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MONTEREY, CALIFORNIA

THESIS

**AN EXPLORATORY ANALYSIS OF INTERMEDIATE
MAINTENANCE ACTIVITY BEYOND CAPABILITY OF
MAINTENANCE TRANSACTIONS: DO END OF FISCAL
YEAR BEHAVIORS IMPACT COST?**

by

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ACTIVITY BEYOND CAPABILITY OF MAINTENANCE TRANSACTIONS:
DO END OF FISCAL YEAR BEHAVIORS IMPACT COST?**

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ABSTRACT

There is a widely accepted notion that fiscal spending increases at the end of the fiscal year across different government levels. This phenomenon, particularly across the military services, is driven by the notion that follow-on-year authorizations will be decremented because these funds were not obligated to a 99.8% level of execution. There is anecdotal evidence of increased spend rates in the fourth quarter of the fiscal year. This study analyzes cost-driving trends across intermediate maintenance activities in support of Marine Corps aircraft squadrons to identify the year-end spend behavior. This study identifies end-of-year spending trends within a Marine Aviation Logistics Squadron (MALS). It proceeds with an exploratory analysis of the impact of spending patterns at the end of the fiscal year. The researcher focuses on beyond capability of maintenance (BCM) trends on the CH-53E aircraft to determine how end-of-year spending, maintenance practices, operational drivers, and financial constraints may impact stock position at the MALS. The researcher proceeds to examine the impact of priority levels on end-of-year spending. Additionally, data analyzed in this research cover a period of five years to identify trends as they pertain to the time elapsed while components await parts and the maintenance actions before the parts are processed as BCM.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFAST	Aviation Financial Analysis Support Tool
AFM	aviation fleet maintenance
AMO	aircraft maintenance officer
AMSRR	Aviation Maintenance/Supply Readiness Reporting
ASO	aviation supply officer
AVDLR	aviation depot level repairables
BCM	beyond capability of maintenance
BER	beyond economic repair
DECKPLATE	Decision Knowledge Programming for Logistics Analysis and Technical Evaluation
EOFY	end of fiscal year
FMC	full mission capable
ICRL	individual component repair list
ILS	integrated logistics support
IMA	intermediate maintenance activity
JCN	job control number
MAF	maintenance action form
MAG	Marine Aircraft Group
MALS	Marine Aviation Logistics Squadron
MCAS	Marine Corps Air Station
MCN	MAF control number
NAE	Naval Aviation Enterprise
NALCOMIS	Naval Aviation Logistics Command Management Information System
N-ERP	Navy-Enterprise Resource Planning
NIIN	national item identification number
NMCM	non-mission capable, maintenance
NMCS	non-mission capable supply
NRBA	non-ready basic aircraft
OMA	organizational maintenance activity

P/N	part number
PMCS/M	partial mission capable, supply/maintenance
RBA	ready basic aircraft
RFI	ready for issue
T/M/S	type/model/series
T-WING	Type Wing Tool

EXECUTIVE SUMMARY

This research examines year-end spending behaviors as they relate to Aviation Depot Level Repairables that are processed as beyond capability of maintenance (BCM). The researcher investigates on the notion that there is increased spending at the end of the fiscal year and explores to what extent end-of-year increased spending behaviors are observed in support of aviation operations. The aim of this study is to identify if increased spending exists, as determined by a series of tests for statistical significance. The researcher analyzes CH-53E transaction-level data across 5 fiscal years. This study explores spending patterns, the impact of priority levels, and project codes on BCM actions. Additionally, the researcher explores how the number of days awaiting maintenance at the Intermediate Maintenance Activity (IMA) deviates from the norm toward the end of the fiscal year.

The researcher initiates the analysis by compiling data from the Aviation Financial Analysis Support Tool (AFAST). Upon reviewing the data, the researcher develops an analytical approach that consists of a series of two-sample t-tests in order to test for a difference in means between the periods being analyzed. End-of-year periods of interest, for purposes of this study, are focused around the last 15 days of the fiscal year. The researcher's interest lies in identifying whether there are any significant changes in spending behavior as the fiscal year comes to an end. This expectation is supported by varied sources of literature as discussed in the Literature Review chapter of this study.

Given the large amount of data being analyzed, once processed and normalized utilizing Microsoft Excel, the data is imported into the R software environment for follow-on statistical analyses. The analysis progresses through four iterations. The first iteration conducts a series of t-tests for each fiscal year being analyzed, comparing the end-of-year period, heretofore referred to as the hockey stick period, to the rest of the fiscal year. The second iteration calculates the time elapsed awaiting maintenance for each component that is eventually processed as BCM. For the purposes of this study, this time difference is referred to by the researcher as the age of the component. The third iteration of the analysis explores the differences in priority levels and project codes of components that are eventually processed as BCM. The researcher intends to identify if there are any

differences of statistical significance between the hockey stick period and the non-hockey stick period across all fiscal years being analyzed. The final iteration of the analysis aims to identify the impact that end-of-year BCM processing has on timely replenishments. In this iteration, the researcher compares BCMs processed during the hockey stick period of one year and compares it to the non-hockey stick period of the following year.

The underlying assumption is that fund expiration at the end of the year may lead to a series of financial transactions processed to clear the backlog of parts in either the awaiting maintenance (AWM) or awaiting parts (AWP) status in the maintenance departments.

The results of the analysis indicate that there is no discernible difference in spending at the end of the fiscal year when compared to transactions that occur throughout the rest of the fiscal year.

Additionally, this study explores the differences in time elapsed between induction of a component to the IMA and eventual BCM action. The results of this study indicate that there is a statistically significant difference in the time a component that is processed as BCM (at the end of the fiscal year) spends at the IMA when compared to the components processed as BCM throughout the rest of the year. In particular, end-of-year BCMs show, on average, an increase in time elapsed in an awaiting maintenance status prior to BCM action.

Results show no discernible differences in BCM patterns as they pertain to priority levels or project codes in BCMs at the end of the fiscal year and when compared to the rest of the fiscal year across any of the fiscal years analyzed in this study.

Although there is no evidence that supports the theory that end-of-year spending increases when it pertains to aviation depot level repairables (AVDLR) expenditures, there is sufficient evidence found in this study to indicate that I-Level prioritization efforts are tied to the age of components. However, it is important to note that the study does not find that this behavior results in an increase in spending toward the end-of-year period. It is the researcher's opinion that no indication of increased spending is a result of active monitoring and good management of financial resources in support of aviation operations.

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I. INTRODUCTION

Like all enterprises, Naval Aviation must meet mission requirements within budget and resource allocations. Understanding cost drivers also has a direct relationship to the efficient generation of readiness. The Cost Management philosophy for Marine Aviation CR [current readiness] will include better decision support to eliminate waste and non-value added activity, improve supporting efforts and best practices, reduce variability in quality and methods between units, improve purchasing decisions for equipment end items, and bit/piece support, and incorporate best practices within, and across, Marine Aviation and the NAE [Naval Aviation Enterprise] . (U.S. Marine Corps, 2018, p. 3-15)

Year after year, military organizations across the Department of Defense (DOD) increase spending toward the end of the fiscal year. The generally accepted notion is that any excess funds that have yet to be obligated at the end of the fiscal year must become obligated by any means necessary. This institutional behavior may result from overly cautious spend patterns in the first three quarters of the fiscal year in anticipation of some unforeseen requirement. This leads to the redistribution of funds from one underspent organization to another that might execute the remaining funds as the fiscal year comes to a close. Spending with caution throughout the majority of the fiscal year may simply be financial posturing by managers in the event that a sizable, unidentified event or deficiency presents itself. This anticipatory conservatism in spending could easily lead to a fruitless effort and excess amounts of funds pending execution just prior to end of fiscal year (EOFY) closeouts. Inevitably, such overly conservative spending may lead to a secondary behavior that is the focus of this study: end of the fiscal year “use it or lose it” financial transaction processing. The researcher’s interest lies in understanding fiscal trends and how the aviation logistics community can best position itself to maximize the effect of its yearly spending. It is understood that, by and large, spending on Aviation Depot Level Repairables (AVDLR) is critically necessary to ultimately ensure continuity of flight line operations. However, the researcher believes there are areas in which the aviation logistics community can improve how it spends funds in support of the flight line. This chapter lays the foundation of this study and its organization.

As systemic supply and maintenance response issues continue to plague the CH-53E, which is the Marine Corps' heavy lift platform (Ericson, 2018, p. 1), the aviation logistics community actively participates in coordinated logistics response efforts across the fleet. This aircraft has increasingly and consistently been plagued with low readiness levels over the past 10 years. In 2014, the then– Deputy Commandant for Aviation (DCA), Lieutenant General Jon Davis, ordered an independent readiness review of all platforms in the Marine Corps' inventory (Naval Air Systems Command [NAVAIR], 2016). Following the results of the Super Stallion Readiness Review (U.S. Marine Corps, 2017, p. 17), the Marine Corps embarked on a 3-year reset effort focused on improving the heavily degraded material condition of the aircraft after years of operational deployments in support of Operations Iraqi Freedom and Enduring Freedom (NAVAIR, 2016).

The CH-53 reset initiative requires community-wide highlighted focus as well as attention from the CH-53E enterprise-wide working groups and Commander, Naval Air Forces (COMNAVAIRFOR)– sponsored “Cost War Rooms” to discuss expenditures in support of the initiative as one of its topics (U.S. Marine Corps, 2018b, p. 3-15). From the researcher's experience of attending Cost War Room working group discussions, these meetings assist the fleet in identifying trends found in high dollar value components that have been deemed to be beyond capability of maintenance (BCM) at an intermediate level of maintenance. One method by which the groups seek to assist is to challenge activities with cost spikes to justify their decision to BCM a component. While the focus is on cost avoidance, the benefit of working groups like these is to raise community-wide awareness on current and forecasted parts issues. Additionally, logistics support and cost avoidance working groups assist in consolidating all outstanding critical aircraft requirements across the fleet and provide visibility to stakeholders across the enterprise.

Via this medium, the CH-53E community has harnessed the power of integrated collaborative efforts by drawing upon the knowledge and experience of a collective pool of professionals (U.S. Marine Corps, 2018b, p. 3-15). However, the fact of the matter is that logistics actions and aircraft requirements drive the response to aviation operational requirements (U.S. Marine Corps, 2018a). Industry sometimes cannot readily respond to these requirements in the most time-expedient manner due to numerous issues, like

inventory planning, contracting, manufacturing, repair/rework, delivery, and levels of prioritization. These issues, combined with the difficulty in capturing appropriate demand signals, prove to be a challenge to supply planners who seek proactive posturing instead of the reactive approach, which is one of many causes currently impacting fleet-wide degraders (Ellis, 2019). These factors contribute to forced maintenance actions such as “cannibalization” actions by organizational level maintainers to meet mission requirements.

A. PURPOSE

This research aims to identify trends in components deemed BCM, focusing on behavioral patterns throughout the fiscal year. The end state of this research is to identify whether financial activities are occurring in an attempt to consume budget authorizations granted to the IMA in support of flying squadrons for purposes of meeting pre-determined end-of-fiscal-year obligation targets. This study intends to provide aviation logisticians insight into how some managerial practices may have negative financial impacts in the long run and provide recommendations on how to maximize spending to positively impact aviation operations toward the end of the fiscal year.

The researcher aims to identify spending trends consistent with the notion of excessive spending in the fourth quarter of the fiscal year. Increased spending in the fourth quarter of the fiscal year might indicate that there is insufficient spending throughout the rest of the year. Further, the purpose of this study is to conduct a series of analyses that aim to discount alternate actions or behaviors that may appear to be driving increased spend rates in the fourth quarter as opposed to the proposed notion of arbitrary execution of funds in end-of-year spending that is typically observed across the DOD and down to the individual unit level.

In a Marine Aircraft Group (MAG), the Marine Aviation Logistics Squadron (MALS) manages all aviation-related financial transactions in support of aviation operations. A significant portion of the budget is comprised of funds in support of AVDLR. These funds are typically consumed when a repairable component cannot be repaired at the Intermediate Maintenance Activity (IMA) and is subsequently processed as

a BCM. Repairable aircraft components, otherwise referred to as AVDLR, are Weapons Replaceable Assemblies (WRA) and Shop Replaceable Assemblies (SRA) that can be removed, repaired, and replaced when deemed inoperable. The successful repair and return of AVDLR components are referred to as Ready for Issue (RFI) components. Any fruitless attempts to repair AVDLRs result in an administrative and financial action referred to as BCM. Components often remain at the IMA, awaiting repair action for extended periods before the maintenance departments determine that the component cannot be repaired at the IMA. There appears to be anecdotal evidence indicating that BCM transactions increase at the end of the year as maintenance departments attempt to “clear the decks” in advance of a new fiscal year. This is seen as beneficial to both the maintenance departments and the supply department’s accounting division, which are usually racing against time at the end of the fiscal year in the quest for a 99.8% obligation rate of AVDLR funds. This behavior leads to questions about the effect of increased spend rates as a result of BCM processing and how that translates to stock position.

B. PROBLEM

This section outlines the problem for the reader and proposes the research questions and their corresponding results. Additionally, the method of analysis is briefly discussed along with the scope of the study. This section concludes with the organization of this study.

1. Problem Framing

Within the aviation logistics (AVLOG) community in the U.S. Marine Corps, there is anecdotal evidence that points to an anticipated increase in spending as time-limited funding approaches its date of expiry. As outlined in MCO 4400.177G, “requirements for additional funding will be identified as far in advance as possible. Quarterly and Fiscal Year obligation rates will meet percentages established by higher headquarters. Excess funds will be reported to higher headquarters for possible redistribution or reprogramming” (U.S. Marine Corps, 2014, p. 2-17). As a result, during the final quarter of the fiscal year, each Marine Aviation Logistics Squadron (MALS) is typically granted additional funds by its respective Aviation Logistics Department (ALD) situated at one of the three active duty

Marine Aircraft Wings (MAWs). It is the researcher's belief that this sizable plus-up in operating target grants across each MALS results from over-cautious fiscal planning throughout the fiscal year. Additionally, the researcher believes that risk-averse managers maintain a funds buffer in the event that an unanticipated operational requirement presents itself. As the end of the fiscal year nears, data calls are typically promulgated from the MAWs, which advise the MALS to list requirements “due-in from maintenance” (DIFM) that, at the discretion of the MALS leadership, may be more economical to repair at the depot level of maintenance as opposed to maintaining the component in a waiting status at the MALS until either the parts, resources, or personnel become available for continued repair action. In coordination with the aircraft maintenance officer (AMO), and the production control officer (PCO), the aviation supply officer (ASO) compiles an informal list of components that require maintenance but are deemed to be beyond economic repair. These components are typically processed as beyond capability of maintenance (BCM), sometimes in batches, at the end of the fiscal year. When a component cannot be repaired at the IMA, the resulting BCM transaction incurs a charge for the net repair price of the component that is chargeable against the MALS budget in support of Aviation Depot Level Repairables (AVDLR). In exchange for the BCM component and its net repair price, the MALS receives a component from the supply system that is ready for issue (RFI). This effort helps the maintenance departments to clear out aged requirements pending action, and it assists the MALS, and ultimately the MAWs, with the execution of AVDLR funds while seeking a “99.8%” obligation target at the time the funds expire (Department of the Navy [DON], 2019, p. 57). The researcher is interested in identifying trends that lead to a component’s selection as a BCM candidate at the end of the fiscal year and the potential impact on the stock position over time.

