2016-12

Unmanned Maritime Systems incremental acquisition approach

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Monterey, California: Naval Postgraduate School

https://hdl.handle.net/10945/51684

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

UNMANNED MARITIME SYSTEMS INCREMENTAL ACQUISITION APPROACH

December 2016

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704–0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** December 2016	**3. REPORT TYPE AND DATES COVERED** MBA professional report	
4. TITLE AND SUBTITLE UNMANNED MARITIME SYSTEMS INCREMENTAL ACQUISITION APPROACH			**5. FUNDING NUMBERS**
6. AUTHOR(S) Thomas Driscoll and Jason Richesin			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB number ____N/A____.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.			**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

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14. SUBJECT TERMS acquisition strategy, Unmanned Maritime Systems			**15. NUMBER OF PAGES** 65
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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UNMANNED MARITIME SYSTEMS INCREMENTAL ACQUISITION APPROACH

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
December 2016

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ABSTRACT

The purpose of this MBA report is to explore and understand the issues involved in the DOD's acquisition process for Unmanned Maritime Systems (UMS) in order to recommend a new acquisition approach or solutions that would allow the military to keep pace with the rapid unmanned technology development cycle found in the commercial industry. We find that current UMS acquisitions are utilizing previous acquisition reforms, but could benefit from additional contractor peer competition and peer review. Additional cost and schedule benefits could result from contractor competition during build processes in each incremental process. We recommend that further analysis be performed to alleviate funding issues associated with evolutionary acquisition.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAP	Abbreviated Acquisition Program
ACAT	Acquisition Category
AOA	Analysis of Alternatives
AOR	Area of Responsibility
APB	Acquisition Program Baseline
ARCI	Acoustic Rapid COTS Insertion
AUV	Autonomous Underwater Vehicle
C4ISR	Naval Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAE	Component Acquisition Executive
CAIV	Cost as an Independent Variable
CDD	Capabilities Development Document
CIO	Chief Information Officer
COIN	Common Operator Interface Navy-EOD
COTS	Commercial off-the-Shelf
DAPA	Defense Acquisition Performance Assessment
DAS	Department of Defense Acquisition System
DAU	Defense Acquisition University
DAWIA	Defense Acquisition Workforce Improvement Act
DOD	Department Of Defense
DRI	Defense Reform Initiative
DSB	Defense Science Board
EXM	Expeditionary Missions
FDD	Full Development Decision
GIG-ES	Global Information Grid Enterprise Services
HASC	House Armed Services Committee
ICD	Initial Capabilities Document
INP	Innovative Naval Prototypes
IP	Intellectual Property
IPOE	Intelligence Preparation of the Operational Environment

IPPD	Integrated Product and Process Development
IPTs	Integrated Product Teams
ISR	Intelligence, Surveillance and Reconnaissance
JCIDS	Joint Capabilities Integration and Development System
JCS	Joint Chiefs of Staff
JUON	Joint Urgent Operational Needs
LBS	Littoral Battlespace Sensing
LBSF&I	Littoral Battlespace Sensing, Fusion and Integration
LDUUV	Large Displacement Unmanned Undersea Vehicle
LRIP	Low-Rate Initial production
MCM	Mine Countermeasures Missions
MDA	Milestone Decision Authority
MDAP’s	Major Defense Acquisition Programs
METOC	Joint Meteorological & Oceanographic
MHLD	Maritime Homeland Defense
MK-18 Mod	1Man-Portable Unmanned underwater vehicle
MK-18 Mod 2	Light-Weight Unmanned Underwater Vehicle
MOSA	Modular Open Systems Approach
NUWC	Naval Undersea Warfare Command
OEM	Original Equipment Manufacturer
OIF	Operation Iraqi Freedom
ONR	Office of Naval Research
OPNAV	Office of the Chief of Naval Operations
OT&E	Operational Test and Evaluation
PEO LCS	Program Executive Office Littoral Combat Ships
PMW	Program Manager Warfare
POR	Program of Record
PPBE	Planning, Programming, Budgeting, and Execution
REMUS	Hydroid’s Remote Environmental Measuring Units
RFP	Request for Proposal
RHIB	Rigid-Hull Inflatable Boat
SOS	System of System’s

SOW	Statement of Work
SRD	System Requirements Document
TDA	Tactical Decision Aid
UAS	Unmanned Aircraft Systems
UGS	Unmanned Ground Systems
UMS	Unmanned Maritime Systems
UMV	Unmanned Maritime Vehicles
USD AT&L	Undersecretary of Defense for Acquisition, Technology, and Logistics
USV	Unmanned Surface Vehicles
UUV	Unmanned Underwater Vehicles
VSW	Very Shallow Water

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ACKNOWLEDGEMENTS

We would like to thank and acknowledge Rear Admiral (Ret) Richard Williams for his guidance and direction of our MBA project. Without his introduction and continued networking in the unmanned systems field this project would not have been possible.

We would also like to thank the acquisition professionals at the Explosive Ordinance Disposal Program Management Office (PMS 408), the Battlespace Awareness and Information Operations Program Management Operations (PMW 120), and the Unmanned Maritime Systems Program Office (PMS 406). The knowledge and resources provided concerning the unmanned systems researched were invaluable to the completion of this project.

We would especially like to thank our advisors, Professor Chad Seagren and Colonel (Ret) Ray Jones, for their dedication and professionalism throughout this process.

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I. INTRODUCTION

A. UNMANNED MARITIME VEHICLE ACQUISITION WITHIN THE DEPARTMENT OF THE NAVY

Today's warfighter can employ a vast array of unmanned systems for on-field advantage. In many cases, the Joint Urgent Operational Needs (JUONs) process allowed these systems to be quickly developed and employed. While this process made the systems more readily deployable, a consequence is that some of these programs have not undergone a thorough requirements review and coordination through the normal Joint Capabilities Integration and Development System (JCIDS) process.

The Unmanned Systems Integrated Roadmap describes the full range of unmanned systems operated by the DOD, specifically that unmanned maritime systems (UMS) are divided into unmanned underwater vehicles (UUVs) and unmanned surface vehicles (USVs), collectively known as unmanned maritime vehicles (UMVs) (Department of Defense [DOD], 2011).

The Navy currently has a number of UMS that perform a variety of missions including mine countermeasures, maritime security, hydrographic surveying, environmental analysis, special operations, and oceanographic research (see Figure 1) (DOD, 2011). The acquisition and subsequent delivery to the combatant commander requires an acquisition strategy that can keep up with the pace of technology development as well as capability requirements.

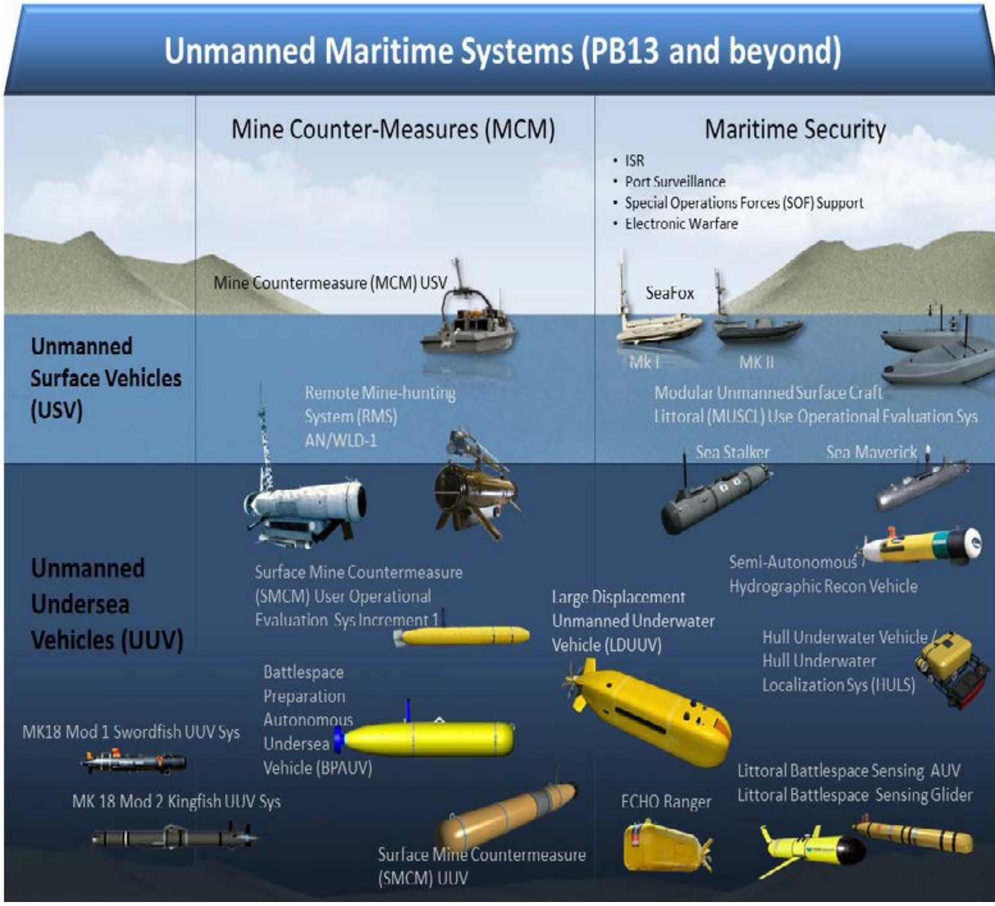

Figure 1. Unmanned Maritime System Integration. Source: DOD (2011).

