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RECOMMENDATIONS FOR THE DOD REQUIREMENTS DEVELOPMENT PROCESS FOR ACCELERATED ACQUISITIONS: A STUDY OF THE MK 18 MOD 1 UUV PROGRAM

June 2023

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Acquisition is complex, costly, and relies on successful requirements development for timely delivery to the Fleet. The requirements development process is still a problem in large acquisition category (ACAT) programs and even more so for accelerated acquisition programs that require faster delivery. However, there have been successful programs that developed requirements accurately and on time to provide an efficient product for their end users. One such program is the MK 18 Mod 1 unmanned underwater vehicle (UUV), which utilized the User Operational Evaluation System (UOES) to inform and structure the requirements development process. This research identifies the features of the UOES that contributed to the success of the MK 18 Mod 1 program and its requirements development, lessons learned and best practices, and ultimately, recommendations that can be provided to the Navy and DOD as a whole. As the Navy increases its reliance on unmanned systems, particularly in the underwater domain, future programs may benefit from implementing aspects from this procurement and its application of the UOES in the requirements development process.

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ABSTRACT

Acquisition is complex, costly, and relies on successful requirements development for timely delivery to the Fleet. The requirements development process is still a problem in large acquisition category (ACAT) programs and even more so for accelerated acquisition programs that require faster delivery. However, there have been successful programs that developed requirements accurately and on time to provide an efficient product for their end users. One such program is the MK 18 Mod 1 unmanned underwater vehicle (UUV), which utilized the User Operational Evaluation System (UOES) to inform and structure the requirements development process. This research identifies the features of the UOES that contributed to the success of the MK 18 Mod 1 program and its requirements development, lessons learned and best practices, and ultimately, recommendations that can be provided to the Navy and DOD as a whole. As the Navy increases its reliance on unmanned systems, particularly in the underwater domain, future programs may benefit from implementing aspects from this procurement and its application of the UOES in the requirements development process.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAF	Adaptive Acquisition Framework
AAP	Abbreviated Acquisition Program
ACAT	Acquisition Category
ACTD	Advanced Concept Technology Demonstrations
ADA	Acquisition Decision Authority
AOA	Analysis of Alternatives
APA	Additional Performance Attribute
APR	Annual Performance Report
ASN	Assistant Secretary of the Navy
ATD	Advanced Technology Demonstration
BAA	Broad Industry Announcement
BBP	Better Buying Power
BZ	Beach Zone
C4I	Command, Control, Computers, Communications, and Intelligence
CATF	Commander, Amphibious Task Force
CDD	Capability Development Document
CLIN	Contract Line Item Number
CMS	Contract Management Standard
COMEODGRU	Commander, Explosive Ordnance Disposal Group
COMOPTEVFOR	Commander Operational Test and Evaluation Force
CONOPS	Concept of Operations
DA	Decision Authorities
DAS	Defense Acquisition System
DET	Detachment
DRPM	Direct Reporting Program Manager
DON	Department of the Navy
EODGRU	Explosive Ordnance Disposal Group

FBE-J	Fleet Battle Experiment Juliet
FNC	Future Naval Capabilities
FOS	Family of Systems
FP	Force Protection
JCIDS	Joint Capabilities Integration and Development System
IDA	Institute for Defense Analysis
IRB	Institutional Review Board
IT&EA	Independent Test and Evaluation Agent
JHUAPL	Johns Hopkins University Applied Physics Laboratory
KPP	Key Performance Parameters
KSA	Key System Attributes
MCM	Mine Countermeasure
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDD	Materiel Development Decision
MEDAL	Mine Warfare Environmental Decision Aid Library
MMA	Marine Mammal Systems
MOA	Memorandum of Agreement
MTA	Middle Tier of Acquisition
NPS	Naval Postgraduate School
NRAC	Naval Research Advisory Committee
NSCT	Naval Special Clearance Team
NSW	Naval Special Warfare
OEM	Original Equipment Manufacturer
ONR	Office of Naval Research
OSA	Other Support Attribute
P3I	Pre-Planned Product Improvements
PEO	Program Executive Office
PM	Program Manager

PPBE	Planning Programming Budgeting and Execution
PPBS	Planning Programming and Budgeting System
QRA	Quick Reaction Assessment
RAA	Rapid Acquisition Authority
RD&A	Research Development and Acquisition
RDT&E	Research Development Test and Evaluation
REMUS	Remote Environmental Monitoring Units
RFI	Request for Information
RIMPAC	Rim of the Pacific
RPED	Rapid Prototyping Experimentation and Demonstration
RWG	Requirements Working Group
S-C-M	Search Classify Map
SE	Systems Engineering
SME	Subject Matter Expert
SOP	Standard Operating Procedure
S&T	Science and Technology
TBD	To Be Determined
T&E	Test and Evaluation
TECHREP	Technical Representative
TRL	Technology Readiness Level
TTA	Technology Transition Agreement
UARC	University Affiliated Research Center
UCA	Urgent Capability Acquisition
UMCM	Underwater Mine Countermeasures
UMS	Unmanned Maritime Systems
UOES	User Operational System
UON	Urgent Operational Need
USMC	United States Marine Corps
UUV	Unmanned Underwater Vehicle

VSW	Very Shallow Water
WHOI	Woods Hole Oceanographic Institute

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I. INTRODUCTION

This chapter introduces the research topic and provides information that sets the foundation for the research. First, a background of the research topic is provided. Next, the problem statement and the purpose of the research are discussed. Research questions and the methodology of the research are presented. Then, the benefits and limitations of the research are identified. Last, the structure and organization of the report is outlined.

A. BACKGROUND

Defense acquisition programs are complex and considered to be a high risk area by GAO (GAO, 2021). The acquisition life cycle for DOD acquisitions is often lengthy, and the accurateness of the requirements development process is vital to program success (DAU, 2022), especially in an acquisition program for an evolutionary system such as an Unmanned Underwater Vehicle (UUV). However, there have been some programs that have been quite effective. The MK 18 Mod 1 UUV program (herein referred to as MK 18) is one example. The MK 18 is a small, lightweight, and relatively inexpensive UUV used for exploration and reconnaissance in support of Mine Countermeasure (MCM) operations; amphibious landing; and hydrographic mapping (Autonomous Undersea Vehicle Applications Center, 2020). A determining factor of the program's success was the use of the User Operational Evaluation System (UOES). The purpose of the UOES was to allow end user feedback on the operational capability of the UUV prototype, in theater, to further define and improve the system requirements and design (Ervin et al., 2014).

The MK 18 program is not only an example of effective requirements definition and development but also of strong stakeholder engagement and working relationship with the Fleet that led to the delivery of an operationally successful system. To aid understanding of the accelerated acquisition process for the MK 18 program, a section of the literature review will cover an overview of Mine Countermeasure (MCM) Unmanned Underwater Vehicles (UUVs) acquisition history.

B. PROBLEM STATEMENT

The requirements development process for DOD acquisitions poses challenges to the RDT&E community, acquisition team, stakeholders, and end-users. It is important to distinguish that requirements development is a subset of the requirements management process. (Requirements management encompasses an approved set of requirements over the entire acquisition life cycle (DAU, n.d.). Operational requirements generation and system concepts generation are vital processes by which the DOD decides what systems need to be developed and acquired to achieve national security and program mission objectives. If the requirements development process is not executed correctly, then time, money, and resources are lost, and the warfighter does not have a usable end product. This research seeks to address the issues surrounding requirements development for accelerated (sometimes referred to as "abbreviated" but for the purpose of this research will be referred to as accelerated) acquisition programs.

C. PURPOSE STATEMENT

The purpose of this research is to identify how the UOES process assisted the requirements development process and execution of the successful MK 18 Mod 1 accelerated acquisition program. Research results will assist in the identification of best practices and recommendations to the Navy and DOD as a whole.

D. RESEARCH QUESTIONS

This research will answer the following questions.

1. How did UOES inform and improve the requirements development process for the MK 18 Mod 1 program?
2. What were the roadblocks and challenges associated with using UOES, and how were they overcome?
3. What lessons learned and best practices for the DOD's requirements development process can be gleaned from the use of the UOES in this accelerated acquisition?

E. METHODOLOGY

The purpose of this research is to focus on the requirements development process of the MK 18 Mod 1 program and, more specifically, how the utilization of the UOES assisted and enhanced this process. The methodology used in this research will involve interviews with subject matter experts in the MCM UUV field. The interviews will include questions about the MK 18 Mod 1 requirements development process and how the UOES aided the program’s success. The results and findings from these interviews will follow. Last, the analysis of the findings will be presented, and recommendations will be developed for the Navy and DOD to improve the requirements development process for accelerated acquisitions.

F. BENEFITS AND LIMITATIONS OF THE RESEARCH

This research topic is timely and relevant, as the Navy is increasing its reliance on and investment in unmanned systems, particularly in the underwater domain. Future acquisition programs may benefit from implementing aspects of the MK 18 Mod 1 requirements development process that contributed to its success. Readers will receive a usable end-product (research report) that discusses challenges to requirements development and provides specific recommendations. Areas for further/future research will be included in this research and may result in future contributions to this research area and the DOD acquisition process.

There are some limitations to this research. The MK 18 program evolved from nearly a decade of prototyping and testing other related UUV systems; however, this research will focus specifically on the MK 18 Mod 1 requirements development process and how it benefited from the implementation of the UOES. There are many elements of this procurement that contributed to its success, but the UOES is the primary aspect that will be researched. The UOES process may be divided into seven distinct phases, each of which could be examined in great detail. In this research, however, the UOES process will be covered at a high level.

G. ORGANIZATION OF THE REPORT

This report is structured into six chapters. Chapter I includes background information, the problem statement and purpose of the research, the research questions, benefits and limitations, and the methodology used. Chapter II reviews the theoretical foundation that forms the basis of this research. A discussion of Agency Theory is provided because the relationship between the government and industry is an integral component of acquisition. Chapter II then reviews available literature concerning the requirements development process, assesses current DOD policy, modern acquisition reforms, several GAO and institutional reports, and highlights other items concerning requirements development in DOD acquisition. It also studies the principal publications on the MK 18 accelerated acquisition program. Chapter III examines the requirements development process for the MK 18 Mod 1 and how the UOES made the program successful. Chapter IV presents the methodology used to obtain and analyze the data. This chapter also discusses the selection of interview participants. Chapter V provides the research findings, the analysis of the interview data, and recommendations to the Navy and DOD for process improvement. Chapter VI provides a summary of the background, the problem statement, and the purpose of the research. The conclusion of Chapter VI provides answers to the research questions, recommendations to the Navy and DOD for improving the requirements development process, and areas to consider for further research.

H. CHAPTER SUMMARY

This chapter introduced the research topic and set expectations for the content contained in the subsequent chapters. First, a background of the research topic was provided. Next, the problem statement and the purpose of the research were discussed. Research questions, along with the methodology, were presented. The benefits and limitations of the research were identified. Last, the structure and organization of the report were outlined. The next chapter provides a literature review that serves as a foundation for this research.

II. LITERATURE REVIEW

A. INTRODUCTION

This chapter begins with a discussion of the theoretical foundation that forms the basis of the research. First, there is a discussion of Agency Theory because it explains the nature of the relationship between the government and industry from an acquisition perspective. After the discussion of Agency Theory, there is a review of available literature concerning the requirements development process. Next, this chapter assesses the current DOD policy on accelerated acquisitions and requirements development, modern acquisition reforms, several GAO reports, Institute for Defense Analyses report "Assessment of Accelerated Acquisitions," Inspector General Report "Rapid Acquisition and Fielding of Materiel by the Navy," and highlights other areas concerning requirements development in DOD acquisition. This chapter then studies the other scholarly research on requirements development. Lastly, a summary of the chapter is provided.

B. AGENCY THEORY

Agency Theory is an economic theory that describes the relationship between a principal and agent in regard to a contract. In government contracting, the government (principal) contracts with the contractor (agent) for the performance of a specific task, such as providing a service or developing and producing a product (Rendon, 2015, pp. 1481–1508). Agency theory states that at times, there are conflicting interests and objectives between these parties. The objectives of the government include obtaining, through applicable public policy and statutory requirements, the right quality and quantity product or service at the right time and price, from the right source (Rendon, 2015, pp. 1481–1508).

Contrastingly, in addition to satisfying customer requirements, industry partners aim to fulfill their objectives of being profitable, preserving or growing market share, and stimulating cash flow, for several examples. The theory also describes the problem of "asymmetrical information" between principal and agent. In relationships that contain more uncertainty and risk, the information that is accessible to the government and the contractor is normally different, or asymmetrical. Take for instance the acquisition of an advanced weapon system. The government might know more about the mission and the requirement, whereas the contractor might have more information regarding the cost drivers or technical capability (Rendon, 2015, pp. 1481–1508).

The presence of conflicting objectives and asymmetrical information imposes different motivating factors for the principal and agent. Agency theory considers these two problems and is focused on the ways that information is obtained (e.g., on the potential source, or the supply or service). This theory also concerns implementing proper tools for risk sharing. This includes choosing the right contract type and incentives to mitigate adverse selection. It also includes employing a system for monitoring contractor performance, which can reduce the probability of moral hazard and its effects (Rendon, 2015, pp. 1481–1508). It is clear that the contract planning method, requirements development process, and award process all have roots in agency theory and the principal-agent theory.

Getting the requirements development process right is vital, especially in accelerated acquisitions. When moving quickly through any process, it is possible that important aspects of the requirement are missed. However, the requirement is the heart of the program, and must be accurately formed. The next section will provide an overview of requirements development.

C. REQUIREMENTS DEVELOPMENT

Operational requirements are formed to address deficiencies or gaps in operational capabilities, and as such, the purpose of generating requirements is to identify military needs and their priorities. Operational requirements are typically identified during the Stakeholder Requirements Definition and Requirements Analysis processes (Office of the Deputy Director for Engineering, 2022). System requirements are desired performance and functional characteristics of a particular weapon system. Summarily, operational requirements describe the problem and system requirements describe the features of system concepts that are possible solutions to the problem (Dillman, 1992).