2. Research Questions

The primary question the researcher intends to address is presented below and followed by a series of secondary questions that support the researcher’s primary question and each question’s corresponding results:

Primary

1. How do end-of-year spend patterns as a result of BCM transactions differ when compared to the rest of the fiscal year?

The analysis conducted in this study suggests that no consistent evidence exists to support the notion that there is an increase in spending toward the end of the fiscal year when compared to spending patterns that occur throughout the rest of the fiscal year. Although the study highlights that there is an increase in spending toward the end of fiscal year 2020, this spike in spending is not observed in the fiscal years 2016 through 2018. Therefore, a multi-year level of support for the hypothesis that there is an increase in spending during the end of the fiscal is inconclusive.

Secondary Questions

2. How aged are components tied to BCM transactions at the end of the year when compared to the rest of the fiscal year?

The results of the analysis suggest that there is strong evidence to support the notion that repairable components processed as BCM toward the end of the fiscal year have been pending maintenance actions at the intermediate level of maintenance longer than components processed as BCM throughout the rest of the fiscal year. Further, the results suggest that there is strong multi-year support based on the statistical evidence presented in the analysis chapter.

3. How does the level of requirements priority impact BCM spending patterns?

Based on anecdotal evidence, the researcher conducts an analysis to identify whether any evidence exists to support the notion that there is an increase of lower priority requirements processed as BCM toward the end

of the fiscal year. There is no evidence, as a result of this analysis, to suggest that there is a difference in the priority levels or project codes of requirements processed as BCM toward the end of this fiscal year. These results are consistent across fiscal years, as no support for the hypothesis was identified from a multi-year perspective.

4. How do end-of-year spending patterns affect changes in stock position over time?

The results of the analysis conducted on the time it takes to receive a replenishment component as a result of BCM actions processed toward the end of the fiscal year when compared to the rest of the year are inconclusive. Based on anecdotal evidence, analysis was conducted to see if BCM transactions took longer when processed toward the end of the fiscal year. There is no evidence to suggest that the speed at which replenishment components are received post-BCM action differs for transactions that are processed as BCM toward the end of the fiscal year. In fact, mixed multi-year support was identified for the opposing notion that replenishment of components processed as BCM take longer, on average, during the rest-of-year BCM processing period when compared to end-of-year replenishment documents for fiscal years 2017–2018 and 2018–2019.

C. METHOD OF ANALYSIS

The researcher utilizes a series of tools to both graphically depict and statistically quantify differences in patterns and trends. The researcher employs empirical analysis techniques to identify and quantify trends within requisition data in support of aviation operations. An analysis and assessment of the data help aviation logisticians better understand trends of prior year executions across the enterprise. Trends identified can be of use to the community as it prioritizes its maintenance efforts in the years ahead. The researcher conducts trend analyses to identify how our current fleet-wide aircraft degraders

have impacted the aircraft over time and how BCM actions continue to compound the problem, particularly with respect to the top aircraft-degrading components. Identifying trends on how the Marine Corps spends financial resources in support of aviation operations is critical to ensuring that expenditures are effectively and efficiently contributing to overall mission capability and aircraft readiness.

D. SCOPE OF STUDY

Due to considerations regarding this study's scope, the researcher focused his research on the CH-53E platform. With the majority of its fleet in a non-mission capable status, the CH-53E has been receiving increased attention over the years from Marine Corps Deputy Commandants for Aviation (DCA), the H-53 Program Office (PMA-261), COMNAVAIRFOR, and leaders across the Naval Aviation Enterprise (NAE; Ericson, 2018, p. 11). The Marine Corps has multiple aircraft platforms in its inventory that fulfill a range of mission sets. For this study's purposes, the researcher focuses on maintenance and financial actions that occur at the I-Level, which is also referred to as the Intermediate Maintenance Activity (IMA). Each MAG is comprised of one or more Type/Model/Series (T/M/S) aircraft. The researcher conducts a BCM trend analysis on the CH-53E, the Marine Corps' heavy lift platform.

E. STUDY ORGANIZATION

This study follows a six-chapter format of introduction, background, literature review, methodology, data analysis, and conclusion and recommendations. In Chapter I, the researcher frames the problem by identifying the research questions and guides the reader through background information. Chapter II is focused on providing background information to the reader to provide context. Chapter III delves into a review of literature that supports the claims the researcher is making. In addition, this chapter discusses select policies and procedures from the Naval Aviation Maintenance Program (NAMP) in order to provide the reader with the requisite information necessary to follow along for the remainder of the study. Chapter IV provides a discussion of the methodological approach undertaken in order to analyze the data available to the researcher. In Chapter V, data analysis follows the application of the methodology to the data, and the researcher presents

the results. This chapter forms the basis from which the study's recommendations can both be corroborated and quantified. Finally, Chapter VI concludes the study and proposes recommendations along with areas for future research.

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II. BACKGROUND

This chapter provides the reader with the background information required to support the analysis conducted in this thesis. Each section within this chapter details a specific aspect of aviation logistics aimed at providing a general overview. Further, it establishes a foundational framework that assists the reader to readily interpret the analysis.

A. LEVELS OF MAINTENANCE

Parts for aircraft maintenance actions fall into one of two main categories: consumable and repairable. The latter of the two is the focus of this study. The levels of maintenance are stratified sequentially from the organizational level (O-Level) to the intermediate level (I-Level) and the depot level (D-Level; Commander of Naval Air Forces, 2021). Each level of maintenance can perform the appropriate predetermined maintenance actions authorized at that level. Each echelon is equipped with the resources, personnel, training, and equipment that are commensurate with its capability.

An aircraft squadron has maintainers assigned that are equipped with the training and experience to troubleshoot and, in some cases, resolve mechanical and technical issues impacting the aircraft that are assigned to a squadron. This is considered the O-Level. The O-Level is, in fact, the lowest level of maintenance and is where “scheduled and unscheduled maintenance, as well as servicing and inspecting the aircraft” occurs (Ericson, 2018, p. 8). When maintainers at the O-Level identify a component to be inoperable as determined by the associated troubleshooting steps, the component is removed and inducted into the maintenance repair cycle at the I-Level.

Each Marine Aircraft Group (MAG) is composed of multiple flying squadrons and one MALS squadron. The MALS is referred to as the I-Level. Maintainers assigned to the I-Level perform “more in-depth repair of aircraft structures, systems, and support equipment than the O-Level is capable. I-Level repair facilities have more in-depth tooling and specialized equipment, which allow for higher-level repairs to be performed” (Ericson, 2018, p. 9). At the I-Level, repairable components received from the O-Level for maintenance action usually result in one of two broad outcomes: either Ready for Issue (RFI) or BCM. RFI refers to

successful repair action conducted on a component in the I-Level where the component can be returned to the supply officer stores to fulfill future customer demands, whereby the customer is the squadron. On the other hand, a BCM is an action taken at the I-Level as a result of unsuccessful repair actions or lack of ability to repair at the I-Level. A BCM action triggers a financial transaction that immediately charges the unit a hefty net repair price while, in tandem, registering a demand signal with the supply system for a replacement component in exchange for the non-working component that is now destined to the D-Level for rework/repair (U.S. Marine Corps, 2014). Suppose the I-level cannot perform any substantive maintenance actions on the inoperable component. In that case, the component is processed under one of nine BCM transaction codes that justify the specific reason for the assumption of the net repair cost of an inoperable part (Commander of Naval Air Forces, 2021).

In the event that the IMA cannot repair a component, the component is processed as a BCM and sent to the D-Level. The D-Level focuses on

materiel maintenance requiring major overhaul of a complete rebuilding of parts, assemblies, subassemblies, and end items, including the manufacture of parts, modifications, testing, and reclamation as required. Depot maintenance serves to support lower categories of maintenance by providing technical assistance and performing that maintenance beyond their responsibility. Depot maintenance provides stocks of serviceable equipment because it has available more extensive facilities for repair than are available in lower maintenance activities. (Ericson, 2018, p. 9)

In exchange for the in-depth services provided in support of the lower levels of maintenance, the component's net repair price requiring depot-level maintenance is charged to the IMA processing the requirement.

B. OVERVIEW OF INTERMEDIATE MAINTENANCE ACTIVITIES AND SUPPORTED AIRCRAFT

The Marine Corps has 11 active MALSS. Each MALS is comprised of four departments: Avionics, Maintenance, Supply, and Ordnance. Typically, the MALS is often referred to as the IMA in support of the individual flying squadrons that comprise the MAG. Each MAG has one MALS, and although the MALS has its own commanding

officer, the aviation supply officer (ASO) and the aviation maintenance officer (AMO) are often referred to as the MAG commander's ASO and AMO. Marine Corps Tactical Publication (MCTP) 3-20A describes the MALS as "the AVLOG staff to the MAG Commander and provides AVLOG support, such as aviation-specific maintenance, ordnance, avionics, and supply, for subordinate elements of a MAG" (U.S. Marine Corps, 2012, p. 3-1). This is because maintenance and supply decisions that are taken at the MALS inevitably impact the squadrons on the flight line.

The MALS forms the primary aviation logistics framework from the Marine Corps and its supported flying squadrons. These 11 aviation logistics squadrons are directly assigned to each of the 11 MAGs across the four MAWs:

- 1st MAW: MALS-12, MALS-24, and MALS-36
- 2nd MAW: MALS-26, MALS-29, and MALS-31
- 3rd MAW: MALS-11, MALS-13, and MALS-16
- 4th MAW: MALS-41, and MALS-49

In response to contingency operations, the Marine Corps can stand up MALS-40, MALS-50 or MALS-70 in support of forward-deployed operational requirements or in support of scalable Special Purpose Marine Air-Ground Task Forces. The MALS in support of the CH-53E are MALS-29 at Marine Corps Air Station (MCAS) New River, NC, MALS-16 at MCAS Miramar, CA, and MALS-24 at MCAS Kaneohe Bay, HI.

C. NAVAL SUPPLY SYSTEMS COMMAND ALLOWANCING

Each MALS supply department maintains stock on allowed AVDLR components by T/M/S aircraft (U.S. Marine Corps, 2014). The stock levels do not exceed the pre-determined allowance as directed by the Naval Supply Systems Command (NAVSUP). NAVSUP Weapons System Support (WSS) controls all AVDLRs as the primary inventory control point in support of naval aviation. NAVSUP WSS in Philadelphia does not engage in warehousing operations; its functions are strictly administrative in direct support of fleet-wide aviation requirements. NAVSUP AVDLR allowances are referred to as the Aviation Consolidated Allowance Listing (AVCAL). AVCALs delineate the material that is required to support a planned aircraft load while taking into consideration local maintenance capabilities.

For purposes of a MALS, the AVCAL is designed to support sustained wartime flying hours covering a period of 90 days (U.S. Marine Corps, 2014). Through the AVCAL allowancing process, the MALS may be authorized additional spares to carry in the supply officer's stores. NAVSUP determines base allowances based on a model used internally. These results are usually sent to the respective ALDs and MALS for review, reconciliation, and recommendations (U.S. Marine Corps, 2014). This reconciliation process is continuous and occurs approximately once a fiscal year. Allowances for AVDLRs are closely monitored, given the expense of acquiring spares and balancing the spares currently working in the system. Requests submitted by a MALS for allowance increases are subjected to a high degree of scrutiny before allowance increases are deemed justifiable, as outlined in the validation process within MCO 4400.177G. Given this monitoring and control mechanism, it is rare that an activity has an excess on-hand quantity of a specific AVDLR other than what its NAVSUP allowances dictate.

D. UNIFORM MATERIEL MOVEMENT AND ISSUE PRIORITY SYSTEM

The DOD maintains a material management regulation from which most services outline service-specific orders and regulations, further defining interpretation of the DOD regulation. The Marine Corps published the Uniform Materiel Movement and Issue Priority System (UMMIPS) order, cataloged as Marine Corps Order 4400.16H. The UMMIPS serves as the guide to prioritizing resources and assigning relative importance to demands placed on the logistics system (U.S. Marine Corps, 2010).

1. Urgency of Need Designators

Parts requisitions are categorized into priority levels. Urgency of Need Designators (UNDs) notably prioritize requirements in support of contingency and wartime operations over peacetime demands. The UMMIPS prioritizes the demands placed on the logistics system by way of 15 priority designators that are further organized under three categories to define the urgency of the requirement and are thereby assigned a UND. As depicted in Table 1 in the next section, the UNDs form a matrix with the force/activity designator outlined in the next section.

2. Force Activity Designators

Levels of priority are further determined by the Force Activity Designator (FAD) assigned to a specific unit or activity. Every activity in the Marine Corps is assigned a FAD level depending on the unit's particular mission at the time. Suppose an activity is gearing up to deploy in support of some contingency operation or other requirement that results in a change in mission; its respective FADs change along with the shift in operational demands. FAD levels correlate "with an urgency of need requirement to determine the priority assigned to requisitions" as defined in the NAMP (Office of the Chief of Naval Operations, 2005). The NAMP makes an effort to instruct that "the priority, not the project code, assigned to the material requisition determines the speed with which a requisition must be filled by the supply system" (Office of the Chief of Naval Operations, 2018). Project codes, discussed in the next section, provide an additional layer to track requirements but in no way determine how the supply system will respond to the requirement in question. Table 1 outlines the priority levels as defined in the UMMIPS order. The researcher intends to analyze impacts across priority 02 and 03 compared to priority 05 and 06 for AVDLR components.

