NPS-HR-20-024

# ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

## Talent Management Analysis for the Air Wing of the Future

December 2019

**LCDR Michael J. Bartolf, USN**
**LCDR Louis D'Antonio, USN**

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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

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# ABSTRACT

The Air Wing of the Future (AWOTF) will provide unmatched lethality and capability in future theaters of operations. The addition of the F-35C Lightning II, MQ-25 Stingray, and CMV-22B to the combat proven team of F/A-18E/F Super Hornets, EA-18G Growlers, E-2D Hawkeyes, and MH-60R/S Seahawks also comes with increased manpower support requirements over today's carrier air wing. The increased complement of personnel necessary to operate the AWOTF will either require a multimillion-dollar ship modification to the baseline design, or a reduction to the individual squadron manpower documents. The objective of this capstone was to analyze manpower talent management, maintenance training, and squadron-level maintenance activities to determine whether a training improvement solution could substantiate a manpower reduction by creating a higher-quality, more capable work force. The culmination of this research did not strongly validate any recommendations for reduction of manpower requirements due to limitations in the available data, but did demonstrate marginal benefits in the form of increased labor production efficiency among a higher-quality work force (as defined by Aviation Maintenance Experience [AMEX]). There is a clear signal for the value of AMEX in detailing activities as well as greater unit-level training capabilities.

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# ABOUT THE AUTHORS

**LCDR Mike Bartolf** is a native of Chesapeake, Virginia; however, he spent his formative years in Fairmont, West Virginia. He received his Bachelor of Arts in Political Science from Virginia Polytechnic Institute & State University (Virginia Tech) in 2004 and was commissioned as an Ensign in the United States Navy. He received his Naval Flight Officer Wings of Gold in 2007 and was selected for follow-on training as an Electronic Countermeasures Officer (ECMO) in the venerable EA-6B Prowler, home based at Naval Air Station (NAS) Whidbey Island. After completing initial training at the Fleet Replacement Squadron (FRS) he reported to VAQ-139 in June 2008. He completed three deployments in support of OPERATION ENDURING FREEDOM and OPERATION NEW DAWN with the Cougars, flying from USS RONALD REAGAN (CVN 76). He is also a graduate of the prestigious EA-6B Electronic Attack Weapons School.

LCDR Bartolf reported to VAQ-129 in July 2011 as an FRS instructor where he instructed newly minted Naval Aviators and Naval Flight Officers in the EA-6B and the EA-18G Growler (following his transition to the Growler in 2012). He attended the Naval Aviation Safety Officer School in 2012. In February 2014 he reported to COMMANDER, CARRIER AIR WING FIVE in Atsugi, Japan for his disassociated sea tour where he completed two more deployments on board the aircraft carriers USS GEORGE WASHINGTON (CVN 73) and USS RONALD REAGAN (CVN 76) in the Western Pacific. He returned to NAS Whidbey Island in November 2015 for his department head tour with the Wizards of VAQ-133. He completed his sixth cruise in August 2016 to the Western Pacific on board USS JOHN C STENNIS (CVN 74). During his department head tour, he served as the Safety Officer, Administrative Officer, and Operations Officer. LCDR Bartolf accumulated over 2,100 hours flying tactical jets and 560 arrested landings on board eight aircraft carriers.

Lieutenant Commander Bartolf is currently pursuing his MBA in Financial Management at Naval Postgraduate School and a certificate in Advanced Acquisition Studies. He is also the President of the Board of Directors for the Monterey Navy Flying

Club. Following graduation in December 2019, he will execute follow-on orders to the Integration Support Directorate in the Office of the Deputy Under Secretary of the Navy. He is an avid outdoorsman and enjoys flying, hunting, hiking, running, golf, and building scale model airplanes. He is happily married to Ms. D'Marie Ellison of Moorpark, CA and they have two children (twins), Thomas and Adaline.

**CDR Louis "*DiB*" D'Antonio** is a native of West Palm Beach, Florida, and received a Bachelor of Science in Aerospace Engineering from Embry-Riddle Aeronautical University, Daytona Beach in 2002. He left a young career as a transportation engineer to join the Navy in 2003, and was commissioned as an Ensign through OCS in Pensacola, FL. After completion of training at VT-21 in Kingsville, TX in 2006, he received his Wings of Gold and was designated a Naval Aviator. His follow-on assignment was for initial training in the F/A-18E/F at VFA-122, home based at Naval Air Station (NAS) Lemoore. After completing initial training at the Fleet Replacement Squadron (FRS) he reported to VFA-2 in January 2007. He completed a deployment in support of OPERATION ENDURING FREEDOM and OPERATION IRAQI FREEDOM with the Bounty Hunters, flying from USS ABRAHAM LINOCOLN (CVN 72) throughout 2008.

CDR D'Antonio reported back to VT-21 in April 2010 as a flight instructor where he instructed multi-service flight students while they progressed through advanced flight training immediately prior to earning their Wings of Gold. He amassed over 1,000 flight hours in the T-45 A/C and was awarded as Training Air Wing TWO Instructor of the Year, 2012 prior to transferring in March 2013. He subsequently attended Joint Terminal Attack Controller training and reported to Naval Special Warfare Group TWO as division officer of Strategic Mobility and Joint Fires where he filled the specialty as Fires Officer. He deployed to Africa in support of SEAL Teams EIGHT and FOUR in 2014.

He returned to NAS Lemoore in July 2015 to attend refresher training with VFA-122 prior to his department head tour with the Black Knights of VFA-154. He completed a deployment in December 2017 to the Western Pacific and North Arabian Gulf on board USS NIMITZ (CVN 68) min support of Operation INHERENT RESOLVE. During his department head tour, he served as the Safety Officer, Operations Officer, and Maintenance

Officer. CDR D'Antonio accumulated over 2,900 hours flying tactical jets and 450 arrested landings on board six aircraft carriers.

Commander D'Antonio is currently completing his MBA in Financial Management at Naval Postgraduate School. Following graduation in December 2019, he will execute follow-on orders to the position of Operations Officer at Carrier Air Wing NINE stationed at NAS Lemoore. He is an avid outdoorsman and enjoys flying, fishing, running, golf, and most of all his family. He is happily married to Ms. Amber Holland of Arlington, TX and they have four children, Ryan, Alexis, Emma, and Dylan.

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# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| A2AD | Anti-Access Area Denial |
| AD | Aviation Machinist's Mate |
| AE | Aviation Electrician's Mate |
| AIMD | Aviation Intermediate Maintenance Department |
| AM | Aviation Structural Mechanic |
| AMD | Activity Manning Document |
| AME | Aviation Structural Mechanic-Safety Equipment |
| AMEX | Aviation Maintenance Experience |
| AO | Aviation Ordnanceman |
| AOR | Area of Responsibility |
| AS | Administrative Support |
| AT | Aviation Electronics Technician |
| AWOTF | Air Wing of the Future |
| AZ | Aviation Maintenance Administrationman |
| BA | Billets Authorized |
| BRS | Blended Retirement System |
| BUPERS | Bureau of Naval Personnel |
| CDI | Collateral Duty Inspector |
| CDQAR | Collateral Duty Quality Assurance Representative |
| CENTCOM | U.S. Central Command |
| CM | Corrective Maintenance |
| CMS-ID | Career Management System-Interactive Detailing |
| CNAF | Commander, Naval Air Forces |
| CNEC | Critical Navy Enlisted Classification Codes |
| COB | Current On Board |
| CONUS | Continental United States |
| CSG | Carrier Strike Group |
| CVN | Aircraft Carrier Fixed Wing Nuclear Powered |
| CVW | Carrier Air Wing |
| DEMOT | A combination of critical enlisted manning rate abbreviations: A(D), A(E), A(M), A(O), A(T) |

| | |
|---|---|
| DoN | Department of the Navy |
| DOTMLPF-P | Doctrine Organization Training Materiel Leadership and Education Personnel Facilities-Policy |
| DRRS-N | Defense Readiness Reporting System-Navy |
| FDNF | Forward Deployed Naval Forces |
| FM | Facilities Maintenance |
| FYDP | Future Years Defense Program |
| HSC | Helicopter Sea Combat Squadron (MH-60S Knighthawk) |
| HSM | Helicopter Maritime Strike Squadron (MH-60R Seahawk) |
| IETM | Interactive Electronic Technical Manual |
| JCIDS | Joint Capabilities Integration and Development System |
| LHA | Landing Helicopter Assault |
| LHD | Landing Helicopter Dock |
| LOE | Lines of Effort |
| LS | Logistics Support |
| MHRS/FLTHR | Maintenance Man-Hours per Flight-Hour |
| MILPERS | Military Personnel |
| NAE | Naval Aviation Enterprise |
| NALDA | Naval Air Systems Command Logistics Data Analysis Database |
| NAMP | Naval Aviation Maintenance Program |
| NAS | Naval Air Station |
| NAVAIR | Naval Air Systems Command |
| NAVMAC | Navy Manpower Analysis Center |
| NAVPERS | Navy Personal Command |
| NEC | Navy Enlisted Classification Code |
| NEOCS | Navy Enlisted Occupational Classification System |
| OFRP | Optimized Fleet Response Plan |
| OPTAR | Operational Target |
| PAA | Primary Aircraft Authorized |
| PPBE | Planning Programming Budget Execution |
| PR | Aircrew Survival Equipmentman |
| QAR | Quality Assurance Representative |
| QPA | Qualified Professional Apprentice |

| | |
|---|---|
| QPJ | Qualified Professional Journeyman |
| RBA | Ready Baseline Aircraft |
| ROC/POE | Required Operational Capability/Projected Operational Environment |
| SA | Support Action |
| SFF | Safe-For-Flight |
| SMD | Ship Manpower Document |
| SORTS | Status of Resources and Training System |
| SQMD | Squadron Manpower Document |
| T/M/S | Type/Model/Series |
| TFMMS | Total Force Manpower Management System |
| UAS | Unmanned Aerial System |
| UCAV | Unmanned Combat Aerial Vehicle |
| UT | Utility Tasking |
| VAQ | Electronic Attack Squadron (EA-18G Growler) |
| VAW | Airborne Early Warning Squadron (E-2D Hawkeye) |
| VFA | Strike Fighter Squadron (F/A-18E/F Super Hornet, F-35 Lightning II) |
| VRC | Fleet Logistics Support Squadron (C-2A Greyhound) |
| VRM | Fleet Logistics Multi-Mission Squadron (CMV-22B Osprey) |

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# EXECUTIVE SUMMARY

Naval Aviation is facing future physical growth challenges with the USS Ford-class carriers and an evolving carrier air wing composition. The air wing is transforming from a homogenous organization that includes five squadrons of the Super Hornet variants (F/A-18E/F and EA-18G), two squadrons of the Hawkeye variant (E-2/C-2), and two squadrons of the Seahawk variant of aircraft to a more heterogeneous organization that replaces two F/A-18E/F squadrons with F-35C Lightning II, swaps the C-2A Greyhound for the CMV-22B Osprey, and adds the MQ-25 Stingray throughout the next decade. The evolution is expected to change the supporting manpower requirements and increase the number of personnel and minimum skill needed to support operational tasking. Therefore, the possibility exists for the future air wing manpower requirements to outgrow the capacity of Ford-class carriers.

The purpose of this research was to identify if manpower requirements could be reduced through a higher quality (trained and qualified) workforce. The current method of resourcing shortfalls in squadron manning was evaluated by comparing Navy-enlisted classification code-based fit-fill distribution with Aviation Maintenance Experience (AMEX) 2.0. The focus was to determine if labor production efficiency (measured in maintenance man-hours per flight-hour) for more experienced squadrons was greater than squadrons with similar fit-fill, but lower AMEX values. The scope of the research was narrow and observed two squadrons of similar type, model, and series aircraft that were attached to two different air wings. In addition, the squadrons were chosen because they shared a similar required operational capability/projected operational environment (ROC/POE) and had the same manpower requirements. The period of observation was limited to 18 months, and included portions from all phases of the optimized fleet response plan (OFRP) to capture data within similar resourcing constraints for comparison. The production efficiency was compared between the two squadrons during each observed month and across each phase of the OFRP. Major trends and descriptive statistics were used to identify maximums, minimums, and most acceptable central tendencies for each squadron's production efficiency.

The findings of the research, while not decisively conclusive, do show a small benefit to having a more experienced and better-trained workforce. The limitations of the research proved to be in the determination of labor production efficiency metrics. Maintenance man-hours per flight-hour was not a good utility for determining labor production efficiency due to measurement error that caused logged maintenance action times to be unreliable. The benefits of a higher-quality workforce are obvious; however, a conclusion on naval aviation's net ability to reduce manpower requirements needs more research, a clearer understanding of the tradeoffs, and a follow-on sensitivity analysis.

Despite the research's inability to conclusively answer the primary research question, it does expose value added in pursuit of enhanced unit-level maintenance training systems, such as cloud-based artificial intelligence or augmented reality. Therefore, it is recommended that a higher-quality workforce be pursued through enhanced training systems and further research on reducing required manpower be conducted using other indicating metrics for labor production efficiency such as repeated maintenance actions or "could not duplicate" corrective actions to determine if personnel savings can be realized.

# I. INTRODUCTION

## A. PREFACE

Talent management in the Naval Aviation Enterprise (NAE) is at a critical juncture. Achieving optimal manning levels in operational naval aviation squadrons has been a delicate balancing act for the last decade. Proper manning in a Naval Aviation squadron must account for qualitative and quantitative factors. Manning is more than the number of personnel allocated to a squadron. Effective squadrons have a balance of experience, skill sets, career progression, sea–shore rotations, and externalities. There are numerous internal and external factors that heavily influence the health of the force, including (but not limited to) high operational tempo, civilian employment opportunities, service-funded educational benefits, "Up or Out" and other force-shaping policies, introduction of the Blended Retirement System (BRS), rapid cultural changes, and even a decline in patriotic sentiment as the United States enters its 18th year of conflict in the Central Command (CENTCOM) area of responsibility (AOR). Regardless of what drives sailors to depart the sea service, their absence often leaves an impactful hole in the NAE's ability to fix and fly airplanes. As a result, the NAE and Bureau of Naval Personnel (BUPERS) are mired in a "shell game" where key personnel are moved from one deploying squadron to another to ensure readiness metrics meet the mark before the squadron ships out.

The shell game is only one part of the problem. Capability needs are shifting to meet emergent threats and refocus on big power competitions. As a result, growth in the air wing is quickly outpacing the current capacity of the aircraft carriers. The ultimate solution will require a combination of changes to doctrine, organization, training, materiel, leadership and education, and personnel at a minimum. The scope of the problem is very large. Executive-level changes must occur for the Navy to stay on pace as a viable deterrent and fighting force.

A Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Policy (DOTMLPF-P) functional solutions analysis approach is required to understand the problem and seek solutions. This capstone project and the associated research is geared exclusively toward training and how it may or may not be useful in containing air wing growth. Additional, relevant DOTMLPF-P areas are discussed in Chapter V as areas for further research.

## B. FRAMING THE PROBLEM

Naval Aviation is on the cusp of major changes to the composition and function of the carrier air wing (CVW). The changes provide the Department of the Navy (DoN) with the opportunity and obligation to re-evaluate how the NAE will be manned to operate the Air Wing of the Future (AWOTF). Mission specialization requirements over multi-role capability will be essential to future success in near-peer fights. Growth in the AWOTF must be conducted smartly, with careful consideration given toward maximizing lethality and capitalizing on existing opportunities. Emergent technologies and knowledge about training and learning systems are two such opportunities.

The transformation from the current CVW makeup to the AWOTF is already underway. Fifth generation F-35C Lightning II strike fighters, as seen in Figure 1, reached initial operational capability (IOC) in 2018. Strike Fighter Squadron (VFA) 147 will take the F-35C on its inaugural cruise in 2021. The F-35C squadron will initially replace a single F/A-18E Super Hornet squadron in the air wing. When sufficient airframes exist, F-35C squadrons will replace two of the three F/A-18E squadrons within the air wing, leaving one F/A-18E and one F/A-18F squadron in the AWOTF (CVN 79/CVN 80 Program Office, email to author November 13, 2018). According to a pre-decisional brief for the Ford-class aircraft carrier program office, the number of personnel currently required for F-35C squadrons is projected to increase by 45 (CVN 79/CVN 80 Program Office, email to author November 13, 2018).

Source: Eshleman (2017).

Figure 1. A Division of F-35Cs Returning to NAS Lemoore

In addition to the F-35C, CMV-22B Ospreys (see Figure 2) are replacing the C-2A Greyhound (see Figure 3) as the carrier strike group's carrier onboard delivery (COD) aircraft. The CMV-22B is scheduled to achieve IOC by 2021 and full operational capability (FOC) in 2022. C-2A maintenance personnel typically share work spaces with the E-2 Hawkeye squadron due to the marginal commonality between the two Grumman turboprop aircraft. However, CMV-22B is a hybrid rotary-wing and fixed-wing aircraft and will not have any commonality with any platform aboard the aircraft carrier. CMV-22B implementation will add 53 personnel to the air wing complement (CVN 79/CVN 80 Program Office, email to author November 13, 2018).

Source: https://www.thedrive.com/the-war-zone/22921/navy-details-plans-for-carrier-onboard-delivery-cmv-22-osprey-squadrons-as-tests-continue

Figure 2. CMV-22B Osprey

The AWOTF recently added increased electronic attack capability with additional EA-18G Growlers and airborne early warning with extra E-2D Advanced Hawkeye (both seen in Figure 5) in 2017. Personnel growth for the E-2D and EA-18G additions are still to be determined. USS *Carl Vinson* (CVN 70) will deploy with the first iteration of the transforming AWOTF, and there will no doubt be many lessons learned, particularly in terms of logistics; however, these lessons learned may not be easily transferrable to the Ford-class CVN.

Source: Yamada (2017).

Figure 3. C-2A Greyhound

In 2024, the NAE is expected to accept the first MQ-25A Stingray unmanned aircraft system (UAS) (Department of the Navy, 2019). The Stingray is being touted primarily as an aerial refueling platform to extend the range of current assets to meet the needs of ever-increasing anti-access/area denial (A2/AD) threats from big power competitors such as Russia and China. The MQ-25A UAS will be an added capability, unlike CMV-22B and F-35C, which will replace legacy assets in the AWOTF, as will the extra EA-18Gs and E-2D. The Stingray will add 120 personnel to the air wing. By 2025, the projected air wing growth, shown in Figure 4, will be approximately 173 personnel (only 15 of 53 CMV-22B personnel will be permanent onboard the aircraft carrier; (CVN 79/CVN 80 Program Office, email to author November 13, 2018).

| | | | |
|---|---|---|---|
| **2014 Accomodation Design** | | | **4,660** |
| Ship's Company | 2,716 | | |
| Airwing | 1,758 | | |
| Embarked Staff | 124 | | |
| Tech Reps | 12 | | |
| DVs | 12 | **2018 Total** | **4,622** |
| **2018 Requirement (Surplus to design)** | | | **38** |
| Ship's Company | 2,716 | | |
| Airwing | 1,758 | | |
| F-35C adds | 38 | | |
| CMV-22 adds | 53 | | |
| MQ-25 adds | 120 | | |
| E/A-18G adds | TBD | | |
| E-2D adds | TBD | | |
| Embarked Staff | 124 | | |
| Tech Reps | 12 | | |
| DVs | 12 | **2025 Total** | **4,833** |
| **2025 Estimate (Shortfall to design)** | | | **(173)** |

Source: (CVN 79/CVN 80 Program Office, email to author (November 13, 2018).