The purpose of system concept generation is to frame and evaluate system concept alternatives to fulfill military needs; the result of this process is selecting one or a very few system concepts deemed most appropriate for development and acquisition. Together, operational requirements and system concept generation create what is referred to as requirements development planning. These are the first steps in the acquisition life cycle and influence the rest of the acquisition life cycle. Inherently, these decisions are complex and accompanied by certain levels of risk and uncertainty. Where this section discussed the objectives of requirements development, the following section will address the objectives of accelerated acquisition.

D. CONTRACT MANAGEMENT

The Contract Management Standard (CMS) defines contract management as "the actions of a contract manager to develop solicitations, develop offers, form contract, perform contracts, and close contracts" (National Contract Management Association [NCMA], 2022, p. 2). The CMS also defines the processes involved in the three phases of the contract life cycle. These phases are discussed below.

The first phase of the contract life cycle is Pre-Award. This phase includes contract planning and the processes for buyers to plan and develop solicitations and sellers to prepare offers. During solicitation planning, all buyer personnel responsible for the acquisition of goods or services coordinate efforts to perform market research, perform risk analysis, and form a comprehensive plan for the timely fulfillment of customer needs at a reasonable price. The overall acquisition strategy is also established at this stage. At solicitation development, the customer requirement and all accompanying elements (business, technical, regulatory, etc.) are described to the sellers (NCMA, 2022). When the customer requirement has been accurately captured in the form of a solicitation, buyers then request offers from sellers via the issuance of the solicitation. Ideally, this results in responsive offers that lead to successful contract performance.

Award is the second contract life cycle phase. The main task of the Award phase is forming the contract. The buyer comprehends offers, evaluates the sellers' terms, determines reasonable pricing through performing either price or cost analysis, and documents the results of this analysis. If negotiations are required, the buyer prepares requests for clarification, documents negotiation objectives, and conducts negotiations with the seller(s). Source selection is the next step in the award phase, where offers are analyzed "in accordance with solicitation evaluation criteria" (NCMA, 2022, p. 13). This process mitigates buyer risk by selecting the offeror with the highest probability of satisfactorily performing the contract and ensures a consistent source selection process (NCMA, 2022). After the successful offer is selected, the contract document is prepared, reviewed, and approved before award. After award, unsuccessful offerors are notified and debriefs are performed if requested.

The third and last phase of the contract life cycle is Post-Award. This phase includes the contract management functions of "contract administration" and "contract close-out."

After the contract is awarded, a post-award conference meeting is held between the buyer and the seller to ensure there is mutual understanding of the requirements and contract terms. Contract administration follows, which involves monitoring contract performance, maintaining communications between internal and external stakeholders, and evaluating interim contractor performance. Quality assurance and management of contract changes are also part of contract administration. Contract administration provides risk monitoring and ensures that contract terms and conditions are adhered to throughout performance of the contract, up to closeout or termination. Finally, contract closeout is "the process of verifying requirements of the contract are satisfied, settling unresolved matters, and reconciling the contract to make final payment" (NCMA, 2022, p. 19). This section described the phases and processes of the contract life cycle for all acquisitions. The next section discusses the tenants of accelerated acquisitions.

E. ACCELERATED ACQUISITION

SECNAV INSTRUCTION 5000.42 "Department of the Navy Accelerated Acquisition for the Rapid Development, Demonstration and Fielding of Capability" (2016) defines "Accelerated Acquisition." It is an overarching term utilized by the

Department of the Navy (DON) to include all initiatives designed to resolve critical operational gaps and provide solutions more rapidly than the traditional systems; Defense Acquisition System (DAS), Joint Capabilities Integration and Development System (JCIDS), and Planning, Programming, Budgeting, and Execution (PPBE). SECNAVINST 5000.42 (since superseded by SECNAVINST 5000.2G) established authority to implement urgent needs and accelerated acquisition policies for "the analysis and execution of rapid prototyping, experimentation, and demonstration (RPED) initiatives" (Office of the Secretary [OSD], 2016, p. 1). The policy directs the Department of the Navy to implement accelerated processes to address urgent operational needs (UONs). These processes shall serve to diminish current threats, mitigate potential threats, or utilize advances in technology that will "enable Naval forces to maintain their operational and technological superiority over potential adversaries" (OSD, 2016, p. 2). Figure 1 shows the acquisition life cycle for accelerated acquisition programs. This accelerated life cycle eliminates phases of the traditional acquisition process and enables capability deployment on a compressed schedule.

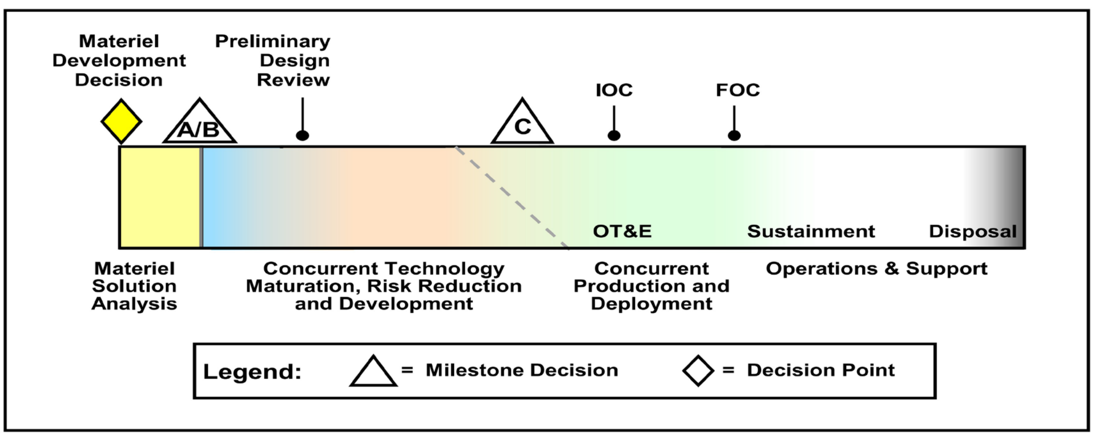

Figure 1. Acquisition Model for Accelerated Acquisitions. Source: Interim DODI 5000.02 (2013).

Current defense acquisition system policy emphasizes acquiring and delivering products and systems at the speed of relevance. Reducing the "cycle time," or the length of time to attain and field force capabilities, is a common theme. DOD Directive 5000.01

“The Defense Acquisition System” (2020) directs that simplified acquisition policy, tailored acquisition approaches, and an adaptive acquisition framework be employed to support this concept. The previous year, Rapid Acquisition Authority was effected by the Department of Defense (DOD) to provide a process for rapidly fulfilling urgent operational needs.

Although the DOD has provided these policies, clear guidance on simplifying and tailoring acquisitions, especially in terms of requirements development, is not provided. Standard acquisition and requirements development processes are not appropriate for evolutionary, accelerated acquisitions. Much of today’s policy on streamlining has been left open to interpretation by program managers (PMs). Critical and innovative thinking is imperative to successfully executing an accelerated acquisition program.

Accelerated acquisition programs are empowered to tailor both the program requirements and acquisition strategy from the Materiel Development Decision to Production and Deployment phases. There have been a handful of accelerated acquisition programs that have succeeded in defining requirements, development and testing, and ultimately fielding the system to the warfighter (Van Atta et al., 2016). This research will focus on one such program, the MK 18 Mod 1 UUV program. Prior to directly addressing that program, the following sections will review and discuss the prior research and documentation regarding acquisition reform relevant to accelerated acquisition.

1. Past Acquisition Reform Initiatives

The need for reforms to the acquisition system have been recognized by both the DOD and Congress. The amount of directives and legislative acts that have ensued over the years is proof of this. The Packard Commission, created in 1986 by Executive Order 12526, was focused on reducing inefficiencies in DOD procurements of defense systems (Christensen et al., 2015). The commission placed emphasis on the acquisition process, although its main purpose was to examine the management of defense practices. Recommendations from this commission were to simplify and improve both the acquisition and acquisition planning processes and to implement prototyping and testing. Also during this year, the Goldwater-Nichols Department of the Defense Reorganization

Act of 1986 was established. CRS report (No. R44474) explains that the Goldwater-Nichols Act strengthened civilian authority in the DOD and revised the military's command structure, enabling a more direct line between the Joint Chiefs of Staff and combatant commanders (McInnis, 2016). The report further states that this act gave emphasis to interoperability between the military components and had a positive effect on reducing bureaucracy.

In 2003, the Joint Capabilities Integration and Development System (JCIDS) was implemented (DAU, n.d.). As noted by DAU, it replaced the threat-based Requirements Generation System for identifying needed warfighter capabilities that had been in use since 1991. In the previous requirements generation system, each service developed its own response to perceived threats. With the implementation of the JCIDS, DOD turned to a capabilities-based approach, which was conducive to more collaboration across the services in identifying capability gaps. The JCIDS became the formal DOD process for "documentation, review, and validation of capability requirements" upon which acquisition programs are built (DAU, n.d.).

Another change that occurred in the early 2000s was the revamping of the DOD budget process from the Planning, Programming, and Budgeting System (PPBS) to the Planning, Programming, Budgeting, and Execution (PPBE) system (DAU, n.d.). Both versions of the budget process outlined the methodology used to allocate resources within the DOD. However, according to DAU, a larger emphasis was given to better management of the execution of the budget authority by adding "Execution" to the process. DAU further notes that this addition included within the PPBE the need for an analysis comparison between what DOD planned to do with its appropriations and what outcomes were actually achieved. This analysis aids in the DOD preparation of the Annual Performance Report (APR).

The Defense Acquisition System (DAS) is the third component of the decision making process for acquisition. The DAS is the process followed for buying and providing capabilities to the end user. Policy for the DAS is found in DOD's 5000 Series, DODD 5000.01 (2020) and DODI 5000.02 (2020). In general, "milestones" are used to manage the acquisition process. Per DAS policy, in order for a program to move from one phase to the next, the statutory and regulatory requirements applicable to that milestone must be met (Office of the Under Secretary of Defense Acquisition and Sustainment [OUSD] (A&S), 2021). As described by CRS, the first of the three milestones is Milestone A, where "technology maturation and risk reduction" begins (Schwartz, 2014, p. 6). Then, Milestone B authorizes engineering and manufacturing development. Finally, at Milestone C, production and deployment begins (Schwartz, 2014). DODI 5000.02 instructs that a recommendation be made to the Milestone Decision Authority (MDA) at each milestone on whether the program should progress to the following phase. Major Defense Acquisition Programs (MDAPs) are required to adhere to the DAS framework throughout the program life cycle (OUSD (A&S), 2020). The DAS has undergone multiple changes focused on bettering the process for buying weapon systems. Still, its main objective remains to promote the National Defense Strategy by supporting the acquisition of supplies and services that satisfy user needs (OUSD (A&S), 2020).

SECNAVINST 5000.2F (2019) delineates the roles, responsibilities, and processes to be used for the DAS and JCIDS for Navy acquisitions. The instruction applies to "all DON acquisition programs except those managed under separate procedures for" (1) Defense Business Systems; (2) the middle-tier rapid prototyping and rapid fielding pathways; and (3) certain prototyping efforts (Office of the Secretary, 2019).

Based on these various acquisition reform initiatives, the DOD has developed acquisition frameworks that can be adapted to address the peculiarities of different acquisitions. The next section discusses the Adaptive Acquisition Framework.

2. Operation of the Adaptive Acquisition Framework

DOD Instruction 5000.02 sets the foundation for operating and utilizing the Adaptive Acquisition Framework (AAF). The purpose of the AAF is to support the DAS with the intent of providing "effective, suitable, survivable, sustainable, and affordable solutions to the end user" on time (OUSD (A&S), 2020, p. 4). Broad discretion is given to "Milestone Decision Authorities (MDAs), other Decision Authorities (DAs), and

Program Managers (PMs)" to organize and oversee their programs in accordance with good business practices. In addition, the acquisition pathways of the AAF afford flexibility for decision authorities and managers to develop and use acquisition strategies and processes that are tailored to the desired capability. (See Figure 2.)

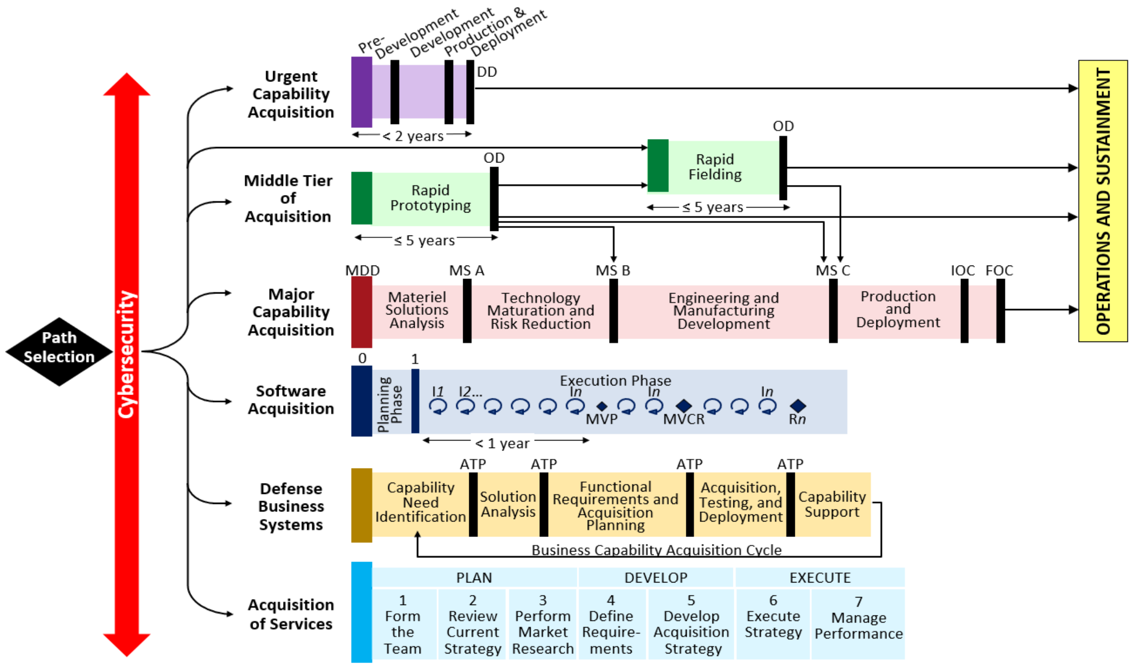

Figure 2. Adaptive Acquisition Framework. Source: DAU (n.d.).

