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ACQUISITION RESEARCH PROGRAM
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Disconnected From the Front Lines: Lack of Warfighter Experience in Acquisitions Yields Unacceptable End States

June 2022

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ABSTRACT

Over the past few decades, the Defense Acquisition System (DAS) has been under constant fire by Congress, taxpayers, and warfighters for unacceptable cost, schedule, and performance outcomes. This plague has been well documented, discussed, and many potential corrective measures implemented over the years with futile results. This leaves the warfighter with delivered capabilities not meeting actual operational needs, routinely late to field, yielding them irrelevant, and coming with unrecoverable cost overruns. One significant area of the acquisition process, the focus of this research, has the most impact on a program's outcome yet had the least amount of change: who represents the warfighter during requirements generation and management throughout the life cycle. A program's requirements establish the end cost, schedule, and performance thresholds that, once a program matures, are extremely difficult to change without a sizable penalty. This research documents a correlation between troubled programs and poor requirements support due to an operational knowledge gap caused by a lack of proficient end-user warfighter representatives involved and empowered in the process. Related, due to the inherent differences in views, experience, and expectations between a career acquisition professional and a warfighter, data shows a need for a blended professional within the DAS. The research shows failure to bridge this personnel gap will predictably yield the same unacceptable results.

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TABLE OF CONTENTS

I. INTRODUCTION....1
- A. OVERVIEW....1
- B. KNOWLEDGE GAPS IN ACQUISITIONS....3
- C. IMPACTS OF DISCONNECTS WITH THE FRONT LINES....5
- D. RESEARCH APPROACH AND QUESTIONS....6
  - 1. Primary Questions....6
  - 2. Secondary Questions....6

II. METHODOLOGY....7
- A. SCOPE....7
- B. RESEARCH METHODS....8
- C. UNACCEPTABLE END-STATE CONSIDERATIONS....9

III. DATA ANALYSIS AND FINDINGS....11
- A. WARFIGHTER INTEGRATION DURING THE LIFE CYCLE....11
  - 1. Warfighter Representation Pre–Milestone A....11
  - 2. Warfighter Representation Milestone A through Milestone C....15
  - 3. Warfighter Representation Post–Milestone C and during Operations and Sustainment....17
- B. SERVICE SPECIFIC DESIGNATORS SUPPORTING ACQUISITIONS....18
  - 1. United States Air Force....18
  - 2. Department of the Navy (DON)....22
  - 3. United States Marine Corps....26
  - 4. United States Army....28
- C. REQUIREMENTS MANAGEMENT CASE STUDIES....30
  - 1. F-22A Raptor and F/A-18E/F Super Hornet....30
  - 2. F-35 Joint Strike Fighter Program....40
  - 3. F-111....48
  - 4. B-2 Spirit....55
- D. EXPERIENCED WARFIGHTER RETENTION CHALLENGES....61

IV. CONCLUSION AND AREAS OF FURTHER RESEARCH....67
- A. DISCUSSION OF RESULTS....67
- B. RECOMMENDATIONS....71

1. Utilization of an AEDO-Based Model Cross-Trained Warfighter 72
2. Addition of a Dedicated Requirements Management Career Path.....73
C. STUDY LIMITATIONS 74
D. AREAS FOR FURTHER RESEARCH.....75

APPENDIX.....77
A. DEFENSE ACQUISITION PROCESSES AND DEFINITIONS 77
1. Operation of the Adaptive Acquisition Framework.....77
2. Requirements Process.....79
3. Funding Process 81
4. Program Development Execution.....82
5. Product Fielding and Sustainment.....83
B. PROGRAM REQUIREMENTS AND DECISION AUTHORITIES 84
1. Initial Large-Scale Requirements and Decision-Makers 84
2. Small-Scale Decomposed Requirements During Development 87
C. DEFENSE ACQUISITION WORKFORCE.....88
1. Defense Acquisition Workforce Positions.....88
2. DOD Instruction 5000.66.....89
3. Defense Acquisition Workforce Program Desk Guide.....90
4. Mandated Acquisition Training 91

LIST OF REFERENCES 97

LIST OF FIGURES

Figure 1. U.S. Federal Debt as a Percentage of Gross Domestic Product Source: Dahl (2021). 1

Figure 2. Anticipated Flat or Declining DOD Acquisition Budget in Upcoming Years. Source: Arthur and Woodward (2020). 2

Figure 3. JROC Subordinate Boards and Related Organizations. Source: Chairman of the Joint Chiefs of Staff [CJCS], 2018). 12

Figure 4. DON Requirements/Acquisition Two-Pass Seven-Gate Process. Source: Assistant Secretary of the Navy for Research, Development, and Acquisition [ASN(RDA)] (2019) 14

Figure 5. Program Workforce Size and Composition Across 11 Studied MDAPs. Source: DiNapoli (2019) 16

Figure 6. Potential Career Broadening Opportunities for USAF Acquisitions Officers. Source: Department of the Air Force (2020). 20

Figure 7. USAF Acquisition Manager (63AX) Career Progression. Source: Air Force Personnel Center (2021a). 20

Figure 8. USAF Developmental Engineer (62EXX) Career Progression. Source: Air Force Personnel Center (2021a). 22

Figure 9. AEDO Bridge the Gap Role. Source: Naval Personnel Command (2022a). 23

Figure 10. AEDO Career Progression and Acquisition Training Requirements. Source: Naval Personnel Command (2022b). 24

Figure 11. AMDO Career Path and Acquisition Training Requirements. Source: Naval Personnel Command (2022b). 25

Figure 12. USMC Active Duty/Civilian Acquisition MOS Career Path. Source: United States Marine Corps (2022). 27

Figure 13. Army Acquisition Corps Officer Career Timeline. Source: Department of the Army (2021). 29

Figure 14. Army Acquisition Corp NCO Career Timeline. Source United States Army Acquisition Support Center (2022b). 30

Figure 15. F-22A and F/A-18E/F Schedule and Cost Predictions vs Actuals for Program Development Phase. Source: Younossi et al. (2005). 32

Figure 16. F-22A and F/A-18E/F Schedule Estimates Changes During Development Phases. Source: Younossi et al. (2005). 33

Figure 17. F-22 vs F/A-18E/F Cost Growth Trends. Source: Younossi et al. (2005)..39

Figure 18. JSF PEO's 1997 Requirements Generation Roadmap Leading to the JORD and the AoA. Source: Kenne (1997)..44

Figure 19. JSF Program Office's Requirements Generation Process in 1997. Source: Kenne (1997). 46

Figure 20. Boeing Proposal (Left) and General Dynamics Proposal (Right). Source: Richey (2004). 51

Figure 21. Trade-off Analysis of Predicted Dash Distance at Various Speeds. Source: Richey (2004). 52

Figure 22. Naval Aviation Officer Career Progression. Source: Naval Personnel Command (2022b). 62

Figure 23. Pilot Retention at MSR + 1. Source: Bureau of Naval Personnel, personal communication (2021a)...64

Figure 24. NFO Retention at MSR + 1. Source: Bureau of Naval Personnel, personal communication (2021a)...65

Figure 25. Naval Aviation Senior Officer Inventory. Source: Bureau of Naval Personnel, personal communication (2021a)...65

Figure 26. Proposed Requirements Management Career Progression by Designator...73

Figure 27. Traditional Acquisition Process. Source: Bilvas et al. (2020). 78

Figure 28. The Adaptive Acquisition Framework. Source: DOD (2020a). 79

Figure 29. JCIDS Process. Source: CJCS (2018)...81

Figure 30. Program Office Execution Balance Diagram. Source: Mortlock (2016)..83

Figure 31. AWF Career Progression. Source: Under Secretary of Defense for Acquisition and Sustainment [USD(A&S)] (2022). 90

LIST OF TABLES

Table 1. JPO OAG Membership Table and Voting Members from 2003. Source: JSF Program Office (2003). 45

Table 2. F-111 Variants Specification and Configurations. Source: Richey (2004). 54

Table 3. Evolution of B-2 Requirements from RFP to Specifications. Source: Griffin & Kinnu (2004). 58

Table 4. B-2's Projected vs Actual Execution Timeline. Source: Griffin & Kinnu (2004). 59

Table 5. Navy Retention Study Responses. Source: Snodgrass (2020). 63

Table 6. Description and Decision Authority for ACAT I – III Programs. Source: Under Secretary of Defense for Acquisition, Technology, and Logistics [USD(AT&L)] (2021). 86

Table 7. Comparison of DAWIA Program Management and Requirements Management Certification Standards. Source: Defense Acquisition University (2022). 93

Table 8. OPNAV Requirements Management Certification Training Matrix. Source: Chief of Naval Operations [CNO] (2019). 95

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LIST OF ACRONYMS AND ABBREVIATIONS

AAF	Adaptive Acquisition Framework
AC	Acquisition Corps
ACC	Air Combat Command
ADM	acquisition decision memorandum
AEDO	Aerospace Engineering Duty Officer
AESA	Active Electronically Scanned Array
AFC	Airframe Change
AFIT-CSE	Air Force Institute of Technology-Center for Systems Engineering
AFOCD	Air Force Officer Classification Directory
AFSC	Air Force Specialty Code
AMOS	additional military occupational specialty
AO	Action Officer
AoA	Analysis of Alternatives
AQD	Additional Qualification Designator
ASN(RDA)	Assistant Secretary of the Navy for Research, Development, and Acquisition
ASR	Air System Requirements
ASTOVL	Advanced Short Takeoff and Vertical Landing
ATF	Advanced Tactical Fighter
AWF	Acquisition Workforce
BUPERS	Bureau of Naval Personnel
BUR	Bottom-Up-Review
CAIV	Cost as an Independent Variable
CALF	Common Affordable Lightweight Fighter
CAP	Critical Acquisition Position
CAPE	Cost Assessment and Program Evaluation
CARD	Cost Analysis Requirements Description
CBA	Capabilities-Based Assessment
CBO	Congressional Budget Office
CDD	Capability Development Document

CDR	Critical Design Review
CL	Continuous Learning
COPT	Cost/Operational Performance Trades
CTE	critical technology element
DAC	Defense Acquisition Corps
DARPA	Defense Advanced Research Projects Agency
DAS	Defense Acquisition System
DAU	Defense Acquisition University
DAWIA	Defense Acquisition Workforce Improvement Act
DCMA	Defense Contract Management Agency
DCR	DOTmL-PF change recommendation
DDR&E	Directorate of Defense Research and Engineering
DOD	Department of Defense
DON	Department of the Navy
DOTmL-PF	doctrine, organization, training, materiel, leadership and education, personnel, and facilities
DR	discrepancy resolution
DSB	Defense Science Board
eDACM	electronic DON Acquisition Career Management System
EDO	Engineering Duty Officer
EMD	Engineering and Manufacturing Development
EVM	Earned Value Management
FLIR	Forward-Looking Infrared
FMS	Foreign Military Sales
FOM	Follow-on Modernization
FRS	Fleet Replacement Squadron
FY	Fiscal Year
FYDP	Future Years Defense Program
GAO	Government Accountability Office
GOR	General Operational Requirement
IBR	Integrated Baseline Review
ICD	Initial Capabilities Document

IDP	Individual Development Plan
IOC	Initial Operational Capability
IPT	Integrated Product Team
JCIDS	Joint Capability Integration and Development System
JEON	Joint Emergent Operational Need
JESB	JSF Executive Steering Board
JET	Joint Estimating Team
JIRD	Joint Initial Requirements Document
JORD	Joint Operational Requirements Document
JPO	JSF Program Office
JROC	Joint Requirements Oversight Committee
JSF	Joint Strike Fighter
JUON	Joint Urgent Operational Need
KLP	Key Leadership Position
LM	Lockheed-Martin
LRIP	Low-Rate Initial Production
MAJCOM	Major Command
MAO	Marine Acquisition Officer
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDCITA	Multidisciplinary Counterintelligence Threat Assessment
MDD	Material Development Decision
MGUE	Military Global Positioning System User Equipment
MIT	Massachusetts Institute of Technology
MOE	measure of effectiveness
MOP	measure of performance
MOS	measure of suitability
MRF	Multi-Role Fighter
MSA	materiel solution analysis
MSR	Minimum Service Requirement
N98	OPNAV Director of Air Warfare
NA	Naval Aviator

NAE	Naval Aviation Enterprise
NAVAIR	Naval Air Systems Command
NAWDC	Naval Aviation Warfare Development Center
NCIP	Navy Capabilities-based Assessments Integration Process
NCO	Non-Commissioned Officer
NDAA	National Defense Authorization Act
NFO	Naval Flight Officer
NPS	Naval Postgraduate School
NSS	National Security Strategy
OA	Operational Assessment
OAG	Operational Advisory Group
OODA	Observe-Orient-Decide-Act
OPNAV	Office of the Chief of Naval Operations
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
PEO	Program Executive Officer
PM	Program Manager
PMOS	primary military occupational specialty
POM	Program Objective Memorandum
PPBE	Planning, Programming, Budgeting, Execution
RCS	Radar Cross Section
RFI	Request for Information
RFP	request for proposal
RL	Restricted Line
RO	Requirements Officer
SAC	Strategic Air Command
SAF/AQ	Assistant Secretary of the Air Force for Acquisition
SAM	Surface-to-Air Missiles
SASC	Senate Armed Services Committee
SDD	System Design and Development
SECDEF	Secretary of Defense
SOR	Special Operational Requirement

SORA	System Operations Requirements Analysis
SPO	System Program Office
SWO AP	Surface (or Subsurface) Warfare Officer Acquisitional Professional
SWO	Surface (or Subsurface) Warfare Officer
SYSCOM	Naval Systems Command
TAC	Tactical Air Command
TACAIR	Tactical Aircraft
TFX	Tactical Fighter Experimental
TMRR	Technology Maturation and Risk Reduction
TTP	Tactics, Techniques, and Procedures
TYCOM	Type Commander
UK	United Kingdom
URL	Unrestricted Line
USAF	United States Air Force
USD(A&S)	Under Secretary of Defense for Acquisition and Sustainment
USMC	United States Marine Corps
USN	United States Navy
V/STOL	vertical and short takeoff and landing

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EXECUTIVE SUMMARY

BACKGROUND

On the heels of a vast increase in government spending from the COVID-19 pandemic relief and adding significant social mandatory spending programs in 2021, tremendous top pressure was placed on the remaining defense discretionary funding available in the U.S. budget. Meanwhile, China continues to outpace the U.S. in military development putting the U.S. strategic deterrence and military advantage at significant risk. This results in a critical need for defense acquisition to be more efficient in getting frontline warfighters the capabilities they need to win – quickly, correctly, and without wasting resources.

While recently enacted acquisition reform efforts focus primarily on cost and schedule reduction, the performance output of these acquisition efforts remains a deep-seated concern by warfighters. This concern is rooted in a repetition of DOD acquisitions leaving the warfighter with a product that is ineffective or insufficient in operational environments, difficult to maintain, or arrives with already dated performance compared to peer threat nations. With budgets growing smaller and the time to field long, the DOD cannot afford to continue a disconnect from the front lines wasting time and money.

PROBLEM

Frontline warfighter involvement in DOD acquisitions is largely limited to the initial requirements submissions, followed by a significant gap until developmental and operational tests begin with the end-user years later. Compounding the problem is a DOD acquisition workforce made up of only 9.8% uniformed servicemembers (Congressional Research Service, 2016), the majority of whom never served on the frontlines, yields an operational knowledge gap in decisions made during the recess period. By the time warfighters get a chance to significantly interact with a program such as F-35, covered in this research, the program is too mature to make significant changes without severe cost growth and delays. Warfighters are then left to use Tactics, Techniques, and Procedures to mitigate the capability gap hoping something else will be developed in acquisitions quickly to close it.

RESEARCH QUESTIONS

The overarching intent of this research was to identify, quantify, and provide an actionable mitigation solution *within the DOD's current resource constraints* addressing the question: Does a significant operational knowledge gap in DOD acquisitions exist today, and does it translate to unacceptable programmatic end-states? The thesis examines specifically the use of frontline combat-qualified warfighters throughout the acquisition life cycle, or the lack thereof, and the resulting programmatic end states.

METHODOLOGY

This thesis methodology first explores warfighter integration during the entire acquisition life cycle. This is to understand when warfighters are engaged and what decisions are being made within a program office without warfighter input. Second, the thesis covers the Services' uniformed acquisition professionals' career paths and experience to qualitatively show who are the 9.8% of the uniformed acquisition workforce. Lastly, the thesis explores four significant case studies – F-22A vs F/A-18E/F, F-35, F-111, and B-2, showing warfighter engagements as part of those programs and how that affected program success or failures and why.

SUMMARY OF FINDINGS

The research showed that an operational knowledge gap of significance has previously, and does currently, exist in DOD acquisitions translating to unacceptable end states. This gap was shown at all levels of the acquisition life cycle, most notably tied to requirements development and management during the design process. While having an operational knowledge gap at the senior leadership level comes with significant consequences, its occurrence is significantly less often than the gap found within program offices.

Further, this research showed that of all Services, only USN/USMC uniformed acquisition professionals have operational experience (a pre-requisite), but they are relatively few in number. This lack of operational experience by program office decision-makers leads to a significant knowledge gap affecting critical phases of a program: CDD decomposition to specifications, setting and executing the acquisition strategy based on priorities, and the design and development phase naturally requiring trade-off decisions. All sets much of the program ‘in-stone’ before it reaches the warfighter in the testing phase.

The research also showed that while program offices do interact externally with warfighter representatives via the resource sponsor’s Requirements Officers (ROs) from OPNAV and Major Commands such as Air Combat Command, the exchanges are relatively limited. First, the program offices and the ROs are almost always not co-located restricting information exchanges, awareness of issues, or accessibility for questions. Second, most ROs are post-command O-5s, not DAWIA certified, and only hold the position for an average of 18–24 months. This is only enough to “begin to develop the ‘journeyman’ understanding and skills needed to be effective as a requirements officer [sic] or programmer” (Blickstein et al., 2016). Lastly, most RO units are severely understaffed and the ROs simultaneously juggle budget cycles, supporting flag officer needs, and dealing with current-day fleet issues. This limits the effectiveness of the ROs to close the knowledge gap or fully understand program office considerations during tradeoffs.

RECOMMENDATIONS

All Services should prioritize the implementation of acquisition cross-trained warfighters, such as the Navy’s Aviation Engineering Duty Officer (AEDO) designator, within program offices and resource sponsor RO units. Ideally, these warfighters should also be proficient and experienced in the same or similar field as the program itself – i.e., a fighter pilot for a fighter aircraft or air-to-air missile program. As documented in the research cases of F/A-18E/F and B-2, embedding warfighters – especially cross-trained warfighters, yielded very successful programs. Defense acquisition, to be successful, needs operators to transition their experience into empowered and influential roles within acquisition program offices to inform and prioritize the deconfliction of capability needs, budgets, and technology development alongside the career acquisition professionals.

AEDOs exist to bridge the gap between the professional acquisition workforce and the operational Navy ensuring that warfighter equities are represented throughout the acquisition process. They are currently divided into three lines of effort: Test and Evaluation, Program Management, and Fleet Support & Production. This thesis further recommends the addition of a dedicated Requirements Management career path focused on requirements generation, validation, and management offsetting current RO limitations. This additional path provides a promotion path that promotes retention and growth of this knowledge base within the requirements channels through the O-6 level instead of detouring to hit other milestone tours in the other pathways.

Staying within the bounds of a solution *within the DOD's current resource constraints*, the thesis identified that retaining of end of commitment warfighters would be best for this role as opposed to pulling warfighters from combat units. Data suggests that a large quantity of separating warfighters did so based on the exhaustion of multiple deployments and lack of stability at home. Having a non-deploying and promotable designator option such as an AEDO can keep Services from losing millions more in sunk costs, such as the $4.4M per Navy fighter pilot in training costs alone, and provide the operational experience required for this role (OPNAV N98, personal communication, 2020).

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I. INTRODUCTION

A. OVERVIEW

On the heels of a vast increase in U.S. government spending in the wake of both the SARS-CoV-2 (COVID-19) pandemic and additional social mandatory spending programs in 2021, enacted without sunset dates, tremendous top pressure was placed on the remaining defense discretionary funding available in the budget. Figures 1 and 2 show the Congressional Budget Office (CBO) anticipates, even before the approval of additional anticipated spending measures (including H.R. 5376 – Build Back Better Act) at the time of this report, that there will likely be either no gain or a reduction in funding available for defense acquisitions in the upcoming years. Meanwhile, China continues to outpace the U.S. in military growth and development putting the United States' strategic deterrence and military advantage at significant risk. This combination results in a critical need for defense acquisition programs to be more efficient than ever getting frontline warfighters the capabilities they need to win – quickly, correctly, and without wasting resources.

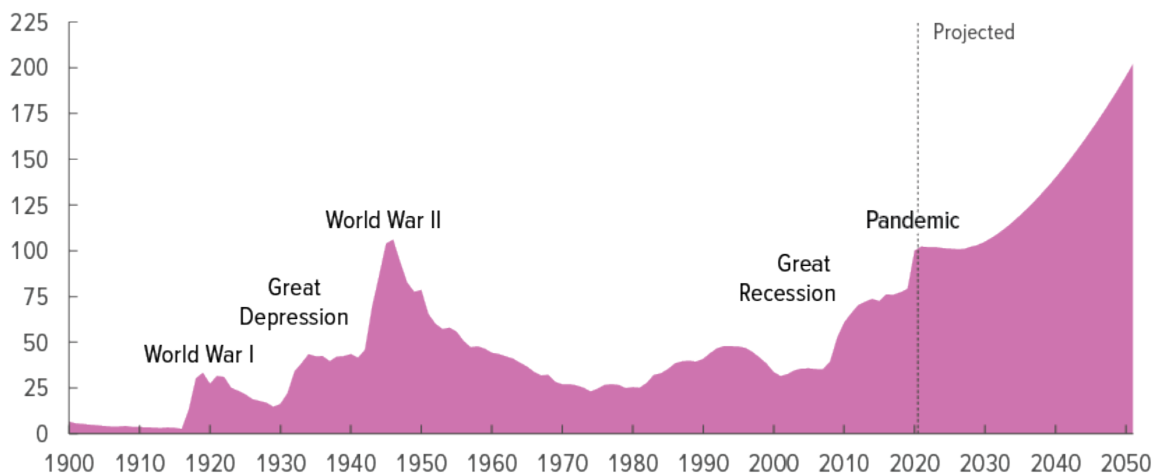

Figure 1. U.S. Federal Debt as a Percentage of Gross Domestic Product
Source: Dahl (2021).

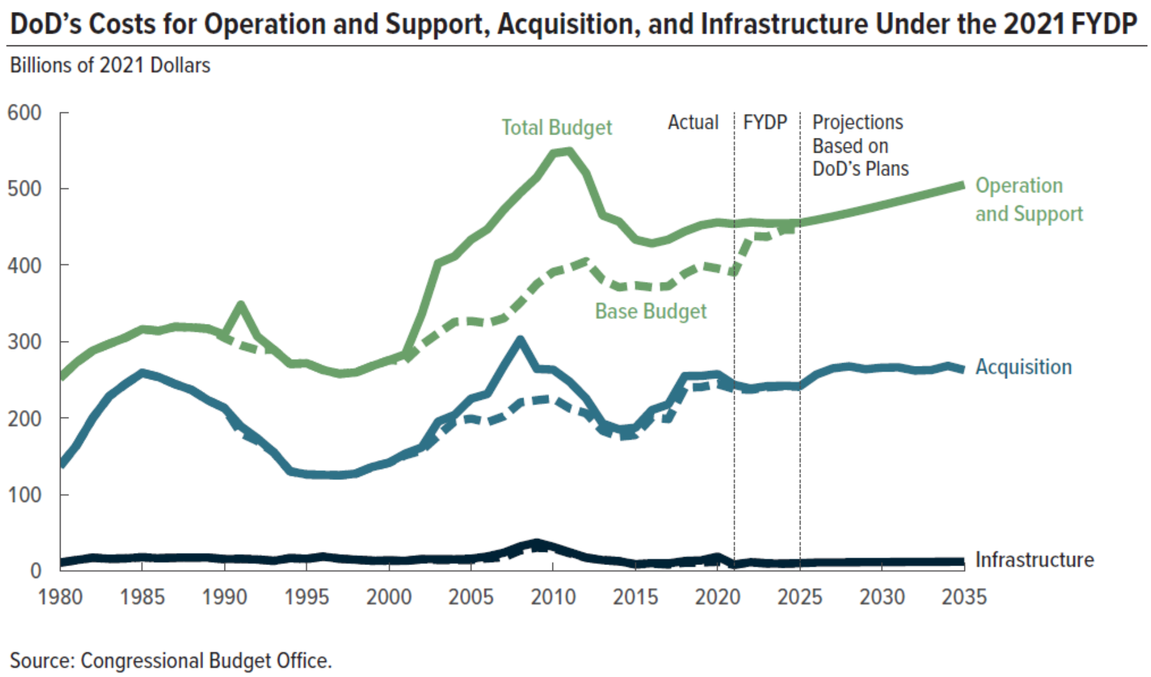

Figure 2. Anticipated Flat or Declining DOD Acquisition Budget in Upcoming Years. Source: Arthur and Woodward (2020).

However, for decades Congress, the Department of Defense (DOD), researchers, taxpayers, and warfighters alike have been attempting to identify and fix the way the DOD conducts military acquisitions to achieve better success. Widely reported as a sluggish, inefficient, inflexible, and dated, the Defense Acquisition System (DAS) is becoming more synonymous with high-visibility failures than widespread successes. In 2017, the Government Accountability Office (GAO) reported "Congress and DOD have long sought to improve how major weapon systems are acquired, yet many DOD programs fall short of cost, schedule, and performance expectations, meaning DOD pays more than anticipated, can buy less than expected, and, in some cases, delivers less capability to the warfighter" (Mihm, 2017). While Congress has recently enacted, via National Defense Authorization Act (NDAA) language, some acquisition reform efforts that focus primarily on cost and schedule reductions, the performance output of these acquisition efforts remains a deep-seated concern by frontline warfighters.

Specifically, the GAO testified this year that "programs using the new middle-tier pathway face increasing risk that they will fall short of expected performance goals as a result of starting without sound business cases" (Oakley, 2021). Underpinning their assessment of programs falling short of performance goals, the GAO continued by highlighting the importance of having the appropriate knowledge throughout the life cycle.

> Yet even as the acquisition environment continues to evolve, the fundamental need for knowledge during the acquisition process remains unchanged. For years, we have reported on the importance of using a solid, executable business case – a justification for a proposed project or undertaking – before committing resources to a new product development effort…In addition, our work has repeatedly demonstrated that knowledge attainment at key points throughout the life cycle underpins the sound business case, positioning programs to meet their cost and schedule goals. (Oakley, 2021)

While the GAO's testimony primarily communicated a need for using knowledge on a more macro-scale – to make better initial decisions on starting or not starting a sizeable acquisition program such as a new aircraft or weapon, this research effort focuses on identifying how this translates to lower levels of the DAS. The goal is to understand how to best reconnect programmatic decision-makers such as Program Managers (PMs) and resource sponsors with experienced and proficient warfighters to minimize the operational or use-case knowledge gaps.

This research resulted in a proposed concept for the development and use of an active-duty blended warfighter acquisition professional, with a career path and role, based on a modification to the United States Navy's (USN) Aerospace Engineering Duty Officer (AEDO) model. This concept brings frontline experienced warfighters into a tailored DOD acquisition professional role, focusing on closing the knowledge gaps, especially at the critical front end of the acquisition life cycle. This would allow Service leadership an additional executable option – that is within their control – to help quickly repair the DAS in conjunction with the already ongoing reform efforts to yield greater efficiency and effectiveness in program execution.