Figure 4. Air Wing Manning Requirements

The current CVW consists of eight squadrons and one C-2 detachment. By 2026, the air wing will be expanded to nine squadrons and one detachment. It will no longer be feasible for the COD detachment (flying CMV-22B) to share spaces with the E-2D squadron. MQ-25 will require spaces for command and control, maintenance, administration, and aircrew. Also, these added personnel will need spaces to live and sleep. In addition to the space required to house nine additional aircraft, berth additional personnel, and provide workspaces required to operate and maintain the aerial refueling UAS, CMV-22, and F-35C, the Aviation Intermediate Maintenance Department (AIMD) and the Supply Department will also have need for expansion. Without prudent and direct action to contain or deflect the effects of growth, this will place an especially high burden on the aircraft carriers on which the AWOTF will embark.

Source: Sherman (2019).

Figure 5. EA-18G Growler and E-2D Advanced Hawkeye Conduct a Fourth of July Fly-by in the Arabian Sea

While it may be too late in the planning, programming, budget, and execution (PPBE) process to effectively influence DOTMLPF-P changes for the 2021 air wing, recommendations could be implemented to affect future PPBE cycles, AWOTF 2026, and beyond, particularly materiel changes. In the meantime, critical thought must be applied to marginal solutions such as improved training, higher manpower quality (capability derived from personnel with higher aptitude and skill), and organizational restructuring to capitalize on apparent and existing opportunities.

## C. PURPOSE

Commander, Naval Air Forces (CNAF), is aware of the growth issues for AWOTF and is seeking to identify problems and solutions to address the limit of aircraft carrier capacity. Long lead-times and prohibitive costing make materiel solutions less viable; therefore, the answers must come from careful, unbiased marginal analysis. This capstone project will provide quantifiable, qualifiable, and defensible analysis to solve one piece (training) of a multipart solution to a complex problem.

## D. RESEARCH QUESTIONS

We attempt to answer the following questions in this project.

### 1. Primary Research Question

If manpower quality and aviation maintenance experience (AMEX) are increased in a squadron, can manning requirements be eased for the AWOTF?

### 2. Secondary Research Questions

1. Do squadrons with greater fit-fill values perform less maintenance (in measurable form, such as maintenance man-hours per flight-hour) than squadrons with lower fit-fill values under a given set of assumptions?
2. Do squadrons with greater aviation maintenance experience in type, model, or series of aircraft perform less maintenance (in a measurable form, such as maintenance man-hours per flight-hour) than squadrons with a more diverse background under a given set of assumptions?

## E. ORGANIZATION AND ASSUMPTIONS

A brief description outlining the format that the research is presented in subsequent sections, and an overview of the broad assumptions that were made during the analysis follows.

### 1. Organization

Chapter I introduced the area of research, framed the issue of growth of personnel within the AWOTF, and outlined the research questions and methodology. Chapter II is a review of manpower drivers and how manning is contrived by taking a macro to micro approach. The *National Security Strategy* and *National Defense Strategy* (macro) create a demand signal for capabilities (in this case, airpower from the sea). The required operational capability and projected operational environment (ROC/POE) bridges strategic imperatives with operational capabilities, refines requirements, and provides a baseline of performance expectations for readiness. The Naval Manpower Analysis Center determines the requirements to meet the demands of the ROC/POE. Ultimately, bodies are placed at the unit (micro) level to fill these billets at a level determined by funding authorizations. Chapter II also reviews the enlisted maintenance professional's typical career track. Chapter III introduces Aviation Maintenance Experience 2.0 (AMEX 2.0) and how it captures the value of expertise gained in a type/model/series of aircraft, as well as manpower quality. The supporting data is also presented in Chapter III, along with a detailed analysis of the narrative the data shows. Chapter IV contains the findings and results of the data analysis. Finally, Chapter V is where recommendations, conclusions, and areas for further research are addressed.

### 2. Assumptions

For the purpose of keeping the discussion at an unclassified level, specific and identifying details have been purposely omitted. The squadrons used for analysis were selected based on the same type/model/series of aircraft, similar lots of aircraft, and utilization of the same squadron manpower document (SQMD). Similar lot aircraft will have accumulated roughly the same number of flight-hours on the airframes (wear and tear or grooming, depending on how one chooses to view aircraft usage) and equipment. They will be compared at identical points in the Optimized Fleet Response Plan (OFRP), which includes the Maintenance, Basic, Integrated, Deployment, and Sustainment phases, to reduce variability associated with DEMOT (DEMOT is a combination of critical enlisted manning rate abbreviations AD, AE, AM, AO, and AT) fit-fill, manpower strength authorized, ready baseline aircraft (RBA) authorized, parts priority, and flight-hours funding.

## F. METHODOLOGY

The data collection effort for this project was accomplished with the help of CNAF and NAVMAC personnel who provided aggregated data on aviation maintenance experience, fit-fill data, Navy Enlisted Classification code (NEC) data, maintenance data, and flight-hours. The time period of the data is October 1, 2017, through June 30, 2019.

Analysis involved applying the assumptions to the data set to identify squadrons who fit the assumptions and then evaluating data from those respective time periods. The steps were as follows:

1. Identify like-squadrons in AMEX 2.0 data, fit-fill data, DEMOT data, flight-hours, and maintenance man-hours data.
2. Determine the lot number of squadron aircraft and find similar lot aircraft squadrons for comparison.
3. Using deployment scheduling, determine what months corresponded to the Maintenance, Basic, Integrated, and Sustainment phases of OFRP for the respective squadrons.
4. Use fit-fill data to determine manning levels.
5. Prepare a spreadsheet containing aggregated data for each squadron as a basis for comparison.
6. Analyze the spreadsheets to identify trends within the data.

The selected data aims to answer the primary research question via the secondary research questions. A measurable squadron output of maintenance man-hours per flight-hour is the baseline for comparison. DEMOT fit-fill data and NEC fit-fill between squadrons was analyzed to determine the appropriateness of the workforce in the first secondary research question, or simply stated, “Does the squadron have the right mix of sailors, and if there are differences, is there a measurable change in output?” AMEX 2.0 is analyzed in the second secondary research question to see if there is a relationship between experience (and the qualifications of Qualified Professional Apprentices [QPA], Qualified Professional Journeyman [QPJ], Collateral Duty Inspector [CDI], Collateral Duty Quality Assurance Representative [CDQAR], Quality Assurance Representative [QAR], and supervisors that AMEX encapsulates) and maintenance output. Any clear, objective results from the secondary research questions can then be used to answer the primary research question.

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# II. LITERATURE REVIEW

The process of constructing organizational manpower architecture is complex. Furthermore, attempting to locate a single powerful input that is capable of tangibly changing the sum of the output is unlikely, yet there are ways to test some theories. The following chapter outlines some very important manpower inputs and their relationships to the outputs required by Naval Aviation squadrons to produce full mission-capable aircraft. In basic terms, a squadron's manpower document is birthed from doctrine that guides the capacity and the capabilities that manpower requirements must support. In the Navy, capital assets generally represent the cumulative requirements that the organization needs for support of the president's policies. Examples of this include a strike fighter squadron that is equipped with 10 F/A-18Es, or a command and control squadron that is equipped with five E-2Ds. The assigned number of aircraft supports the capacity of flights that the squadron must perform and fulfills the many assumptions that must be met for effective operations.

A quick summary of how the Navy (and therefore Naval Aviation) determines requirements begins in the oval office when the president formulates strategic policy. After it is promulgated, many other subordinate strategic policy documents are created or amended to align with the president's strategy. These subordinate documents identify capability gaps that must be filled to accomplish the president's national security objectives. The service components rely on a defense acquisitions process and the requirements generation process called the Joint Capabilities Integration and Development System (JCIDS) to identify capability gaps and source requirements to fill those gaps as described in the CJCSI 5123.01H (Chairman of the Joint Chiefs Of Staff, 2018). JCIDS categorizes requirements into segments that are manageable and digestible, including doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTMLPF-P). The focus of this research is not all inclusive of DOTMLPF-P and only attempts to specifically address how personnel and training are related and performing; however, this chapter does discuss high-level background topics relevant to doctrine, organization, materiel, leadership and education, and personnel.

## A. THE *NATIONAL SECURITY STRATEGY* DRIVES REQUIREMENTS

The intent of the following sections is to outline the manpower requirements generation process from general to specific.

### 1. *Design 2.0* and the Naval Aviation Enterprise

Strategic interrelationships should be forged in the foundation of the United States' national objectives, and they are critical to the success of all follow-on actions. The Navy's strategy is designed and developed to support the president's *National Security Strategy*, but it must also align with the *National Military* and *National Defense Strategies* as the two guiding policy documents under the president's *National Security Strategy*. *Design 2.0* was a planned revision to the Navy's *A Design for Maintaining Maritime Superiority, Version 1.0* strategic policy document released in January 2016. *Design 2.0* was planned to ensure the Navy's policy aligned with President Trump's *National Security Strategy* (Department of the Navy, 2018a). *Design 2.0* also considered intermediate progress that was made on version 1.0 and validated assumptions made about the strategic security environment drafted in version 1.0 (Department of the Navy, 2018a).

*Design 2.0* is a continuation of *Design 1.0*, and even though there were no major course corrections, modifications were made by providing operational guidance to link strategy to execution. For example, the goals of the supporting tasks of the lines of effort were updated, and the line of effort (LOE) titled "Achieving High Velocity Learning" was amended to change the focus to outputs instead of processes. The new title is "Achieve High Velocity Outcomes." Another required action of *Design 2.0* is to provide a framework of objectives that guides the Navy's investments and expectations for the Planning, Programming, Budgeting, and Execution system (PPBE) and Future Years Defense Program (FYDP; (Department of the Navy, 2018b). The FYDP is designed to capture major strategic efforts over the proceeding five-year period, while the PPBE includes past, present, and future timeframes extending beyond the FYDP into out-years greater than five years. The planning and programming phases of the PPBE and the FYDP include projections of future Department of Defense (DoD) funding, manpower, and force structure needs (Congressional Research Service, 2018). In summary, *Design 2.0* is expected to establish policy to guide defense planning and budgeting for attainment of national defense and strategic objectives.

Throughout *Design 2.0*, the Navy stated that its focus has been adjusted to compete for “sea control, sea lines of communication, access to world markets, and diplomatic partnerships” (Department of the Navy, 2018a). The plan of action is to first “increase the use of oceans, seas, waterways, and the seafloor;” second, “utilize data in decision-making through the use of global information systems;” and third, “capture technological creation and adoption” (Department of the Navy, 2018a). The four LOEs listed are

- LOE Blue: Strengthen Naval Power at and from the Sea
- LOE Green: Achieve High Velocity Outcomes
- LOE Gold: Strengthen Our Navy Team for the Future
- LOE Purple: Expand and Strengthen Our Network of Partners (Department of the Navy, 2018a).

Some tasks within the Blue, Green, and Purple LOEs that will affect the NAE include establishing data-driven decisions; fielding artificial intelligence/machine learning algorithms; expanding the use of live, virtual, and constructive training; and rapid acquisitions of materiel solutions. The number one task assigned under the Gold LOE is “Continue to improve and modernize military personnel management and training systems” (Department of the Navy, 2018a). This will be achieved through the Sailor 2025 program and is expected to deliver a talent management dashboard to commanding officers, a detailing marketplace, a new performance evaluation system, a modernization of personnel and pay systems, and a complete “transition to block learning while selecting the training technology portfolio to deliver Ready, Relevant Learning” (Department of the Navy, 2018a). The Gold LOE and supporting task are especially important to this research because they directly address talent management and the characterization of manpower quality and quantity. However, manpower in the Navy is mostly a function of the capital assets that it supports. Circling back to the JCIDS process, capital assets are part of the materiel solutions to fill capability gaps identified after the strategic policy documents are analyzed. The NAE appears to be returning from multi-role platforms to a higher degree of specialization, and the skillsets of supporting personnel must adapt.

### 2. Capital Asset Requirements: Air Assets

The capital asset requirements pertinent to the AWOTF include the F-35C, F/A-18E/F, EA-18G, E-2D, CMV-22, MH-60R/S, and the MQ-25. Also, the Next Generation Air Dominance platform will be entering the acquisition process. According to the *Highlights of the Department of the Navy FY2020 Budget*, the Navy has planned to procure 120 F-35Cs, 84 F/A-18E/Fs (including EA-18Gs), 18 E-2Ds, 42 CMV-22Bs, and eight MQ-25s for the FYDP between fiscal year 2020 and fiscal year 2024 (Office of Budget-2019, 2019). The total number of aircraft procured in the FYDP and following out-years will most likely complement those similar type, model, and series (T/M/S) aircraft already in service to create air wings composed of 20 F-35s, 24 F/A-18E/Fs, seven E/A-18Gs, five E-2Ds, three CMV-22s, six MH-60Rs, five MH-60Ss, and five MQ-25s by 2032. In 2017, the Navy transitioned to nine carrier air wings and plans to continue with nine through FY2020 as outlined in the FY2019 and FY2020 Department of the Navy budget and proposal (Office of Budget-2019, 2019). The Navy's responsibility after determining procurement plans is to clarify the manner in which the assets will be employed. This action is carried out through the creation of the ROC/POEs.

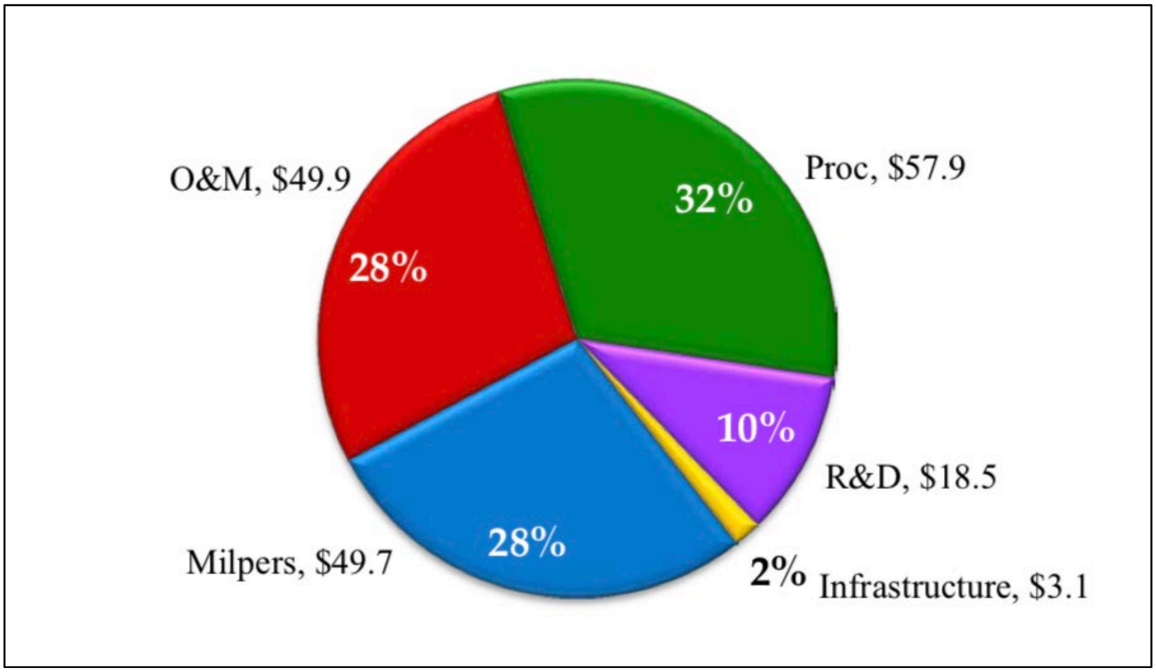
### 3. Required Operational Capabilities/Projected Operational Environments, A Critical Link

Each individual aircraft T/M/S has an associated required operational capability and projected operational environment (ROC/POE) that defines the mission objectives of the commands that it is assigned to. The ROC defines the basic mission of the aircraft, while the POE defines the location, time, and frequency that the aircraft will carry out the mission (Navy Manpower Analysis Center [NAVMAC], 2019a). Operational commands will be able to ensure they are supportive of the Navy's, and the nation's, strategic objectives by adhering to the ROC/POEs (NAVMAC, 2019b). This represents a major link between strategy and operational execution. The ROC/POEs also establish the readiness requirements for mission-capable aircraft and total sorties (flights) that must be flown during a specified period of time. Additionally, required combat systems such as communication equipment, sensors, and weapons are defined. These inputs are valuable when determining the work required for a unit to be considered ready for tasking by ROC/

POE standards. The work required to support and maintain readiness is quantified in many ways, and labor hours is an obvious metric. However, the budget is measured in dollars.

### 4. Budget Planning

The budget estimate determines the monetary constraints applied to the service components as they attempt to fulfill requirements. The total budget requirement for the procurement of air wing capital assets proposed for the 2020 FYDP was approximately $650 billion at the time of this writing (Office of Budget-2019, 2019). Comparatively, the cost of producing and sustaining manpower and personnel is slightly lower as a percentage of the fiscal budget and is calculated by using low fidelity programmed end strength. For example, note the FY2019 budget displayed in Figure 6, which includes all Navy procurement and personnel budget authorization, including the Marine Corps. It shows the totals and percentages of each budget appropriation title. Notice that total procurement, which includes aviation capital assets, makes up 32% of the total budget, while military personnel (MILPERS) represents 5% less at 28% for 212,195 personnel in FY2019. A comparison of the percentages associated with MILPERS and procurement appropriations shows MILPERS slightly trailing procurement at 28.6 versus 30.6% for 206,227 personnel in FY2017, and 27.5 versus 28.7% for 209,008 personnel in FY2018, respectively (Office of Budget-2018, 2018). The comparison between the two illustrates how they pace each other relatively closely, while they are in general, incrementally modified each year. This is important to understand because the majority of the budget for MILPERS accounts for growth and sustainment of the force. This is the amount of budget authority available to apply to labor force growth and distribution




Dollars in billions. Source: Department of the Navy (2018b).

Figure 6. FY2019 DoN Base Budget by Appropriation Title, $179.1 Billion Total

The topics of doctrine, organization, and materiel have been covered to illustrate where the demand signal for capabilities in an asset-driven institution such as the Navy comes from. The president's formulation of policy for the nation is reverberated throughout the Defense Department's policy documentation hierarchy. The policy documents are analyzed for capability gaps; then requirements are assigned to the identified gaps. The requirements encompass changes to defense capital asset portfolios and organizational architecture, such as the composition of Naval Aviation's air wings and the new assets being introduced to the fleet as materiel solutions. Budget formulation requires the changes to the capital asset portfolios as input, and it also needs input from manpower requirements that act to support the capital asset portfolios. The next section discusses the formulation of manpower requirements and sustainment of the force.