The AAF doesn't specifically mention "accelerated acquisition," however, this type of acquisition would generally fall under either the Middle Tier of Acquisition (MTA) or Urgent Capability Acquisition (UCA) pathway. The MTA pathway was established for "rapid prototyping and rapid fielding activities" (OUSD (A&S), 2020, p. 13).

Rapid prototyping aims to deliver a "prototype that meets defined requirements, can be demonstrated in an operational environment," and achieve "operational capability within five years" of the start of the program (OUSD (A&S), 2020, p. 13). These activities are exempt from the Joint Capabilities Integration and Development System and DODD 5000.01 procedures, except to the extent specified by the instruction. Under this pathway, PMs are directed to "tailor-in" reviews, assessments, and documentation, to develop a customized acquisition strategy that addresses the program's unique risks and requirements. PMs are also directed to ensure that technical, operational, and security risks are identified and mitigated to enable fielding of systems that are resilient, capable, and reliable. The UCA pathway is similar, but its purpose is to field capabilities that satisfy urgent or emerging operational needs in under two years. The next section will discuss the Navy's implementation of the Adaptive Acquisition Framework, which facilitates establishment of accelerated acquisition programs.

3. Department of the Navy Implementation of the Defense Acquisition System and the Adaptive Acquisition Framework

This 2022 SECNAV Instruction (5000.2G) provides DON-specific program policies and procedures that supplement the DOD issuances for operation of the DAS and AAF. The instruction includes the DON Urgent Needs Process, delegates responsibilities for acquisition programs providing capabilities to meet Urgent Operational Needs or that can be fielded in under two years, and a supplement to the DOD Middle Tier of Acquisition guidance (Office of the Under Secretary of Defense Acquisition and Sustainment [OUSD (A&S)], 2022). Under the Rapid Prototyping and Rapid Fielding sections, the instruction advises Program Managers to review and recommend to the Acquisition Decision Authority (ADA) those documents that will best support execution of the program. PMs are also advised to "engage the operational test community as early as possible to support the required operational demonstration" (OUSD (A&S), Enclosure 4, 2022, p. 2). These responsibilities play an important role in the timelines for program review and successful phase completions.

An especially important item to note for DON accelerated acquisition is the replacement of Acquisition Category (ACAT) IV with the Abbreviated Acquisition Program (AAP) category. ACAT categories inform the level and extent of review, decision authority, and required procedures (DAU, n.d.). The highest level of oversight is for ACAT I programs and oversight decreases with each lower level category. DAU notes that previously, Navy and Marine Corps programs that were not categorized as ACAT I-III were categorized as ACAT IV. Within ACAT IV there were two types of

ACAT IV programs: IVT (testing) and IVM (monitoring). Now, acquisitions that do not breach ACAT III dollar thresholds are categorized as abbreviated acquisitions. Non-ACAT programs typically require fewer entry criteria and less program oversight. However, the relevant Program Executive Office (PEO), SYSCOM Commander, Direct Reporting Program Manager (DRPM), or PM still bears a responsibility to prepare an AAP designation request. The basis for the designation request shall be the cost estimates for the approved requirements document. Before the AAP can enter into the acquisition system, a Materiel Development Decision (MDD) must occur. In addition, AAPs cannot begin before receipt of "appropriate phase-specific funding from the resource sponsor" and validation of the capabilities document (OUSD (A&S), Enclosure 5, 2022, p. 6). Further requirements for compliance are prescribed in the Instruction (OUSD (A&S), 2022)

The Test and Evaluation (T&E) enclosure of the Instruction provides a "capabilities-based approach to T&E planning and execution" (OUSD (A&S), Enclosure 10, 2022, p. 1). The approach provides guidance for acquisition leaders and resource sponsors with an operational perspective of deficiencies discovered and data generated during program development and testing. The enclosure also provides a table for T&E documentation required at "Initial Acquisition," "Capability Modification," and "Test Documentation Approval" in addition to the written Test and Evaluation Master Plan. Overall, this Instruction and its enclosures provide a systematic plan for generating DON acquisitions under the AAF. The next section will explain the Rapid Acquisition Authority, which can be utilized to establish accelerated acquisition programs under the AAF.

4. Rapid Acquisition Authority

DOD MANUAL 5000.78 (2019) implements policy and assigns responsibilities for the use of Rapid Acquisition Authority (RAA) and provides procedures for the submission of RAA requests. DOD Components may request the use of RAA in situations where adequate resources or authority are not available for a timely response to a need. The guidance (Department of Defense [DOD], 2019) also states that the RAA should be contemplated for rapidly acquiring and deploying supplies and related services that:

- Are presently being developed by DOD or are commercially available,
- Require only minor modifications,
- Are developed or bought through the rapid prototyping or fielding acquisition pathways, and
- Are required to respond to an urgent enemy threat or respond to a major safety situation. (DOD, 2019, p. 7)

SECNAVINST 5000.42 defines “Rapid Acquisition” as a “streamlined and tightly integrated iterative approach, acting upon validated urgent or emergent capability requirements” (OSD, p. 1). The Instruction also provides that rapid acquisitions are utilized for analysis of alternatives and identifying desired solutions; contracting using existing authorities of statutes, regulations, waivers, and deviations suitable to the situation; and identifying and minimizing risks associated with technical development, integration, and manufacturing. The intention of rapid acquisition is to quickly produce and deliver required capabilities. The RAA process relies in large part on prototypes and experimentation, which are addressed as part of the Better Buying Power initiative, discussed in the following section.

5. Better Buying Power

In 2015, Frank Kendall (Former Under Secretary of Defense for Acquisition, Technology and Logistics) issued the third installment to Better Buying Power (BBP) which continues on the core concepts of BBP 1.0 and 2.0 (Kendall, 2015). While the first BBP initiatives instilled the importance of early and close collaboration amongst the requirements and acquisition communities, the overarching theme of BBP 3.0 is decreasing cycle times while ensuring sound investments (Kendall, 2015). BBP 3.0 incentivizes prototyping and experimenting for the purpose of rapidly fielding weapon systems. This is mentioned under the section titled “Incentivize Innovation in Industry and Government.” Kendall states (Kendall, 2015) that the importance of experimentation is in putting prototypes in the hands of the Warfighter for assessment in an operational perspective. These activities assist the requirements definition process; help minimize technical, schedule and cost risk; aid in revealing unanticipated vulnerabilities; and introduce new tactics, techniques, and procedures (Kendall, 2015).

Additionally, BBP 3.0 indicates that excessive time is spent on getting documents ready for review and not on actual program execution. Specific actions for lower-level ACAT programs and delegated programs are for the Milestone Decision Authority (MDA) to consider opportunities for tailoring and streamlining early in program planning to alleviate burdensome review processes where possible and reduce document lead times. Initiatives within the previous BBPs and BBP 3.0 help to incentivize innovation and increase productivity within government and industry for the purpose of improving the acquisition process. It should be noted that not all of DOD's acquisition reforms have been successful. There have been reports that detail the issues in DOD acquisition reform (GAO, 2013; IDA, 2016; GAO-01-288, 2001; and DID IG-2010-028, 2009. The next section discusses a GAO report that recommends where DOD acquisition reform should aim next.

6. GAO-14-145T: Defense Acquisitions—Where Should Reform Aim Next?

In this 2013 testimony before the Committee on Armed Services, the GAO stated that the DOD needs to obtain better outcomes from its weapon system investments. Acquisition reforms have advocated for best practices in management including prototyping, realistic cost estimating, systems engineering, and identifying efficiencies in development and production (Francis, 2013). Though there have been some improvements, problems still exist. First, according to GAO, reforms that concentrate only on methodological acquisition procedures are not complete solutions. These types of reforms do not address incentives for deviating from established practices. Second, many programs proceed without sufficient operational testing to ensure readiness for the next milestone (Francis, 2013). Additional issues addressed by the GAO case are listed below:

- Different participants in the acquisition process impose conflicting demands on weapon programs. (Francis, 2013)
- The budget process forces funding decisions to be made well in advance of program decisions which encourages undue optimism about program risks and costs. (Francis, 2013)

- Key positions throughout the ranks of acquisition leadership have frequent turnover. (Francis, 2013)

The GAO suggests some ways to improve requirements development, which include: pinpointing and resourcing significant risks early on, increasing the extent of developmental testing, and at the beginning of new programs, making funding decisions that support well-informed acquisition strategies (Francis, 2013). GAO also gives the recommendation to attract, train, and retain acquisition managers and staff so that they are qualified and accountable for program results. The next section addresses an Institute for Defense Analysis (IDA) review of programs that included accelerated acquisitions driven by urgent wartime needs, similar to the MK 18.

7. Assessment of Accelerated Acquisition of Defense Programs

This 2016 report, "Assessment of Accelerated Acquisition of Defense Programs," from the Institute for Defense Analyses (IDA) focuses on the "cycle time" of DOD acquisition processes and assesses how effective past efforts to accelerate acquisitions have been. IDA performed a review of approximately 330 major defense acquisitions since 1975. In many cases, what could be produced and when it could be produced were incorrectly estimated and led to subsequent consequences such as wasted resources and unfulfilled mission requirements (IDA, 2016).

IDA found that 18 of these programs qualified as accelerated acquisitions. These past efforts indicated five types of accelerated acquisitions, delineated by the urgency or specificity of the requirement and the readiness of technology. IDA categorized the acquisitions as (1) "Time-Constrained" (2) "Crash" programs (3) "Rapid acquisition" (4) "Early fielding experiments" and (5) "Spiral/evolutionary" (IDA, 2016).

Eleven of the 18 programs were selected for detailed assessment and to garner insights and lessons learned. A key finding of IDA's review was that most of the accelerated programs were driven by unforeseen, urgent wartime needs or efforts to integrate innovative technologies into weapon systems through operational testing and assessment (IDA, 2016). Each of the 11 programs skipped certain steps in planning, management review, or development and testing. This presented risks that standard acquisition processes should not incur. Another key finding was that the capabilities could not have been fielded if the following measures had not been implemented: program designation as high priority by senior management, utilization of technology demonstrations for advanced concepts, innovative contracting methods, and focused management, review boards, or program offices (IDA, 2016).

The report concludes that where the value of obtaining operational capability faster outweighs the risks of omitting or rushing standard acquisition system steps, acquisition programs should be accelerated (IDA, 2016). IDA also identified several points for successful accelerated acquisitions. One point was that strong leadership support is needed to overcome bureaucratic obstacles. Similarly, it is important to have intervention by upper management in the military service or OSD when innovative military capabilities outside current interest areas are considered. Another recommendation was to implement mechanisms for prototyping and experimenting with novel systems in the operational environment to obtain user feedback. A fourth point was to exploit existing systems and technologies where applicable to respond to urgent operational needs. The final recommendation was to have an "organizational structure for transitioning and incrementally improving capabilities based on user feedback" (IDA, 2016, p. 70).

Though the IDA report did not review the program that this research discusses, the above recommendations could easily have been drawn from a review of this accelerated acquisition. In summary, IDA provides valuable insights for future accelerated acquisitions and explores how historical programs navigated the fast delivery of operational capabilities (IDA, 2016). The next section discusses a GAO report that addresses the importance of setting realistic system performance requirements in view of program constraints.

8. GAO-01-288: Better Matching of Needs and Resources Will Lead to Better Weapon Systems Outcomes

This 2001 GAO Best Practices report discusses the difficulty of identifying what resources are needed to meet requirements before program launch. The sequence of events in traditional acquisitions—establishing requirements, initiating an acquisition program, contracting with a developer, and performing systems engineering—is not flexible. GAO recommends improvements to how the DOD "defines and matches weapon system requirements to available resources such as cost, schedule, and mature technologies" (Schinasi, 2001, p. 5).

First, developers should employ system engineering techniques to identify gaps between customer needs and resources in time to make critical trade-offs that precede committing to formal requirements (Schinasi, 2001). DOD has since revised its guidance for requirements setting. The guidance emphasizes the utilization of Advanced Technology Demonstrations to identify and close the aforementioned gaps.

The second GAO recommendation is to lessen the pressures placed upon user representatives to set requirements high in order to gain program approval (Schinasi, 2001). In the DOD 5000 series, evolutionary acquisition is the favored approach for product development. This approach allows the opportunity to postpone challenging requirements until technology maturation occurs.

Third, the Secretary of Defense should require sufficient evidence of an appropriate allocation between a weapon system's requirements and available resources prior to development (Schinasi, 2001). Finally, a best practice to establish accountability is to invoke an official agreement between program stakeholders regarding system development and fielding (Schinasi, 2001).

As noted by the GAO report, the recently updated DOD acquisition policies (5000 series) promote evolutionary methods for development and emphasizes the importance of technology maturity. The DOD guidance also champions the reduction of product development cycle times in that it recommends the development of products in increments, with each increment providing an improved capability to the user. Though evolutionary acquisition approaches are encouraged by DOD policy, they will not succeed if "traditional incentives for setting high and inflexible requirements" continue (Schinasi, 2001, p. 64). The following discussion regards an IG report evaluating procedural impediments to rapid acquisition efforts and recommendations to reduce their effects.