Table 1. UMMIPS Priority Designator Matrix. Source: U.S. Marine Corps (2010).

Force/Activity Designator	Urgency of Need Designator		
	A	B	C
I	01	04	11
II	02	05	12
III	03	06	13
IV	07	09	14
V	08	10	15

E. PROJECT CODES

Assigning project codes to parts requisitions allows for tracking cost and performance data that may be associated with a program. A requisition cannot be released into the supply system without a project code assignment. The researcher intends to categorize the project codes listed in this section as “high-visibility” project codes to conduct the analysis in this study. As listed in Appendix 6 of the NAVSUP P-485, some of the most common project codes utilized in the aviation logistics community are as follows:

AK0/706/756 – These are “assigned by organizational maintenance activities only when they requisition material to restore an aircraft to mission capable (MC) status” (706/756 are designated for 6th and 7th Fleets and 1st MAW use; Department of the Navy, n.d., Appendix 6).

AK7/707/757 – These are “assigned by organizational maintenance activities when they requisition material to return mission-essential subsystems to an operational condition when an aircraft is in a partial mission capable (PMC) status” (707/757 are designated for 6th and 7th Fleets and 1st MAW use; Department of the Navy, n.d., Appendix 6).

ZA9 – These are “forced high-time removal items required for immediate use on primary mission weapons systems. The aircraft concerned is within days of becoming not mission capable supply (NMCS) or partial mission capable supply (PMCS) due to high time forced removal of the required item (15 days in CONUS and 20 days outside continental limits of the United States)” (Department of the Navy, n.d., Appendix 6).

F. COMPONENTS AWAITING MAINTENANCE

Components inducted into the maintenance cycle are processed through the Aeronautical Material Screening Unit (AMSU). AMSU personnel inspect the component before induction into the maintenance cycle to ensure that it has been purged of petroleum, oils, and lubricants. Further, these Marines verify serial number matches to the Maintenance Actions Forms (MAFs). AMSU personnel then catalog the asset’s storage location among a series of other duties and responsibilities (Commander of Naval Air Forces, 2021). Once inducted into the IMA and inspected by the appropriate work center,

the component is deemed to be in an Awaiting Maintenance Status (AWM) or an Awaiting Parts Status (AWP), depending on the maintenance workload prioritization or parts needed to repair. The number of AWM/AWP status components ebb and flow throughout the fiscal year as requirements cycle through the IMA. The backlog of parts is a function of how expedient repairs or BCM recommendations can be completed. According to the NAMP, the IMA is responsible for establishing a centralized storage location for all components inducted into the maintenance cycle because “keeping AWM and AWP items out of the work centers and in a central location helps prevent damage to the items and may reduce indiscriminate, unauthorized cannibalization” (Commander of Naval Air Forces, 2021, p. 5-28). In addition to concerns of parts cannibalization from components in an AWP/AWM status, there is also a concern surrounding workspace management as requirements throughput increases and parts begin to overflow into the work centers. The researcher asserts that storage space is limited for AWM/AMP components, and there is often pressure on the maintenance department’s work centers to alleviate backlogs by reducing the number of MAFs that a MALS is tracking. The researcher believes that work center overflow is prevalent enough across the IMAs that the NAMP authorizes the practice as follows: “when centralized location of AWM items is not possible due to space limitations, AWM items may be stored in the work centers” (Commander of Naval Air Forces, 2021, p. 5-28). This overflow concern may put additional pressure on the maintenance department to clear the decks, particularly at the end of the fiscal year, by processing increased BCM actions, which, in turn, result in the anecdotal end-of-year spike in spending. The researcher believes that this spike in spending is driven by the supply department’s desire to meet obligation targets while the maintenance departments aim to start the new fiscal year with a clean slate.

G. BEYOND CAPABILITY OF MAINTENANCE ACTIONS

In the event that the IMA is unable to repair a part, the result is a BCM transaction. BCM actions are determined by a series of factors including the authorized level of repair, lack of technical skills or data, lack of parts, or lack of repair equipment. There is also some degree of local discretion utilized when deciding to render a component beyond an organization’s maintenance capability. Some of these considerations are driven by

timelines in support of either the flying hour operating budget execution or operational requirements. It is understood that actions taken at the MALS resulting in a BCM determination ultimately lead to a financial transaction. This is due to the inability to repair a component at an I-Level for a series of reasons (as categorized by BCM Codes 1–9).

Millikin (2016, p. 1) explores how the current metrics utilized at a MALS tie to the level of support provided to the flight line. Under the analysis section of this thesis, Millikin tabulates the BCM action codes as presented in Figure 1.

Figure 1. BCM Types. Source: Millikin (2016).

BCM 1	Repair Not Authorized	BCM 4	Lack of Parts	BCM 7	Beyond Authorized Repair Depth
BCM 2	Lack of Equipment, Tools, or Facilities	BCM 5	Fails Check and Test	BCM 8	Administrative
BCM 3	Lack of Technical Skills	BCM 6	Lack of Technical Data	BCM 9	Condemned

As described in the background chapter of this study, Millikin (2016) also explains the cost impact on the organization if the component cannot be repaired at the IMA. Ultimately, there is a cost to doing business, and most of the time that IMA has exhausted all avenues of approach in its attempts to repair a component. Millikin states that “if a MALS must BCM a repairable, the BCM 7 code is preferred ... because it indicates that they have sufficiently done all they are authorized to do and are required to submit the part for a higher level of repair” (p. 45). Maintaining a systematic perspective on how actions are taken resulting in BCM processing, Millikin describes the impact of BCM metrics on flight line operations as follows:

The BCM metric incentivizes cost-reduction through the in-house repair of parts. Focusing on keeping low BCM rates, however, may diminish MALS support to flight line squadrons. There are often long periods of troubleshooting and repair before an item receives a BCM code (with the exception of BCM 1 and most BCM 7 codes). If the goal is to minimize BCM codes, then those periods of troubleshooting and repair will be further extended as maintainers continue to attempt successful repair. These longer repair times could

potentially result in longer wait times for the flight line squadron who requires the part. (p. 45)

While Millikin's (2016) study focuses on metrics and how they translate to aircraft availability, it is essential to note that there is also an inextricable link to how the MALS executes the funds authorized in support of aviation operations. To this effect, Millikin states that "BCM 7 rates can be reduced through BCM interdiction when a MALS receives authorization to conduct maintenance themselves or a local artisan that is not typical of the I-Level," while "BCM 4 rates can be reduced through parts acquisition and inventory management" (p. 45). In essence, if the system worked like it is intended while taking additional actions to prevent unnecessary costs, the MALS stands to deliver increased support to the flight line while reducing overall costs and time associated with referring a part to the depot level for maintenance actions that could have been conducted at the IMA.

H. FLYING HOUR PROGRAM

Naval Aviation is funded by Navy Operations and Maintenance (O&M, N) appropriated dollars. From these appropriated funds, the Navy and Marine Corps obligate funds in support of aviation operations. This is referred to as the Flying Hour Program (FHP). The FHP funds available to Navy and Marine Corps active duty squadrons flow down from the Commander of Naval Air Forces (COMNAVAIRFOR), also referred to as a Type Commander (TYCOM); as such, MCO 4400.177G states that submission of all financial reports must be made to the appropriate TYCOM (U.S. Marine Corps, 2014). According to the NAMP, O&M, N lines of appropriations in support of the flying squadrons is known as Operating Target (OPTAR). The Aircraft Controlling Custodian or the TYCOM "direct[s] fiscal and budgetary actions to support NAMP requirements, including the allocation of budget operating target (OPTAR) allotments to commands" (Commander of Naval Air Forces, 2021, p. 2-5). The FHP budget is referred to as the OP-20. The OP-20 is comprised of the Marine Corps' Sortie Based Training Plan (SBTP) as well as the Navy equivalent Fleet Response Plan (F RTP). For purposes of clarity, references to tactical aircraft (TACAIR) in the OP-20 include fixed, rotary, and tilt-rotor aircraft that are deployable across the Navy and Marine Corps' inventory. In addition to

capturing planned obligations under the FHP, the OP-20 budget exhibit serves as a performance forecasting tool.

1. Funding Aviation Depot Level Repairables

The FHP OPTAR that flows down from COMNAVAIRFOR is further divided into subcategories that identify how allocated funds will be executed (U.S. Marine Corps, 2014). These subcategories are referred to as OPTAR Functional Categories (OFC; U.S. Marine Corps, 2014). The FHP OPTAR is comprised of the following OFCs:

1. OFC-01 - Flight Operations
2. OFC-02 - Staff and Administration
3. OFC-09 - Initial Individual Material Readiness Listing Items
4. OFC-10 - Flight Training
5. OFC-15 - Operations Budget
6. OFC-21 - Travel in support of Aviation Operations
7. OFC-50 - Aviation Operations Maintenance (AOM)
8. OFC-23 - Transportation of Things (DON, n.d.)

AVDLRs are funded under the OFC-50 functional category, which captures maintenance costs in support of aviation operations. AOM costs are further subdivided into aviation fleet maintenance (AFM) costs and AVDLR costs. Costs associated with AFM are funded with 7L funds, which are dedicated to aviation consumables and contracted maintenance requirements. All costs associated with AVDLRs are funded by 9S coded funds in support of depot-level repairables. Per COMNAVAIRFORINST 4790.2D, the essence of how AVDLRs are financed is succinctly captured as follows:

Aviation Depot Level Repairables (AVDLR) are financed by the Navy Working Capital Fund (NWCF). Under the NWCF process, the end user finances the D-level repair and procurement of 7R COG repairables through the local replenishment of these repairables determined to be non-ready for use (NRFU) and Beyond Capability of Maintenance (BCM) at the I-level, and repairables that are lost or missing. Squadrons and Intermediate Maintenance Activities (IMA) initiate requisitions for AVDLRs, and the T/M/S aircraft maintenance plan dictates through Source, Maintenance and Recoverability (SM&R) codes whether repairable materials can be repaired at the I-level or must be sent direct to the Depot Repair Point (DRP). AVDLRs repaired at the I-level result in a charge for the actual material costs of the repair. AVDLRs that are BCM at the I-level result in a set NWCF charge. AVDLRs that are missing or loss result in a NWCF for full replacement. The Intermediate

Maintenance Cost is the gross adjusted obligations used by the IMA to perform I-level maintenance. (Commander of Naval Air Forces, 2021, p. 6-22)

2. Financial Responsibility

Leaders and managers must collectively exercise due diligence when high-dollar-value decisions are made. Leaders across the organization must fight the urge to proceed with business as usual and not fall prey to sticky routines. The NAMP notes that components and services requisitioned by a Navy or Marine Corps squadron results in financial expenditures, as such, the unit incurring the financial obligation should also exercise fiscally responsible measures (Commander of Naval Air Forces, 2021). While conducting day-to-day business operations, it is expected that leaders in the organization aspire to efficiently and effectively utilize the fiscal resources allocated to them. Leaders not only have a responsibility to accomplish the mission and take care of their personnel, but they also have the responsibility to enforce fiscal stewardship across their respective commands. Recording financial transactions tied to maintenance actions is just as critical as performing the required maintenance on the aircraft. With the wealth of data that is collected, the naval aviation community has collaborated across all logistical functions to ensure that there is a one-stop shop for metrics as they relate to financial reporting. These databases are found in information systems like Decision Knowledge Programming for Logistics Analysts and Technical Evaluation (DECKPLATE) and the Aviation Financial Analyst System Tool (AFAST). These data sources increase the level of visibility and provide an almost tangible level of fidelity to all process owners and leaders across the organization.

I. CHAPTER SUMMARY

This chapter highlights aspects of complex aviation logistics procedures that directly link to this study. The researcher provides an overview of MALS and the supported squadrons along with the three levels of maintenance associated with the aircraft maintenance construct. This chapter also outlines the financial resources utilized to support the AVDLR repair process. The particular focus of this study is to conduct an analysis of components that have been processed as BCM; as such, BCM actions are outlined in detail within this chapter. In the methodology chapter, the researcher explains the analytical

approach to the third research question, which aims to explore differences in spending patterns as a result of priority levels and project codes. The chapter concludes with a section highlighting the fiduciary responsibility leaders across the AVLOG community have while performing their duties and responsibilities.

Support to the flight line as it pertains to AVDLR components can be a highly convoluted and complex process. Within this process, there is a great degree of autonomy that is entrusted to both the AMO and the ASO to make decisions on components that are processed as BCM. BCMing components without a screening process to identify candidates can prove to be costly, especially if the IMA has the ability to repair the component locally. Ultimately, there is a series of decisions that is sometimes accompanied by pressures to meet pre-determined targets and goals. However, it is imperative that, with this degree of autonomy, aviation logisticians take a hard look at some of these costly actions to determine if there is a way to avoid the cost. Although meeting obligation targets is important, it is equally important to meet those targets with bona fide requirements for which it makes economic sense to do so, in particular, if the economic gain to the unit will result in manpower hour gains to reprioritize to other efforts or the freeing up of resources.

III. LITERATURE REVIEW

This literature review focuses on the exploration of previous scholarly literature conducted on the year-end spending behavior. This section outlines some of the spending patterns identified across other federal organizations and draws parallels to spending within the aviation logistics community as it pertains to AVDLRs. This literature review creates the foundations of the problem being analyzed in an effort to provide the reader with the requisite information needed to support the analysis being conducted. The literature highlights areas of government where excessive year-end spending has been observed.

A. END-OF-YEAR SPENDING PATTERNS ACROSS THE FEDERAL GOVERNMENT

The literature reviewed in this sections focuses on end-of-year spending patterns within organizations that are not associated with the Department of the Navy. This section aims to provide existing evidence of spending behaviors that support the researcher's hypothesis.