B. KNOWLEDGE GAPS IN ACQUISITIONS

In everyday life, no individual or group of individuals possesses complete and perfect knowledge across all spectrums. Humans for decades have evolved and attempted to mitigate or reduce knowledge gaps by taking classes, utilizing life experiences, or pressing the boundaries of their innate talent to learn what is beyond them, and the DAS is no different. Title 10 has set definitions and minimums in positional billets, responsibilities, and education requirements for the Acquisition Workforce (AWF) to ensure the workforce is knowledgeable in how to conduct DOD acquisitions and all the intricacies involved in it. Recently, acquisition reform efforts both in processes and in the Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) 'Back-to-Basics' initiative that restructures acquisition courses and experience requirements for certifications, try to minimize knowledge gaps and increase proficiency in how DOD acquisitions should be executed. Due to the complexity of the DAS itself, there often is a sizeable acquisition knowledge gap within the AWF from Leadership down to program office workers. This could be within a wide spectrum from how the DAS has structured itself, what contract types are best for certain situations, when certain appropriations expire, to who has decision authority and responsibility for certain overlapping aspects of the program such as test and evaluation. While most acquisition-based knowledge gaps aren't by themselves catastrophic, they aren't insignificant either as there is cascading accumulation. Multiple small gaps in acquisition knowledge within a program office can inadvertently promote negative programmatic results. This can lead to program mismanagement, litigation, delays, overruns, or programmatic failure.

Just as prevalent in DOD acquisitions, but often overlooked or incorrectly judged as not (as) prevalent, is the operational knowledge gap. This knowledge gap is based on the lack of knowledge of how the DOD force operates in the fleet, current Tactics, Techniques, and Procedures (TTPs) used, what warfighters face on the frontlines, and in turn what manners warfighters would or could use the product or weapon system under design. Just as the acquisition knowledge gap requires some form of experience and continuous learning to mitigate, so too does the operational knowledge gap. It is hard for a person without experiences such as landing on an aircraft carrier in zero visibility, coordinating danger-close Close Air Support fires while under attack, or executing a strategic strike deep into enemy territory, to truly understand those environments, warfighter needs, and intricacies around decision making and dealing with variables. Just like other knowledge gaps, this is a hard gap to close as it can be highly subjective, quite complex, varies between Services and/or users of similar products, as well as it has a partial shelf-life. Proficiency plays a role in the operational knowledge gap as well in that a warfighter who had experience flying fighters 10 years ago would not best represent current-day perspectives and TTPs. Like the continuous learning within the acquisition community, it is important to have fresh and updated operational knowledge and experiences to help close this gap in acquisition.

C. IMPACTS OF DISCONNECTS WITH THE FRONT LINES

There are multiple critical impacts due to the disconnect with the front lines in DOD acquisitions. As seen in numerous examples, some of which were uncovered in the research to follow, these disconnects programmatically cause poor decision-making yielding preventable cost and schedule overruns, program cancellation, reduction in procurement quantities, or loss of additional capabilities needed. From the front lines, the disconnect regularly leaves the warfighter with a product that is ineffective in operational environments, is difficult to maintain, or arrives with already dated performance as compared to the improvements made by peer threat nations. Warfighters are then left to use TTPs to try to mitigate the loss of capability while hoping something better will come through in acquisitions to answer the mail.

As the warfighters continue to see DOD acquisitions fail to align with their needs and take significantly longer to field (such as with F-35), there is a significant growing concern that they are close to not having the requisite capabilities needed to be victorious against peer threats. From a National Security impact, this is huge as the continual misses in acquisitions allow countries like China to rapidly close the military capabilities advantage the United States has enjoyed for decades. This should gravely concern DOD leadership, Congress, and U.S. citizens. With budgets growing smaller and the time to field growing, the DOD cannot afford to continue a disconnect from the front lines wasting time and money on something not meeting the needs.

D. RESEARCH APPROACH AND QUESTIONS

Development of the primary and secondary research questions relate to a mixture of the fleet and acquisition experiences of the researchers along with the gathering of common observations/questions derived from numerous case studies, fleet warfighter feedback, and testimonials on failed or failing DOD acquisition programs. The underlying focus of the research is what, while living within the DOD's current resource means, can drastically improve what warfighters are receiving on the frontlines and when. As a result, the primary and secondary questions being addressed in this research are the following:

1. Primary Questions

- Does a significant operational knowledge gap in DOD acquisitions exist today and does it translate to unacceptable programmatic end-states?
- Does the DOD have the ability to mitigate this knowledge gap, and will the mitigation translate to greater programmatic success?

2. Secondary Questions

- Is it possible to mitigate the knowledge gap DOD-wide across all Services with the same solution?
- What would a potential mitigating solution look like, and could there be a solution that has synergy mitigating the Services' current retention issues of experienced warfighters leaving the military at their Minimum Service Requirement (MSR)?

II. METHODOLOGY

A. SCOPE

There are many variables, as have already been explored in years of reporting and testimony, as to why warfighters today are not getting what they need from their acquisition system. So too are the number of variables and complexities remaining after narrowing down to the exploration of the communication and knowledge gaps between Congress, DOD leadership, the acquisition community, and the warfighter. As such, this research is intentionally limited in scope to focus on identifying how knowledge gaps are specifically affecting current acquisition outcomes and how that applies to two knowledge gap variables: requirements development/management and the Services' use of active-duty personnel to support DOD acquisition efforts.

Additionally, the research team acknowledges each of the Services' current unique ways of handling the two above variables come with individual pros and cons that could be identified by a full and detailed exploration of all to provide an ultimate recommendation. However, the need for this document to be concise, focused, and executable in the time allotted further narrowed the scope (aside from the Joint case studies) to primarily observations and analysis of U.S. Navy acquisition execution and their acquisition professionals. However, this compromise still allows providing a jointly applicable recommendation. Scaled research of the other Services was executed for broader observations and identification of similarities that support this joint need statement and recommendation.

Lastly, and in alignment with the overall intent, the research team narrowed the analysis scope to identify and characterize if operational knowledge gaps specifically are/have been negatively affecting acquisitions to allow for the potential for a relatively small change Service leadership could make to mitigate it. This scope reduction allows for a significant reduction of risk and unknowns from the recommendation. The team felt this was a critical requirement of this research and that its results should allow for decision-makers to be able to enact recommended changes swiftly.

B. RESEARCH METHODS

The team intentionally utilized United States Air Force (USAF) Colonel (Ret) John Boyd's Observe-Orient-Decide-Act (OODA) Loop concept with the objective of this research to provide all the information required to enable swift action by leadership (Phillips, 2021). Subsequently, we aligned our data analysis and findings section to provide decision-makers the observations (data), orientations (analysis of the data), and decisions (recommendations) in the following section within the above-narrowed scope to enable the ability to act. Based on the team's intended audience of this research is a combination of Service leadership, Congressmen, as well as decision-makers not as well-versed in the intricacies of DOD acquisitions, a need to revisit and explain some DOD acquisition processes and personnel was required. While elementary to some readers, the team decided it was necessary to set an appropriate knowledge base for those not as familiar. For this type of information, the team utilized the most recent editions of acquisition policy guidance, guidebooks, rules, and regulations. Most of this research can be found in the literature review section of this document.

The data compiled in this research comes from a variety of sources. To assist with the identification and decomposition of programmatic failures and successes within DOD acquisitions, the team leveraged dedicated and neutral third parties associated with Government oversight such as the Government Accountability Office and studies from the Air Force Institute of Technology. Additionally, due to the need to extract current execution analysis from the Services, the team relied both on current Service policies and procedures coupled with specific focused data points provided by the U.S. Navy's Bureau of Naval Personnel in response to the team's requests for information. This raw data was compiled, analyzed, and formatted by the team for digestibility and ease of understanding its context. Related, the team utilized several efforts and studies regarding parts of the Services human resource challenges and opportunities available in support of the recommendation. While in their original form these studies and data points were not focused on acquisition challenges, they do provide an important element for a potential solution to the focus of the research problem by showing lost expertise and sunk cost Services lose when a trained warfighter leaves the military.

C. UNACCEPTABLE END-STATE CONSIDERATIONS

Regardless of if happening in the DOD or the public sector, acquisitions or development of a product is a difficult art, not a science, and as such is never without risk. It is unrealistic to expect a project or program to be problem-free and hit all original cost, schedule, and performance metrics without any evolution or compromise. For this research, unacceptable end-states equate to significant misses that greatly affected the taxpayer (cost) and the warfighter (schedule and performance) that should have been avoided, more appropriately mitigated, or the amplitude reduced by a feasible and proactive alternative action.

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III. DATA ANALYSIS AND FINDINGS

A. WARFIGHTER INTEGRATION DURING THE LIFE CYCLE

The following section will analyze warfighter representation through the multiple phases of a program.

1. Warfighter Representation Pre–Milestone A

Pre-milestone A activities are complex and for simplicity, this section was divided into two focus areas: the JCIDS process and Material Solution Analysis with CDD validation.

a. JCIDS Process

The Joint Capability Integration and Development System (JCIDS) process is a massive undertaking, and its structure is lined with senior leadership engagements. As seen in Figure 3, in the Joint Requirements Oversight Committee (JROC) there are multiple levels of General Officer and Flag Officer Integration groups with O-6 level integrations groups above different Functional Capabilities Board working groups that develop requirement portfolios to push up for approval. This spreads out or can dilute, requirements as they get farther and farther from the source of the need. While there are Joint Urgent Operational Needs (JUONs) and Joint Emergent Operational Needs (JEONs) requirements from the warfighters that bypass a lot of the process to a Joint Rapid Acquisition Cell, most requirements for the JROC take significant time, and the warfighter subject matter experts are fairly separated from the ultimate decision-makers.

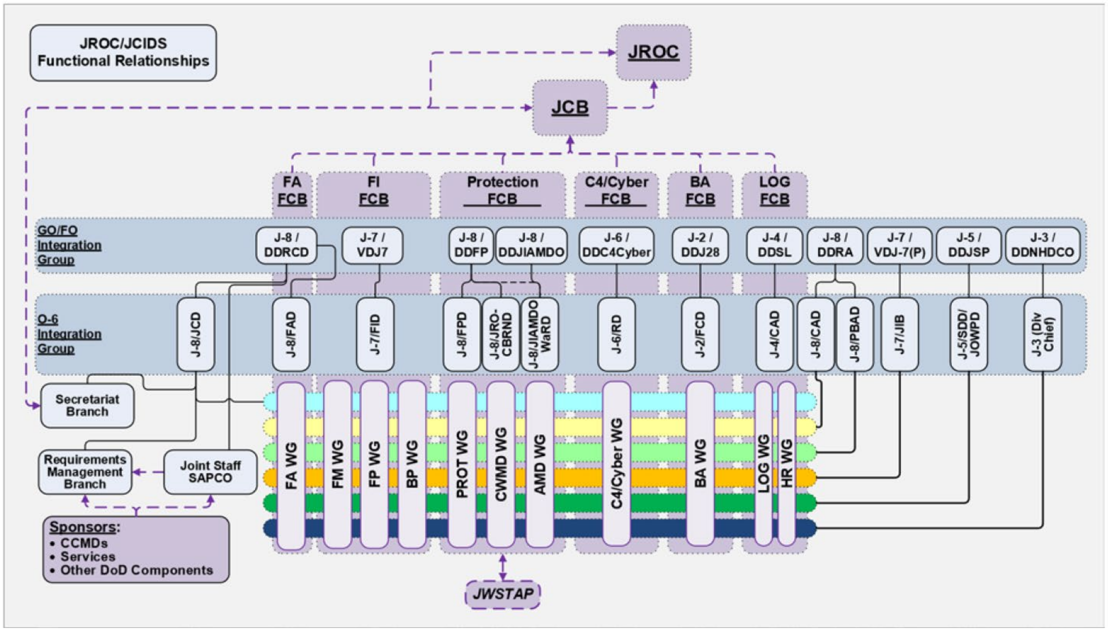

Figure 3. JROC Subordinate Boards and Related Organizations. Source: Chairman of the Joint Chiefs of Staff [CJCS], 2018).

While this is an important strategic forum, decisions and approvals come from a very large pool of requirements and information across the DOD managed via portfolios by the lower tiers. Specifically, regarding the capability requirements portfolio management, the charter states

> a critical aspect of JCIDS is to allow the JROC and its subordinate boards the ability to manage and prioritize capability requirements within and across capability requirements portfolios of the Joint Force. This can then inform other assessments within the Joint Staff and ensures the JROC and the CJCS are able to meet their statutory responsibilities. (CJCS, 2018)

Having a large pool of information and requirements always in flux that requires such a senior approval level does come with some costs, however. While there is management and prioritization delegation to the lower levels of the subordinate boards, all compete for a very limited amount of JROC decision brief airtime which can elongate the time to get a decision made. Additionally, while there may be a few warfighters from the working group in the room for the discussion and to field questions from senior JROC members, it is normally other senior leaders, or the O-6 level representatives left to represent the warfighters. That too can come at a cost of either misunderstanding the actual needs or operational impact from the fleet, or unfortunately, sometimes also injects a more political perspective. Not presenting or downplaying the need for a requirement up to the JROC senior leaders, to save another similar program from being viewed as a failure or not meeting the need and thus risking scrutiny/defunding, has and continues to happen. However, the JROC is not the only requirements approval forum as Service unique requirements can be validated by Service leadership in-house.

Using the Navy as an example, whether feeding JCIDS or Service unique requirements, they use a slew of processes, typically arranged and managed by individual warfare communities, to provide Service leadership and JCIDS with information from the warfighter in the development of operational-level broad requirements. Naval Aviation Requirements Groups (NARG), United States Marine Corps (USMC) Operational Advisory Groups (OAG), Type Commander (TYCOM) Priority Lists (TPL), and Integrated Prioritized Capability Lists (IPCL) are just a few examples of existing processes that enable operational input into the requirements process. The products of these annual working groups and conferences ultimately inform the start of the Navy's Two-Pass Seven-Gate acquisition practice and a Material Development Decision (MDD). Figure 4 serves as a pictorial reference for the position of each gate relative to other critical events and milestones throughout a program's acquisition life cycle.

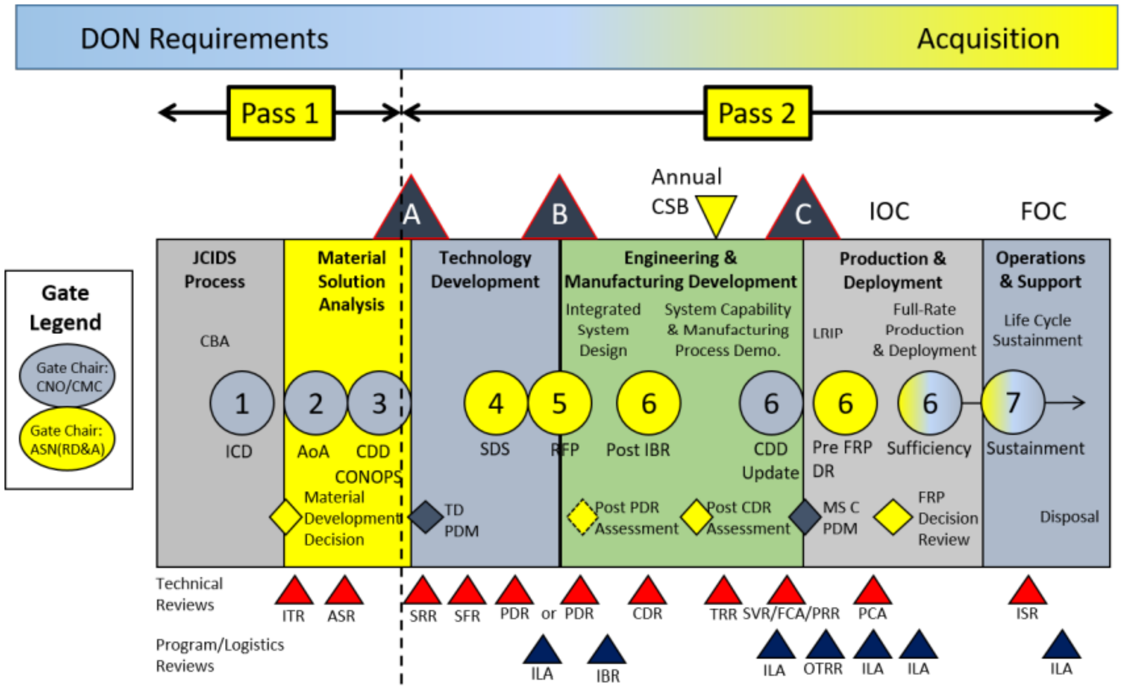

Figure 4. DON Requirements/Acquisition Two-Pass Seven-Gate Process. Source: Assistant Secretary of the Navy for Research, Development, and Acquisition [ASN(RDA)] (2019)

b. MSA to CDD Validation

For the Navy, the Office of the Chief of Naval Operations (OPNAV) conducts reviews of Gates 1–3 via a Resources and Requirements Review Board (R3B). Similarly, for the Air Force, the appropriate Major Command for the program holds the requirements hammer and works with the warfighters to develop and approve the ICD through Capability Development Document (CDD) requirements. Regardless of Service, the initial acquisition phases through CDD approval have the highest level of direct warfighter participation. This includes weapon schools, Fleet Replacement Squadron or other training unit representatives, maintenance representatives expounding upon their inputs from NARGs, etc., in a working group fashion led by the resource/requirements sponsors such as OPNAV or Air Combat Command (ACC) for the respective Service/Major Command. These are also accompanied by white papers and analyses from processes like the Navy Capabilities-based Assessments Integration Process (NCIP) program to ensure the requirements cover the need and threat projections in greater detail.

As part of the annual NCIP program, engineers, integrators, weapon school and operational test warfighters, OPNAV requirements officers, and Navy program managers cover program updates, potential new requirements, and conduct analysis heading into the next year's acquisition and budgeting cycle. This analysis, and other similar efforts by other Services, cover key requirement trade-space in working groups to help the warfighter and resource sponsors put forward the most efficient initial requirements needed in the CDD while deconflicting requirement needs with other programs execution as well. The process of developing and updating the CDD before approval takes a significant amount of time and lots of interactions with the key subject matter experts. Once drafted, the CDD is presented for approval by leadership and handed over to the program office for execution with Milestone A.

2. Warfighter Representation Milestone A through Milestone C

With most of the initial heavy requirements lifting completed via the drafting and approval of the CDD, direct warfighter interaction or presence within a program office is minimal through the Technology Maturation and Risk Reduction (TMRR) and Engineering and Manufacturing Development (EMD) phases. More concerning, as seen in the Figure 5 sample of 11 MDAPs, most program offices have very few military members in them and of that very small number of military members, most have not served in an operational capacity before. In that same 2019 GAO study charged with reviewing military departmental processes used to meet personnel needs, military members in some cases were not even assigned based on experience or talent, but for mere convenience. The report uncovered the Military Global Positioning System User Equipment (MGUE) program, in Figure 5, only had an abnormally large military presence "because it is easier to assign military personnel in high cost-of-living areas than it is to hire civilian personnel" and that program office was in Los Angeles (DiNapoli, 2019). The program office of any acquisition program has incredible importance, especially in this phase of the acquisition life cycle, yet regularly has little military presence within, let alone with recent and relevant operational experience with that type of program end-state product.

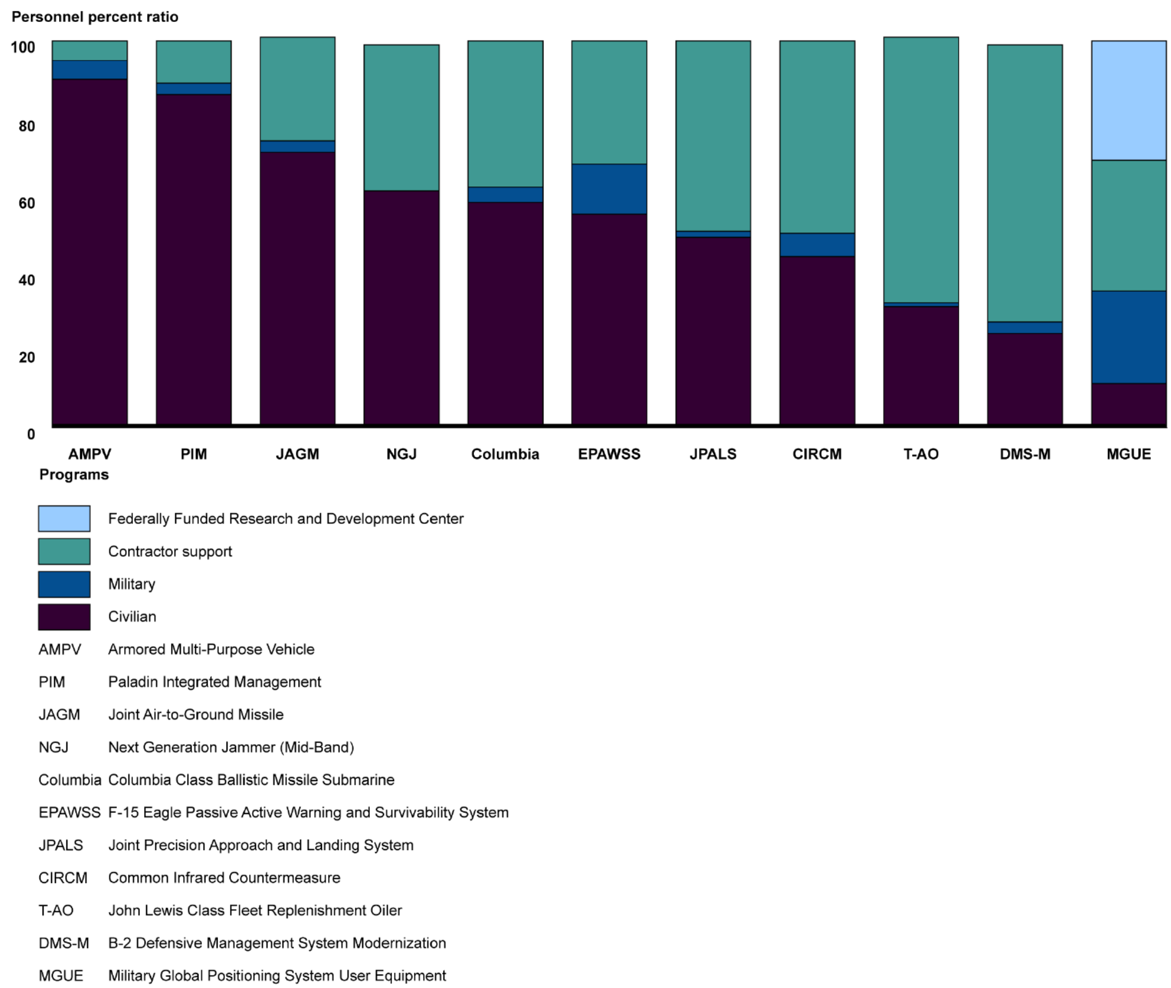

Figure 5. Program Workforce Size and Composition Across 11 Studied MDAPs. Source: DiNapoli (2019).

While the program office is deriving the specification requirements for the program from the CDD and developing the product and capabilities towards those specifications, currently there aren't a lot of direct external warfighter interactions at this point either. The only external warfighter engagement typically comes from the program office to Service requirements officers, such as the OPNAV Requirements Officer (RO) or ACC for example, with program updates or larger decision needs. Again, through the lens of the Navy example in Figure 4, key milestone and gate decisions are being made at a higher level, Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN(RDA)) in this case, further removed from direct interaction from the warfighter.

Warfighter interaction picks up more once the capability is developed and starts to interact with developmental test and operational test warfighters. At this point, warfighter interaction is more reactionary as the design is locked and the program is tested against specifications. Discrepancies are then reported back to the program office that need to be addressed or agreed upon to meet exit criteria before commitment to production at Milestone C.

3. Warfighter Representation Post–Milestone C and during Operations and Sustainment

As a program commits to production, warfighter feedback comes via two forms: discrepancy reporting via Initial Operational Test and Evaluation (IOT&E) feedback and follow-on modernization planning for the program. Discrepancy reporting and dialogue over their validity comes from the operational test community and/or from the fleet if the program does concurrency as happened with programs like F-111 and F-35 which are covered later. As discrepancies grow in parallel with the program's completion run to a full-rate production decision following IOT&E, they compete for the same resources. This naturally results in another round of prioritization and tradeoffs between the program office and resource sponsors like OPNAV directly with some warfighter input, primarily from the test and weapon school communities. NCIP type analysis with concepts of employment and concepts of operations working groups are key to identifying these priorities or the consequences of not correcting them.

Concurrently as initial development begins to draw down, follow on modernization plans are being made via a CDD update along with further discrepancy resolution plans. This also further considers current problems faced by the fleet as a program transitions to the operational and sustainment phase of its life cycle. This becomes a more cyclical drumbeat pattern based on both sustaining a current product while trying to add additional capabilities to it. This more directly correlates to and follows the Program Objective Memorandum (POM) process and warfighter involvement discussed earlier. The challenge with warfighter involvement in this part of the program's life cycle is the steadier need for warfighter feedback but weapons schools, operational testers, and especially warfighters in the fleet cannot commit a lot of time. While they could support one or a few working group engagements to support the big initial requirements development plans, daily or weekly engagements are not possible. Similarly, the warfighter representatives such as OPNAV requirements officers, now have a growing list of tasks to support the now operational program and, as of this research, must do so with very few personnel and are also not cross-trained in acquisition. This leads to both a resource-led problem limiting information exchanges as well as an operational knowledge gap within the program office.

B. SERVICE SPECIFIC DESIGNATORS SUPPORTING ACQUISITIONS

Based on the findings of few military personnel employed within program offices discovered above, the next data point the team wanted to identify was how each Service in the DOD executed and supported its acquisition efforts. Specifically, what active-duty personnel makes up this small group within a program office and what were their backgrounds. This variable was deemed critical to analyze to determine if part of the knowledge gap between the front lines and acquisition decision-makers was due to a lack of combat warfighter experience by servicemembers within a program office or supporting acquisitions via an acquisitional designator.

1. United States Air Force

The United States Air Force deploys two acquisition professional designators in the 63AX and the 63EXX.

a. Acquisition Manager (63AX)

USAF Acquisition Managers, designated by Air Force Specialty Code (AFSC) 63AX, make up a significant portion of the Air Force's uniformed professional acquisition workforce. According to the Air Force Officer Classification Directory (AFOCD) a 63AX

> Manages defense acquisition programs covering every aspect of the acquisition process, including integrating engineering, program control, test and deployment, configuration management, production and manufacturing, quality assurance, and logistics support. Performs functions essential to acquisition programs involving major defense acquisition programs and other than major systems or subsystems. (Air Force Personnel Center, 2021b)

Unique to the Air Force, initial officer candidates are eligible for direct accession to the 63AX AFSC provided they meet specific education program description requirements. Appendix A of the AFOCD contains the educational requirements for acceptance to the 63AX community. According to that appendix, a prospective candidate must possess a baccalaureate degree or higher in one of the following areas of study: Engineering, Physical Science, Computer and Information Sciences and Support Services, Mathematics and Statistics, Economics, or Business and Related Support Services. Additionally, entry may be granted with any degree which requires 24 semester hours of business coursework (Air Force Personnel Center, p.278, 2021b).

Although direct accession into the community is common, the AFOCD contains the following guidance:

> It is desirable that entry into the career field be preceded by assignment in another utilization field whenever possible. Officers who enter the career field on their initial tour should seek a subsequent assignment in another utilization field followed by a return to the acquisition program management career field. This desired career broadening is to provide a better perspective and understanding of the interfaces between functions of acquisition management and related functions in the developing, operating, training, and support commands. Lateral inputs will include only those officers who have clearly demonstrated a potential for effective administration and program management beyond their basic specialty. (Air Force Personnel Center, 2021b)

All 63AX officers should expect to execute at least one "career broadening" tour during their careers. Figure 6 depicts several examples of these potential career-broadening opportunities according to the Air Force Personnel Center. Figure 7 illustrates where these tours fall within a standard 63AX career progression timeline.

