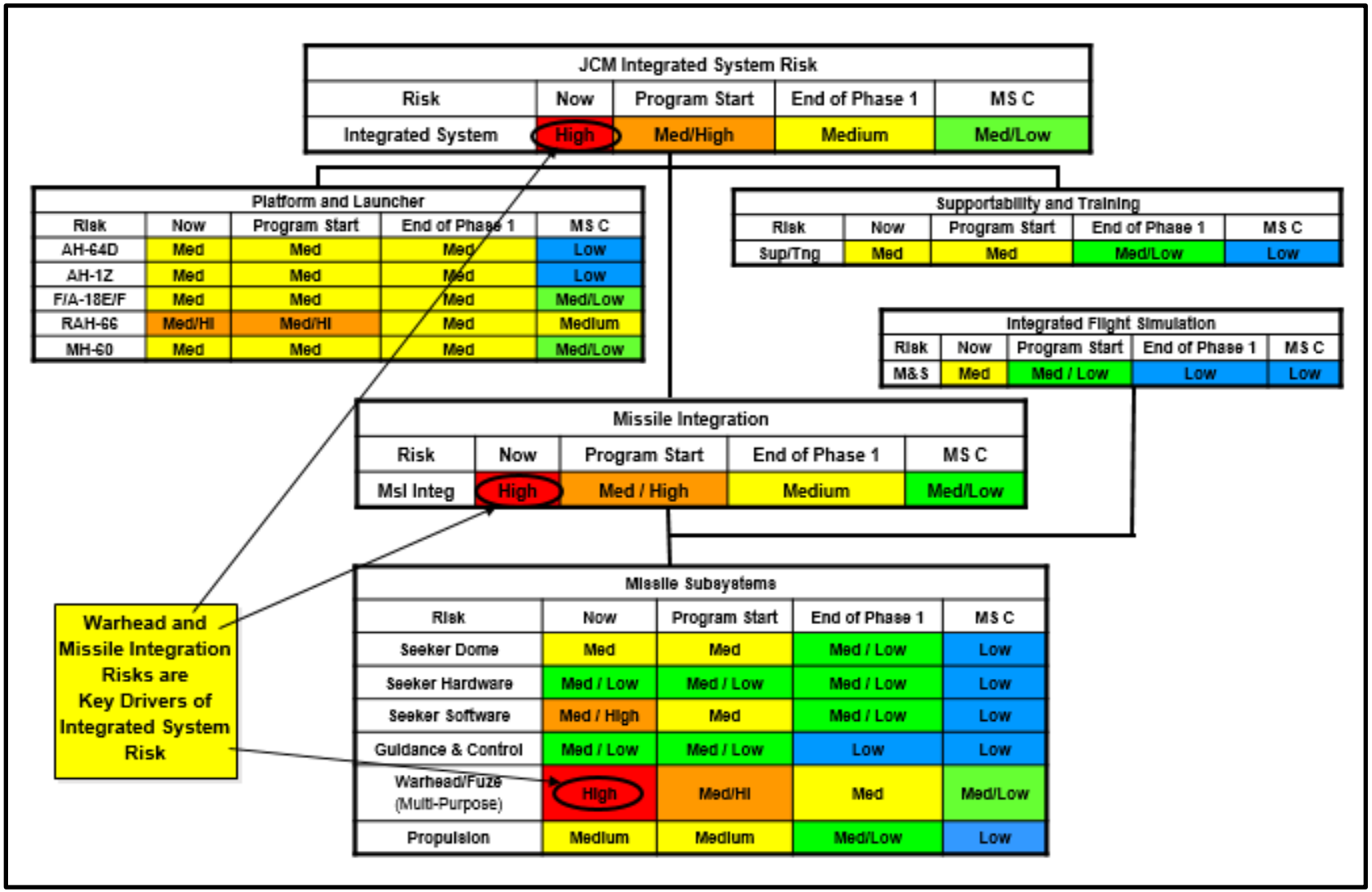


Figure 6. JCM Risk by WBS Level. Source: Army Test and Evaluation Command (2003).

During the JCM MS B brief, the JCM Program Office identified six major program risks, which are displayed in Figure 7 (Joint Common Missile Program Office, 2004). The seeker encompasses the JCM's requirement to operate in three different modes. The modes include the ability for Precision Point Targeting, F&F (Passive), and F&F (Active). The seeker risks were broken down into two critical technology elements, which were the seeker dome and seeker software. Propulsion turn down ratios related to the missile's ability to change propulsion geometry for a boost and sustain phase. These firing phases were necessary to fire the missile from both fixed and rotary-wing platforms at different ranges. Multipurpose warhead fuse technology was critical because the missile needed to hit an array of targets from a T-90 tank to a triple brick wall in a MOUT environment. In addition, the length and diameter of the warhead could have a significant impact on the missile's ability to penetrate armor or buildings (Common Missile Project Office, 2003).

The two remaining risks were missile integration and platform integration. The missile integration focused on the software's ability to control the flight and operation of the missile for its intended target. Platform integration was critical because the JCM needed to fire from fixed and rotary-wing platforms from the Army, Navy, and Marine Corps (Joint Common Missile Program Office, 2004).

Technology Readiness Levels (TRL) are necessary for a program to assess maturity of critical technology elements. Programs need a TRL of 6 to demonstrate system readiness prior to MS B. An independent technology assessment by the Office of the Secretary of Defense Science & Technology subject matter experts determined that the multipurpose warhead, seeker, and propulsion technology elements were at a TRL 6 before MS B based on a successful competitive technology development phase (Joint Common Missile Program Office, 2004). In addition, the risk assessment utilized an evaluation of the likelihood and consequence to determine an appropriate risk level. The likelihood relates to the probability of an inadequate technical performance, and the consequence of the failure on the program's cost, schedule, or performance.

The program office's risk assessment made the following assessments based on technology maturity and integration difficulty. The multipurpose warhead fuze and missile integration were medium/high risk with a likelihood of occurrence rating of 3 and

consequence of 5. The propulsion technology was a medium risk with a likelihood of 2 and consequence of 4. Platform integration and seeker software were medium risks with a likelihood of 3 and consequence of 4. The seeker dome was a medium risk having a likelihood of 4 and consequence of 3. See the JCM risk assessment in Figure 7, which provides a visual representation of the program office risk assessment prior to MS B (Joint Common Missile Program Office, 2004).

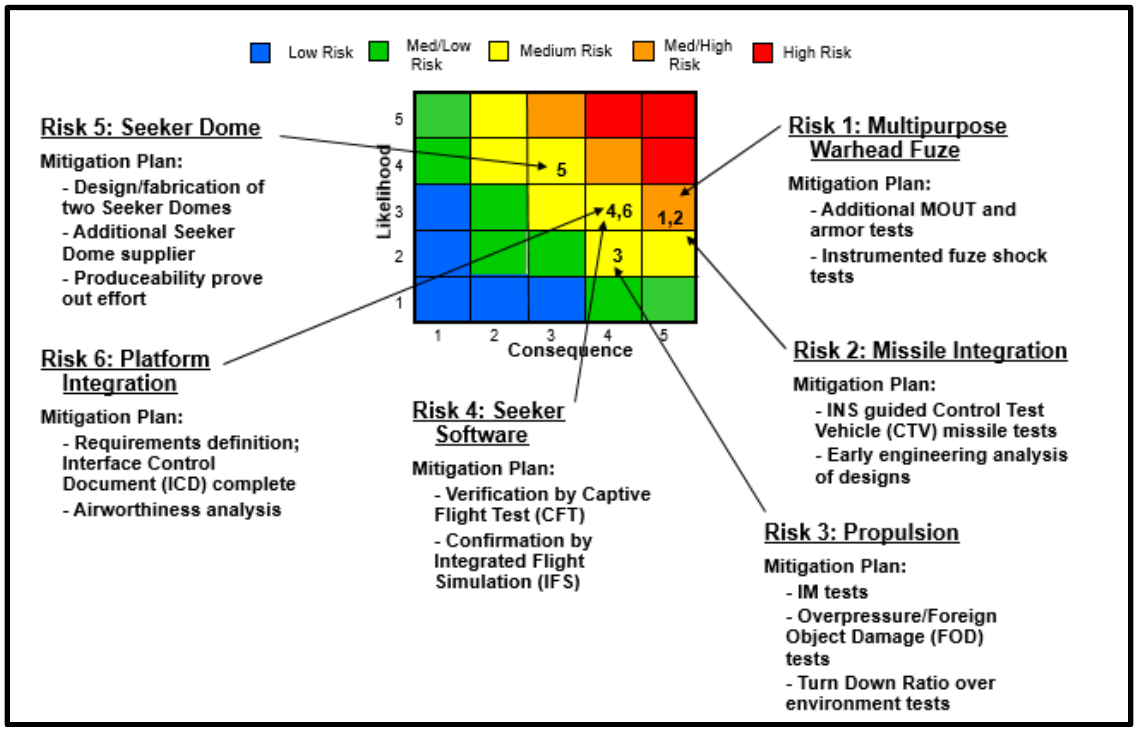


Figure 7. JCM Program Risk. Source: Joint Common Missile Program Office (2004).

5. Program Constraints

Before the JCM became a program of record, several constraints were placed in the CDD that affected cost and schedule elements of the program. The CDD, approved April 12, 2004, outlined the user's need of achieving a target initial operational capability (IOC) in 2009 (JROC, 2004). The target IOC played to the favor of the joint cost proposal (JCP), as it estimated the engineering and manufacturing development phase to be 48 months long (Gregory, 2004). Furthermore, the CDD discussed program affordability in terms of the

acquisition unit procurement cost (AUPC). Using the JCP as a baseline, the CDD identified the JCM AUPC to be $108,000 with a multiyear contract vehicle and $120,000 without a multiyear contract vehicle (JROC, 2004). The inclusion of this information into the CDD would likely influence the MDA's establishment of the PM's APB.

Interestingly, the Cost Analysis Improvement Group (CAIG) approved an independent cost estimate (ICE) for the JCM MS B review the same month the CDD was approved. In it, the CAIG estimated the development phase to be 74 months and having the potential to increase as high as 147 months; a difference of 39% with the JCP. AUPC estimates were also higher at $153,000, a difference of approximately 22% with the JCP (Burke, 2004). As evidenced by the PM's APB, the differences between the JCP and CAIG ICE did not garner enough attention to address.