9. Inspector General Report No. D-2010-028: Rapid Acquisition and Fielding of Materiel by the Navy

In this report issued on December 15, 2009, DOD auditors presented findings from their review of the Navy's procedures for the rapid acquisition and fielding of materiel solutions to fulfill urgent needs (Inspector General [IG], 2009). Navy processes for identifying and validating urgent needs were evaluated for effectiveness and compliance with DOD requirements and acquisition policies. At the time of this report, the Navy had initiated 13 rapid acquisition efforts within five years. The IG auditors found that the Navy's procedures were adequate but still had room for improvement. For example, the IG report indicated that the Assistant Secretary of the Navy did not give acquisition managers clear direction or insights for planning and executing acquisition strategies for urgent requirements. Further, acquisition officials did not receive quick reaction assessments (QRAs) that were necessary for understanding the initial evaluation of material systems' operational effectiveness and suitability before deployment (Inspector General [IG], 2009).

Absent this information, Navy acquisition managers are without guidance for timely planning and execution of urgent needs acquisitions. Per DOD Instruction 5000.02, all operational test and evaluation must be performed by an organization external to the development activity and user commands. The independent organization accountable for Navy operational test and evaluation is Commander, Operational Test and Evaluation Force (COMOPTEVFOR). The IG recommends that, for rapid development and deployment items that are planned for deployment in response to urgent needs requests, program sponsors and acquisition managers require that COMOPTEVFOR perform QRAs before making decisions to deploy the systems (IG, 2009). This will guarantee that acquisition authorities have evidence from an independent evaluation on items' capabilities and limitations prior to making decisions on deployment.

The audit also found that the timelines of PEO approval for acquisition strategies varied greatly because there wasn't an established time frame for approval or disapproval. All eight acquisition strategies reviewed had a range of 11 to 991 days following the ASN approval for initiation of the acquisition. Average PEO approval was 300 days. ASN, Research Development and Acquisition (RD&A), agreed with the auditors that a specified timeline for PEO approval of acquisition strategies was necessary and that it should not exceed 90 days after initial approval by the ASN (IG, 2009).

The report states that lessons learned from acquisition managers experienced in planning and executing rapid acquisitions have not yet been collected by the ASN RD&A. However, the staff for PEO Command, Control, Computers, Communications, and Intelligence (C4I) provided a summary of lessons learned to the auditors to include (1) giving early and specific senior-level guidance to acquisition managers; (2) early and regular coordination with key stakeholders and action officers in the resource, requirements, testing, and acquisition communities; (3) coordinating with the Fleet for prototype performance demonstrations, even prior to starting the actual acquisition efforts; (4) defining operational requirements with discipline to prevent requirements creep; and (5) reviewing lessons learned from previous rapid deployment capability programs (IG, 2009). These lessons learned could be valuable references for managers of current or future rapid acquisitions. The next section identifies relevant past research in the areas of requirements for, and the pace of, accelerated acquisition programs.

F. PAST RESEARCH

There has been a variety of research on requirements development and accelerated acquisition. The next section provides an overview of especially relevant past research on this topic.

In their Naval Postgraduate School (NPS) thesis, Hoff (2009) evaluated how well user needs were translated into requirements for the Department of the Navy. This research was structured similarly to this research. Hoff studied U.S. Navy policy, processes, and current standards to identify recommendations for improving the process of translating needs into systems requirements. The researcher concludes that a better understanding of system engineering by management is required for better policy and resource decisions on requirements development. He also reasons that the use of "methods that can capture the behavior of complex Naval warfare systems, maintain traceability to higher level requirements, and incorporate plain language views of requirements" are needed to improve operational capability (Hoff, 2009).

In another NPS thesis, Conatser (2005) examined accelerated acquisition with respect to contingency operations. The researcher sought to identify the acquisition policy that was utilized for the rapid acquisition, production, and fielding of a useful Command and Control capability "during Operations Enduring Freedom and Iraqi Freedom" (Conatser, 2005). Conatser documented the events involved in the fielding of the capability and provided an assessment of the steps taken and the challenges that were overcome throughout the acquisition (Conatser, 2005). The research culminated in a process for accelerated acquisitions supporting contingency missions.

Lastly, an example of research on acquisition for U.S. Navy Unmanned Maritime Systems (UMS) was conducted by Driscoll and Richesin (2016). This NPS thesis research explored the issues associated with acquisition of evolutionary systems and recommended solutions for an acquisition approach to enable the military to keep pace with rapid technological development. The researchers found that current acquisition efforts are implementing past acquisition reforms, but further contractor peer competition and review could be beneficial in terms of cost and schedule (Driscoll and Richesin, 2016). Five problem areas were also identified: "acquisition workforce and management issues, legislative and oversight issues, requirements and funding issues, testing and evaluation issues, and the issue of extending from lengthy acquisition timelines" (Driscoll and Richesin, 2016, p. 41). The following section provides a summary of the chapter.

G. SUMMARY

This chapter began with a discussion of the theoretical foundation that forms the basis of the research. First, there was a discussion of Agency Theory which explained the nature of the relationship between the government and industry from an acquisition perspective. After discussing Agency Theory, there was a review of available literature concerning the requirements development process. Next, this chapter assessed the current DOD policy on accelerated acquisition and requirements development, modern acquisition reforms, several GAO reports, Institute for Defense Analyses report "Assessment of Accelerated Acquisitions," Inspector General Report "Rapid Acquisition and Fielding of Materiel by the Navy," and highlighted other areas concerning requirements development in DOD acquisitions. This chapter then concluded with discussions of relevant past scholarly research. The next chapter provides information on the requirements development process for the MK 18 Mod 1 program and the implementation of the UOES process.

III. MK 18 MOD 1 AND UOES

A. INTRODUCTION

This chapter begins with an overview of Navy mine countermeasures activities that stimulated the establishment of the Very Shallow Water (VSW) Mine Countermeasures (MCM) Detachment, which led in turn to the UOES testing for the MK 18 Mod 1 accelerated acquisition program. There is a discussion of some of the early Navy UUVs and how the Navy arrived at selecting the REMUS vehicle for the UOES test and evaluation. This chapter also describes the importance of the programmatic documents (Memorandum of Agreement and Fleet Evaluation Plan) that solidified the plans for the VSW MCM UOES. Then, the distinct phases of the UOES and how each contributed to the requirements development process for the accelerated acquisition program are covered. Lastly, a summary of the chapter is provided.

B. VSW MCM DETACHMENT

Beginning in the 1990s, the Navy started seeking alternatives to Navy divers and Marine Mammal Systems for mine countermeasure activities. Both OPERATION EARNEST WILL (1989) and OPERATION DESERT STORM (1990-1991) saw vessels taken out of service by mine destruction. In addition, during OPERATION DESERT STORM, amphibious operations were unlikely, "because of the minefields that lay along the Kuwaiti and Iraqi coast, and the threat posed by Iraqi anti-ship missile capabilities" (Russ, 1997). Consequently, U.S. Marine amphibious efforts were limited to raids and feints to pin Iraqi forces on the Kuwaiti shore, and a Marine Expeditionary Brigade landing in Saudi Arabia. The Navy Special Warfare (NSW) and United States Marine Corps (USMC) Reconnaissance forces tasked with Very Shallow Water (VSW) MCM missions and clearing waterways were poorly equipped because there were no MCM systems deemed suitable for use in these potentially mined areas. A panel conducted by the Naval Research Advisory Committee (NRAC) concluded that the Naval forces would need a family of UUVs and sensor systems tailored to different functions and communicating together as a network in order to fill the operational capability gap in mine avoidance and neutralization (Naval Research Advisory Committee, 2000). After Desert Storm, the Navy increased its investment in the transformation of MCM capabilities (Nagle and Simmons, n.d.).

In 1996, the VSW MCM Detachment (VSW MCM Det) was established under Navy Explosive Ordnance Disposal Group One (EODGRU 1), to improve VSW MCM capabilities, especially in non-permissive environments. In their case study, Nagle and Simmons convey that an additional goal was to reduce reliance upon, and eventually replace, divers and Marine Mammals with Unmanned Underwater Vehicles (UUVs) for locating and clearing mines in the VSW zone (Nagle and Simmons, n.d.). The mission of the VSW MCM Detachment in the littoral region (see Figure 3) was to find an effective method to rapidly patrol the VSW zone of desired landing areas to identify densely mined areas for avoidance, and to clear paths through lightly mined areas for the landing forces. Figure 3 identifies the different littoral areas; Surf Zone, VSW, Shallow Water, and Deep Water. Water depths in the VSW zone are between 10' to 40'.

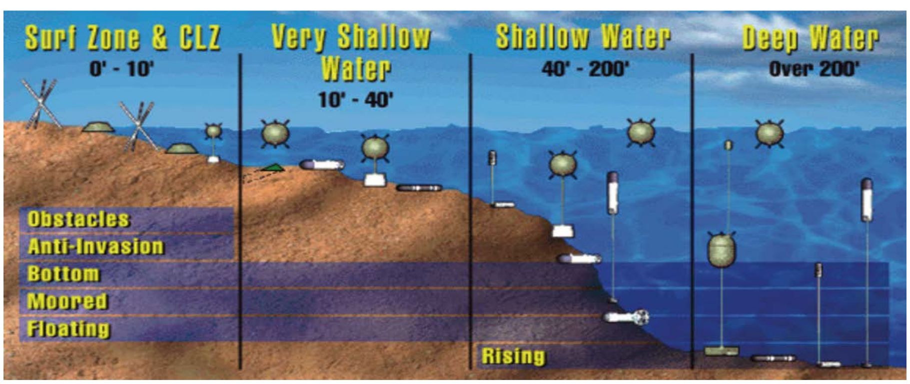

Figure 3. Description of Littoral Areas. Source: Ervin et al. (2014).

The VSW MCM Det Charter combined three communities (Naval Special Warfare (NSW), Marine Reconnaissance, and Explosive Ordnance Disposal). The charter tasked the VSW MCM Det with developing tactics and procedures, evaluating prototype equipment, and identifying requirements for feasible mine reconnaissance and clearance in the VSW region (Clegg and Peterson, 2003). The next section describes the acquisition approach for obtaining UUV prototypes for evaluation.

C. ANALYSIS OF ALTERNATIVES

To identify viable courses of action for the VSW MCM Det and to analyze the then-current and future technology situation for small UUVs, an Analysis of Alternatives (AoA) was performed and a Sources Sought notice was announced to solicit interest from industry. In their report on VSW MCM, Clegg and Peterson state that “Navy VSW clearance divers, civil service engineers, and procurement and logistic specialists” participated in the AoA study (Clegg and Peterson, 2003, p. 3). Concurrent to the AoA, a Requirements Working Group (RWG) worked to generate and prioritize the operational requirement criteria for the small UUV. The RWG primarily consisted of military operators, various UUV and MCM subject matter experts, and officers familiar with the VSW MCM operation (Clegg and Peterson, 2003).

Following receipt of several letters of interest submitted by contractors and research centers, the requirements group conducted an extensive capability analysis. An accelerated procurement was initiated to acquire “limited numbers of two types” of UUV prototypes suitable for the VSW MCM reconnaissance task (Clegg and Peterson, 2003, p. 3). A down-select process followed, and the best available prototype was determined to be the Remote Environmental Monitoring Units (REMUS). The REMUS was born out of the engineering unit at the Oceanographic System Laboratory at Woods Hole Oceanographic Institution (WHOI) in the early 1990s and was the initial UUV in what became over time the MK 18 Family of Systems (FoS) (Ervin et al., 1996). Figure 4 shows the timeline of system development within of the MK 18 FoS. (The SAHRV and the Sculpin were earlier models of small man-portable REMUS UUVs and were tested and fielded by the Navy.)

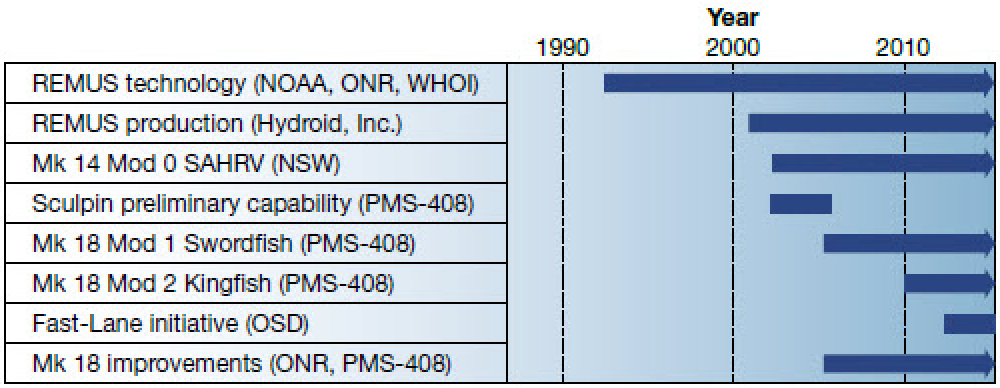

Figure 4. UUV acquisition timeline. Source: Johns Hopkins APL Technical Digest (2014).

One vital recommendation the AoA study offered was to implement a UOES effort for the UUV program. The purpose of the UOES is to deliver technology to the end user for evaluation as early in the acquisition life cycle as possible. In this case, the Fleet end user would evaluate the UUV prototype by utilizing it in an operational environment. Recommendations from the end user would feed the requirements and specifications for production of the system (Clegg & Peterson, 2003).

Two REMUS vehicles underwent the UOES process by the VSW MCM Detachment, the assigned UUV Technical Representative, and VSW MCM Det UUV Platoon. The two vehicles were identical with the exception of side scan sonar frequencies, which would be compared for efficacy during the UOES (Clegg & Peterson, 2003). The UOES effort continued after the VSW MCM Det became the operational Naval Special Clearance Team One (NSCT 1). The programmatic documents that outline the concept of operations for the VSW MCM Det and the implementation plan for UOES are discussed in the next sections.