- PME Instructor (81T)
- Instructor (81T)
    - AFIT, OTS, ROTC, USAFA
- Academic Program Manager (82A)
- Recruiters (83R)
- Honor Guard (85G)
- Ops Management (86M)
- Command & Control (86P)
- IG (87X)
- OPS Staff Officer (16G)
- RAS/PAS (16F/16P)
- Plans & Programs (16R)
- Aide-de-camp (88A)
- Wing Exec (97E)
- Non-6X AFSC CC
- OPEX
- SPEED
- *Deployment (179/365)
- *CNODP (17D)

* May not provide true CB, still enhances prof dev

Figure 6. Potential Career Broadening Opportunities for USAF Acquisitions Officers. Source: Department of the Air Force (2020).

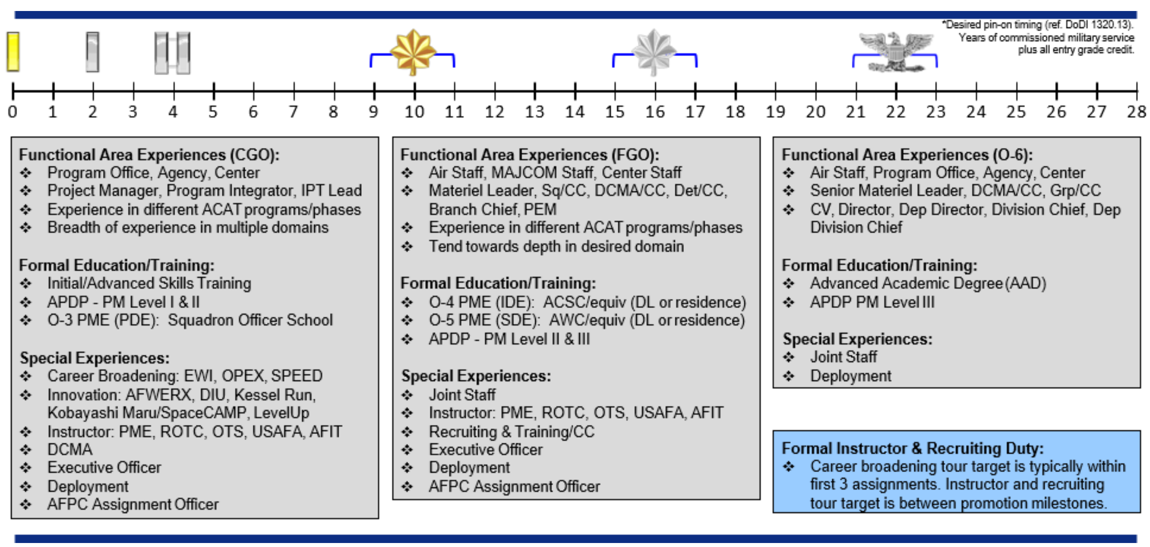

Figure 7. USAF Acquisition Manager (63AX) Career Progression. Source: Air Force Personnel Center (2021a).

While there are many career-broadening opportunities in a wide spectrum of available assignments, it is important to note that they do not include front-line warfighting duties which would be on the receiving end of a USAF acquisition. There are opportunities to interact with warfighters in some of these tours, but at no point in the career path or as a pre-requisite, does this designator require front-line operational experience. Most 63AX officers get diverse perspectives by being assigned to different aspects of acquisitions from a program office to software factories like Kessel Run, to test sites to gain further acquisition experiences but go their entire career solely involved in the acquisitions with the specific focus on a program management track.

b. Developmental Engineer (62EXX)

AFSC 62EXX, Developmental Engineer Utilization Field, is an umbrella community made up of several smaller specialty engineering communities. Their responsibilities include "design, development, installation, modification, testing, and analyses of materials, techniques, and process" management for a myriad of programs, projects, and activities (Air Force Personnel Center, 2021b). Per the AFOCD, a USAF Developmental Engineer

> plans, organizes, manages, and implements systems engineering processes to assure required capability delivery over the life cycle of Air Force systems. Included are accomplishing specialized engineering processes and sub-processes; formulating engineering policy and procedures; and coordinating and directing engineering and technical management activities and operations necessary for system conception, development, production, verification, deployment, sustainment, operations, support, training, and disposal. This includes technical management associated with the requirements definition, design, manufacturing and quality, test, support engineering and technologies, modifications, spares acquisition, technical orders, mission critical computer resources, support equipment, and specialized engineering. (Air Force Personnel Center, 2021b)

As with the 63AX AFSC, direct accessions to 62EXX are permitted providing the candidate has obtained an appropriate undergraduate degree or higher from one of the following disciplines listed in AFOCD Appendix A: "Aerospace/Aeronautical/ Astronautical Engineering, Computer Engineering, Electrical, and Computer Engineering, Electrical Engineering, Mathematics and Statistics, Physical Science, Mechanical Engineering, Systems Engineering, or Industrial Engineering" (Air Force Personnel Center, p.277, 2021b). 62EXX officers can expect similar "career broadening" tours throughout their career progressions. Figure 8 provides a graphical example of a common 62EXX career progression timeline. Similar to the 63AX, it is not a requirement nor is unlikely that a 62EXX AFSC has front-line operational experience.

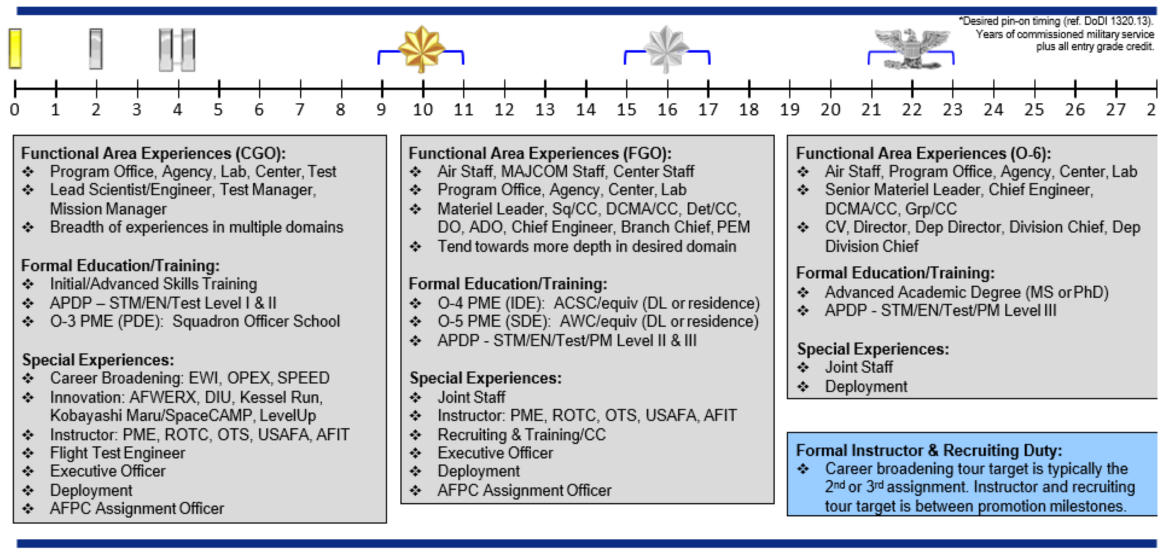

Figure 8. USAF Developmental Engineer (62EXX) Career Progression. Source: Air Force Personnel Center (2021a).

2. Department of the Navy (DON)

The Department of the Navy has multiple career paths that cover different communities within the Navy which are separated below for distinction.

a. Aerospace Engineering Duty Officer (151X)

AEDOs are U.S. Navy active duty and reserve component officers who have laterally transferred from the operational naval aviation community. They provide professional management and technical direction to weapon systems acquisition processes throughout their entire life cycle by leveraging their unique blend of operational, acquisition, and technical knowledge with operational experience and viewpoint. They are divided into three specialties: Test and Evaluation, Program Management, and Fleet Support & Production. As seen in Figure 9, the role was developed to 'bridge the gap' between the AWF and the Fleet by training these front-line warfighters in acquisitions, to Defense Acquisition Workforce Improvement Act (DAWIA) certification standards, and executing DOD acquisition efforts. Specifically, the gap being bridged is a knowledge-based gap between career acquisition professionals and end-user perspectives.

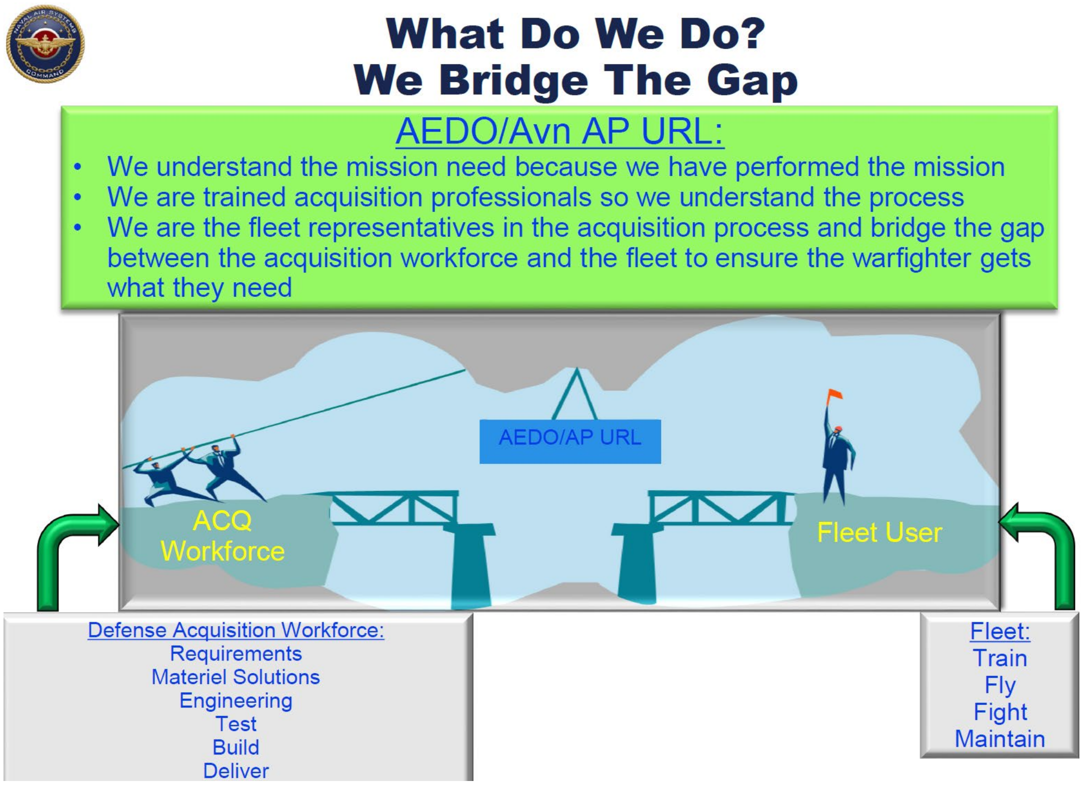

Figure 9. AEDO Bridge the Gap Role. Source: Naval Personnel Command (2022a).

Like the USAF Acquisition Manager career path, Figure 10 shows that AEDOs have a path towards growth and experience in DOD acquisitions built into their career path as well. Unlike the USAF 63AX however, due to their careers following the warfighter career path, AEDO's acquisition education timing is more rapid and the breadth of acquisition positions available is limited due to time constraints. In fact, most AEDOs lateral transfer after their fleet Department Head tour, or their fourth operational squadron assignment. This brings a wealth of knowledge and experience, both tactical and combat, but also from overseeing squadron maintenance and operations departments allowing for a more complete understanding of the variables affecting Naval Aviation operations and sustainment. The downside for the Navy is that as of this research, there are only "305 AEDOs in the inventory" (Bureau of Naval Personnel, personal communication, October 2021).

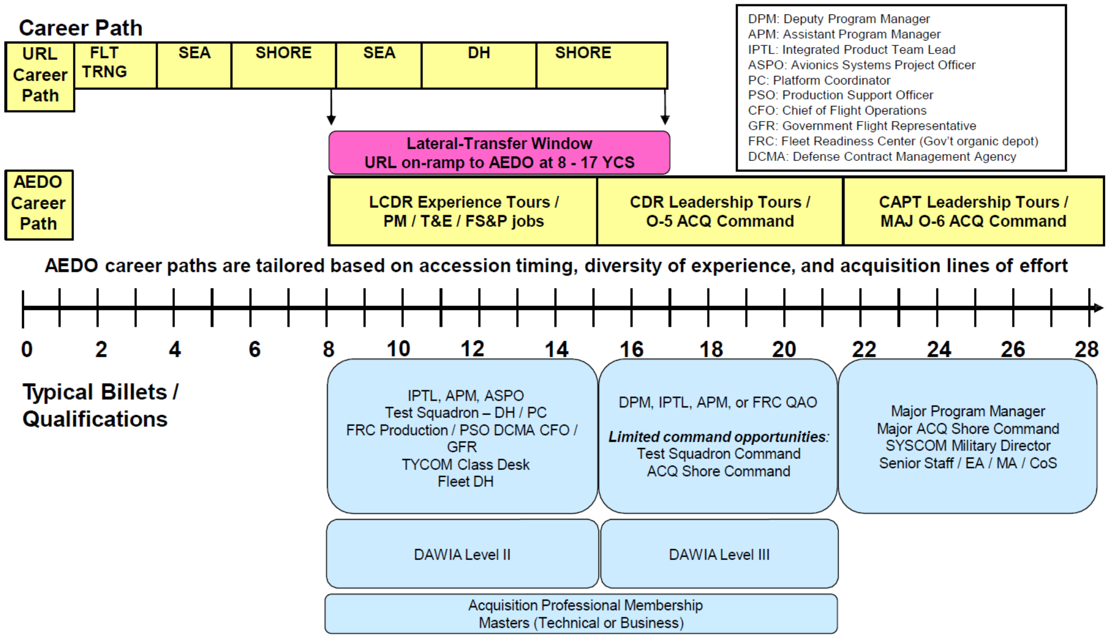

Figure 10. AEDO Career Progression and Acquisition Training Requirements. Source: Naval Personnel Command (2022b).

b. *Aviation Maintenance Duty Officer (152X)*

Aviation Maintenance Duty Officers (AMDOs) are commissioned active duty and reserve Naval Officers who develop, establish and implement fleet-wide maintenance and material management policies and processes in support of aircraft, weapon systems, and support equipment. Primarily working in fleet maintenance organizations, AMDOs additionally provide support to all aspects of system acquisitions as program managers and logistics experts.

As seen in Figure 11, having significant operational and intermediary depot-level maintenance experience, most AMDOs do not come from the fleet to fill acquisition billets until they are post-command O-5s. They support Naval Air Systems Command (NAVAIR) and Naval Systems Command (SYSCOM) programs like AEDOs until selected as an O-6 to be a major program manager.

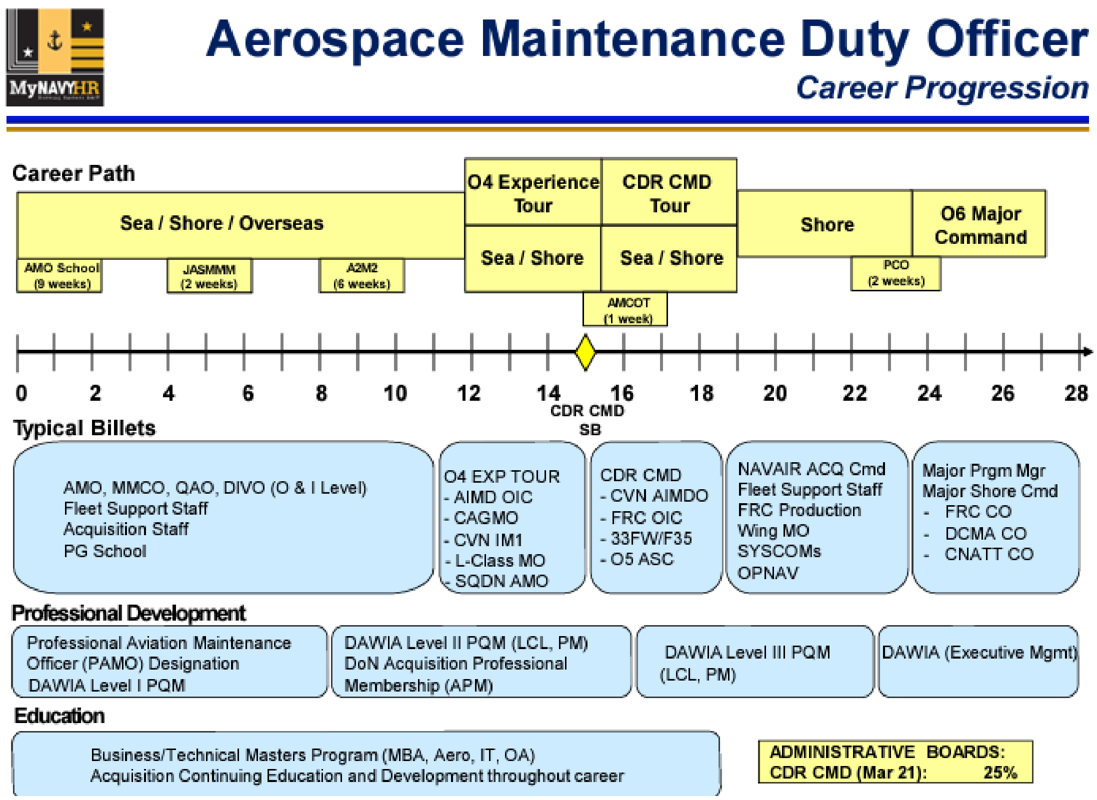

Figure 11. AMDO Career Path and Acquisition Training Requirements. Source: Naval Personnel Command (2022b).

c. *Engineering Duty Officer; Surface/Submarine Warfare Officer Acquisition Professional (144X/111X/112X)*

Unlike AEDOs and AMDOs there is no separate Unrestricted Line (URL) designator for a Surface of Subsurface Warfare Officer (SWO) who becomes an acquisition professional (SWO AP) partially due to it being a new position created around 2014. However, the applicant must commit to the SWO AP role for the rest of their career as part of their package for consideration. The community's core competencies include

> significant leadership experience to include Command-at-sea, acquisition experience, the ability to bring an operator/warfighter's perspective to requirements definition, test and evaluation, sustainability and risk management [with a] blend of technical and tactical acumen. (Naval Personnel Command, 2021)

Additionally, the SWO AP community requires an applicant to be not only warfare qualified but will select only as junior as an O-5 who has been screened for O-5 Command to fill this role. Like other positions above, DAWIA certification is required per Title 10 Acquisition Corps (AC) membership requirements, and PM Level II is the minimum certification to gain under the mandatory timeline. Unlike the AEDOs or AMDOs, because there is no separate designator, the SWO AP members do still compete with fleet SWOs for promotion. As of spring 2021, there were 33 fully certified members with 17 eligible and 51 candidates along with 51 SWO AP applicants and 14 chosen to join the community (Naval Personnel Command, 2021).

Related is the Engineering Duty Officer (EDO) designator which is a Restricted Line (RL), engineering-centric, designator that again requires a SWO or Submariner to earn their URL Warfare Qualification before lateral transferring into the new designator. The difference compared to the SWO/Submarine AP is that the engineering focus requires significant additional education in engineering and as such the lateral transfer window opens earlier between year 4 and year 12 of a SWO or submariner's career. This allows for proper EDO training, and engineering master's degrees from either Naval Postgraduate (NPS) school or Massachusetts Institute of Technology (MIT) before fulfilling engineering-specific acquisition billets – not program management or test billets. This designator is very similar to the USAF 62EXX designator, except for EDOs having operational time, warfare qualifications, and likely Command-at-Sea experiences.

3. United States Marine Corps

The United States Marine Corps acquisition professional program is like the Navy's but is much smaller in size and predominantly focuses on the 8061 and 8059 MOSs.

a. Marine Acquisition Officer (MOS 8061/8059)

Very similar to the Navy's AEDO approach, the USMC also utilizes the warfighter prerequisite for its acquisition officers – Marine Acquisition Officers (MAO). The Marine Corps has two primary military occupational specialties (PMOSs) of 8061 (Acquisition Management Professional) and 8059 (Aviation Acquisition Management Professional) who are "accountable for taking requirements from concept exploration to deployment of an operational piece of equipment" (United States Marine Corps, 2022). They also have two additional military occupational specialties (AMOSs) of 8057 and 8058 that support acquisitions as well. Figure 12 depicts the career progression of a Marine from their operational tours as a warfighter through the application process and transition to an acquisition PMOS fully supporting acquisitions for the rest of their career. AMOS 8057 officers are part of the acquisition workforce that assist with the "planning, directing, coordinating, and supervising specific functional areas that pertain to the acquisition of equipment/weapons" on top of their PMOS duties and are not yet Defense Acquisition Corps (DAC) members (United States Marine Corps, 2022). The only difference between AMOS 8057 and 8058 is that the latter has completed the requirements to be accepted into DAC.

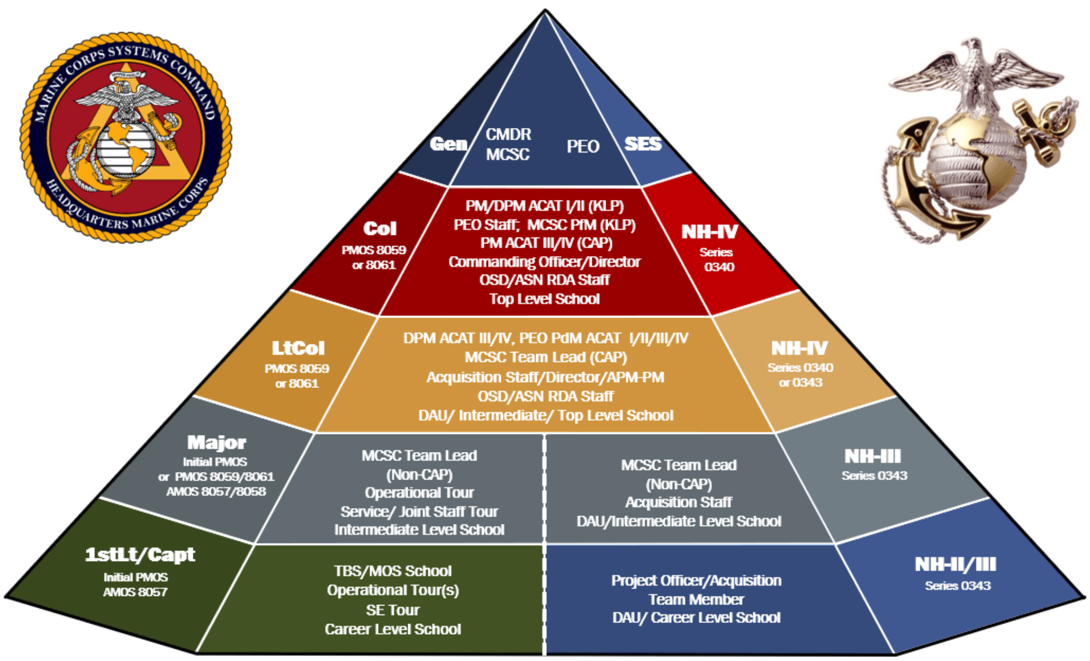

Figure 12. USMC Active Duty/Civilian Acquisition MOS Career Path. Source: United States Marine Corps (2022).

To apply to lateral transfer to the MAO PMOS, a Marine must be at least the rank of Major in and URL PMOS, less than 24 years of service, be certified DAWIA Level II in the primary acquisition career field, and have 36 months of acquisition experience (from the AMOS 8057/8058 time) (United States Marine Corps, 2021). This is a unique difference from the AEDO accession process described above where URL warfighters apply, laterally transfer to AEDO, and then are required to become DAWIA certified within the three-year time limit. This has its advantages in that when a Marine applies for the MAO position, they are already educated and can go into a billet mandated by law to be DAWIA certified. The disadvantage as compared to an AEDO is this requirement to already be Level II certified may adversely limit the number of candidates due to the time required to get certified while executing their PMOS work. Lastly, the USMC also depicts in Figure 12 the CAP and KLP opportunities and where they lie within the MAO career path.

4. United States Army

The Army Acquisition Workforce (AAW) totals approximately 40,000 acquisition professionals and is responsible for converting validated requirements into products and services. Of the 40,000 people, only 4% are military officers or non-commissioned officers. Army officers only serve in three of the 13 acquisition career fields: Contracting, Program Management, and Test and Evaluation. Non-commissioned officers are only eligible to serve in the Contracting career field. The remainder of the workforce is made up of civilians.

The Army Officer onboarding process takes place in years six or seven via semi-annual Voluntary Transfer Incentive Program boards or through the Experimental Test Pilot Program selection process. Competitive officers have demonstrated successful leadership performance in their parent basic branch. This ensures at least six or seven years of operational experience within the officer acquisitions community. Figure 13 depicts a standard Army Acquisition Corp Officer career timeline, note the accession block between years six and eight.

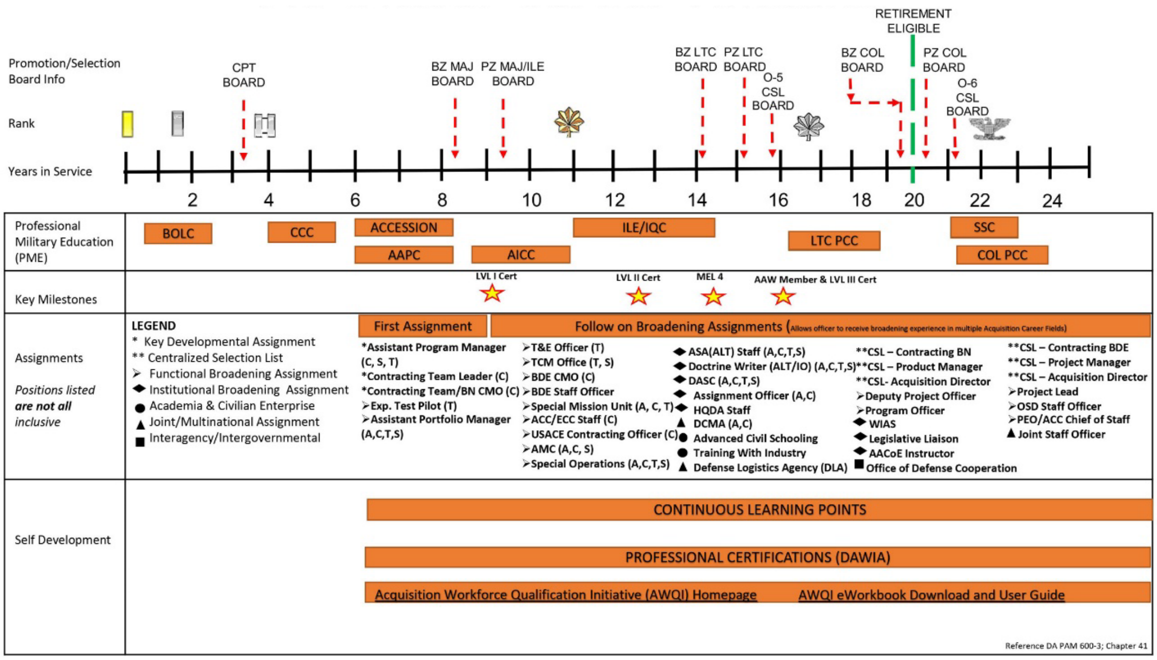

Figure 13. Army Acquisition Corps Officer Career Timeline. Source: Department of the Army (2021).

Non-Commissioned Officer (NCO) accession is somewhat more complex. The window for Army NCOs to redesignate to the AAW depends solely on their ability to meet the Service Remaining Requirement of 60 months but no greater than 12 years of service. Once redesignated, soldiers may not reclassify to any other military occupational specialty during the five-year period (United States Army Acquisition Support Center, 2022a). Figure 14 depicts a common Army NCO Acquisition Corp career timeline.