6. Acquisition Strategy Report

The program acquisition strategy report (ASR) outlined the design and development plan of the JCM in accordance with the then current DODI 5000.02 dated May 12, 2003, and Federal Acquisition Regulation (FAR) dated November 22, 2002 (Common Missile Project Office, 2003). Approved in September 2003, the ASR identified the JCM program as having an overall EA approach through the use of increments. Increment 1 was to provide full performance threshold capability as noted in the CDD, as well as provide versatility for use on fixed and rotary-wing aircraft. As a result, the ASR's primary focus was on the first increment of capability. A second increment that forecasted the development of an anti-radiation homing (ARH) variant had been identified but was not discussed in detail (Common Missile Project Office, 2003). The program office planned to achieve full capability by using existing technologies and maturing them to meet the needs of established KPPs. Furthermore, a combination of Cost-Plus Incentive Fee (CPIF), Fixed-Price Incentive Fee (FPIF), and Firm-Fixed Price (FFP) contract types were templated to incentivize contractors and manage cost/risk sharing opportunities between the government and commercial firms.

a. Acquisition Strategy (Schedule)

The JCM was designed to be a modular system and structured to maximize commonality among rotary and fixed-wing applications (Common Missile Project Office, 2003). Focused on the first increment of capability, the PMO used a multi-phased acquisition approach by planning for two development phases of the program's system development and demonstration (SDD) phase. The first phase of SDD concentrated on mitigating component risk by incorporating a combination of testing and design reviews. This phase was templated to last 12 to 14 months and would be considered successful upon completion of seeker design verification, meeting control test vehicle (CTV) test objectives on track missile design, development of a system design interface control document and a completed preliminary design review (PDR; Common Missile Project Office, 2003). The subsequent phase was templated to last 36 months. The SDD phase focused on the integration of JCM subcomponents into the overall system and intended to demonstrate the system's ability to meet all CDD requirements. However, in the first quarter of Fiscal Year (FY) 2005, the JCM program was terminated while in the first phase of SDD (Joint Attack Munition Systems Project Office, 2015).

B. JOINT AIR-TO-GROUND MISSILE

Program Budget Decision (PBD) 753 terminated the JCM program in the first quarter of FY 2005 due to budget constraints. The JROC instructed the JCM Project Office (PO) to continue maturing key technology with Lockheed Martin and planned a restart for the program in FY 2007 (Joint Attack Munition Systems Project Office, 2016). Prior to 2007, the PO and Lockheed Martin completed a preliminary design review (PDR), and conducted a controlled test vehicle flight, along with more than 3,500 hours of hardware and software testing, and more than 1,000,000 integrated flight simulation runs on missile prototypes. The JCM PO and the Aviation Rockets and Missiles PO merged to form the Joint Attack Munition Systems (JAMS) PO in FY 2007. Soon after formation, the JAMS office began building an AS for a new acquisition category (ACAT) 1 program called the JAGM (Joint Attack Munitions Systems Project Office, 2016).

The JAGM program continues where the JCM technology development (TD) phase left off. The JAGM PO continued developing key technologies from 2008 to 2010, after the

JCM technology maturation and program closeout. The JAGM PO based development of key technologies on the same requirements that outlined the need for JCM production. The JAGM CDD, approved in January 2013, differs from the JCM CDD by outlining a program that has an incremental requirement following an EA approach to reach full capability through three increments (JAGM Product Office, 2014). The CDD states the JAGM strategy

> addresses Increment-One capabilities for the JAGM. Increment-Two will address increases in range, possible inclusion of limited Imaging InfraRed (IIR) for terminal guidance/hit point selection, and other items as technology/schedule can accommodate. Increment-Three will provide full tri-mode seeker capabilities for active and passive engagements as well as an increase in range. (JROC, 2012, p. 14)

1. Requirements

The JAGM CDD contains the same KPPs as the JCM and includes targeting capability, combat effectiveness/reliability, range, interoperability, and carrier/shipboard operability with sustainability (materiel availability) as the only new KPP included in the JAGM CDD (Joint Requirements Oversight Council [JROC], 2012). The biggest differences between the JCM and JAGM KPPs were the inclusion of increments that separated the different threshold requirements for each KPP. Multiple parameters changed from a threshold element in the JCM program to objective level elements for the JAGM.

The targeting capability KPP changed only slightly by identifying the specific differences between the F&F active and passive requirements. Threshold values in Increments 2 and 3 and the Objective values contain F&F passive threshold values against stationary targets only. Increment 1 only contains a Precision Point Targeting and F&F (Active) seeker capability.

Combat effectiveness/reliability requirements included in-flight reliability (Post P-Bit Check) threshold and objective values. The Increment 1 threshold includes initial fielding and system maturity values for the in-flight reliability, with Increments 2 and 3 containing the same values. The Objective value increases the reliability. The other requirements in the combat effectiveness/reliability KPP are the same parameters with different threshold values spread over the different increments and objective elements.

Range requirements for Increment 1 reduced the maximum rotary-wing range to 8km instead of 16km in the JCM CDD. Increment 2 maximum range changed to "greater than 8km," with Increment 3 improving to 16km. Fixed-wing ranges are not required for the JAGM except for the Objective values because of the changes to the Interoperability KPP.

The interoperability KPP contained the biggest changes between the JCM and JAGM. The AH-64D Apache and AH-1Z Cobra helicopters are the only two aircraft identified as platforms for firing the JAGM in all Increment threshold values. The F/A-18 E/F Hornet and MH-60R Seahawk moved to the other Objective level aircraft so that Increments 1–3 are for the two rotary-wing aircraft only.

Carrier/shipboard operability requirements stayed the same, and the last KPP for JAGM that is new is the sustainability (materiel availability) requirement. The KPP describes a required percentage of missiles operationally capable of performing an assigned mission at a given time, based on materiel condition. Increment 1 establishes the same threshold values for Increments 2 and 3, with the Objective level increasing the percentage required.

2. Risks and Risk Management

In 2010, the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA[ALT]) review team conducted a Technology Readiness Assessment (TRA) to review the technology maturity following TD. The two contractors developed materiel solutions for the original JCM requirements up until the TRA. The review team determined that the TRL for the new rocket motor, warhead, and tri-mode seeker/guidance section were either a 5 or 6. The prototype technology of the original JCM requirements were too immature, which could impact the program's cost. Therefore, the program office utilized trade space evaluations to develop an alternative materiel solution with using the Hellfire Romeo backend with a multi-mode seeker for two rotary-wing aircraft. The JAGM program office conducted a risk assessment that evaluated the program risks for the adjusted material solution (see Figure 8; JAGM Product Office, 2014). Compared to the JCM, the JAGM risk assessment did not focus on the development critical technology elements from inception because the technology matured over time from previous TD phases, and the reduced capability utilized existing technology for the dual mode seeker and propulsion system. The program office conducted a risk assessment for the Engineering, Manufacturing, and

Development (EMD) phase to identify integration and manufacturing issues, and to test asset availability.

The first program risk is the Guidance Section (GS) qualification for the JAGM. Guidance Section pertains to the dual mode seeker with precision point and F&F (Active) modes. The design maturity of the GS poses a risk to the cost and schedule of the program. The evaluation determined the likelihood of occurrence as a 2 and the consequence as a 3. Therefore, the overall risk evaluation of the GS was a low rating. The interface of the software and hardware to ensure GS qualification required mitigation through testing and simulation of the contractor's design.

The platform qualification was the second risk as a result of availability of launch assets. The risk was a threat to the program schedule because test asset availability could delay testing. Since the JAGM utilizes the Hellfire backend, the missile would have no issues firing from the existing Apache or Cobra platforms. The program office evaluated the risk as a likelihood rating of 1 and consequence of 4, which results in a low risk to the program.

The third risk was the producibility, or yield, of the JAGM. The program office identified the risk to ensure the missile could meet production rate and quality requirements. If the contractor had inadequate production or quality process maturity, then the schedule could potentially breach. The program office would conduct maintenance readiness level MRL assessments and ensure the contractor demonstrated maturity to an evaluation level of 8 before MS C. The likelihood of this risk was 2, and the consequence was 3, which determined a low risk for the program.

The fourth EMD program risk was in-flight reliability for the missile. The program office identified this risk on the possibility of missile failure during flight. During the EMD, there were 48 firings scheduled to evaluate and mitigate this risk with only two failures expected. The program office would mitigate the risk through additional testing and corrective action and would use previous Hellfire missile reliability data. The likelihood of occurrence was 3 with a consequence of 4, which made the in-flight reliability a medium risk for the program (JAGM Product Office, 2014).