B. PROBLEM STATEMENT

This thesis seeks to address the DOD's process for acquiring new UMS, which has been unable to keep pace with commercial technology production. This is a problem because as the UMS acquisition cycle time increases when projects become Programs of Record (POR), as does cost. It appears the added bureaucracy of becoming a POR delays the delivery of the most current capabilities to the combatant commander. As a result of bureaucratic barriers, newer and potentially better technologies could become available first in the commercial industry and perhaps even to our adversaries.

We propose that the reduced lifecycles of UMS compared to conventional weapons systems, as well as the increased technology refresh rate, places the UMS spectrum of weapons systems on the cusp of the conventional acquisition process. A fresh approach to UMS acquisitions would be beneficial.

C. RESEARCH QUESTION

Which aspects of evolutionary acquisition should be included for UMS type acquisition programs to benefit from incremental, iterative acquisition models?

D. PURPOSE STATEMENT

The purpose of this thesis is to explore and understand the issues involved in the DOD's acquisition process for UMS weapons systems in order to recommend a new acquisition approach or solutions that would allow the military to keep pace with the rapid unmanned technology development cycle found in the commercial industry. This study is important because the DOD increasingly depends on unmanned systems in the undersea spectrum of warfare and the ability to refresh the capabilities, through a defined acquisition approach, provided by these systems is paramount. UMS provide the military with a competitive advantage in achieving dominance in the current and future undersea domain.

E. POTENTIAL BENEFITS

In this thesis, we present a better understanding of the problems within the DOD's acquisition system and offer feasible solutions or recommendations for resolving requirements for systems that are not a direct fit for the current acquisition model. This thesis contributes to the DOD's efforts in resolving the issues that continue to undermine rapidly evolving technology acquisition. The full range of DOD acquisition stakeholders could benefit from this research it explores new approaches to the acquisition process.

F. RESEARCH METHODOLOGY

Nearly a decade ago, the need for a more streamlined approach to the DOD acquisition process became apparent in an attempt to quickly field evolving technologies. This thesis conducts an in-depth review of previous research, current program documents and discussions with subject matter experts in the acquisition of UUVs in an attempt to provide recommendations tailored for the acquisition of quickly evolving UMS weapons systems.

G. BACKGROUND

To aid the understanding of the UMS acquisition issue, the remainder of this chapter presents an overview of the UMS systems and their acquisition associated history.

1. MK-18 Mod 2 "Kingfish"

The MK-18 Mod 2 was born out of the MK-18 Mod 1 program, so an overview of the MK-18 Mod 1 is warranted. The MK-18 Mod 1 "Swordfish" is an UUV that is based on the Hydroid Remote Environmental Monitoring System (REMUS) 100 platform (see Figure 2). The MK-18 Mod 1 is a "man-portable" vehicle that proved the viability of UUV operations during the outset of Operation Iraqi Freedom (OIF) by clearing large areas of the littoral battlespace in mainly the very shallow water region 10'-40', (see Figure 3) and some parts of the shallow water region (Ervin, Madden, & Pollitt, 2014).

Figure 2. Mk-18 Mod 1 and Mod 2. Source: Ervin et al. (2014).

The increased endurance and autonomy of the UUV enabled the compression of timelines for operations at the start of OIF. The size and weight restrictions that increased the portability of the Swordfish also limited the endurance and capability with regards to power generation in support of sensors. An evolution of the system to the MK-18 Mod 2 “Kingfish” was a simple matter of scaling. A side by side comparison is shown (see Figure 2).

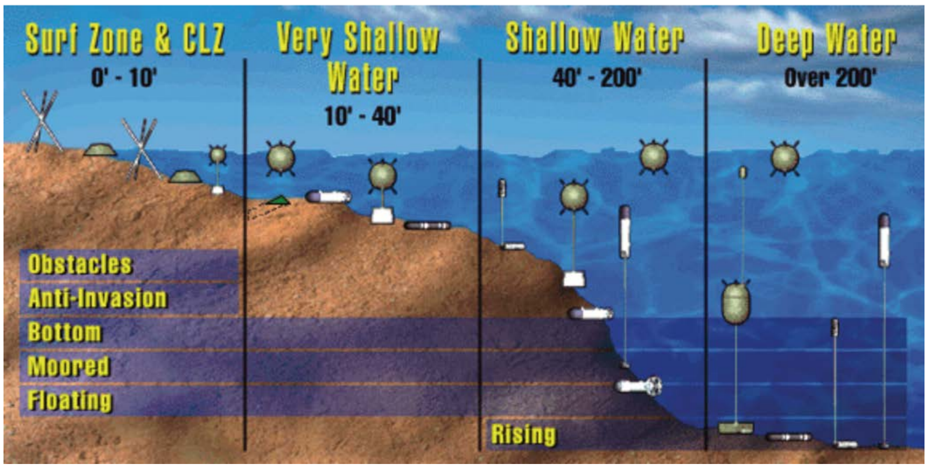

Figure 3. Description of Littoral Areas. Source: Ervin et al. (2014).

The MK 18 Mod 2 “Kingfish” is a larger version of the MK-18 Mod 1. The 21” diameter of the MK-18 Mod 2 technically places it in the “heavyweight” UUV category, but it is still deployable from an 11 meter rigid-hull inflatable boat (RHIB). The MK 18 program is managed by SEA 06 – Expeditionary Missions (EXM) MCM Program Office (PMS 408). The system itself is a variant of the original equipment manufacturer (OEM) Hydroid’s Remote Environmental Measuring Units (REMUS) 600 platform. This commercial off-the-shelf (COTS) vehicle has been adapted and upgraded for the MCM mission. This single-screw vehicle is 11.5 feet long, 12.75 inches in diameter, and weighs roughly 600 pounds. Primary mission areas for this system include intelligence preparation of the operational environment (IPOE), integrated fleet MCM, very shallow water (VSW) MCM, expeditionary port and harbor clearance operations, Maritime Homeland Defense (MHLD) response, and salvage operations support (Office of the Chief of Naval Operations [OPNAV] Programming [N80], 2015). The MK-18 Mod 2 falls outside of the traditional acquisition framework due to the request from Command Fifth Fleet (C5F) for additional expeditionary underwater MCM capabilities. The "Fast Lane" program was established and funded by the Office of Secretary of Defense (OSD) to get the capabilities provided by the MK-18 Mod 2 into theatre as quickly as possible. The "Fast-Lane process worked and seven months later the first wave of MK-18 Mod 2s arrived in theatre (Ervin et al., 2014).

The contractor provided a very large majority of maintenance and operator support for the UUVs both in and outside of the theatre and was also contracted for providing training to Navy EOD personnel. As the program matures more military personnel will assume operator and maintenance responsibilities, but contractor support is intended to shoulder a large portion of the maintenance and technology integration (Team UMS Cohort 311-1430, 2016). The MK-18 Mod 2 began as an Abbreviated Acquisition Program (AAP) and is transitioning to an ACAT-IVM POR.

2. The Littoral Battlespace Sensing AUV

The Littoral Battlespace Sensing (LBS) AUV is another system that has been developed from the Hydroid REMUS 600 platform. The LBS-AUV operates in conjunction with the LBS Gliders, built by Teledyne Brown Engineering, Inc. to comprise a completely integrated System of Systems (SoS) coined the Littoral Battlespace Sensing, Fusion and Integration (LBSF&I). While the LBS-AUV is a short duration autonomous vehicle, the LBS Glider is designed for longer durations of up to 30 days from a lithium battery to ensure long-term data collection and subsequent transmission.

The integration envisioned is summarized in the LBS AUV Statement of Work (SOW). The end result will be the collection of environmental data from the sea floor to the atmosphere, which will subsequently be transmitted to METOC data sites and fused. The collection, fusion, and automatic preparation of data will allow actionable and relevant information to the warfighter at the tactical as well as the strategic levels of war. These products are then integrated into Naval Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) and Tactical

Decision Aid (TDA) systems as part of the Global Information Grid Enterprise Services (GIG-ES)/FORCEnet infrastructure (PMW 120, 2010).

The MK-18 Mod 2 is designed as a standalone system deployed for specific missions and then subsequently recovered by a small detachment aboard a RHIB. The LBS-AUV is designed for a broader spectrum of missions and intentionally designed to be easily adaptable for a variety of future missions, as well as intentionally designed to be integrated into a networked SoS. While both of these programs are developed from the same commercial sole sourced platform, the REMUS 600, they were contracted for very different purposes.

3. Large Displacement Unmanned Undersea Vehicle (LDUUV)

Newest and largest of the UMS in development, the LDUUV shown (see Figure 4) has taken a decidedly different path to development. The 2004 UUV Master Plan laid out a vision for the modularity of the vehicle to increase as the size of the vehicle increased. This is realized in the desired end-state of the LDUUV. The LDUUV is a developmental large-displacement unmanned undersea vehicle. It will provide a new range of capabilities and longer range due to the larger size. The Program Executive Office Littoral Combat Ship (PEO LCS, 2015) states, “The system is being designed for intelligence, surveillance and mine countermeasure missions, and is based on a modular, open architecture that will allow the Navy to incrementally develop new mission sets for the craft” (para. 3). The Office of Naval Research (ONR) is designing the LDUUV to be the “truck” and allow the modularity of the vehicle to lend itself to packages that can be quickly interchanged. The packages can be exchanged as needed for a full spectrum of missions, and can advance with the maturation of technologies still in development. The LDUUV will be able to be employed by multiple-host platforms, to include submarines utilizing the Virginia Payload Module and the Ohio-class guided-missile submarines. The Unmanned Maritime Systems Program Office (PMS-406) which is part of the PEO LCS is developing the LDUUV (PEO LCS, 2015).