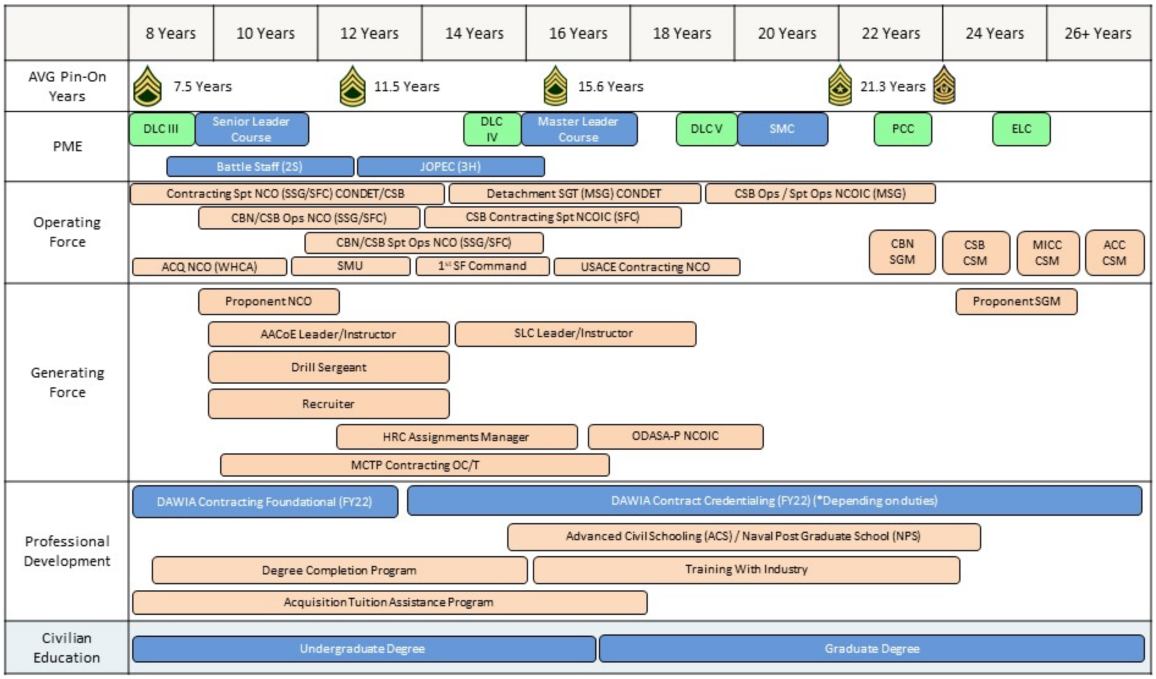

Figure 14. Army Acquisition Corp NCO Career Timeline. Source United States Army Acquisition Support Center (2022b).

C. REQUIREMENTS MANAGEMENT CASE STUDIES

This section will cover 4 high visibility case studies focused on requirements management and the positive and negative outcomes that happened as a result of warfighter involvement, or lack thereof, in the program.

1. F-22A Raptor and F/A-18E/F Super Hornet

The United States' first 5th-generation fighter, the F-22A Raptor was born out of the USAF's Advanced Tactical Fighter (ATF) demonstration program in 1981 searching for a replacement for their aging F-15 platform. Targeting air-to-air superiority for decades to come, the USAF wanted to ensure it was more advanced than the anticipated threat aircraft (Su-27 and MiG-29) being developed at the time. The F-22 acquisition program formally began in 1991 planning for 12 years of development and 648 aircraft. Unfortunately, it ended up taking 14 years with cost and schedule overruns plummeting procurement to just 195 aircraft produced with 182 fielded when production ended in 2012. Separate from a modernization effort for F-22 that began in 2003, "the F-22 acquisition program was completed at a total estimated cost over $67 billion" (Sullivan, 2014). Additionally, EMD phase costs alone doubled from the initial contract of $9.5 billion to over $20.1 billion in 1999 (Defense Acquisition University, 2007).

Although monitoring the ATF competition for a potential naval variant, the Navy chose instead to begin efforts on the F/A-18E/F Super Hornet program. Navy analysis in the late 1980s deemed there was no longer a significant emerging air threat to the battle group to warrant an air-to-air focused replacement for the F-14. While the Navy also had the legacy F/A-18A-D Hornet with significant shelf life left, it had some key flaws that limited its capabilities without undertaking a redesign. Therefore, unlike the F-22A's revolutionary approach, the Navy's Super Hornet's Cost Analysis Requirements Description (CARD) decided on an evolutionary approach. The CARD stated, "the objective of the F/A-18E/F program is to develop, test, produce, and deploy an upgraded F/A-18 with increased mission range, increased aircraft carrier recovery payload, additional growth potential, and enhanced survivability" (Younossi et al., 2005). After completing its development, the program began fielding fleet Super Hornets in 2000 yielding a total of 608 Block I and II variants along with orders for 78 new Block III's beginning in 2019 (Suciu, 2021). Unlike the F-22A program, however, the F/A-18E/F program met both its original cost and schedule estimates after its initial development phase in 2000.

While it is not useful to compare specific dollar figures between the F-22A and F/A-18E/F programs due to different program objectives and technologies, it is relevant to compare their planned versus actual execution data along with the resulting program outcomes. Both programs' development phases were executed under the same DOD instruction 5000.2 (although since reformed) and during nearly the same period from 1991 to 2001. This reduction in external variables affecting the data makes these programs ideal for comparative analysis regarding how knowledge gaps and requirements management played a part in the results.

Figure 15 and Figure 16 show significant deltas between the two programs' cost and schedule execution compared to what was originally forecasted. Notably, Figure 15 shows despite program objectives being significantly different between the two aircraft, both planned development schedules were identical for around 100 months. While F/A-18E/F had a slight delay in execution, F-22A development execution took approximately 57% longer than planned to complete. Similarly, (specific overall dollar value caveat from above aside) while F/A-18E/F came in slightly under cost, F-22A matched its schedule overage by ending nearly 50% over its initial planned cost estimate.

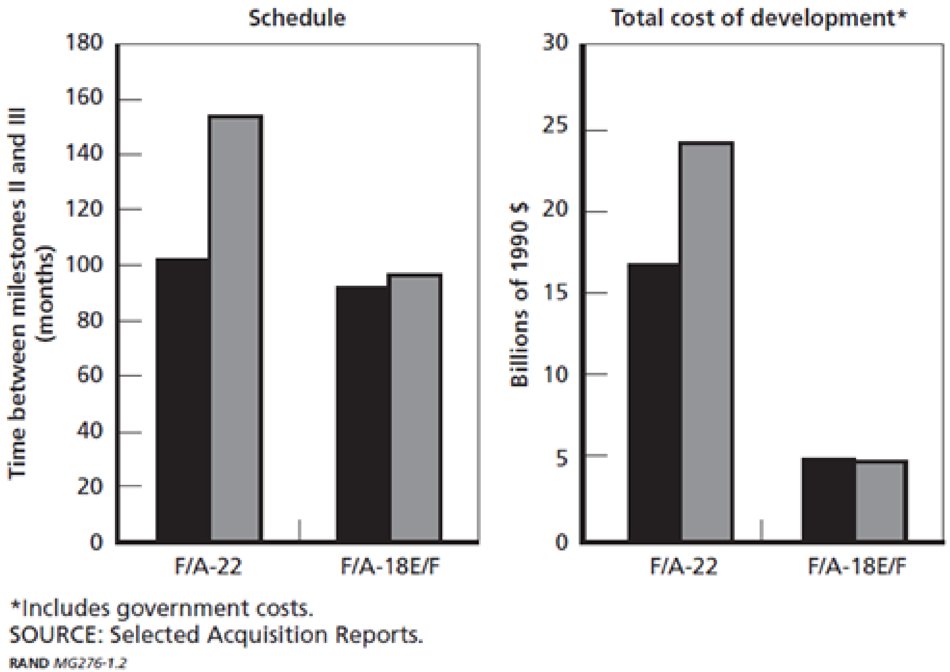

Figure 15. F-22A and F/A-18E/F Schedule and Cost Predictions vs Actuals for Program Development Phase. Source: Younossi et al. (2005).

Particularly noticeable in Figure 16, is the turbulence in the evolution of schedule estimates during development for F-22A as opposed to the flat trajectory of the Super Hornet's. The RAND Corporation's Project Air Force was sponsored by the Assistant Secretary of the Air Force for Acquisition (SAF/AQ) in 2005 to identify causal factors contributing to the differences between these programs through the EMD phase. While a significant portion of their report identifies causal factors such as F-22A's "artificial distribution of the development effort" evenly across three contractors to allow them "to remain competitive as prime contractors for future business," it also uncovers the relationship of requirements development and management as an additional contributor (Younossi et al., 2005).

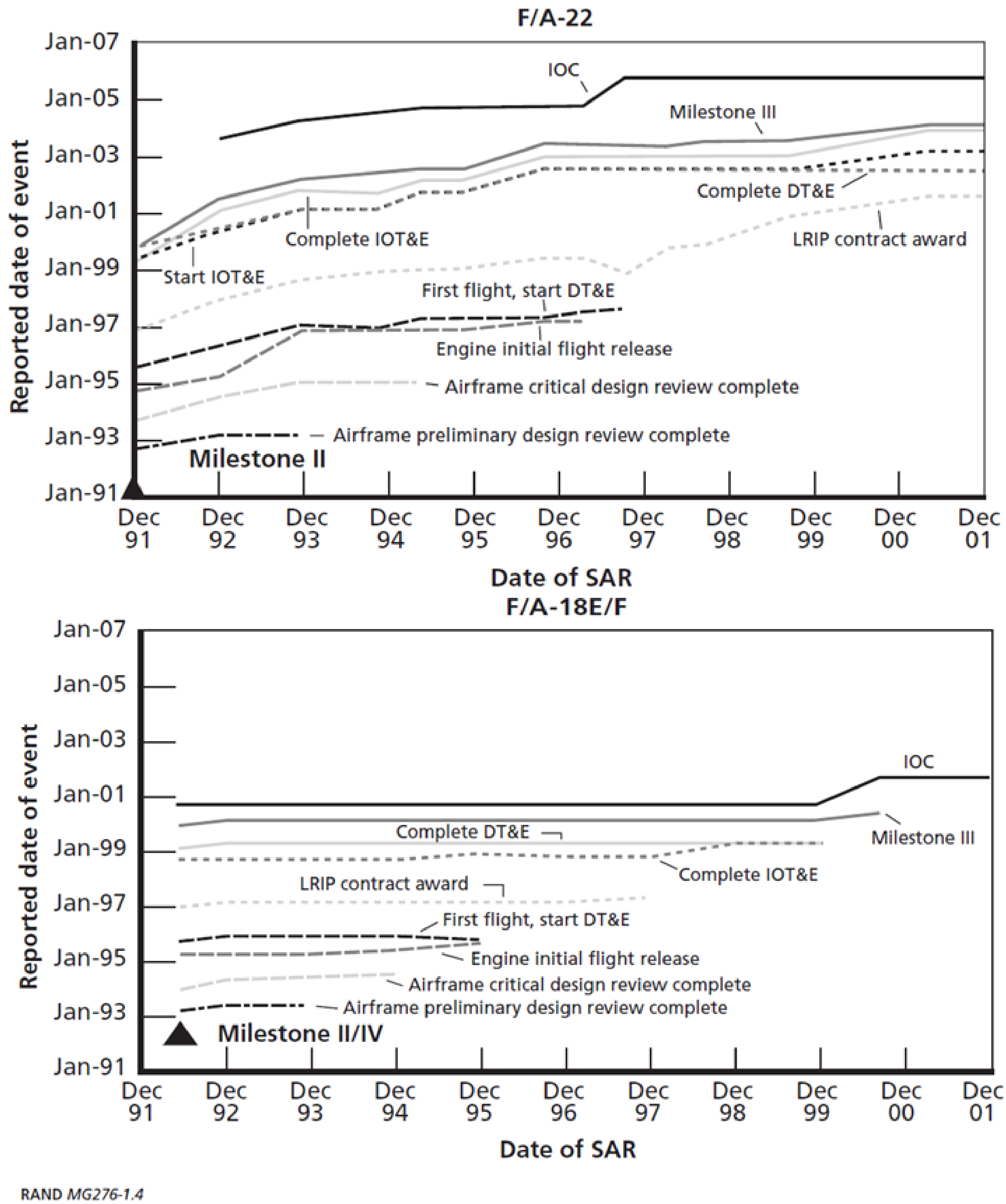

Figure 16. F-22A and F/A-18E/F Schedule Estimates Changes During Development Phases. Source: Younossi et al. (2005).

Of the list of eight major factors, the RAND report communicated upfront to decision-makers from their research, five involved either requirements management, stable and proper team expertise involving the warfighter (knowledge gaps), or both. While there were other acquisition management decisions and Industry-based factors that contributed to the overages, likely playing a sizeable part, we will focus here on in-scope factors.

One of the above factors the RAND report cited critically affecting F-22 was setting ambitious, high-risk, and unwavering requirements out of the gate that also had to deliver at the same time. So much so that far-reaching innovations were included "in all the major areas of the aircraft: airframe, avionics, and propulsion" including thrust-vectoring engines and an Active Electronically Scanned Array (AESA) radar – a first of its kind on a fighter aircraft (Younossi et al., 2005). The requirements for the program also involved three specific high-risk performance requirements:

- Supercruise – ability to cruise at Mach 1.5 without afterburner
- Acceleration – able to accelerate from 0.8 to 1.5 Mach in 5 seconds
- Radar Cross Section (RCS) – front RCS no greater than 0.01 square meters. (Defense Acquisition University, 2007)

Even during the Demonstration/Evaluation phase pre-EMD, "it was generally recognized that the extremely demanding ATF performance requirements…would pose substantial technological, design, engineering, and manufacturing challenges for industry" (Younossi et al., 2005). However, based on the budget constraints in the 1980s and the diminishing U.S. aerospace industry, it was believed the ATF program would be the "only opportunity to develop an all-new, cutting-edge-technology supersonic fighter for the next decade or more" and so the requirements remained fixed (Younossi et al., 2005).

With the establishment of the F-22 program office and the start of EMD, the communication flow was primarily between the F-22 USAF Program Manager and newly created Integrated Product Team (IPT) members (consisting of USAF Acquisition Managers, Material Leaders, or their Government Civilian designees) and their counterparts across the three contractors of Lockheed, Boeing, and General Dynamics. Communication with the requirements owners (and warfighter representatives) of ACC in Langley, VA and the program office in Dayton, OH was executing a directed annual requirements review cadence "based on negative experience with earlier programs (such as the B-1 bomber)," called the Summit Process (Williams, 1999). The purpose of this cadence was to ensure the operational requirements document (ORD) (later replaced within the DAS by the CDD), from which the program office executes its acquisition strategy to achieve the required capabilities, was always updated. Although the Summit Process concept was new, "both the F-22 program office and the warfighting command found this process…immensely helpful in solidifying requirements and preventing unnecessary changes by members of the acquisition process outside of the ACC users" and "[hopefully] preclude problems when the program came up for operational testing" (Williams, 1999). Without interaction with the warfighter representatives like this, previous program execution was mostly reliant upon program office personnel's interpretation and setting further derived performance requirements based on an ORD set at program start potentially years prior.

Unfortunately, the decision to run development and integration of all parts of the F-22 concurrently, coupled with both the physical separation between ACC and the program office on just an annual cadence, suppressed the overall effectiveness of the requirements trade-off Summit Process. While some requirements were eliminated later based on cost and schedule overruns precluding their incorporation, ACC resisted any modification or trading of either schedule or performance of the high-risk requirements (Defense Acquisition University, 2007). To both ACC and USAF resource decision-makers, some problems were hard to comprehend from a non-acquisition-based perspective and/or surfaced late (inadvertently concealed behind the confusion and complexity of the organizational setup with industry) compounding the inability to understand how a rigid stance would negatively affect the program overall. In 1995 however, the Defense Science Board (DSB) warned the USAF and the Senate Armed Services Committee (SASC) about both the risks associated with concurrency stressing the requirements management needed to achieve an acceptable outcome.

> The Task Force would like to stress one point: there are substantial margins throughout the F-22 specifications and a very capable aircraft would result even if performance fell somewhat short of meeting many or even all of these specs. It is therefore important that the [System Program Office] SPO

> and [Office of Secretary of Defense] OSD not take a rigid stance on meeting all specs but rather, as the program progresses, look at the overall performance, cost and schedule impacts in deciding which if any, performance areas need further work. (Defense Science Board, 1995)

This same DSB warning regarding concurrency would again be ignored later with the F-35 program as seen in Section III C 2 with similar results. The USAF was additionally rigid regarding their refusal to export the F-22, which could have alleviated some of the cost constraints they were experiencing. Without enough give and take between the program office and sponsor, and a knowledge gap between both, the results were continual slips in schedule, cost overruns, and final production of just 28% of the F-22s originally planned.

Conversely for the Navy on the heels of an embarrassing A-12 program failure and cancellation in 1991, they learned they had to better "control technological risk and to constrain costs" by being more deliberate in the development of requirements for Super Hornet (Younossi et al., 2005). The Navy did this by taking the same new IPT concept that F-22 was implementing but further enhanced its effectiveness. First, they staffed the program office with AEDOs that had a background in flying USN fighters in the fleet to run different parts of the IPTs. This added a dual warfighter and program manager perspective when translating ORD requirements into program design, specifications, and priorities to be executed. Second, the program office was co-located with other NAVAIR program offices at NAS Patuxent River, MD, not far from the requirements officers and resource sponsors at OPNAV in DC. Lastly, in support of the evolutionary approach, the initial requirements were intentionally far less demanding.

The program struck a balance ensuring the higher risks and costs associated with designing a whole new aircraft were offset by utilizing warfighter acceptable fielded components such as some of the avionics and the upgraded APG-73 radar from the F/A-18A-D. Warfighter representatives agreed with this approach because, by relieving the program of the additional pressure, it better ensured the new airframe addressing the current needed capabilities holding back the legacy Hornet (higher payloads, longer range, and greater bring-back to the carrier) would field sooner. Similarly, the Navy ensured that it did not lose sight of the eventual end state needs of the Super Hornet by adding in similar requirements as the F-22s (such as an AESA radar, upgraded electronics, and a new

Forward Looking Infrared (FLIR) system) into engineering specs as planned upgrades. The ability to draw this line of needed now versus needed later also was enabled by the program "employ[ing] a key acquisition reform concept later formalized as Cost as an Independent Variable (CAIV)" in its dialogue with the warfighters both in and outside the program office (Younossi et al., 2005).

Having an acquisition professional with relevant warfighting experience (in similar platforms) with relative proficiency embedded in the program office also paid dividends after initial requirements were laid. As with most programs, F/A-18E/F also encountered technical challenges that called for appropriate requirements management to make the most advantageous and effective adjustments to maintain cost and schedule with an acceptable level of performance for the warfighter. An example came with an issue over combat radius between the F/A-18E and F models. The program was faced with a choice of either maintaining a mostly common design and part interchangeability between the variants or ensuring the 2 seat F-model, where the additional ejection seat conflicts with fuel tank space, had the same combat radius as the E-model. According to the GAO, the range assessment was that "F model aircraft will be 33 nautical miles short of meeting the interdiction range requirements" (Rodrigues, 1999). The Navy chose to clarify the interdiction range requirement from the ORD as satisfied by the E model design rather than adding significant cost, schedule, and sustainment issues chasing equality of combat range.

While the GAO "[did] not agree with the Navy's assessment that the program [was] meeting all performance requirements" in 1999 due to this delta, in particular, the delta never became a significant operational issue (Rodrigues, 1999). 22 years later the aircraft was dubbed "the jet the U.S. Navy loves" based on both the capability increase (including combat range) while "[having] 42 percent fewer parts [to maintain] than its predecessor the F/A-18C/D variant" (Suciu, 2021). Had the Navy used solely career acquisition professionals in this program it could have allowed an operational knowledge gap, such as the perspective of the GAO testimony in 1999 over combat radius requirements, to force programmatic changes driving up cost and schedule unnecessarily. The effect of the F/A-18E/F program proactively managing requirements from the onset through an integrated warfighter and program manager lens is visible in the Figure 17 comparison.

In the case of F-22, the opposing pull between inflexible requirements from ACC and the program office's attempts to meet these far-reaching performance requirements without room to compromise yielded predictable cost growth. As broached earlier, in 1999 the Program Manager for F-22 recommended to ACC "some performance parameters be slightly relaxed…to constrain development costs and maintain schedule" but was met with "solid resistance" (Defense Acquisition University, 2007). The result left the program to cut support measures and use the remaining management reserves. As seen in Figure 17, with support budgets slashed to try to offset the overruns, it instead further increased the airframe and avionics cost growth equating to 67% of the overall cost growth of the program. RAND's assessment of airframe cost growth was that "weight instability was an early indicator of problems for the F/A-22" as the program continued to redesign to meet requirements (Younossi et al., 2005). Conversely, the F/A-18E/F program shows not only less volatility with cost growth but significantly lower amplitude. As seen specifically in Figure 17, the internal compromise allowing existing avionics to start the program and incrementally increasing capabilities as new technology matured yielded greater flexibility to the riskier airframe design which supported the main requirements. Without measures such as integrating cross-trained warfighters into the program to handle the give and take on requirements daily, the Super Hornet could have easily succumbed to similar cost and schedule overruns like F-22.

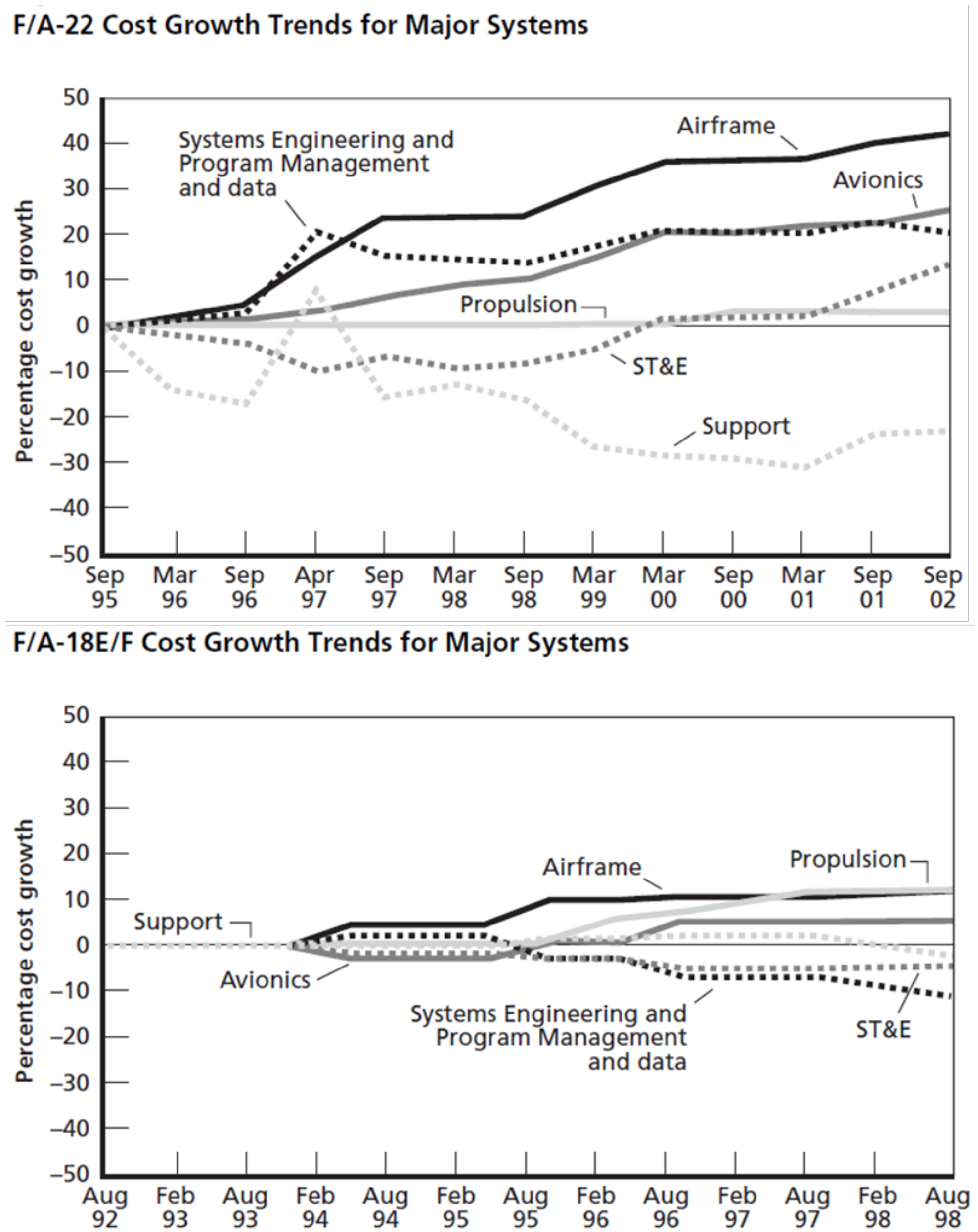

Figure 17. F-22 vs F/A-18E/F Cost Growth Trends. Source: Younossi et al. (2005).

One important aspect of warfighter integration within a program office that the Super Hornet program also demonstrated was the need for those warfighters to be cross-trained in acquisitions. Just as the program highlighted the importance of closing the operational knowledge gap, it too showed not over-correcting with adjustments yielding solely to fleet representatives (without acquisition training) - such as OPNAV or ACC. The Super Hornet program mitigated both operational and acquisitional knowledge gaps by having, in this case, AEDOs providing a referee-type roll between key stakeholders in the program. This allowed for better-informed discussions, analysis, and decisions on challenges facing the program office due to their ability to understand and represent both sides' needs. This reduced the amplitude of the tug-of-war all program offices face due to the innate conflict between the different stakeholders' objectives.

2. F-35 Joint Strike Fighter Program

The proverbial elephant in the DOD acquisition room is the DOD's "most ambitious and costly weapon system in history…at more than $1.7 trillion," the F-35 Joint Strike Fighter (JSF) (Oakley, 2021). The program's execution has been marred by several questionable decisions but in the scope of this thesis and its tie to requirements, this program was doomed from the onset.

At the beginning of the 1990s, the USAF, USN, and USMC all had numerous unique requirements for different Tactical Aircraft (TACAIR) platforms. There were already "plans to acquire four new aircraft over the next decade and a half – the [USAF's] F-22 and Multi-Role Fighter (MRF), and the Navy's F/A-18EF and A/F-X" with an additional effort underway to address the USMC's "requirement for an Advanced Short Takeoff and Vertical Landing (ASTOVL) aircraft" (Defense Science Board, 1994). While the requirements and operational need statements for F-22 and F/A-18E/F were covered in the previous case study, the USAF MRF "was designed to be the future mainstay multi-mission sortie generator" replacement for the aging F-16, and the A/F-X was intended to "satisfy…the unfulfilled requirement for first-day-survivability, stand-alone, longer-range strike capability" leftover from the canceled A-12 program (Defense Science Board, 1994). Lastly, the then called Advanced Research Projects Agency, now known as Defense Advanced Research Projects Agency (DARPA), was working demonstrators trying to satisfy the USMC requirement for a significantly more capable replacement for the AV-8B Harrier that had very limited payload and bring-back abilities. The operational needs and in turn the requirements of all five projects were unique to the different warfighters and environments from which they were to operate.

Just a few years later in October 1993, a 22-year sitting congressman turned Secretary of Defense (SECDEF), Les Aspin, at the direction of new President Bill Clinton, made and released *"The Bottom-Up-Review"* (BUR). This report, which also included budget cuts and a restructuring of the DOD, was to show the future of the U.S. Armed Forces post-Cold War. In the report, SECDEF Aspin directed the creation of the Joint Advanced Strike Technology (JAST) program that would "focus on developing common components – such as engines, avionics, materials, and munitions" to be used to satisfy multiple requirements (Aspin, 1993). Claiming "significantly reducing development and production costs," SECDEF Aspin eventually directed using his JAST to terminate and replace MRF, A/F-X, and ASTOVL all in one (Aspin, 1993). Focusing on cost, rather than actual warfighter needs, SECDEF Aspin downplayed the significant differences between the requirements of the three programs to meet political objectives.