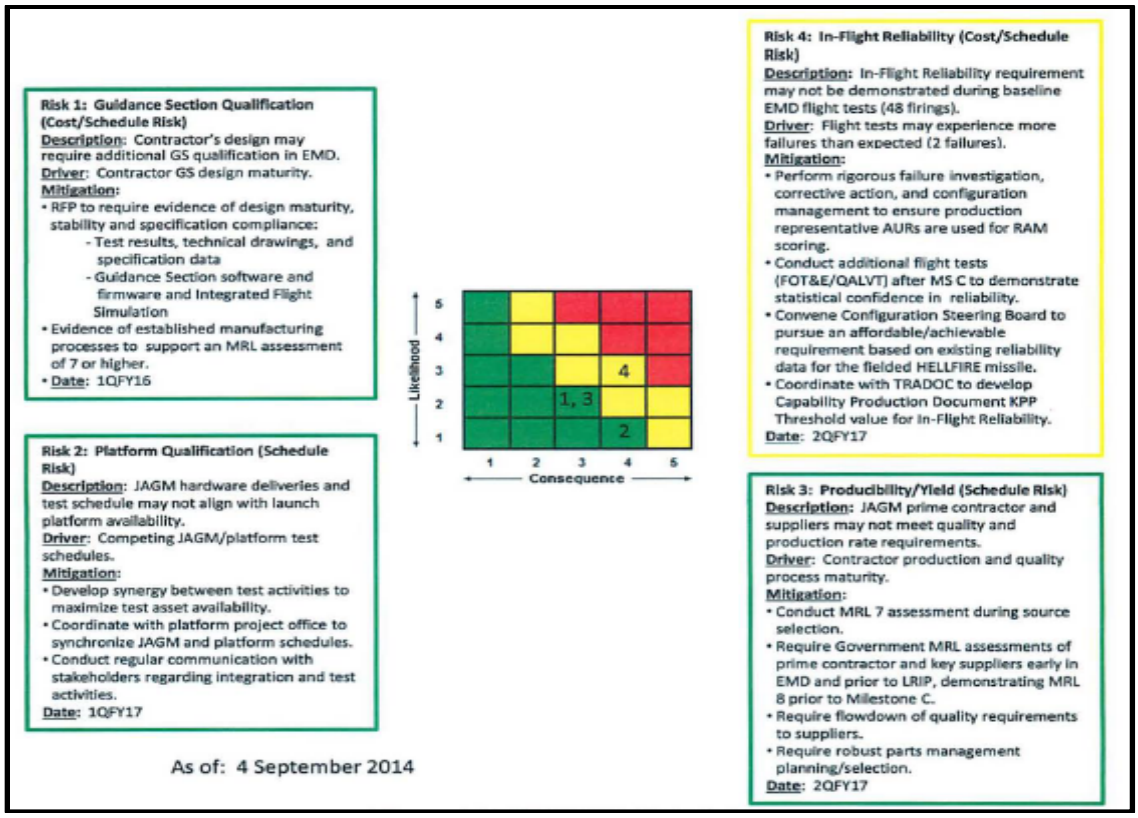


Figure 8. JAGM Risk Assessment. Source: JAGM Product Office (2014).

3. Acquisition Strategy (Schedule)

The program AS, approved on October 2014, outlines the EMD phase and low rate initial production LRIP strategy for Increment 1 of the JAGM program. Like the JCM, the JAGM AS identifies the use of an EA approach through the delivery of capabilities in increments. Comparatively, Increment 1 for the JAGM was not designed to provide full threshold capability, but rather to establish a modular system capable of receiving future upgrades. The EMD phase of Increment 1 sought to mate a multi-mode seeker with the backend of the Hellfire missile. The conclusion to use government furnished equipment (GFE) resulted from multiple trade space evaluations identifying the use of the Hellfire Romeo backend as the most economical materiel solution. Furthermore, Increment 1 focused on system modularity, which facilitated the use of a Modular and Open Systems Architecture (MOSA) to accommodate future increments with the ability to insert technology (JAGM Product Office, 2014).

C. JCM AND JAGM PROGRAM SUMMARY

From 2005 to 2015, the JCM program endured cancellation, re-establishment as the JAGM program, and a subsequent second cancellation. More recently, the restructuring of the JAGM program into increments has resulted in the delay of performance requirements, relating to development of a tri-mode seeker, multipurpose warhead, and common motor, to follow on increments. As such, the first increment of the current JAGM program seeks to develop a dual-mode seeker and mate it with the backend of a Hellfire missile. Figure 9 provides a snapshot comparison of the two programs over a 10-year period. To avoid the same "lost decade" on future programs, the research points to the need for a survey to elicit feedback from acquisition professionals. The survey intends to provide insight on what program elements acquisition professionals consider critical in developing a program acquisition strategy. Chapter IV provides a detailed explanation of the methodology used in creating a survey based off these needs.

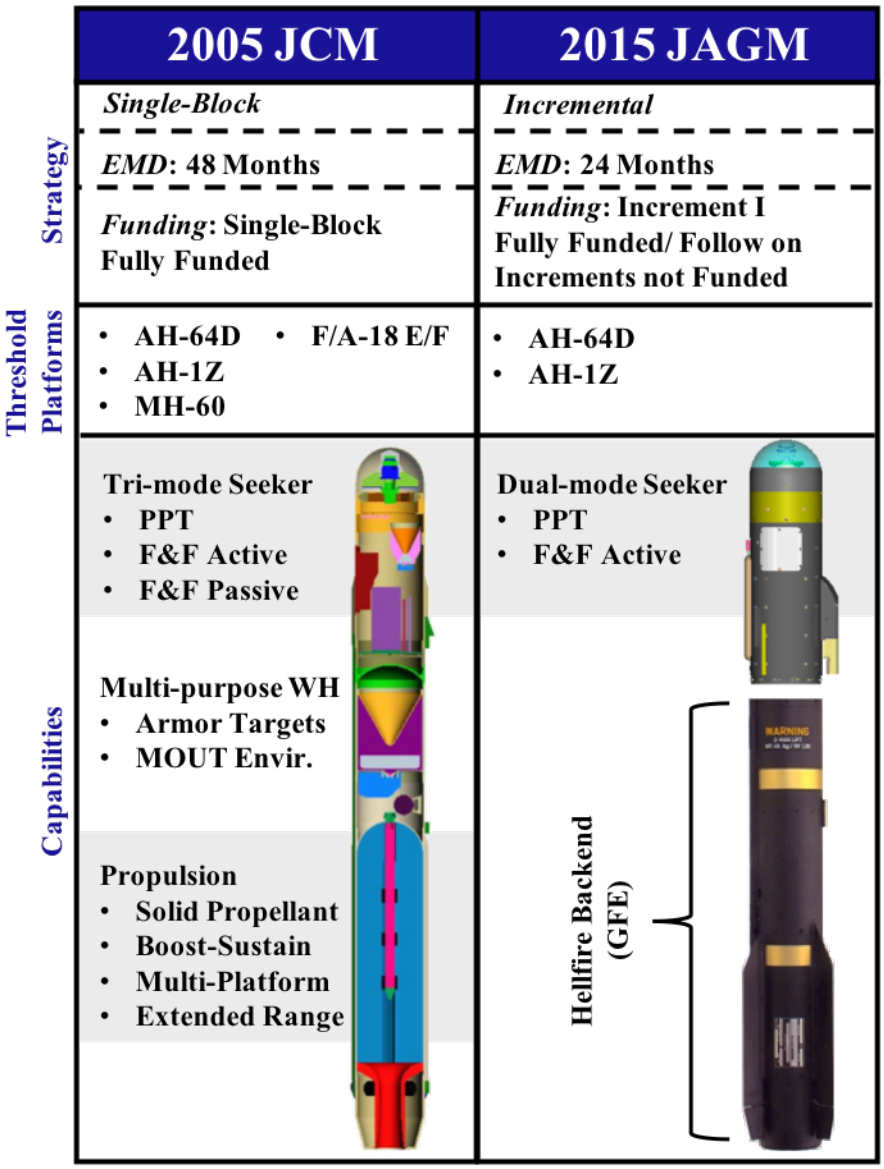


Figure 9. JCM and JAGM Comparison

IV. SURVEY METHODOLOGY

To answer the question "How difficult is it to develop a successful incremental acquisition approach for defense acquisition programs?," this thesis's research is used to develop a survey that collects and evaluates acquisition professionals' knowledge baseline of EA. Chapter IV describes the development of the survey and the format used for delivery to participants for completion. The survey uses the JCM program background information for participants to analyze when completing the survey's acquisition strategy questions. This chapter describes that background and why the JCM is an appropriate topic to use in developing the survey. The end of the chapter reviews the expected feedback and data collected from survey results.

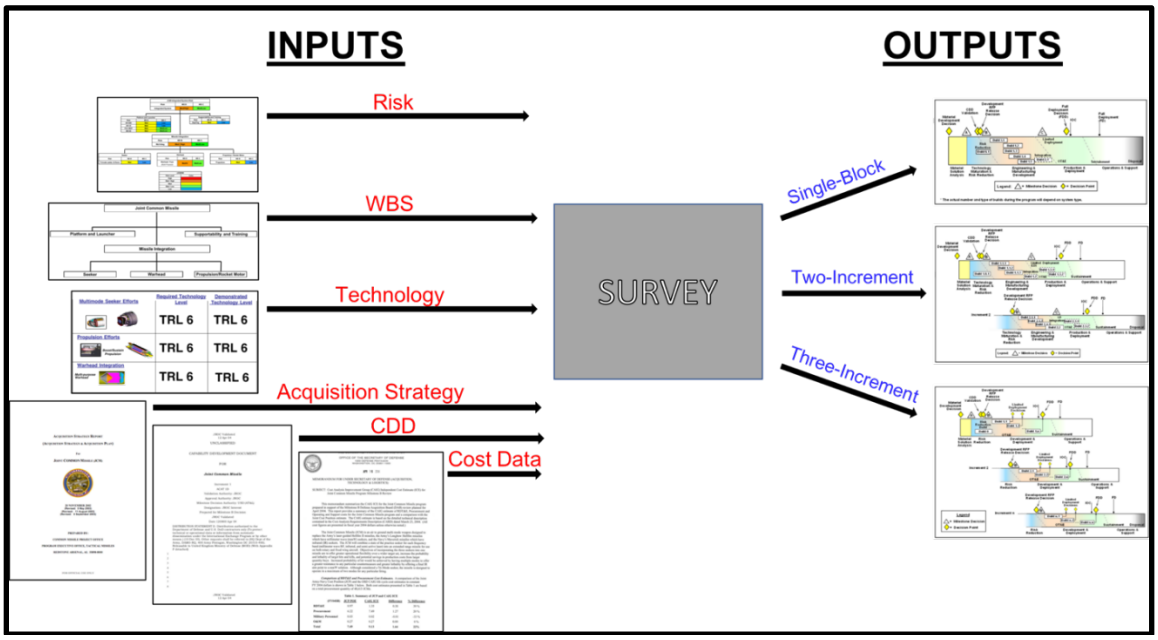
A. DATA COLLECTION MEDIUM

A survey format allows the collection of current acquisition professionals' thoughts on acquisition strategies. Being able to query the field of individuals with knowledge of acquisition program strategies helps to identify current knowledge bases and understandings of the DOD's preferred method of EA with incremental approaches. The survey collects personal data on the individual participant's level of acquisition experience and education. The personal data enables the identification of which level of experience likely results in a higher understanding of acquisition strategies.

An academic setting is the intended environment to administer the survey. Administering the survey during a pre or post-acquisition academic course timeframe is appropriate for instructors to gather feedback and evaluate a participant's knowledge level. Institutions such as the Defense Acquisition University (DAU) or the Naval Postgraduate School (NPS) allow instructors to gain an understanding of student's acquisition strategy knowledge base and tailor lessons to push the DOD's preferred methods.