Figure 4. LDUUV at Sea-Air-Space Exposition, 2015

One unusual aspect of the LDUUV is the departure from the standard acquisition process. According to Naval Drones (2015), in 2012 ONR awarded Hydroid, the maker of the MK-18 series, a sole source $5.9 million contract to develop technologies for energy systems, littoral autonomy, and endurance. In 2012 and 2013, ONR awarded other multi-million dollar contracts to aid the development of fuel cell technologies, autonomy, and mission planning software to a variety of companies (Naval Drones, 2015).

Naval Drones (2015) reported on the turbulent history of the LDUUV. In 2014, a Milestone A decision for the LDUUV was reached and the program was granted authority to move to the next phase of development. Following the Milestone A decision, a Request for Proposal (RFP) was released in preparation for a classified "industry day" for future development. The change in the LDUUV's acquisition strategy came in March of 2016 when NAVSEA stated it would no longer solicit proposals from industry, but that Naval Undersea Warfare Command (NUWC) would lead the design and fabrication of the LDUUV prototypes (Naval Drones, 2015).

H. ORGANIZATION OF THESIS

After this introduction, chapter II consists of a thorough literature review of the acquisition research conducted since 2009: government reports, academic papers, and proposed strategies for reforming the UMS acquisition system. Chapter III discusses acquisition reform efforts and current UMS acquisition systems. Chapter IV presents an analysis of both benefits and shortfalls of the current UMS acquisition process and looks at other potential solutions, offering a recommended approach to UMS acquisition. Finally, Chapter V closes the study with findings and recommendations, and conclusion.

I. CHAPTER SUMMARY

Chapter I discussed the background of three UUV programs and their differing acquisition models. The MK-18 MOD 2, which is focused on the mine countermeasure aspect of undersea warfare, has perhaps the most unique history with being rapidly placed in operation with the "Fast-Lane" initiative and the program's subsequent recovery from this accelerated process to becoming an ACAT-IVM POR.

The LBS-AUV is being designed from an SoS approach and interacts with the LBS-Gliders to collect and transmit data that is actionable to warfighters at the highest levels. The LBS-AUV, also based off the REMUS 600, has piggybacked off the operational fielding of the MK-18 Mod 2 is an ACAT-IVM program being tested in operational environments. The LDUUV is still in the prototype stage and is taking a different approach with its acquisition strategy in that the ONR has chosen to maintain the role as primary integrator. The three different programs are part of the UMS family, but all three are striving to become operational through different navigation of the acquisition process.

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II. LITERATURE REVIEW

Many references are available regarding the Department of Defense Acquisition system (DAS). The DAS is responsible for the supervision of the technological, programmatic and product support investment in support of the Department of Defense (DOD) (Under Secretary of Defense for Acquisition, Technology, and Logistics [USD (AT&L)], 2007). The objective of the DAS is to acquire products that measurably improve mission capability while satisfying the needs of the end user (USD [AT&L]), 2007). The Joint Capabilities Integration and Development System (JCIDS), under the auspices of the Chairman of the Joint Chiefs of Staff (JCS), employs a systematic method. The Defense Acquisition University (2013) states that JCIDS was established, "for identifying, assessing, and prioritizing gaps in joint warfighting capabilities and recommending potential solution approaches to resolve these differences" (Defense Acquisition University [DAU], 2013, p. 6). Through this process, the JCIDS develops an Initial Capabilities Document (ICD) that is published to support the material development process.

The undersea domain is a warfare spectrum in which technological innovation and its acquisition plays an important role. This chapter provides an in-depth insight into the biggest problems surrounding UMS acquisition within the DOD. The key issues include: long developmental timelines, testing and evaluation problems, acquisition workforce, legislative impediment, oversight requirements, funding issues, and management problems. This chapter will provide a detailed text on these challenges that will compel the reader to explore possible remedies presented in the proceeding chapters.

A. ISSUES WITHIN THE DOD ACQUISITION SYSTEM

As earlier indicated, this chapter will address the problems, bottlenecks, and discontinuities within the system. To achieve this objective, this review will analyze the Packard Commission (1986) and Goldwater Nichols Act of 1986 and highlight other pivotal items concerning DOD acquisitions.

1. 1986 Packard Commission

In their article (Christensen, Searle, & Vickerey, 2015) explain that even with best intentions, administrative and regulatory implementation have failed to deliver the improvements the acquisition community has been seeking for more than three decades. The Packard Commission was created by Executive Order 12526 and commissioned by President Reagan to facilitate the study of a broad range of areas of management functionality within the DOD (Christensen et al., 2015). The 1986 Packard Commission was aimed at reducing inefficiencies in the procurement of defense systems. Despite the fact that the commission examined the management of defense practices, it placed an emphasis on the acquisition process. The commission concluded that the key problems with most acquisition processes had been identified previously: performance shortfalls, schedule delays, and cost growth (Christensen et al., 2015). The commission recommended simplifying the acquisition process, improving the planning process, prototyping, and testing. Changing the culture and adopting the competitive firm model were also recommended.

2. Goldwater–Nichols Department of the Defense Reorganization Act of 1986

Some of the most revolutionizing changes made to the DOD, since the 1947 National Security Act, came from the Goldwater–Nichols Act of 1986. It made the most significant changes to the DOD since the department's establishment in 1947. The Goldwater–Nichols Act built on the Packard Commission and restructured the U.S. military's command structure, placing the Joint Chiefs of Staff and combatant commanders in a more direct line with the President. The service chiefs' new role became primarily to train and equip their forces for employment by the combatant commanders and to act as advisors to the SECDEF and President. In total, the act reduced bureaucratic redundancy and streamlined interoperability between the military components.

3. Better Buying Power

In his article, The Honorable Frank Kendall (2014) defined Better Buying Power (BBP) as the implementation of the best practices with an aim of strengthening DOD's buying power, providing an affordable military capability to the Warfighter at a value, as well as improving industry productivity. Launched in the year 2010, Better Buying Power comprised a set of significant principles of acquisition towards the achievement of efficiencies by controlling cost, affordability, the elimination of bureaucracy, and promoting competition. Better Buying Power initiatives help in incentivizing innovation as well as productivity in government and industry, and improving tradecraft in the acquisition of services.

4. Joint Capabilities Integration and Development System (JCIDS)

A capabilities-based approach is how the Department of the Navy (DON) determines acquisition programs. SECNAVINST 5000.2E directs the roles and responsibilities as well as the processes to be used. The DON utilizes multiple processes that meld well with the joint process of JCIDS that is the formal DOD procedure (Office of the Secretary of the Navy [SECNAV], 2011). JCIDS evolved out of a previous process that allowed services to specify requirements. The JCIDS moves the requirement generation and validation to the Joint Chiefs of Staff. The capabilities and requirements delineated in this process aims to ensure the future needs of all four services are met.

5. Defense Science Board Task Force on DOD Policies and Procedures for Acquisition of UMS

The Defense Acquisition System (DAS) is structured to accomplish the National Security Strategy and support the DOD. The acquisition strategy of the DOD is targeted to provide for the current forces, but also the forces in the near and distant future. The primary purpose of DOD procurement is to support the end users. The support will continue to provide improved capabilities and support at a reasonable cost (USD[AT&L], 2007).

In accordance with the House Armed Services Committee (HASC, 2010) report, the acquisition of weapon systems has, over the years, placed an emphasis on the incorporation of technology into capital-intensive programs. These large technology dependent weapons systems result in remarkably long cycles of development. With respect to this view, it is worth noting that the burden of developing cutting edge technology will require the integration and development of an extended technology. Without the investment of large amounts of capital the desired requirements will not be met and the opportunity to develop and achieve them will be missed. As a result, the development cycle spurs competition, which leads to the creation of unneeded requirements on systems to reap scarce resources.

6. House Armed Services Committee Panel on Defense Acquisition Reform Findings and Recommendations

DOD acquisition efforts often focus on state-of-the art systems and system of systems. Capital equipment such as naval ships, aircraft, and vehicles are the primary cost drivers of weapon systems acquisition costs. These high-tech ambitions create an acquisition environment that demands lengthy technological development and integration. End users are savvy to the process involving capital-intensive systems and recognize requirement identification is a must in the beginning or risk losing capabilities on a piece of equipment. The HASC report identified cycles caused by the acquisition process with “two dynamics form a feedback loop wherein the pressure to enhance requirements extends development cycles and consumes resources, which increases the competition for resources, which increases the pressure to include additional requirements on systems in line to receive those scarce resources” (HASC, 2010, p. 7).

The problems noted in these documents therefore affect the metrics of any acquisition procedure—namely, cost, performance and schedule. These issues of UMS acquisition fall under five problem areas or groups: workforce and management, oversight, funding and requirements, testing, and extended timelines

a. Concerns within the Acquisition Workforce and Management

The DOD Acquisition Workforce is tasked with procuring systems and services to meet military requirements within stipulated timelines to satisfy national security objectives (National Research Council [NRC], 2010). This UMS acquisition community comprises many professional disciplines such as contracting officer, auditor, program management, test and evaluation, and UMS acquisition personnel. The workforce, therefore, requires highly qualified personnel, particularly in the fields of science, undersea warfare, engineering, testing, business, and program management. However, studies have indicated the existence of insufficient technical proficiency in the acquisition workforce and its future status due to relatively few personnel having the required expertise (NRC, 2010).

Defense Science Board (DSB) (DOD, 2009) identifies the issues of cost, schedule and performance were due to deficiencies in the acquisition workforce. The workforce leadership lacked understanding, experience and had inadequate exposure to the acquisition processes. Many of the issues were caused from the complex bureaucratic processes where many unaccountable people must give approval before authority to proceed is granted. The major issue, however, was the lack of experience in the acquisition profession.