Without experience in aviation or the military, aside from a 2-year stint as a U.S. Army systems analyst in the Pentagon in 1966, SECDEF Aspin concluded that "different airframes – the chief differentiator between land-based and carrier-based aircraft – are a lesser part of overall aircraft cost…thus, we are aiming for a combat aircraft that, in terms of costs, is 80 percent 'joint' although there may be different airframe silhouettes" (Aspin, 1993). This significant oversimplification of what the aircraft looked like on the flight line as compared to capabilities delivered showed a significant acquisition and operational knowledge gap. Moreover, his creation of JAST in the report countered his observation two pages prior where prior "efforts at joint development of a single aircraft type to meet the requirements of both services have met with very limited success" (Aspin, 1993). Regardless, the change was directed citing a "lack of resources to support all these programs in the Future Years Defense Program [FYDP]" even with clear pushback from the Services and DSB that "still, there was a valid need for the diverse capabilities they were intended to provide" (Defense Science Board, 1994). Lastly, the DSB reiterated in its report on JAST that "there must be no confusion about the JAST role…and JAST should be a *customer* for S&T programs" and not attempt to be a sole manager and product for multiple diverse requirements (Defense Science Board, 1994). The DSB supported the need for additional aircraft to complement the F-22 and F/A-18E/F project but warned that the remaining "diverse requirements are difficult to reconcile in a multi-Service vehicle" (Defense Science Board, 1994). Regardless, in 1994 the JAST program office was established absorbing the DARPA Common Affordable Lightweight Fighter (CALF) and ASTOVL programs, and merging the other canceled efforts rebranding to the Joint Strike Fighter (JSF) program in 1996 and becoming an MDAP ACAT 1D program (Global Security, 2021).

Just as hastily as the decision to cancel the MRF, A/F-X, and ASTOVL programs were made, so too were the initial broad requirements for the program. These included mandating the aircraft was to be single-piloted and single-engine (a significant risk to at-sea operations) to reduce costs while forcing the "80 percent joint airframe" concept and the competition began by the end of 1994. Additionally, both trying to further drive down costs and to appeal to interested allies, the JAST program leadership, and Congress opened initial program requirements discussions to international partners starting with the United Kingdom (UK) in 1995, Canada in 1997, and several others followed. By the conclusion of the competition in October 2001, won by Lockheed-Martin's (LM) X-35, the 3 U.S. Services were competing for requirements trade space along with the UK and with influence by the additional 7 international partners and Foreign Military Sales customers. As Michael Hughes pointed out:

> Questions arise as to how effectively any of these models can address the requirements of a specific user while at the same time maintaining the design goal of 80 percent commonality between the airframes. In other words, to what degree must the performance requirements of any model of the F-35 be compromised to be able to simultaneously meet other, but different user requirements, such that 80 percent of the airframes of all three models remain the same? For example, imagine going to a car dealership and telling the salesman that you want to buy a single vehicle that performs like the most powerful and best handling sports car on the road, but also that this vehicle must be able to transport six adults in comfort and it must be able to readily haul large objects such as refrigerators, riding lawnmowers, motorcycles, and other bulky cargo. Also, somehow, this vehicle must be better at all these tasks than any competing vehicles, specialized or not, because second place is not an option. The salesman is liable to look at you as though you are just plain nuts, but many will tell you that this is

> essentially on the order of what is being asked of and promised by the maker of the F-35 - Lockheed Martin. (Hughes, 2015)

Whether shopping for a car or just trying to decide where to go to dinner, the more individual unique needs you are asked to satisfy further reduce the chance of successfully meeting them with a single product or selection.

One thing the JSF program did attempt to do, albeit unsuccessfully, was to have warfighter input into requirements and a link within the program office. On the heels of the famous 1986 Packard Commission addressing acquisition reform, the JSF Program Office (JPO) elected to adopt several of the commission's recommendations including "get the warfighter and technologist together to enable leveraging cost-performance trades" and "ensure that the solutions are joint" (Steidle, 1997). The JPO's answer to this was to create an OAG consisting of O-6 representatives from the 3 Services and the UK to represent the warfighter at decision-making events along with creating a System Operations Requirements Analysis (SORA) team within the JPO. These events included the evolution of the Joint Initial Requirements Document (JIRD) starting in 1995 into the Joint Operational Requirement Document (JORD) (Figure 18 and Figure 19) before the Analysis of Alternatives (AoA) competition and continue to this day. However, the implementation and execution of using the OAG and the SORA (later renamed the Air System Requirement (ASR) team) were flawed.

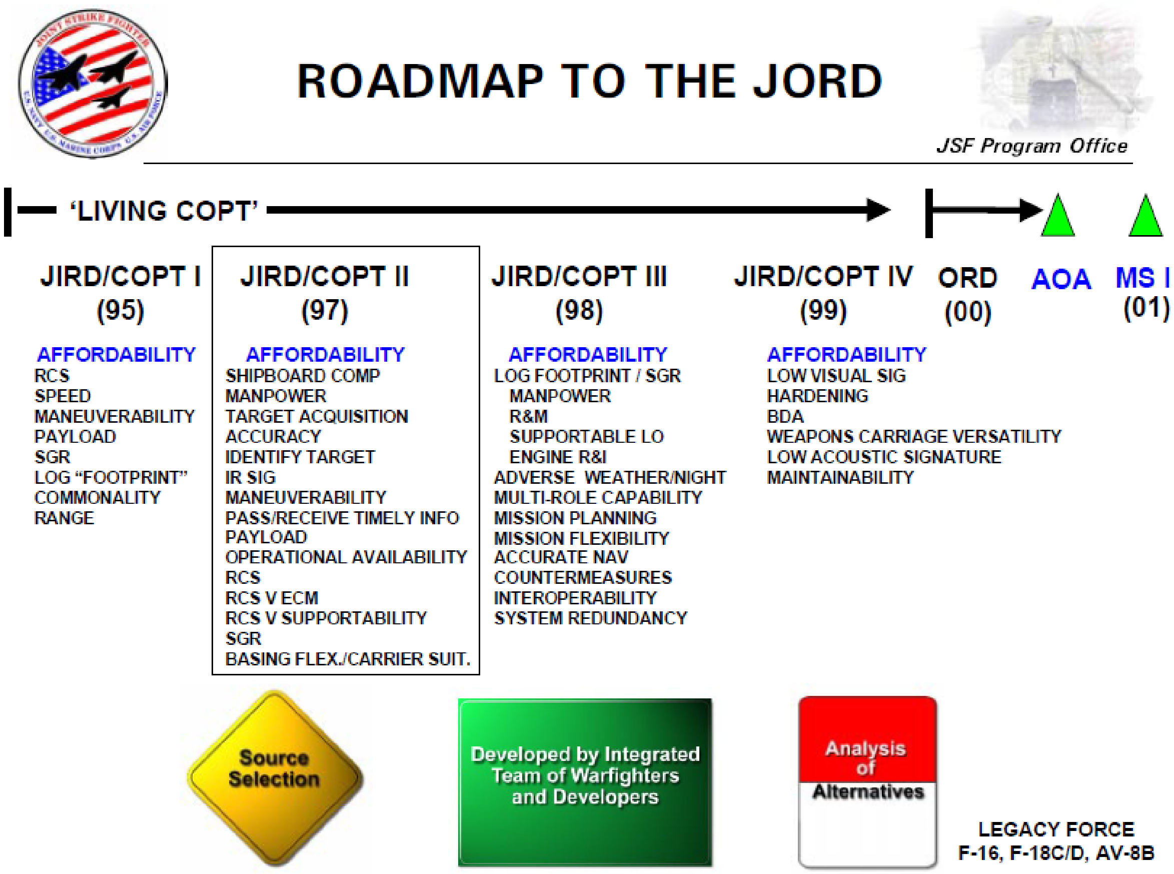

Figure 18. JSF PEO's 1997 Requirements Generation Roadmap Leading to the JORD and the AoA. Source: Kenne (1997).

First as seen in Table 1, while there was a total of 11 customers at the time for the F-35, the only voting members for these decisions were the USAF, USN, USMC, and UK representatives. This made the remaining countries upset that they didn't have a voting say in the requirements trade-off and decision-making process. This was later amended a few years later so that all U.S. Services and the 8 Partner nations (not Foreign Military Sales (FMS) customers like Japan and Korea) had a vote but the U.S. Services had a higher weighted vote. The second problem with this implementation and execution came with who were the voting members and how many members were truly active in the process. For example, while the list covers several member groups including resource sponsors, weapon schools, and test squadrons, most were not actively involved day-to-day in information exchanges due to their normal obligations and/or distance. Instead, on occasions or at decision-briefings, these important but "general members" would be asked to give their input "cold" (without prior requisite knowledge or preparation) when presented a problem or question and were rarely consulted afterward when the program tried to understand their feedback to execute. Related, most of these members were not anywhere near the JPO just as in the F-22 case study with ACC. This contributed to the lack of awareness of the intricacies within decision options and reduced the ability to participate actively in day-to-day information exchanges by the warfighter membership.

Table 1. JPO OAG Membership Table and Voting Members from 2003. Source: JSF Program Office (2003).

Air Force	**Navy**	**Marine Corps**	**UK**	**JPO**
ACC/DR*	CINCLANT/CFFC*	HQMC*	UK MOD*	SORA**
SAF/AQ	N-78	MCCDC	Australia, Canada	
AF/XOR	CNAF	MAWTS-1	Denmark, Italy	
AFOTEC	COMNAVAIRFOR	VX-23	Netherlands, Norway	
AWFC	COMOPTEVFOR		Turkey	
	NSAWC			
*Denotes Voting Member; all others are general members. CINCLANT/CFFC defers voting privileges to N-78 until further notice. **JPO member will perform duties as administrative chair.				

Further limiting the requirements development and requirements management of the program, beyond the complexities of trying to satisfy the unique needs of 11 different customers, was the 'paralysis by analysis' due to the overemphasis on cost reduction by the program and taking a Block approach binning large capabilities together instead of an incremental approach. As seen in Figure 19, the JPO also was utilizing the fairly new approach of CAIV that F-22 and F/A-18E/F did but so at a significant schedule and performance cost. Figure 19 shows the lengthy process starting with fielding the need statements from the frontline warfighters, taking those inputs through three rounds of computer studies and analysis before using those outputs to form the official validated requirements for the JIRD/JORD. This process took well over 5 years to accomplish (Figure 18) and yielded JORD requirements far different in performance levels than asked for in the beginning. As time passed from the initial need statement from the warfighter, the requirements drew more and more stale. Additionally, like the OAG limitation of regular frontline warfighter engagement, the Cost/Operational Performance Trades (COPT) process had heavy warfighter input upfront but not as much towards the end where the tradeoffs from the analysis process became a program of record JORD requirements.

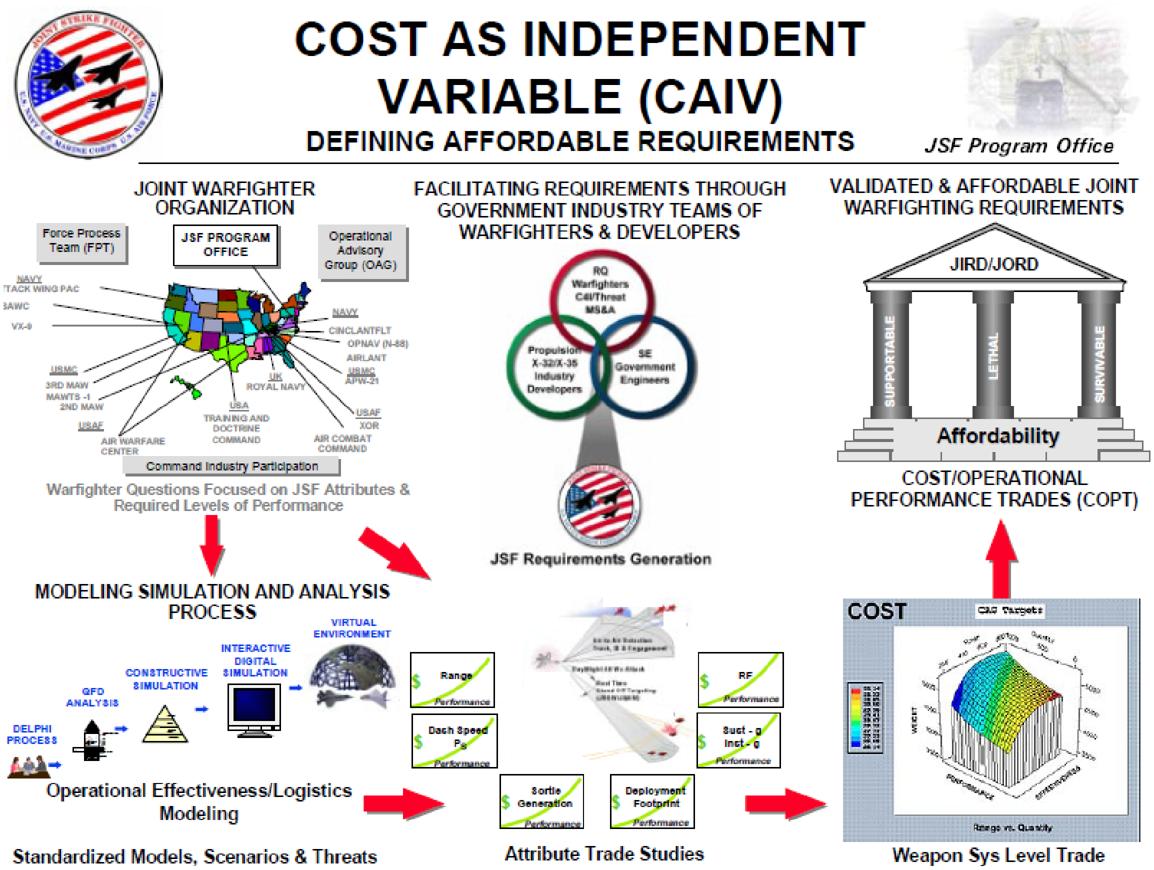

Figure 19. JSF Program Office's Requirements Generation Process in 1997.
Source: Kenne (1997).

The JPO attempted over the last half-decade to strike a more appropriate requirements management balance via the use of its cost, schedule, and performance neutral ASR team, the only team in the JPO made up solely of current and former aviation warfighters. The team, as in the OAG charter when called SORA, was to help facilitate dialogue between customers and JPO PMs to help make more Earned Value Management

(EVM) based decisions and drive key capabilities processes through the governance up to the JSF Executive Steering Board (JESB) for approval. In the end, however, the application of this embedded warfighter in the program office fell short for two main reasons: lack of empowerment within the program office and the ever-growing need of customers to have their already delivered aircraft work as needed. Within the program office, the ASR team worked with every PM regularly advising them on efforts PMs were pursuing that would eventually prove futile or lacked the priority of the customer. However, due to a lack of clearly defined, written, and supported roles, responsibilities, and expectations from JPO leadership as to the use of ASR, their priorities and warnings were rarely followed by PMs of the component products in the JPO. This yielded numerous discrepancies and insufficient performance of capabilities found years later in Operational Test. By the time these came to light, discrepancy resolutions (DRs) were unobtainable, too costly or time-consuming to attempt, or would come at a further delay to additional capabilities that were already differed in the program.

Today, 22 years after the JORD requirements were set, there are now more than 700 F-35s fielded across the globe with the program still yet to complete IOT&E and approve Full-Rate Production (FRP). Part of that significant lag, other than the choice to execute the program with concurrency, is that the aircraft continues to deliver late or does so with only part of the capability needed from multiple customer perspectives. According to the GAO in 2021, "Air Force officials told us that they and the other services are already making difficult choices due to the costs associated with achieving the requirements the F-35 program was supposed to deliver," equating to the aircraft never having the ability to reach the capability the customers needed and are looking to strategically pivot towards a new program because of it (Oakley, 2021). Congress in the Fiscal Year (FY) 22 NDAA seems to have sealed the fate of the program by reducing the number of aircraft the Services can buy and mandating "the JPO must transfer all sustainment activities for the F-35A to the Air Force by the start of FY28, with the department of the Navy becoming the sustainment authority for the F-35B and C variants at the same time. In addition, the JPO must relinquish all F-35 acquisition functions to the Air Force and Navy by the beginning of FY30" (Insinna, 2021).

3. F-111

The F-35 program was far from the first program to suffer from requirements paralysis and the boxing-in of program execution by an appointed Secretary of Defense. The "80% common [ality] in the airframe, engines, subsystems and avionics" was first forced upon a program to solve multiple customers' needs 32 years prior in 1961 with a similar outcome (Richey, 2004). Just a few months after being selected SECDEF by new President John F. Kennedy, businessman and Harvard alum Robert McNamara directed the creation of the Tactical Fighter Experimental (TFX) program. The creation came along with the forced combination of existing USAF and USN unique fighter requirements and the desired combination of "Army and the Marine Corps [sic] close-air-support aircraft [requirements in hopes] that this strategy would reduce procurement costs substantially" (Richey, 2004). While the Services were able to "convince McNamara the close-air-support mission could not be satisfied by TFX," he instructed the USAF and USN to "work closely together to combine their requirements before issuing a joint request for proposal (RFP), although both the USAF and the Navy thought that this idea was completely unrealistic" (Richey, 2004).

Coming out of the 1950s both the USAF and the USN were pursuing replacements for different parts of their fleet of aircraft. The USAF struggled with its internal conflicting requirements for several years looking to replace multiple aircraft at the same time. Initially, in 1958, the USAF issued General Operational Requirement (GOR) 169, "a Mach 2+, 60,000 foot altitude, all-weather fighter capable of vertical and short takeoff and landing (V/STOL)…[with] operational deployment by 1964" (Richey, 2004). Just a year later, the USAF canceled GOL 169 "recognizing that a V/STOL fighter capable of such performance was simply not feasible" but writing a new requirement in 1960 including most of GOL 169 minus the V/STOL portion (Richey, 2004). Surprisingly, the USAF merely four months later decided to combine this new requirement with another existing USAF requirement for a separate attack aircraft. In the end, Special Operational Requirement (SOR) 183 was issued in June 1960 with a staggering list of requirements to meet. Tactical Air Command's SOR 183 called for an attack aircraft capable of achieving a Mach 2.5 performance at high altitude and a low-level dash capability of Mach 1.2. It was to have short and rough airfield performance and was to be capable of operating out of airfields as short as 3000 feet in length. The low-level radius was to be 800 miles including 400 miles on the deck at Mach 1.2 speeds. In addition, it was to have an un-refueled ferry range capable of crossing the Atlantic Ocean. It was to have a 1000-pound internal payload plus a lifting payload between 15,000 and 30,000 pounds. (Richey, 2004)

This dizzying combination of conflicting requirements alone made it challenging to identify ways to solve the problem that required two totally different airframe designs. One aircraft optimized for high speeds and efficiency like the thin, swept-wing designs of the existing F-105 and another aircraft with large wings and fuselage to have short takeoff capabilities and carry large payloads. USAF and industry studies at the time yielded a "variable sweep wing based on technology developed at the NASA Langley Research Center, and an afterburning turbofan engine would be needed to satisfy these diverse Air Force mission requirements" (Richey, 2004). Unfortunately, due to the direction of SECDEF McNamara, these wouldn't be as diverse as the requirements would ultimately get.

Simultaneously with the USAF requirements development process, the Navy was developing its requirement to replace the F-4 Phantom and the F-8 Crusader focused on carrier-based fleet air defense. The Navy needed an aircraft that "[had] the ability to loiter on patrol for much longer times with substantially larger and more capable air-to-air missiles, and was to be able to meet and counter threats to the carrier group at much larger ranges" (Richey, 2004). Initially the Navy thought it had an aircraft in the subsonic F6D-1 Missileer design but analysis showed it would be "too costly and too specialized, and was thought to be too slow to be capable of defending itself" (Richey, 2004). In 1960 the program was canceled along with its matching missile effort leaving the requirement for the replacement aircraft still unfulfilled.

In coming together to form a joint RFP as directed by SECDEF, "the USAF and Navy agreed that the use of variable-geometry wings would be a good idea. However, on just almost everything else, they differed substantially" (Richey, 2004). The Navy needed a large air-to-air optimized radar while the USAF needed one optimized for terrain-following and the Navy needed long-loiter times at subsonic speeds with the USAF needing supersonic dash performance. Expectedly, the requirements deemed untradable by the USAF led to a 75,000-pound gross weight aircraft where the Navy needed to keep it below 50,000 pounds and 56 feet in length for carrier operations. The initial requirements tradeoff process became so difficult that in 1961, the Secretary of the Navy reported to McNamara that "the compromised TFX design could not meet the Navy requirements" (Richey, 2004). Despite the objection, McNamara ordered the Navy to accept a design that didn't meet the radar size requirement they needed as well as one up to 55,000 pounds.

Expectedly, the joint RFP proposals' four rounds and year-long process were evidence of the incapability of executing disparate requirements with 80% aircraft commonality while meeting the cost and schedule budgets expected. Many of the proposals determined that 80% commonality was impossible. One of those, Boeing, proposed a 40% common base pair of aircraft (Figure 20, left) and the lone 80% common proposal came from General Dynamics/Grumman (Figure 20, right) but at the expense of it being at an empty gross weight near the Navy's maximum takeoff weight (leaving little room for fuel and ordinance) and nearly 20 feet longer than the Navy needed at a whopping 73 feet. With the proposals in, the warfighter and the Services had to weigh in on their requirements and the feasibility of the program.

> The Air Force and Navy military operators favored Boeing because two structurally different planes would not be compromised as much as a common design to meet disparate service performance requirements – in effect, two different airplanes, as originally desired by AF and Navy. But to SECDEF McNamara, commonality in the GD/Grumman design validated his fundamental premise that a joint-service fighter was feasible, and would be most likely to realize the cost savings inherent in the TFX joint development approach, so he unilaterally over-turned the source selection board recommendation for Boeing, and awarded the F-111 contract (RDT&E to be followed by production of Air Force F-111A and Navy F-111B) to General Dynamics and Grumman in December 1962. (Richey, 2004)

Just as would happen 30 years later to the F-35, warfighter feedback and warnings were ignored and overruled, seeking an idealistic outcome empowered by an operational knowledge gap.

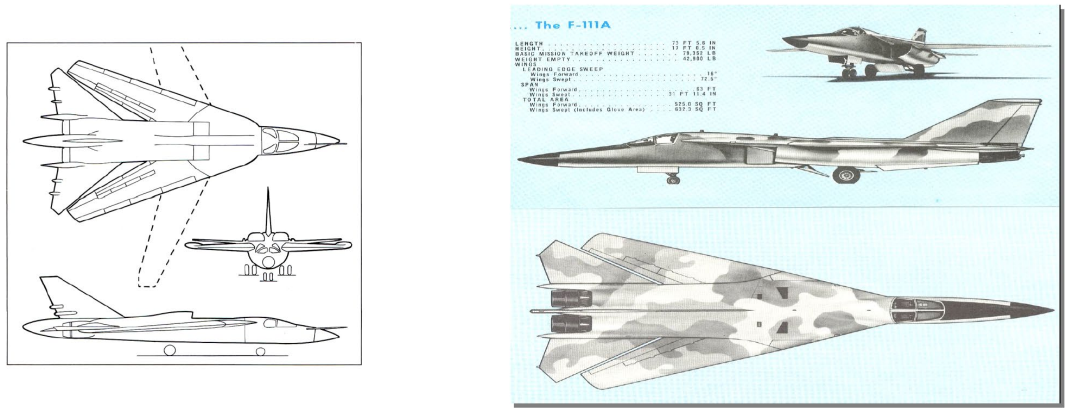

Figure 20. Boeing Proposal (Left) and General Dynamics Proposal (Right).
Source: Richey (2004).

The Services weren't free from their own mishandling requirements trade-offs once the contract was awarded, however. It is critical for any program that "Systems Architecture and Conceptual Design has to identify the important design choices very early in the design process that need to be made in order to achieve a design that is balanced for performance, mission effectiveness, including survivability, at cost, risk, and schedule impacts" (Richey, 2004). In the case of the F-111, the voice of the customer was Tactical Air Command (TAC, later renamed ACC), and they refused any trade-off analysis as part of this process that would require altering their requirements. An example of this was when an analysis identifying the impact of speed against dash distance and mission radius, seen in Figure 21, was conducted. Transonic drag rise is a phenomenon where aerodynamic drag significantly increases when an aircraft accelerates to between Mach 0.7 and 1.4 due to the shock waves and gets worse the wider the aircraft is. The F-111 design was already wide due to the Navy requiring the crew members to sit side by side so it would be more susceptible to a transonic drag rise penalty.

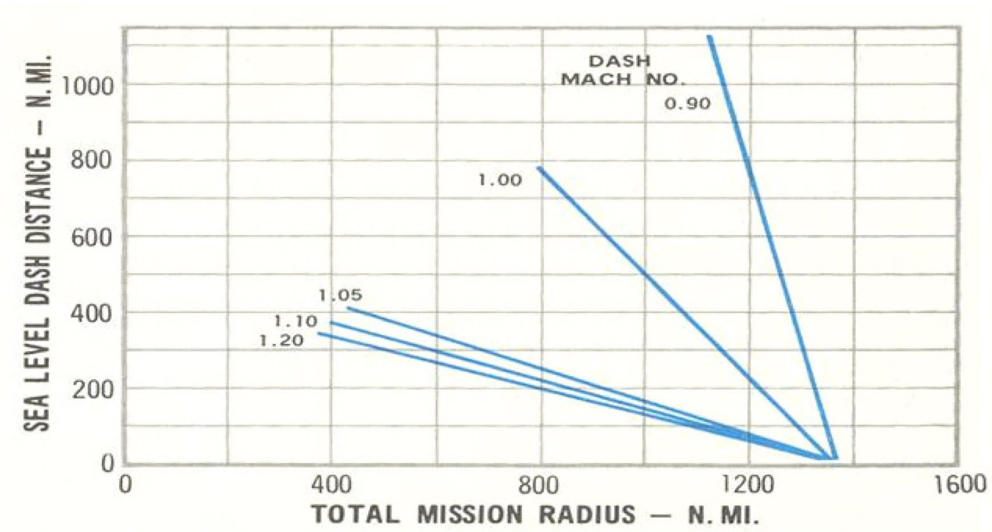

Figure 21. Trade-off Analysis of Predicted Dash Distance at Various Speeds. Source: Richey (2004).

Internally, the analysis team questioned the survivability benefit of choosing a Mach 1.2 dash speed versus a speed below the transonic dash rise speed for the F-111 design as both we not likely to outrun many threat missiles. The team consulted with operations research analysts at Wright-Patterson Air Force Base who determined that "the survivability increase was marginal, but the impact on aircraft weight to penetrate for 200 [nautical miles] at sea level flying at Mach 1.2 was substantial" (Richey, 2004). Despite this concern by the program office, it never was raised to Tactical Air Command based on their position of not accepting any analysis that would alter a requirement. In the end, both based on this inflexible position coupled with a lack of warfighter presence within the program office to hear about this concern, the aircraft design continued to balloon in size trying to hit the Mach 1.2 at sea level requirement. While the aircraft was eventually able to dash at Mach 1.2 at sea level, the transonic drag rise crushed the distance it could do that, falling well short of the 200 nautical mile range down to just 39 nautical miles in flight test. Years later after this issue was part of several serious deficiencies in the F-111 drawing congressional attention in 1978, then Chairman and CEO of General Dynamics David S. Lewis said

> The F-111 is truly a remarkable aircraft but unfortunately is very heavy, expensive, and has poor reliability. Had more thorough tradeoffs been made

> at the outset, it is almost certain that a decision would have been made that a sea-level dash speed of Mach 0.8 or 0.9 would have had an acceptably high probability of survival. The airplane would have been smaller, simpler, and much cheaper. The USAF could have afforded many more and the effectiveness of the overall inventory would have been much higher for the dollars expended. (Richey, 2004)

Another trade-off decision regarding mission performance versus reliability, cost, and program risk involved the F-111 avionics. As Initial Operational Capability (IOC) for the F-111A approached in 1966, the program was already being pushed to improve its avionics. However, this push for improvement didn't come from the warfighters in the form of a deficiency to the F-111A's being flown but via the DOD Directorate for Defense Research and Engineering (DDR&E) Director Harold Brown and the President's Scientific Advisory Board. The F-111A's Mark I avionics was an analog system that was reliable and met the requirements it was originally asked to do. The Mark II avionics system was a new set of systems that were based around new digital technology being developed but was still in its infancy. Both the program office and the primary customer, TAC, strongly opposed changing the avionics at that time. The TAC Commander had experience with several other acquisition efforts that were struggling due to digital avionics development. Regardless of the objections from the warfighter, "DDR&E pushed hard for the new avionics program…describ [ing] the 'Mark I' analog avionics systems…[as] not capable of giving the F-111 the true multi-purpose capability McNamara sought" and as such McNamara directed the switch in 1966 (Richey, 2004). As predicted, the "Mark II program schedules slipped by two years, and the system itself proved to be only 15 percent as reliable as stated in the proposal" and led to significant cost problems as well (Richey, 2004). It did not become operational until 1973 "costing four times original estimates, or approximately $1 billion" and resulted in a need for additional dollars to design a stripped-down version of the system sacrificing some performance to increase the reliability (Richey, 2004). As seen in Table 2, this also led to a sustainability challenge by having over eight variations of F-111 to maintain with different combinations of capability levels and differing avionics and engine packages.