1. Study by Liebman and Mahoney (2017)

Liebman and Mahoney (2017) conduct a study on wasteful spending in the federal government. The purpose of this study is to conduct an exploratory analysis of how the “‘use-it-or-lose-it’ feature of time-limited budget authority has the potential to result in low-value spending (p. 3510).” Most funding authorized by the federal government to its departments usually expires at the end of a fiscal year. In the researcher’s view, it is generally accepted that throughout the fiscal year, managers across the organization make their best effort to execute funds in support of their respective missions while balancing their duty to be good stewards of the taxpayer dollar. However, as presented in this study, as the fiscal year begins to wind down, organizations across the federal government appear to ramp up spending in the final quarter. These efforts are usually a result of underspent funds accumulated throughout a fiscal year in the event an unforeseen financial obligation should present itself. Liebman and Mahoney (2017) succinctly describe this phenomenon:

This “use-it-or-lose-it” feature of time-limited budget authority has the potential to result in low-value spending since the opportunity cost to organizations of spending about-to-expire funds is effectively zero. Exacerbating this problem is the incentive to build up a rainy-day fund over the front end of the budget cycle. Most organizations are de facto liquidity constrained, facing at the very least a high cost of acquiring mid-cycle budget authority. When future spending demands are uncertain, organizations have an incentive to hold back on marginal spending early in the budget cycle and then burn through this buffer-stock at the end of the year. (p. 1)

Although there is no definitive explanation of what excessive spending at the end of a fiscal year looks like, the notion that it does exist is widely spread and often described as a behavior of its own: year-end spend behavior. At the start of their study, Liebman and Mahoney (2017) explicitly state, “There is no hard evidence on whether U.S. federal spending surges at the end of the fiscal year or whether year-end spending is a lower value than spending during the rest of the year” (p. 3511). When it comes to spending, it is easy to simply quantify spending based on how much is spent throughout the fiscal year. Liebman and Mahoney take care also to note that the quality of the expenditure is an essential category of spending that is worthy of analysis. This approach to their study creates the basis of an objective approach by both exploring the quantity and quality of expenditures throughout a given fiscal year. This approach to analyzing spending patterns lays the foundation to truly understanding how military organizations spend their funds.

It is imperative to understand the difference between spending that is categorized as fraudulent or wasteful and bona fide spending that has been withheld throughout the fiscal year in an effort to prioritize higher impact requirements in an organization. The Government Accountability Office (GAO) Principles of Appropriations Law defines a *bona fide needs rule* as “one of the fundamental principles of appropriations law [in which] a fiscal year appropriation may be obligated only to meet a legitimate, or *bona fide*, need arising in, or in some cases arising prior to but continuing to exist in, the fiscal year for which the appropriation was made” (Government Accountability Office, 2004, p. 5-11)

Liebman and Mahoney (2017) analyzed federal procurement spending data covering a 5-year time period and totaling \$2.6 trillion in government spending. In their study, the researchers aimed to identify if there was any indication of wasteful spending toward the end of the fiscal year when compared to the rest of the year. A follow-on area

of interest to support their study was to identify the quality of spending done at the end of the fiscal year when compared to expenditures from the rest of the year. In their recommendations, the researchers proposed a solution that advocates for the “roll-over” of time-limited funding in an effort to curb unnecessary excessive spending at the end of the fiscal year.

Liebman and Mahoney’s (2017) study concludes that there is both “a surge in spending at the end of the year” and that “end-of-year spending is of lower quality.” The most significant of their findings is the impact of introducing a roll-over feature to the current time-limited budget authorities. Liebman and Mahoney (2017) proposed that “a natural way to increase efficiency would be to allow organizations to roll over budget authority across years” (p. 3536). They continue by indicating that “budgeting would still occur on an annual basis, but rather than expiring at year’s end, unused funds would be added to the newly granted budget authority in the next year” (Liebman & Mahoney, 2017, p. 3536). The researchers extend their model by removing its timelimits, and the findings indicate that by removing end-of-year time-limit restrictions on spending, the quality of spending increases. The easing of time-limited restrictions on budgets with expiring funds proves to be a potential solution to excessive, low-quality end-of-year spending observed across federal government procurements. Figure 2 is a graphical comparison of weekly spending and weekly number of information technology projects throughout fiscal year 2009, as introduced by Liebman and Mahoney. Similarly, Figure 3 presents a graphical comparison of weekly spending and number of projects with the added quality rating criteria assigned by Liebman and Mahoney.

Figure 2. Total Spending on Information Technology Projects in 2009.
Source: Liebman and Mahoney (2017).

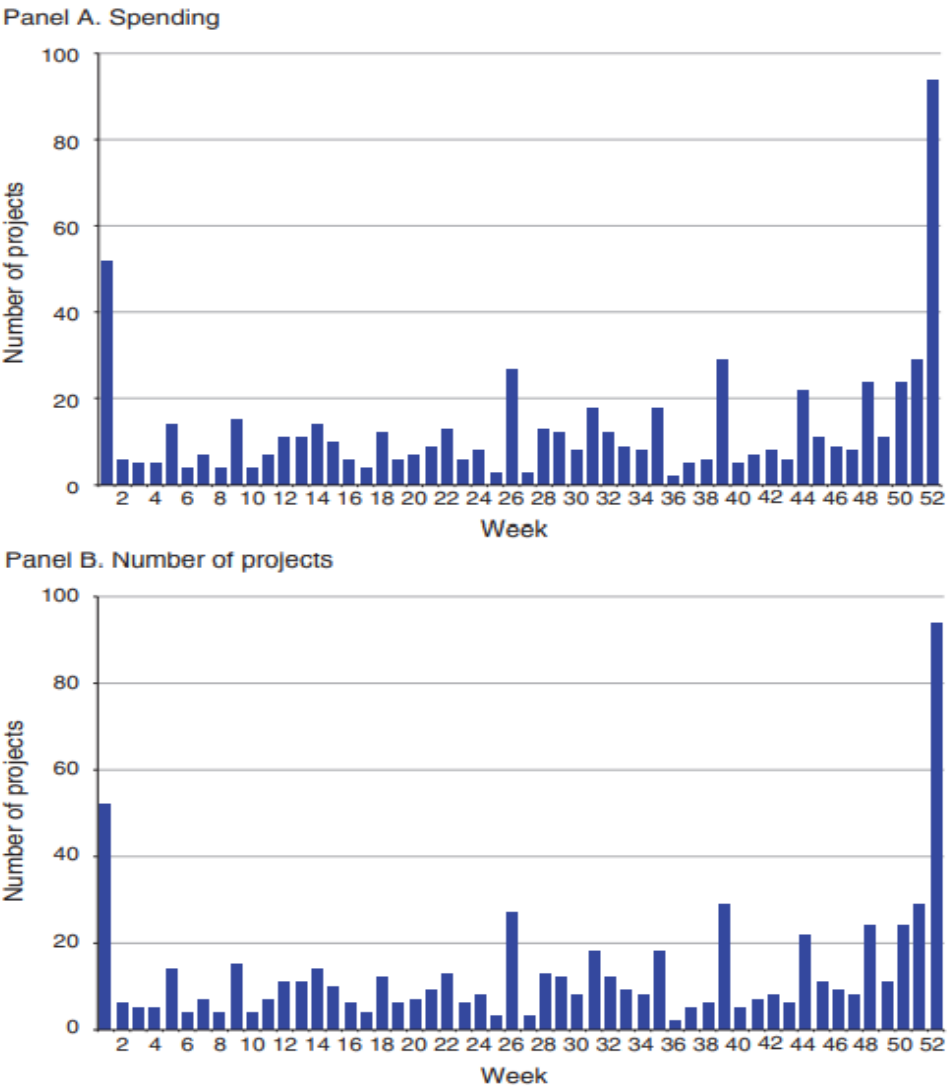
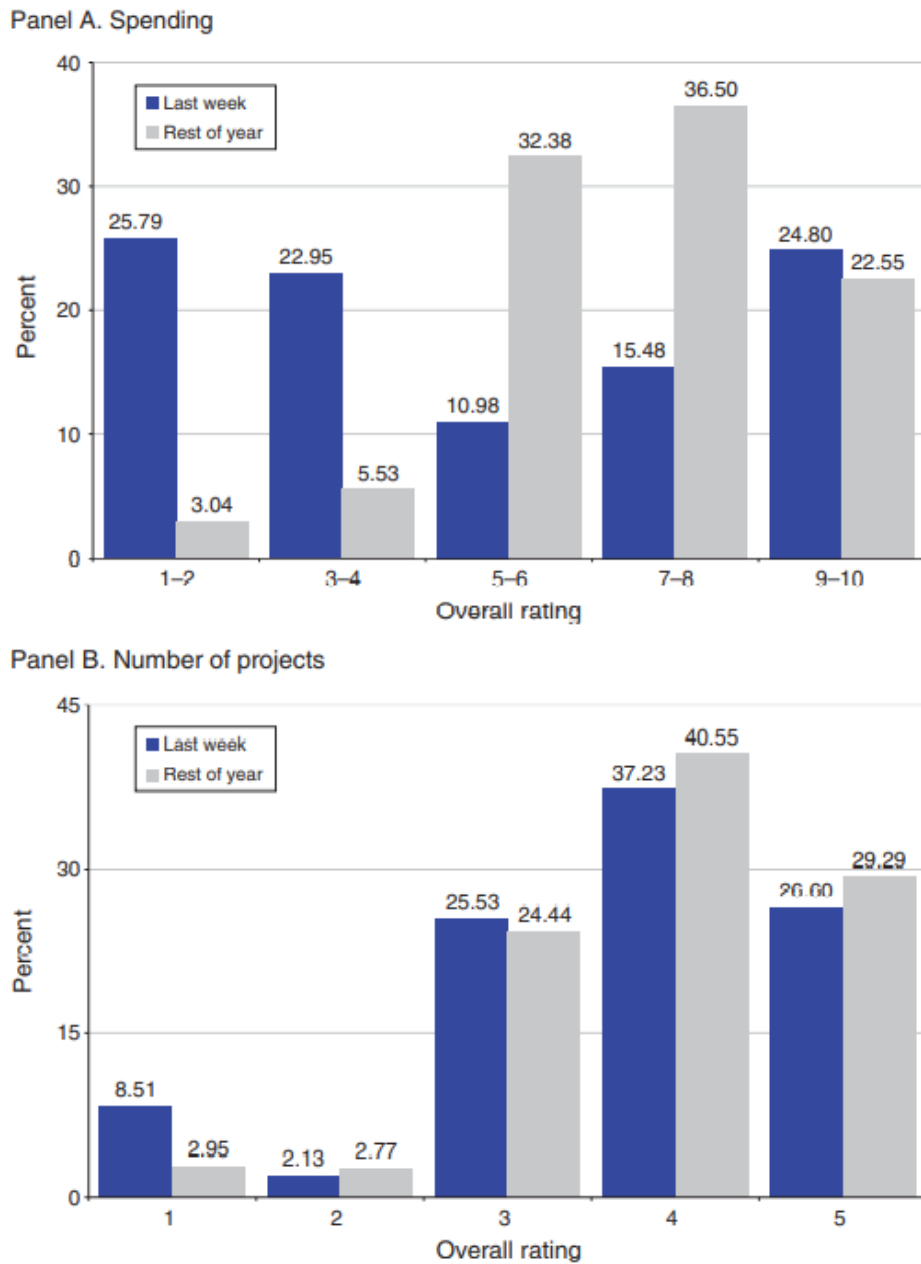


Figure 3. Overall Rating on Information Technology Projects in 2009.
Source: Liebman and Mahoney (2017).



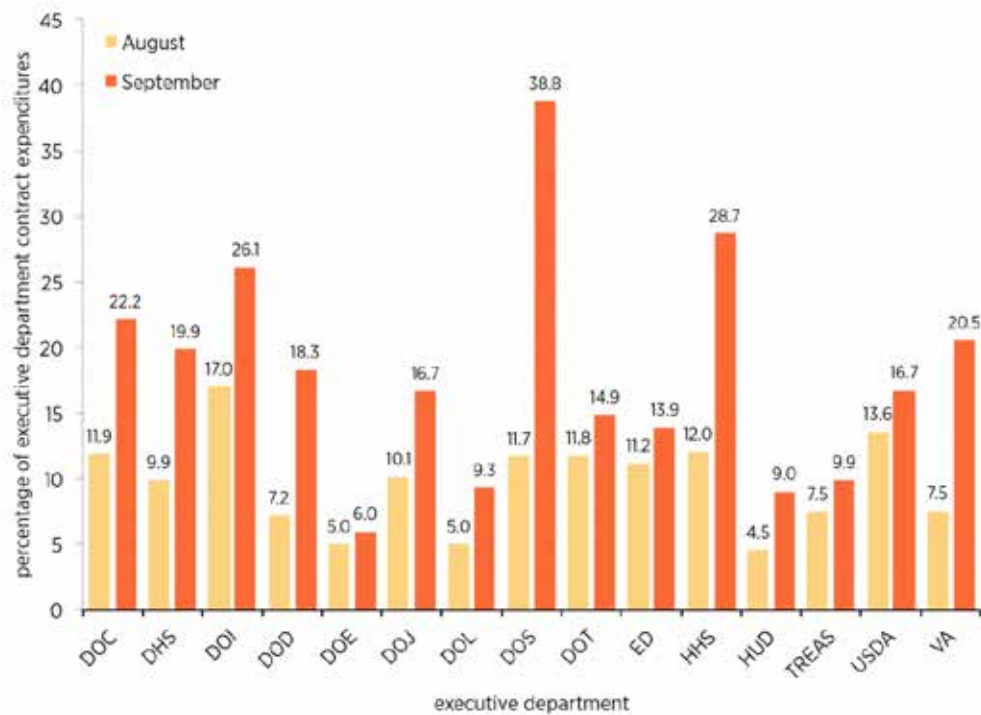
Although there is evidence resulting from modeling and empirical analyses conducted in their study, Liebman and Mahoney (2017) recognize that “one should not lose sight of the potential benefits of one-year budget periods” (p. 3543). They believe that

annual appropriations cycles may benefit from greater Congressional control over executive operations (p. 3543). In sum, a roll-over authority provides a degree of relief from the pressure to execute prior to the expiry of funds. However, while operating under a time-limited budget, managers across the AVLOG community shall utilize resources throughout the fiscal year instead of falling prey to overly cautious spending patterns and the end-of-year spending increases observed across federal entities with authority to expend dollars in support of their respective operational requirements.