D. CONCEPT OF OPERATIONS

In 1997, a Concept of Operations (CONOPS) for Development and Employment of the VSW MCM Det was co-signed by the Director of Expeditionary Warfare Division N85, Program Executive Officer of Mine Warfare, Commandant of the Marine Corps, and the Commander of the Naval Special Warfare Command. The CONOPS begins with a review of the problems faced by the Fleet in the 20th century. These include: threats posed by a sophisticated arsenal of naval mines from adversaries, increased danger to divers and marine mammal systems (MMS) engaged in tactical efforts to remove the mine threats, and lack of autonomous systems with sensors and neutralization capabilities to replace the divers/MMS. The CONOPS then discussed the fundamental concepts for the VSW MCM Det operations (Department of the Navy Commander Mine Warfare Command [DON], 1997).

The primary mission of the VSW MCM Det, comprising a Diver Platoon, a Mammal Platoon, and a UUV Platoon, was to implement a small unit of equipped and specially trained forces for "low visibility" mine exploration and recovery operations. These operations were to be conducted in the VSW with emphasis on non-permissive environments. According to the CONOPs, the core focus for the VSW MCM team was to develop and maintain the following capabilities: verifying the presence of mines in designated areas of the VSW; identifying and reacquiring mine-like contacts in the VSW; preparing large obstacles and mines for neutralization in the VSW, and delivering VSW mission data to the Commander, Amphibious Task Force (CATF) (DON, 1997, pp. 6–7).

The CONOPS also identified the VSW MCM Det's role during both peacetime and in amphibious operations and rehearsals. During Peacetime, the VSW MCM Det was to serve as a component of the Navy's MCM forces (as stated in the Mine Warfare Plan), test and evaluate prototypical equipment to further their utility and operational potential, and participate in fleet MCM exercises and regular fleet training for development and refinement of VSW MCM tactics. During operations, the VSW MCM Det was to be available on short notice (within 48 hours) to deploy to an embarkation point assigned by CATF, and in rehearsal for these operations, the combat forces were to train in tactics and equipment so that operational tasks could be carried out collectively (DON, 1997, p. 7).

Three objectives for the development of tactics in VSW MCM missions were discussed in the CONOPS (DON, 1997, p. 8). The first objective was to limit the search area for divers and marine mammals. Obtaining maximum benefit in the area being searched requires detailed planning, use of large area mine detection systems, and human intelligence. The second objective was to utilize the best VSW MCM systems for the anticipated environment. Equipment and tactics could then be refined from lessons learned in previous missions. Increasing search rates while decreasing transit time were included as efforts to pursue under this objective as well. The last objective was to reduce diver vulnerability, specifically through employment of low-visibility tactics in the near term and autonomous systems in the mid to long term.

The CONOPS also identified objectives in the near, mid, and long term for the use of diver, marine mammal, and autonomous systems (DON, 1997, pp. 14–15). Of particular interest are the objectives for autonomous systems. The near-term objective was to conduct Advance Technology Demonstrations (ATD) for those systems validated by the VSW MCM Test Detachment. Mid-term, the objective for the VSW MCM Det was to evaluate prototype autonomous systems that could potentially reduce dependence on divers and marine mammal systems and improve neutralization capabilities. The far term objective was to deliver mature autonomous systems to the VSW MCM Det for incorporation into tactics and to eventually eliminate the need for divers and marine mammals, enabling unmanned, full-mission profiles to perform mine reconnaissance and neutralization operations. Under this objective it was stated that the VSW MCM Det would be required to operate these specialized autonomous systems. The next section discusses the Memorandum of Agreement, which outlined the responsibilities, schedule, and other purposes for evaluating and operating the prototype UUV during the UOES.

E. MEMORANDUM OF AGREEMENT

A Memorandum of Agreement (MOA) between the program office (Program Executive Office for Mine and Undersea Warfare, Explosive Ordnance Disposal Group ONE (PMS EOD)) and the Fleet operational units (Commander, Explosive Ordnance Disposal Group ONE (COMEODGRU ONE) and the VSW MCM Det) was implemented in March 2001 to ensure that the UOES effort was organized. The MOA also represented clear leadership buy-in from the Program Office (PMS EOD) and Operational Command (COMEODGRU ONE), which is essential to keeping a program on its feet (Mine Warfare Association & NAVSEA, 2012). This document delegated organizational responsibilities, defined objectives, established a schedule, identified the resources needed, and listed reports needed from the phased user evaluation (Clegg & Peterson, 2003). Additionally, it provided an overarching evaluation plan for the 18 month UOES phase of the UUV development cycle. The MOA (Program Executive Office Mine and Undersea Warfare [PMS EOD], 2001, p. 3) stated that "the evaluation of the UOES would form the foundation for the refinement of the requirements document and the system performance specification."

The Memorandum also explained that a key component to the successful evaluation of the UOES would be the ability of the team to successfully maintain and execute a routine schedule of mission operations, test, and evaluation events. The schedule was estimated to include three in-water days of operations a week, with the objective of at least 12 in-water days a month. The intent of this regimen was to ensure that the necessary quality and quantity of data for fulfilling the objectives of the evaluation period would be provided (PMS EOD, 2001).

As stated earlier, the MOA defined the responsibilities for the commands (PMS EOD, VSW MCM Det and Unmanned System Platoon, and COMEODGRU ONE) involved in the UOES. PMS EOD was responsible for the development of the UOES Evaluation Plan and for providing all UUV equipment and hardware required for evaluation. This command was also responsible for submitting quarterly lessons learned reports documenting operation results, performance, and failures; two interim UOES Progress Summary Reports; and a final UOES Progress Summary report to the required recipients (COMEODGRU ONE, VSW MCM Det, PMS-EOD). Each of these reports, prepared by the VSW MCM Det to support the UUV Acquisition Strategy, entailed a status on basic objectives as developed in the UOES evaluation plan; specifically, system requirements determination, suitability factors, and the development of UUV employment concepts (PMS EOD, 2001, p. 7). Another crucial task was ensuring that a certified UUV Technical Representative (TECHREP) was on-site 24/7 and available for duty when a UOES event was scheduled.

The VSW MCM Det was responsible for providing a minimum of five full time, trained military personnel to support program success. The Detachment was tasked with providing non-UUV unique equipment and hardware such as boats and dive gear, in addition to establishing and maintaining the UUV training minefield. They also provided operation planning expertise for Fleet exercises involving the UOES and ensured that the TECHREP was fully integrated into Fleet exercises in terms of preparation, planning, and execution. The TECHREP's responsibilities as outlined in the MOA (PMS EOD, 2001, p. 4) included acting as the operation and maintenance UUV Subject Matter Expert (SME) and performing UUV data collection through the performance tracking module of the UOES database. In addition, the TECHREP served as the liaison between the VSW MCM Det and UUV manufacturer and coordinated with PMS-EOD and the VSW MCM Det crew for any related UUV issues on-site. In these tasks, the TECHREP lessened the administrative burden of Fleet operators.

COMEODGRU ONE was responsible for providing timely information to PMS-EOD regarding annual fleet exercises so that developmental testing could be planned to meet the exercise schedule. Because COMEODGRU ONE had administrative control over the VSW MCM Det's involvement in the UOES, requests for VSW MCM Det in additional exercises beyond the annual fleet exercise were coordinated with PMS EOD (PMS EOD, 2001). The next section details the Fleet Evaluation plan which specified guidelines for the UOES.

F. FLEET EVALUATION PLAN

The Search-Classify-Map UUV Fleet Evaluation Plan (2001) outlined the basic guidelines for the UOES. The objective of the UOES phase was to gain insight into the best use of small UUV systems in Fleet operations and to support an accelerated acquisition for first generation UUV systems in VSW MCM operations. "Early fleet engagement and feedback" in the accelerated acquisition process was identified as the main priority and purpose of the UOES (Program Executive Office Mine and Undersea Warfare [PMS EOD], 2001). Three objectives were detailed in the evaluation plan. Objective One, Performance Requirements, focused on refining the initial requirements and establishing details for developing a performance specification. This was to be accomplished through continuous data collection on performance capabilities, limitations, and lessons learned through UOES. The intent of Objective Two, Suitability and

Supportability Requirements, was to identify suitability and supportability requirements for the employment of UUV systems, to assist in determining maintenance and training plans, and in setting realistic thresholds for performance, reliability, maintainability, and availability for future UUV systems. The third objective, Employment Concepts, was centered on 1) examining the best tactical employment method for small UUV prototypes to improve safety and efficiency and 2) examining the UUV systems ability to interoperate with diver and marine mammal platoons. The desired outputs of this objective were a basic tactical memorandum and guidelines for employment that would serve as the reference point for follow-on capabilities. The evaluation plan also provided guidelines for the day-to-day use of the UUVs during the initial 18-month UOES period which consists of seven phases (PMS EOD, 2001, p. 1). These seven phases are described in the next section.

G. USER OPERATIONAL EVALUATION SYSTEM IN MK 18 REQUIREMENTS DEVELOPMENT

The UOES was implemented through seven phases, Phase A through G. The first phase, Phase A, involved vendor supplied training for equipment familiarization and the basic operations of the REMUS UUV (the civilian version of the MK 18 Mod 1) during early June 2001 (Clegg & Peterson, 2003). As indicated in the VSW MCM report by Clegg and Peterson, the phase lasted about ten days and the VSW MCM Detachment participated in classroom lectures, hands-on training, and daily open-ocean training missions. By the end of this phase, operators had begun to operate the UUVs without vendor assistance. Mission data was recorded in the UOES database on a weekly basis and the phase concluded with a lessons learned summary composed by the Unmanned System Platoon of the VSW MCM Det.

Phase B covered current baseline tactics and the comparison of the side scan sonar on the two vehicles (PMS EOD, 2001, p. A-1). A key finding of this phase was that while one frequency side scan sonar offered longer range, it did not provide high resolution hydrographs. The other frequency side scan sonar had limited range but higher quality resolution. Per the Clegg and Peterson report, another focus of Phase B was to determine the ideal "search geometry for conducting Search, Classify, Map (S-C-M)

MCM missions under different environmental and tactical conditions" (Clegg & Peterson, 2003, p. 4). During this phase, the Platoon carried out two real-world operations. One operation surveyed several sites in the Hawaiian Islands, where the Platoon successfully surveyed underwater boat mooring sites and gained insight regarding side scan reading in coral growth environment. The second was a survey of the San Diego Aircraft Carrier Basin, after the September 11th terrorist attacks. The Platoon accomplished a survey of the entire basin in one night, in preparation for the docking of two aircraft carriers. Aside from analysis of data and manpower, maintenance requirements, and training efficiency, the output of this phase was a set of Standard Operating Procedures (SOPs) for the UUVs which included contingency procedures, based on the mission results (Clegg & Peterson, 2003).

Phase C, Concept of Operations Variations, centered on missions that would gauge the reliability of the UUVs and record information on the mean time between failures during long duration missions (Clegg & Peterson, 2003). According to the Clegg and Peterson report, findings during this phase identified a corrosion-related degradation of material in the motor framework and navigation transducer. The manufacturer was able to utilize a different material that counteracted the corrosive effects of salt water on these critical components. This failure mode would not have been revealed until production if it weren't for the time dedicated to UOES. An underwater survey was conducted during this period, off the shore of Camp Pendleton, CA, to identify an area of ocean bottom type suitable for testing. The crew first launched the REMUS from a small craft and then "returned to a standby position at a small boat harbor within 15 minutes of the operations area" (Clegg & Peterson, 2003, p. 5). The crew remained in control over the vehicle via a radio tracking buoy system while the eight hour survey was conducted. This tracking system also enabled the crew to "send an abort signal to the vehicle to return it to the recovery point" if necessary (Clegg & Peterson, 2003, p. 5).

Phase D, Integration Operations, evaluated the UUV's compatibility with existing Navy Mine Warfare VSW MCM Det systems, such as the Navy's Mine Warfare Environmental Decision Aid Library (MEDAL). In November 2001, an exercise off of Camp Pendleton's coast incorporated the three Platoons (COMEODGRU ONE, VSW

MCM Det, PMS-EOD) and generated important lessons learned in regard to how well the UUVs exchanged information. According to the Clegg and Peterson report, some compatibility issues with processing large MEDAL messages from REMUS were identified but these were quickly addressed and fixed by the contractor (Clegg & Peterson, 2003). By including all of the units in the exercise, leadership was exposed to the technological capabilities of the UUV. Seeing the UUV in operation along with the mine intelligence and environmental data it collected brought confidence as to the utility of vehicle as a mine-hunting device. This phase also included the discovery of the need to enable cooperation between the navigation hardware of both "the UUV and the diver navigation system" (Clegg and Peterson, 2003, p. 5). The intent of the interoperability effort was to reduce diver navigational errors associated with reacquiring targets already located by the UUV. Although additional modifications and work were needed, this phase provided fundamental insight into the UUV system requirements and improvements.

The purpose of Phase E, Environmental Conditions, was to verify that equipment operated as needed throughout the range of probable environmental conditions (Evaluation Plan, 2001, p. A-1). Test locations were chosen based on similar features (bottom type, salinity, water temperature, current, etc.) to the anticipated operational deployment sites. A "cold water vehicle duration test" conducted off of Whidbey Island, Washington in March 2002 during this phase emphasized another key benefit of the UUV system over humans or marine mammals (Clegg & Peterson, 2003, p. 6). The elements (winds, snow, and water temperature) had no effect on the UUV and other than the brief launch and recovery of the vehicle, human operators were able to remain at the command post to monitor the operation from a safe distance. Another test in the Persian Gulf was conducted in high temperature and high salinity water. The warm water test demonstrated that the UUV had capability in a geographic area where "the U.S. Navy has had extensive real world MCM experience" (Clegg & Peterson, 2003, p. 6). Additionally, this phase included a human factors study for equipment handling and system launch and recovery. The purpose of this study was to evaluate, identify, and resolve any possible human interface issues with the UUV system (Clegg & Peterson, 2003).

Phase F comprised blind tests that were conducted during the warm and cold water tests mentioned above. These tests aided in determining the Platoon's ability to achieve mine hunting performance metrics without knowing the location, quantity, or type of mines (Clegg and Peterson, 2003). The central purpose of the blind tests was to collect "accurate data on system classification and detection capabilities, as well as false alarm rates" (Clegg and Peterson, 2003, p. 6). One of the three tests served as an engineering evaluation of the UUV, wherein its location accuracy and its ability to repeat navigations were tested. This test also showed the operators' skill in distinguishing between actual targets and the distractors that were purposely placed in the search field (Clegg & Peterson, 2003).