Leadership is a key requirement, in addition to specific and extensive technical knowledge, when developing, implementing, and managing the acquisition process of UMS systems. These requirements are paramount at the DOD level, and the Services, to give the managers the ability to provide oversight and decision-making at different milestones (DOD, 2009). The deficiency in requisite knowledge and skills in UMS acquisition is mainly due to lack of trained staff in the acquisition community. According to the DSB (2009), concern for the viability of a continued stream of home grown engineering and science students is elevating into a national security problem (DSB, 2009).

Acquisition personnel need experience, and that takes time. Frank Kendall (2012) stated that at the end of the day the capability of a workforce and professionalism and how they are supported significantly affect the acquisition results. In addition, Frank Kendall (2012) confirmed that when an organization develops its program managers, chief managers, workforce, the logistic specialist, and the private support staff, they may not have a shortfall at any given time. In contrast a shortfall of these key individuals will result in a very long recovery time for correcting errors (Fryer-Biggs, 2012).

Historically, and still today, DOD agencies have had to govern complex roles and responsibilities regarding the management of the acquisition system (DSB, 2009). This may occur because authority in the DOD is contained in several different organizations, which reduces coordination and/or synchronization. Even though the Secretary of Defense for Acquisition, Technology, and Logistics USD (AT&L) seems to maintain control over acquisition, the Secretary of Defense has many on his staff that contribute to the decision process. These agencies serve separate functions and provide different services within the DOD. According to Congress, these offices were often not aligned and it is unclear if these organizations are serving with a common focus toward improving the acquisition process (DSB, 2009).

b. Issues in Oversight

Supervisors throughout the DOD are in place in order to lead and manage complex systems and organizations; this holds true for the acquisition community as well (NRC, 2010). Many entities throughout the government exercise oversight processes. These entities may consist of acquisition officials, DOD, and even Congress. The role Congress plays in the acquisition process is by the authorization and appropriation of funds and enacting laws that govern procurement. Each party can produce demands on the acquisition process during their oversight. With multiple oversight bodies monitoring and reviewing the program, the acquisition system gives additional attention to parties that often are not stakeholders (e.g., end users) in the process (NRC, 2010). This instability can have tremendous effects on the program.

Too much oversight can delay or obstruct the acquisition of UMS. In 2009 the Defense Acquisition Performance Assessment Panel stated, "Current governance structure does not promote program success—actually, programs advance in spite of the oversight process rather than because of it" (DSB, 2009, pg. 59). Monitoring is intended to be beneficial, yet some controlling bodies are so burdensome that they delay programs and actually increase the likelihood of failure (Gilligan, Heitkamp, & McCoy, 2009).

c. Requirements and Funding Issues

The most important part of the acquisition process, requirements determination, outlines end user needs and expectations and sets in place the purpose and outline of the acquisition program. Requirements can be described as either essential requirements (Big-R) or detailed requirements (Small-r). The “Big-R” requirements are a broader range of understood capabilities and the product expected from employing those capabilities (NRC, 2010). In contrast, “Small-r” requirements are more detailed and focus on specifics for the user and their utilities and interfaces required. Needs such as the ability to prioritize logistics requests based on time or unit (NRC, 2010). Essential and detailed requirements have equal priority and can cause issues within the acquisition process.

Problems involving conditions lengthen the UMS acquisition process. As illustrated previously, too many specific requirements placed on UMS acquisition programs by multiple parties can cause friction in the process. Further, the requirements specified often contain poor or incorrect descriptions of the end user needs. These inaccuracies in the requirements cause issues when the budget has been authorized, yet a new need or requirement is discovered. The current process is also inflexible and vulnerable to over-specification of requirements.

Another concern closely related to conditions is contained in the funding process for UMS acquisition. The acquisition process typically takes years and does not support a suitable solution that is needed for short lifecycle and high technology turnover systems such as the AUV/UUV. The DOD’s Planning, Programming, Budgeting, and Execution (PPBE) system is the source of the problem, yet is a necessary evil. The budgeting process begins two years in advance due to the complex requirements to receive authorization and appropriation of funding from Congress. The PPBE process offers little in the way of flexibility.

d. Issues in Testing and Evaluation

DOD 5000.01 stresses that the integration of the evaluation and testing is a priority throughout the acquisition process. However, in traditional acquisition process, key stakeholders are required to understand the depth and breadth of testing requirements in an effort to ensure testing requirements are necessary and meet the full spectrum of needs. Testing issues are often identified too late in traditional acquisition practices. Programs involving new technology rely heavily on user feedback. These reviews from the end user can be interpreted and incorporated in the form of new elements or better design. Continuous testing can actually decrease development time by reducing redesign once problems are discovered. Also, unnecessary testing can cost time, money, and cause delays. In reference to COTS technologies, they are not tested effectively, overly tailored, and unduly delayed, according to the National Research Council (NRC, 2010).

e. Problems Due to Long Acquisition Lifecycles

DOD systems are not as timely despite the rate of advancement in automation, which strains the acquisition processes (DSB, 2009). Notwithstanding, military operations are requiring a more direct path into theater (DSB, 2009). The DOD utilizes an acquisition process that involves disjointed parts and processes prone to errors that are unnecessary for UMS acquisition. One major point of failure can occur at milestone decision points. Milestones are critical junctures in every acquisition program where a program must be approved at multiple levels of bureaucracy. The process has a great potential to stall at milestone decision points. The review process for a major decision point can take up to 90 days (DSB, 2009). These delays differentiate the existing process from commercial best practices (Gansler & Lucyshyn, 2012).

B. ACQUISITION REFORMS: 1980S TO PRESENT

There have been issues in the DOD acquisition system for great length of time, and both the DOD and congress have acknowledged the need for reform as evidenced by number of commissions and legislative acts that have occurred. The Packard Commission and Blue Ribbon Commission, as well as many other studies, have informed the DOD of the shortcomings of the acquisition system. These two prominent commissions and the other studies have initiated changes to policy and process. Technology advancement in the commercial sector has been a key driving factor in acquisition reform (Burch-Bynum, 2013).

As Allen and Eide explain in their 2012 journal article, acquisition reform in the early 1980s occurred due to fraud, waste, and abuse. The authors further explain that the Blue Ribbon Commission responded to these issues with new legislation that included the Goldwater-Nichols DOD Reorganization Act of 1986. In regard to DOD, the Blue Ribbon Commission found that diluted authority of execution existed within the Department, so a major restructuring ensued as a result of the Goldwater-Nichols Act to include the creation of the Office of the Under Secretary of Defense for Acquisition (Allen & Eide, 2012).

The Blue Ribbon Commission introduced further reform recommendations that changed how the DOD conducted business, commercialized its procedures, and viewed its human capital. The Defense Acquisition Workforce Improvement Act (DAWIA) of 1990 was created to improve the quality of the acquisition workforce. DAWIA established requirements for education along with career paths for the acquisition workforce. Further, program execution would now be managed by Integrated Product Teams (IPTs) using the process of Integrated Product and Process Development (IPPD) and the strategy of Cost as an Independent Variable (CAIV) utilized to limit the growth of associated costs (Allen & Eide, 2012).

The 1990s continued the reform efforts with: The Federal Acquisition Streamlining Act of 1994, the Clinger Cohen Act of 1996, and the 1996 change to the Brooks Act of 1965. The Federal Streamlining Act made commercial, off-the-shelf products more readily available to government users (Allen & Eide, 2012). In 1996, there was a significant change to the 1965 Brooks Act regarding information technology which has a short lifecycle and rapid technological refresh rate—much like the UMS of today.

Ultimately, the Federal Streamlining Act and the Clinger Cohen Act improved acquisition outcomes by reducing government barriers to the procurement process and encouraging commercial innovation (Allen & Eide, 2012). In 1997, Secretary of Defense

William Cohen created the Defense Reform Initiative (DRI). The DRI espoused adopting commercial methods of business, maximizing synergy by eliminating redundancy, reducing costs and improving quality through competition, and eliminating excess structures in order to free resources (Allen & Eide, 2012). The DOD acquisition community adopted a more business mindset to fixing acquisition issues, which carried over into the next century.

The DOD continued to revolutionize the way it conducted business with the move to net-centric operations in the early 2000s. The USD (AT&L) Jacques Gansler had a great deal of significance on this revolution which persists to the present day. Gansler utilized the lessons learned from the Congressional studies and sought to change acquisitions for the long-term. The new direction wanted to reduce development times for new weapons systems, reduce costs, and realize savings through efficiencies and maximizing flexibility with appropriately sized infrastructure and workforce (Gansler, 2000). Gansler sought to introduce training of the acquisition workforce in commercial business practices, place cost and schedule above performance, and integrate the uniformed personnel of the military with their civilian counterparts (Allen & Eide, 2012). These priorities did not have UMS in mind, but they related to UMS too. Secretary of Defense Rumsfeld believed that network-centric capabilities were more important to future conflict than the traditional legacy systems (Adler, 2007). Secretary of Defense Rumsfeld strived for the DOD to seek innovative solutions from nontraditional defense industries.