Table 2. F-111 Variants Specification and Configurations. Source: Richey (2004).

F-111 Variants

F-111 Variant	F-111A	EF-111A	F-111B	F-111C	F-111D	F-111E	F-111F	FB-111A
Length	73ft 6in	74ft 0in	66ft 9in	73ft 6in	73ft 6in	73ft 6in	73ft 6in	73ft 6in
Height	17ft 0½in	20ft 0in	15ft 9in	17ft 0½in	17ft 0½in	17ft 0½in	17ft 0½in	17ft 0½in
Span @ 16°	63ft 0in	63ft 0in	70ft 0in	70ft 0in	63ft 0in	63ft 0in	63ft 0in	70ft 0in
Span @72.5°	31ft 11in	31ft 11in	33ft 11in	33ft 11in	31ft 11in	31ft 11in	31ft 11in	33ft 11in
Gross weight (normal)	91,300lb	88,950lb	79,002lb	114,300lb	100,000lb	91,300lb	100,000lb	114,300lb
Engine (TF30 X 2)	P-3/-103	P-109	P-12	P-3	P-9/-109	P-3/-103	P-100	P-7/-107
Maximum thrust (each)	18,500lb	20,840lb	20,250lb	18,500lb	20,840lb	18,500lb	25,100lb	20,350lb
Triple Plow Inlets	TP I	TP I	TP I	TP II	TP II	TP II	TP II	TP II
Mission avionics and special ordnance	Mk. I	Mk. I/TJS	Phoenix	Mk. I	Mk. II	Mk. I	Mk. IIB	Mk. IIB
Attack radar set*	APQ-113	APQ-160	AWG-9	APQ-113	APQ-130	APQ-113	APQ-144	APQ-114
Doppler radar	-	-	-	-	APN-189	-	-	APN-185
Terrain-following radar	APQ-110	APQ-110	-	APQ-110	APQ-128	APQ-110	APQ-146	APQ-134

Finally, the F-111 while considered a Joint program, SPO control was given to the USAF under a General Officer with a Navy O-6 Deputy. Instead of executing the program where both Services could have an active role such as in Washington, DC, the program office and engineers were moved to Wright-Patterson AFB, OH. This broadened the inter-Service disconnect but also removed the program office from both the Service warfighters (including customer representative TAC in Langley, VA) and other operational support teams. The apex problem this lack of warfighter integration in the program office caused was unacceptable weight growth. The first chance the Navy had to perform a Preliminary Evaluation on the F-111B (naval variant) was in 1965, over four years into the program design. By this point "the F-111B was seriously overweight…takeoff weight for a fully-equipped aircraft was estimated by the Navy at nearly 78,000 pounds, well over the upper limit of 55,000 pounds" which was already 5,000 over the Navy deemed maxed weight (Richey, 2004). Despite efforts to do a Super Weight Improvement Program, only a 4% reduction in weight was possible convincing the Navy that "the F-111B would never be developed into a useful carrier aircraft" (Richey, 2004). This resulted in the Navy successfully protesting to Congress to cancel the F-111B in 1968, four years after Critical Design Review (CDR), and the design was frozen. This resulted in the USAF being stuck with all the Navy-related design compromises in their aircraft and sole financial responsibility for the program.

Like the F-22 case study, there were additional significant additional non-requirements management-based factors that contributed to the struggles of the F-111 program. These included SECDEF's over-control of the program, wing-box structural failures, and significant cost, schedule, and performance consequences of doing concurrent design and production on a complex weapon system which was repeated 30 years later with F-35. That said, the F-111 program is a significant example of the need for warfighter integration in initial requirements development, what happens if they aren't consulted over requirements concerns (transonic drag), but also their utility in the requirements trade-off process during the Systems Architecture and Critical Design phases of the program. The TAC Commander, as a warfighter with additional experience around acquisitions, was able to timely and accurately spot a problem with the Mark II push before the technology was ready even if he was overruled. Had there had been more of this interaction both inside the program office and supporting DOD leadership to make better-informed decisions, it could have alleviated some of the negative influences. Additionally, after the departure of the Navy from the program, the USAF warfighters found a utility from the large size and speed of the F-111A and were able to repurpose the initial design to create the FB-111 for the Strategic Air Command which "turned out to be one of the most effective all-weather interdiction aircraft in the world. There was no other fighter-bomber in service with the USAF at the time which could carry out the F-111's mission of long-range/high-payload precise air strikes" (Richey, 2004).

4. B-2 Spirit

Not all historic DOD acquisition efforts have been failures in the integration of experienced warfighters into program execution. The early phases of the B-2 Spirit stealth bomber program, particularly in what is now called the System Design and Development (SDD) phase, highlight success and the opportunity available writ large to adopting this mindset. In conjunction with the creation/maturity of the Systems Engineering process at the time, former B-2 Director of Engineering John Griffin and Vice President & Program Manager James Kinnu from Northrop recalled:

> [The] B-2 program benefited profoundly from an important early decision to integrate the customer's requirements development process into the company teams' design and development process. This resulted in a culture of continual systems engineering trade studies from the very top-level system requirements down to the simplest design details that affected all aspects of the aircraft design, maintenance, supportability, and training. Specialists from the technical and management disciplines worked as a team to assess the need for a specific performance level of a requirement to enhance operational effectiveness or trade for a lower level of performance to reduce cost or risk. (Griffin & Kinnu, 2004)

As part of the same case study series directed by the Air Force Center for Systems Engineering as the F-111 case study referenced above, Griffin and Kinnu found five critical learning principles in the review that were considered influential to the success of the B-2 program. According to their analysis, the most influential learning principle was the "*Integration of the Requirements and Design Processes*" where "the integration facilitated continual trade studies conducted by the specialists from the User/SPO government team with the company specialists to fully assess the performance trade-offs against schedule, cost, and risk" throughout the life cycle (Griffin & Kinnu, 2004).

To fully understand why this was the most important out of all the learning principles uncovered from a massive program effort, we must rewind to the beginning of the program coming out of Vietnam and into the Cold War with the Soviet Union. Vietnam showed the USAF that radar-guided Surface-to-Air Missiles (SAMs) were becoming more prevalent and a serious threat to U.S. aircraft attempting bombing missions or air to air missions over hostile territory. DARPA began working on an initiative to test low-RCS vehicles and conducted tests that led to the validation of the 'stealth' design principles with demonstrations through the late 1970s and early 1980s. Having proven this design was practical, the USAF funded several more focused studies relating to the technology transition opportunities for different mission roles – one of which was a penetrating platform for the Strategic Air Command (SAC) where the current B-52 and FB-111 fleet were susceptible to this SAM threat. Rather than simply force a program by adding new 'stealth' design requirements on top of an existing requirement for a supersonic bomber, to cover the USAF's loss of the B-1A program in 1977, the USAF focused on identifying where requirements trade-offs would lie with this new technology. Thus, in 1980, the USAF initiated the Advanced Strategic Penetrating Aircraft (ASPA) study with Northrop which lost to Lockheed Martin (later becoming the F-117) in the DARPA effort a few years prior.

Making this study even more useful and resulting in the number one learning principle (in hindsight) of the program's success described above, was embedding warfighters into the program from the start.

> Once Northrop committed to conducting a company-funded study in mid-1979, USAF/RDQ and SAC provided a limited number of experienced, on-site/on-call representatives to provide functional and performance requirements guidance as Northrop examined various performance and planform alternatives for performing the strategic missions. (Griffin & Kinnu, 2004)

This integration of warfighters into the process allowed for the team to compare measures of effectiveness (MOEs) across several different aircraft options including comparing a high-altitude versus low altitude penetration profiles and in just two months, found a combination of design and profile that would be survivable for the next 20 years of projected threats. The analysis found that "the presence of the SAC and RDQ representatives greatly facilitated these efforts because Northrop did not have a large knowledge base of SAC operations and the [sic] mission" execution (Griffin & Kinnu, 2004). This marriage of expertise allowed the B-2 program to rapidly evolve and the "requirements for the B-2 were derived, traded and balanced, approved and documented" in just over 2 years taking it from bar napkin to the start of EMD (Griffin & Kinnu, 2004).

Unlike other DOD acquisition efforts though, the USAF didn't pull the warfighter integration and input after the CDD. In fact, the USAF made sure there was a full-time presence as development continued. The Northrop and SPO team benefited from this partnership by "increasing the speed and communication between government and contractor with a spirit of cooperation that has not been observed either before or after the B-2 program" along with the ability to have "many in-depth discussions with operational personnel" a former Northrop executive noted (Griffin & Kinnu, 2004). Having never had a warfighter integration like this before, the engineers (both at the SPO and Northrop) helped the warfighters "understand the implications of requirements that exceed that which would be required to satisfactorily conduct operations" and allowed the reduction of requirements creep and greater proactive flexibility in the specifications negotiations (Griffin & Kinnu, 2004).

Table 3 shows a small segment of how some of the requirements collectively evolved during the tradeoff studies and technological maturity analysis. The combination of the experience and expertise of the integrated team allowed for a fully informed knowledge exchange between the warfighters who had the information and means to conduct war-gaming 'what ifs' with the continuously supplied design options and their associated risks from industry. This proved critical when there was a structural issue in the wing found after PDR 1 for the aircraft and a redesign was required.

Table 3. Evolution of B-2 Requirements from RFP to Specifications. Source: Griffin & Kinnu (2004).

Document	RFP	Proposal	Specification
Range nautical miles	6,000	8,500	6,000
Payload lbs	40,000	40,000	40,000
Low altitude alt above terrain Mach	Residual Capacity	400' w/o TF 0.6M	200' w/ TF 0.7M
High altitude Cruise altitude Cruise Mach	>35,000 ft >0.8M	>50,000 ft >0.8M	50,000 ft max >0.8M
PSR	0.90	0.90	0.90
Wing span	--	172 ft	--
Gross weight	--	269,000 lbs	--
Legend TF = Terrain Following PSR = Primary System Reliability			

Because both parties, industry and the SPO with embedded warfighters, had done the analysis together and jointly constructed the wording of the requirements, the understanding of the underlying requirements and the trade space was high to deal with this unplanned structural issue. Even though the need to redesign "put both the contractor and government at risk…the benefit though was the derivation of a clearly understood set of requirements that all parties reach with mutual agreement" allowed for relatively rapid recovery (Griffin & Kinnu, 2004). While a lot of the technical assistance by the government in the recovery was due to engineering support from the SPO, SAC assisted with a "staff of about 20 officers…assigned to the program…played a vital role in helping the engineers understand the conduct of the SAC mission and the needs of the crew and maintenance people" which resulted in the removal of a compartment for a third crewman that allowed for space and weight savings opportunity in the redesign to compensate for the additional weight gain from added structural support (Griffin & Kinnu, 2004). In the end, this helped reduce the schedule slip to the first flight associated with the major redesign to just 18 months.

Table 4. B-2's Projected vs Actual Execution Timeline. Source: Griffin & Kinnu (2004).

Milestone	Contract Date	Contract, MAC	Actual MAC Achieved
Contract Award	December 1981		
PDR 1[10]	October 1982	11	11
Configuration Freeze	July 1983	19	19
PDR 2	Mar- Apr 1984	28	28
ICDs	June 1984	30	32
CDR	December 1985	48	48 structures 51 Engine/inlet 54-56 subsystems
First Flight	December 1987	72	90
Legend PDR - Preliminary Design Review ICD - Interface Control Documents		CDR - Critical Design Review MAC- months after contract go-ahead	

In concluding their study on the execution of the B-2 program and how it was able to be so successful despite taking on the significantly challenging and complex task of utilizing new and relatively unproven technologies while handling a major unforeseen redesign need, and do so in secrecy, the Air Force Institute of Technology-Center for

Systems Engineering (AFIT-CSE) was unwavering in their assessment of the integration of warfighters into the process.

> The systems engineering process of the B-2 development program was systemic to the design process and the engineers, manufacturing, Quality Assurance, logisticians, and program specialists from the customer, User, and contractors all participated as equals. Everyone contributed to the development of the requirements and the evolution of the design. When a requirement was causing a design risk that would manifest itself as a cost, schedule, or performance impact, the team would construct alternative approaches, the SPO members would assess the change to performance with the User to evaluate the necessity to achieve full compliance or rebalance capability. Cost and schedule alternatives would be developed. Many times, the problems could be resolved within the teams or traded within interfacing capabilities. The day-to-day involvement with the technical specialists kept the team ready to make rapid assessments (Griffin & Kinnu, 2004).

It cannot be undersold the importance of not just having warfighter feedback, but also having the warfighter on-site embedded in the team. This provided exclusive access that both program managers at the SPO and the industry partner were not used to having. The study concluded its top learning principle by expounding on the importance of this relationship for other programs to utilize in the future and addressed concerns some acquisition professionals have with the inclusion of warfighters (users) in the process and when the warfighters change roles into advisors vice decision-makers in the design process to allow for execution

> Besides the obvious lesson learned from the efficiencies gleaned from the combined efforts of the specialists and the overall program philosophy of cooperation, there is a subtle, but important point that must be highlighted to caution the practitioner of the potential pitfalls of this strategy. After the CDR milestone, it is vital to control this working relationship. The effort from CDR to first flight is centered on manufacturing the parts, assembling the aircraft, qualifying the components, and checking out the assembled system. This is simply hard work, and any unnecessary or superfluous change is an enormous and unwanted burden on an already burdensome time frame. Since the WBS Task Teams worked so closely and had implemented the design in conjunction with the Using command, and since there is always a “better” way to implement some of the features of the design, there is a constant pressure at the working level to make enhancements. In order to control this culture after the CDR, all the Using command officers were only participants in formal Technical Interchange Meetings (Griffin & Kinnu, 2004).

Having been embedded in the process the entire way, the SAC warfighters understood this and the SPO and industry were able to complete the project in a similar manner to which they were used to without being inhibited by the presence of the warfighters. In the end, the B-2 was able to be rapidly fielded and has proven operationally successful for decades now as a strategic national asset that works well for the warfighter, is a strategic deterrent asset as part of the U.S. National Defense Strategy, and a model program for acquisition efforts to come.

D. EXPERIENCED WARFIGHTER RETENTION CHALLENGES

It takes a very long time to qualify and train warfighters such as Naval Aviators (NA) and Naval Flight Officers (NFO). Time to train metrics widely vary based on several variables including platform pipeline and NA vs NFO training. The current average time to train a NA is 118 weeks while NFOs are trained slightly faster at 86 weeks (Naval Aviator Production Process Integrated Production Data Repository, 2022). These numbers only account for winged aviators who must still complete a lengthy syllabus, 43 weeks for NFOs and 44 weeks for pilots, at a Fleet Replacement Squadron (FRS) in their ultimate aircraft before being qualified to fly for any operational squadron and begin generating a positive return on investment (ROI) to the Navy.

In addition to the time spent training these warfighters, there exists a significant monetary cost as well. Again, dollar figures to create a winged aviator vary greatly depending on qualification (NA vs NFO) and platform type. The current average cost to wing a NA/NFO is $1.9M (OPNAV N98, personal communication, 2020). As with time to train, this only accounts for a wing aviator that still requires a costly syllabus at an FRS before they are fully qualified and eligible for placement in an operational squadron. Average costs for an FRS syllabus are $2.5M for NAs/NFOs (OPNAV N98, personal communication, 2020). The average NFO takes two and half years to create while the average NA takes over three years and $4.4M to create (OPNAV N98, personal communication, 2020). Because of such a heavy upfront cost requirement, the Navy has instituted MSRs of six and eight years respectively to ensure ROI in each of its aviators. Figure 22 gives a graphical representation of a standard aviation officer's career progression. For reference, at 13 years of combined service (YCS) approximately $15.5M training and equipping its aircrew.

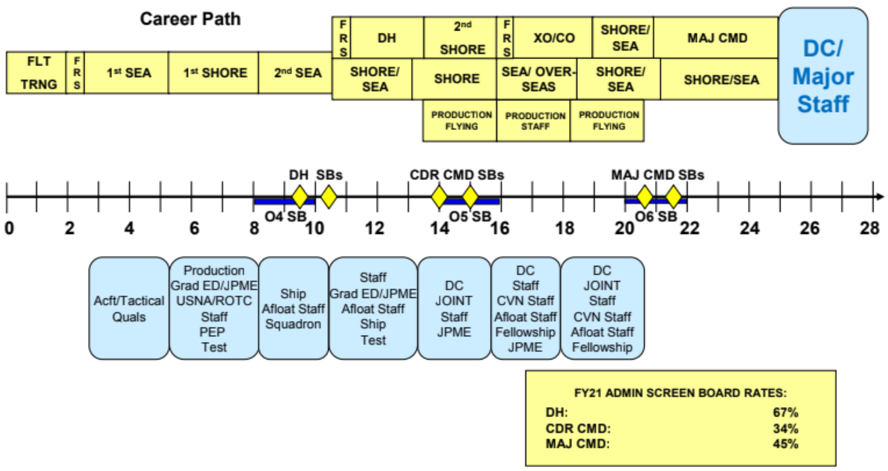

Figure 22. Naval Aviation Officer Career Progression. Source: Naval Personnel Command (2022b).

Regardless of platform or qualification by the time an aviator has reached their MSR, they have spent two and a half to three years becoming qualified, three years obtaining aircraft and tactical qualifications, spent an additional two to three years as an FRS or training command instructor, or obtained advanced warfare qualifications by graduating from one of the platform weapons schools at Naval Aviation Warfare Development Center (NAWDC). The Navy spends a decade and millions of dollars equipping and training these individuals by the time their commitment has ended. This moment in time represents their highest proficiency, currency, and lethality before either leaving the service or executing orders outside of the cockpit on a staff or other non-flying opportunities such as graduate education at the Navy War College or Navy Postgraduate School.

In 2014, then-CDR Guy M. Snodgrass penned an article titled “Keep a Weather Eye on the Horizon: A Navy Officer Retention Study” in the Naval War College Review. In the article, CDR Snodgrass uses 29 pages and three figures to defend his simple assertion that “The U.S. Navy has a looming officer-retention problem.” (Snodgrass, 2014). The community response to his article persuaded CDR Snodgrass, with team members Ben Kohlmann and Chris O'Keefe, to create the Navy Retention Study, a self-proclaimed "unofficial survey being conducted by active-duty members of the U.S. Navy, but in their personal capacity and during their off-duty time" (Snodgrass, 2014).

Although several articles exist criticizing and questioning the methodology used in the survey, the raw data collected by the survey is useful, nonetheless. Nearly 1500 aviation officers, ranging from O1-O9, completed the survey. Of the approximately 1400 respondents that answered each question, Table 5 shows nearly 70 percent of O-1 through O-5 respondents reported that they disagreed that the level of work-life balance is ideal in the Navy as a whole (Snodgrass, 2020). With most decisions to stay in or get out occurring at MSR which is primarily in the O2 to senior O3 timeframe, the data suggest a correlation between the issue of work-life balance and 55.8 percent of O1-O3 responding either leaving at MSR, leaning towards leaving at MSR, or undecided. A potential opportunity statistic for the Navy can be shown for the post-MSR O4-O5 community where, while still displeased with the work-life balance, they are 75.4 percent planning to stay in until the 20-year retirement mark or more.

Table 5. Navy Retention Study Responses. Source: Snodgrass (2020).

		O1 - O3		O4 - O5	
Level of work-life balance is ideal in the Navy as a whole	Agree	102	13.7%	82	13.0%
	Neither	114	15.3%	116	18.4%
	Disagree	528	71.0%	433	68.6%
	Blank	32		30	
What are your long term career intentions?	I will definitely leave at my MSR	98	13.4%	30	4.9%
	I am leaning towards leaving at my MSR	190	25.9%	21	3.4%
	I am leaning towards staying beyond my MSR	95	12.9%	8	1.3%
	I plan to meet the 20-yr milestone and then retire	63	8.6%	206	33.7%
	I plan to meet the 20-yr milestone and then re-evaluate	126	17.2%	255	41.7%
	Remain as long as possible	46	6.3%	40	6.5%
	undecided	116	15.8%	52	8.5%

Figure 23 shows USN pilot retention trends between Fiscal Year (FY) 12 and FY 19 in the tactical air, maritime, and helicopter communities. Save for a few abnormal points of volatility, the overall trend lines for each community are overwhelmingly negative. Figure 24 shows the same data for NFOs. Unlike pilot retention, NFO retention has shown to be remarkably stable over the past decade. Figure 25 shows an aggregate of O-4 to O-6 inventory from 2010 to 2021. The Navy has seen its inventory of O-4s decrease by almost 600 officers from 2,300 in 2010 to 1,755 in 2021, likely due, in part, to the inability to retain pilots past their initial MSRs. All data and figures were sourced from Navy Personnel Command.

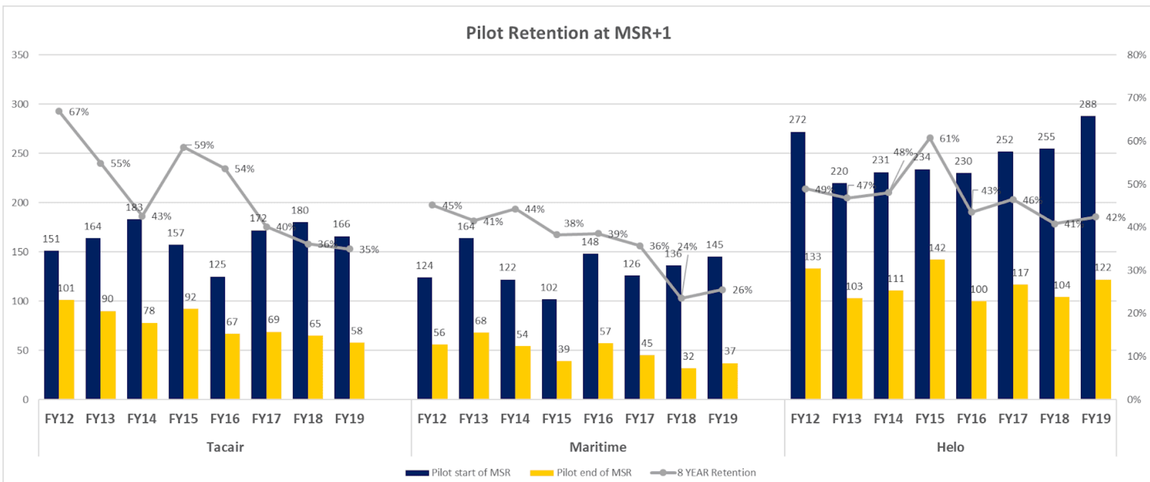

Figure 23. Pilot Retention at MSR + 1. Source: Bureau of Naval Personnel, personal communication (2021a).

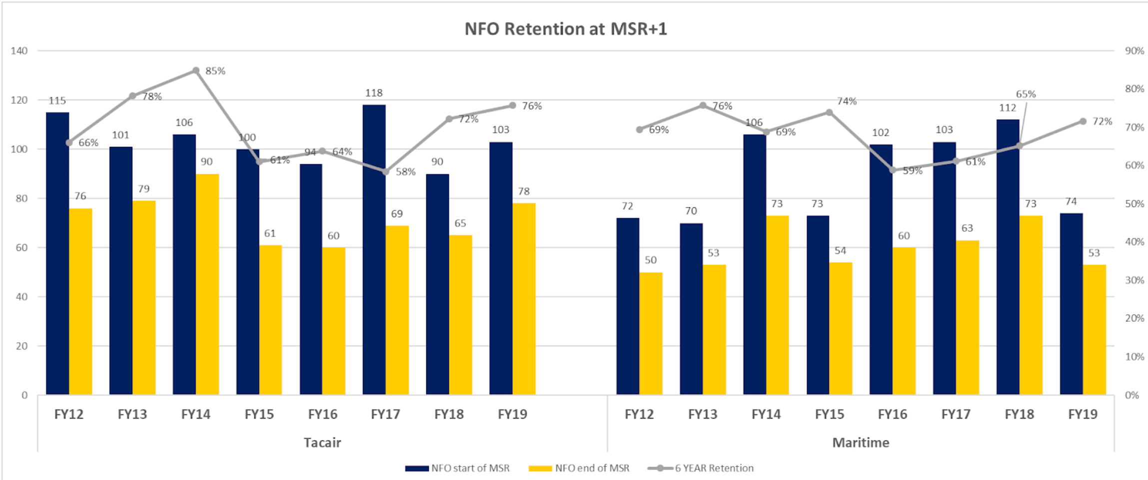

Figure 24. NFO Retention at MSR + 1. Source: Bureau of Naval Personnel, personal communication (2021a).

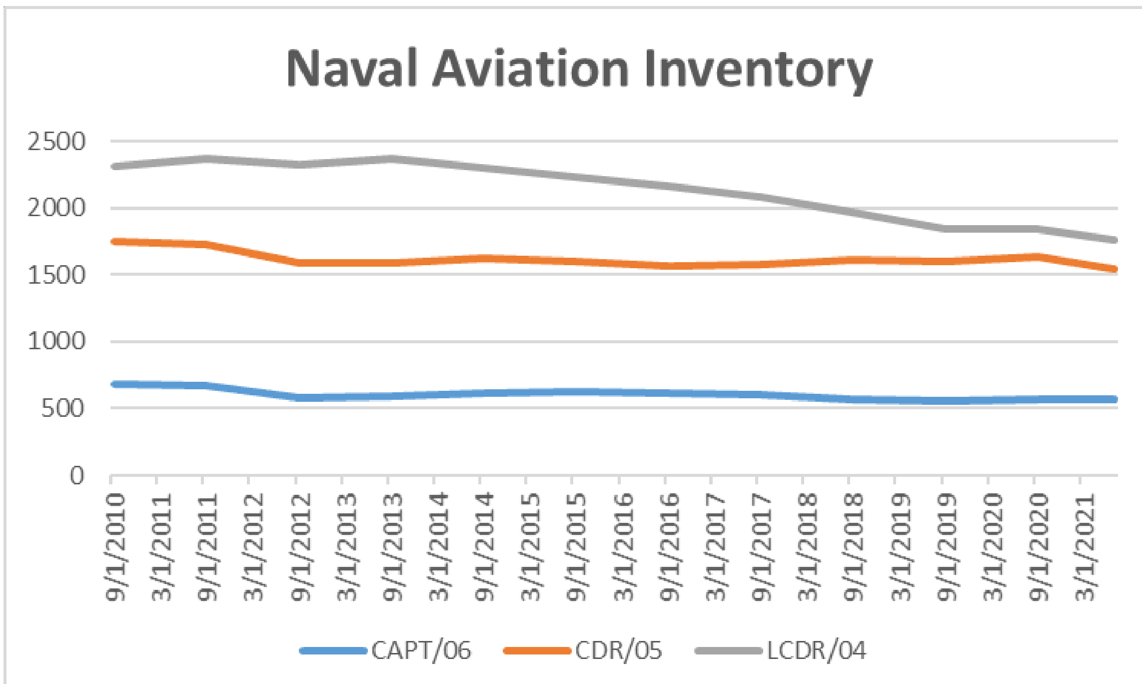

Figure 25. Naval Aviation Senior Officer Inventory. Source: Bureau of Naval Personnel, personal communication (2021a).