In Phase G, Fleet Exercises, the objective was to demonstrate shipboard deployment of the UUV Platoon. The UUV Platoon participated in "major naval exercises and Fleet Battle Experiments," where the emerging UUV capabilities and concepts were shared with the surface Navy (Clegg & Peterson, 2003, p. 6). They are discussed in detail below.

The first of the exercises, Exercise Bank Shot, deployed the UUV from a high-speed vessel (HSV-X1) in cold waters off of North Carolina. The HSV-X1 provided support as a platform for experimentation in launching various MCM systems during several Fleet Battle Experiment exercises, including the REMUS UUV (Gallup et al., 2003). The UUV again demonstrated operability in cold water temperatures, however, it was observed that the internal battery charging system would not work until the temperature inside the UUV reached a certain degree (Clegg & Peterson, 2003, p. 6). With credit to the UOES, this discovery was made on the prototype and not the production model, and the resulting necessary changes to specifications were made before delivery of the final model to the fleet.

The second exercise was part of Rim of the Pacific (RIMPAC), wherein the mission was to "clear a landing zone prior to an amphibious assault on a simulated enemy shore" in Kauai, Hawaii (Clegg & Peterson, 2003, p. 7). In June 2002, the VSW MCM Det deployed to Oahu and Kauai for several weeks of workups before the MCM portion of the exercise (Clegg & Peterson, 2003). Divers from the U.S., Canada, Australia, and

Britain also participated; providing an important opportunity for the VSW MCM Det to share the UUV concepts with other nations MCM forces. The experience gained from the RIMPAC exercise and the validation of techniques were vital for the progress of the UUV Platoon and NSCT-1.

Directly after RIMPAC, the UUV Platoon returned stateside for an Office of Naval Research technology demonstration entitled Fleet Battle Experiment Juliet (FBH-Juliet), again operating from HSV-X1 to demonstrate the ability of the REMUS to receive and execute commands from a control ship, and to transmit operational data from a minefield. The HSV and REMUS operated remotely from Fleet operator control onboard a ship. The REMUS demonstrated the ability to process contact data and send that data to the HSV through an acoustic modem and radio frequency. This data was returned to the command center on the ship (Clegg & Peterson, 2003). The exercises also proved REMUS' capability to conduct a mission using a GPS. The UUV Platoon provided fleet feedback and recommendations for the UOES vehicles based on these experiments.

The success that the VSW MCM Det saw during the UOES period led to the establishment of Naval Special Clearance Team ONE (NSCT-1) in 2002. In 2003, NSCT-1 was deployed to lead the Underwater Mine Countermeasures (UMCM) efforts in Operation Iraqi Freedom (R3 Strategic Support Group, 2019). As stated in the Clegg and Peterson report, NSCT-1 was tasked with assisting in clearing several Southern Iraq ports of mines in order to deliver humanitarian aid (Clegg & Peterson, 2003, p. 7). The report further provides that the NSCT-1 landed in Umm Qasr on 24 March 2003 and conducted mine search and clearance operations for eight days to clear that port. Though conditions were challenging, with narrow time windows available to use the UUV each day due to strong currents and a harsh bottom type, the team was ultimately able to clear the port of mines. Further assignment was given to the team for search and clearance operations at the Az Zubayr port. These NSCT-1 operations were accomplished within only two days after arrival. Shortly thereafter, the first relief ship carrying emergency supplies for the Iraqi people arrived safely at the port facility of Umm Qasr (Clegg & Peterson, 2003). The clearance missions of Operation Iraqi Freedom saw the successful introduction of the UUV into the mine warfare field and further validated the concept of the UOES. Because of thorough testing and evaluation in a variety of environments during the UOES, and continuous interaction between the operators and Program Office, a comprehensive understanding of the UUV technology and standard operating procedures for a variety of scenarios were achieved.

H. SUMMARY

This chapter began with an overview of Navy mine countermeasures activities that stimulated the establishment of the VSW Very Shallow Water (VSW) MCM Detachment, which in turn led to the UOES testing for the MK 18 Mod 1 accelerated acquisition program. There was a discussion of some of the early Navy UUVs and how the Navy arrived at selecting the REMUS vehicle for the UOES test and evaluation. This chapter also described the importance of the programmatic documents (CONOPS, Memorandum of Agreement, and Fleet Evaluation Plan) that solidified the plans for the VSW MCM Det UUV UOES. Finally, the distinct phases of the UOES and how each contributed to the requirements development process for the accelerated acquisition program were covered. The next chapter presents the methodology used to obtain and analyze the data and discusses the selection of interview participants.

IV. RESEARCH METHODOLOGY

A. INTRODUCTION

This chapter presents the methodology used to obtain and analyze the data of this research. It also presents the sources of the data, interviews with four subject matter experts and a relevant 2015 case study provided by several of the interviewees. The types of data are responses from interviewees and selected excerpts from the case study. Finally, this chapter explains how the data will be analyzed.

B. SOURCE OF DATA

The source of data is interviews held through phone calls and emails. I asked the interviewees to reflect on their experiences during their involvement with the Mk 18 Mod 1 program through six interview questions. The purpose of these interviews was to collect data and determine lessons learned and best practices from the Mk 18 Mod 1 program in addition to the takeaways gathered during my research. The respondents provided a detailed case study, "Expeditionary UUV Systems for Mine Countermeasures," (Nagle et al., 2015), that three of them were greatly involved in. This case study provided much of the foundation for the data collected.

Participants for this study were selected based on their involvement in different aspects of the program's requirement development process and the implementation of the UOES. The individuals interviewed hold distinctive qualifications in that they are in positions to provide unique insight and give accounts of the program this research focuses on. The interviewees desired for this study met the following criteria:

- They possessed a background in Program Management, Science and Technology, Test and Evaluation, or Fleet employment of the UOES effort that preceded MK 18 Mod 1 fielding.
- They were experts in the field of Navy acquisition, especially small systems, and its supporting disciplines.

I obtained contact information for these individuals through professional networking. No personally identifiable information was maintained or published in this report. The study design was submitted to the Naval Postgraduate School Institutional Review Board (IRB) for review. It was determined by the IRB that this method did not constitute human subject research on 20 December 2022.

C. DATA COLLECTION

This study was conducted through interviews on an individual basis. Four persons were identified as meeting the criteria and four persons were available for interview. The overall aim of this study was to evaluate the impact of the UOES on the MK 18 Mod 1 accelerated acquisition effort and requirements development. Questions were designed to elicit detailed responses and to allow interviewees some flexibility in responding. I also formulated the questions to eliminate bias to the maximum extent possible. Furthermore, I was interested in what the interviewees found to be the most important aspects of the requirements development process and the implementation of the UOES for the Mk 18 Mod 1 program. I asked the individuals to participate in this study through email notification. Interview questions were provided in the email so that the individuals could determine if they were interested in participating. Interviews took place via email and telephone. The one telephone interview lasted approximately 30 minutes.

D. DATA ANALYSIS

After the interviews were completed, I compiled the notes from all participants. I also evaluated the case study to identify pertinent passages and information that highlighted the issues of interest. After reviewing the summary of the data, I grouped it into categories based on consistencies revealed through common responses to the interview questions.

E. SUMMARY

This chapter presented the methodology used to obtain and analyze the data of this research. It also presented the sources of the data, interviews with four subject matter experts and a relevant 2015 case study provided by several of the interviewees. Finally, this chapter explained how the data will be analyzed. The findings from the data analysis and recommendations to help improve the requirements development process for the Navy and DOD are presented in the next chapter.

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V. FINDINGS AND RECOMMENDATIONS

A. INTRODUCTION

This chapter presents the findings of this research on the requirements development process and application of the UOES for the MK 18 Mod 1 using the data obtained from interviews and the case study (Nagle et al., 2015). Following the presentation of the findings is a discussion of the implications of the findings. Finally, the analysis leads to recommendations that will help improve the requirements development process for the Navy and DOD based on insights gained during this research and interviews.

B. INTERVIEW RESPONSES

Respondents frequently referred to the case study "Expeditionary UUV Systems for Mine Countermeasures" (Nagle et al., 2015), and one respondent stated that all of his answers and comments were reflected in the case study. Three of the respondents contributed heavily to the development of the case study. Consequently, this summary of the responses will address the questions first from a synopsis of what was presented in the case study, and then use the respondents' answers to add to or clarify the case study information.

Interview Question One: Briefly describe how the MK 18 Mod 1 System-specific requirements development process worked, beginning with identification of the over-arching Operational Requirements.

Case Study: During Operation Desert Storm, U.S. operations plans were hindered by a lack of MCM capabilities. The planned amphibious assault to free Kuwait never occurred (Nagle et al., 2015, p. 7). In the aftermath, capability gaps were recognized—there were virtually no suitable pre-assault MCM capabilities in the Very Shallow Water (VSW) and Beach Zones (BZ) (Nagle et al., 2015). This highlighted existing gaps in Doctrine, Equipment, and Technology, and motivated the Navy to address the lack of VSW MCM capability. A 1994 NSW post-war analysis by Naval Special Warfare determined that the most effective and suitable alternatives for correcting longstanding VSW MCM capability deficiencies were: Divers equipped with improved systems, specially outfitted marine mammal systems (MMS), and tactically integrated, easily deployable unmanned vehicles (Nagle et al., 2015, p. 13). Unmanned systems were recognized as solutions enabling transformational concepts. A UOES-based accelerated acquisition approach was selected to meet the need for VSW reconnaissance and clearance. Requirements Working Groups with heavy Fleet involvement were embedded in the Analysis of Alternatives efforts to identify the best technological candidates. General requirements were identified and agreed upon by the OPNAV sponsor who gave permission for a UOES-based accelerated acquisition effort to refine Unmanned Systems technology and requirements, and meet those requirements. The approach to requirements identification and system development was "build-a-little, test-a-little," following the spiral development model in which the baseline system was steadily improved over several pre-planned product improvements (Nagle et al., 2015, p. 54).

Summary of Responses: The over-arching requirement evolved from U.S. forces not being able to conduct an amphibious operation in support of Operation Desert Storm, i.e., put Marines on the Kuwaiti beaches due to the presence of sea mines in the shallow and very shallow water regions. Existing surface and airborne MCM sensor/navigation suites/platforms weren't suitable for VSW mine detection, location, and neutralization. Operational capability, equipment, and technology gaps demonstrated during Operation Desert Storm highlighted the need for underwater technology that could detect the presence of sea mines in SW and VSW regions. These gaps evolved into an accelerated acquisition requirements document that was validated and approved by the OPNAV resource sponsor.

Interview Question Two: What principal factors affected the Requirements development and approval process (e.g., performance parameter identification, Fleet involvement, technology maturity, UOES concept, test/evaluation feedback, sponsor relations) and how?

Case Study: The principal problem was that even though the need was identified, the top-level and detailed requirements were not yet fully known or articulated. The

UOES development and testing efforts would inform requirements development efforts as to what viable capabilities were within reach. The approach was "walk-then-run"—identify and down-select the most mature alternative that met the basic requirements known at the time, with follow on options (Nagle et al., 2015, p. 34)—and then improve, integrate, and test the UOES. This provided feedback regarding general and detailed requirements along with development goals and timelines. Some key requirements were left as "To Be Determined" (TBD), pending further experiment, test, and exercise results. Sponsor-validated requirements and ONR and Program Office concurrence on goals (e.g., exit criteria, metrics, etc.) were all documented in Technology Transition Agreements (TTAs) or similar agreements and were pursued as key ingredients for success (Nagle et al., 2015).

Summary of Responses: All the factors highlighted above impacted the ultimate requirements documents and prototype development. Fleet involvement and technology maturity developed from ONR S&T initiatives reduced overall acquisition risk. Additionally, specific performance parameters that were not fully understood or had not yet been demonstrated were left as "TBD" and were ultimately determined as the program matured, i.e., through T&E or technical analysis.

Interview Question Three: What were the key roadblocks or impediments to the MK 18 Mod 1 System Requirements development process?

Case Study: The primary impediment to MK 18 Mod 1 requirements development was that the top-level requirements were not directed by the sponsor in the hope that testing and exercise results would inform the requirements development process and minimize technical risk. Consequently, identification and recommendation of achievable, beneficial thresholds on the part of the development team was difficult and required an iterative negotiating process to arrive at acceptable requirements (Nagle et al., 2015). Even though the issues of requirements creep and imposition of new requirements were not problematic during the MK 18 Mod 1 UOES effort, the effort had to undergo a "requirements discovery" process alongside the conduct of field testing and exercise events (Nagle et al., 2015, pg. 76). This process was necessary to find a balance of achievable threshold values and ensure these thresholds were set high enough to provide value to the Fleet and merit sponsor buy-in. To minimize technical risk, requirements thresholds that were "good enough" were initially identified, as opposed to better or ideal performance and suitability requirements. Some goals were pushed over to the next planned increment in anticipation of improved technology and this-increment test results (Nagle et al., 2015).

Summary of Responses: Impediments to the requirements development process included the lack of actual warfighting field employment of the subject technologies, i.e., unmanned systems, precise underwater navigation, acoustic based sensors for mine identification, etc. Additionally, unmanned systems and technologies had not actually been employed or fielded in the warfighting domain before.

Interview Question Four: How were the key roadblocks or impediments overcome and how did they affect the end product?