## B. THE CURRENT NAVY MANNING PLAN

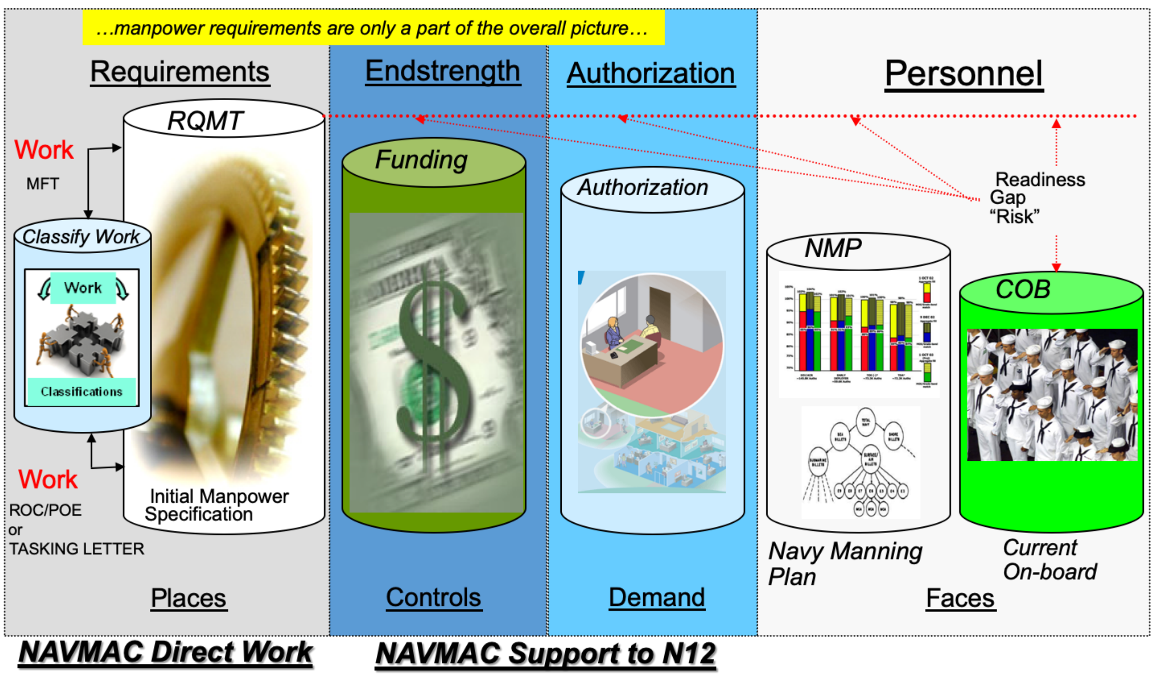
A significant portion of the planning and execution of this organizational change involves the labor force, which consists of two main drivers: manpower quantity and quality. The generation of manpower requirements culminate in Activity Manpower Documents (AMD), which describe an organization in terms of manpower and personnel characteristics. It is important to delineate the difference in the definitions of the terms *personnel* and *manpower*. Personnel requirements most often refer to the range of skills, knowledge, abilities, and experience necessary for job performance and can be thought of as the faces of an organization. Manpower requirements most often describe the total workload and skills needed, and can be considered the spaces of an organization (NAVMAC, 2019b). This section illustrates some of the processes in action that attempt to place the best quantity and quality of personnel into billets and finishes with a look at the career milestones for a current aviation maintainer with a production rating from the perspective of a sailor.

The production ratings are known as DEMOT, an acronym composed of a combination of the rating codes AD, AE, AM, AO and AT. An AD is an Aviation Machinist's Mate, AE is Aviation Electrician's Mate, AM is Aviation Structural Mechanic, AO is Aviation Ordnanceman, and AT is Aviation Electronics Technician (Navy Personnel Command, 2019b). These ratings are important to this research because they are deemed essential to the production of ready aircraft. There are other rates, such as Aviation Structural Mechanic-Safety Equipment (AME) and Aircrew Survival Equipmentman (PR) that are also vital to training and readiness production, but they are currently not considered as such in the literature reviewed.

It is also important to understand the relationship between the macro-level organization and smallest form of labor unit, the worker (sailor). This relationship provides the foundation to analyze personnel and manpower quality and quantity among operational Naval Aviation commands. The following discussion begins with the creation of manpower requirements and the subsequent SQMDs and AMDs.

### 1. Manpower Requirements Determination

The highest level of accounting for manpower and personnel in the Navy is done within the Total Force Manpower Management System (TFMMS). OPNAVINST 1000.16L provides a comprehensive method for determination, validation, documentation, and use of manpower requirements (Department of the Navy, 2016). TFMMS also acts to inform budget formulation and facilitates decision-making through resource prioritization. Additionally, it is used to carry demand signals from unit-level authorizations for personnel, training, and education. It is important to consider that fiscal budget constraints often restrict the Navy from funding or buying the validated force requirements. Funding constraints have traditionally produced a readiness gap because validated manpower requirements exceed billets authorized and filled (Department of the Navy, 2016). Figure 7 illustrates this condition.




Source: NAVMAC (2019b).

Figure 7. Manpower versus Personnel

Navy decision-makers seek the best value by requesting to fund billets based on workload and mission contribution. The outcome results in a selection of billets to be funded based on occupational series, skill and pay grade, pay band, and career group (Department of the Navy, 2016). This showcases the Navy's focus on specific manpower quality when billet funding is requested, which ensures the health and executability of each community (e.g., electronic attack, strike fighter, or helicopter maritime strike communities). Approved requirements are captured in updated Ship (SMD) or SQMDs and Activity Manpower Documents (AMD), which reside within the TFFMS (Department of the Navy, 2016). Funded billets are then filled from the total force distribution. That is how manpower programming adds, deletes, and realigns programmed end strength within the PPBE. The next discussion covers the general process of generating squadron manpower requirements.

### 2. The Creation of a Squadron Manpower Document (SQMD)

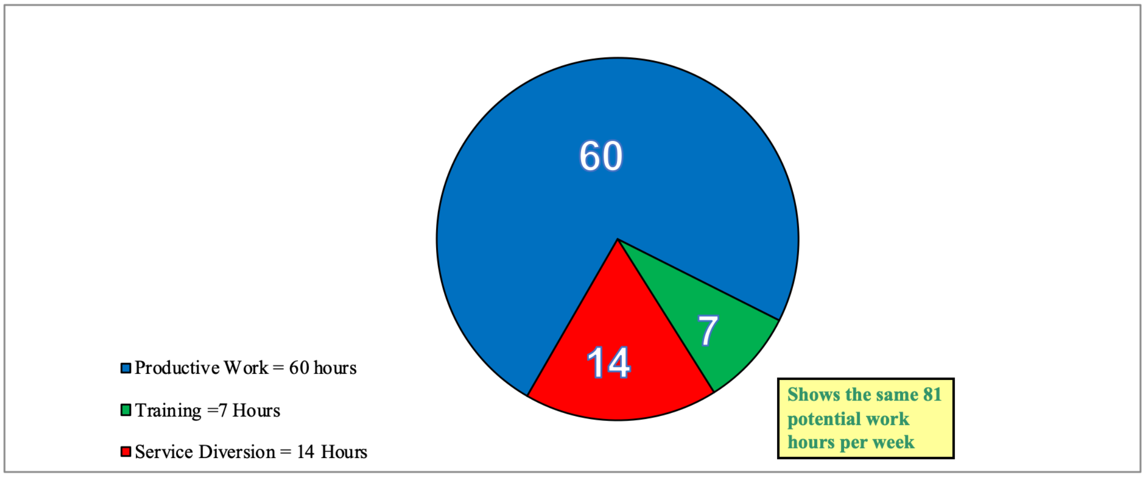
The level of strength and type of manpower needed to carry out the missions delineated in the Navy's approved ROC/POEs are assigned to billet-level qualifiers within a command. They define the duties, tasks, and functions that personnel must perform. Additionally, they provide general guidance for the level of skill required to perform the assigned functions. The Naval Manpower Analysis Center (NAVMAC) performs the OPNAV-approved methodologies to determine requirements for the four major types of manpower requirements: fleet manpower, shore manpower, individuals account (IA) and outside Navy requirements such as combatant commands (Department of the Navy, 2016). NAVMAC's mission is to determine the minimum quantity and quality to meet 100% of the mission in a defined scenario (ROC/POE; NAVMAC, 2019b).

Fleet manpower requirements are designed to uphold any given command's approved ROC/POE and are unique to each ROC/POE. The supported documents are the initial basis and input for requirements generation. Another input to requirements generation includes two categories of Navy staffing standards: internal and comprehensive staffing standards. Internal staffing standards are limited to a group of standards applicable within organizational boundaries (Department of the Navy, 2016). Comprehensive staffing standards are a group of standards that are specific to functions across all organizations (Department of the Navy, 2016). Staffing standards are relevant in the calculation of non-production work center requirements and are not thoroughly analyzed within this research. The last input for discussion of total force and fleet manpower requirements generation is manpower quality. Manpower quality is identified at the AMD level, and the portion that is relevant to this research is enlisted manpower quality. Enlisted manpower quality consists of rate or rating, Navy enlisted classification codes (NEC), and functional area codes (FAC) (Department of the Navy, 2016). Measurement of manpower quality within Naval Aviation's enlisted maintenance manpower is the primary pillar to further discussion and analysis. The next section captures the remaining inputs used to generate manpower requirements for an SQMD in addition to a ROC/POE, staffing standards, and manpower quality.

### 3. Squadron Manpower Document Inputs

The next step in the creation of an SQMD is to progress from general fleet manpower requirements drivers into those specific to the aviation commands. They are subdivided into each separate type, model, and/or series of aircraft, (which are differentiated by significantly different configurations or ROC/POE document). The first major input comes from an accurate measure of the workload. Workload data is collected from workload elements during workload studies across various aviation activities. The workload elements are relevant to production work centers and include administrative support (AS), facilities maintenance (FM), utility tasking (UT), support action (SA), preventive maintenance (PM), and corrective maintenance (CM) (NAVMAC, 2019a). PM and CM are the two most significant workload elements, and they are calculated and updated based on data taken from completed maintenance actions performed on aircraft. PM is scheduled maintenance and is used as a predictor. It is collected from standard maintenance requirements cards issued by Naval Air Systems Command (NAVAIR) to each activity based on type, model, and series aircraft assigned. In addition, a 17% make ready/put away allowance is added to the workload to account for work center time spent preparing for and concluding daily work (NAVMAC, 2019a). Throughout the course of a 12-hour work day, make ready/put away allows for one hour of job-site preparation and one hour of job-site clean-up. CM workload is calculated and used as a predictor as well. The CM data is collected from the NAVAIR Logistics Data Analysis (NALDA) database and consists of historical corrective maintenance logged from completed maintenance action forms (NAVMAC, 2019a). Maintenance action forms document the work issued and completed on each specific aircraft. The sum of the workload elements is calculated for each work center and used along with the production availability factor.

The productive availability factor is a function of the type of activity under analysis. Shore-based deployable squadrons are considered to have 81 available hours per week. The assumptions are seven work days per week, 12 hours per day, excluding three hours for worship. Figure 8 shows the breakdown of the available production time remaining.




Source: NAVMAC (2019a).

Figure 8. Productive Availability Factor, Shore-Based Deployable.

The seven hours of training account for both individual and unit training, and service diversions account for liberty during non-working weekends. The sum of an entire work center's weekly workload is then divided by the total hours in a work week to approximate the manpower requirements. The workload equation is written as

$$Work\ center\ requirements = \frac{AS + FM + UT + SA + PM + CM\ (HRS/WK)}{Total\ hours\ per\ work\ week}$$

As an example, a hypothetical work center titled Work Center 110 experiences the following:

$$Work\ Center\ 110 = \frac{154 + 5 + 6 + 221 + 105 + 242\ \left(\frac{HRS}{WK}\right)}{60\ (HRS/WK} = \mathbf{12.22\ requirements}$$

The total manpower requirements for the hypothetical Work Center 110 are rounded down to 12 and are a measure of manpower quantity. The measure of manpower quality is determined by a paygrade matrix and is represented by the example of the same hypothetical Work Center 110 in Table 1.

Table 1. Example Paygrade Matrix, Work Center 110

| PAYGRADE | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E-8 | | | | | | | | | | | | | | | | | | | | |
| E-7 | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| E-6 | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| E-5 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 |
| E-4 | | | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 |
| E-3 | | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 |

Source: NAVMAC (2019).

The paygrade table is generated from industrial-based analysis, and it illustrates that hypothetical Work Center 110 would require a manpower quality that consists of one E-7, one E-6, two E-5s, four E-4s, and four E-3s. The example shows the method of requirements determination used for production work centers. Non-production and support work centers also use pre-established staffing standards to calculate their manpower requirements. Once the activity has calculated the requirements for all work centers, it will sum them to generate a single aggregate requirement total. An example of the total number of requirements that can be expected from a shore-based deployable squadron taken from NAVMAC's fleet manpower requirements determination for aviation criteria is 254.7 taken from a 12-aircraft fixed-wing activity. The total quantity and quality of requirements for production work centers is now predicted and ready for documentation on the draft SQMD (NAVMAC, 2019a).

### 4. Non-Production Work Center Requirements

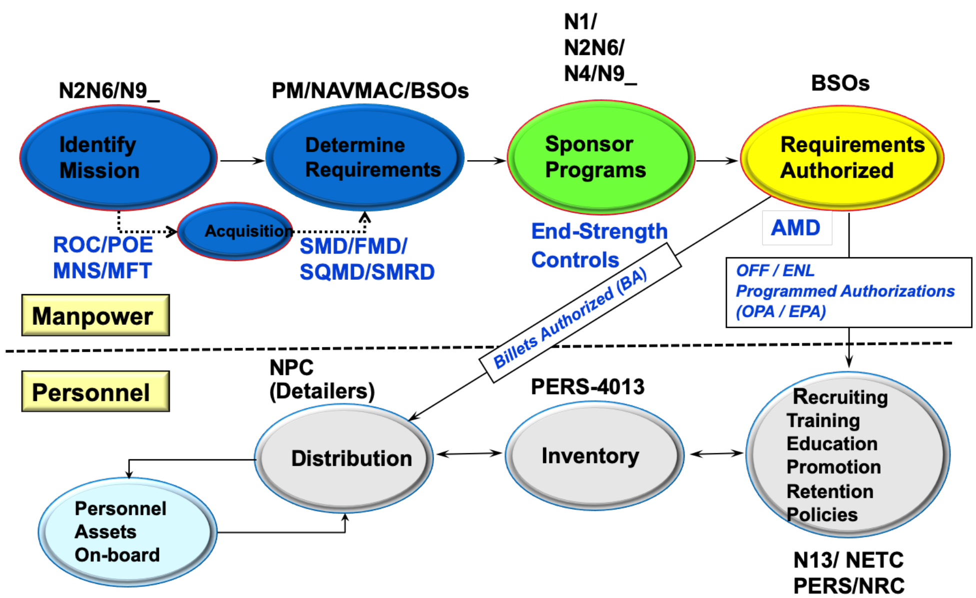
Non-production and supportive work center manpower requirements are another major element of squadron manpower that must be modeled from sampled work data. These requirements originate from staffing standards and directive policy documents, and they are supported programs such as the Sexual Assault Prevention and Response Program. As discussed previously, staffing standards are requirements drivers, and they can be further categorized into engineered and directed staffing standards. Engineered staffing standards utilize work study data that estimates the average time to perform supportive tasks for each requirement supported. These data are used to calculate the number of manpower requirements that supporting work centers need (NAVMAC, 2019a). Directed staffing standards originate from a governing direction, such as the Naval Aviation Maintenance Program (NAMP). Directed staffing requires billets such as the Command Master Chief and assigns work centers such as Quality Assurance. Together, the non-productive and the productive work centers make up the majority of a squadron's manpower requirements by accounting for the workload across each of the four categories. NAVMAC analyzes the workload for operational manpower (watch station), maintenance (preventive and corrective), own unit support (administrative and support functions), and directed requirements. Upon completion of the calculation of workload and manpower requirements, a draft manpower document is created (NAVMAC, 2000).

Once the draft SQMD is compiled by NAVMAC, it is forwarded to type commanders and operational commanders for validation. A reclama is issued with feedback from the future end-users of the draft manpower documents. Once a consensus is achieved amongst the stakeholders, adjudication completes the process. The SQMD is loaded into TFMMS, and a squadron begins to be sourced for its ROC/POE mission NAVMAC, 2000). As discussed previously, appropriated funding becomes the resource that limits the remainder of the process.

In summary of the process covered up to this point, requirements determination begins with an activity's assigned ROC/POE. The capital assets are assigned to the unit to carry out the approved mission, along with the basis for requirements determination. There are common fleet manpower requirements drivers and unique activity requirements drivers. Staffing standards are both fleet-common and activity-based, and manpower quality is the final fleet-common manpower requirements driver. At the lower level of the activity, workload is measured and applied to work centers using the workload equation to determine the manpower requirements of each work center assigned to the activity. The sum of the production and non-production work centers gives way to the draft SQMD, which is subsequently validated and sourced. Unfortunately, manpower management is a dynamic process that requires constant updating and rebalancing.

### 5. Rebalancing and the Detailing Process

The manpower process transitions to the personnel management process as the distribution of manning resources are transferred to the new activity. Throughout the remainder of the life cycle of the new activity, rebalancing and resourcing will continue until decommission of the activity. Figure 9 illustrates the organizational transition from manpower (spaces) into personnel (faces) as the activity requirements are authorized by the budget submitting offices into validated AMDs. As a review, billets authorized are the requirements that are funded, and personnel are sourced from the total force end strength and distributable inventory. The distribution of personnel to AMDs result in "faces" at morning muster that are counted as current onboard (COB).




Source: NAVMAC (2019a).

Figure 9. Theoretical Manpower Process

When the COB is measured against the billets authorized (BA), it gives a commonly accepted measure of personnel readiness within an activity. This is also known as satisfying fit and fill criteria, or quantity and quality of the BA for an activity (DoN, 2016). The enlisted detailing process is designed to answer demand signals sent through fit and fill criteria so that readiness is produced at the appropriate time in the optimized fleet response plan (OFRP).

The enlisted detailing process issues orders to sailors within the distributable inventory system based on three priorities. The first priority is to fulfill the needs of the Navy. The second is to satisfy the career needs of the individual, and third are the desires of the individual (Navy Personnel Command, 2016). The Navy uses a system called Career Management System—Interactive Detailing (CMS-ID) that was adopted in 2016 to provide a better alignment of manpower resources. CMS-ID was developed and implemented because the previous Navy Manning Plan was supportive of the previous version of readiness reporting used by the Navy called the Status of Resources and Training System (SORTS). CMS-ID modified the way that personnel were detailed and reported to better align with the modern readiness reporting system called Defense Readiness Reporting System—Navy (DRRS-N; Navy Personnel Command, 2016).