The data above shows an important trend and some key triggers when assessing the ability to retain experienced warfighters. As operation tempo picked up above historic norms beginning around 2014 and deployments that used to be nine months long were now going over a year and with minimal downtime in between, significant dissatisfaction grew over work-life balance as seen across the pay grade spectrum. This predictably led to a significant trend of USN officers, in this case, leaving at MSR – again above historic norms. As previously stated, these individuals represent millions of dollars and decades of training. In 2014, there existed a likely pool of at least 125–300 junior and 50–100 more senior highly trained and qualified warfighters that were either leaving or potentially leaving the Naval Service. That trend has only grown and solidified in the time between CDR Snodgrass's article and now.

At the time of this Navy retention survey, the AEDO community was one of few non-deploying designator off-ramps for frontline warfighters and was capped at only a few hundred billets overall in turn selecting only a handful of applicants in each lateral transfer board. Without more off-ramps that provide a better work-life balance or time away from high operational tempo deployments, the trend continues to this day that more and more warfighters choose to leave at their MSR. If the Services, such as the Navy, in this case, were to provide more off-ramp opportunities that provided a better work-life balance without compromising promotion opportunities, the data suggests they would be able to retain not only more warfighters but also retain them through the 20-year mark or more.

IV. CONCLUSION AND AREAS OF FURTHER RESEARCH

A. DISCUSSION OF RESULTS

The DAS and DOD acquisition programs have, and always will be, enormous in size, complexity, and importance to the national security of the United States. However, with the U.S. federal debt skyrocketing as part of recent mandatory spending increases and the resulting reduction of DOD discretionary acquisition funding, the importance of getting capabilities the warfighters need correct on the first attempt is critical. External research for years has shown the DAS takes too long, is inefficient, and has led to significant high-visibility failures leading to the acquisition reform started over the last few years. This research, however, has shown that there is a vital component with proven ties to increased agility and success of a program that is not currently being addressed – the operational knowledge gap within DOD acquisitions due to lack of appropriate warfighter integration. Below are specific collated results to the research's primary questions.

(1) Does a significant operational knowledge gap exist in DOD acquisitions today and does it translate to unacceptable programmatic end-states?

The research clearly shows that an operational knowledge gap of significance has, and does currently, exist in DOD acquisitions that translates to unacceptable end states. This operational knowledge gap was shown at all levels of the acquisition life cycle, most notably tied to requirements development and management during the design process. While warfighters are very much involved both inside the JCIDS process via the lower-level functional working groups and within regular Service requirements development channels such as NARGs, NCIP working groups, etc., they are not as prevalent at the senior leadership decision levels such as the JROC or with MDD at the Service Secretary level. This has led to some requirements being watered down, avoided, or misunderstood at the middle leadership level. While mostly due to misunderstandings within the telephone game as the info is briefed further away from the source, in some cases however it has been more intentional with an intermediary trying to protect an underperforming related program they oversee from being redirected, funding reduced, or canceled. Similarly, this same effect happened outside the JCIDS process such as in the cases of the F-111 and the F-35 programs. There Secretary of Defenses (SECDEFs) Robert McNamara and Les Aspin had no operational knowledge or experience to help them understand how forcing significantly disparate warfighter requirements to be solved by a singular, 80% common platform was not going to ever meet the needs of the warfighters and was setting the programs up for turmoil. This unilateral decision drove significant cost and schedule overruns, inhibited success in those programs, and the warfighter was still left without the capabilities they needed.

While having an operational knowledge gap at the senior leadership level comes with significant consequences, its occurrence is significantly less often than the operational knowledge gap found within program offices. This research showed that the majority of MDAP program offices have very few if any, active-duty military members working inside the program office which are dominated by government civilian and contract personnel. Further, this research showed that of all Services, only USN/USMC uniformed acquisition professionals have operational experience (which is a pre-requisite), but they are relatively few. This lack of experience leads to an operational knowledge gap during some of the most critical phases of a program: the CDD decomposition to specifications, setting and executing the acquisition strategy based on priorities, and the design and development that naturally will require trade-off decisions and will set a large amount of the program 'in-stone' before it reaches the warfighter test community.

The research additionally showed that while program offices do interact and communicate externally with warfighter representatives via the resource sponsor's ROs from OPNAV and Major Commands (MAJCOMs), such as ACC, the exchanges are relatively limited for a few reasons. First, the program offices and the ROs are almost always not co-located which restricts information exchanges and awareness of issues or accessibility for questions. Second, most ROs are traditionally post-command O-5s that are not DAWIA trained or certified and are in the position for only an average of 18–24 months. This amount of time is only enough for them to "begin to develop the 'journeyman' understanding and skills needed to be effective as a requirements officer [sic] or programmer" (Blickstein et al., 2016). Third, most RO units are severely understaffed and the ROs simultaneously juggle POM preparations, supporting flag officer needs, dealing with fleet communications and issues, as well as maintaining awareness of future requirements and potential technology or weapons development for consideration on the platform. Couple this with learning on the job about acquisitions limits the effectiveness and availability of the ROs to close the knowledge gap within the program office or fully understand program office considerations or opportunities during tradeoff discussions. Lastly, due to most ROs picking up Major Command and/or retiring before their orders are complete, RO billets are regularly gapped only further hampering continuity and dialogue with their respective program offices.

The case studies showed that the utilization of empowered warfighters within the programs directly impacted end-state outcomes. F/A-18E/F and B-2 programs that did utilize the warfighters appropriately resulted in successful programs. While F-35 had the functional elements to mitigate the operational knowledge gap, the warfighters were not empowered. For F-111 and F-22A, warfighters were not incorporated also yielding a significant operational knowledge gap. This gap has contributed to many unacceptable end states including F-22 procurement stoppage due to cost overruns, F-35 lacking critical capabilities at the right time along with a 14+ year schedule delay of FRP, and the F-111 being so overweight the Navy left the program post-design-freeze locking in the USAF to a compromised design and total funding responsibilities. Moreover, these unacceptable end-states, while realized towards the end of the program, were caused or initiated by the operational knowledge gap being present during the initial requirements development and/or during the tradeoff process in conjunction with the design phase. As seen in the F-35 research, there are plenty of decisions and compromises made within this phase that have long-term operational consequences that most non-warfighter acquisition professionals are not likely to catch, or care about, because they won't be realized for years to come.

(2) Does the DOD have the ability to mitigate this knowledge gap and does the mitigation measure translate to greater programmatic success?

The research confirmed that there is a successful mitigation measure to close the operational knowledge gap that has been used before just not with the size, leadership emphasis, or career path that is required to yield more widespread successful outcomes across DOD acquisitions. This is the integration of warfighters, specifically, the acquisition cross-trained warfighters, into both program offices and the requirements management offices such as OPNAV and the appropriate MAJCOMs.

F/A-18E/F Super Hornet and B-2 Spirit showed that a committed and empowered warfighter presence attached to a program was critical to understanding the operational impact of requirement trades and providing proactive and reactive operational feedback to program managers and engineers in response to problems. For the F/A-18E/F program, this came from both warfighter-experienced AEDO military program managers as well as the integration and consultation with frontline warfighters over requirements tradeoffs to balance risks. This yielded significant benefits that allowed the Super Hornet to be developed incrementally prioritizing key physical enablers while initially using current day avionics– resulting in no growth of cost or schedule while meeting warfighter performance metrics all the way to IOC.

The B-2 program took warfighter integration and the requirements management process to a new level where the USAF committed early on to bringing in 20 dedicated warfighters to assist with the program. This setup a program culture of collaboration, knowledge sharing, and more effective execution by having the systems engineering process and the requirements analysis process fed by on-site operational feedback of how the aircraft would be used in the fleet. A notable quote from an after-action study on the success of the B-2 program highlighted the importance of the warfighter (User) being embedded in the program.

> When a requirement was causing a design risk that would manifest itself as a cost, schedule, or performance impact, the team would construct alternative approaches, the SPO members would assess the change to performance with the User to evaluate the necessity to achieve full compliance or rebalance capability. Cost and schedule alternatives would be developed. Many times, the problems could be resolved within the teams or traded within interfacing capabilities. The day-to-day involvement with the technical specialists kept the team ready to make rapid assessments (Griffin & Kinnu, 2004).

This day-to-day involvement of the warfighter resulted in the creation of a national asset that overcame significant risks from incorporating new stealth technology and designs and losing only 18 months of schedule when a structural redesign was required post-PDR.

Emphasis is placed on 'empowered' in the mitigation measure because as seen in the case of the F-35 program office's attempt, just the presence of warfighters will not translate into successful outcomes if the warfighter feedback isn't utilized. The F-35 JPO also attempted to embed experienced warfighters in their program office (the ASR team) to handle requirements management and advise program managers. This consultant-type role was to liaise with the Service and Partner ROs and current users from within the program office while aiding PMs in making more EVM-based decisions considering the ever-growing delays and backlog in capabilities left to field. A lack of clearly defined written roles, responsibilities, and expectations from JPO leadership with regards to the warfighters' role led to regular dismissal of feedback and exclusion of warfighters in meetings by PMs who preferred focusing on potential near-term 'success' opportunities to counter the near-term problems consuming their office instead of thinking strategically. This yielded numerous discrepancies and insufficient capability performance found years later in flight tests, far after the original decision-maker had moved on. This is an important assumption when discussing mitigation measures for the Services.

B. RECOMMENDATIONS

All Services should prioritize the implementation of acquisition cross-trained warfighters, such as the Navy's AEDO specialty, in empowered leadership roles within program offices and within resource sponsor RO units such as OPNAV and corresponding MAJCOMs. Ideally, these warfighters should also be proficient and experienced in the same or similar field as the program itself – i.e., a fighter pilot for a new fighter or air-to-air missile program.

> The Office of the Secretary of Defense (OSD) and service leaders are the most capable leaders in the history of the profession of arms, as evidenced by the most respected, technologically advanced, and most capable military force successfully executing missions around the world. OSD and service leaders are in many ways the equivalent of private sector CEOs, overseeing programs in the billions of dollars. Like the rest of us, they have their capability gaps; the really successful CEOs recognize these limitations and surround themselves with a team that compensates for these gaps. For example, would the CEO of $2 billion company make a large financial commitment without the expert advice of at least one business adviser or a

team of MBAs, as well as the board of directors? Not likely (Mortlock, 2016).

This post-data recommendation also comes following a baseline acquisition literature review with additional fundamental information included within the following Appendix, which examined currently written guidance directing the execution of the various processes that make up the DOD acquisition machine. Section III C offered real-world practical case studies highlighting a spectrum of issues regarding requirements management and their detrimental effects on the programs that experienced them. To identify this viable recommendation, we focused on a potential pool of available personnel due to retention issues within Naval Aviation, as an example, covered in Section III D. By providing a non-deploying and/or a more positive work-life balance as compared to the operational fleet, there is likely a significant number of departing warfighters who would not only stay in past their MSR but likely would stay to the 20-year mark or more. Finally, we analyzed an established community within DOD to pair with a pool of valuable personnel to solve the issues outlined previously. The following discusses current limitations to the AEDO model along with amplifying recommendations for refinement both inside the Navy and for other Services to implement as part of the larger recommendation.

1. Utilization of an AEDO-Based Model Cross-Trained Warfighter

As discussed in Section III B, the Department of the Navy employs a community of tactically qualified former warfighters to manage several aspects of its acquisition activities called AEDOs. They exist to bridge the gap between the professional acquisition workforce and the operational Navy ensuring that warfighter equities are represented throughout the acquisition process. They are divided into three lines of effort: Test and Evaluation, Program Management, and Fleet Support & Production. AEDOs within this community interface with OPNAV resource sponsors, defense contractors, Congress, as well as other services and agencies. Most of these 300 billets reside at Naval Air Systems Command in the form of Program Management activities. Also included are billets that support Naval Information Warfare Systems development and space acquisition.

2. Addition of a Dedicated Requirements Management Career Path

AEDOs have input and are major stakeholders in every Naval Aviation acquisition effort throughout the entirety of its life cycle. Conspicuously absent from the timeline, and the adjustment needed as part of this thesis' recommendation, is AEDO input on the initial portion of an acquisition process: requirements generation, validation, and management. With their unique blend of tactical experience and their intimate knowledge of the complex processes that make up military acquisitions, AEDOs are perfectly situated and trained to fill this critical process gap. The coincident timelines for the average RO length of orders and the average time it takes to reach an understanding level required to be an effective RO present a significant problem. A dedicated community of cross-trained individuals with both operational and acquisitions experience than can be filled from a large pool of potential personnel losses represents the best solution to that problem. Figure 26 shows a proposed career progression timeline from laterally transferring warfighters into the requirements management specialty career path for AEDOs as an example.

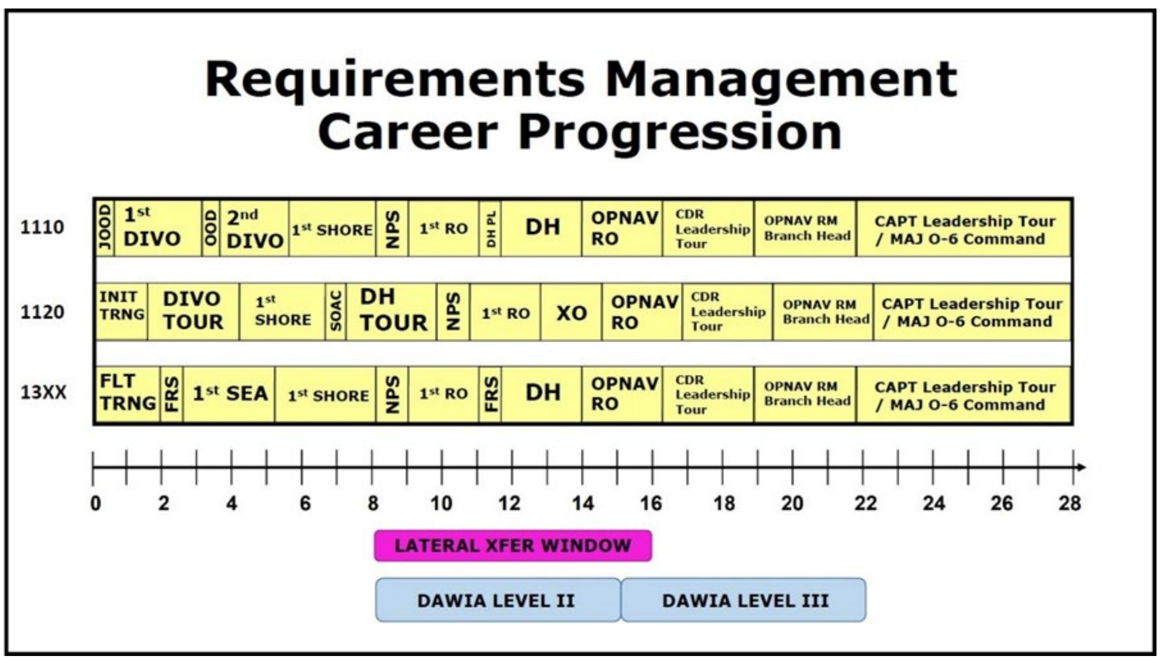

Figure 26. Proposed Requirements Management Career Progression by Designator.

The recommended implementation of a requirements management addition along with the greater AEDO model is critical allowing for prolonged and repeated assignments focused on assisting Service acquisitions specifically from the resource sponsor perspective. Without the addition of this career path, these professionals would likely be forced to return to other focus areas such as program management positions to be competitive for advancement which would again leave resource sponsor commands without prolonged expertise in their area. It is critical to begin adding the acquisition cross-trained warfighter as a regular and committed presence in this portion of a Services acquisition workforce to begin, and further, refine, this role and its implementation as experience is gained.

C. STUDY LIMITATIONS

Much of our research and analysis was not only centered on DOD acquisitions but focused on a specific niche within the Department, Naval Aviation. Being that our areas of expertise reside within this community, there was greater baseline knowledge about its processes, institutions, and organizational architecture as well as it provided the quickest access to relevant data to support the thesis timeline. We relied on colleagues who occupy billets at several commands such as BUPERS, OPNAV, JPO, NAVAIR, ACC, and the DSB to assist us to gather much of the data provided here. While all data presented is objectively accurate, the sources from which it was generated contain a certain amount of implicit bias due to the subjective nature of the subject matter. Additionally, while focused primarily on aviation, this material still applies to other parts of the Navy and larger DOD such as submarines, troop transports, or infantry efforts.

We elected not to conduct surveys of statistically relevant populations of operationally active Sailors or their acquisition counterparts. We determined that the information these surveys would have provided would ultimately be useful, but outside the scope of this paper and would have acted as a distractor. Thus, we chose to deliberately limit the extent of our research to problem identification and offer a potential solution architecture.

D. AREAS FOR FURTHER RESEARCH

While this research has a significant focus on aviation programs and examples of issues affecting requirements management throughout the life cycle, similar studies could be performed on communities within the DOD, we believe there will be similar root causes. Continuation of this research to other non-aviation programs within the DOD would allow for a greater degree of certainty in the results seen here as well as promote greater awareness of the disconnect between acquisitions and the frontlines throughout the DOD - ideally leading to the identification of more optimized solutions. Additionally, further research likely will yield more tailored personnel recommendations on the 'who' to fill this role based on community flexibility or challenges with experienced manning or career options.

Although we offered the framework of a potential solution, additional research, and a more thorough analysis of potential courses of action are necessary. The complex interrelations between manpower management, Congressional budgets, and any laws or policies need to be analyzed to determine if they are viable. However, this research should provide stakeholders with the ability to see the importance of closing this operational knowledge gap and potential cost savings, and allow for rapidly starting decision dialogues.

Finally, the landscape of the potential pool of personnel needs to be defined or reanalyzed for accuracy. When all is said and done, we are dealing with the desires and personalities of thousands of human beings. The surveys and research papers on retention cited in this paper are nearing a decade old. The assumptions and data generated from those studies likely no longer hold. Different generations think differently and desire different things. New surveys need to be performed and the data garnered analyzed using current techniques and technology. This will uncover whether the pool of potential warfighters still exists or if a new avenue is required.

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APPENDIX

A. DEFENSE ACQUISITION PROCESSES AND DEFINITIONS

The baseline knowledge required to properly understand the previous concepts, data, and analysis, is provided via a top-level overview of the fundamentals of the Defense Acquisition System and its associated subcomponents in the following Appendix. Covered subcomponents include the Adaptive Acquisition Framework (AAF), JCIDS, and the Planning, Programming, Budgeting, Execution (PPBE) funding cycle. In addition, we will specifically cover program execution and product fielding and sustainment because of their significant impact on the programmatic success. The available content from each of these sections could generate multiple papers by itself. The overall goal of the appendix is to provide a fundamental current knowledge base.

1. Operation of the Adaptive Acquisition Framework

DOD Directive 5000.01 has historically guided the execution of the DAS. Its objective is to "support the National Defense Strategy, through the development of a more lethal force based on U.S. technological innovation and a culture of performance that yields a decisive and sustained U.S. military advantage" (DOD, 2020). Critics of the system have pointed out that, until recently, it had not undergone a significant change since its inception several decades ago. This conventional acquisition pathway is displayed in Figure 27. It consists of five different phases separated by three different decision points called milestones. They are typically measured in cycle times defined as the amount of elapsed time between Milestone B, which delineates program initiation, and IOC. Historically, this period averages 6.9 years with a 31.3% cycle time growth over initial estimates (Bilvas et al., 2020).

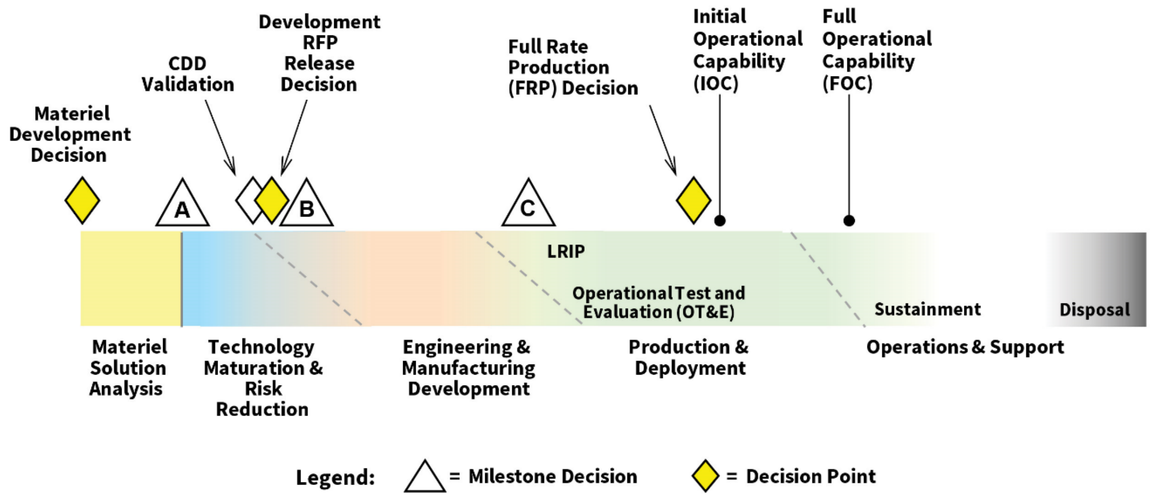

Figure 27. Traditional Acquisition Process. Source: Bilvas et al. (2020).

In response to years of criticism of the archaic and inflexible nature of the DAS, DOD Instruction 5000.02 was introduced and formalized the AAF. The AAF created six unique acquisition pathways providing program managers and decision authorities the ability to move away from the one-size-fits-all model and allowing them to use a pathway that is tailored to their program. The overall goal of this evolution of the DAS was to minimize schedule delays due to bureaucratic statutory requirements that do not apply to every acquisition program. Figure 28 displays the six different pathways provided by the AAF: Urgent Capability Acquisition (2 years), Middle Tier Acquisition (<5 years), Major Capability Acquisition (average 6.9 years), Software Acquisition (iterative), Defense Business System Acquisition, and Acquisition of Services (DOD 2020a).

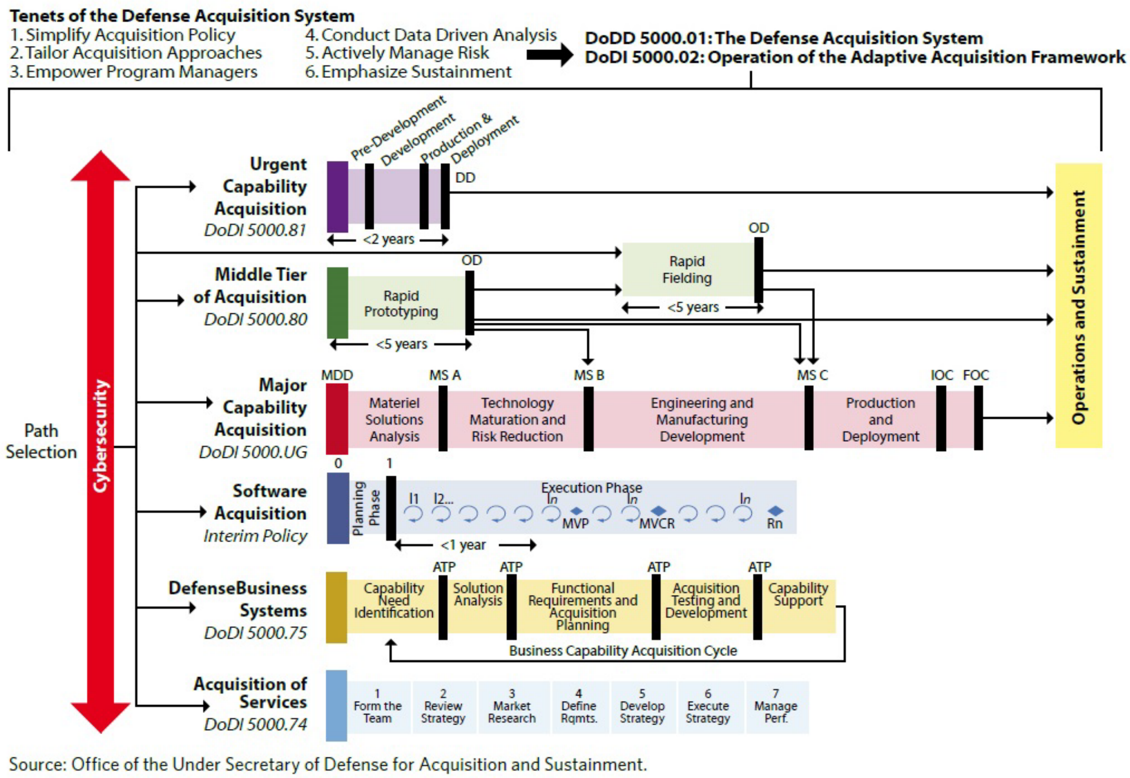

Figure 28. The Adaptive Acquisition Framework. Source: DOD (2020a).

2. Requirements Process

The DOD requirements process is a lengthy complex process that involves multiple stakeholders at several different levels. Fundamentally, the goal of the process is to take warfighter-generated requirements and validate them through a system called the Joint Capabilities Integration and Development System to then pass them off to the JROC who decides whether to enter the requirement into the Defense Acquisition System and funding cycle.

JCIDS is made up of three supporting steps. The first step is to execute a Capabilities Based Assessment (CBA). During this assessment, capability gaps are validated by providing mission identification, required capabilities, associated operational characteristics, capability gaps and their associated risks, non-material solution viability, and recommendations for potential solutions. If a material solution is recommended an Initial Capabilities Document will be created covering why non-material changes alone are not appropriate solutions. If a material solution is determined to be inappropriate a doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTmL-PF) change recommendation (DCR) will be generated in support of a non-material solution.

For purposes of this research, we will focus on the material solution due to its more involved path. Once an ICD is created it is sent to the JROC for validation and approval. With an approved ICD the JROC will then choose one of three courses of action. They may choose to accept the risk by taking no action. The JROC may elect to explore an alternative non-material solution to close the capability gap. Finally, the JROC may recommend a new material solution by making an MDD.

If the JROC selects the new material solution course, a draft CDD will be created. The CDD includes significant amounts of system-specific data including Key Performance Parameters (KPPs), Key System Attributes (KSAs), Life Cycle Costs (LCCs), as well as more esoteric information such as operational context and threat summaries (CJCS, 2018). The CDD's goal is to provide measurable and testable threshold and objective performance values and attributes in support of TMRR. The approval of a CDD is commonly linked to the end of the TMRR phase and program initiation leading into the engineering and manufacturing development (EMD) phase. Figure 29 gives a graphical depiction of the interaction between the JCIDS and the DAS. A breakdown of decision-makers and warfighter involvement in the requirements process will be expanded upon further in later sections.