2. Study by Fichtner and Greene (2014)

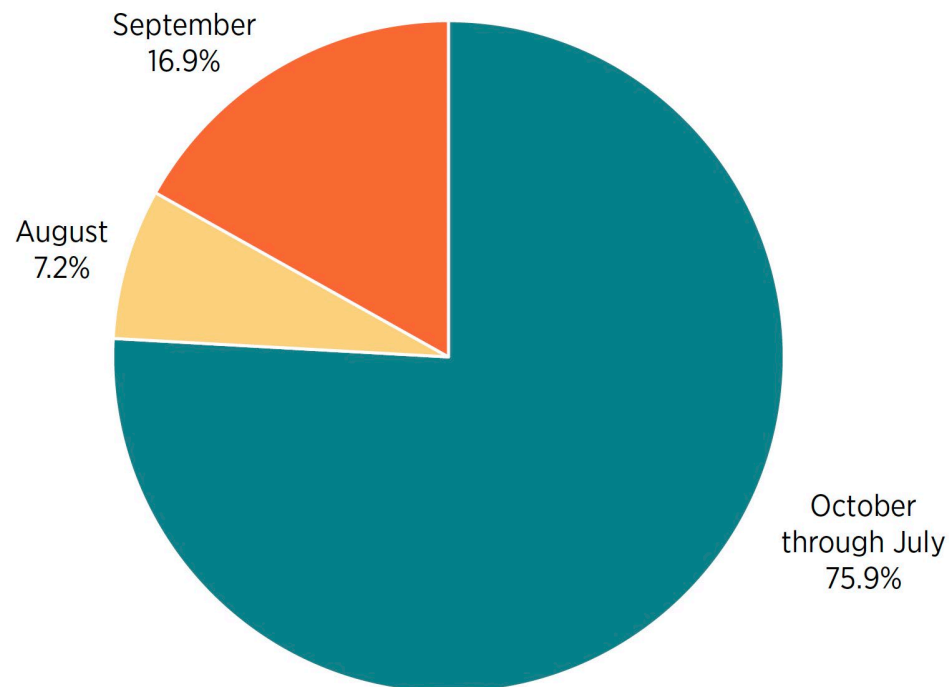
Fichtner and Greene (2014) identify patterns in spending that indicate an increase in spending across federal organizations toward the end of the fiscal year. The researchers in this study also refer to this behavior as a “use it or lose it” phenomenon. Fichtner and Greene define (2014) this phenomenon as “the propensity of U.S. government agencies to spend unused financial resources toward the end of the fiscal year out of fear that leftover resources will be returned to the Department of the Treasury and will prompt future congressional budget cuts for the agency” (p. 3). According to the researchers, at the time this study was published, there was a minimal amount of literature that analyzed, on an empirical basis, fiscal year spending trends within the U.S. federal agencies (Fichtner & Greene, 2014, p. 7). After compiling data from sources like the General Services Administration (GSA) and Federal Funding Accountability and Transparency Act (FFATA) Subaward Reporting System, the researchers were able to generate sufficient data to conduct analyses across federal agencies (Fichtner & Greene, 2014, p. 8). Figure 4 present a graphical depiction of contract expenditures in the last two months of the sample fiscal years as presented by Fichtner and Greene.

Figure 4. Contract Expenditures by Executive Department. Source: Fichtner and Greene (p. 9).



Fichtner and Greene (2014) find that “over the years and across departments, the trend of executive departments spending a disproportionately large amount of resources in the final month of the fiscal year is apparent, regardless of administration, party control of Congress, or delays in finalizing agency appropriations” (p. 17). The researchers make an effort to further amplify these large amounts of spending in the final quarter of the fiscal year by stating that over a period of 10 years “across all executive departments, 16.9 percent of obligated contract expenditures occurred during the month of September—more than twice what we would expect if spending were split evenly over 12 months (8.3 percent per month)” (Fichtner & Greene, 2014, p. 18). Prior to this study, a significant amount of literature pointing to the use it or lose it behavior existed; however, most did not quantify the behaviors until this working paper was published. Figure 5 highlights the increased amount of expenditures that occur towards to end of the fiscal year in August and September when compared expenditures occurring from October through July.

Figure 5. Year-End Expenditures Distribution. Source: Fichtner and Greene (2014).



In an effort to alleviate the increased spending trends observed at the end of the fiscal year, which could also lead to lower quality purchases, Fichtner and Greene (2014) propose a roll-over mechanism to time-limited funds as well. This mechanism would figure as what they state is a “carry-over authority [that] allows agencies to move a certain percentage of unspent funds from the fiscal year in which they were appropriated to the subsequent year” (Fichtner & Greene, 2014, p. 18). Fichtner and Greene (2014) quote a study published in a 2003 issue of *Public Budgeting and Finance* in which the authors, McNab and Melese, assert that “carry-over provisions enable departments to achieve cost savings by ‘defeating the use it or lose it behavior associated with control-oriented budgets” (p. 20). Although this roll-over concept may appear seemingly impossible to implement across the DOD, it is important to note that the researchers cite a 1992 appropriations act that authorizes the Department of Justice (DOJ) “to carry over unlimited portions of unobligated balances that remain at the end of the fiscal year into a working capital fund” (Fichtner & Greene, 2014, p. 19). The researchers also take care to note that spikes in end-of-year spending may not be “inherently wasteful, [it] enable[s] executive departments to

manage their budgets without artificial deadlines [and] would likely improve the efficiency of spending by the departments and their subcomponents” (Fichtner & Greene, 2014, p. 25). Although arguments have arisen in some Senate subcommittees on the efficiency of roll-over funds, this model could prove to be of significant impact to the readiness of the U.S. military services while creating an avenue from which to curb end-of-year spending associated with the use it or lose it phenomenon (Fichtner & Greene, 2014, p. 22).

3. Study by Balakrishnan, Soderstrom, and West (2007)

Balakrishnan, Soderstrom, and West (2007) conduct an empirical analysis of the effects of unused funds that would ultimately be reverted to the U.S. Treasury. The research team aims to identify to what extent hospital administrators were stockpiling pharmaceuticals and medical supplies as the end of the fiscal year approached to exhaust all remaining funds in the time-limited budget authority authorized to these organizations. Their study identifies spending patterns that indicate an increase in spending toward the end of the fiscal year and a lull in spending at the beginning of the next. Balakrishnan et al. (2007) not only want to empirically understand the magnitude and impact of spending increases toward the end of the fiscal year; they also set out to “give pause to the argument that a year-end spike in spending is wasteful” (p. 3).

Through a series of hypothesis testing, utilization of descriptive statistics, and multilinear regression modeling analysis, the research team indicates that “a ‘saving-dissaving’ model appears to be at work—managers stock up on resources at year-end and draw them down at the start of the next fiscal year” (Balakrishnan et al., 2007, p. 22). Balakrishnan et al. (2007) term this phenomenon *expense shifting* and observe the highest occurrence in a department with the ability to exercise greater discretion over its spending activities (p. 22). The research team succinctly captures its findings as follows:

Hospital administrators appear to stockpile pharmaceuticals and other supplies toward the end of a fiscal year, leading to a significant spike in spending that potentially exhausts their budget. Interestingly, data show a decline at the start of the next fiscal year that is larger than the preceding spike, indicating that managers build a reserve for later use. The magnitude of the reserve accumulated at the start of a year is reliably persistent across the year and accelerates the upward trend in spending throughout the year. That is, managers increasingly expend the reserve as environmental uncertainty decreases. We

conclude that risk-aversion plays a significant role in determining intra-year trends. (Balakrishnan et al., 2007, p. 1)

In summary, Balakrishnan et al. (2007) discover that there is an increase in spending in end-of-year transactions due to the stockpiling of medical supplies. This is a behavior that is magnified as a result of overly cautious spending in the first three quarters of the fiscal year as managers attempt to navigate through uncertainty as the year progresses. According to the researchers, the intent that most hospital managers and departments have toward the end of the fiscal year is to stockpile medical supplies and pharmaceuticals that they can use at the beginning of the following fiscal year. This behavior, one can argue, also serves the organization well as they hedge against experiencing operational disruptions due to issues like continuing resolutions, which can severely restrict how funding flows down to these activities. Balakrishnan et al. take considerable care not to refer to these spending spikes as wasteful spending. Instead, they propose that these medical facilities essentially starve themselves off resources throughout the fiscal year due to cautious spending. As a result of this behavior, they process a significantly substantial requirements list to replenish discretionary items in preparation for the incoming fiscal year.

B. SPENDING PATTERNS OBSERVED IN THE MARINE CORPS

The literature reviewed in this sections focuses on end-of-year spending patterns within the United States Marine Corps. This section aims to provide existing evidence of existing spending patterns and associated behaviors within the U.S. Marine Corps that support the researcher's hypothesis.

1. Study by Mora (2019)

A Naval Postgraduate School (NPS) thesis by Mora in 2019 analyzes spending patterns associated with secondary repairables (SECREPs) as they pertain to ground logistics in the U.S. Marine Corps. This research identifies spending patterns throughout the fiscal year in a ground logistics setting within the Marine Corps and the associated impact on equipment availability. In addition to the exploratory analysis on spending patterns, Mora (2019) endeavors to identify if the “increased SECREP parts purchases at

the end of fiscal quarter affect service levels at RIPs [Repairable Issue Points] (p. 2).” Mora structures his analysis by grouping weekly obligation amounts by fiscal quarters. Within each quarter, the researcher identifies a “non-hockey stick period,” which consists of the first 2 months in the quarter, and the “hockey stick period,” which consists of the last month in the fiscal quarter (Mora, 2019, p. 13). After identifying positive results in the hockey stick phenomenon across quarters in average weekly expenditures, Mora uses a two-sample t-test on each of the quarters, separating them by hockey stick and non-hockey stick periods.

Upon capturing statistics on the differences depicted by the hockey stick tabulations, the researcher continues to identify the impact of spending on the Marine Expeditionary Force (MEF) Metrics Score Card, a tool utilized by the MEF logistics departments to identify performance across key areas of interest. For purposes of his study, Mora (2019) focuses on what he calls the “SECREP R: Percentage of Total MARES [Marine Corps Automated Readiness Evaluation System] Reportable PEIs [Principal End Items] deadlined with a SECREP on order” metric (p. 21). He assigns score values to the metrics and quantifies their results by way of a “Wilcoxon/Kruskal-Wallis Test [which] is a ‘nonparametric test based on ranks and so is resistant to outliers and does not require normality’” (Mora, 2019, p. 25). This enables the researcher to examine the effects of increased purchases on MEF RIP service levels.

Mora’s (2019) research finds that there is no evidence indicating that increased spending in the fourth quarter of the fiscal year leads to increased readiness levels. Mora concludes that the recommended purchases at the end of the fiscal year are non-critical items that usually have extended lead times. These long-lead-time, non-critical items are mostly canceled in order to make funds available should items of a higher priority become a requirement. Understanding that this is an institutional behavior, Mora (2019) recommends that “the RIP should purchase items with long-enough lead times to enable the leverage of policy on cancellations if higher-priority spending needs arise, but short enough lead times so that the purchases can impact performance in the time frame for which those allocated funds were intended” (p. 37).

2. Study by Okyere-Boateng (2015)

One 2015 NPS thesis includes a trend analysis on the selective interchange of parts between aircraft. Okyere-Boateng (2015) restates the aviation community's definition of this behavior as "cannibalization [which] is the removal of a working or functional component from one aircraft for installation in another non-flyable aircraft" (p. 1). Okyere-Boateng (2015) conducts an analysis to identify differing trends between squadrons and the causes of those trends across time (p. 3). Ultimately, the researcher wants to determine if there is a tie to aircraft availability as a result of cannibalization actions. Okyere-Boateng (2015) concisely summarizes the reason why squadrons cannibalize into four categories: supply system shortages, high operational tempo, high readiness demands, and supply response time (p. 18).

Okyere-Boateng (2015) utilizes an inductive approach to research in order to "identify trends, patterns and differences in the practice of cannibalization between squadrons and over time" (p. 20). He compiles and organizes transactional data received from across 5 fiscal years into pivot tables and utilizes "descriptive statistics, frequency charts, scatter plots, and ratio/percentage analysis ... to establish patterns and variations in cannibalization among the different squadrons, and also analyze the squadron performance on a cannibalization rate basis" (Okyere-Boateng, 2015, p. 21). In an effort to clearly depict the impact of individual components on cannibalizations, the researcher analyzes the top degrading aircraft components by year and the top trending components across fiscal years. He then analyzes the top cannibalized components in a given fiscal year in order to further identify trends that drive or contribute to increased instances of cannibalization actions. Okyere-Boateng (2015) contends that "the underlying rationale for any cannibalization is to improve availability, but [his] research found no significant relationship between cannibalization rates and availability" (p. 84). The methodical approach to the trend analysis conducted in this study creates a methodological template for studies of similar interests such as this one.

C. ORGANIZATIONAL BEHAVIOR EFFECTS ON SPENDING

The purpose of this section is to highlight that organizations are ultimately driven by human interactions and their impact on organizational behaviors and associated processes. Any change implementation as a result of policy recommendations should involve a whole of organization approach. The following study reviewed as part of this literature review chapter is focused on implementing change within the aviation logistics community.

1. Study by Beeson and Ripley (2013)

An NPS study conducted by Beeson and Ripley in 2013 addresses a myriad of qualitative topics that posed as barriers to the modernization of the Marine Aviation Logistics Support Program (MALSP) from MALSP to MALSP II. In their study, the researchers drew upon their collective experiences serving within aviation logistics communities as well as communications with members of the community at large in order to address topics that act as an inhibitor to effect change within the aviation logistics community in the Marine Corps. The study was timely in that it came at a critical point in which aviation logisticians across all levels of the Marine Corps were looking to modernize an aviation logistics support structure that revolves around a heavy footprint when forward-deployed (Bagley, 2015, p. 1). Since their study, the Marine Corps' aviation logistics community has undergone yet another doctrinal change from MALSP II to MALSP Modernization (Office of the Deputy Commandant for Aviation, 2016).

In their chapter on organization barriers, the researchers note that “organizations, as well as humans in general, resist change” (Beeson & Ripley, 2013, p. 29). They propose that humans “want to continue to travel in the same direction propelled by inertia” (Beeson & Ripley, 2013, p. 29). The researchers suggest that when addressing barriers to organizational change, leaders have to address three critical topics as presented in one of their references authored by Giovanni Gavetti in 2005—sticky routines, ingrained culture, and leadership failures (Beeson & Ripley, 2013, p. 30). In order to be successful and ensure positive inertia within the aviation logistics community as it faces change, leaders must address these three elements that act as barriers to change in an organization. Implementing

a change to how leaders conduct business on a day-to-day basis requires a clear vision and a healthy amount of education throughout the chain of command in order to both promote buy-in and facilitate the transition from one way of “doing business” to another. The researchers note that “educating not only the policy-makers but also the tactical subordinates in the trenches will dramatically increase the chances for a successful MALSP II implantation” (Beeson & Ripley, 2013, p. 38). On addressing ingrained culture, the researchers recommend incremental changes. And finally, on addressing leadership failures, the researchers recommend that leaders wholly understand the vision of MALSP II and create opportunities for successful implementation and incentives in support of change implementation (Beeson & Ripley, 2013, p. 41). The researcher of this report proposes that by actively working to overcome the three elements that act as barriers toward the implementation of a new policy or modernization efforts, leaders across the organization can collectively come together under one aligned vision in order to effectuate positive change.