Prior to continuing further, some common terminology should be reviewed. Billets authorized (BA) are requirements that are funded by the activity's resource sponsor. Unfunded billets are billets that are not funded and result in a requirements gap (risk). Refillable excess are billets that have requirements but are in excess of the authorized funding, and non-refillable excess are billets that have no requirement at the activity (Navy Personnel Command, 2016). Current onboard (COB) is the total inventory of billets filled for the activity, broken down by several measures such as apprentice, journeyman, and supervisor. Prospective and tentative gains and losses are projected changes to the COB for the specified period that is being portrayed, commonly between nine and 12 months from the current date. Lastly, personnel are sometimes unaligned to a billet and are referred to simply as unaligned (Navy Personnel Command, 2016). As discussed in *Design 2.0*, manpower alignment is stated as an objective within the first task of the Gold LOE (Department of the Navy, 2018a). According to the BUPERS CMS-ID website, billet-based distribution is an application within CMS-ID that "focuses on enabling the Navy to better manage force structure and readiness by more accurately matching sailors and their unique skill sets to individual billets" (Navy Personnel Command, n.d.). This enhancement to the detailing system dramatically improves the enlisted rating and NEC fit of personnel across the Navy over the prior Navy Manning Plan, and it attempts to align labor resources to labor requirements. The old system used a fair share distribution and did not provide accurate demand signals for Navy AMD fit-fill criteria. The most significant takeaway from this section is that billet-based detailing is designed to send and receive demand signals from activities to activity manning managers in the most efficient and effective manner. Lastly, and in review, CMS-ID billet-based detailing matches sailors to billets based on rating, NECs, and critical NECs (CNEC), and advertises activities to sailors with significantly similar criteria needed to meet readiness milestones (Navy Personnel Command, 2016). The shift to CMS-ID was a significant step in improving manpower quantity and quality fleet wide and answers the call for the detailing priority of meeting the needs of the Navy. Next, this paper includes a brief discussion of the detailing process's second priority, the needs of the sailor. Interestingly, the sailors' needs have a large influence on the activity level's demand signal.

## C. THE AVIATION MAINTENANCE SAILOR

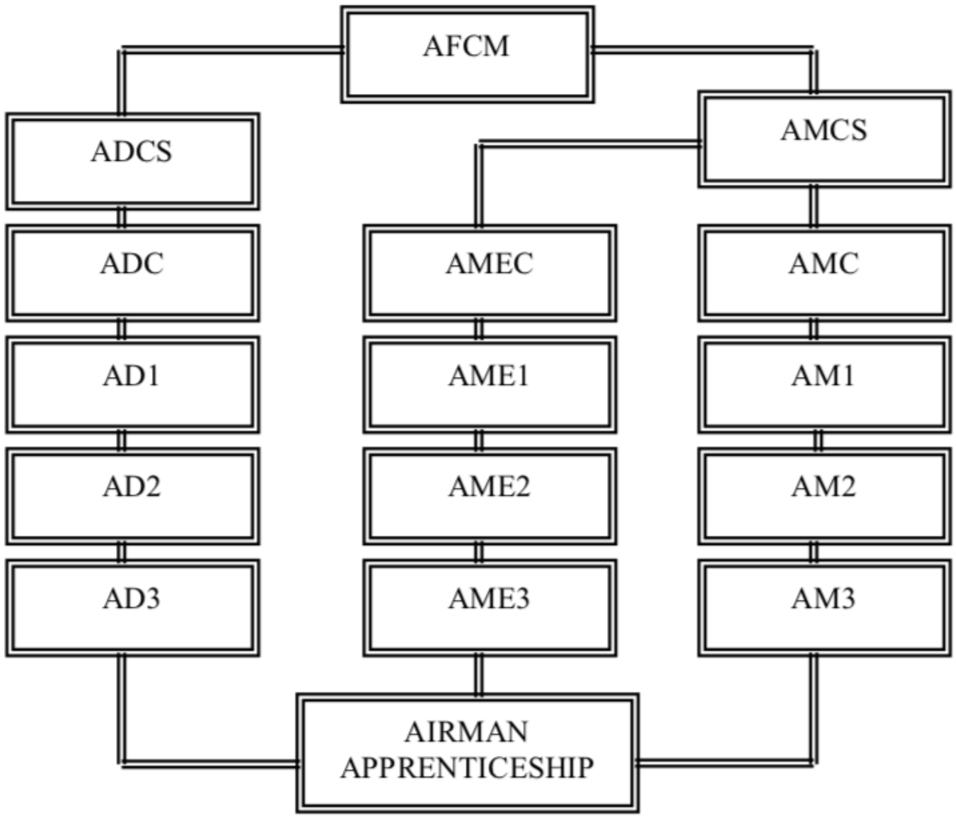
The Navy uses the Congress-approved end strength as authorization to recruit and procure its quota of new sailors needed to sustain its organizational objectives. The introductory training for a new recruit is called basic, where indoctrination to military standards occurs. Following basic, sailors who have received a rating will attend foundational in-rating job training known as Apprentice school, or "A" school. These sailors are called designated strikers. Sailors who have not been selected for a rating are often detailed to a command where they can apply for a rating under the title of an undesignated striker. Striker relates to the paygrade of E-1 through E-3. As sailors gather more experience, skill sets, and proficiency, they conquer career milestones and promote through the ranks of petty officer into chief petty officers. The following section discusses the ratings that are significant to this research and illustrate some basic terminology.

### 1. Enlisted Occupational Classifications and Ratings

Ratings are one of two elements that make up the Naval Enlisted Occupational Classification Systems (NEOCS). The NEOCS is the system used to "support enlisted personnel planning, procurement, training, promotion, distribution, assignment, and mobilization" (Navy Personnel Command, 2019b). Furthermore, it defines the skill levels and knowledge required for enlisted personnel within each career field and paygrade. The enlisted rating structure is an architecture of occupational fields and is supplemented by the other key element of the NEOCS, called NECs. Ratings, along with enlisted rates, which are the paygrades within a rating, provide the framework for enlisted career development, advancement, identification, and classification (Navy Personnel Command, 2019b). As previously discussed, the rates and ratings within a command are used to perform billet alignments and fit-fill detailing based on the requirements that were identified during the work study analyses.

### 2. The Production Ratings

The organizational-level (O-level) production ratings are the focus of this research and include Aviation Machinist's Mates (AD), Aviation Electrician's Mates (AE), Aviation Structural Mechanics (AM), Aviation Ordnancemen (AO), and Aviation Electronics Technicians (AT). O-level pertains to tasks performed at the operational command activity level. The ADs perform scheduled and unscheduled maintenance on aircraft engines, transmissions, rotors, propellers, fuel systems, and lubrication systems (Navy Personnel Command, 2019b). O-level AMs perform scheduled and unscheduled maintenance on the metallic, non-metallic fuel cell, hydraulic, pneumatic, landing gear, utility, and flight control systems (Navy Personnel Command, 2019b). Additionally, they perform all corrosion prevention on the activity's aircraft. The career pattern for ADs and AMs is displayed in Figure 10. Notice that they all start out as apprentices, then promote through the journeyman pay bands as third, second, and first-class petty officers until becoming supervisors. Petty officer ratings depict a sailor's occupational specialty and paygrade. For example, an E-4 is a third-class petty officer. If that E-4 is rated as an AD, then the full rate/rating classification is depicted as AD3. If E-5, then it is depicted as AD2 for second-class petty officer. Once a sailor is promoted to a supervisory paygrade, E-7 through E-9, then the rate/rating is depicted as ADC through AFCM.

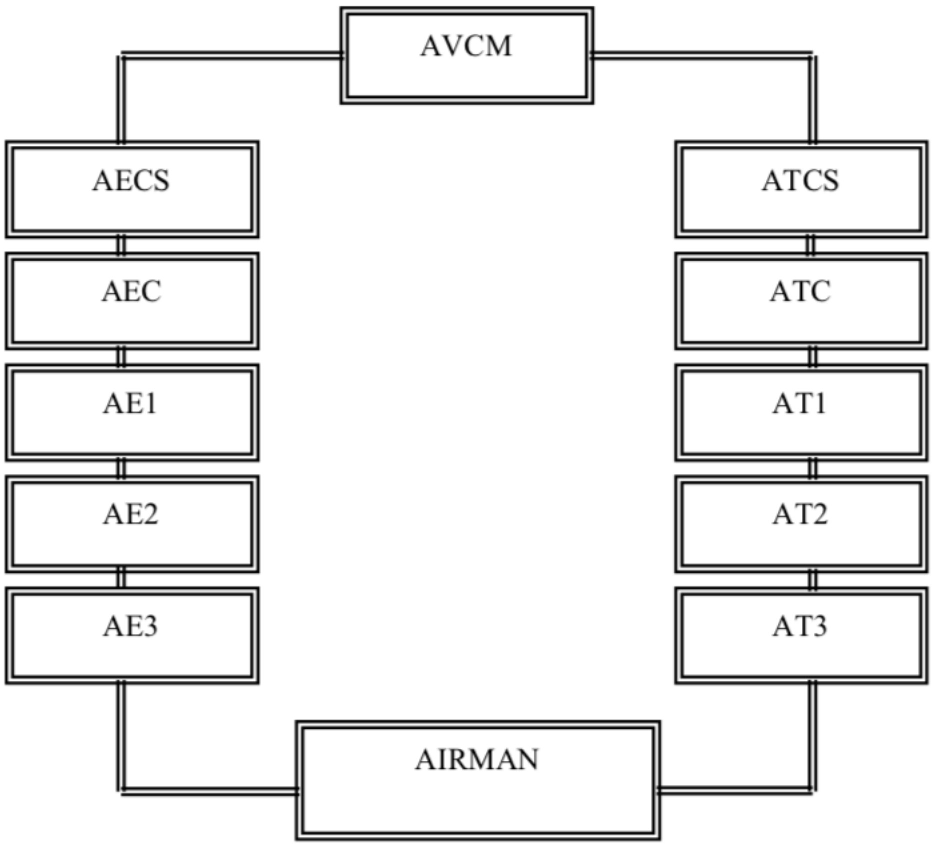



Source: Navy Personnel Command (2019b).

Figure 10. Career Pattern for Aviation Machinist's Mate and Aviation Structural Mechanic

The Aviation Structural Mechanic (Equipment), or AME, rating is also displayed on this career pattern diagram. This rating is critical to the production of ready aircraft and flight equipment and is also currently considered production under the AM rating. A rating that is not considered is the rating of an Aircrew Survival Equipmentman (PR). This non-production rating has a very significant impact on a squadron's readiness because PRs are not necessarily considered in the production work center fit-fill process. Impacts and work-arounds are discussed in the following chapter.

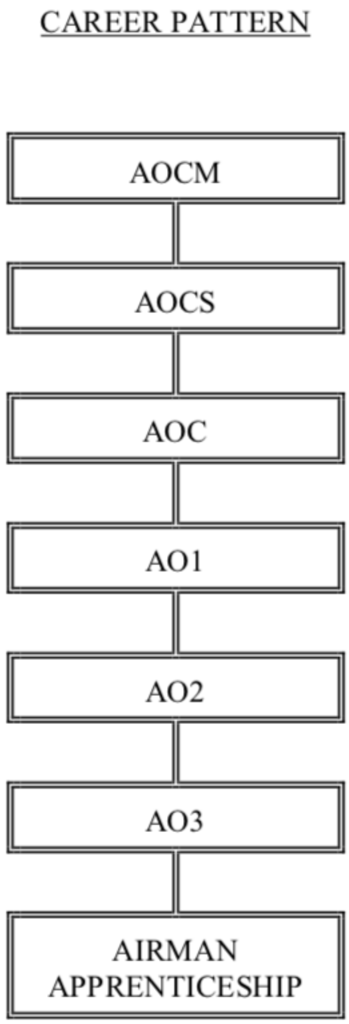
The AE rating is the occupational classification that is responsible for performing scheduled and unscheduled maintenance on aircraft electrical power generating, control, and converting systems (Navy Personnel Command, 2019b). Also, AEs are specialists in non-instrument–type warning and indicating systems. The O-level AT rating performs scheduled and unscheduled maintenance on avionics and combat systems. The career pattern for AEs and ATs is displayed in Figure 11.




Source: Navy Personnel Command (2019b).

Figure 11. Career Pattern for Aviation Electrician's Mate and Aviation Electronics Technician

O-level Aviation Ordnancemen are rated within the occupational classification that is responsible for the operation and handling of guns, bombs, torpedoes, rockets, missiles, and bullets. Additionally, their duties include maintenance of armament weapons support equipment, ordnance handling equipment, aircraft armament systems, and materials handling equipment. Lastly, the AOs are responsible for ordnance safety programs and procedures such as the Hazards of Electromagnetic Radiation to Ordnance program and proper logging and inventory of explosive material. The Aviation Ordnanceman career pattern is displayed in Figure 12, and it is similar to the others without sharing a track with another rating.




Source: Navy Personnel Command (2019b).

Figure 12. Career Pattern for Aviation Ordnancemen.

Production ratings are especially important because they perform the majority of work related to maintaining a squadron's aircraft. Also, this is the work that was measured during requirements generation, and the output from it continuously updates the assumptions about corrective and preventive maintenance. A squadron is able to generate a demand signal when production ratings are under-sourced using the assignment, detailing, and rebalancing built into the Navy Manning Plan. The next section discusses relevant information pertaining to how aviation maintainers get their skills.

### 3. Apprentice School and Career School

Core skills and abilities are learned in two environments for aviation maintainers, on the job at a squadron and in a classroom. A-school was introduced as the foundational training within a sailor's rating. It is where rated aviation maintainers receive training in skills such as equipment selection, systems evaluation and analysis, troubleshooting, and repairing. Furthermore, focus is placed on relevant systems to their rating. For example, an AD will learn basic procedures for inspection of an aircraft-mounted auxiliary power unit. Chapter 3 in Volume I of the NEOCS outlines the core and non-core task types for each paygrade within the rating of AD. An example is shown in Figure 13.

**AUXILIARY POWER**

| Paygrade | Task Type | Task Statements |
|---|---|---|
| E5 | CORE | Inspect Auxiliary Power Plant (APP) |
| E5 | CORE | Inspect Auxiliary Power Units (APU) |
| E4 | CORE | Maintain Auxiliary Power Plant (APP) |
| E4 | CORE | Maintain Auxiliary Power Unit (APU) systems |
| E5 | CORE | Troubleshoot Auxiliary Power Plant (APP) |
| E5 | CORE | Troubleshoot Auxiliary Power Units (APU) |

Source: Navy Personnel Command (2019b).

Figure 13. An Example of Tasks Assigned to the Rating of AD within the Rate of E5

Sailors use the skills they get from A-school to produce work output in their assigned activity, where on-the-job training also occurs. On-the-job training contributes to the sailors' progression through the apprentice and journeyman personnel qualification standards established in the Naval Aviation Maintenance Program (Commander, Naval Air Forces, 2017). The progression through apprentice and journeyman signify advancement of qualification and accomplishment of career milestones. The other element of the NEOCS, a sailor's NECs, are awarded at attainment of several personnel qualification standards.

NECs are supplemental to ratings and are used to identify personnel and billets in manpower authorizations (Navy Personnel Command, 2019a). Also, they are indicative of non–rating-wide skills, knowledge, and qualifications attained by personnel through special training. Those personnel are awarded a code that is used by manpower managers, and it facilitates alignment of NEC-coded billets with personnel who have attained the training required for assignment. One of the most common routes for sailors to obtain this code is through career (C) and follow-on (F) schools, which are a utility for the Navy to deliver follow-on training for personnel. These are schools that offer higher-fidelity training in rating specialties and usually culminate in NEC assignments for sailors who complete them. A type of NEC that is particularly pertinent to SQMD billets and assigned sailors is the Rating Career Field NEC Code (Navy Personnel Command, 2019a). This type of code is established for a specific rating, and it displays completion of A, C, and F-schools or identifies unique billet skill and knowledge requirements beyond those defined within a general rating. An example of this type of NEC is the code E19A, which is earned after C-school. Figure 14 shows an example of the defining data specified under the NEC in the NEOCS. Note the differentiation between the billet paygrades and the personnel paygrades because this is used during manpower alignments.

E19A - F/A-18E/F Systems Organizational Career Maintenance Technician
Performs organizational career level maintenance on the F/A-18E/F aircraft.

| | | |
|---|---|---|
| Source Rating: AT, AE, AME, AD, AO, AM | Billet Paygrades: E5-E7 | Personnel Paygrades: E4-E7 |
| Course: Mandatory | CIN: C-601-9975 (AD) | CDP: 2838, 401B (AD) |
| | C-602-9977 (AE) | 283J, 401T (AE) |
| | C-603-9975 (AM) | 2923, 4030 (AM) |
| | C-602-9979 (AME) | 2889, 4027 (AME) |
| | C-646-9975 (AO) | 294V, 4034 (AO) |
| | C-102-9978 (AT) | 2758, 4019 (AT) |
| Sequence Code: 4 | ESTB Date: REV Date: 7/1/18 | NR Ind: A |
| Component NEC: E38A | Related NEC: | Legacy NEC Code: 8341 |
| Primary Advisor: OPNAV(N98) | Technical Advisor: NAVAIR | ECM: BUPERS-32 |

Source: Navy Personnel Command (2019a)

Figure 14. Example of NEC information from NEC E19A

A practical summary of this section illustrates the career path of an AE in finer detail than the broad overview discussed thus far. Reference Table 2 for discussion points on the overlap of qualifications important to an AE's career development and the function of an operational squadron. This figure is only a partial view of the complete career path that can be found on the NAVPERS website.

Table 2. Partial Career Path of an Aviation Electrician's Mate (Air Warfare)

| YEARS OF SERVICE | CAREER MILESTONES | AVERAGE TIME TO ADVANCE | COMMISSIONING OR OTHER SPECIAL PROGRAMS | SEA/SHORE FLOW | TYPICAL CAREER PATH DEVELOPMENT |
|---|---|---|---|---|---|
| 6-9 | AE2<br>AE3 | 4.4 Yrs<br>2.8 | MECP, STA-21, Naval Academy, NROTC, LDO, RDC, Recruiter, Detailer, Honor Guard | 36 | 1st Shore Tour<br>Billet: IMA Tech, CORR CTRL, QA, CAL Tech, Instructor<br>Duty: Squadron, FRC, NATTC, NRC<br>Qualification: CDI, QAR, 2M (micro/mini), Journeyman's License, NEC 805A, Master Training Specialist if assigned as Instructor |
| 1-6 | AE3 | 2.8 Yrs | MECP, STA-21, Naval Academy, NROTC, RDC, Recruiter, Drug and Alcohol Intern, USS CONSTITUTION, Brig Duty | 54 | 1st Sea Tour<br>Billet: Maintenance Tech, Plane Captain, CORR CTRL, CAL Tech<br>Duty: Squadron/AIMD<br>Qualification: Plane Captain, EAWS, Workcenter, CDI |
| 1+/- | AEAN<br>AEAA<br>Accession Training | 9 Months | | | Recruit Training (8 weeks)/'A' School (8 weeks)/'C' School for aircraft platform or AIMD |

Source: U.S. Navy (2018).

The chart shows the progression of a sailor from accession through the rank of E-5, or AEAR through AE2. Additionally, the expected years of service that the sailor has served and the average time to advance to the next paygrade are listed. These are important because they show an average experience level attained by paygrade and rating. The farthest column to the right is especially important because it lists various qualifications that are not necessarily represented by NECs. Some of the qualifications that are listed are extremely important to the daily function of a squadron, such as Plane Captain, Collateral Duty Inspector (CDI), and Quality Assurance Representative (QAR). These qualifications are very accretive in a squadron's production of mission-capable aircraft and its ability to train future qualified maintainers. Unfortunately, the CMS-ID BBD does not align billets and personnel using these O-level production qualifications. Requirements generation and manpower rebalancing only consider rate, rating, and NEC as the "fit" and quantity assigned (COB) as the "fill" DoN (2016). This dynamic creates a divergence in the definitions of "manpower quality" as it is defined by the manpower requirements process and operational reality.