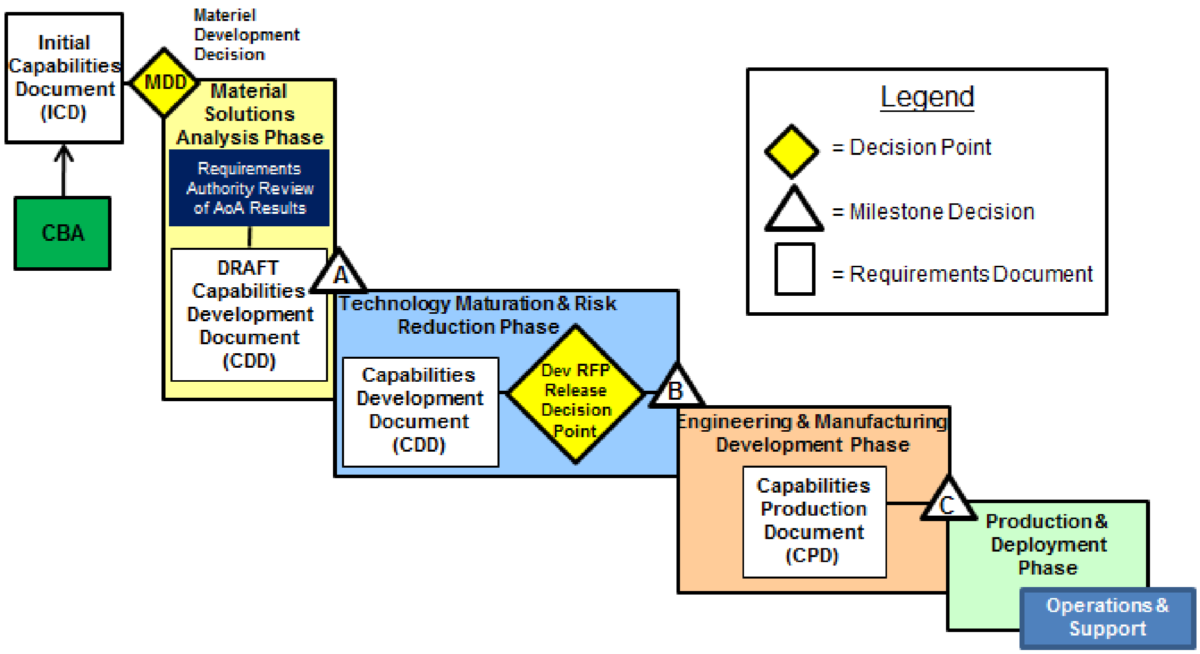

Figure 29. JCIDS Process. Source: CJCS (2018).

3. Funding Process

Military acquisitions rely almost exclusively, outside industry investments or foreign joint contributions, on funds provided by the federal government. The process by which the funds are made available to the DOD is called the Planning, Programming, Budget, and Execution (PPBE) cycle. It focuses on fiscal resource allocation and financial management of current and future acquisition programs. True to its title, the PPBE cycle consists of four periods, each with its distinct timeline and goals. The planning phase begins the cycle and begins with a review of the National Security Strategy (NSS) once issued by the National Security Council as well as other levels of strategic guidance issued by their associated organizations. During this phase, changes to operational variables, environments, threats, and technology are analyzed to better understand their near, mid, and long-term implications.

During the programming phase, the analysis will inform DOD's fiscal investment blueprint called a POM. The planning for each of the POMs is rolled up into five-year increments called the FYDP. This helps translate overall planning guidance received from the various strategic planning documents into fiscal tools. Most often these tools manifest themselves into time-phased funding allocation requirements.

In the budgeting phase, which runs concurrently with the programming phase, programmatic language is translated into the Congressional funding structure using the Budget Estimate Summary as well as associated justifying documentation. Budgeting resources two years into the future but contains significantly more detailed financial information than its sister POM. At the end of this phase, the President submits his/her Presidential Budget to Congress for review and approval. The final phase of the PPBE cycle is the execution phase. Funds are appropriated, distributed, and executed during this phase. Reviews analyzing the efficiency of obligated and expended funds as well as planned to executed accomplishments, often called outcomes achieved, are completed to evaluate programmatic efficiency and return on investment. The results of these reviews have far-reaching effects on future appropriations, budget submissions, and program continuation.

4. Program Development Execution

Once a requirement has been validated and funding has been obtained for proposed solutions, a program can be officially initiated with guidance via an acquisition decision memorandum (ADM). At this point, the program will be folded into a portfolio headed by a Program Executive Officer (PEO) and managed by a program office headed by a Program Manager (PM). As seen in Figure 30, and directed by DoDI 5000.85, the PM must balance competing inputs to develop, produce, test, and field a new product within acceptable cost, schedule, and performance parameters (USD(AT&L), 2021). This includes setting the acquisition strategy, assessing program risk with mitigation actions, and achieving milestone requirements while reporting to the MDA. While the PM is the leading action officer (AO) for executing the program day-to-day with industry or government partners, large milestone decisions still require approval of the MDA. Decisions and guidance for the program to meet milestones and exit criteria are documented in additional ADMs prepared by the PM but approved by the MDA.

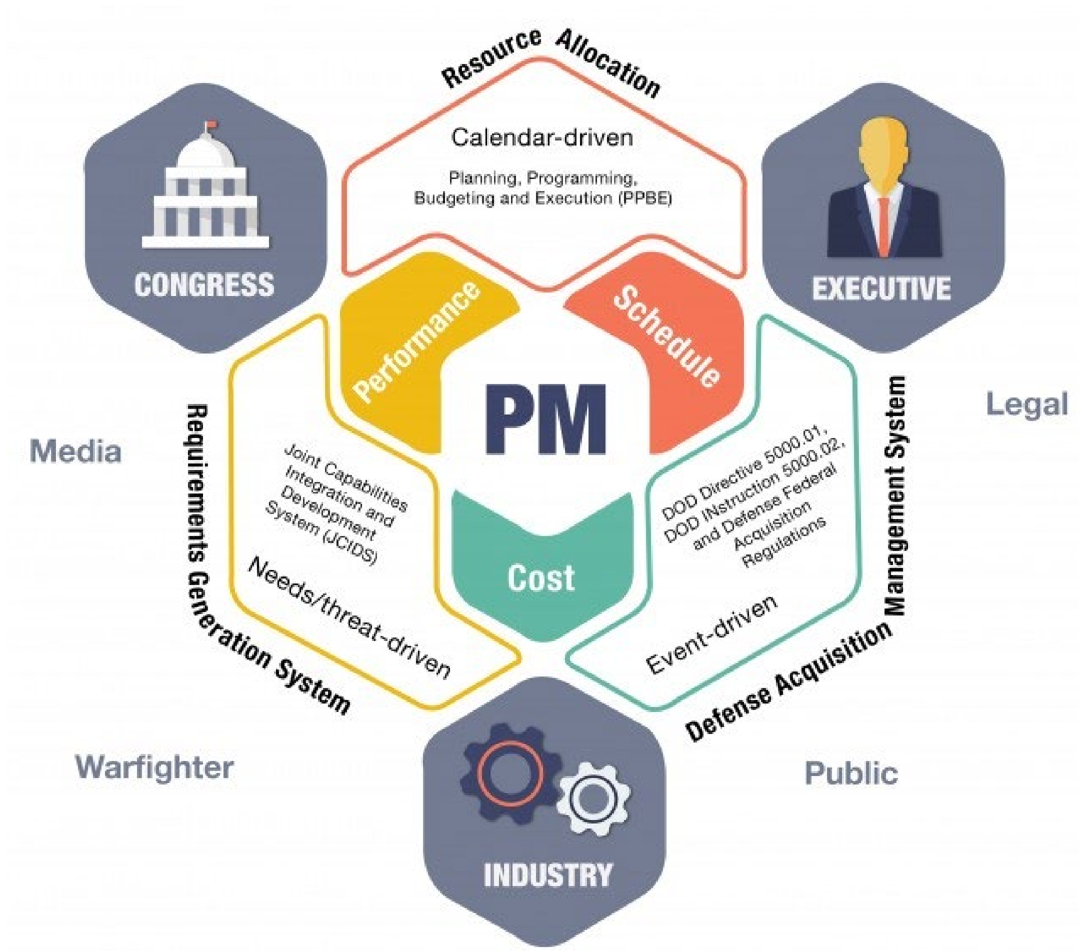

Figure 30. Program Office Execution Balance Diagram. Source: Mortlock (2016).

5. Product Fielding and Sustainment

Once a program has completed the EMD phase, it is considered mature enough to begin production, deployment, and ultimately operations and sustainment. Production, deployment, operations, and sustainment phases all feature iterative updates and upgrades in the form of both hardware and software for almost all acquisition activities. These upgrades represent a spectrum of modifications and capability enhancements. On one end of the spectrum are relatively inexpensive engineering technical directives that correct design deficiencies critical to platform performance like Airframe Change (AFC) 649 A1 which replaces hydraulic return lines in F/A-18 Super Hornets and EA-18G Growlers, a causal factor to at least one class A mishap. On the other are wholesale evolutionary capability improvements like the F-35 Joint Strike Fighter's Block 4 follow-on modernization (FOM) effort totaling almost $15B in development cost (Ludwigson, 2021).

Constantly modifying and improving current platforms while their replacements are being developed is both operationally necessary and fiscally responsible. Available to the PM are multiple tools to assist in capability gap assessment and associated solution development. The Validated Online Life cycle Threat (VOLT) report is tailored to specific programs and provides a threat capability assessment which creates an associated capability gap. Similarly, a Multidiscipline Counterintelligence Threat Assessment (MDCITA) provides an assessment of any foreign intelligence collection threats to Critical Program Information (CPI) associated with a specific program. These assessments, coupled with CDD updates and FOM priorities among others, provide the basis for continual updates and upgrades during the operations and sustainment phase of a program's life cycle.

B. PROGRAM REQUIREMENTS AND DECISION AUTHORITIES

1. Initial Large-Scale Requirements and Decision-Makers

Before the introduction of the AAF and the six unique acquisition pathways seen in Figure 28, most new program execution followed the Major Capability Acquisition pathway. While overall decision authority will differ in programs taking alternative pathways, likely at significantly lower levels of leadership within the DOD compared to MDAPs, this section will focus on the Major Capability Acquisition pathway based on history reflection and the size/consequence relationship in scope with this research.

DOD MDAPs, much like any commercial or governmental acquisition efforts, require an ultimate authority who exercises final control over decision points and procedures for programs assigned to it. In the DOD, this person is called the Milestone Decision Authority (MDA). Several instructions, laws, and policies at multiple levels govern or give guidance as to the level at which authority shall reside and what processes and decisions the MDA is required to accomplish. Although Title 10 of the U.S. Code contains multiple sections dedicated to MDAP MDAs, DODI 5000.85 Major Capability

Acquisition contains comprehensive guidance based on Congressional statutory requirements.

MDAP MDA oversight level generally depends on the ACAT level and the ACAT level generally depends on the estimated dollar value of the program or if that program is labeled as a special interest. Table 6 gives a graphical representation of the current MDA level methodology for ACAT I to III programs. In general, the authority will fall to the Defense Acquisition Executive (DAE), Service Acquisition Executive (SAE), the Head of the DOD Component, or the Component Acquisition Executive (CAE). Additionally, Chapter 321 Section 4204 of Title 10 of the U.S. Code provides the Secretary of Defense specific authority to designate an alternate MDA if any of the following applies to the MDAP:

1. Subject to subsection (f), the Secretary determines that the program is addressing a joint requirement.
2. The Secretary determines that the program is best managed by a Defense Agency.
3. The program has incurred a unit cost increase greater than the significant cost threshold or critical cost threshold under sections 4371 through 4375 of this title.
4. The program is critical to a major interagency requirement or technology development effort or has significant international partner involvement.
5. The Secretary determines that an alternate official serving as the milestone decision authority will best provide for the program to achieve desired cost, schedule, and performance outcomes (General Military Law, 2021).

A great deal of flexibility exists for the Secretary of Defense to determine at what level an MDA will reside.

Table 6. Description and Decision Authority for ACAT I – III Programs. Source: Under Secretary of Defense for Acquisition, Technology, and Logistics [USD(AT&L)] (2021).

ACAT	Reason for ACAT Designation	Decision Authority
ACAT I	• MDAP[1] (Section 2430 of Title 10, U.S.C.) ○ Dollar value for all increments of the program: estimated by the DAE to require an eventual total expenditure for research, development, and test and evaluation of more than $525 million in Fiscal Year (FY) 2020 constant dollars or, for procurement, of more than $3.065 billion in FY 2020 constant dollars ○ MDA designation • MDA designation as special interest[3]	ACAT ID: DAE ACAT IB: SAE[2] ACAT IC: Head of the DoD Component or, if delegated, the CAE
ACAT II	• Does not meet criteria for ACAT I • Major system (Section 2302d of Title 10, U.S.C.) ○ Dollar value: estimated by the DoD Component head to require an eventual total expenditure for research, development, and test and evaluation of more than $200 million in FY 2020 constant dollars, or for procurement of more than $920 million in FY 2020 constant dollars ○ MDA designation (Section 2302 of Title 10, U.S.C.)	CAE or the individual designated by the CAE[4]
ACAT III	• Does not meet dollar value thresholds for ACAT II or above • Is not designated a "major system" by the MDA	Designated by the CAE[4]
Footnotes		
1. Unless designated an MDAP by the Secretary of Defense (SecDef), AIS programs[5], Defense Business System programs, and programs or projects carried out using rapid prototyping or fielding procedures pursuant to Section 804 of Public Law (PL) 114-92, do not meet the definition of an MDAP. 2. ACAT IB decision authority is assigned pursuant to Section 2430 of Title 10, U.S.C. Paragraph 3A.2.b. provides DoD implementation details. 3. The Special Interest designation is typically based on one or more of the following factors: technological complexity; congressional interest; a large commitment of resources; or the program is critical to the achievement of a capability or set of capabilities, part of a system of systems, or a joint program. Programs that already meet the MDAP thresholds cannot be designated as Special Interest. 4. As delegated by the SecDef or Secretary of the Military Department.		

With MDA authority for MDAPs generally held at high levels of leadership, so too are the initial large-scale requirements decisions for a program. These deliberations and decisions happen at the top senior-leader level within the DOD, such as the Secretary of the DOD component fielding the system and the Military Service Chiefs. Specifically, DoDI 5000.85 directs:

> The Secretary of the Military Department acquiring an MDAP represents the customer…[and] in coordination with the Military Service Chiefs, balances resources against priorities and ensures the appropriate trade-offs are made among cost, schedule, technical feasibility, and performance throughout the life of the program. [Additionally they] ensure that the requirements document supporting a Milestone B or subsequent decision for an MDAP are not approved until the Service Chief determines in writing that the requirements in the document are necessary and realistic in relation to the program cost and fielding targets. (USD(AT&L), 2021)

Additionally, the Military Service Chiefs play a large role in acquisition decisions of a program including (but not limited to)

1. Decisions regarding the balancing of resources and priorities, and associated trade-offs among cost, schedule, technical feasibility, and performance on MDAPs
2. The coordination of measures to control requirements creep
3. The recommendation of trade-offs among life-cycle cost, schedule, and performance objectives, and procurement quantity objectives, to ensure acquisition programs deliver best value in meeting the approved military requirements
4. Termination of development programs or procurement programs for which life-cycle cost, schedule, and performance expectations are no longer consistent with approved military requirements and levels of priority, or which no longer have approved military requirements
5. The development and management of career paths in acquisition for military personnel pursuant to Section 1722a of Title 10, U.S.C. (USD(AT&L), 2021)

All of this leads to heavy, high-leadership involvement and decision making in the materiel solution analysis (MSA) phase of the program with the purpose of beginning "translating validated capability gaps into system-specific requirement, and to conduct planning to support a decision on the acquisition strategy of a product" (USD(AT&L), 2021). This initial large-scale requirements development continues through Milestone A until a formal CDD is validated and released within the TMRR phase for the program to execute/develop.

2. Small-Scale Decomposed Requirements During Development

It is a commonly held misconception that requirements development and management conclude once a program is started. There exists an entire range of processes dedicated to continuing the evolution of requirements including Integrated Baseline Reviews (IBR), Critical Design Reviews (CDR), Operational Assessments (OA), CDD updates, and independent analysis provided by the Cost Assessment and Program Evaluation (CAPE) office for instance. With the evolution of the AAF, seen in Figure 28, "PMs will "tailor-in" the regulatory information that will be used to describe their program at the [Material Development Decision] or program inception." (USD(AT&L), 2021). This allows for a much more streamlined process while still providing the PM the tools to continue to effectively manage requirements. These processes are necessary due to several variables including the volatile nature of government funding. Small changes in an operational environment, Congressional composition, or technological development can send shockwaves through an MDAP that significantly alter requirements or their priorities, necessitate tradeoffs to cost/schedule/performance, or require updates to the acquisition strategy.

The smaller-scale requirements decomposition and management begin once a validated CDD and CONOPS have been approved after the large-scale requirements process above. This additional process is initiated by members of the program management office and often involves the development contractor. Within the CDD exist several KPPs, KSA, and other performance attributes. These combined with additional information from the ICD, CDD, AoA, and Systems Threat Analysis (STA) are used to generate technical specifications which are used in the generation of an RFP.

These technical specifications are derived even further guided by the broader CDD requirements, via a dendritic model, into critical technology elements (CTE) and eventually Critical Technical Parameters (CTP). The CTPs generated from this process are desired to be objective, testable, and traceable back to the original validated requirement(s) and are called measures of effectiveness (MOE), measures of suitability (MOS), and measures of performance (MOP). MOE/MOS/MOPs are critical to system development and design and form the basis for a program's Test and Evaluation Master Plan (TEMP). Ultimately, these derived requirements are what most directly transfer into the exact product created and delivered to the fleet.

C. DEFENSE ACQUISITION WORKFORCE

1. Defense Acquisition Workforce Positions

The Defense Acquisition Workforce Improvement Act was signed into law by the 101st Congress as part of the FY91 Defense Authorization Act. The Act called for the establishment of an Acquisition Corp thereby professionalizing the Department of Defense acquisition workforce. Its aim centered on improving the effectiveness and quality of the personnel who implement and manage defense acquisition programs through education, training, and practical work experience. Secondly, it created an official vehicle through which members of the workforce could be recognized as having achieved professional certification. Thus, core certification standards were developed to guarantee the quality of various certification levels.

Section 1721 of Title 10 U.S.C. Chapter 87 forms the basis of the professionalization of the AWF. It states "The Secretary of Defense shall designate in regulations those positions in the Department of Defense that are acquisition positions for purposes of this chapter. The Secretary shall also designate in regulations those career fields in the Department of Defense that are acquisition workforce career fields for purposes of this chapter" (Defense Acquisition Workforce Improvement Act, 2019). It directs DOD to designate, at a minimum, 13 specific acquisition-related positions including Program Management, Quality Control and Assurance, and Education, Training, and Career Development among others.

2. DOD Instruction 5000.66

DOD Instruction 5000.66 provides direction on the implementation of the directives established by Congress under Title 10 U.S.C. regarding the AWF. It establishes a positional hierarchy including using the billet designations of Critical Acquisition Position (CAP) and Key Leadership Position (KLP). The instruction defines CAPs as "typically located in a program office, PEO portfolio, or organization that has a primary acquisition mission. CAPs require tenure to ensure stability and provide accountability for the acquisition program, effort, or function, and must be filled by military officers at the O-5 grade or higher or civilians at the GS-14 grade or higher (and equivalent)" (USD(A&S), 2022). Figure 31 gives an overview of career progression for AWF members and depicts the relationships between CAPs and KLPs.

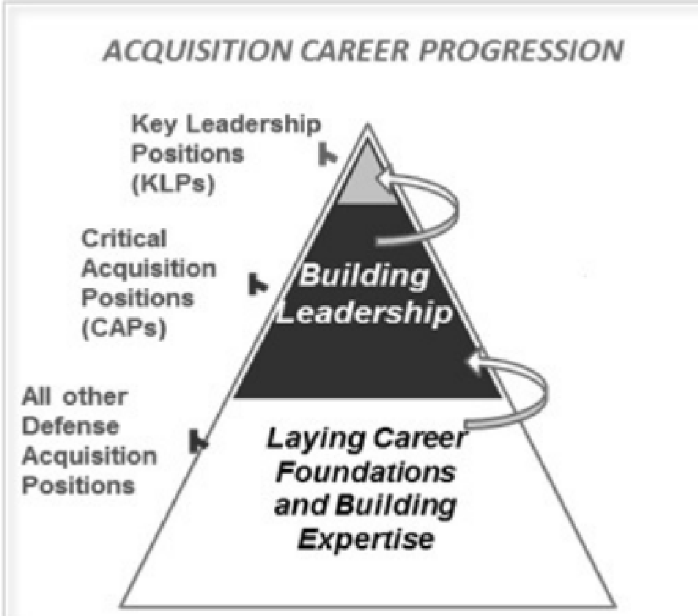

Figure 31. AWF Career Progression. Source: Under Secretary of Defense for Acquisition and Sustainment [USD(A&S)] (2022).

Additionally, DoDI 5000.66 designates the following positions as mandatory KLPs for ACAT I and IA programs and must be dedicated to a single ACAT program (except for Program Executive Officers, Deputy Program Executive Officer, and Senior Contracting Officials):

1. Program Executive Officer (PEO)/Deputy PEO (DPEO).
2. Senior Contracting Official.
3. Program Manager (PM) (Additionally, ACAT II).
4. Deputy Program Manager (DPM).
5. Chief Engineer/Lead Systems Engineer.
6. Product Support Manager (PSM) (Program Lead Logistician).
7. Chief Developmental Tester.
8. Program Lead, Business Financial Manager (USD(A&S), 2022)

3. Defense Acquisition Workforce Program Desk Guide

In 2017, the Undersecretary of Defense for Acquisition, Technology, and Logistics, Human Capital Initiatives Director published the Defense Acquisition Workforce Program Desk Guide to provide detailed procedures for implementing policy established by DODI 5000.66. It establishes requirements once a position has been designated and coded as an AWF position (USD(A&S), 2022). These requirements include career field certification, Acquisition Corps membership, tenure, special statutory requirements, assignment-specific training, and continuous learning and are all based on Chapter 87 of Title 10 U.S.C.

4. Mandated Acquisition Training

DAWIA AWF certification has four elements: "Education, Defense Acquisition University Training, Experience, and Continuous Learning" (ASN(RD&A), 2019).

a. Education

Title 10 U.S.C. requires members of the AWF to meet education standards for each Career Field certification. To obtain Career Field certification or Acquisition Corps membership, AWF members and their supervisors are responsible for completing the required academic education for their designated certification level. Specific education requirements vary greatly between Career Fields and their associated certification levels.

b. Defense Acquisition University Training

The Defense Acquisition University was created in 1991 and consists of five main regional campuses and two colleges that offer resident and virtual courses. Its mission is to "provide a global learning environment to develop qualified acquisition, requirements and contingency professionals who deliver and sustain effective and affordable warfighting capabilities" (Defense Acquisition University, n.d.). Each AWF member is responsible for identifying, incorporating, and executing required DAU training into their Individual Development Plan (IDP) to be awarded Career Field certification.

c. Experience

Every acquisition Career Field and its associated levels require either general or specific acquisition experience. There exist three avenues to satisfying experience requirements for certification according to the 2019 DON DAWIA Operating Guide. First, all experience gained in acquisition-coded positions and a portion of acquisition-related positions count toward certification statutory experience requirements. Additionally, requirements may be met with experience gained from private industry, non-DOD federal agencies, or because of an "O-5 or O-6 command tour" on a case-by-case basis (p.20).

Finally, a graduate-level degree in technical, hard science, business, or acquisition-related field or acquisition-related military schools such as Test Pilot Schools or Nuclear Power Training may be used as a credit toward experience requirements (p.21).

d. Continuous Learning

To assure currency of the AWF, Continuous Learning (CL) requirements were developed. While assigned to an acquisition position, AWF members are required to complete 80 hours of continuous learning every two years (USD(A&S), 2022). This allows AWF members to "continue to grow their knowledge and skills in their primary acquisition Career Field, cross-functional areas, acquisition policy initiatives, and leadership" (USD(A&S), 2022).

e. Requirements Management Comparison

The Defense Acquisition University DAWIA Certification & Development Guide currently lists seven active functional areas in which a member of the community may be certified:

1. Business-Cost Estimating
2. Business-Financial Management
3. Contracting
4. Engineering and Technical Management
5. Life Cycle Logistics
6. Program Management
7. Test & Evaluation

Additionally, two knowledge areas are listed:

1. International
   Requirements Management (Defense Acquisition University, 2022)

Certification standards for each functional area are delineated and once achieved, result in DAWIA certification which can be viewed on a member's DAWIA transcript granting them eligibility for certain acquisition-coded billets.

On October 17, 2006, the 109th Congress of the United States published Public Law 109-364, more commonly known as the Fiscal Year 2007 NDAA. Subtitle A

"Provisions Relating to Major Defense Acquisition Programs" Section 801 is titled "Requirements Management Certification Training Program." The section directs the Under Secretary of Defense for Acquisition, Technology, and Logistics to develop a training program to certify military and civilian personnel within the DOD who are responsible for generating MDAP requirements. These certifications became requisite for certain requirements generating billets on September 30, 2008, per the Act.

Table 7. Comparison of DAWIA Program Management and Requirements Management Certification Standards. Source: Defense Acquisition University (2022).

Program Management		Requirements Management	
Practicioner	34 hours of computer-based training 8 days of in-resident training	Level A (Apprentice)	3 hours
	4 years of relevant acquisition experience in program management		None
		Level B (Journeyman)	21 hours
Advanced	19 hours of computer-based training 14.5 days of in-resident training		None
		Level C (Core Expert)	5 days
	8 years of program management[a]		None

[a]At least 2 of these years with cost, schedule and performance responsibilities in a program management office or similar organization (dedicated matrix support to a PM, PEO, DCMA program integrator, or supervisor of shipbuilding)

Despite the passage of this law, no such DAWIA certification currently exists for the Requirements Management knowledge area. For comparison, Table 7 shows the virtual and in-resident certification standards (in hours for virtual and days for in-resident) and the experience requirements of both Program Management and Requirements Management certifications. A cursory investigation of Table 7 shows a significant imbalance in the amount of functional training required for certification at each level. The disparity only grows when optional education and required experience are factored in.

Table 8 shows the Navy-specific Requirements Management Certification Training required and managed by the Chief of Naval Operations. For the scope of this paper, the Office of the Chief of Naval Operations (OPNAV) Director of Air Warfare (N98) directorate will be examined. In the researchers' communications with manpower managers at Navy Personnel Command, Requirements Officers (ROs)/Resource Sponsors are required to be either Level B or C qualified (depending on billet level) or require the billet to be filled by a post-Command O-5 with an Additional Qualification Designator (AQD) of DU1. Unlike DAWIA-created career fields which are tracked with the electronic DON Acquisition Career Management System (eDACM), there is currently no official management process for tracking qualifications outside of OPNAV-managed processes.

Table 8. OPNAV Requirements Management Certification Training Matrix. Source: Chief of Naval Operations (2019).

Cert Level	A	B	C	D	
Applicable OPNAV personnel (MIL or GOV only)	• ROs • Support staff to ROs	• ROs • Reqmnts IPT lead in PEO or PM office	• Supervisors of ROs • ROs for ACAT I or JROC Interest programs • Navy FCB reps • R3B Secretariat (N9IJ)	• GO/FO/SES	• CNO, VCNO
Position Description	• Contributor to the writing of Major Defense Acq Program (MDAP) requirement docs.	• Leading requirements development or adjudicating comments on MDAP requirement docs.	• Validating or approving requirements docs or participating in the approval chain for the docs.	• Flag/SES for organizations developing or managing requirements.	• 4-Star / Agency Head
Defense Acquisition University (DAU) Courses Required	• CLR 101 Intro to JCIDS (online, 4-6 hours) • (or CLM 041 Capabilities Based Planning, if taken previously)	Level A *PLUS*: • RQM 110 Core Concepts for Requirements Management (online, 24-30 hours)	Level B *PLUS*: • RQM 310 Advanced Concepts for Requirements Management (4.5 days, classroom) N9IJ & Directorate Training POCs Centrally Control RQM 310 Quotas	• RQM 403 Requirements Management Executive Overview (one day, classroom or VTC) N9IJ Manages Quotas for RQM 403 & RQM 413	• RQM 413 • Senior Leader Requirements Course (tailored, desk-side)
OPNAV Courses Required	• AO Course (DNS-led) • RO Course (N9I-led)	• AO Course (DNS-led) • RO Course (N9I-led)	• AO Course (DNS-led) • RO Course (N9I-led) • PPBE Course (N80-led)		

In the case of the USN, RO orders are written for a 36-month term in conformance to Title 10. However, ROs rarely execute their orders as written due to a variety of reasons including the needs of the Navy, successfully screening for Major Command, or fitness report timing. Recently, RO tour lengths have ranged from nine to even greater than 36 months but the average is 18–24 months.

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