Figure 10 provides a visual depiction of how program inputs are translated by the survey participant into one of three acquisition strategy outputs. The survey incorporates program inputs relating to elements of cost, schedule, performance, risk, and technology readiness levels. It is understood that the PM would have access to this information to facilitate formulation of program-related decisions. When completing the survey, the

participant is presented with program inputs and prompted to choose from three expected outputs relating to the program schedule: single-block approach, two-increment approach, and three-increment approach.



Adapted from Joint Common Missile Program Office (2004); Army Test and Evaluation Command (2003); JROC (2004); Common Missile Project Office (2003); Burke (2004); OUSD(AT&L) (2017a).

Figure 10. Acquisition Schedule Survey Model.

B. JCM PROGRAM INPUTS

As the DOD began to adjust the DOD 5000.01 series to guide acquisition professionals in program development, the JCM program came to fruition as an MDAP. As highlighted in Chapter II, the DOD focused on developing weapon programs in an EA approach with blocks or increments as highlighted in the NDAA for 2002 and 2003. The JCM was the first program of record with a JROC-approved CDD under the JCIDS process. Therefore, the need for the JCM arose during the shift in the DOD policy to develop weapon systems in an EA approach. The cancellation of the JCM program, and then its reinstatement as the JAGM program, demonstrated how some trade-offs were made to account for cost, schedule, and performance considerations. For this research, the initial JCM estimates and assessments were the critical components to developing a survey, which ultimately was used

to determine how difficult it is to successfully implement an incremental acquisition approach for a defense weapons program.

Critical JCM program information provided the necessary inputs to develop a survey that analyzes an acquisition professional's thought process when generating a program schedule. As a highly complex system dependent upon improved software and technology with component and platform integration considerations, the JCM program possessed many factors to consider when developing a strategy. In addition, the JCM program had a joint cost proposal and IOC, while the CAIG had a different estimate for the average unit procurement cost AUPC and schedule estimates. These estimates are inputs a program manager must consider and justify for developing a proper acquisition strategy. The program office also conducted a thorough risk assessment that tied the requirements to high risk critical technology elements through the WBS. These program elements provided the critical inputs for designing the survey to elicit responses from acquisition professionals that help to determine the difficulty in developing an incremental approach for an acquisition strategy. Adjustment of some JCM information was necessary to simplify critical technology explanations and requirements to make it easier for the participant to understand.

C. SURVEY FORMAT

To create a logical flow, the survey comprises several distinct sections, each aimed to either provide information to or request input from the user. The following headings were used to categorize each section: Participant Demographics, Instructions, Situation, Draft APB Information, Survey Questions, and Participant Feedback. The following paragraphs provide a description of each survey section.

1. Participant Demographics

The Participant Demographics section of the survey requests the user to choose from a defined selection of rank/grade, experience, and educational options (Figure 11). This section is used to gather participant demographic information for comparative use when a statistically relevant sample size can be achieved through future dissemination. An example of how this information could be used is that the data collected could highlight whether a specific pay grade or education level possesses a better understanding of implementing an

incremental acquisition approach during schedule development. Specific personal identifiable information is not in the participant demographics section or the overall survey.

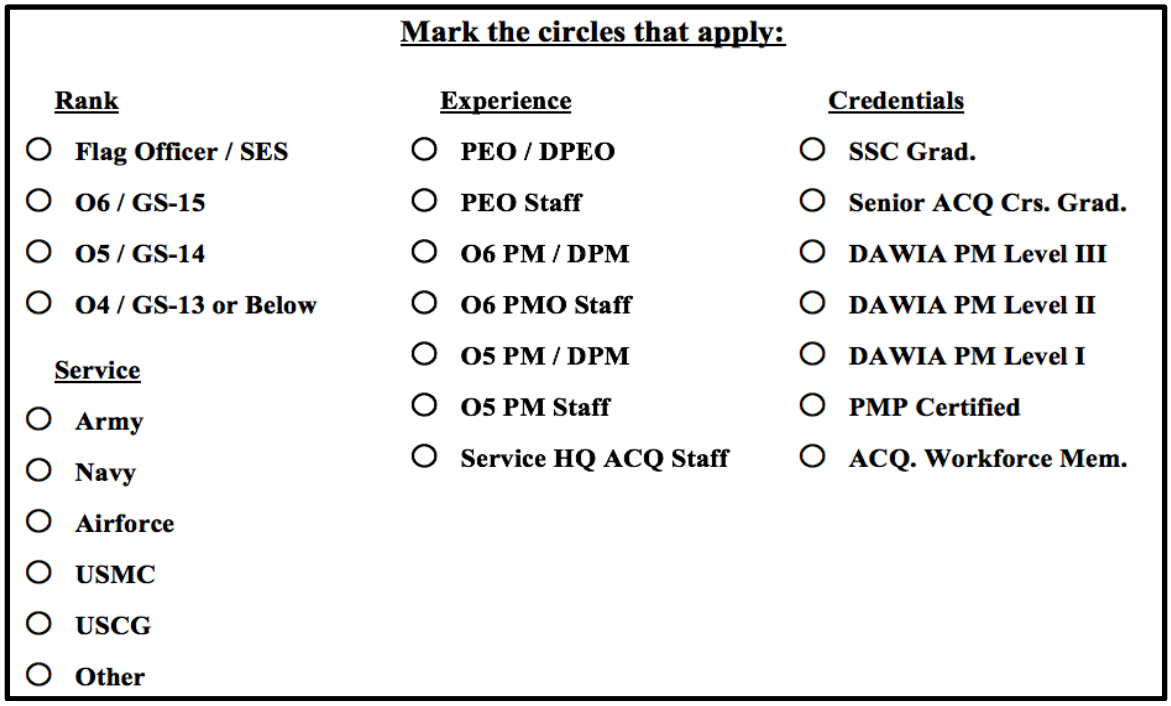


Figure 11. Participant Demographic Selection

2. Instructions

The Instructions section outlines the objective of the survey taker in the simple format of task, conditions, and standard. The directions clearly articulate how the survey taker must analyze the provided JCM system inputs, use critical thinking, determine what acquisition approach to follow for program development given the draft APB, and provide reasoning for decisions or trade-offs made during the survey. The instructions establish the conditions and time constraints for the survey in a classroom environment. The survey taker should have a clear understanding of expectations for the survey after reading the instructions.

3. Situation

In the Situation section, a detailed description of the acquisition environment is necessary to create realistic context for the JCM program for the survey taker. Most of the information for this research is from the JCM prior to cancellation; therefore, the situation

places the survey taker in the role as the PM prior to MS B and awaiting the award of an EMD contract. Background on the maturation of critical technology, approved JCIDS documents, and estimates provide additional context for the program inputs. This section also describes the importance and urgency of the need for the JCM to replace the Maverick, Hellfire, and TOW to decrease the logistic footprint and life-cycle costs with improved capability. The survey taker should understand the current state and importance of the JCM upon reading this section.

4. Draft APB

The Draft APB section presents cost, schedule, and performance information for the participant's consideration in developing their acquisition strategy. The following paragraphs describe in detail what information is presented to the user.

a. CDD Performance Requirements

To account for the varying degrees of acquisition professionals' technical background, the simplification of technical requirements was necessary to provide more clarity to the survey taker. The targeting KPP for a tri-mode seeker is simplified and separated into the modes of precision point and F&F active or passive with simple explanation of the targeting mode as either laser, radar, or infrared designation. The combat effectiveness KPP relates to the need for a multipurpose warhead, which describes the different armor and antipersonnel requirements. The range and interoperability KPPs simplification was necessary to distinguish the missile functionality on different platforms. The addition of the physical dimension requirement was important for understanding the JCM size. The creation of the CDD performance requirements table in the survey provides the survey taker with a snapshot of the user requirements in simple terms (see Figure 12).

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

Figure 12. CDD Performance Requirements

b. Schedule

The Schedule section of the survey describes how the current program utilizes a single-step approach to system development. The schedule inputs are additional constraints the survey taker must consider, which align with the original JCM schedule requirements from the CDD. The explanation of schedule inputs is in terms of months or years in relation to MS B. This is a result of the situation for the survey taker acting as the PM just before a MS B decision and waiting to enter EMD. The services require the MS C in 48 months and IOC 60 months from MS B. The EMD estimate is from the original JCM schedule, and the CDD possessed the original IOC criteria for the services.

c. Cost

The program office estimates for the JCP are the inputs for the survey's Cost section. The intent of this section is to provide the survey taker with an understanding of the average unit procurement cost (AUPC) for the JCM from the program office's perspective and provide options before the MS B decision. The actual estimates were $108,000 with a multi-

year contract and $120,000 without a multi-year contract for an acquisition objective of 63,978 missiles. In addition, this section outlines a beneficial budgetary environment because of the program incorporation into the POM (Program Objective Memorandum) and full funding support for a 48-month EMD and 10-year production and development (P&D). The survey taker must account for these program office cost estimates and determine whether or not to implement the program office or CAIG estimates when determining the appropriate acquisition strategy.

d. Work Breakdown Structure

The intent of the Work Breakdown Structure section is to highlight the major components of the system. To simplify the original JCM WBS, the diagram was organized to show three levels with the bottom level being the three major components of the system. The seeker, warhead, and propulsion/rocket motor are the three major components of the JCM correlating with the system risks. The WBS presented in this manner illustrates to the survey taker how the requirements are linked to the system design. In addition, the diagram links the requirements with the program risks. The survey taker should understand the basic system design and potential trade-offs when observing the simplified JCM WBS (Figure 13).