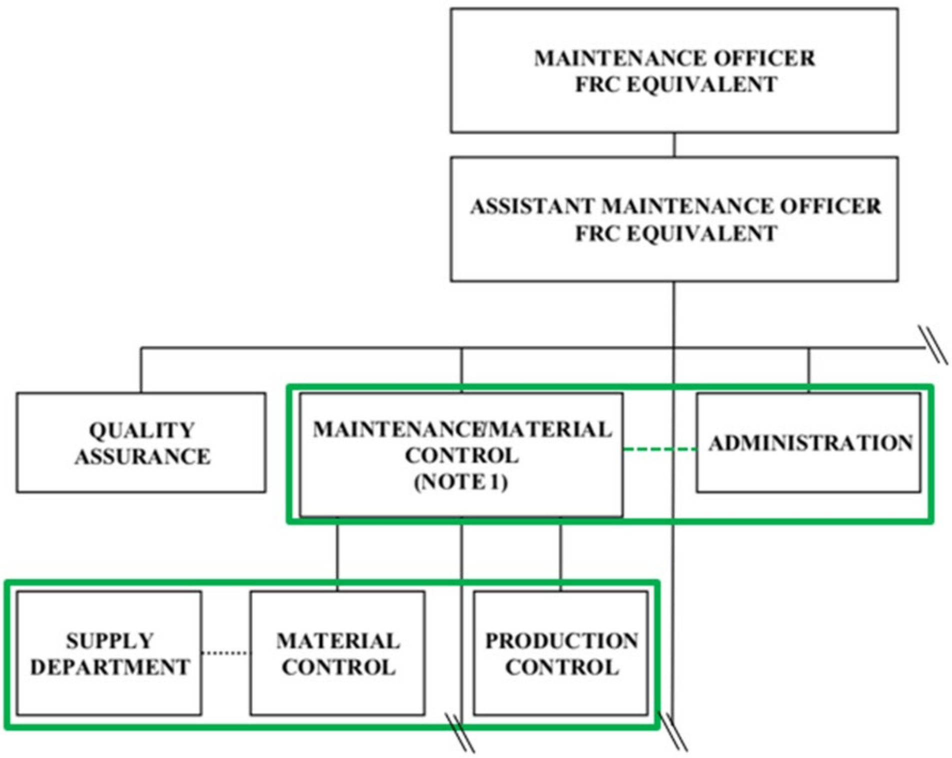
## D. UNIT-LEVEL MANPOWER REQUIREMENTS

As previously discussed, O-level manpower requirements are generated from workload and staffing standards. The production requirements have been discussed in depth, but the directed staffing standards have only been introduced. Aviation activities have many different directed staffing standards within organizational aviation maintenance. Some work centers include Maintenance Control, Material Control, and Maintenance Administration. They work together to accomplish the mission of the Maintenance department.

### 1. Directed Staffing Standards and Maintenance Work Centers

The function of this Maintenance Control is to manage the maintenance workload of all work centers assigned to the maintenance department and to support squadron operations by preparing and releasing aircraft that meet the specifications for mission capabilities. Without Maintenance Control, aviation maintenance work would stagnate and there would be no central node for coordination with the Operations department. Maintenance Control operates under the purview of personnel who are highly experienced and qualified. They are most often production-rated supervisors who are E-7 and above, but occasionally high-performing E-6 production-rated personnel are trained and function there. One example of a qualification that is extremely important to daily squadron maintenance and flight operations is the safe-for-flight (SFF) qualification. Unfortunately, it does not have a personnel demand signal tied to it through an NEC that can be sent to BUPERS. A maintainer who is SFF-qualified is trusted by the squadron to maintain a complete and accurate list of all of the squadron's aircraft discrepancies and the status of mission capability for each. This information is used to ensure that aircraft that are released to fly are "safe for flight." The SFF-qualified personnel in Maintenance Control hold the aircraft release authority. No aircraft shall be used for flight operations unless it is released to do so (Commander, Naval Air Forces, 2017).

The two other work centers listed previously, Aviation Administration and Material Control, are directly responsible to Maintenance Control for keeping updated aircraft utilization records and repair/replacement part statuses. The ratings of Aviation Maintenance Administrationman (AZ) and Logistics Specialist (LS) are staffed to these work centers. Reference Figure 15 for a pictorial view of the relationship. Together, the production work centers communicate with Maintenance Control to meet the squadron's operational demand for its aircraft, while the Logs and Records and Aviation Supply work centers provide Maintenance Control with enough data to ensure that aircraft are properly maintained. It is incumbent on O-level squadron activities to be able to train their assigned personnel to fill directed staffing standards and qualifications that are not able to be sourced because they are not accounted for during manpower requirements generation and assignment. The SFF qualification is one of those qualifications.




Adapted from Commander, Naval Air Forces (2017).

Figure 15. Organizational Relationship between Maintenance Control, Maintenance Administration, and Material Control.

### 2. The Operational Reality

The level of organic training that must be conducted in a squadron is directly proportional to the number of aircraft to which it is resourced and funded. For example, a squadron that is assigned 10 aircraft may only be resourced to operate four of them during the Maintenance phase. As a (non-forward deployed) squadron progresses through its Optimized Fleet Response Plan (OFRP), it is incrementally funded and sourced with operational target funding (OPTAR or flight-hours) and personnel (fit-fill) to meet the phase of training it is in. As the OFRP progresses up to deployment, the number of authorized aircraft increases, along with the resourcing levels, until it is sourced to operate 100% of its assigned aircraft.

At the beginning of the OFRP, it is fiscally responsible to resource squadrons to a reduced level of readiness. This occurs when squadrons are transitioning out of the Deployment and Sustainment phases, then back into the Maintenance phase. They begin to rebuild as they exit the Maintenance phase and re-enter the Basic and Integrated phases. The Maintenance phase is intended for post-deployment restoration of squadron assets, including aircraft, combat systems, personnel, and qualifications. The operation of four primary aircraft will not need as many qualified personnel as a squadron that is funded to operate 10. However, the squadron will still be assigned 10 aircraft, and it must maintain them despite the resource level.

Frequently, O-level squadrons will lose many of the qualifications that were attained over the previous OFRP cycle along with the departing personnel. Many of those qualifications are not represented within the billet architecture because they are not represented by an NEC, so no demand signal is sent to activity manpower managers. As a review, replacement personnel are assigned to billets based on the billet and personnel attribute alignment. When personnel are assigned to billets based on NEC, rating, and paygrade, it can easily result in assignment of personnel to a squadron who have no experience in the squadron's type of aircraft. For example, an AD2 who worked on MH-60 Seahawk helicopters for eight years can be assigned to an EA-18G power plant's work center. The problem is exacerbated when that AD2 is assigned to a billet where his or her career development requires a position as a work center Leading Petty Officer. Occasionally, junior work center personnel hold more production qualifications and have more experience on aircraft types than the newly assigned work center supervisor. The burden falls back on the squadron to manufacture its personnel's qualifications at the same time as its aircraft.

## E. SUMMARY

The process of generating manpower requirements builds a strong foundation for operational activities to accomplish their objectives defined in each ROC/POE. The aggregate success of O-level activities through completion of OFRPs is directly linked to *National Defense* and *National Security Strategies* through their respective ROC/POEs. The individual successes that make up the aggregate should be scrutinized, and a sharp eye with attention to detail should survey for areas of improvement.

Talent management within carrier-based Naval Aviation Maintenance is the area that is scrutinized in this research. Manpower is very fluid, and it is always in a state of flux due to inputs from doctrine, workload measurements, funding constraints, and staffing standards. Rebalancing and personnel alignment add additional layers of complexity to the system, but categorization of billets and personnel based on labor and skill attributes aid the replenishment of personnel and qualifications to Aviation Maintenance departments. Rates and ratings facilitate a proper 'fit' during assignment and realignment, and NECs supplement the process to even greater measures; however, squadrons are still responsible for a great deal of organic training to qualify and certify its personnel to perform many critical, essential, and enhancing tasks.

In carrier-based aviation squadrons, personnel have two significantly different environments in which they must perform their jobs, ashore and embarked. Additionally, there are many qualifications that personnel must attain that go unrecorded as a rating or NEC. Squadrons must administer a great amount of organic training to nurture their personnel's qualifications to meet directed standards. Significant and meaningful force development is done in the fleet. The following chapter introduces one method that manpower managers are using to identify qualifications that are critical to squadron operation and how informal demand signals are enabling successful assignment.

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# III. TOPIC INTRODUCTION AND ANALYSIS

In Chapter II, the expectation of future doctrine, organization, materiel, and personnel was discussed to provide a supporting level of knowledge prior to this discussion and analysis of the value of training. A value-added approach must be taken when the traditional billet assignment process does not fully meet the needs of a command. As discussed in Chapter II, there are many qualifications that are not represented by a rate, rating, or NEC that squadrons rely on to perform daily maintenance and flight operations. Naval Aviation's maintainers attain these qualifications by simultaneously training and performing maintenance tasks within a squadron. This duality should be quantified during the consideration of personnel placement. The reason for emphasis on this topic is because NEC-based detailing is designed to source squadrons with the minimum personnel and the minimum manpower quality to meet readiness milestones (NAVMAC, 2019b).

In traditional labor economics, as labor output is measured with respect to the quantity of labor supplied, there is a reduction in the slope of the labor output. This effect is called the diminishing marginal product of labor and is depicted in Figure 16. The figure is a graphical depiction of the diminishing productivity that occurs when scarce labor resources, such as Panasonic Toughbooks, which serve as the hosts for interactive electronic technical manuals (IETM) and maintenance publications, can only be used by a few personnel from each work center at a time.

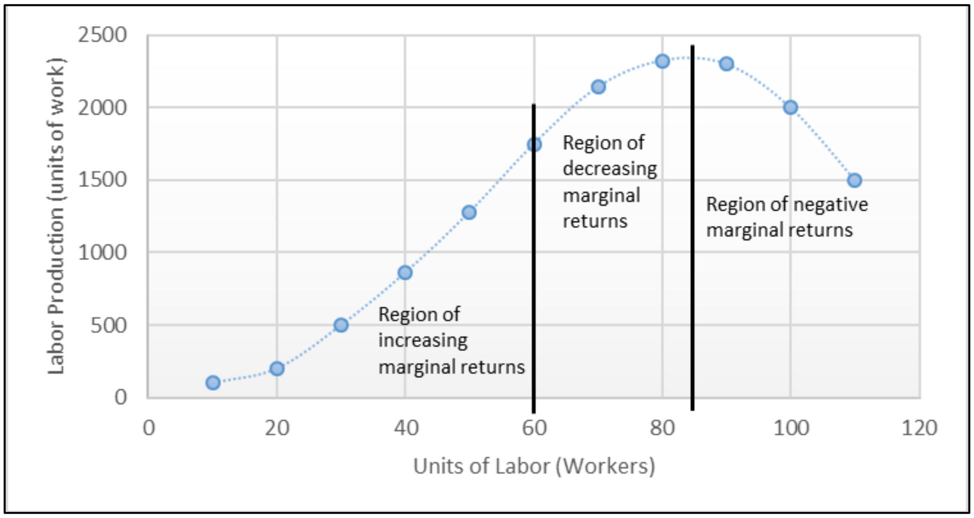



Figure 16. Example of the Diminishing Marginal Product of Labor

In the example displayed, notice that when the number of workers in the labor supply increases above 60, the slope of the graph begins to shallow, indicating a transition from increasing to decreasing marginal productivity. When the 61st worker is introduced to the labor system, more productivity is captured, but the marginal increase is lower than the previous 60 workers. The slope of the graph continues to flatten until it becomes negative, where productivity becomes handicapped by the addition of approximately the 85th worker. This is important because squadrons should strive to employ their labor as efficiently as possible, and it should be intuitive which region of the production curve Naval Aviation maintenance should target. Additionally, the 61st through the 84th worker added should be as qualified as possible to capture the maximum productivity available. This is the importance of manpower quality.

When activity manpower managers need an alternate definition for manpower quality from the definition given by NAVMAC, there are two components of special interest that are applicable to production-rated maintainers. The first of those components measures the time spent assigned to the activity's type/model/series aircraft, and the second quantifies the specifically relevant qualifications that are held (Wilson, 2018). Squadrons utilize the tools at their disposal to send supplementary demand signals when the CMS-ID processes provide substandard quantity and quality, including submitting enlisted manning inquiry reports (EMIR) and personnel manning assistance reports (PERSMAR). There is another informal method that this research focuses on, and it is called Aviation Maintenance Experience.

## A. AVIATION MAINTENANCE EXPERIENCE

Aviation Maintenance Experience (AMEX) is an aggregate score assigned to a squadron after consideration of every DEMOT-rated E-4 through E-8. It is the method used to categorize and quantify the job experience of each squadron's aviation production maintainers. The system of stimuli and responses that AMEX generates was born in 2014 by an NAE total force cross-functional team that was canvassing for solutions to narrowing budgets and limited personnel inventory. A major pillar to success would be if the system could accurately measure readiness risk and provide actionable results.

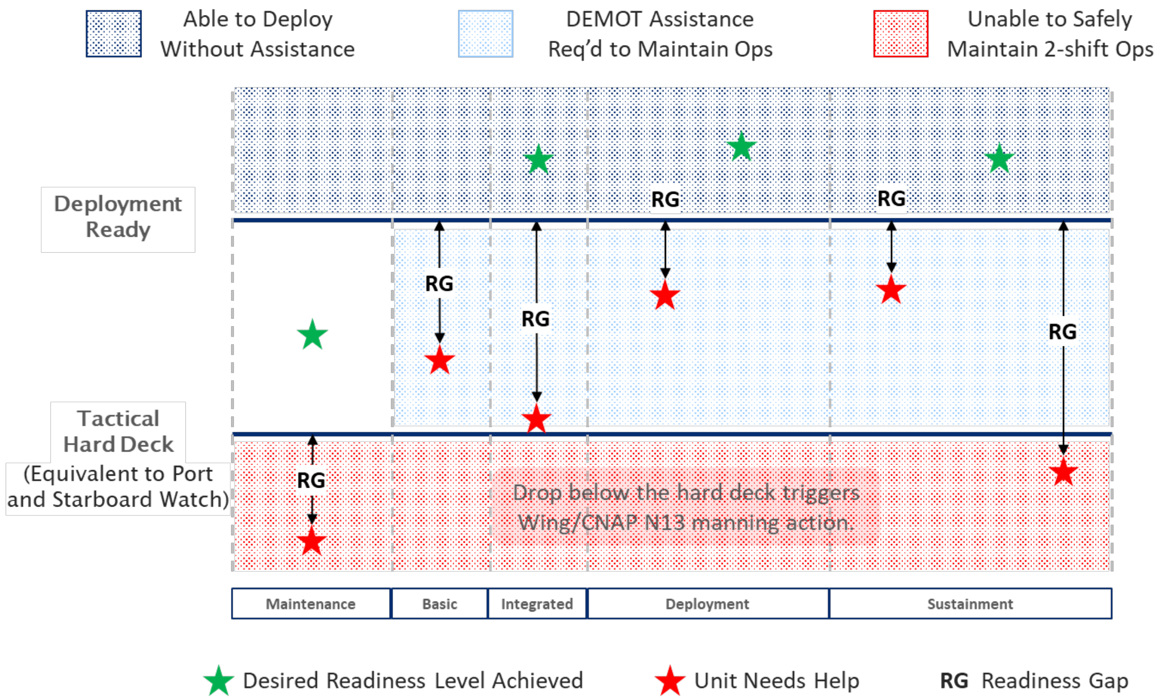
### 1. AMEX Hard Deck and Deployment Threshold Lines

Initially in 2014, AMEX measured E5 through E9 sailors on a binary scale of 0 or 1 based on their type-model experience. The total experience was compared against the billets authorized by Naval Air Forces to reflect readiness risk, and the result was displayed using stoplight criteria (green, yellow, and red) for the squadron's total personnel readiness risk. The early AMEX system was minimally actionable (Naval Aviation Enterprise Total Force Cross Functional Team [NAE Total Force CFT], email to author September 16, 2019). A more robust measurement was required.

The NAE modified AMEX in 2016 to better capture the value harnessed by re-utilizing maintainer skill sets for aviation maintenance production. It uses an aggregate qualitative measure of a squadron's readiness risk to guide personnel distribution decisions, and it now measures E4 through E8 DEMOT-rated aviation maintainers. The source data used to calculate each sailor's individual score is pulled from many qualitative manpower systems, including Advanced Skills Management (ASM), the Navy Enlisted System (NES), Fleet Training Management and Planning System (FLTMPS), OPNAV Aircraft Program Data File (APDF), NAVMAC's TMS SQMDs, TFMMS, and the Master Aviation Plan (NAE Total Force CFT, email to author September 16, 2019). ASM, NES, TFMMS, and OFRP data are updated at least monthly along with billet re-alignment, APDF data is updated annually, and SQMDs are updated with new document implementation by

NAVMAC such as TFMMS updates (Wilson, 2018). Accordingly, AMEX scores can be derived by type wing, carrier air wing, squadron, pay band, and/or rating, and they are plotted against two lines, a threshold and an objective (NAE Total Force CFT, email to author September 16, 2019).

The lower threshold is called the hard deck, and the higher is called the deployment threshold. Both are used as baselines to measure a given squadron being analyzed, and they are created from the associated SQMD. More specifically, the baselines are unique to each SQMD, and they ensure each squadron is resourced for compliance with the OPNAV 4790 in addition to its ROC/POE. An AMEX below the hard deck indicates that a squadron can no longer conduct two-shift maintenance, and it triggers action to manpower managers to avoid squadron readiness interruptions (NAE Total Force CFT, email to author September 16, 2019). The deployment threshold only applies to the Basic through Sustainment phases of the OFRP, and an AMEX score above it indicates that a squadron is capable of conducting all tasking without external maintenance support. External support is usually sourced from a squadron scored above the deployment threshold to a squadron that scored below the hard deck, and production-rated maintainers would be either assigned temporary assignment of duty orders or informally loaned from a sister squadron. AMEX threshold values are updated along with new document implementation by NAVMAC. Figure 17 illustrates the use of hard deck and deployment thresholds.

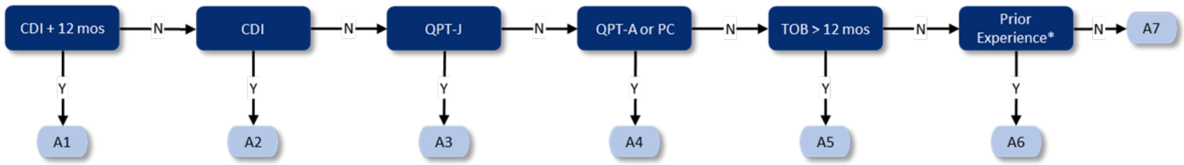



Source: Maner and Saunders (2018).

Figure 17. Squadron Personnel Readiness as Measured by AMEX

### 2. Method of Calculation

The method of measuring each squadron's AMEX begins with measuring each sailor's AMEX score. The NAE's cross functional team established an architecture of logic trees that yield AMEX scores from each sailor's current TMS assignment, rating, pay band, and qualifications that were selected as relevant. An example of a logic tree is shown in Figure 18, and it illustrates the outcome of some of the selected qualifications. The selected qualifications used to calculate squadron-level baseline scores across all production ratings and pay bands are Safe-for-flight (SFF), Quality Assurance Safety Observer (QASO), Collateral Duty Inspector (CDI), Collateral Duty Quality Assurance Representative (CDQAR), Quality Assurance Representative (QAR), Qualified and Proficient Technician–Apprentice (QPT-A), Qualified and Proficient Technician–Journeyman (QPT-J), and Plane Captain (PC) (NAE Total Force CFT, email to author September 16, 2019). None of those qualifications listed are tracked by NEC, and all are required by OPNAV 4790.