Case Study: The approach taken was to develop and demonstrate lower risk UUV-based technologies to incrementally satisfy mission requirements in the near term, coupled with early and sustained end user engagement. Longer term efforts concentrated on development and proving of a "system of systems" concept to ultimately remove divers and marine mammals from dangerous VSW/SZ MCM operations (Nagle et al., 2015, p. 23). Prototyping and experimentation informed the requirements development process and identified the capabilities and limitations of early prototypes. ONR experimentation objectives supported this by expediting the fielding of emerging "MCM technologies with emphasis on near shore operations and the use of unmanned vehicles" (Nagle et al., 2015, p. 25). Operational prototyping informed the acquisition/S&T team of more detailed requirements for follow on increments and assisted risk mitigation. In addition, Fleet advocacy for operational requirements and Organic MCM Future Naval Capabilities (FNC) initiatives promoted program objectives (Nagle et al., 2015, p. 25). The military utility of prototype systems was validated and improved by incorporating Fleet perspectives into developmental refinements. This supported the UOES "buy-then-fly" approach, while early engagement of the Fleet in the acquisition process, along with operational prototype deliveries, enabled tactics evaluation and feedback on Fleet employment concepts. Fleet engagement also addressed and mitigated concerns related to requirements refinement, affordability, suitability, and logistics supportability (Nagle et al., 2015, p. 33). The acquisition/engineering team-oriented Analysis of Alternatives (AoA) working groups were instituted with concurrent user-based requirements working groups (RWG). A Memorandum of Agreement (MOA) was implemented between the acquisition team and Fleet leadership that focused on small, incremental steps. This MOA was reflected in a structured, phased UOES plan supported by Fleet representatives. Operational prototyping informed the acquisition/S&T team on more detailed requirements for follow-on increments and assisted risk mitigation. Routine progress reports were initiated (monthly initially, quarterly once up and running). The whole process culminated in an independent User Evaluation conducted by a Navy University-Affiliated Research Center (UARC) -based independent test and evaluation agent (IT&EA) Johns Hopkins University Applied Physics Laboratory (JHU/APL).

Summary of Responses: None of the respondents chose to specifically address the issue of how the roadblocks to requirements development were overcome.

> **Interview Question Five: The MK 18 Mod 1 UOES process provided critical, early feedback to the acquisition community and manufacturers, technologists, and the Fleet on areas where more refined requirements and focused testing were required. Describe how the UOES requirements and testing processes benefited the following groups: Acquisition Team; Technologists; Fleet End Users; Program Offices; and Other.**

Case Study - Acquisition Team (PM, KO, Stakeholders): The MK 18 Mod 1 UOES process, including requirements and testing, formed the basis for designing and conducting industry days. It also enabled acquisition risk reduction through development of effective source selection criteria and promoted user and resource sponsor buy-in to the acquisition process (e.g., contract down select, industry day participation, etc.). It enabled contract design (e.g., inclusion of engineering enhancement clauses) to address pre-planned product improvements (P3I) (Nagle et al., 2015, p. 65). The UOES process engaged Fleet users, the resource sponsor and acquisition office in a systematic, phased evaluation of prototypes for operational utility, suitability, and supportability (Nagle et al., 2015, p. 34). It supported the maturation of evolving concepts of operation (CONOPS) among stakeholders, operators and technology/acquisition teams and identified P3I needs for future improvements (Nagle et al., 2015, p. 62).

Case Study – Technologists (Engineers, Scientists, ONR): The MK 18 Mod 1 UOES process, including operational prototyping, informed the acquisition/S&T team on more detailed requirements for follow on increments. It promoted synergistic partnerships between S&T, acquisition, and requirements teams (Nagle et al., 2015, p. 82). It kept ONR informed of technology issues/improvements needed and enabled more rapid fielding of military capability to the forward theater (Nagle et al., 2015, p. 73).

Case Study - Fleet End Users: UOES and operational prototypes were procured and provided to the Fleet to aid in early engagement of Fleet in acquisition. This strategy put novel military systems in the hands of the warfighter in the early stages of a lengthy acquisition process, thereby enabling more rapid fielding of military capability to the forward theater (Nagle et al., 2015, p. 73). It also ensured that when delivered, the MK 18 Mod 1 had been vetted for tactics, capabilities, and suitability and a cadre of trained operators was available to utilize it quickly (Nagle et al., 2015).

Case Study - Program Office (PMS 495, EOD, Oversight/MDAs): The UOES process ensured that the Program office was informed over the conduct of the process and postured the program for more rapid fielding of military capability to the Fleet users (Nagle et al., 2015, p. 73). It provided a high return on investment, in that it delivered operational prototypes to the Fleet nine months after the start of the program, implemented a data collection process to provide an empirical basis for a refined operational requirement, and ensured that Fleet user involvement was planned, supported, and sustained (Nagle et al., 2015, p. 32).

Case Study – Other: The early successes by operational commanders enabled by the UOES process reinforced among stakeholders (Resource sponsors, TYCOMs, etc.) the "achievability" of results and the benefit of accelerated acquisition programs (Nagle et al., 2015, p. 66). In addition, the continuous flow of communication between end users, the acquisition team and developers encouraged the exchange of critical information about effectiveness, ruggedness, operability, interoperability and tactical integration/ CONOPS (Nagle et al., 2015, p. 42).

Summary of Responses: All of the subject stakeholders benefited through employment of the subject technologies (i.e., operational prototypes developed from the ONR S&T development process). The Fleet was able to develop first generation requirements and a notional concept of employment through testing in relevant operational environments. Using these prototypes in relevant operational environments highlighted capabilities and limitations of the subject technologies for the subject mission area. This enhanced the value of operational testing and the evolution of the relevant technologies and source selection criteria that was used in the contract award process.

Interview Question Six: What lessons learned and best practices for accelerated acquisition system requirements development process can be gleaned from the use of the UOES in this accelerated acquisition?

Case Study: The Case Study identified various best practices, which are discussed in more detail below.

The first best practice identified by the Case Study is to develop clear/quantifiable performance metrics/exit criteria. This would include forming technical working groups within the project team and engaging Fleet, ONR and other technical SMEs in AoA studies to assist in identifying these metrics and criteria (Nagle et al., 2015, p. 53). This may also include continuous technology transition program planning to ensure technology changes can be accommodated and that first generation system design allows for system level upgrades (Nagle et al., 2015, p. 80).

The next best practice is to use internal USN organizational relationships to reduce acquisition risk. This would include establishing and maintaining a consistent relationship with relevant program stakeholders and engaging the USN S&T organizations to understand technology maturity and "application specific" risk areas. This best practice may also involve promoting the cause and future direction for the program through the use of Strategic Plans and Technology Transition Agreements (Nagle et al., 2015, p. 79).

The third best practice presented by the Case Study is to challenge industry to demonstrate the ability to perform and improve to meet requirements. This means utilizing industry days to engage industry early in the acquisition life cycle and to identify "high risk" effectiveness and suitability requirements. This may also involve the use of selected technology demonstration events (AUVFests, etc.) to identify emerging capabilities. Finally, this best practice should include the analysis of proposals to establish a competitive range of a small number of vendors for contract award (Nagle et al., 2015, p. 80).

The last best practice from the Case Study is to employ a structured UOES. The application of the UOES could be valuable if the technology application in the intended mission area is immature. A UOES phase of a minimum of six months will aid the refinement of operational requirements, generate first generation tactics, techniques, and procedures and will establish a user perspective on future system acquisitions. This best practice should include establishing a systematic method for gaining "near real-time" user perspective throughout the system life cycle. This best practice also involves ensuring that the Fleet operator's voice is heard throughout the UOES process, initial operational employment, and beyond (Nagle et al., 2015, p. 81). The research identified that operator feedback is crucial to requirements development and refinement.

Summary of Responses to Interview Questions:

The respondents identified several lessons learned from experience and two best practices in their responses, which are discussed in more detail below.

The first lesson learned is not to specify high-risk thresholds for requirements as "make or break," since these high-risk requirements can drive program cost growth and cause schedule slippages. Most often, at the outset of efforts to transition a system, it is not fully understood what is in the realm of possible in terms of metrics. Based on proof-of-concept technology demonstrations, an objective target for a metric (e.g., Probability of Detection, Classification, Contact Localization Accuracy, endurance, etc.) can be estimated. However, the objective is still likely an educated guess at what the minimum acceptable threshold should be.

Another lesson learned is not to define too many Key Performance Parameters (KPPs) or Key System Attributes (KSAs) in a requirements document (e.g., a Capability Development Document (CDD)). It is possible to change a KPP requirement later, but it requires re-staffing for approval, and a strong case for why it is being relaxed needs to be made. Even if a strong case exists, it delays the program. If there is trade space that would be acceptable, and uncertainty as to what the minimum acceptable threshold target should be—make it an Additional Performance Attribute (APA) or an Other Support Attribute (OSA). If the requirements review team finds this allowable, keep the threshold target TBD until enough information is obtained to set it at an achievable level that enables a "good enough" near-term material solution. The goal for the near-term material solution is one that addresses gaps in a manner that improves over current (legacy) capabilities.

A third lesson learned is not to cave into recommendations for every metric to be designated a KPP. KPPs should be discussed at the resource sponsor level as the requirement works its way through the process. There are mandatory KPPs (e.g., Survivability, Force Protection (FP), Sustainment, and Energy) which are necessary and difficult, and then there are selectively applied KPPs—the ones the program office determines are important to satisfying the system requirement for addressing the capability need. The number of KPPs should be minimized and discussed, debated, and whittled down to the essential one or two. The more KPPs there are, the more unlikely transition to acquisition will be successful.

One of the best practices for the MK 18 Mod 1 was maintaining requirements flexibility by specifying "TBD" for high-risk thresholds and allowing T&E to help identify what a reasonable target was for some of the key metrics. Characterizing performance through T&E helps to set the minimum acceptable level once more information is gained.

Finally, a second best practice was proven in the development of the contract structure, wherein the pre-planned product improvement concept was employed. Specifically, engineering enhancement CLINS and provisions were included in the contract so the Original Equipment Manufacturer (OEM) could easily modify the baseline configuration based on Fleet feedback and technical analysis. This gave flexibility to what was possible through the contract vehicle.

C. DISCUSSION AND IMPLICATIONS OF FINDINGS

A review of the responses revealed that they could be grouped into categories based on their applicability to different processes of Systems Engineering (SE). The SE practice is comprised of 16 processes: "eight technical management processes and eight technical processes" as shown in Figure 5 (Office of the Deputy Director for Engineering, 2022, p. 4). These 16 processes offer a structured method for increasing a system's technical maturity and the probability that "the capability being developed balances mission performance with cost, schedule, risk, and design constraints" (Office of the Deputy Director for Engineering, 2022, p. 4).

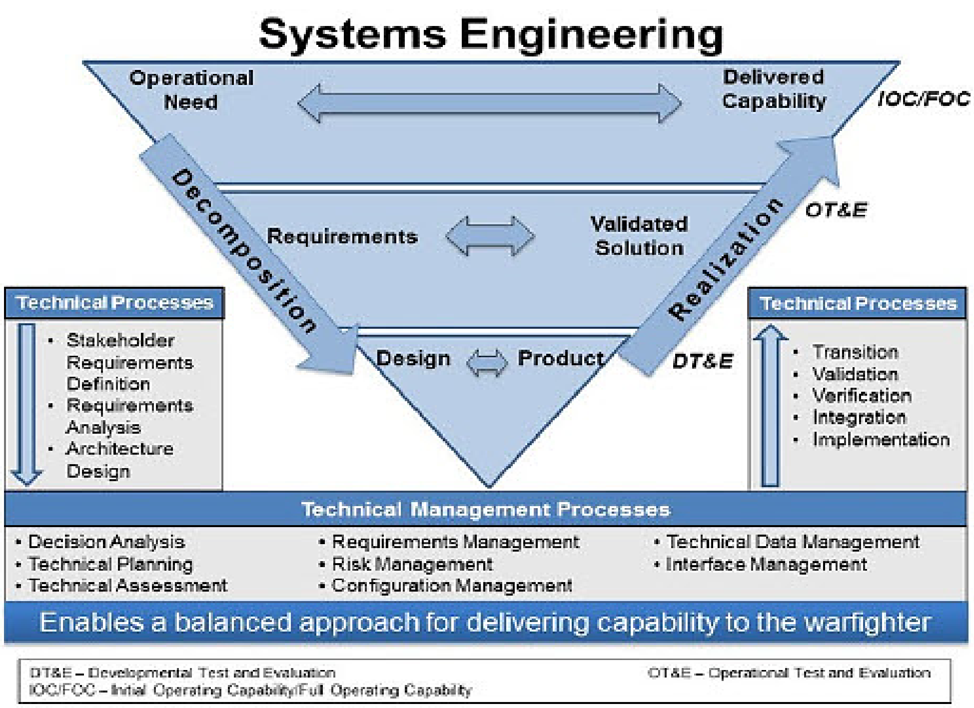

Figure 5. Systems Engineering Processes. Source: Systems Engineering Guidebook (2022).

Responses to Question 1 can be categorized under the "Stakeholder Requirements Definition" process. The responses and excerpts from the case study commonly referred to the capability gap in MCM capabilities, identification of an operational need, and development of top-level requirements. These activities are characteristic of the Stakeholder Requirements Definition process, wherein the Systems Engineering team translates operational "requirements from relevant stakeholders into a set of top-level technical requirements" (Office of the Deputy Director for Engineering, 2022, p.4).

Responses to Question 2 can be categorized as "Technical Planning." The case study referenced the strategy and approach for T&E (i.e., walk-then-run, and build-a-little, test-a-little), for both developmental and operational testing; characteristic considerations of the Technical Planning process (Systems Engineering Guidebook, 2022, p. 96). Technical planning should also anticipate the advancement of capabilities to meet changing threats, human performance requirements, technology insertion, and interoperability (Office of the Deputy Director for Engineering, 2022, p. 94). Both the case study excerpt and responses touched on these aspects of the Technical Planning process.