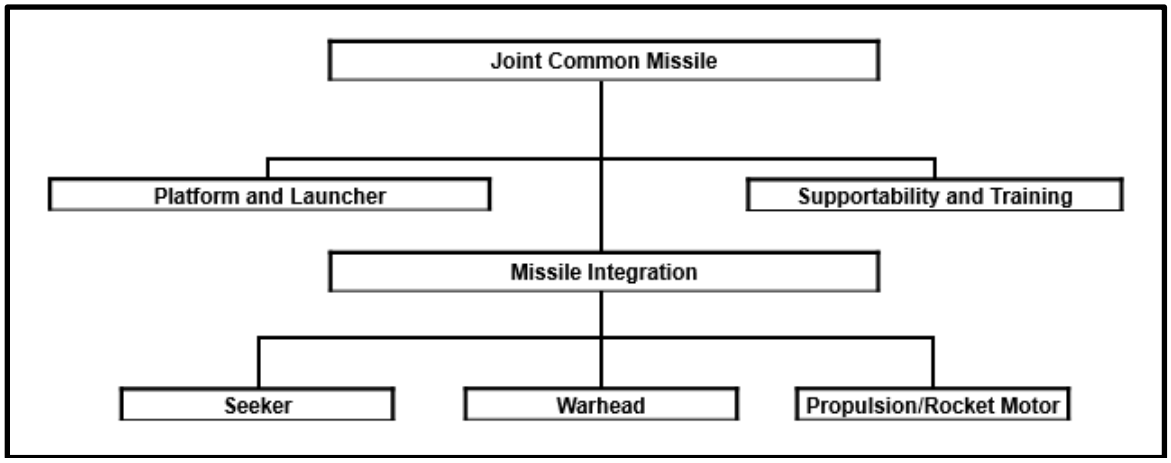


Figure 13. Simplified Survey WBS

e. Risk Assessment

The Risk Assessment section of the survey provides the participant with traceability of risk to the elements of the WBS (Figure 14). The intent of presenting the risk assessment in this manner is to highlight program risk by sub-component and allow the participant to visualize overall program risk. Like the simplified WBS, this section was simplified from actual program information in order to present data in a non-technical manner and account for participants whose knowledge base does not include that of a missile program.

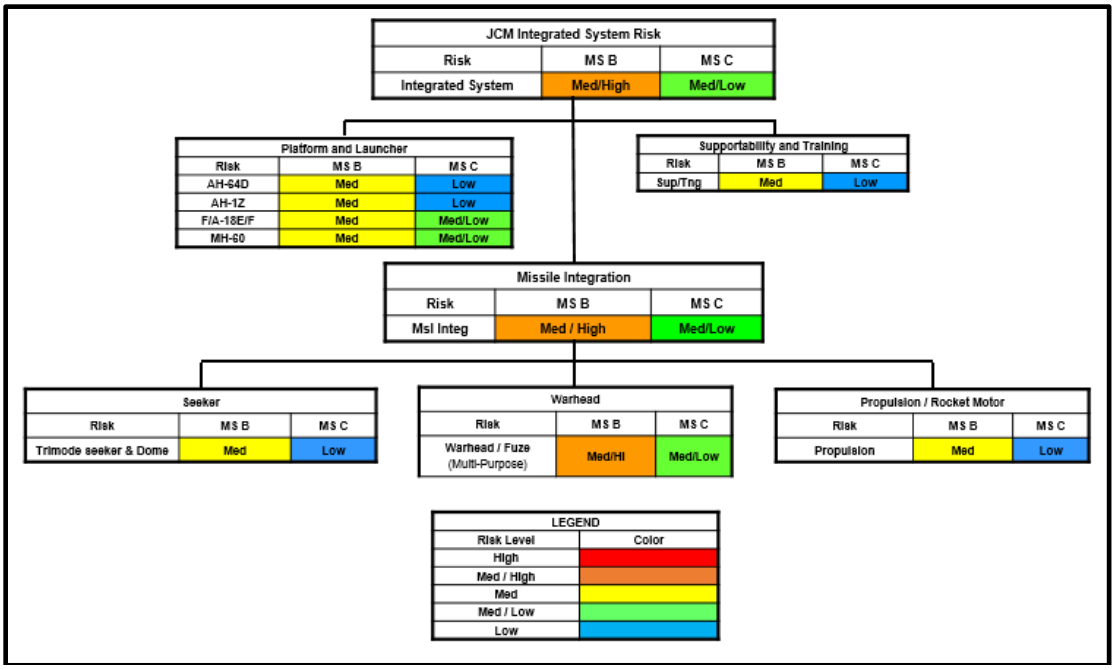


Figure 14. Simplified Survey Risk Assessment

f. Technology Readiness Levels

The TRLs provided to the participant in this survey reflect that of the actual program. Each critical component of the JCM (multi-purpose warhead, common rocket motor, tri-mode seeker) was assessed at TRL 6, an assessed level conducive with entering MS B for a program.

g. ICE and Affordability Assessment

Program affordability is one of the more important elements of a defense acquisition program. Fiscal projections are typically accounted for in such items as the POM and Future Years Defense Plan (FYDP), and as such remain one of the binding elements for a PM to manage on a program. This informative section of the survey provides the participant with a simplified affordability assessment derived from the CAIG ICE. The inclusion of the CAIG's estimate for program development and AUPC is aimed to generate thought on behalf of the participant. Discussed earlier, the CAIG estimate differs significantly from the JCP. It is up to the participant to discern whether this difference is significant enough to warrant requesting a change to the program APB.

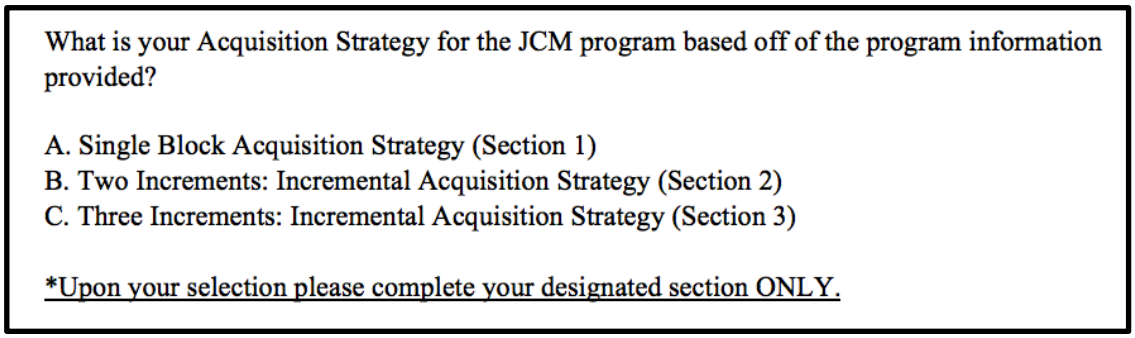
5. Survey Questions

This section of the survey transitions from providing information to requesting information from the participant. Within it, the participant is prompted to make choices in regards to elements of program cost, schedule, and performance. At the conclusion of this section, the participant has effectively distilled the program information and translated it into acquisition strategy–related answers for the program.

a. Strategy Selection

The strategy selection question is the first JCM program–specific question the survey participant must answer (Figure 15). The answer to the strategy selection leads the participant to answer specific APB questions for the type of strategy they chose. Selecting answer "A" declares the participant chose "Single Block Acquisition Strategy (Section 1)" as their preferred acquisition strategy for the JCM program based on the situation and draft APB data given. Selecting answer "B" identifies that participant chose "Two Increments: Incremental Acquisition Strategy (Section 2)" as their preferred strategy. Selecting answer "C" indicates that the participant desires "Three Increments: Incremental Acquisition Strategy (Section 3)" as their preferred strategy. Once one of the three strategy types is chosen, the participant is directed to answer the APB questions in the section only pertaining to their desired acquisition strategy. Answering their section-specific acquisition questions allows the

participant to better explain their strategy decision for the JCM and the specific APB applications in their own view.


What is your Acquisition Strategy for the JCM program based off of the program information provided?

A. Single Block Acquisition Strategy (Section 1)
B. Two Increments: Incremental Acquisition Strategy (Section 2)
C. Three Increments: Incremental Acquisition Strategy (Section 3)

*Upon your selection please complete your designated section ONLY.

Figure 15. Acquisition Strategy Selection Question

b. Single-Block Strategy

If a survey participant selects the first answer of the strategy selection question, they indicate a desire for a "Single Block Acquisition Strategy (Section 1)." The survey directs the participant to answer only Section 1 acquisition questions, which pertain to a single-block strategy only. Section 1 has a total of four questions that pertain to the participant's desired EMD phase length, AUPC amount, JCM capabilities, and options to address a strategy's possible breach of the JCM program's APB.

Question 1 of Section 1 requires the participant to select a length of time for their strategy's EMD phase (Figure 16). The question is a multiple-choice type and contains the three different time lengths of 48 months, 72 months, and 144 months for answers A through C, respectively. Answer D is an "Other" type of answer which allows the participant to write in a desired number of months for their strategy's EMD phase length. Sub questions A and B following question 1 require the participant to justify the selection of time for their EMD phase and to address high-risk schedule concerns if the 48-month option is selected.

The JCM situation and draft APB data given to the participant in the beginning section of the survey provide information that is critical when choosing EMD time length. The participant should understand critical events anticipated in the schedule section and analyze the capabilities of the JCM's subcomponents and their capability for integration with

one another. The WBS and risk analysis are essential elements for the participant to compare with the schedule of critical events given.

Question 2 of Section 1 requires the participant to select an amount of money for the JCM programs AUPC. Question 2 is a multiple-choice type and contains the three different monetary values of $108,000, which is the draft APB amount based on a multi-year contract; $120,000, which is the draft APB amount based on a single-year contract; and $153,000, which is what the CAIG ICE estimated in the situation section. The dollar figures are the options for answers A through C, respectively. Answer D is again another "Other" type of answer that allows the participant to write in a desired dollar amount for their strategy's AUPC.

Question 3 of Section 1 requires the participant to select which capabilities their strategy includes for the JCM's initial production. The capabilities are broken up into the four categories of seeker, warhead, propulsion, and platform integrated. Question 3 is a check-box type question that allows the participant to choose as many of the options as they like. A commercial-off-the-shelf (COTS) or key performance parameter (KPP) option is given for the seeker, warhead, and propulsion categories. The two different options allow the participant to analyze the JCM program's risk analysis and tech maturity to better determine the likely capabilities included in the first JCMs produced.

The platform integrated category allows the participants to choose the priority of the aircraft that will fire the JCM. The platform category requires analysis of the aircraft included as a part of the integration KPP and any information in the situation that could reduce the total amount of aircraft from the initial KPP list. The survey requires participants to explain how they expect to gain relief from not selecting all of the KPP-directed requirements.