Source: Maner and Saunders (2018).

Figure 18. Example of a Logic Tree for an FA-18A-F Apprentice

Subjective point values were assigned for each logic tree outcome, and they are also assigned an experience-weighting factor. The sum of a sailor's weighted points represents a cumulative experience score that the sailor contributes to his or her squadron's total AMEX. In addition, sailors' AMEX scores can be summed across pay bands, work centers, and units to measure the aggregate experience, or training and readiness, of an aviation maintenance work force. An example of the point assignments from the logic outcomes is displayed in Table 3.

Table 3. Example of Logic Tree Outcomes and Points (0.5 Weighting)

| **Outcome** | **Definition** | **Points** | **Weighted Points** |
|---|---|---|---|
| A1 - CDI+12mos | Holds a CDI and has held CDI for longer than 12 months. | 5 | 2.5 |
| A2 - CDI | CDI. | 4 | 2 |
| A3 - QPT-J | QPT-J. | 3 | 1.5 |
| A4 - QPT-A/PC | QPT-A or PC. | 2 | 1 |
| A5 - TOB>12 | Onboard longer than 12 months. | 1 | .5 |
| A6 - PrevExp | Has prev. experience (e.g., in community, Type, etc.) as specified in logic tree. | 1 | .5 |
| A7 - Other | No previous aviation unit experience. | 0 | 0 |
| - NONE - | Billet may be gapped. | 0 | 0 |

Source: NAE Total Force CFT, email to author (September 16, 2019).

The second step in calculation establishes the hard deck and deployment thresholds that are used for measurement. As previously discussed, subjective scores were established by the cross-functional team, and they have been assigned to each E4 through E8 funded billet requirement. Table 4 shows sample data that represent deployment and hard deck outcomes and scores for funded AD-rated billet requirements for a 12-aircraft squadron.

Once these standards have been established for a squadron, they only change when SQMD or OPNAV 4790 changes are implemented.

Table 4. Sample of Billet-Assigned Outcomes and Scores Used to Calculate Thresholds

| | | | | Deployment | | Hard Deck | |
|---|---|---|---|---|---|---|---|
| BILLET TITLE | RATING | PG | Payband | Qualification | Pts | Qualification | Pts |
| AVENG SYS O-LV/SUPV | AD | E7 | Supervisor | S3 - SFF/QASO | 16.5 | S6 - PrevAvSqdnAndProfile | 6 |
| AVENG SYS O-LV | AD | E6 | Journeyman | J3 - CDI | 9 | J3 - CDI | 9 |
| AVENG SYS O-LV | AD | E5 | Journeyman | J3 - CDI | 9 | J3 - CDI | 9 |
| AVENG SYS O-LV | AD | E5 | Journeyman | J3 - CDI | 9 | J4 - QPJ | 6 |
| AVENG SYS O-LV | AD | E5 | Journeyman | J4 - QPJ | 6 | J9 - PrevTMSw/QPT-A | 4 |
| AVENG SYS O-LV | AD | E4 | Apprentice | A4 - QPT-A/PC | 1 | A4 - QPT-A/PC | 1 |
| AVENG SYS O-LV | AD | E4 | Apprentice | A4 - QPT-A/PC | 1 | A6 - PrevExp | 0.5 |
| AVENG SYS O-LV | AD | E4 | Apprentice | A6 - PrevExp | 0.5 | A7 - Other | 0 |

Source: NAE Total Force CFT, email to author (September 16, 2019).

Following the calculation of billet and sailor AMEX scores, data is displayed in a manner similar to that shown in Table 5 and Table 6. The non-static information in Table 5 illustrates the personnel readiness of a sample squadron across each pay band and production work center and in total. It is compared to the static hard deck and deployment thresholds displayed in Table 6 to identify areas of relative strength and weakness within each category. Manning control authorities use this comparative information to source specific personnel and qualifications to squadrons that need it.

Table 5. Sample of Squadron AMEX Scores Calculated from COB Personnel

| | AD | AE | AM | AME | AO | AT | Total |
|---|---|---|---|---|---|---|---|
| **Apprentice** | 7 | 6 | 7 | 4 | 16 | 11 | 51 |
| **Journeyman** | 34 | 35 | 59 | 32 | 49 | 57 | 266 |
| **Supervisor** | 32 | 16 | 18 | 9 | 6 | 9 | 90 |
| **Total** | 73 | 57 | 84 | 45 | 71 | 77 | **407** |

Source: NAE Total Force CFT, email to author (September 16, 2019).

Table 6. Example of AMEX Thresholds Calculated from Billet Expectations

| | SQMD Deployment AMEX Points | | | | | | | SQMD Hard Deck AMEX Points | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AD | AE | AM | AME | AO | AT | Total | AD | AE | AM | AME | AO | AT | Total |
| Apprentice | 15 | 8 | 6 | 3 | 14 | 9 | 55 | 12 | 4 | 5 | 1 | 8 | 5 | 35 |
| Journeyman | 60 | 41 | 86 | 46 | 62 | 49 | 344 | 54 | 38 | 77 | 40 | 49 | 41 | 299 |
| Supervisor | 15 | 24 | 18 | 6 | 15 | 21 | 99 | 13 | 19 | 16 | 4 | 13 | 16 | 81 |
| **Total** | 90 | 73 | 110 | 55 | 91 | 79 | **498** | 79 | 61 | 98 | 45 | 70 | 62 | **415** |

Source: NAE Total Force CFT, email to author (September 16, 2019).

Notice the total AMEX within the AM rating in Table 5 is below the hard deck in Table 6. This condition prompts action from NAE manpower managers to bring the AM-rating's AMEX above the hard deck, provided the squadron that is being measured in the example is not in Maintenance phase. One last detail that needs to be considered is that not all SQMDs are equivalent. A squadron that is assigned 12 aircraft and a particular ROC/POE will have different AMEX billet requirements than a squadron with 10 aircraft and a different ROC/POE. Manpower managers must make decisions from normalized AMEX scores to make fair comparisons and appropriate distributive actions. The following equation is used so that talent managers and distribution decision-makers can maximize labor efficiency (NAE Total Force CFT, email to author September 16, 2019).

$$AMEX\ Score\ = 1 - \frac{(SQMD\ Deployment\ AMEX\ Points - AMEX\ Points)}{(SQMD\ Deployment\ AMEX\ Points - SQMD\ Hard\ Deck\ AMEX\ Points)}$$

### 3. Hypothesis

A unit of measure for comparison and analysis is necessary. A common metric used to establish design characteristics of aircraft maintainability is maintenance–man-hours per flight-hour (MHRS/FLTHR). Labor hours are used as the dependent variable, while flight-hours are the independent variable. This conditional relationship was selected because flight-hour execution is a direct measure of mission execution as defined by the ROC/POE. It is also a display of squadron tasking. Therefore, support must be able to rise to the challenge for conditional success through maintenance support actions. Additionally, higher AMEX scores imply a higher degree of familiarity with the T/M/S aircraft and a higher level of qualification (QPA through QAR and supervisor). Operational experience and logic provide additional basis for the formulation of the hypothesis.

The hypothesis states that a squadron with more experienced and highly trained sailors should perform measurably fewer maintenance man-hours per flight-hour than squadrons with less experience and qualification. This hypothesis assumes that AMEX accurately represents training and experience in a particular T/M/S of aircraft. The rate of production output should reflect an increase in production efficiency, and labor hours per flight-hour should drop as maintainers perform a higher quality of work. This should be explained by observing a drop in production rate due to an increase in production efficiency.

## B. ANALYSIS

The analysis is presented using the same organization with which the overall research has been presented. NEC fit-fill percentages are shown for two squadrons as they progress through 18 months of their respective OFRPs. These data are representative of the personnel readiness, measured in percentages, of the requirements that are satisfied. Each chart also includes the labor force's observed efficiency measured in man-hours per flight-hour. This comparison should display how scheduled changes in resources and OPTEMPO affect the output of the squadrons, as measured by traditional manpower requirements.

The section that follows the presentation of NEC fit and fill data shows a measure of the squadrons' AMEX and labor efficiency as they progress through the same 18-month period. The analysis focuses on overall trends and irregularities in the labor output for comparison to those observed through the optic of requirements-derived fit and fill. Lastly, inspection of the data bins between the separate phases of the OFRP are noted for unique observations that aren't available by analyzing the larger trends and the data maximums and minimums.

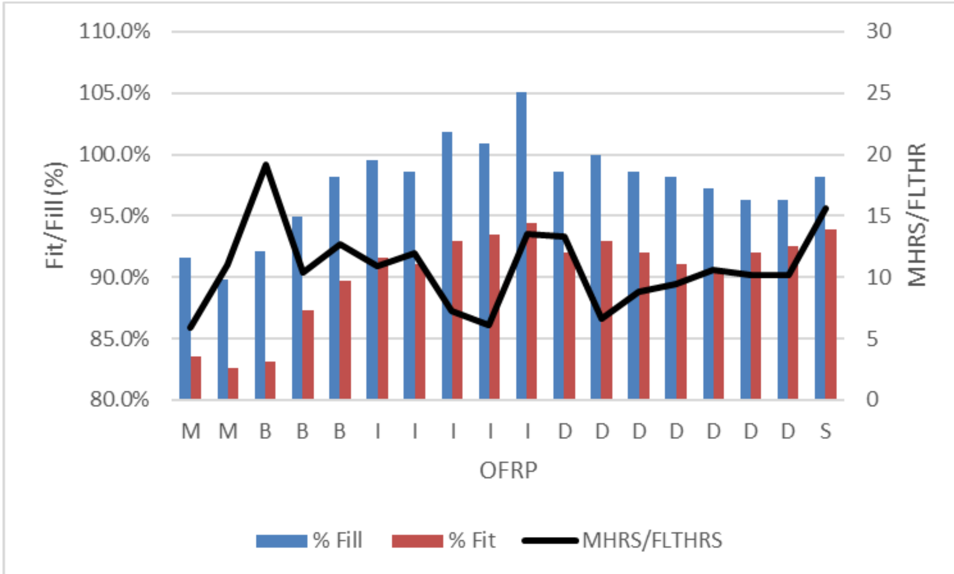
### 1. The NEC Fit-Fill Data

NEOCS data is used to generate the requirements that are resourced within each squadron's SQMD. As a review, manpower requirements include pay band, rating, and NEC as major requirements drivers. As the billets that house the requirements are filled with personnel, the fit and fill percentage is calculated. As previously stated, it represents personnel readiness as measured by DRRS-N. The following figures show arbitrary position holders on the horizontal axis, which represent a month of time, and the particular phase of the OFRP that each squadron was in. The characters of ‘M,’ ‘B,’ ‘I,’ ‘D,’ and ‘S’ represent the Maintenance, Basic, Integrated, Deployment, and Sustainment phases, respectively. The primary vertical axis displayed on the left measures percent for fit and fill, while the secondary vertical axis on the right measures labor output in man-hours per flight-hour.

Squadron A is depicted in Figure 19 and is observed beginning well into the Maintenance phase, where it only had two months remaining. The last month of the Maintenance phase is the low data point on the chart and displays an 82.5% fit and an 89% fill. Concurrently, labor efficiency was decreasing from six man-hours per flight-hour to the maximum of 20 man-hours per flight-hour during the transition into Basic phase. Personnel resources increased throughout Basic and Integrated phase, where the chart’s maximum is at the first of two modes. This was during the last month of Integrated phase, where fit was 94.4%, and fill was 105%. Labor efficiency concurrently degraded prior to deployment, and rose from a minimum of six, to 13.5 man-hours per flight-hour.

The second mode of the squadron’s fit and fill was in the first month of sustainment, where fit was approximately 94%, nearly 6% closer to the 98% fill than the previous mode. Labor efficiency decreased again from 10 to 16 man-hours per flight-hour as the squadron transitioned from deployment into sustainment. A noteworthy characteristic of these data is the difference between the fit and fill percentages. The gap between the two metrics averages approximately 5% throughout.

The overall trends of Squadron A as it progressed through the OFRP included an increasing fit and fill percentage and increasing labor efficiency resulting in lower man-hours per flight-hour as it began deployment. After commencing deployment, the labor efficiency slowly decreased until sharply falling as sustainment started.



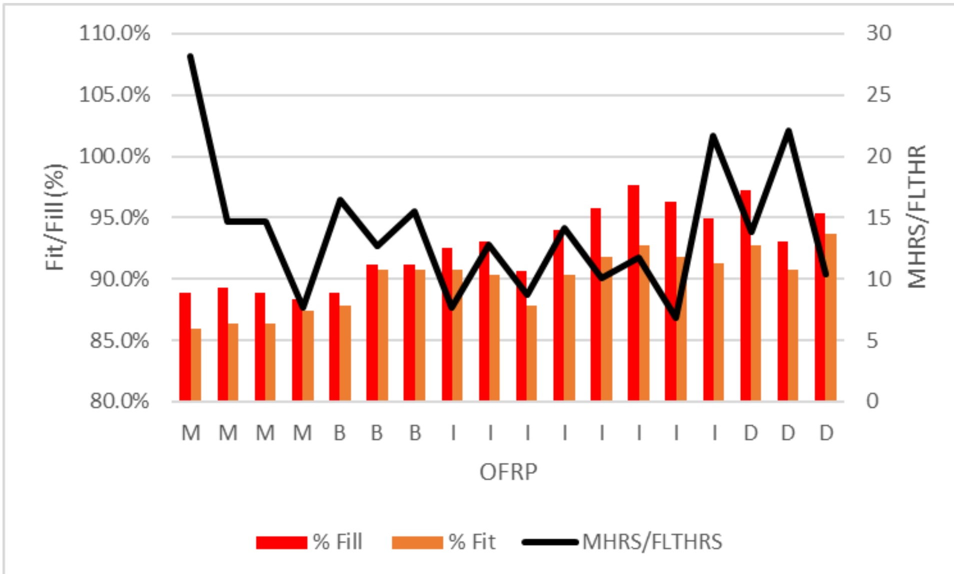

Source: CNAF (personal communication, 2019).

Figure 19. Squadron A Fit-Fill and MHRS/FLTHR over OFRP

Squadron B is depicted in Figure 20 and was observed beginning with four months remaining in the Maintenance phase. The first month of observation was the lowest data point on the chart for fit and fill and displayed an 85.9% fit and an 88% fill. Concurrently, labor efficiency was observed at its poorest performance, which yielded 28 man-hours per flight-hour. The labor efficiency immediately improved moving into the observed period, as man-hours per flight-hour dropped to a local minimum of 7.6 man-hours per flight-hour during the last month of the Maintenance phase.

Personnel resources increased throughout the Basic and Integrated phases, where the chart's maximum fill was observed at its mode of 97.7%. This occurred during the sixth month of the Integrated phase, where fit was 92.7% and was 5% less than fill. Labor efficiency was relatively stable during the Basic and Integrated phases and was pivoting between the chart's minimum of 6.8 and 14 man-hours per flight-hour. The maximum fit was observed in the last month of observation, which was the third month of the Deployment phase. The fit was 93.7%, and labor efficiency was returning to a better performance of approximately 10 man-hours per flight-hour.

The overall trends of Squadron B as it progressed through the OFRP included an increasing trend for fit and fill and a steady labor efficiency that resulted in a median labor efficiency of approximately 13 man-hours per flight-hour. After commencing deployment, the labor efficiency decreased sharply before it improved sharply through the end of the observed period.




Source: CNAF (personal communication, 2019).

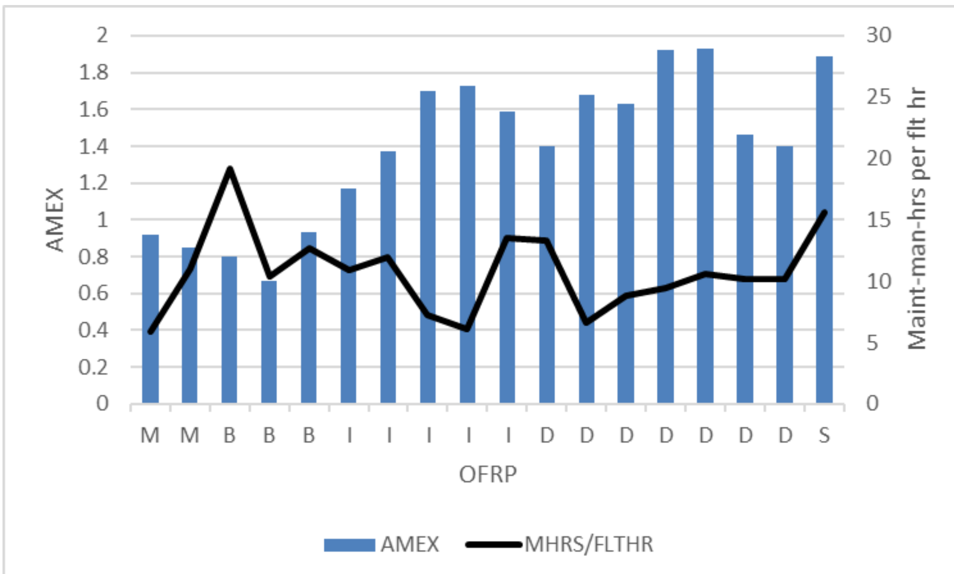
Figure 20. Squadron B Fit-Fill and MHRS/FLTHR over OFRP

### 2. The AMEX Data

Figures 21 and 22 are depictions of the AMEX scores in columns with labor efficiency depicted in MHRS/FLTHR depicted as a line across the observed period. The horizontal axis is represented by the same convention used in the previous section that illustrates a month of time and the appropriate OFRP phase.

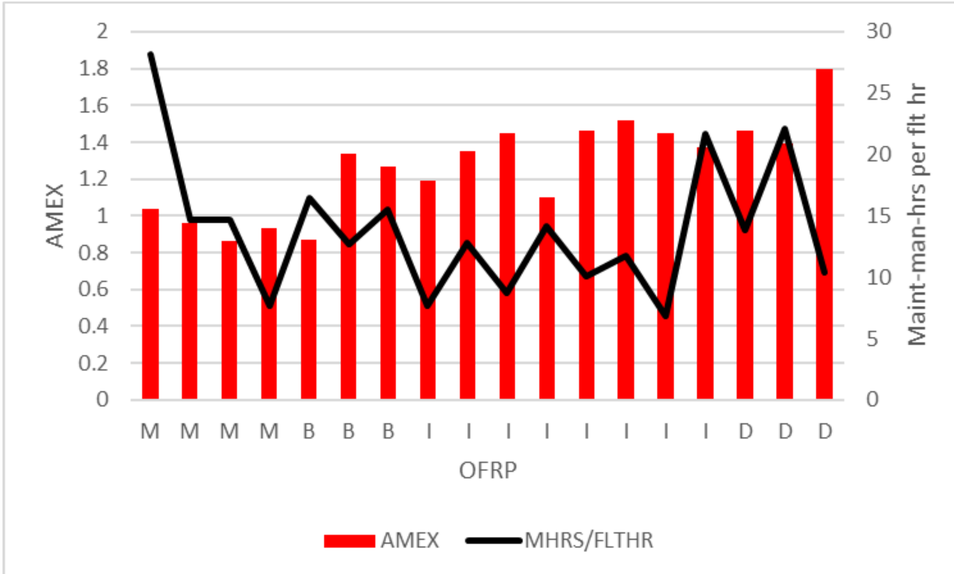
Squadron A in Figure 21 showed some support for the hypothesis: as AMEX increased, maintenance efficiency increased. There are two modes seen in the distributions. The first mode was a spike in maintenance production efficiency during the Maintenance and Basic phases, where AMEX scores were lower. The second mode appeared where AMEX increased and production efficiency increased in the Integrated and Deployment phases; however, upon closer inspection, production efficiency was slowly decreasing during deployment months two through five despite an increase in AMEX scores.