The DOD and Congress began to question the acquisition system by 2005 and felt the acquisition system was not working as desired, even with all of the recent reforms (Kadish, Abbott, Cappuccio, Hawley, Kern, & Kozlowski, 2006). Due to this lack of confidence in the system, the Defense Acquisition Performance Assessment (DAPA) Project was created. In 2006, DAPA conducted an overall assessment of the entire acquisition process. One of the major findings was that complexity and the extent of the oversight were affecting schedule and cost (Allen & Eide, 2012). The additional laws and regulations, while intended to aid the process, actually made it more cumbersome and costly. The NDAAs of 2005, 2007, and 2009 held too many ambiguities and actually stifled innovation and flexible responses instead of creating it. The same ambiguities actually led to more structure, documentation and subsequent cost increases (Gansler & Lucyshyn, 2012). Goldwater-Nichols, Clinger Cohen and the federal laws that resulted complicated the acquisition process and caused redundancies between the USD (AT&L), the Department's CIO, and the Deputy Chief Management Officer.

Since 2008 more acquisition reform initiatives have been instituted; however, some were not thorough enough in terms of allowing the flexible structure needed for UMS acquisitions. Secretary of Defense Robert Gates began his own version of needed acquisition reform by completing an overhaul of the DOD's approach to acquisition (Gates, 2009). Gates illustrated that in the face of budget reductions and diminishing economic resources, further shifts were needed in the acquisition community. Program managers must be able to cut failing programs as needed, requirements must be carefully evaluated to avoid overruns in schedule and cost, and proper staffing for oversight was required. Cost estimates needed to be more realistic, and to ensure stability in the programs the budgets must be protected (Allen & Eide, 2012).

The road to acquisition reforms within the federal government and the DOD began nearly 30 years ago and much has been done to identify the problems, implement solutions, and execute reform actions. Most reform efforts appear to initiate a return to the conclusion that more reform is needed. It is necessary to turn our attention to the current acquisition process and how it has been affected by these latest reform efforts (Burch-Bynum, 2013).

C. THE PRESENT DEFENSE ACQUISITION SYSTEM (DAS)

The DAS is published in DOD's 5000 Series, DODD 5000.01 and DODI 5000.02. The management of the DOD system is a complex synchronization between three interdependent processes: requirements, budgets, and procurements (Gansler & Lucyshyn, 2012). These three processes are meant to operate separately and together in order to meet DOD objectives. The requirements for an acquisition program are defined in the JCIDS. This process also enables evaluation criteria for the program. The budgeting process allocates and manages the funds that congress authorizes for the development and procurement of acquisition programs. The DAS is the final step in the acquisition process and is the actual procurement process utilized to provide material capabilities to the end user (Chairman of the Joint Chiefs of Staff [CJCS], 2015). In order to achieve a successful program all three aspects of the process must be fulfilled in total.

Major Defense Acquisition Programs (MDAPs) must follow the DAS framework over each program's lifespan, from planning through maintenance (GAO, 2013). Five lifecycle phases (Figure 5) including five decision points give the process its basic structure. Milestones A, B, and C are three key review points at development stages, while another decision point occurs at the onset, or materiel development decision, and near the end of the lifecycle with the decision to initiate full deployment of the project (indicated in Figure 5 by white triangles) (Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics [USD(AT&L)], 2015a). The materiel development decision provides officials authority to conduct an Analyses of Alternatives (AoA). The AoA assesses potential solutions that can satisfy the program's requirements. The Full Deployment Decision (FDD) is the last step that enables the deployment of the program (GAO, 2013). For programs that are required to use this framework, the milestone decision authority (MDA) will either be the USD (AT&L); the DOD component head; a component acquisition executive (CAE); or when authorized, a designee (USD[AT&L], 2015a).

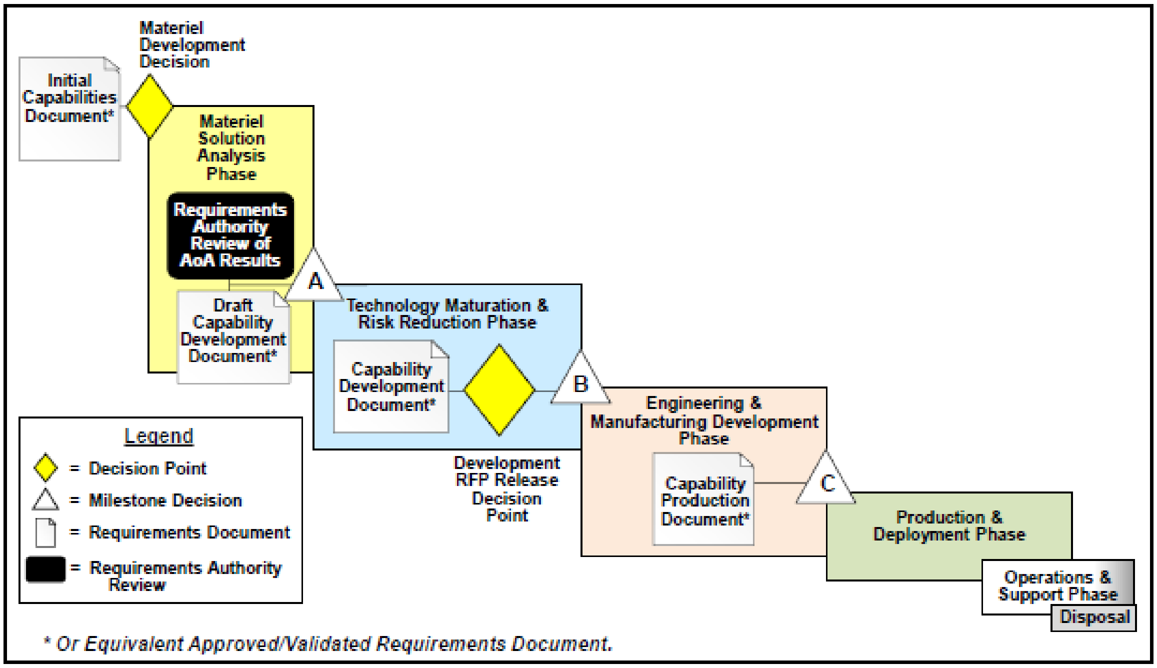

Figure 5. Illustration of the Interaction between the Capability Requirements Process and the Acquisition Process. Source: USD(AT&L) (2015a).

The Defense Acquisition Framework consists of the following phases as depicted in Figure 5:

- Materiel Solution Analysis: Refine the initial system solution (concept); and to create a strategy for acquiring the solution. A decision is made at the end of this phase to authorize acquisition of the program-referred to as milestone A.

- Technology Development: Determine the appropriate set of technologies to be integrated into the system solution while simultaneously refining user requirements. A decision is made at the end of this phase to authorize product development based on well- defined technology and a reasonable system design plan—referred to as milestone B…The first APB is established after the program has assessed the viability of various technologies and refined user requirements to identify the most appropriate technology solution that demonstrates that it can meet users' needs.

- Engineering and Manufacturing Development. Develop a system and demonstrate through developer testing that the system can function in its target environment. A decision is made at the end of this phase to authorize entry of the system into the production and deployment phase or into limited deployment in support of operational testing—referred to as milestone C. [Low-rate initial production (LRIP) is authorized post milestone C to support operational testing.]

- Production and Deployment. During this phase, the system is produced, operationally tested, and deployed. At this point, the system achieves an operational capability that satisfies the end-users needs, as verified through independent operational testing and evaluation, and is implemented at all applicable locations.
- Operations and Support. This is the final phase. Program personnel ensure that the system is sustained in the most cost-effective manner over its lifecycle. (GAO, 2013, p. 7–8)

The acquisition system is designed to ensure needs or requirements are transferred into stable and affordable acquisition programs and have been fairly successful at producing the more traditional weapons systems (Gansler & Lucyshyn, 2012). The traditional Defense Acquisition Systems framework is complex and its phases do not conform well to commercial industry best practices or adapting COTS products.

D. CHAPTER SUMMARY

The issues of UMS acquisition fall under five problem areas or groups, namely, Acquisition Workforce and Management Issues, Legislative Impediment and Oversight Issues, Requirements and Funding Issues, Testing and Evaluation Issues, and Issues Extending from Lengthy Acquisition Timelines. It has also been noted that too much oversight can be a barrier in the acquisition of UMS. Although monitoring is intended to be a good thing, some control entities are so burdensome that they slow programs down and even increase the probability of failure.

The history of acquisition reform and the workforce that comprises it was discussed from 1980 to present day. The need for reform was acknowledged since the early 1980s. The Packard Commission along with the Blue Ribbon Commission helped to identify some of the downfalls of the legacy system and aided the implementation of reform initiatives to include the creation of the position Under Secretary of Defense for Acquisition. The reform initiatives continued through the 1990s. The Clinger Cohen Act and the Federal Streamlining Act helped to greatly reduce the bureaucracy that was previously in place in the acquisition world. This reduction was assisted by the Secretary of Defense with the Defense Reform Initiative (DRI) which identified four pillars of reform which helped the DOD to approach acquisition from a business minded entity.

The 2000s saw continued emphasis on improvement in the acquisition community that focused on being net-centric, reducing total cost, and training the acquisition workforce.

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III. DATA: CURRENT UMS ACQUISITION MODELS: MK-18 MOD 2, LBS-AUV, LDUUV

A. MK-18 MOD 2

Having outlined the role of the Department of Defense Acquisition System (DAS) in the previous chapter, we now discuss the beginning of the acquisition process of the Underwater Unmanned Vehicle (UUV) and specifically the MK-18 Mod 2. This section provides a broad insight into the whole process of the acquisition and the perennial success of the MK-18 Mod 2 implementation in various missions.

Early stages of the acquisition of the MK-18 Mod 2 began in December 2011 when the Office of the Secretary of Defense approved a “Fast Lane Initiative” to provide the MK-18 Mod 2 Kingfish UUV and associated sensors and upgrades to the Commander 5th Fleet (C5F) on an accelerated basis (Ervin et al., 2014). The “Fast Lane Initiative” is an initiative which the DAS, through the Office of the Secretary of Defense, adopted to field key components of the MK-18 UUV in order to accelerate the transition of existing and planned MK-18 Mod 2, families of systems, to meet the operational needs in the Central Command Area of Responsibility (AOR). This initiative has resulted in improved operational mine countermeasure mission (MCM) and advanced sensors.