Should the Marine Corps and the Naval Aviation Enterprise want to address the anecdotal end of year spending spikes in order to ensure its spending has a more significant impact on operations as opposed to a superficial target based on fiscal year obligation rates, all stakeholders, collectively, need to recognize the patterns and move to start breaking away from sticky routines. Once patterns are recognized, leaders would, naturally, take steps toward implementing changes that will hopefully translate to increased tangible and intangible benefits of implementing changes that yield positive results.

D. CHAPTER SUMMARY

Increased end-of-year spending is a concern for some federally funded organizations, as suggested by the literature reviewed in this chapter. Liebman and Mahoney (2017) describe the increase in end-of-year spending of federal funds as the use-it-or-lose-it feature of the time-limited budget that is typical of federal government organizations (p. 1). Fichtner and Greene (2014) further expand on the effect of increased end-of-year spending by describing it as “the propensity of US government agencies to spend unused financial resources toward the end of the fiscal year” (p. 3). They continue

to propose the idea of a budget authority with a built-in roll-over feature that would allow organizations to continue to obligate funds under a budget authority beyond its expiry.

Fichtner and Greene (2014) also provide the example of how the DOJ manages its funding by way of a roll-over feature that authorizes the DOJ to continue spending beyond fiscal year time-limit expiration of funding. Balakrishnan et al. (2007) analyze increases in end-of-year spending as Army hospitals stockpile medical supplies prior to the beginning of a new fiscal year. This chapter largely describes end-of-year spending increases observed in organizations external to the U.S. Marine Corps. Mora (2019), however, finds that increased quarterly spending patterns may be related to time-limited obligation targets.

As with any organization, there is a human behavior component that is inextricably linked to organizational behavior. As such, the researcher reviews literature that highlights behavioral patterns that may act as barriers to both change and performance within an organization, as noted in the Beeson and Ripley (2013) study.

According to the existing literature, it appears that the year-end spend phenomenon has been empirically quantified across other federal agencies and even within the Marine Corps, as outlined in Mora's (2019) study. In light of aviation logistics squadrons' increased spending in the fourth quarter of the fiscal year, the literature reviewed in this chapter could serve as a basis for how to best manage this spending pattern to the benefit of the organization.

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IV. METHODOLOGY

This section explains how the data is collected and analyzed in this study and how the researcher employs it to substantiate the problem statement. The sources and data collection subsection describes the sources sought for data exploration. This data is accessible by DOD government employees and service members. The data validation subsection describes how the data is cross-validated with data from parallel reporting sources. The researcher outlines some of the inconsistencies identified within the data and how the researcher addresses the topic of data comparison across multiple fiscal years. The researcher outlines the analytical approach utilized to quantify the responses to the questions of interest in this study. The data analyzed is drawn from NAVAIR's Decision Knowledge Programming for Logistics Analysis and Technical Evaluation (DECKPLATE) project office and COMNAVAIRFOR's Aviation Financial Analyst Support Tool (AFAST). Various organizations like NAVAIR and COMNAVAIRFOR have embarked on varied analyses in an effort to ensure that the public is getting the maximum return on its taxpayer dollars while balancing mission accomplishment. This section lists the data sources and methodology utilized as the basis of analysis aimed at identifying spending trends toward the end of the fiscal year when compared to the rest of the fiscal year.

A. DATA SOURCES

Data sources utilized for this research are VECTOR and DECKPLATE from the NAVAIR DECKPLATE program office. Both of these databases consolidate maintenance and financial information and make it accessible to the aviation logistics community. In addition to these two aforementioned sources of data, the researcher also requests access to the cost databases of COMNAVAIRFOR's AFAST project in support of this study.

The researcher intends to make this a replicable study by utilizing fleet-accessible data from Naval Air Systems Command (NAVAIR), Naval Supply Systems Command (NAVSUP), and COMNAVAIRFOR. The method of analysis presented ahead is replicable

and can be a useful tool in quantifying the effects of anecdotal behaviors that may lead to effectual changes in policy or operational procedures in the future.

1. Type Wing Data Source

The data collection effort for this analysis begins with the CH-53E type wing (T-Wing) tool. The T-Wing tool compiles information from different sources that the maintainers and supply personnel use to track supply/maintenance metrics. This includes the Naval Aviation Logistics Command Management Information System (NALCOMIS) and the Optimized Organizational Maintenance Activity (OOMA) information system. Information drawdowns from these information systems are archived by fiscal year in a Microsoft Access database. This study specifically focuses on a 5-year period for all BCM codes 1–9 compiled into one dataset. This dataset has detailed data by fiscal year for all BCM codes for the CH-53E T/M/S.

2. Decision Knowledge Programming for Logistics Analysis and Technical Evaluation Data Source

Aircraft readiness and tracking indicator rates are extracted out of the DECKPLATE database and compiled based on organization codes for monthly inventory and readiness levels in terms of flight hours and the average number of aircraft in a reporting status out of the total inventory. The Detailed Flight Inventory report is also used from the DECKPLATE system to identify aircraft counts and average flight hours.

3. Naval Supply Systems Command Allowance Data

In coordination with NAVSUP Weapons Systems Support (WSS) points of contact, the researcher obtained all allowances for each MALS on the CH-53E. NAVSUP WSS provided the researcher with a listing that compiled the allowances by national item identification number (NIIN) for each AVDLR that is allowanced to a MALS. These allowances are aggregated by NIIN into the AFAST dataset utilized for this research.

B. DATA MANAGEMENT

The quantity of aggregated data requires that each data source is appropriately documented. Although the data is obtained from authoritative data sources, the researcher

must still be concerned with its validity; the data collected from maintenance activities may, in some instances, capture input data incorrectly. The researcher is also mindful of data evolution and concerns about how data collection in the fleet and its compilation has changed over time.

1. Aggregation of the Data

The data processed from AFAST is organized in a Microsoft Access database by fiscal year. The researcher analyzes data covering a 5-year period from 2016–2020. Once extracted, that data is aggregated in Microsoft Excel and sorted by fiscal year and transaction date. Because the focus of the study is particularly on AVDLRs that have been processed as BCM, the researcher removes all cognizance codes other than the 7R Cog, which is an identifier for aviation depot level repairables. After extracting AVDLRs, the researcher removes all transactions in the data set that are not subject to BCM actions 1–9. In addition to aggregating and processing the AFAST data, the researcher appends (by NIIN) the NAVSUP allowance data received from NAVSUP WSS for each of the MALS with CH-53E allowances. This populates into five columns: MALS-16, MALS-24, MALS-29, MALS-36, and a totals column. Within each fiscal year of the data set, the transactions are listed by calendar-year date. In order to ensure that all of the data in the master aggregated file can be distinguished by fiscal year, the researcher adds an additional column identifying the individual transaction’s fiscal year. The processed data set results in 37,911 instances of components processed from BCM over a period of 5 years.

2. Data Normalization

A focal point of this study revolves around financial expenditures with respect to AVDLRs. Understanding that these data cover a period of 5 fiscal years, the researcher believes it prudent to normalize the by-item charges to the MALS in an effort to standardize dollar-to-dollar comparisons across all fiscal years. The Naval Center for Naval Analysis (NCCA) maintains a Joint Inflation Calculator (JIC), which proves to be an effective tool in identifying the inflation factor by lines of appropriation. The researcher incorporates the inflation factors by fiscal year into the aggregated data and normalizes those costs to conform to 2020 constant year dollars, which, according to Mislick and Nussbaum (2015),

“reflect the purchasing power or value of the dollar in the specified constant fiscal year” (p. 88). This effort to normalize costs across fiscal years enables the researcher to make comparisons by fiscal years without the need to adjust for factors of inflation later in the process. Data normalization is significantly useful to this analysis, as it ensures consistency throughout the analysis.

3. Data Organization

Processing a large amount of data without a way to organize it can prove challenging. The researcher makes effective use of Excel pivot tables to extract the sum total of prices and ages of transactions organized by fiscal-year months and also fiscal-year weeks. The researcher also determines that the period of interest for the analysis begins 15 days before the end of the fiscal year and utilizes the pivot table to extract pertinent information to facilitate follow-on analyses. Fiscal years 2016 and 2020 also happen to be leap years. The researcher takes note of the additional day in both of these years and accounts for it while analyzing the data. The researcher creates graphical representations of the data to visually identify areas of increased spending and age of transactions. Next, the researcher conducts statistical tests to determine if the graphical representations indicate any trends that may lead to statistical significance.

4. Data Anomalies

The fiscal year 2019 AFAST database did not capture transactions conducted in the month of September. Because the researcher is analyzing the end-of-year period by comparing it to the rest of the fiscal year, it follows that analysis of this month in fiscal year 2019 would provide inaccurate results. Given the analysis’ methodological structure, the researcher opts to omit fiscal year 2019 from this study.

C. METHODS OF ANALYSIS

This research presents a series of questions that aim to identify how much the Marine Corps spends on AVDLRs at the end of the fiscal year when compared to the rest of the year in addition to patterns that may be associated with the priority of the requirements. Given the research questions, this study uses a deductive approach to

research the magnitude of the difference in spending between the test periods; this difference in spending is also linked to how the MALS spends money in support of aviation operations on the flight line. The following methods are utilized in this study to ascertain if any relationships between the magnitude and types of spending exist, followed by the appropriate test for statistical significance.

1. Hockey Stick Phenomenon

A hockey stick phenomenon indicates that work pace increases exponentially resulting in “higher sales (and sales effort) towards the end of the incentive period” (Sohoni et al., 2010, p. 503). For the purposes of the analysis, the measure of “work” is based on a two-pronged approach. The response variables are both on transaction cost and time the component is awaiting maintenance before being processed as BCM. The researcher refers to the test period as the hockey stick period. The researcher intends to graphically depict end-of-year effects that indicate the behavior of BCM trends as the deadline approaches, relative to the remainder of the fiscal year.

2. Hypothesis Testing

The method that is utilized to test the researcher’s hypotheses is a Two-Sample t-Test with unequal variances. Given the structure of the questions being asked, the researcher intends to test end-of-year patterns against rest-of-year patterns. It follows that the number of observations in the rest of the year are larger than the number of observations during the hockey stick period. The test for significance may yield a *p*-value that falls within the t-distribution and outside of the rejection region for a one-sided t-test, in which case the researcher would reject the notion that there is a large enough difference in both spending and age of the requisitions given that it proves to not be statistically significant.

Hockey stick effects are identified between samples by comparing mean differences between the samples along with the t-statistic. The significance level lends perspective to the test as to whether or not the differences observed by comparison are statistically significant. A negative t-statistic initially indicates that there is a hockey stick effect toward the end of the fiscal year. The statistical significance of the hockey stick

effect is determined by whether or not the one-sided p -value falls above or below an alpha of .05 that is constant throughout the study.

3. Standard Score Conversion

Converting the data to a standard score (z-score) allows the researcher to make comparisons between two normal distributions. By converting to a z-score, the researcher is able to set the mean of the sample distribution to 0 and the standard deviation to 1, thereby organizing each individual observation's score relative to how far it deviates from the sample mean. This allows for a cleaner presentation and relative comparison between samples by way of statistical hypothesis testing. The researcher takes caution to convert the cost and age variables into z-scores in the event that these are required at any point through this analysis. For purposes of this study, the z-scores are obtained by calculating the average price and average age of both the hockey stick period and the rest of the fiscal year samples, as well as their associated standard deviations. Once the means and standard deviations are calculated, the researcher proceeds to calculate the z-score for each observation by subtracting the mean from each observation and dividing by the sample standard deviation. This leads to a z-score conversion to be utilized as an alternative approach to the analysis.

The z-score allows the researcher to equalize cost and age across the samples and compare the slopes of each sample. This approach enables the researcher to measure the steepness of the slope during the hockey stick period compared to the non-hockey stick period.

D. ANALYSIS APPROACH

The researcher opts to analyze each fiscal year individually as opposed to pooling the data across fiscal years. As a result, a t-test is run for each fiscal year independently. Each result is assessed via a measure of overall support in favor of the alternative hypothesis. Table 2 describes the method of assessment utilized to established levels of support in favor of the hypothesis.

Table 2. Multi-Year Levels of Support Criteria

Support Criteria		Levels of Support to the Alternative Hypothesis
Fiscal Years	4 of 4	Strong Support
	3 of 4	Moderate Support
	2 of 4	Mixed Support
	<=1 of 4	No Support

These levels of support highlight the number of years analyzed that support the alternative hypothesis that there is a difference in means that is statistically significant. This criterion allows for the interpretation of the individual tests conducted for each fiscal year as a method to overcome the notion that chance alone could yield support in favor of the alternative hypothesis in any one single year. By establishing levels of support as they pertain to the alternative hypothesis, the researcher aims to highlight trends across fiscal years.

1. Research Question 1: Cost Differences in BCMs

The hockey stick period of interest is the last 15 days of the fiscal year. As such, the researcher divides the data into two samples. The samples tested are composed of the last 15 days of the fiscal year and all other days of the fiscal year. As outlined in Table 3, the researcher defines the conduct of the t-test in support of identifying cost differences between periods.

Table 3. End-of-Year Cost Comparison Method

Average Total Cost			
FY	Variable Description	Test Period	Expected Result
2016	Non-Hockey Stick Period	Days 1-350	
	Hockey Stick Period	Last 15 Days	+
2017	Non-Hockey Stick Period	Days 1-350	
	Hockey Stick Period	Last 15 Days	+
2018	Non-Hockey Stick Period	Days 1-350	
	Hockey Stick Period	Last 15 Days	+
2020	Non-Hockey Stick Period	Days 1-350	
	Hockey Stick Period	Last 15 Days	+

The Expected Result column in Table 3 is utilized to describe the direction of the expected outcome of the hockey stick period when compared to the non-hockey stick period. By utilizing a directional hypothesis, the actual results can more readily be compared to the expected results to ascertain whether or not the hypothesis is supported by the analysis. The researcher performs a one-sided Two-Sample t-Test assuming unequal variances on the costs of these two samples in order to determine the size of the hockey stick effect and its statistical significance.