Squadron B in Figure 22 lacked the definitive modes seen in Figure 21. The AMEX score for Squadron B remained relatively constant from the second month of the Basic phase through the second month of the Deployment phase. The production efficiency line was also devoid of any large deviations, as seen in Figure 21. There were peaks in MHRS/FLTHR that corresponded with AMEX dips; however, the magnitude of the change in MHRS/FLTHR was better explained by considering Figure 25 and noting the large decreases in flight-hours that correspond to production efficiency lows.




Source: CNAF (personal communication, 2019).

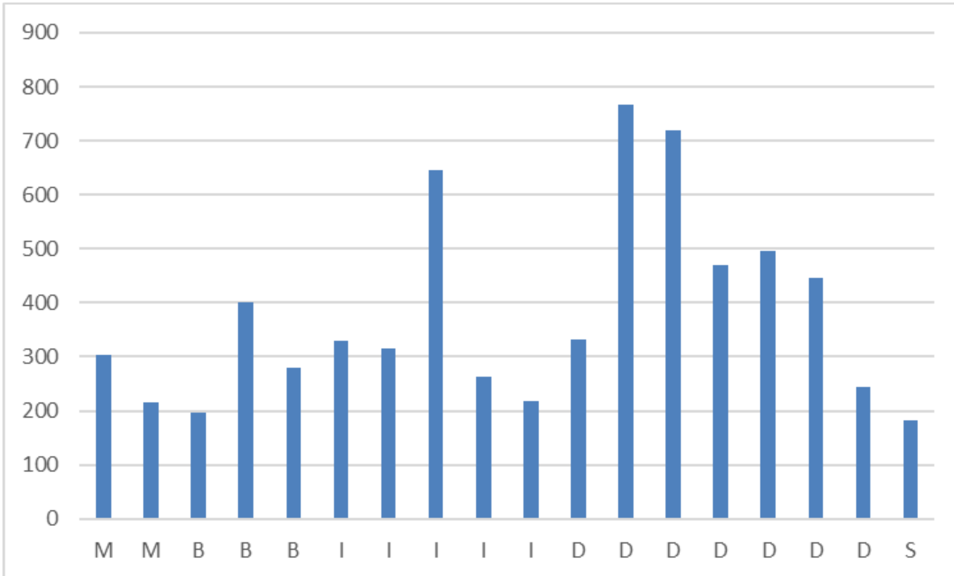
Figure 21. Squadron A AMEX and MHRS/FLTHR over OFRP




Source: CNAF (personal communication, 2019).

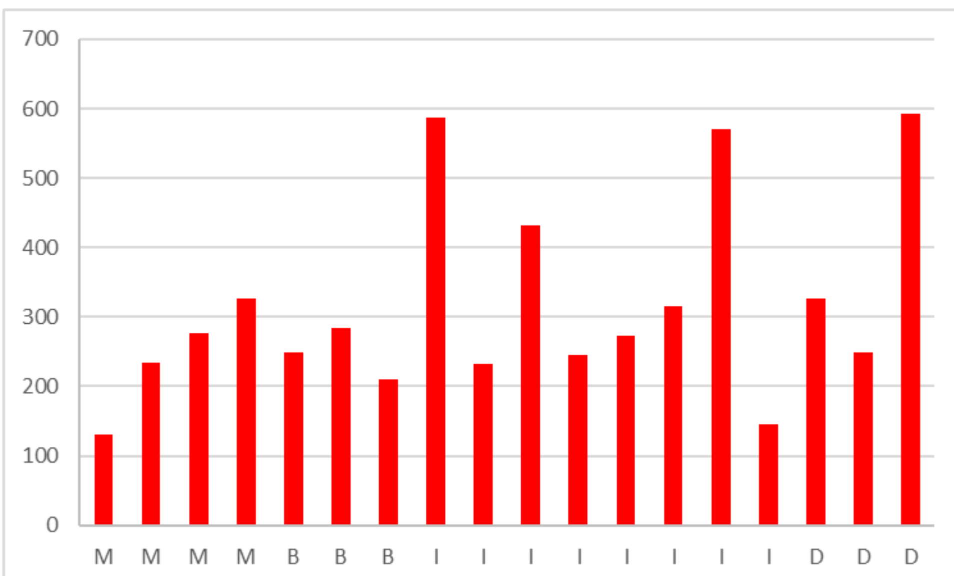
Figure 22. Squadron B AMEX and MHRS/FLTHR over OFRP

In Figure 23 and Figure 24, the number of flight-hours achieved in a month are shown in each squadron's respective OFRP month. When Figures 21 and 22 are compared to Figures 23 and 24, the changes in MHRS/FLTHRS show a strong correlation to changes in flight-hours and behave with an inverse relationship. This may imply causality, but was not tested for it. The peaks in MHRS/FLTHR occur in months of low flight-hour execution. The valleys for MHRS/FLTHR occur during periods of high flight-hour execution. This trend is apparent in both squadrons and provides a much stronger correlation than AMEX scores and MHRS/FTLHR.




Source: CNAF (personal communication, 2019).

Figure 23. Squadron A Flight-Hours by Month

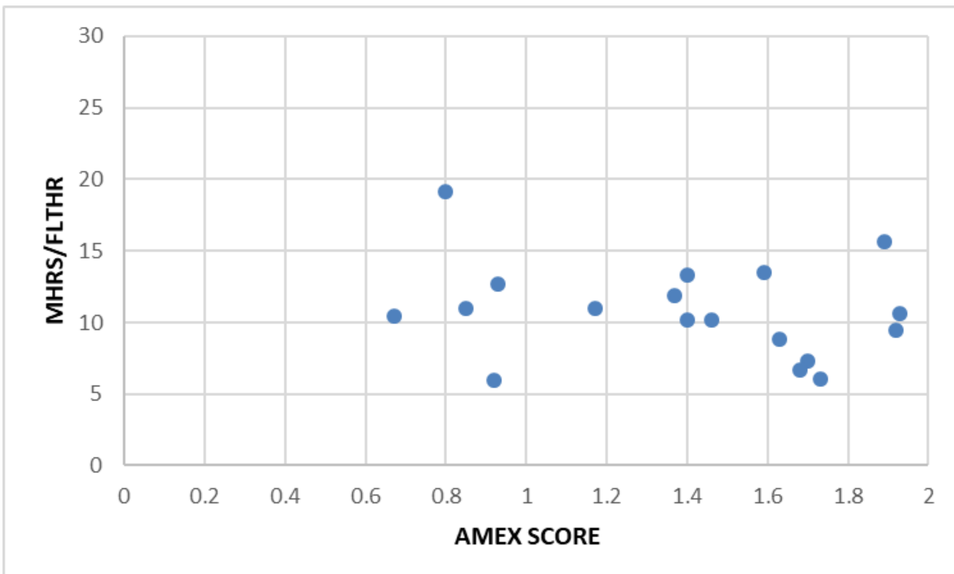



Source: CNAF (personal communication, 2019).

Figure 24. Squadron B Flight-Hours by Month

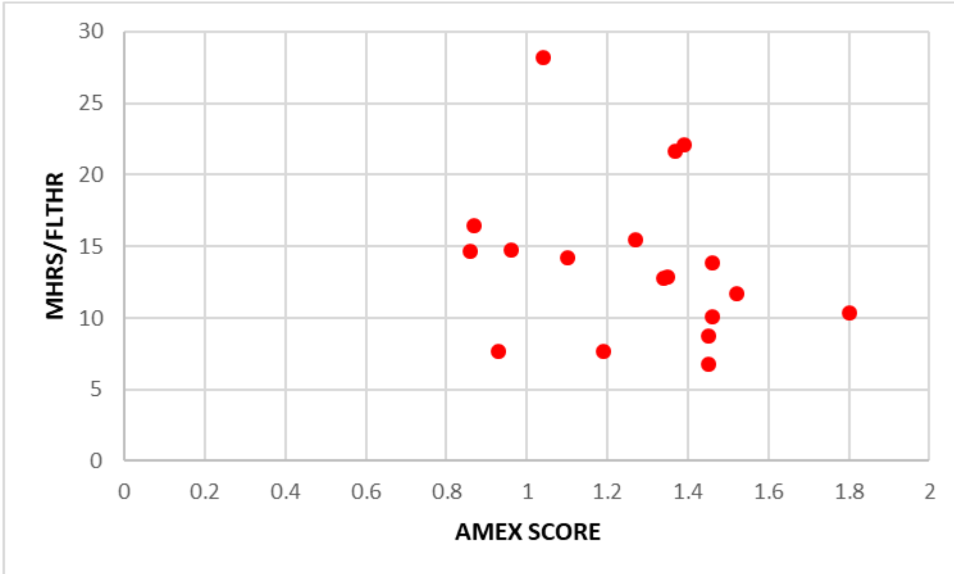
The scatter plots in Figures 25 and 26 show a larger concentration of high production efficiency (five to 10 MHRS/FLTHR) above 1.4 AMEX Score. In the case of Squadron A, AMEX values between 0.8 and 1.4 are concentrated around 11–12 MHRS/FLTHR.

Squadron B AMEX values between 0.8 and 1.4 leaned closer to 14–15 MHRS/FLTHR. Both figures contained data points far to the right of their mean MHRS/FLTHR. These can be categorized within Maintenance phase activities where jets are “built up” as their RBA begins to increase for Basic phase. The monthly instances of low AMEX and high production efficiency were more difficult to explain and required consideration of effects displayed throughout Figures 23 and 24. As the total executed monthly flight-hours diminished to or below 200 flight-hours per month, production efficiency decreased.




Source: CNAF (personal communication, 2019).

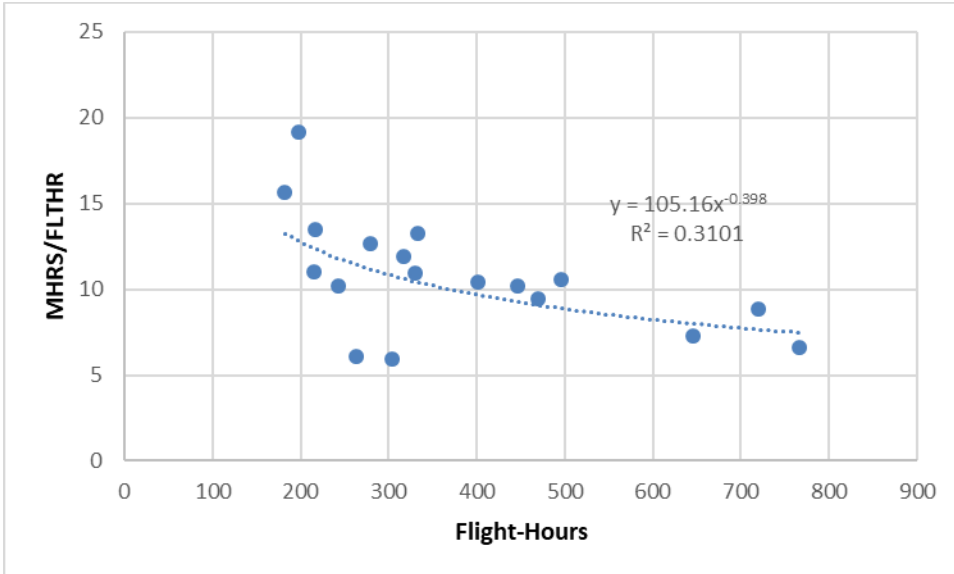
Figure 25. Squadron A Production Efficiency as a Function of AMEX.




Source: CNAF (personal communication, 2019).

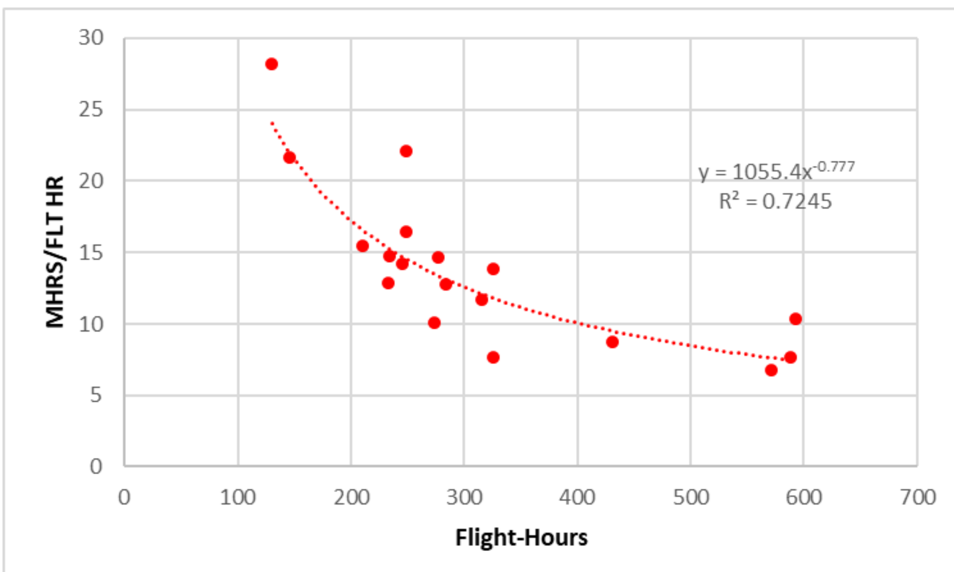
Figure 26. Squadron B Production Efficiency as a Function of AMEX

Figures 27 and 28 depict the production efficiency (MHRS/FLTHR) on the y-axis versus flight-hours on the x-axis. A power function was used to model the best-fit line, which showed Squadron B was significantly better than Squadron A and attained a higher quality regression with an R-square value of 0.7245. Both squadrons showed a general decreasing trend of production efficiency as flight-hours per month increased, note that Squadron A's maximum flight-hours per month were nearly 200 hours greater than Squadron B's, which is one explanation for the difference in the $R^2$ values (0.3101 vs 0.7245).




Source: CNAF (personal communication, 2019).

Figure 27. Squadron A Production Efficiency as a Function of Flight-Hours




Source: CNAF (personal communication, 2019).

Figure 28. Squadron B Production Efficiency as a Function of Flight-Hours

### 3. Optimized Fleet Response Plan Aggregated Data by Phase

The data from each phase was combined and averaged to provide an easy-to-digest snapshot of individual squadron characteristics and performance throughout each phase of the

OFRP. This section helps the reader discern some effects from the different levels of resourcing that occur between each phase of the OFRP.

### *a. Basic Phase*

Squadron A had an average AMEX score of 0.8 (80% of the deployment point threshold of 732 AMEX points) during the Basic phase of OFRP. Its average fit-fill was 86.7% fit and 95% fill. Its maintenance production efficiency was 14.07 over an average of 292.4 flight-hours.

Squadron B had an average AMEX score of 1.16 (116% of the deployment point threshold of 732 AMEX points) during the Basic phase of OFRP. Its average fit-fill was 89.8% fit and 90.4% fill. Its maintenance production efficiency was 14.89 over an average of 247.6 flight-hours.

Squadron A had a considerably lower AMEX than Squadron B did during the Basic phase of their respective OFRPs, indicating that Squadron B had much more experience and qualification. AMEX is first used as a decision and distribution tool by NAE manpower managers during the Basic phase, and a comparison of Squadron A to B shows that A was resourced to 97% of B's fit and 105% of B's fill. AMEX-based personnel resourcing may not yet have had any effects on Squadron A. This further enforces that Squadron B was more qualified. Lastly, the production efficiency of A was slightly better than B, but A also had a greater reducing effect due to conducting 45 more flight-hours than B. In this comparison, production efficiency isn't discernably better within either squadron.

### *b. Integrated Phase*

Squadron A had an average AMEX score of 1.51 (151% of the deployment point threshold of 732 AMEX points) during the Integrated phase of OFRP. Its average fit-fill was 92.7% fit, and 101.2% fill. Its maintenance production efficiency was 9.94 over an average of 354.52 flight-hours.

Squadron B had an average AMEX score of 1.36 (136% of the deployment point threshold of 732 AMEX points) during the Integrated phase of OFRP. Its average fit-fill was

90.8% fit and 94.4% fill. Its maintenance production efficiency was 11.72 over an average of 350.39 flight-hours.

Moving into the Integrated phase, Squadron A gained an average of 6.2% fill and 6% fit alignment for its personnel resources. Additionally, A experienced a boost in AMEX of 0.71, which took it beyond the deployment readiness threshold of 1.0. Squadron B only slightly improved from its Basic phase measurements and improved personnel fit by 1% and fill by 4%. AMEX for Squadron B increased by 0.2, indicating that it likely trained its existing personnel to gain qualification points. A better comparison of production efficiencies can be made between the two squadrons during the Integrated phase because they executed similar flight-hour totals. Squadron A was 1.78 hours more efficient than Squadron B.

#### *c. Deployment Phase*

Squadron A had an average AMEX score of 1.63 (163% of the deployment point threshold of 732 AMEX points) during the Deployment phase of OFRP. Its average fit-fill was 91.9% fit and 97.9% fill. Its maintenance production efficiency was 9.88 over an average of 496.43 flight-hours.

Squadron B had an average AMEX score of 1.55 (155% of the deployment point threshold of 732 AMEX points) during the Deployment phase of OFRP. Its average fit-fill was 92.4% fit and 95.2% fill. Its maintenance production efficiency was 15.45 over an average of 389.23 flight-hours.

Both squadrons had comparable AMEX scores while on deployment and were within 5% of each other. Additionally, both were very similar in personnel fit and fill measurements. However, Squadron A was observed for seven months during the Deployment phase, while Squadron B was only observed for three. This caused the average flight-hours executed by Squadron B to be calculated from incomplete data because it hadn't completed the phase. Furthermore, the production efficiency dropped significantly, resulting in 15.45 MHRS/FLTHR as a result of reduced flight-hour execution. The comparison between Squadrons A and B during the Deployment phase should not be made due to limitations in data completeness. At the completion of Squadron B's Deployment phase, it is expected that its production efficiency and average flight-hour execution would be similar to Squadron A's and could be compared at a later date.

#### *d. Sustainment Phase*

Squadron A had an AMEX score of 1.89 (189% of the deployment point threshold of 732 AMEX points) during the Basic phase of OFRP. Its average fit-fill was 93.9% fit and 98.1% fill. Their maintenance man-hour per flight-hour was 15.63 over 181.9 flight-hours.

Squadron B was still on deployment and has no sustainment data for comparison. Squadron A showed signs of personnel growth from the Deployment phase in two of the three personnel measurements. AMEX grew by 0.26, and personnel fit grew by 2%. Personnel fill stayed nearly the same, growing by only 0.02%. The AMEX and personnel fit show that Squadron A trained its maintenance labor force while on deployment, resulting in higher AMEX and personnel alignment values.