Through the “Fast Lane Initiative", the first batch of the MK-18 Mod2 Kingfish UUVs was delivered in July 2012 to the C5F AOR to begin the search, classification and map missions in the Middle East. Subsequent second and third batches were delivered in February 2013 and October 2013 respectively. In February 2014 and April 2014 the MK-18 Mod 2 Kingfish UUVs were put into an operational environment and proved its capabilities.

The MK-18 has recorded a significant number of successes including being deployed to the Gulf of Mexico for a mock test and it has replaced the MK-18 Mod 1 in the Persian Gulf as an answer to the continued need in the AOR. The MK-18 Mod 2 has a wider swath scan, higher resolution imagery and buried target detection making it more versatile than the previous Mod 1. The success of the MK-18 Mod 2 can be attributed to a technologically mature design and outstanding contractor support, for both operational and maintenance support.

The MK-18 Mod 2 vehicle is based on the REMUS 600 platform. The state of the vehicle's development has provided us an autonomous UUV that matches the vision stated in the DOD Roadmap for Unmanned Systems, with "the seamless integration of diverse unmanned capabilities that provide flexible options…persistence, size, speed, maneuverability, and reduced risk to human life" (DOD, 2011, p.3). The MK-18 Mod 2 transitioned from an Abbreviated Acquisition Program (AAP) to a Program of Record (POR) in 2015 in order to meet future defense operation requirements. The MK-18 Mod 2 entered the JCIDS process as an ACAT IVM POR and "Increment 1" is intended to achieve Milestone C in November of 2017 (Simmons, 2015).

B. LITTORAL BATTLESPACE SENSOR (LBS)

The REMUS 600 began development in 2003 at the Woods Hole Oceanographic Institute. The crossover of the MCM to the larger vehicle as a simple scaling issue, yet this would leave a gap in the capabilities outlined in "The Navy Unmanned Undersea Vehicle (UUV) Master Plan of 2004" and successive documents.

The LBS addresses the sub-pillars of ISR, Oceanography, and Communication/Navigation Network Node, through the Gliders. The term intelligence preparation of the environment (IPOE) is utilized while defining the LBS-Glider/AUV SoS. The 2015 U.S. Navy Program Guide describes the LBS capabilities with, "Critical to realizing undersea dominance, the system has delivered buoyancy-driven undersea gliders (LBS-G) and electrically powered, autonomous undersea vehicles (LBS-AUV) to enable anti-submarine, mine countermeasures, expeditionary, and naval special warfare planning and execution and persistent intelligence preparation of the environment (IPOE)" (U.S. Navy [USN], 2015).

Utilizing the previous development completed by the operational fielding of the MK-18 Mod 2 in the Central Command AOR the LBS-AUV was able to demonstrate a more mature system and enter later in the JCIDS process. The LBS-AUV completed its Critical Design Review (CDR) in 2011 and went on to meet the Milestone C requirements in 2012 and continue with Low Rate Initial Production (LRIP). The LBS-AUV was deemed Initial Operationally Capable (IOC) IN 2013 and delivered seven vehicles in 2014.

C. LARGE DISPLACEMENT UNMANNED UNDERSEA VEHICLE (LDUUV)

The LDUUV, unlike the smaller MK-18 and LBS-AUV, is still developmental. The LDUUV, due to its size, has not been as commercially viable and is a more “typical” DOD product in that it has a much more military specific character. The 2015 Navy Program Guide describes the mission of the LDUUV with “the Large Displacement Unmanned Undersea Vehicle will provide a robust, long endurance, persistent, multi-mission, unmanned undersea vehicle capability for the Navy” (USN, 2015).

The missions that will be required of the LDUUV will require a larger energy source and modularity not required of the smaller UUVs. The LDUUV is larger in order to meet the many sub-pillars outlined in the 2004 UUV master plan of persistent ISR, ASW Hold at Risk, Long Range Oceanography, and payload delivery (Deputy Assistant Secretary of the Navy [DASN], 2004).

The development of the LDUUV is not a stop gap measure, but is instead intended to jump ahead of the curve and help to define the future battlefield. The LDUUV is being developed under the Innovative Naval Prototype (INP) program which was founded in FY 2011. The Office of Naval Research (ONR) website describes the INP program as one that attempts to anticipate the nation’s need by developing high-payoff, high-risk, game-changing, emerging technologies that define our future battlespace. INP programs are disruptive technologies which carry high risks and require high level leadership support in order to survive (Office of Naval Research [ONR], 2016).

The LDUUV achieved Milestone A in 2014 and was progressing in a more traditionally open market competitive acquisition framework until early in 2016. In March of 2016 it was announced that Naval Undersea Warfare Center in Newport Rhode Island would be the government system integrator for the LDUUV and the acquisition plan for the LDUUV had been revised. Lee Hudson of “Inside Defense” quoted an email from Naval Sea Systems Command which described how ONR is attempting to expedite the maturation of technology readiness and deliver the latest technology to the Fleet with their government-led design approach while at the same time reducing risk (Hudson, 2016a).

This level of risk, as mentioned above, requires senior level sponsorship. The level of sponsorship is not always carried over into the House or Senate appropriations. Both the House and Senate cut funding for the projects from the President’s budget proposal. The House cut $43 million and the Senate cut $55 million from the President’s request of $57 million (Hudson, 2016b).

The 2015 Program Guide says, “The Navy will achieve an early operational capability in FY 2017 by converting three ONR LDUUV INP vehicles into user operational evaluation systems to begin development of tactics, techniques and procedures. LDUUV initial operational capability is expected in FY 2022” (USN, 2015). The proposed cut in requested funding will undoubtedly have an effect on technology maturation and fielding of the INP vehicles, thus affecting the schedule and risking cost increases to the program.

D. CHAPTER SUMMARY

This chapter identified the current acquisition models for the three different UUVs. The MK-18 Mod 2 was a follow-up to the smaller MK-18 Mod 1 and was introduced to the operational environment via the “Fastlane Initiative” and is now an ACAT IVM POR. THE LBS-AUV utilizes the same base hardware as the MK-18 Mod 2 and due to performance demonstrated has been able to enter as an ACAT IVM POR record and achieved a Milestone C decision in 2011. The LDUUV was reviewed due to its status as a prototype and the non-traditional approach to acquisition that is being taken by ONR and the subsequent lack of funding by congress.

IV. ANALYSIS: MODELS ADAPTABLE FOR UMS

The Department of Defense employs various broadly based procurement models that close gaps present in traditional acquisition models. These baseline models are recommendations, but each acquisition program is unique and should have a tailored strategy (USD[AT&L], 2015a).

The Department of Defense utilizes six program models framing its acquisition process (USD[AT&L], 2015a).These program standards are outlined in DOD Instruction (DODI) 5000.02. Among the six models, four models are considered basic. These four basic models are structured to the type of product being acquired or to the requirement for accelerated acquisition: Defense Unique Software Intensive Program, Hardware Intensive Program, Incrementally Deployed Software Intensive Program, and Accelerated Acquisition program. The remaining two models are hybrids, merging the features of complex and basic models and are usually modified to the dominant attribute of the end product. The hybrid models are the Hardware Dominant hybrid model and the Software Dominant hybrid model. The Incrementally Deployed Software Intensive Program and the Software Dominant hybrid model will be examined as these effectively apply to the acquisition of the majority of UMS.

A. MODEL 3: INCREMENTALLY DEPLOYED SOFTWARE INTENSIVE PROGRAM.

The schematic representation of the Incrementally Deployed Software Intensive Program is shown in Figure 6.