2. Research Question 2: Age Differences in BCMs

In conducting this study, the researcher aims to ensure consistency throughout the analytical approach. As a result, the approach for Research Question Two varies only in the variable being analyzed. The hockey stick period of interest is the last 15 days of the fiscal year, and the researcher divides the data into samples. Table 4 lists the variables and test periods utilized in support of the t-test for end-of-year to rest-of-year BCM age comparison.

Table 4. End-of-Year Age Comparison Method

Average Age Awaiting Maintenance Prior to BCM			
FY	Variable Description	Test Period	Expected Result
2016	Non-Hockey Stick Period	Days 1-350	
	Hockey Stick Period	Last 15 Days	+
2017	Non-Hockey Stick Period	Days 1-350	
	Hockey Stick Period	Last 15 Days	+
2018	Non-Hockey Stick Period	Days 1-350	
	Hockey Stick Period	Last 15 Days	+
2020	Non-Hockey Stick Period	Days 1-350	
	Hockey Stick Period	Last 15 Days	+

A one-sided Two-Sample t-Test is also conducted, this time focusing on the age of each observation as opposed to the cost. The Two-Sample t-test yields the mean differences and t-statistic of the average age between samples as well as its statistical significance. The level of support for this aspect of the analysis is described in Table 2.

3. Research Question 3: Priority and Project Code Differences by Cost

Similar to the first two research questions, the researcher seeks to quantify differences between hockey stick and non-hockey stick periods by analyzing if there is any statistical significance associated with the comparison of hockey stick and non-hockey stick periods as it pertains to levels of priority and project codes.

a. Issue Priority Approach

As outlined in the UMMIPS order, the purpose of priorities is to serve as a “system for allocating materiel and other logistics resources among competing demands” (U.S. Marine Corps, 2010, Enclosure 1). For purposes of this study, the researcher divides the yearly data into two samples. The researcher classifies the first sample as “High Priority,” as it includes all priorities that fall under Urgency of Need Designator (UND) category “A.” The second sample contains the “Low Priorities,” which include all priorities that fall under UND categories “B” and “C.” By categorizing the data in this fashion, the researcher is able to collect descriptive statistics on both samples and conduct a t-test between

samples. Table 5 outlines the methodological approach the researcher takes in testing for differences between priority levels within both periods.

Table 5. Priority Level Comparison Method

Weekly Average Cost by Priority Levels					
FY	Variable Description	Level of Priority	Test Period	T-Test Samples	Expected Result
2016	Non-Hockey Stick Period	High Priority	Weeks 1-50	Weekly Mean Difference	
		Low Priority			
	Hockey Stick Period	High Priority	Last 2 Weeks	Weekly Mean Difference	-
		Low Priority			
2017	Non-Hockey Stick Period	High Priority	Weeks 1-50	Weekly Mean Difference	
		Low Priority			
	Hockey Stick Period	High Priority	Last 2 Weeks	Weekly Mean Difference	-
		Low Priority			
2018	Non-Hockey Stick Period	High Priority	Weeks 1-50	Weekly Mean Difference	
		Low Priority			
	Hockey Stick Period	High Priority	Last 2 Weeks	Weekly Mean Difference	-
		Low Priority			
2020	Non-Hockey Stick Period	High Priority	Weeks 1-50	Weekly Mean Difference	
		Low Priority			
	Hockey Stick Period	High Priority	Last 2 Weeks	Weekly Mean Difference	-
		Low Priority			

A t-test in this instance determines if any measure of statistical significance between the magnitude of the difference in means of hockey stick and non-hockey stick periods exists between UND A and UND B/C categories. This process is conducted by cost and age for each fiscal year being analyzed. The level of support for this aspect of the analysis is described in Table 2.

b. Project Code Approach

Similar to the priority approach, the researcher divides the yearly data into two samples. The first sample contains high visibility project codes as determined by the researcher: AK0/706, AK7/707, and ZA9. The second sample contains all other project codes deemed to be non-high-visibility by the researcher for purposes of this study. By categorizing the data in this fashion, the researcher is able to collect descriptive statistics

on both samples and conduct a t-test between samples. Similar to Table 5, Table 6 outlines the approach the researcher takes to test differences in project codes between both periods.

Table 6. Project Code Comparison Method

Weekly Average Cost by Project Codes					
FY	Variable Description	Project Code	Test Period	T-Test Samples	Expected Result
2016	Non-Hockey Stick Period	High Visibility	Weeks 1-50	Weekly Mean Difference	
		Low Visibility			
	Hockey Stick Period	High Visibility	Last 2 Weeks	Weekly Mean Difference	-
		Low Visibility			
2017	Non-Hockey Stick Period	High Visibility	Weeks 1-50	Weekly Mean Difference	
		Low Visibility			
	Hockey Stick Period	High Visibility	Last 2 Weeks	Weekly Mean Difference	-
		Low Visibility			
2018	Non-Hockey Stick Period	High Visibility	Weeks 1-50	Weekly Mean Difference	
		Low Visibility			
	Hockey Stick Period	High Visibility	Last 2 Weeks	Weekly Mean Difference	-
		Low Visibility			
2020	Non-Hockey Stick Period	High Visibility	Weeks 1-50	Weekly Mean Difference	
		Low Visibility			
	Hockey Stick Period	High Visibility	Last 2 Weeks	Weekly Mean Difference	-
		Low Visibility			

As in the case of priority levels, a t-test in this instance determines if any measure of statistical significance between the magnitude of the difference in means of the hockey stick and non-hockey stick periods exists between high-visibility project codes and all other project codes. This process is conducted twice for each fiscal year to account for cost and age. The level of support for this aspect of the analysis is described in Table 2.

4. Research Question 4: Age Differences between Completed Transactions

The final research question focuses on the time it takes for a transaction to be completed after the component is processed as BCM. This indicates that the replacement RFI component was received by the MALS, and the transaction was completed out. The researcher calculates the difference in time elapsed per observation by subtracting the date of the completed transaction from the date of the BCM transaction. The researcher then

conducts a t-test between the hockey stick period of the closing fiscal year with the non-hockey stick period of the following fiscal year to determine the differences in time elapsed until an RFI asset is received between requirements, processed as BCM during the hockey stick period, and the rest of the incoming fiscal year, minus the observations that fall within its hockey stick period. Table 7 outlines the approach the researcher takes in composing a test of age differences in completed requisitions between both test periods.

Table 7. Completed Requisition Age Comparison Method

Average Age to RFI Receipt After BCM Transaction			
FY	Variable Description	Test Period	Expected Result
2016	Hockey Stick Period	Last 15 Days	+
2017	Non-Hockey Stick Period	Days 1-350	
2017	Non-Hockey Stick Period	Days 1-350	+
2018	Hockey Stick Period	Last 15 Days	
2018	Non-Hockey Stick Period	Days 1-350	+
2019	Hockey Stick Period	Last 15 Days	

This analysis is forward-looking in that the researcher concatenates the hockey stick period of one fiscal year with the non-hockey stick period of the following fiscal year in order to quantify the differences in time elapsed between completions across the samples being tested. The researcher conducts this process for four out of the five fiscal years in the data set. The level of support for this aspect of the analysis is described in Table 2.

E. STUDY LIMITATIONS

This study only focuses on AVDLR components identified by a 7R Cognizance Code. It excludes other cognizance codes from the analysis. Spending patterns in consumable components may yield different results than what this study suggests are results for AVDLR components. However, consumable components are out of scope for this study; a follow-on study on this aspect of spending at a MALS can prove to be beneficial in identifying patterns of interest to the AVLOG community.

Additionally, this study only analyzes the cost incurred by a MALS as a result of BCM action. It does not take into account the costs avoided by a MALS based on the AVDLR components that were successfully repaired at the IMA and returned to the RFI pool. Each time a component that is inducted into the IMA is repaired, the RFI component returns to the supply officer stores. The successful repairs conducted at the IMA translate to cost savings for the MALS, given that the successful repair does not result in BCM action and subsequent repair costs. In order to place the overall spending of a MALS into context, there needs to be the opposite measure of overall cost savings as a result of actions related to components that are successfully repaired at the I-Level.

Each MALS may have different repair capabilities as determined by their Individual Components Repair List (ICRL). Each MALS has an ICRL that is constantly updated depending on capabilities it might gain or lose throughout the fiscal year. This research did not have access to the specific capability to repair per component. As such, there are instances in the data where AVDLR components were processed as BCM because the IMA had no ability or limited ability to repair. Capability to repair some components can differ between MALSs depending on the resources, personnel, and equipment they might have available at any given time. Each MALS is unique, to some degree, in its capability sets. A between-MALS comparison may allow the researcher to control for differences between MALSs in order to analyze trends in spending and formulate a sound cross-MALS comparison approach that aims to identify the true differences in spending patterns across MALSs. The researcher recognizes this as a limitation of this study, but its inclusion may add unexplained variance that would increase the complexity of results interpretation. In sum, though the lack of cross-MALS comparison may appear to be a limitation of this study, it also serves as an opportunity to support instances where mixed or moderate support for the hypothesis may exist.

Finally, due to scope consideration, this study particularly focuses on the CH-53E aircraft platform in the Marine Corps' inventory. Results of the analysis may vary if the scope of the analysis is expanded to include additional T/M/S aircraft. The results presented in the analysis section may be specific to the CH-53E. Should this analysis be expanded, there is a potential that cross-platform comparisons may yield varied results.

F. CHAPTER SUMMARY

This chapter outlines the methodological approach that the researcher undertakes. The chapter begins with identifying the sources of the data and the data aggregation process. Importantly, the researcher outlines the data normalization process undertaken to be able to accurately compare analyses across fiscal years. The researcher outlines the analytical approach for each question in sequence, as they are presented in the introduction chapter. Within each section describing the analytical approach, the researcher describes the variables utilized for the analysis and how they are categorized. Lastly, the researcher identifies a limitation of the study as it pertains to the assessment of individual repair capabilities across MALSSs.

V. DATA ANALYSIS

This chapter focuses on the presentation of the analysis conducted on the processed dataset discussed in Chapter IV. The analysis focuses on a 5-year period from 2016–2020. As noted in the Methodology chapter, for purposes of this analysis, the researcher omits fiscal year 2019 because data for the hockey stick period is not available in the AFAST tool. The researcher aims to measure whether there are any significant differences between the hockey stick and non-hockey stick periods described in Chapter IV. The analysis in this section is constructed in the R software environment utilized for statistical computing.

A. RESEARCH QUESTION 1 RESULTS

The first research question proposed as part of this analysis introduces the notion that there are anecdotal spending increases toward the end of the fiscal year. The researcher identifies the end of the fiscal year hockey stick period as the last 15 days of the fiscal year and proceeds to compare the prices of the samples from the last 15 days of the fiscal year to the remainder of the cost for AVDLR transactions occurring throughout the rest of the fiscal year. The AFAST tool for 2019 notes that it does not cover the month of September 2019, as that data was not available at the time that the database was compiled. For purposes of this analysis, the researcher omits fiscal year 2019. The researcher proceeds to test both sample periods to ascertain whether or not the difference in means is statistically significant. Table 8 presents the results of the Two-Sample t-tests conducted between the end-of-year spending period when compared to the rest-of-year spending period for fiscal years 2016 through 2018 and 2020. Additionally, Table 8 highlights the overall level of support for the alternative hypothesis.

Table 8. BCM Cost Differences between Test Periods

	<i>Welch Two-Sample t-test:</i>			
	BCM Cost Comparison Between Periods			
	FY 2016	FY 2017	FY 2018	FY 2020
	(1)	(2)	(3)	(4)
Hockey-Stick Period Mean	27,904	31,818	37,231	65,568
Non-Hockey-Stick Period Mean	34,389	35,932	37,654	40,412
Test statistic	1.634	0.572	0.036	-1.87
DF	442.4	340.5	291.5	404.7
p value	0.9485	0.7161	0.514	0.031*
Alternative hypothesis	less	less	less	less
Multi-Year Level of Support:	<i>No Support</i>			
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			

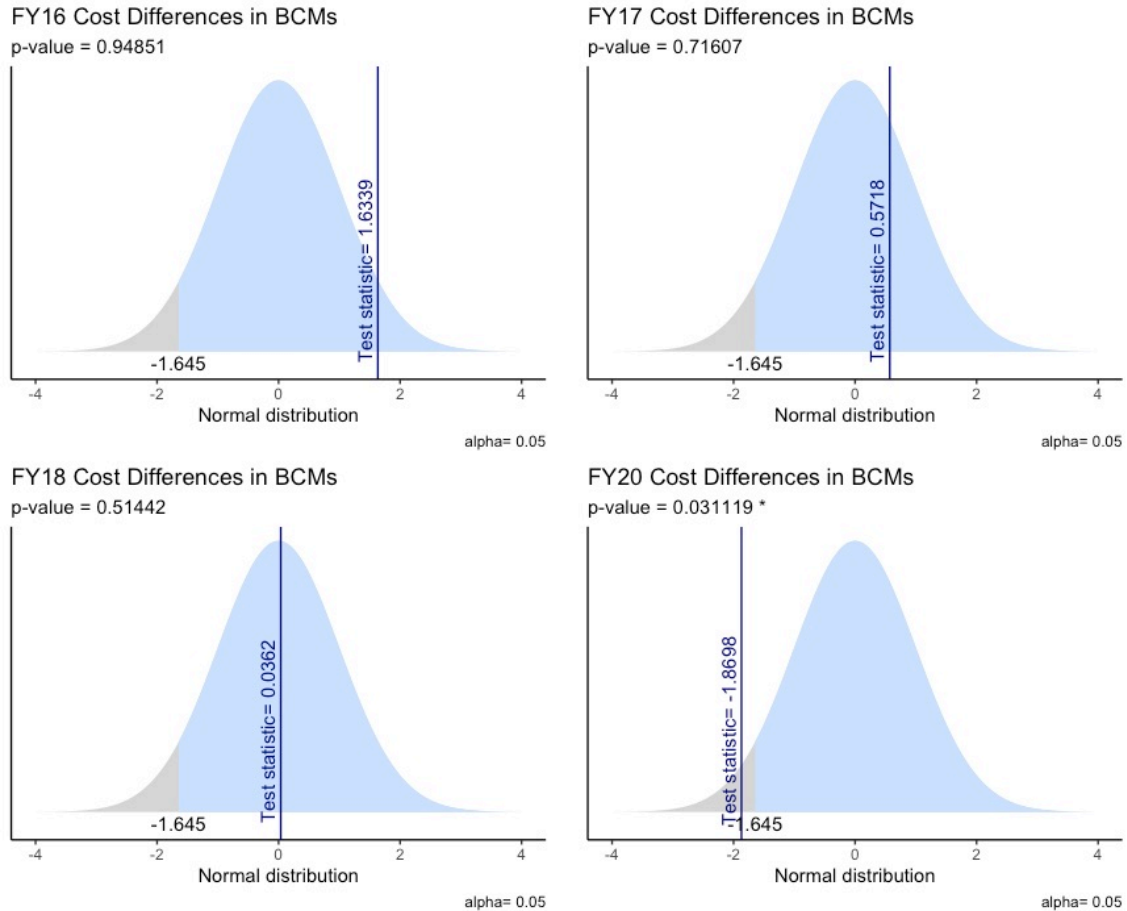
The mean transaction costs for the test periods are highlighted in Table 8. During the hockey stick period of fiscal year 2016, the average transaction cost totaled \$27,904. By comparison, the non-hockey stick period's average transaction cost totaled \$34,389. This results in a mean difference of \$6,485 between both samples. By contrast, the mean difference between both samples in fiscal year 2020 results in a difference of (\$25,157). This negative mean difference is commensurate with the negative t-statistic of -1.87 in the direction of the hypothesis.