Question 4 of Section 1 is the final question and requires the participant to explain how they plan to address the affordability concerns and the high likelihood of cost and schedule breaches. Question 4 is a long, written answer that requires the participant to analyze the choices they made in order to determine what schedule and cost risks they need to mitigate.

SECTION 1: SINGLE BLOCK ACQUISITION

1. Based off the program information, select the length of EMD phase appropriate for your strategy.

A. 48 Months *(Draft APB based on POM)*
B. 72 Months *(Low CAIG ICE Estimate)*
C. 144 months (12 years) *(High CAIG ICE Estimate)*
D. Other (Specify) _____Months

a) Justify your selection.

b) How would you address the high-risk schedule concerns if you select a 48-month EMD phase?

Figure 16. Example Single Block Survey Question

c. Incremental Strategy: Two Increments

Selecting option B, in the acquisition strategy selection question will direct participants to answer only the questions in Section 2 related to a two-increment acquisition strategy (Figure 15). Similar to Section 1, Section 2 has a total of four questions. However, each question now has a dual increment component to it pertaining to the desired EMD phase length, AUPC amount, JCM capabilities, and justification to address delaying the JCM by one year to realign requirements and funding. Figure 17 provides an example of a two-increment strategy question.

SECTION 2: TWO INCREMENTS: INCREMENTAL APPROACH

1. Based off the program information, select the length of EMD phase by increment appropriate for your strategy.

Increment I
A. 48 Months
B. 72 Months
C. 144 Months
D. Other (Specify) _____Months

Increment II
A. 48 Months
B. 72 Months
C. 144 Months
D. Other (Specify) _____Months

Justify your selection.

Figure 17. Example Two-Increment Survey Question

Selection of the two-increment approach by the participant should provoke a deeper analysis. Compared to the single-block method, the participant now has to decide what length of development would best suit each increment, how that should affect the increment AUPC, and what capabilities each increment will address. As a byproduct of selecting this strategy, the PM would have to receive service approval to delay an MS B decision, obtain JROC CDD approval, and realign the service POM submission. The conclusion of this section requests the participant to elaborate on how they would navigate and obtain proper approvals to employ this strategy.

d. Incremental Strategy: Three Increments

This section addresses questions if a participant chooses a three-increment acquisition strategy. Similar to the two-increment approach section, the three-increment strategy provides for an additional increment to achieve the end-user's requirements outlined in the CDD. Selection of this approach should provoke the deepest analysis compared to the two other acquisition strategy options. Figure 18 provides an example of a three-increment strategy question.

SECTION 3: THREE INCREMENTS: INCREMENTAL APPROACH

1. Based off the program information, select the length of EMD phase by increment appropriate for your strategy.

Increment I	**Increment II**	**Increment III**
A. 48 Months	A. 48 Months	A. 48 Months
B. 72 Months	B. 72 Months	B. 72 Months
C. 147 Months	C. 147 Months	C. 147 Months
D. Other (Specify) _____Months	D. Other (Specify) _____Months	D. Other (Specify) _____Months

Justify your selection.

Figure 18. Example Three-Increment Survey Question

6. Participant Feedback

The Participant Feedback section at the end of the survey allows the initial survey administrators to gather critical feedback on the content of the input data given and quality of the questions. Feedback from acquisition professionals allows the administrators to better understand the knowledge base of the survey takers and continue improving the content over time.

V. CONCLUSION AND RECOMMENDATIONS

The intent of this research is to answer the primary research question: How difficult is it to develop a successful incremental acquisition approach for a defense acquisition program (Acquisition Research Program, n.d.)? This research is based upon the history of EA and incremental approach development as the DOD's preferred approach. An outline of the history behind the DOD's acceptance of the incremental approach as policy highlighted the importance of an acquisition professional's ability to implement the approach and adhere to DOD policy. In addition, the example of the Small Diameter Bomb demonstrated how an incremental approach could lead to a successful program and prevention of a Nunn-McCurdy breach. Even though there are successful examples such as the Small Diameter Bomb, some DOD programs still do not utilize an incremental approach or stay within cost, schedule, and performance. The research utilized the evolution of the JCM into the JAGM program as a case study with adequate program information. The JCM program had JROC-approved requirements documents, a detailed risk assessment, and thorough cost estimate; however, the DOD eventually canceled the program but brought it back to life years later as the JAGM. To answer the primary research question, JCM program information is used as inputs for a survey, whose elements potentially determine the difficulty of implementing an incremental approach. Initial feedback from acquisition professionals further refined the beta survey to assist research efforts. The following sections provide critical research findings and recommendations for further research to eventual survey distribution.

A. REQUIREMENTS TO ANSWER THESIS QUESTION

The research team decided to use a survey to provide a problem set to acquisition professionals, and eventually collection of data over a large population of the acquisition workforce. The target audience for the survey was program managers within the DOD acquisition. Upon publication of this research, future survey participants will provide the objective data to determine the difficulty of implementing the DOD policy for acquisition strategies.

B. RESULTS OF RESEARCH

The research conducted for this thesis provided answers to the primary and secondary research questions detailed in Chapter I. DOD regulation and instruction documents, governmental reports, and past acquisition program data provided needed information about the history and implementation of EA with incremental approaches. The following section details data that helped answer the primary and secondary questions.

1. Primary Research Question

The primary research question for this thesis asks how difficult it is to develop a successful incremental acquisition approach for defense acquisition programs (Acquisition Research Program, n.d.). Future survey administrators will provide answers to the primary research question with survey results and analysis. The survey created during the research for this thesis's primary question will be beneficial for future data collection of acquisition professional's understanding of the DOD Acquisition preferred approach. Acquisition subject matter experts reviewed the preliminary survey and concluded it can and will address the thesis' primary research question.

2. Secondary Research Questions

The first of the secondary research questions asks about the history of EA and an incremental development approach. A foundational look at the history of the idea of EA and an incremental approach highlighted how the technique became DOD policy. Previous Congressional legislation such as the Goldwater–Nichols Act of 1986, NDAA from the 1980s through the 2000s, and DOD 5000.01 and 5000.02 policies dating back to the early 1990s established the historical context of DOD acceptance of EA with an incremental approach. The research analyzed the JCM and JAGM program to gather realistic information for survey development. The use of the information from these programs provides credibility to the survey since the JROC approved the requirements and achieved a successful MS B.

The secondary research question that asks how effective the DOD is at implementing an EA strategy with an incremental approach is partially answered by two GAO reports completed in 2014 and 2016. The 2014 GAO report titled *Agencies Need to Establish and Implement Incremental Development Policies* revealed one of 37 DOD programs planned to

deliver functionality every six months (Government Accountability Office, 2014). The GAO report outlines the need for incremental approaches, especially in IT intensive programs and long-term system development projects. The lack of incremental strategies led the GAO to continue reporting on the use of the important acquisition strategy.

The GAO report titled *Agencies Need to Increase Their Use of Incremental Development Practices* details the total DOD information technology (IT) intensive programs in 2015 and 2016 that utilized an incremental approach (Government Accountability Office, 2016). The DOD's reporting on their primary IT-intensive programs to the Office of Management and Budget (OMB) inconclusively details the effectiveness of their program's incremental strategies. The GAO reported the DOD has one of the lowest rates among government agencies for using incremental acquisition approaches. However, reporting discrepancies outlined in the DOD rebuttal explain a breakdown of status reporting to the OMB about incremental strategies used and a planned approach to increase reporting accuracy in the future.

The DOD's effective implementation of EA strategies with incremental approaches cannot be conclusively answered due to the lack of data consolidated on past acquisition programs. The current means of extracting the data needed to answer the secondary question are not used to the maximum potential. A strong emphasis required for reporting and consolidating the DOD's use of evolutionary strategies does not exist.

The third secondary research question requires an example of a successful implementation of an incremental approach. The Small Diameter Bomb program, outlined in Chapter II, describes an effective and successful incremental approach to an MDAP. The RAND study also outlined in Chapter II detailed the incremental approach taken to the SDB program, which led to lower costs and zero APB breaches.

The fourth secondary research question asks how the JCM program evolved into the JAGM program. After reviewing program-specific information, this question is answered in Chapter III of the thesis. Additionally, Figure 19 provides a visual depiction of the program's evolution.

Figure 19. Evolution of the JCM Program. Source: Joint Attack Munition Systems Project Office (2015).

The final secondary research question asks to what extent acquisition professionals understand program risks and the necessity of using an incremental approach. The preliminary survey allows future administrators to alter risk and TRL levels to better analyze acquisition professional's baseline knowledge for managing program risk. Alteration of these inputs allows administrators to identify participants' thresholds for selecting an incremental approach. The survey created during this thesis's research helps to identify the knowledge base and emphasis acquisition professionals put on strategies with evolutionary and incremental approaches.

C. DEVELOPMENT OF SURVEY

Effective guidance, basic participant information, and situational context provide survey participants with an idea of the survey expectations. The situation explains how the survey participant has inherited the JCM program prior to MS B and is awaiting EMD contract approval, and provides the operational concept and urgency of the program. The inputs for the survey included a draft APB that included requirements, cost and schedules estimates, WBS, risk assessment tied to the requirements, technology readiness levels, ICE,

and affordability assessments. Survey participants must internalize the inputs and decide on a single step, two increments, or three increments for the program schedule. This selection and the rationale for selection provides critical information to the survey administrator for the issues with implementing an incremental acquisition strategy. The survey provides the best medium for data collection and further analysis into the primary research question.

The software program, Google Forms, helped create a digital version of the survey as an alternate medium for disbursement and data analysis. Using Google Forms to create a digital format allows survey administrators to easily consolidate and analyze responses from participants. The Google program proves to be very user-friendly for the survey creator and administrator. Being free of charge, Google Forms has a better price point than many other survey programs and performs well with this research's type of questioning.

D. PRELIMINARY CRITICAL FEEDBACK (JAGM SOLUTION ANSWER)

Preliminary editorial feedback received from acquisition subject matter experts mostly pertained to clarification of survey content and expectations for questions from future survey participants. The survey does not have a specified correct answer to the strategy type and corresponding questions. However, a survey participant who chooses the strategy type and answers questions that are closest to resembling the JAGM program and its incremental strategy is considered to have correctly predicted the most appropriate outcome.