Responses to Question 3 can be grouped into the Decision Analysis and Risk Management processes of Systems Engineering. The case study describes the trade-off analysis in finding a balance of achievable threshold values and ensuring these thresholds were set high enough. Tradeoff analysis is a characteristic of the Decision Analysis process. Other key activities of Decision Analysis that were described in the case study are: recording, tracking, evaluating, and reporting decision outcomes (Office of the Deputy Director for Engineering, 2022, p. 15). Key activities in the Risk Management process are assisting in "risk, issue, and opportunity planning, identification, analysis, mitigation/management and monitoring" (Office of the Deputy Director for Engineering, 2022, p. 16). The case study referred to minimizing technical risk and the interview responses commonly listed the same risks (novel technology, no real-world field application). The case study also mentioned that to mitigate risk, some goals were pushed over to the next planned increment in anticipation of improved technology and test results. The responses also reinforced the idea of delaying high-risk thresholds until enabling technology was available.

For Question 4, the case study often referred to prototyping and experimenting, and thus can be categorized under the Implementation and Verification System Engineering processes. Implementation deals with development of the system design, prototypes, and realization of the system and system elements (Office of the Deputy Director for Engineering, 2022, p. 24). Features of the Verification process include "determining the system and system elements performance as designed through demonstration, examination, analysis and test" (Office of the Deputy Director for Engineering, 2022, p. 24). The case study and responses emphasized the importance of a highly regarded Independent Test and Evaluation agent to observe and sometimes direct test events.

The case study excerpt and responses to Question 5 can be categorized under the Validation and Transition System Engineering processes. The Validation process aids in evaluating the "effectiveness, suitability, and survivability of the system in meeting end-user needs" (Office of the Deputy Director for Engineering, 2022, p. 16). The Transition process aids in the planning and execution of delivery and deployment "of the system to the end user for use in the operational environment" (Office of the Deputy Director for Engineering, 2022, p. 24). The case study excerpt and responses frequently referred to the evaluation of the system in terms of meeting end-user needs and the fielding of the system in the operational environment.

For Question 6, the case study excerpts and responses can be categorized under both the Stakeholder Requirements Definition and Technical Assessment System Engineering processes. A common theme in the responses to Question 6 was tracking, measuring, and assessing metrics. These are key activities of Technical Assessment (Office of the Deputy Director for Engineering, 2022, p. 24). Additionally, the case study and responses commonly referred to translating operational "requirements from relevant stakeholders into a set of top-level technical requirements" (KPPs and metrics) which aligns with the activities of the Stakeholder Requirements Definition process (Office of the Deputy Director for Engineering, 2022, p. 24).

A review of the interview questions and what was gleaned from the case study and interviews have been analyzed to discuss the implications of the research findings which are presented below.

A primary implication from the findings is that the UOES process can be very useful in Accelerated Acquisition Programs. It provides hardware to the Fleet quickly and enables constant feedback loops between the acquisition team, technologists, Fleet end users, test and evaluation efforts, and the program office. The UOES process enables a planned spiral development process that provides incremental improvements based on achievable, acceptable requirements.

A second implication from the findings is that the requirements development process for accelerated acquisition should be closely linked to the UOES-enabled spiral development based on achievable improvements in Fleet capability. The acquisition team should avoid setting or accepting high-risk thresholds. Requirements should be negotiated among all stakeholders to create achievable, beneficial increments and accelerated acquisition requirements should be within the realm of the achievable to encourage industry and interest and participation.

A third implication is that Fleet participation in Accelerated Acquisition Programs is critical, and the UOES process can stimulate increased Fleet involvement in the acquisition efforts. Putting a potentially enhanced warfighting capability in the hands of the operators early in the acquisition and fielding process can generate Fleet interest and enthusiasm in the effort. Properly structured UOES participation in Fleet exercises increases visibility of and confidence in the AAP objectives. Fleet support of T&E efforts promotes an understanding of the limitations, along with benefits, of UOES technology and can aid in establishing acceptable, realistic requirements supporting the spiral development process.

A final implication is that a partnership with ONR can support Pre-Planned Product Improvements by providing an avenue to enable technology for downstream increments. ONR-supported prototyping and experimentation was critical in the MK 18

Mod 1 effort, in that necessary technology innovations identified in T&E were programmed into ONR efforts to support requirements when available.

D. RECOMMENDATIONS FOR IMPROVING THE REQUIREMENTS DEVELOPMENT PROCESS

Based on the discussed findings and the implications of those findings, below are the recommendations to the DOD for improving the requirements development process for accelerated acquisitions.

Recommendation #1: The findings showed that the Mk 18 Mod 1 program saw success from the utilization of a "walk-then-run" and "build-a-little, test-a-little" phased requirements development process. Thus, the following recommendation is made: Where feasible, establish a phased requirements development process coupled with prototype experimentation to help further refine requirements before the solicitation phase. This will ensure that achievable requirements will be identified and entice qualified industrial sources to compete.

Recommendation #2: The results of the research indicated a best practice of utilizing an MOA to define the responsibilities of the commands and establish the program objectives. Based on this best practice, the next recommendation is provided: Implement a sponsored agreement such as an MOA, listing near-term, mid-term, and long-term goals for the program. This will help ensure that all stakeholders are aware of where the current proposed requirements fit in the program life cycle and will support introduction of the evolving technology via Technology Transition Agreements.

Recommendation #3: Through the research, utility was found in the AoA and requirements working group that were employed in the Mk 18 Mod 1 program's acquisition planning. Based on this finding, the third recommendation is made: Utilize AoA requirements working groups with participation by all stakeholders (Fleet, program office, technologists, sponsors, etc.) early in the requirements/acquisition planning. Ensure that effective Requirements Working Groups are embedded in the AoA process. This will ensure that identified alternatives are evaluated with respect to real requirements, rather than idealized performance attributes.

Recommendation #4: The findings showed that the attainable requirements set for the Mk 18 Mod 1 UUV provided opportunities for broader industry participation and spurred interest by industry and research centers. Hence, the fourth recommendation is provided: Establish requirements within the realm of the achievable to encourage industry participation in industry days, technology demonstration events, Requests for Information (RFIs), and Broad Agency Announcements (BAAs). This will stimulate the interest of potential qualified contractors prior to the solicitation phase.

Recommendation #5: Because of lessons learned from previous acquisitions that had stringent, high risk KPPs, and the successful best practice of leaving some unknown parameters as TBD for the Mk 18 Mod 1 UUV, the fifth recommendation is made: KPPs should be designed for achievable results to reduce program risk. This will enable successful completion of program milestones and avoid cost increases, schedule delays, and technical impasses.

Recommendation #6: The findings identified that there was a successful partnership between ONR and the technologists, scientists, and engineers for the Mk 18 Mod 1 program. Therefore, the sixth recommendation is established: Utilize a partnership with ONR to identify enabling technology and plan follow-on enhancements based on the anticipated availability of the enabling technology. This will reduce program technical risk and enable implementation of Pre-Planned Product Improvements (P3I) as scheduled.

Recommendation #7: The research found that there was a strong collaboration with JHU/APL as the IT&EA for the Mk 18 Mod 1 program. This leads to the final recommendation: Seek a University Affiliated Research Center (UARC) partnership for involvement as observers in project T&E efforts, and as Test Directors for milestone tests. The assignment of a UARC as the IT&EA in the T&E process, especially at milestone validation/verification tests, will assure stakeholders that the testing was conducted fairly, rigorously, and in accordance with the established requirements for that milestone.

E. SUMMARY

This chapter presented the findings of this research on the requirements development process and application of the UOES for the MK 18 Mod 1 using the data obtained from interviews and the case study (Nagle et al., 2015). Following the presentation of the findings was a discussion of the implications of the findings. The chapter concluded with recommendations for improving the requirements development process for the Navy and DOD based on insights gained during this research and interviews. The following chapter presents the research summary, conclusion, and areas for further research.

VI. SUMMARY, CONCLUSION, AND AREAS FOR FURTHER RESEARCH

A. INTRODUCTION

This chapter provided a summary of the background, the problem statement, and the purpose of the research. The conclusion of this chapter summarizes answers to the research questions, provides recommendations to the Navy and DOD for improving the requirements development process, and identifies areas to consider for further research.

B. SUMMARY

The background introduced the topic of this research, the Mk 18 Mod 1 evolutionary acquisition, its requirements development process, and the implementation of the UOES. The MK 18 program is not only an example of effective requirements definition and development but also of strong stakeholder engagement and working relationship with the Fleet that led to the delivery of an operationally successful system. The problem associated with DOD acquisitions is that the acquisition life cycle is often lengthy, and the fidelity of the requirements development process is vital to program success (DAU, 2022). Getting the requirements development process right is especially important in an acquisition program for an evolutionary system such as an Unmanned Underwater Vehicle (UUV). The purpose of this research was to identify how the MK 18 Mod 1 UOES process assisted the requirements development process and the program's success. In addition, this research identified recommendations for improving the requirements development process.

C. CONCLUSION

Based on the review of program documents and analysis of the interview results and case study, the following conclusions are provided in the form of answers to the research questions.

1. How Did UOES Inform and Improve the Requirements Development Process for the MK 18 Mod 1 Program?

The UOES process engaged Fleet end users early on in the requirements development process and the phased evaluations provided insight into system design and requirements for operational utility, suitability and supportability. Documentation of performance results, operational employment events, and qualitative feedback from the Fleet established the baseline for the Mk 18 Mod 1 requirements parameters which minimized program risk and ensured Fleet and sponsor buy-in. The criteria established from the UOES process in turn were utilized in the contracting process in terms of source selection factors and quantifiable performance metrics.

2. What Were the Roadblocks and Challenges Associated with Using UOES, and How Were They Overcome?

There were several roadblocks and challenges associated with using UOES. First, the top-level requirements were not directed by the sponsor because the intent was for testing and exercise results to inform the requirements development process and minimize technical risk. In turn, it was difficult for the development team to identify and recommend achievable, beneficial requirements. The MK 18 Mod 1 UOES effort underwent a "requirements discovery" process alongside the conduct of field testing and exercise events.

An additional impediment was the lack of actual warfighting field employment of the subject technologies, i.e., unmanned systems, precise underwater navigation, acoustic based sensors for mine identification, etc. To overcome these challenges, the approach taken was to develop and demonstrate lower risk UUV based technologies, incrementally satisfy mission requirements in the near term, and establish early, sustained end user engagement. Further, Fleet advocacy for operational requirements and Organic MCM Future Naval Capabilities (FNC) initiatives promoted program objectives. Finally, the military utility of the MK 18 Mod 1 prototype system was improved by incorporating Fleet perspectives into developmental refinements that were validated in Fleet exercises and battle experiments.

3. What Lessons Learned and Best Practices for the DOD's Requirements Development Process Can Be Gleaned from the Use of the UOES in This Accelerated Acquisition?

There were many valuable lessons learned and best practices identified from the use of the UOES in the MK 18 Mod 1 AAP. The first lesson learned is to engage the Fleet, ONR and other technical subject matter experts in AoA studies. Early and sustained stakeholder engagement will maintain momentum for the requirement.

Another lesson learned as it pertains to novel accelerated acquisition is to develop a UOES plan that engages the Fleet users, resource sponsor and acquisition office in systematic, phased evaluation of prototypes for operational utility, suitability, and supportability. The UOES will help define clear, quantifiable, and achievable performance metrics. These will feed directly into milestone entry/exit criteria and support the formal requirements process.

A third lesson learned is to ensure there is continuous technology transition program planning for the requirement. ONR participation and coordination can support this by delivering key enabling technology in time for insertion into planned increments. Planning for rapid prototyping to reach Technology Level (TRL) 6, wherein the prototype is fully functional, will support transition to acquisition. Additionally, the program budget must support the technology insertion process.

One best practice for the MK 18 Mod 1 was remaining flexible in terms of identifying key metrics. This was accomplished by specifying "TBD" for high-risk thresholds and allowing T&E to help identify what a reasonable target was for some of the key metrics. Characterizing performance through T&E helped set the minimum acceptable level once more information was gained and helped reduce program risk. Another best practice was found in the use of selected technology demonstration events, industry days, and RFIs. These tools for engagement encouraged industry participation and informed the Government requirements team of existing capabilities.

A third best practice was proven in the development of the contract structure, which utilized the pre-planned product improvement concept. Engineering enhancement Contract Line Items (CLINs) and provisions included in the contract gave the ability for the Original Equipment Manufacturer (OEM) to easily modify the baseline configuration based on Fleet feedback and technical analysis.

A fourth best practice was the experimentation early and often with the Fleet end-users. Fleet exercises and battle experiments helped to validate system attributes and performance, and identify capability, technology, and system gaps. It also ensured that the end-users gained experience operating the system in relevant environments and scenarios before the capability was fielded. Participation in Fleet exercises and battle experiments provided valuable feedback to sponsors and helped summon end-user buy-in.

D. AREAS FOR FURTHER RESEARCH

There are areas within this research for which follow on research and further investigation opportunities exist.

The first area for further research would be evaluation of the requirements development processes for newer UMS (unmanned maritime system) technologies and how they compare to this accelerated acquisition. This research only analyzed one Navy program for a specific UUV. Incorporating other programs into future research will help generalize the current government trends in terms of requirements development and system refinement and potentially convince program offices across the Navy and DOD of the value of the UOES process.

A second area for further research would be to examine another element of this accelerated acquisition program, that being contract development and structure. The MK 18 Mod 1 contract was unique in that it included provisions and options for Pre-Planned Product Improvements and engineering enhancements. It would be beneficial to conduct additional research on the contracts for evolutionary systems such as the MK 18 Mod 1 and other modern UMS. This could provide the Navy and DOD lessons learned and best practices for accelerated acquisition contracts planning.

A third area for further research may be to conduct further interviews or analysis on the Mk 18 Mod 1 program to identify how obstacles to the requirements development were overcome. During the interview process, none of the respondents chose to identify specific roadblocks to the requirements development, how they were solved, and how they affected the end product. A study on this specific area would provide insight into how better to anticipate and deal with requirements development challenges in future accelerated acquisition efforts.

A final area for further research may be to explore the importance of University Affiliated Research Center (UARC) partnerships in evolutionary procurements that require significant test and evaluation and an external Independent Test and Evaluation Agent (ITE&A). Many of the DOD's advanced technologies could not have been fielded for the warfighter without the involvement of external research centers in validating the technology. To better understand the vital role that these actors play, additional research should be conducted.

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