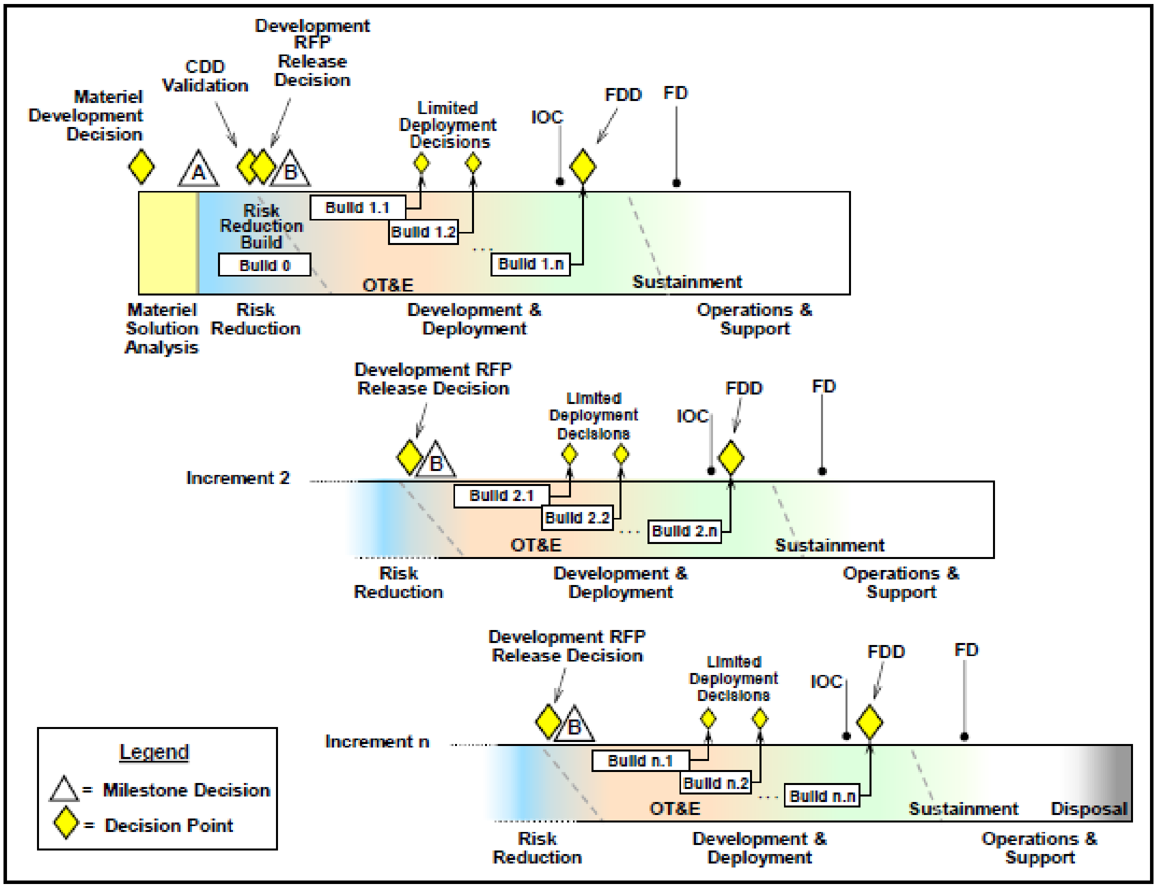

Figure 6. Incrementally Deployed Software Intensive Program.
Source: USD(AT&L) (2015a).

The Incrementally Deployed Software Intensive model offers rapid delivery of capability through several limited deployments, as opposed to the Defense Unique Software Intensive Program's single cycle of milestone B and C review points leading to one production run. As DODI 5000.02 explains, "Each increment may have several limited deployments; each deployment will result from a specific build and provide the user with a mature and tested sub-element of the overall incremental capability" (USD[AT&L], 2015a, p. 11). In this model, several builds and deployments are usually required in satisfying accepted necessities for an increment of competence (USD[AT&L], 2015a). This model is typically useful in cases where COTS software are acquired and adapted for DOD uses. The Incrementally Deployed Software Intensive model can offer risk to timeline as it features recurrent milestone or fielding decision points and detailed endorsement reviews. The issue of associated cycle time incurred with these reviews and the recent improvements made was outlined in the 2015 annual report on the performance of defense acquisition system. The annual report responds that initiatives have created to limit the review process in the OSD to less than 14 days, and has implemented a coordinating tool to allow for parallel reviews (USD[AT&L], 2015b). The Incrementally Deployed Software Intensive model is suitable for weapon systems software that reaches full capacity after multiple 1- to 2-year cycles.

B. MODEL 6: HYBRID PROGRAM B (SOFTWARE DOMINANT)

The schematic representation of the hybrid program B (Software Dominant) is shown in Figure 7.

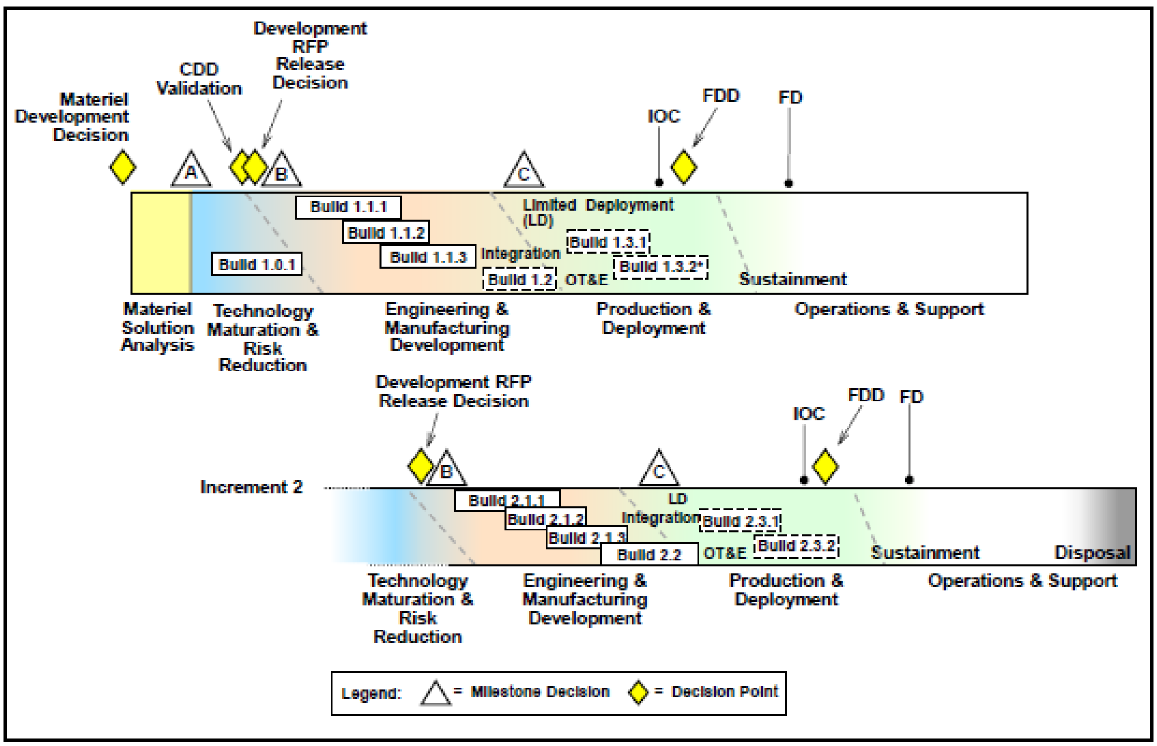

Figure 7. Hybrid Program B (Software Dominant). Source: USD(AT&L) (2015a).

Figure 7 illustrates how software-intensive products can consist of a combination of incremental software upgrades or releases containing standard builds in order to continue product development. In this program model, highly integrated and sophisticated software and hardware development risks require proper management throughout the product lifecycle (DAU, 2013). The program also requires special interest at decision points and milestones. Another fundamental characteristic of the Software Dominant model is that it includes all the features found in the Incrementally Deployed Software Intensive Program.

Both the Incrementally Deployed Software Intensive and Software Dominant model begin with a materiel development decision that is based on the ICD or similar document, the completion of an Analysis of Alternatives study guidance and study plan. In both models, the materiel development decision initiates the execution of the AoA and permits the DOD component to perform the Materiel Solution Analysis. The second phase in both models is the Materiel Solution Analysis stage. The Materiel Solution Analysis is necessary in choosing the product concept to be acquired as well as initiating validated capability loopholes into system specific requirements. Both of these processes support the decision on the acquisition strategy for the product.

After the Materiel Solution Analysis, the procurement process paves the way for the Milestone A decision. At this point, the team seeks approval for the program to enter the technology maturation and risk reduction phase for the dominant software model and the risk reduction phase for the Incrementally Deployed Software Intensive Model (Ryan, 2016). The responsible DOD component may issue contracts for product delivery at this stage.

In the Software Dominant model, the acquisition process enters the Engineering and Manufacturing Development phase after Milestone B, authorizing the relevant DOD component to award contracts. In the Incrementally Deployed Software Intensive Model, the acquisition process enters the Development and Fielding phase—meaning that the product can be deployed at this stage.

The acquisition process includes a Milestone C decision or a FDD. At this stage; the process is reviewed for entry into the production and deployment phase. It is imperative that the management team conducts demonstrations to prove the stability of output and deployment. After full deployment, the product enters the Sustainment Operations and Support phase in both models. The Sustainment Operations and Support phase executes product support strategies in a bid to satisfy material readiness, performance requirements of operations support, and sustainment throughout a program's lifecycle.

Considering the rapid changes in technology and the dynamic development of UUVs, the Software Dominant model is not the most suitable model for the acquisition of UUV systems. This is because the Software Dominant model keeps track of minor changes in technology and allows the product under consideration to pass through a series of sophisticated analysis stages in the acquisition process. This requires significant program manager involvement to manage this complex model. The Incrementally Deployed Software Intensive model does not include an engineering and manufacturing development phase but instead jumps to deployment after the risk reduction phase. Engineering and manufacturing development is not particularly fundamental for autonomous systems due to the selection of COTS products. This is highlighted in the LBS-UUV in which an industry analysis was performed that indicated several commercially available UUV products were available. A low risk was assigned for delivering required capabilities within cost and schedule (PMW 120, 2009). The Software Dominant model involves more steps and milestone decisions which increase the length of time in the acquisition process. The Incrementally Deployed Software Intensive Model should, therefore, be adopted for the acquisition of unmanned underwater vehicle systems.

C. INCREMENTALLY DEPLOYED SOFTWARE INTENSIVE APPLICATION

As covered in chapter two of this document, the reformation of the acquisition community and the requirements that govern DOD acquisitions allowed the streamlining of the DOD's acquisition process. While the JCIDS process is still a complicated system to navigate, it is functional and allows the acquisition workforce to develop, deploy, and maintain extremely complicated weapons systems while mitigating risks to schedule and cost.

The MK-18 Mod 2 is the most successful UUV that this report has covered. The MK-18 Mod 2, while previously an AAP, has been able to transition to an ACAT IVM POR. The current acquisition strategy is for the MK-18 Mod 2 to be developed in three increments utilizing the evolutionary approach (H. Williams, personal communication, October 20, 2016). The evolutionary method is becoming the preferred method for many acquisition programs utilizing mature technology. Utilizing mature technology mitigates risk in the program, and allows the product to move through the JCIDS process more readily. This benefit is demonstrated by the development process of MK-18 Mod 2 and the LBS-AUV, as both were able to enter at the post-Milestone B decision (Simmons, 2015; USN, 2015).