E. RECOMMENDATIONS

The recommendations facilitate follow-on research to further analyze acquisition professional's propensity to implement an incremental approach during acquisition strategy development. The survey handover and future distribution enables survey administrators a platform to collect data. Survey adjustment and additional versions provide the ability to change inputs to determine whether different program inputs elicit participants to utilize an incremental approach. The final recommendation highlights potential incentives to increase the survey participation. Further details of the recommendations are presented in the following sections.

1. Future Distribution

To gather feedback necessary to analyze and answer the thesis question, the survey requires distribution to a target audience of acquisition professionals. Initially, it is recommended to limit distribution of the survey to acquisition professionals undergoing training at service equivalent educational institutions such as the Army Acquisition Center of Excellence (AACoE) and Senior Service College (SSC). Doing this provides control of survey distribution and guarantees a means of data collection. Through collaboration with the respective service institution, the survey can be incorporated into the program of instruction with adequate time allocated for its completion. Time allocation is especially important as the survey is estimated to take 45 to 60 minutes to complete.

After achieving an adequate baseline of feedback through service institutions, consideration should be given to expanding distribution of the survey to all DOD acquisition professionals. It is acknowledged that the current form of the survey is extensive; therefore, future distribution should be tailored to minimize impacts on professionals performing their duties. This is achieved through reducing survey justification requirements from the participant.

2. Future Versions of the Survey

Variable information of the survey includes the risk assessment, technology readiness levels, and ICE and affordability assessment. The survey administrator should adjust these variable inputs to determine whether acquisition professionals would be more prone to an incremental approach. As a result, a sensitivity analysis on these inputs may provide further information into how acquisition professionals prioritize information and what would trigger an incremental approach selection in the survey.

Certain changes to the survey inputs may drive participant responses to create a JAGM-like strategy. One recommendation for the survey administrator is to change levels of risk in the risk assessment. A higher risk level for a missile subcomponent or system integration capability would likely change a participant's view on the needed strategy changes. The TRL is another change that would likely adjust a strategy to replicate the JAGM's strategy. Changing the projected timeframe for the JCM's EMD phase to a point of

impacting the IOC is also likely to push the survey participant to implement an incremental approach.

3. Incentives for Survey Takers to Increase Percentage of Completion

The survey's application is appropriate for a final capstone course within an acquisition systems management curriculum. The survey requires participants to recall lessons learned and apply critical thinking to answer the questions. The survey administrator can easily assess knowledge retained and the effectiveness of key points addressed prior to the capstone course. Administrators have multiple options to mandate survey completion. An instructor may structure a final exam around the survey and require participation for course graduation.

Defense Acquisition University administrators use continuous learning points to ensure that professional growth is emphasized in the workforce. The DOD Instruction 5000.66 states that "All AWF members must engage in at least 80 hours of CL every 2 years (with a goal of engaging in 40 hours annually), commencing from the time the member enters an AWF position throughout his or her continuous tenure in the AWF" (OUSD[AT&L], 2017b, p. 28). Survey administrators can utilize the survey to gather data on the workforce's knowledge base of the current preferred acquisition strategies and provide a learning experience to participants.

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APPENDIX. PRELIMINARY SURVEY

Acquisition Strategy Survey

Naval Postgraduate School
Graduate School of Business and Public Policy

☐ **By checking this box, you agree to participate in this preliminary survey that is intended to collect data on the development of acquisition strategies.**

Mark the circles that apply:

Rank

- O **Flag Officer / SES**
- O **O6 / GS-15**
- O **O5 / GS-14**
- O **O4 / GS-13 or Below**

Service

- O **Army**
- O **Navy**
- O **Airforce**
- O **USMC**
- O **USCG**
- O **Other**

Experience

- O **PEO / DPEO**
- O **PEO Staff**
- O **O6 PM / DPM**
- O **O6 PMO Staff**
- O **O5 PM / DPM**
- O **O5 PM Staff**
- O **Service HQ ACQ Staff**

Credentials

- O **SSC Grad.**
- O **Senior ACQ Crs. Grad.**
- O **DAWIA PM Level III**
- O **DAWIA PM Level II**
- O **DAWIA PM Level I**
- O **PMP Certified**
- O **ACQ. Workforce Mem.**

INSTRUCTIONS:

You are currently the PM for the Joint Common Missile (JCM) following the Materiel Development Decision (MDD) to begin development of a materiel solution.

TASK:
Thoroughly read and analyze the JCM background, constraints, and strategy options. Choose the best strategy option and support your selection by answering the follow-up questions for the section you chose.

CONDITION:
Given the JCM key performance parameters (KPP), previously completed risk assessment, budgetary environment, and JCM timeline constraints, complete the survey in a classroom environment.

STANDARD:
Choose the best JCM strategy option based on your assessment of the program constraints. Answer the follow-up questions to explain your choices.

SITUATION:

You are preparing for a Milestone (MS) B decision to enter Engineering & Manufacturing Development (EMD) and award competitive EMD contracts. The JCM program is an Acquisition Category-1D (ACAT-1D) program with planned MS B in six months. The JCM program just finished a very successful three-year Technology Maturation & 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 & Technology Objectives (STO) efforts by Research Development & Engineering Command (RDECOM) proceeded the TMRR phase. Solid 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) helped solidify the Joint Requirements Oversight Council (JROC) approved Capability Development Document (CDD) requirements, including the 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 logistic footprint. The current platforms and accompanied missiles are as follows: the Hellfire (average unit procurement cost [AUPC] = $58,200–$115,600) is shot from the AH-64D with either precision point (PP) or millimeter wavelength (MMW) targeting modes with separate warheads; the TOW (AUPC = $63,700–$92,500) is fired from the AH-1Z and MH-60 wire-guided targeting; and the Maverick (AUPC = $179,000) is fired from the F/A-18 E/F with either PP or infrared (IR) targeting with a different warheads. 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.

Draft Acquisition Program Baseline (APB): The following performance, schedule and cost data outlines the constraints applied to the JCM program.

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

SCHEDULE:

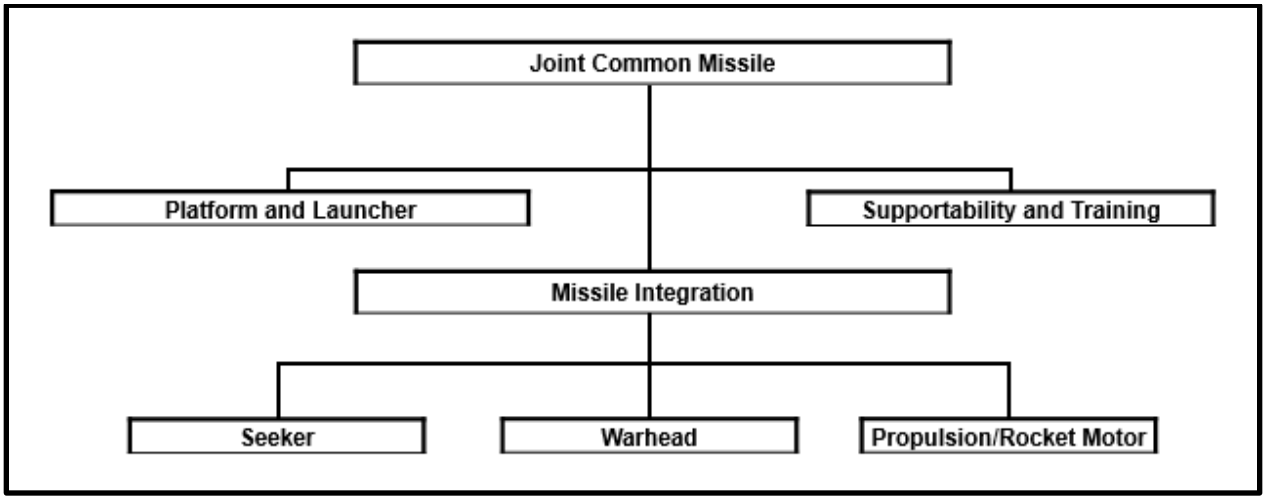
The current program is constructed to support a single block acquisition strategy and will deliver full capability thereafter. The CDD has forecasted Initial Operational Capability (IOC) of the JCM at MS B +5 years (60 months). The EMD phase has been planned for 48 months. Therefore, the significant event estimates are a 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 have determined an AUPC of $108,000 (with multi-year contract vehicle) and $120,000 (without multi-year contract vehicle) by the program office. The program has been incorporated into the services POM and 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 development (P&D) with procurement funding.

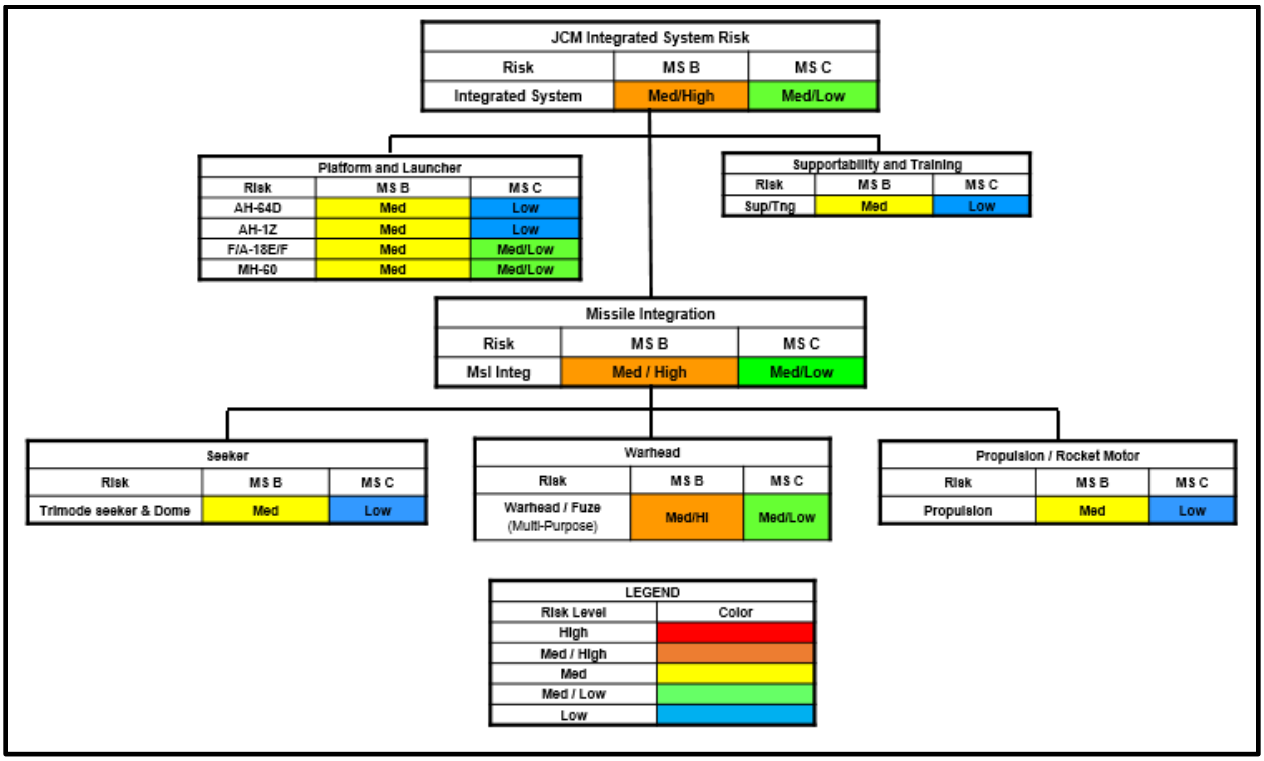
WORK BREAKDOWN STRUCTURE:

The JCM has the following work breakdown structure (WBS) that highlights traceability of requirements to the system design.



RISK ASSESSMENT:

The program's Integrated Product Team (IPT) conducted a thorough risk assessment approved by both the Army and Navy. The following risk assessment (RA) links the critical technology elements of the design with the user requirements. A narrative of risks follows the figure.



Risk 1: Multipurpose Warhead Fuse–The JCM must defeat a wide array of targets (KKP 2). The warhead technology is highly complex because each target requires different engagement mechanisms to achieve the required lethality.

Risk 2: Missile Integration–The tri-mode seeker, multi-purpose warhead, and propulsion system require intensive software synchronization.

Risk 3: Propulsion–The boost and sustain technology requires high turn down ratios to adjust the propulsion nozzle in order to achieve rotary and fixed wing ranges (KKP 3). Most existing platforms have a turn down ratio of 4, but the JCM requires a ratio of 8. In addition, the wide range of environmental conditions between rotary and fixed wing assets is hard to address in a single motor.

Risk 4: Seeker Software–The tri-mode seeker requires integrated hardware and software for real time acquisition and tracking of targets with the three sensors (KKP 1).
Risk 4a: Seeker Dome–The dome must be able to transmit radiation for the radar wave, infrared signature, and laser designation (KPP 1). However, the seeker must prevent radar penetration other radar bands in the operational environment, which complicates the dome design and material usage.

Risk 5: Platform Integration–The missile must integrate with the on-board fire control systems for each of the service platforms (KPP4). In addition, the JCM must be shipboard compatible.

TECHNOLOGY READINESS LEVELS:

The JCM program stakeholders agree that the three most important sub-component technologies are currently assessed at the following readiness levels:

Tri-mode Seeker–TRL 6
Multipurpose Warhead–TRL 6
Common Rocket Motor–TRL 6

ICE and Affordability Assessment:

The Cost Analysis Improvement Group (CAIG) estimated the EMD phase to be from 72 to 144 months.

The CAIG estimated the AUPC as $153,000.

These estimates are based on previous service missile efforts for dual mode seekers. The CAIG independent cost estimate (ICE) raises some affordability concerns based on the draft APB AUPC and execution concerns because of the high likelihood of cost and schedule breaches with the draft APB.

----------END OF PROGRAM DATA----------

SURVEY:

The section below requires you to select cost, schedule, and performance options based off the JCM program data annotated above. Each section addresses different acquisition strategy methods you can choose from. After completing the initial question of acquisition strategy choice (Single Block, Two Increments, Three Increments), you will in turn answer questions corresponding to one of the three sections and justify your position.

What is your Acquisition Strategy for the JCM program based off of the program information provided?

A. Single Block Acquisition Strategy (Section 1)
B. Two Increments: Incremental Acquisition Strategy (Section 2)
C. Three Increments: Incremental Acquisition Strategy (Section 3)

*Upon your selection please complete your designated section ONLY.

SECTION 1: SINGLE BLOCK ACQUISITION

1. Based on the program information, select the length of EMD phase appropriate for your strategy.

A. 48 Months *(Draft APB based on POM)*
B. 72 Months *(Low CAIG ICE Estimate)*
C. 144 months (12 years) *(High CAIG ICE Estimate)*
D. Other (Specify) _____Months

a) Justify your selection.

b) How would you address the high-risk schedule concerns if you select a 48-month EMD phase?

2. Select the program AUPC appropriate for your strategy.

A. $108,000 *(Draft APB based on JCP with Multi-Year Contract)*
B. $120,000 *(Draft APB based on JCP without Multi-Year Contract)*
C. $153,000 *(CAIG ICE estimate)*
D. Other (Specify) $_____

Justify your selection.

3. Based on the requirements, select the capabilities of the JCM that you will develop:

Seeker
- o Single Mode (Commercial Off-The-Shelf [COTS])
- o Dual-Mode
- o Tri-Mode (KPP)

Propulsion
- o Single Motor (COTS)
- o Common Motor (KPP)

Platform Integrated
- o AH-64 (KPP)
- o AH-1Z (KPP)
- o F/A-18 (KPP)
- o UH-60 (KPP)

Warhead
- o Single (COTS)
- o Multi-Purpose (KPP)

If you did not select a KPP, how do you propose to get relief from a directed KPP?

4. How would you address the affordability concerns and the high likelihood of cost and schedule breaches?

SECTION 2: TWO INCREMENTS: INCREMENTAL APPROACH

1. Based on the program information, select the length of EMD phase by increment appropriate for your strategy.

Increment I
A. 48 Months
B. 72 Months
C. 144 Months
D. Other (Specify) _____Months

Increment II
A. 48 Months
B. 72 Months
C. 144 Months
D. Other (Specify) _____Months

Justify your selection.

2. Select the program AUPC appropriate for your strategy.

Increment I
A. $108,000
B. $120,000
C. $153,000
D. Other (Specify) $_____

Justify your selection.

Increment II
A. $108,000
B. $120,000
C. $153,000
D. Other (Specify) $_____

Justify your selection.

3. Based on the requirements, select the capabilities of the JCM that you will develop:

INCREMENT I

Seeker
- o Single Mode (COTS)
- o Dual-Mode
- o Tri-Mode (KPP)

Propulsion
- o Single Motor (COTS)
- o Common Motor (KPP)

Platform Integrated
- o AH-64 (KPP)
- o AH-1Z (KPP)
- o F/A-18 (KPP)
- o UH-60 (KPP

Warhead
- o Single (COTS)
- o Multi-Purpose (KPP)

INCREMENT II

Seeker
- Single Mode (COTS)
- Dual-Mode
- Tri-Mode (KPP)

Propulsion
- Single Motor (COTS)
- Common Motor (KPP)

Platform Integrated
- AH-64 (KPP)
- AH-1Z (KPP)
- F/A-18 (KPP)
- UH-60 (KPP

Warhead
- Single (COTS)
- Multi-Purpose (KPP)

If you did not select a KPP, how do you propose to get relief from a directed KPP?

4. This COA would require a year delay in program start to align requirements and funding, and the current year RDT&E money would be lost. How would you receive service approval to delay MS B, get JROC CDD approval, and realigning the services Program Objective Memorandum (POM) submission and the JCP?

SECTION 3: THREE INCREMENTS: INCREMENTAL APPROACH

1. Based off the program information, select the length of EMD phase by increment appropriate for your strategy.

Increment I
A. 48 Months
B. 72 Months
C. 147 Months
D. Other (Specify) _____Months

Increment II
A. 48 Months
B. 72 Months
C. 147 Months
D. Other (Specify) _____Months

Increment III
A. 48 Months
B. 72 Months
C. 147 Months
D. Other (Specify) _____Months

Justify your selection.

2. Select the program AUPC appropriate for your strategy.

Increment I
A. $108,000
B. $120,000
C. $153,000
D. Other
(Specify) $_____

Increment II
A. $108,000
B. $120,000
C. $153,000
D. Other
(Specify) $_____

Increment III
A. $108,000
B. $120,000
C. $153,000
D. Other
(Specify) $_____

3. Based on the requirements, select the capabilities of the JCM that you will develop:

INCREMENT I

Seeker
- o Single Mode (COTS)
- o Dual-Mode
- o Tri-Mode (KPP)

Propulsion
- o Single Motor (COTS)
- o Common Motor (KPP)

Platform Integrated
- o AH-64 (KPP)
- o AH-1Z (KPP)
- o F/A-18 (KPP)
- o UH-60 (KPP)

Warhead
- o Single (COTS)
- o Multi-Purpose (KPP)

INCREMENT II

Seeker
- Single Mode (COTS)
- Dual-Mode
- Tri-Mode (KPP)

Propulsion
- Single Motor (COTS)
- Common Motor (KPP)

Platform Integrated
- AH-64 (KPP)
- AH-1Z (KPP)
- F/A-18 (KPP)
- UH-60 (KPP)

Warhead
- Single (COTS)
- Multi-Purpose (KPP)

INCREMENT III

Seeker
- Single Mode (COTS)
- Dual-Mode
- Tri-Mode (KPP)

Propulsion
- Single Motor (COTS)
- Common Motor (KPP)

Platform Integrated
- AH-64 (KPP)
- AH-1Z (KPP)
- F/A-18 (KPP)
- UH-60 (KPP)

Warhead
- Single (COTS)
- Multi-Purpose (KPP)

If you did not select a KPP, how do you propose to get relief from a directed KPP?

4. This COA would require a year delay in program start to align requirements and funding, and the current year RDT&E money would be lost. How would you receive service approval to delay MS B, get JROC CDD approval, and realigning the services POM submission and the JCP?

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