### 4. Conclusion

The overall trends and distribution characteristics produced by the two squadrons described a clear relationship between personnel resources gained or lost throughout the OFRP. As personnel were sourced to each squadron, the fit and fill metrics increased until the Deployment phase. Squadron A was the only squadron that contained data for the Sustainment phase, but a reduction in AMEX and personnel fit and fill was observed. On average, production efficiency behaved as expected and increased with higher AMEX and fit scores. Also, production efficiency marginally decreased when AMEX and fit scores decreased.

The execution of operational tasking in the form of flight-hours was a major driver in the shape of the production efficiency curve. During months within the OFRP where flying was high, production efficiency increased as a direct result. The inverse was true during months where flying was low. The significance of the influence that flight-hour execution had on production efficiency was greater than expected, and a lack of observable data for Squadron B handicapped the comparison with Squadron A during their Deployment and Sustainment phases. However, during the Integrated phase, flight-hours were similar, and a comparison was made that showed a small advantage favoring Squadron A.

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# IV. FINDINGS AND SENSITIVITY ANALYSIS

The goal of this chapter is to summarize the analysis into quantitative and qualitative results while adding perspective, experience, and real-world factors to the observed data. The flow of discussion begins with general findings, then progresses into more specific details attempting to provoke thoughts and further analysis relatable to the research questions.

## A. FINDINGS

Marginal productivity was an indirect focus of the research that was designed to support the hypothesis that an increased experience pool of specifically qualified aviation maintainers would yield higher production efficiency. The observed data measured by using man-hours per flight-hour did not support a strong correlation in most presentations, but the comparison during the Integrated phase could lead to a general conclusion. During the Integrated phase, Squadron A recorded a productivity benefit of 1.78 MHRS/FLTHR, which it did while maintaining an AMEX score 10 points higher than Squadron B. This results in an average marginal benefit equal to 10 fewer minutes of required maintenance productivity for every AMEX point over 955 total squadron points.

Flight-hour execution was nearly the same, with Squadron A executing only four hours and eight minutes more flight time than Squadron B. Furthermore, referencing Figures 27 and 28, Squadron A exhibited a higher production efficiency than Squadron B within the observed region of executed flight-hours. Predictably, Squadron A can be found crossing a production efficiency equal to 10 MHRS/FLTHR at approximately 350 flight-hours executed, while Squadron B is at approximately 12 MHRS/FLTHR. Lastly, the highest concentration of observations occurred at approximately 300 flight-hours executed. This appears to be the best measure of central tendency for the comparison of the observed data. If the sample data can be accepted as a representation of a population, it should be modeled at this interval.

Aside from the Integrated phase, production efficiency appeared very irregular with respect to AMEX scores and NEC-based metrics. Figures 25 and 26 display a scatter plot with minimums and maximums for AMEX and production efficiency that appear to have no correlative pattern for either Squadron A or Squadron B. This is assumed to be due to the large influence that aircraft availability and job task trade-offs have while a squadron is flying more heavily. Simply, the aircraft are not as available, and neither are the maintainers when flight operations are more intense.

A supporting research question was designed to explore interrelationships between NEC-based fit-fill percentages and AMEX scores. Also, there was an expectation that a higher AMEX would discernably show a better production efficiency than a squadron resourced solely from NEC-based fit and fill. While AMEX uses NEC metrics as a foundation for scoring, it was unclear whether AMEX forecasted a higher production efficiency than NEC-based detailing. Without question, AMEX-based decision-making is a useful tool for resourcing critical and essential qualifications to squadrons, but no consistent observations were found that displayed AMEX was superior to NEC-based detailing for most maintenance personnel. This indicated that the quantity of labor resourced to either observed squadron was sufficiently below the region of negative marginal productivity returns.

There are many organizational variables that affect the productivity of the maintenance departments throughout Naval Aviation. The use of maintenance-man-hours per flight-hour was one example of measuring output from the aviation support system. The strength of the relationship between this unit of measure to the underlying activities' mission objectives provided both strengths and weaknesses. Some strengths included the direct relationship with mission tasking to its support, the relationship between flight-hours and the requirements generation process within NALDA, and the normalizing qualities that flight-hours have across the many different resourcing phases of the OFRP. Weaknesses included the large influence that flight-hours have on production of stable data, a strong reaction to changes in resourcing levels throughout the OFRP, and minor differences in OPTEMPO between the measured squadrons. The resultant finding was that the use of MHRS/FLTHR was not consistently satisfactory for construction of a defensible conclusion. Naval Aviation should engineer a feedback signal that can provide a better measurement of the value added to a squadron as a measure of personnel and aggregate maintenance output.

Lastly, it is important to recognize that there are many other dependent variables that act as factors that shroud the data that may negate these conclusions. Some examples that are common operational practices include logging job completion times that are based on the recommendation and not the reality, non-accounting or dual-accounting for time spent training, and command-specific tasking that shares manpower with another squadron. Each of these examples creates a loss of fidelity within the time recorded for job tasks and is not indicative of the actual time required to complete that action. For these reasons, the underlying data should be questioned. Fundamental differences are cultural within commands, and they dictate how maintenance departments log maintenance actions.

## B. SENSITIVITY ANALYSIS

The greatest observed area for sensitivity analysis was flight-hour execution. Flight-hour execution is a direct reflection of the tasking each squadron was required to fulfill. The Maintenance phase represents the lowest level of flight-hour execution during OFRP. The primary purpose of the Maintenance phase is obvious, given the title and the fact that resourcing for flights is historically low, just enough to maintain basic flying proficiency for squadron aircrew. Low flight-hours and a focus on in-depth maintenance actions typically drive the MHRS/FLTHR figures substantially above other phases of OFRP. There are anomalies that occur due to non-flying tasking, such as sending personnel to support weapon school detachments, providing support for Rhino Recovery teams, specialty schools, etc., that may leave a squadron with a single shift of maintenance. These times lead to especially low maintenance output (MHRS/FLTHR), as their capacity dictates focusing on normal flight ops, typically with a well-groomed aircraft.

During the Basic and Integrated phases of OFRP, each squadron is tasked with readying aircraft and personnel for deployment. This is accomplished through several major exercises, at-sea periods, and meticulous maintenance planning and execution. As each squadron progresses through this portion of OFRP (often referred to as workups), flight-hour execution increases. Flight-hour funding increases, fuel budgets increase, squadron priority level for critical parts increases, and RBA increases as workups crescendo, which enables increased flight-hour execution. The frequency and duration of flights was found to be an important influence on maintenance man-hours per flight-hour.

The more the airplanes fly, the lower the maintenance man-hour per flight-hour figure becomes. The explanation for this is two-fold. First, maintenance actions cannot be completed while the aircraft is airborne. During periods of intense flight operations, conditional inspections and non-downing corrective maintenance are planned in a way to minimally impact operational aircraft availability. Second, and less intuitive, the more an airplane sits, the more it breaks. Groomed airplanes require less maintenance; therefore, the more airplanes fly, the better they perform.

Deployment and Sustainment phases follow similar patterns. When tasking is high for aircraft, as seen through high flight-hour execution, the measured maintenance output is lower. During periods of low tasking, deferred or preventive maintenance actions are performed, and the measured output increases.

The availability of high-quality manpower is and will continue to primarily be a function of national economic conditions. Economic fluctuations have a profound effect on recruitment, retention, and the quality of the pools of manpower available in an all-volunteer military. Lucrative opportunities in the private business sector significantly draw down the talent pool for recruitment, as the labor market competes with higher wages, desirable locations, stability, etc., during conditions of economic prosperity. Conversely, talent availability during times of economic downturn, high unemployment rates, and other less-than-favorable economic conditions have a boosting effect on manpower quality in the military. There is one additional condition affecting manpower quality that is independent of the economy: patriotism. This was prevalent in the aftermath of 9/11 as Americans answered the call to arms in droves and provided an enduring boost to manpower quality throughout the 2000s prior to the Great Recession of 2009.

Another valuable area for sensitivity analysis is Temporary Assigned Duty (TAD) requirements and contingency planning. TAD personnel are required from each squadron during periods of embarkation for critical quality-of-life and habitability services, as well as to form specialized teams within the ship–air wing team to provide critical warfighting services. These services include cranking mess (cooking and serving food, busing tables, and cleaning dishes), providing laundry services, providing janitorial services, forming armament building teams, or forming teams tasked with cleaning the flight deck and removing foreign object debris (FOD), which causes expensive (sometimes catastrophic) damage to aircraft operating aboard the aircraft carrier. The sailors pulled from each squadron for 90 days of TAD onboard the aircraft carrier are generally junior enlisted sailors who lack substantial qualifications or, in many cases, are non-rated personnel. A focus on decreasing manpower within a squadron by increasing qualifications and quality of manpower within a squadron will require a new solution for TAD requirements.

This AMEX-driven focus on improved qualifications and manpower quality, while beneficial to the NAE, would come at a cost. These benefits would come with a reduction in flexibility to Navy detailers and sailors in terms of duty stations or job-fill requirements if AMEX was adopted and prioritized over NEC-based detailing. For example, a sailor selected for service as an AT and detailed to the VAQ community would be restricted to NAS Whidbey Island, WA, or MCAS Iwakuni, Japan, for sea-duty billets. While this can be a positive attribute for the sailor looking to homestead in an area, there are obvious drawbacks for a detailer in Millington, TN, who needs to provide another squadron outside of the VAQ community with that sailor's NEC. Shortfalls in manning from one community to the next would be difficult to fill with existing manpower if detailers were cuffed to AMEX criteria to fill billets.

The final piece of sensitivity analysis involves contingency planning. Preparations for contingencies include maintaining a sufficient amount of personnel to fight the ship in combat conditions, support around-the-clock operations if required, and absorb losses without sacrificing combat power should a catastrophic event such as a crash or fire occur. In short, any reduction in manning will have an adverse effect on contingency planning for operations onboard an aircraft carrier, and the risks will require heavy analysis and weighting by the proper authorities to determine if the objectives can still be met.

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# V. CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes and reviews the selected data and research used to identify potential manpower efficiencies to be gained through higher quality manpower. First, the primary and secondary research questions are answered in the Results section, along with a brief narrative on how the answers were derived. Next, the conclusions drawn and recommendations formed are discussed in Chapter V, section C. Finally, areas that were outside of the scope of this capstone project areas, but warrant further discussion and research, are highlighted in section D.

## A. CONCLUSIONS

### 1. Primary Research Question

The primary research question asked, “If manpower quality and aviation maintenance experience (AMEX) are increased in a squadron, can manning requirements be eased for the air wing of the future?” The initial hypothesis stated the notion that more experienced and highly trained sailors should perform less maintenance man-hours per flight-hour than squadrons with lower AMEX scores (less qualifications in T/M/S). The foundation was rooted in the belief that sailors with a higher level of practical experience and training in a specific aviation platform would be able to perform maintenance actions faster, troubleshoot more efficiently, and spend less time repairing and returning aircraft to service. Some reliable data collected between October 2017 and June 2019 support the hypothesis. There are measurable benefits in terms of reduced output in maintenance man-hours per flight-hour as demonstrated through the AMEX point system. While the incentives of higher AMEX point values in this research were marginal, through the research and analysis of other available data, greater benefits may be discovered through closer scrutiny.

### 2. Secondary Research Questions

The first secondary research question asked, “Do squadrons with greater fit-fill values perform less maintenance (in measurable form, such as maintenance man-hours per flight-hour) than squadrons with lower fit-fill values under a given set of assumptions?”

The purpose of this question was to identify trends between maintenance man-hours per flight-hour and how well a squadron is manned in terms of numbers and NECs required. As previously stated in the findings section of this paper, total productivity increased as NEC-based fit and fill percentages increased. However, due to the large influence that flight-hour execution had on production efficiency, there were no strong correlations that could be made other than establishing that Naval Aviation resourced personnel according to the front of the labor productivity curve. This was concluded because as squadrons progressed through the OFRP with higher resource levels, greater productivity occurred.

The remaining secondary research question sought to answer, "Do squadrons with greater aviation maintenance experience in type, model, or series of aircraft perform less maintenance (in a measurable form, such as maintenance man-hours per flight-hour) than squadrons with a more diverse background under a given set of assumptions?" The purpose of this question was to identify and quantify the benefits of a squadron composed of sailors who were trained, qualified, and familiar with a T/M/S of aircraft over NEC-based detailing. No conclusion for this research question was found. Two squadrons were analyzed with similar periods of observation, resource levels, and T/M/S. Due to this situation, they were resourced personnel by NAE manpower managers based on NEC-based fit and fill and AMEX decisions. The decision-making process was the same for each squadron and resulted in very similar talent management and qualification growth over the long-run.

## B. RECOMMENDATIONS

The research and analysis of data shows the value of a higher-quality workforce and the resulting reduction in MHRS/FLTHR required during various phases of OFRP. The analysis also reinforces the value of repetition and practice to drive down the time required to perform maintenance actions as an observed learning curve throughout workups. AMEX is a valuable tool for the NAE to identify the quality of the workforce in a given squadron. The investment made by individual squadrons within each community to turn unqualified airmen into technically competent, highly-trained professionals is immense, and maintaining that expertise within the community is vital to sustaining a ready force.

At this time, the results of the research do not supersede the implications of the sensitivity analysis to reduce manpower purely based on quality as defined by AMEX. Further research is required to determine the extent of the implications on other fundamentally important facets of shipboard life as well as derive a better sense of the true costs and benefits of a higher-quality workforce. The marginal reduction in MHRS/FLTHR does support a recommendation to continue investing in training systems to be used at the squadron level to increase T/M/S familiarity and qualifications (similar to simulator ops for aircrew) for maintenance personnel. The development of a cloud-based artificial intelligence (AI) and augmented reality (AR) solution compatible with IETMS is strongly recommended, would yield significant impact, and should be fielded as soon as possible.

## C. FURTHER RESEARCH

The genesis of this capstone project was to find areas where manpower savings could be realized provided the sensitivity analysis does not preclude those savings' inclusion into future policy. The findings from the analysis of the data did support the hypothesis and therefore potential gains through training; however, limitations of the data provided were also discovered. A common practice among maintenance departments is to log the time to complete maintenance actions based on previously established standards and not the actual time required to complete those actions. For example, if the IETMS states that a particular maintenance action requires 1.5 man-hours to accomplish the job, it is logged as action complete with a time of 1.5 hours. This may not be indicative of the actual time required to complete that action but is more a function of how maintenance departments log maintenance actions. This practice is deeply rooted in past experiences where successful maintenance teams and their perceived excess capacity to do maintenance were "robbed" to prop up squadrons who were not as successful in completing maintenance. The end result is logging maintenance activities according to what the job estimates, not the actual time required, to smooth the results and not be highlighted for loss of valuable, low density, high demand sailors.

A future study should aim to capture more specific data points that may illuminate shortfalls in training and experience such as the prevalence of "repeat" and "could not duplicate on deck" maintenance action forms (MAF). While it would not be prudent to signal every one of these MAFs as a sign of inexperience or low-quality personnel, the presence of large numbers of "repeat" or "could not duplicate on deck" MAFs may indicate a lack of experience or gap in training when linked to other metrics such as AMEX or unscheduled maintenance hours. Identifying inexperience through this method will provide more granular data to analyze and advise future funding and training. The results of this particular research could have a significant impact on training, training systems, and personnel distribution.

This paper focused on training; however, there are still other portions of the DOTMLPF-P spectrum from which further analysis and smart application may have added value for the U.S. Navy. The future of Naval Aviation will undoubtedly shift from manned to unmanned assets. Specialization will be required to dominate the battlespace in a high-end fight. Doctrinally, the U.S. Navy and NAE must have a solid transition plan in place to shift doctrinal mindsets from a "jack-of-all-trades, master of none" mentality to one of specialization. Additionally, the acceptance of unmanned technology as an opportunity to increase capability and lethality while maintaining a man-in-the-loop from afar must also occur to assert U.S. dominance in a near-peer fight. Unmanned aviation assets will require fewer personnel. There are no life-support systems, oxygen transport or generation requirements, crew comfort considerations, ejection seats, or pressurization requirements, which simplifies design and maintenance on aircraft. Artificial intelligence and machine learning are making great strides in development. There are UCAS "wingmen" on the proverbial drawing board, and when the technology meshes with tactics, techniques, and procedures (TTP), they will be a force multiplier along with the remaining manned air assets such as EA-18G, E-2D, and F-35C.

Another doctrinal change that warrants further investigation is distributing the firepower of the air wing among several vessels instead of a single capital ship. For example, removing most of the HSC and HSM helicopters from the aircraft carrier can increase the utility of those platforms by placing them in better positions in the battlespace to affect the fight. There is no need to "lily pad" an MH-60R to a position 300+ nautical miles from the aircraft carrier to search for submarines carrying long-range anti-ship missiles if it is already positioned there. The second order effect of such a move is reduced footprint on an overcrowded aircraft carrier.

A change in doctrine will necessitate a redesign of the carrier strike group. Additional destroyers, frigates, or other fighting ships will need to be incorporated into the strike group architecture to achieve proper force distribution. Large deck amphibious ships such as Landing Helicopter Dock ships (LHD) and Landing Helicopter Assault (LHA) ships could conceivably be repurposed as light aircraft carriers (CVL) and used as screens for CVNs, providing additional and displaced striking power or protection to the carrier strike group (CSG). The air wing complement of the newly repurposed assault ships could be composed of MH-60Rs, F-35Bs, CMV-22Bs, and the future's stealthy short take-off/ vertical landing-capable un-manned combat aerial vehicles with strike, ISR, and electronic attack capabilities. The true value of recapitalizing these ships and restructuring the CSG can only be realized through further research.

One of the major hurdles to reducing manpower required for the AWOTF will be organizational. Reorganization of aviation squadrons and maintenance personnel to capitalize on airframe commonalities and reduce manning is required to maximize the advantages offered by the AWOTF. A potential reorganization opportunity exists by consolidating maintenance efforts for common platforms at the CAG level for deployments. Squadrons will retain their complement of sailors throughout the Maintenance phase and Basic phase. The future Integration phase would then fuse the maintenance teams for F/A-18E/F/G and MH-60R/S together during Air Wing Fallon. These teams will remain constituted through Integrated and the Deployment phase. When the air wing enters the Sustainment phase, the sailors return to their home commands.

The NAE will be reluctant to give up command opportunities, size of commands, and mission. However, the AWOTF should not have the same personnel makeup as today's CVW. For example, ready rooms for unmanned squadrons will be much smaller than their current levels. Another opportunity to reduce manning is aviation maintenance. The FA-18E/F/G share an 85% commonality, yet there are still five separate maintenance departments in today's CVW (one for each squadron). The NAE is not maximizing the value of these common airframes because the institutional organization does not provide for it. Naval aviators and naval flight officers in command and leadership positions will push back on reducing command opportunities and sizes as well as reducing manned aviation assets on the front line in favor of UCAVs. This will be a hinderance to progress.

The organization of the AWOTF needs to be deliberate, with careful thought applied to maximizing capability, opportunities in manpower savings, and lethality. One large second-order effect is the effect of lost or diminished command opportunities. This will force the Navy to rethink how it is going to produce captains, admirals, aircraft carrier commanding officers, and other officers to fill strategic leadership positions and force an earlier identification of potential strategic leaders. Regardless, consolidating maintenance efforts where commonality exists is a viable area for further research.

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