Not all UMS programs will possess the level of mature technology as in the MK-18 Mod 2 and the LBS-AUV. The LDUUV is a prime example of this. The LDUUV is an INP program and as stated by ONR, an INP program "attempts to anticipate the nation's need by developing high-payoff, high-risk, game-changing, emerging technologies that define our future battlespace" (ONR, 2016). The LDUUV is not a COTS program, and similarities with the MK-18 family of UUVs are few. Due to the size and development of cutting edge technology the LDUUV is more specialized and military specific in mission. The LDUUV is scheduled to achieve initial operational capability in FY 2022, but will place three prototypes in operational testing in 2017 (USN, 2015).

Not all UMS are adaptable to the evolutionary acquisition model. The DODI 5000.02 illustrates the approach with Figure 6, the Incrementally Deployed Software Intensive model. For the MK-18 Mod 2 and LBS-AUV programs the Incrementally

Deployed Software Intensive model is a better fit for their development and fielding. Much of the REMUS 600 hardware has been unchanged over the past decade. It is the development of the software, or additional plug-and-play hardware such as SONAR that will be utilized in future versions and are planned for the follow-on increments. All of the successive hardware and software updates must meet the approved requirements. The model shown in Figure 6 allows this development to occur in an incremental and iterative process while at the same time providing the capability of the program to the end user.

D. BUILDING A UMS MODEL: SOFTWARE DOMINANT

The commencement of the POR begins with a defined need. Once it has been determined that no program currently exists to meet that need, a new program is created and a list of capability requirements generated. These capability requirements are not expected to remain constant and although the requirements are known, the technology may not exist to achieve the required capability. The incremental acquisition process allows the introduction of operational systems that can achieve a portion of the requirements and allow the continued development of future capabilities utilizing the same base platform.

As the list of requirements is developed and ready capabilities identified, the increments of evolutionary acquisitions take shape. The mature technology will be incorporated into the first increment of the program. Future increments will incorporate technology that is in development, but not yet proven in an operational environment. Although the evolutionary acquisition model has evolved to expedite the implementation of current technology into the operational environment for the end user, the requirements for each increment must be established prior to Milestone C (USD[AT&L], 2015a).The period between increments introduces an artificial lull in the technology maturation time and the deployment of units to the end user. This period also allows the program managers the ability to update capabilities for future increments.

As shown in Figure 6, pre-planned builds can be executed during the OT&E phase. This would allow the implementation of a “build-test-refine-deploy” process in which the latest software updates are being implemented in units in an operational environment. The subsequent fixes are either rolled into the next build or the update is planned into that build timeframe. This implementation of build stages also allows the planning of capability documents for the follow-on increments and the subsequent maturation of the program capabilities. UMS dependence on software for autonomy, communications, data processing, power usage, and the seamless integration that corresponds to these tasks is in a continuous update cycle and the quicker the product improvement cycle, the quicker the development and deployment of capabilities (USD[AT&L], 2015a).

1. Competition

Many military solutions require the development of technology, or a capability, that raises the classification level beyond the affordability of many potential DOD business partners. In the case of UMS, much of the software is available in industry and competition is available. The implementation of competition in UMS development will be key to progressing past the current state of capability.

The use of competition in the Acoustic Rapid COTS Insertion (ARCI) on submarine SONAR systems is often used as a model to demonstrate the implementation of Modular Open Systems Approach (MOSA) and the benefits of competition in the rapid achievement of capabilities for a program (Boudreau, 2006). By ensuring that the systems of the UMS are open, this allows multiple competitors to compete for the next build. The LBS-UUV program has embraced both the evolutionary acquisition approach and the use of MOSA to deliver capabilities while reducing cost (PMW 120, 2011). In the case of the MK-18 Mod 2, the use of the Common Operator Interface Navy-EOD (COIN) allowed the operators to have a common application that spanned multiple types of UUVs. This common interface provides consistency amongst the operators and yet allows the open system for the specific UUV mission functions. As Ervin states, “The program manager decreed that for any UUV manufacturer to compete for future production opportunities, the vehicles must be able to exchange information via the COIN system” (Ervin et al., 2014). The rights to the software and licenses were purchased from the developer Seebyte. Seebyte, a small foreign company, has continued to provide software products for the MK-18 Mod 2 program.

2. Cost Reduction

The costs of an acquisition program can change due to a variety of factors, but are generally balanced by three overarching items: time, cost, scope. These three aspects of the program are interrelated and interdependent. An increase in the scope of a project, the amount being produced, or capabilities desired will directly affect the time and cost. Every minute of a program's schedule costs money due to overhead and the intangible of reduced capability in the operational environment. The ability to utilize mature technology available in the commercial environment can greatly reduce the time and cost of a program. In the implementation of MOSA in the ARCI program the benefits of open architecture and competition were able to reduce the cost over the lifespan of the program by 5:1 (Boudreau, 2006).

3. Intellectual Property and Peer Review

The development of competition in the beginning of an acquisition program is key to ensuring that it lasts throughout the process. Competition is important throughout the program, but with UMS we are speaking to open system architectures that enable competition for upgrades during the builds (USD[AT&L], 2015a).The development of competition amongst government contractors can be difficult. As highlighted by the ARCI case, creating an equitable competition amongst the contractors relied heavily on Intellectual Property (IP) rights. The implementation of the ground rules allowing for competition and fairness amongst IP are established or inherent in the contracts for the builds. The balance of protecting a contractor's IP while at the same time maintaining an open system proved difficult, but ARCI helped to form guidance for this type of contracting. The competing solutions proposed for the builds would be demonstrated during the OT&E phase, allowing real world feedback. This would enable the best solution for each build (Boudreau, 2006). The recent preponderance in civilian UAV technology along with the already established UUV contributors should allow a competitive environment if the correct business environment can be established.

E. CHAPTER SUMMARY

This chapter discussed the basic models provided in the DOD Instruction 5000.02 and identified two that lend themselves to mature technology acquisition that is software dominant. The two were analyzed and due to lower risk and level of program management throughout the process the Incrementally Deployed Software Intensive model was selected for mature technology UMS programs employment, but as stated in the DOD Instruction 5000.02 every acquisition program is unique and models can very.

The Incrementally Deployed Software Intensive was utilized as a possible acquisition strategy for a generic UMS program. The use of "builds" throughout the incremental process was highlighted as an excellent ability to maintain a capability commensurate with technology maturation. The importance of developing competition amongst contractors was highlighted. The use of open architecture and fair contracting employment in order to protect intellectual property is key to ensuring the desire of competitors to compete and rewarding those that provide the capabilities desired.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

With the increase in software and unmanned systems technology the acquisition process must continue to evolve and adapt. The use of smaller autonomous vehicles and associated technology does not fit easily in the traditional acquisition framework developed for B-52s or Destroyers. The shorter lifecycles of UMS platforms and their technology enable the continued introduction of capabilities throughout OT&E for the benefit of the end users.

From the research conducted, the delays in the DOD's acquisition process for UMS and other weapon systems can be linked to five major problem areas. Key areas for improvement are: acquisition workforce and management issues, legislative and oversight issues, requirements and funding issues, testing and evaluation issue, and the issues of extending from lengthy acquisition timelines.

While the acquisitions workforce is now more educated in the acquisition processes, there are some elements that lack proficiency. Some delays are caused by poor cost scheduling and performance, resulting from senior managers and leaders lacking experience and understanding of the acquisition process. The acquisition processes are bureaucratic and cumbersome. Several approvals are required before authority is granted to implement acquisition decision process, which in turn consumes time. The exercise of management authority within the DOD is also composed of several complex roles and responsibilities, with coordination between these entities difficult and costly. The coordination requirements carry over to the legislative and oversight agencies as well. The plethora of monitoring bodies and authorities slows down the acquisition process and adds to a program's chance of failure.

The funding process is an issue for many acquisition programs. Our research identified funding as an issue in the ARCI case due to the evolutionary acquisition profile that the program was following. The LBS-UUV program, in which the Glider and AUV had to be purchased in two separate increments, also saw issues to due to lack of funding and the AUV production has ceased after a single increment.

B. RECOMMENDATIONS

The following recommendations can help reduce the DOD's acquisition process for the UMS weapons:

1. Future UMS models should analyze the lessons learned from UMS acquisition models applied in this report as well as the ARCI case study. The use of multiple "builds" in each increment could help to refine and advance the capabilities at a quicker pace throughout the development cycle of the program.

2. Increase the competition for each build/increment. To advance capabilities at a quicker pace developers must be driven and at the same time protected. The intellectual property of the developers must be protected, yet ensure that their product interacts freely with the open architecture. The competitors will be more willing to compete for the contracts with knowledge of IP protection. This was evidenced in the ARCI case study.

3. To reduce the time wasted by the oversight activities, the DOD should ensure that operations of the several branches are synchronized. However, there must be an independent authority to oversee the operations. This would greatly reduce the time spent in the approval stage.

4. While acquisition reformation has made improvements in the process, funding remains an issue. This is partly by design of the division between executive and legislative branches of government, and the dissolution of requirements over time. Future research into innovative, yet practical methods of funding UMS-type acquisition programs could be beneficial to increase the flexibility as well as increase the program's chances of success.

The implementation of the recommendations can greatly reduce the costs of UMS programs and ensure that the capabilities acquired are as current as possible, and giving the end user the best product available.

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