With the exception of the t-statistic for fiscal year 2020, all reported t-statistics are positive, indicating that the average spending in the non-hockey stick period is larger than that of the hockey stick period. Although the t-statistic is positive, the results indicate that the mean comparisons between both periods are not statistically significant in fiscal years 2016 through 2018, as indicated by their respective *p*-values. However, the t-statistic for fiscal year 2020 is -1.87 and is statistically significant as indicated by its respective *p*-value. Fiscal year 2020 is the only year that indicates support in favor of the alternative hypothesis.

The findings in this section indicate that there are no statistically significant differences between test periods across each of the fiscal year t-tests. Figure 6 graphically

presents the results of each of the tests in a distribution along with the associated statistics necessary to visually process the results.

Figure 6. Graphical Summary of BCM Costs



Each one of the fiscal year tests falls outside of the rejection regions shaded in grey, with the exception of fiscal year 2020. Although the test statistic for fiscal year 2020 falls inside of the rejection region, it is important to note that according to the support criteria outlined in Table 2, these tests indicate that there is no consistent support for the notion that end-of-year spending increases toward the end of the fiscal year when compared to rest-of-year spending on AVDLRs in support of aviation operations.

B. RESEARCH QUESTION 2 RESULTS

The second research question aims to identify if there are significant differences in the time that a component is inducted into the maintenance at the IMA until it is processed as BCM between the hockey stick and non-hockey stick periods. The researcher refers to the amount of time a component is in an awaiting status prior to BCM. This aspect of the study amplifies behaviors that may be related to how the MALS prioritizes its requirements processing throughout the fiscal year. As indicated in the previous section, the AFAST tool for 2019 notes that it does not cover the month of September 2019, as that data was not available at the time that the database was compiled. For purposes of this analysis, the researcher omits fiscal year 2019. The researcher proceeds to test both sample periods to ascertain whether or not the difference in means is statistically significant. Table 9 presents the results of the Two-Sample t-tests conducted between the end-of-year hockey stick period when compared to the rest-of-year non-hockey stick period for fiscal years 2016 through 2018 and 2020. Additionally, Table 9 highlights the overall level of support for the alternative hypothesis.

Table 9. BCM Age Differences between Test Periods

	<i>Welch Two-Sample t-test:</i>			
	BCM Age Comparison Between Periods			
	FY 2016	FY 2017	FY 2018	FY 2020
	(1)	(2)	(3)	(4)
Hockey-Stick Period Mean	49.8	65.29	58.95	86.34
Non-Hockey-Stick Period Mean	37.18	36.28	38.61	48.16
Test statistic	-2.324	-5.261	-4.143	-6.938
DF	289	307.1	291.3	413.4
p value	0.0104*	0.0000***	0.0000***	0.0000***
Alternative hypothesis	less	less	less	less
Multi-Year Level of Support:	<i>Strong Support</i>			
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			

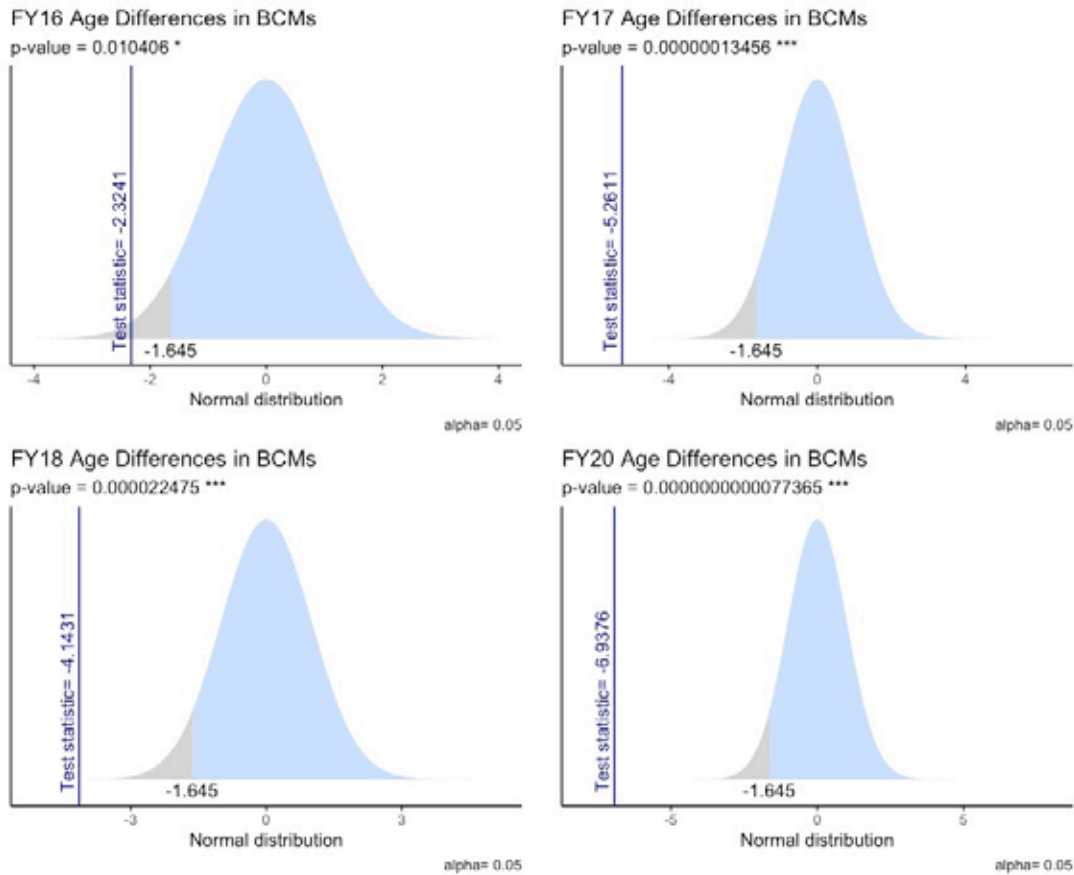
The mean transaction days elapsed until BCM processing for the second research question are highlighted in Table 9. During the Hockey-Stick period of fiscal year 2016, the average transaction age totaled 49.8 days. By comparison, the non-hockey stick period's average transaction age totaled 37.18. This results in a mean difference of (12.62) days between both samples. This pattern repeats itself for the remaining fiscal years tested in this analysis, resulting in negative mean differences that are commensurate with the negative t-statistics in support of the hypothesis.

The t-statistic is negative across all fiscal years, indicating that the average number of days awaited prior to BCM of the component in the hockey stick period is larger than that of the non-hockey stick period. Along with the reported negative t-statistics, the results indicate that the mean comparisons between both periods are statistically significant across all fiscal years, as indicated by their respective *p*-values. In sum, age differences between both samples tested are significant enough that they indicate support for the notion that AVDLR components processed as BCM toward the end of the fiscal year have, in fact, been in an awaiting maintenance status longer than AVDLR components processed as BCM throughout the rest of the fiscal year. These results indicate that the findings may be inaccurate 0.1% of the time given a significance level of .001 (as indicated by the triple

asterisk in Table 9), with a probability of this occurring 0% of the time as indicated by the p -value. Given the small p -values obtained across the fiscal years, no multiple comparison protection was deemed necessary.

The findings in this section indicate that there are statistically significant differences between test periods in each of the fiscal year t -tests. Figure 7 graphically presents the results of each of the tests in a distribution along with the supporting statistics necessary to visually process the results.

Figure 7. Graphical Summary of BCM Age Differences



For each of the fiscal years analyzed in this section of the analysis, it is evident that there are statistically significant differences in the age of components that are processed as BCM at the end of the fiscal year when compared to the rest of the fiscal year. There is

sufficient evidence to indicate that a common behavior across the MALSS is to BCM components that have been pending maintenance for a significant amount of time when compared to the rest-of-year BCM transactions. This supports the notion that the MALSS are processing older components for BCM action at the end of the year in an effort to clear out components that have long lead times for their awaiting parts, or there is insufficient manpower or capability to repair these components throughout the fiscal year. Importantly, according to the support criteria outlined in Table 2, these tests indicate that there is strong multi-year support that is consistent with the notion that end-of-year components being processed as BCM are significantly aged compared to components processed throughout the rest of the fiscal year.

C. RESEARCH QUESTION 3 RESULTS

The third research question explores differences in both priority levels and project codes initially assigned to components that have ultimately been processed as BCM. The going-in assumption revolves around the notion that there may be a difference between the requirement priorities or project codes that receive close attention on readiness reports.

1. Priority Level Analysis

As discussed in the Methodology chapter, the researcher conducts two separate analyses in this section of the study. The priority level analysis compares differences between requirements of priority levels 02 and 03 with requirements of priority levels 05 and 06 both in end-of-year BCM processing and rest-of-year BCM processing. Similar to the previous sections, the researcher omits fiscal year 2019. The researcher proceeds to test both sample periods to ascertain whether or not the difference in means is statistically significant. Table 10 presents the results of the Two-Sample t-tests conducted between the end-of-year spending period and the rest-of-year spending period for fiscal years 2016 through 2018 and 2020 by the priority levels as described in Chapter IV. Additionally, Table 10 highlights the overall level of support for the alternative hypothesis as outlined in Table 5.

Table 10. BCM Priority Level Differences between Test Periods

	<i>Welch Two-Sample t-test:</i>			
	BCM Priority Level Comparison Between Periods			
	FY 2016	FY 2017	FY 2018	FY 2020
	(1)	(2)	(3)	(4)
Hockey-Stick Period Mean	(32,806)	(20,900)	29,098	34,269
Non-Hockey-Stick Period Mean	(29,930)	(6,238)	(13,713)	333
Test statistic	0.072	0.3985	-1.305	-1.275
DF	1.5	1.08	1.4	1.45
p value	0.475	0.377	0.819	0.815
Alternative hypothesis	greater	greater	greater	greater
Multi-Year Level of Support:	<i>No Support</i>			
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			

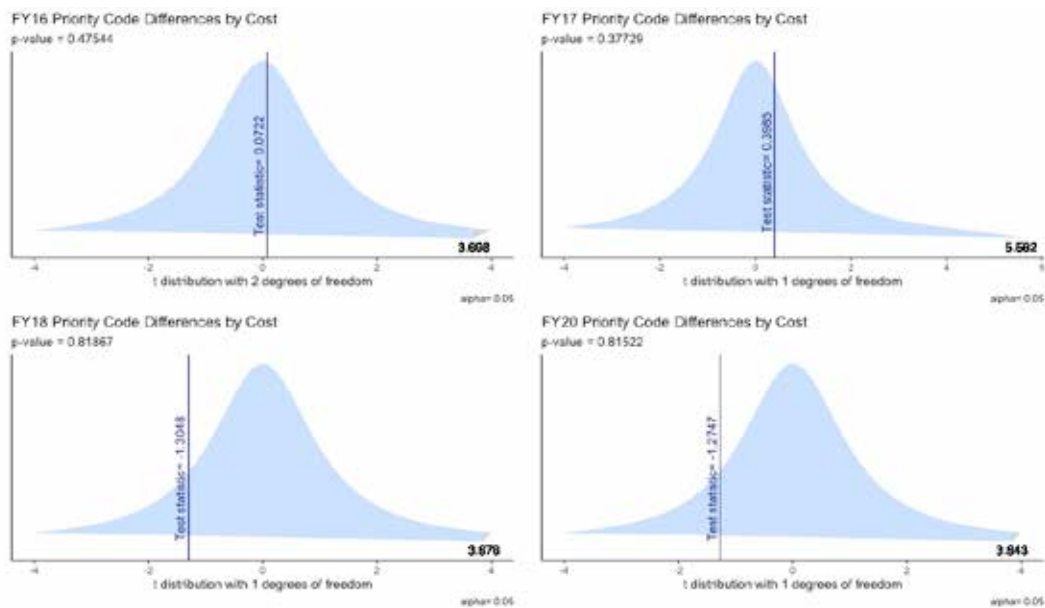
The mean transaction costs for the test periods are highlighted in Table 10. During the hockey stick period of fiscal year 2016, the average difference in transaction cost between high-priority and low-priority requirements totaled (\$32,806). By comparison, the non-hockey stick period's average difference in transaction cost totaled (\$29,930). This results in a mean difference of \$2,876 between both samples. By contrast, the mean difference between both samples in fiscal years 2018 and 2020 results in a difference of (\$42,811) and (\$33,936), respectively. These negative mean differences are commensurate with the negative t-statistics in the direction of the hypothesis.

The t-statistic for fiscal years 2016 and 2017 is slightly positive, indicating that the average spending in the non-hockey stick period is slightly larger than in the hockey stick period. However, the t-statistic for fiscal years 2018 and 2020 is negative, indicating that the average spending in the hockey stick period is larger than in the non-hockey stick period. Given that two out of four test statistics point in the direction of the alternative hypothesis and the other two fiscal years point away from the alternative hypothesis, early indications suggest that there may be multi-year mixed support. However, the results indicate that the mean comparisons between both periods are not statistically significant, as indicated in each year's respective *p*-value. In accordance with the multi-year criteria listed in Table 2, none of the hypothesis tests for differences in priority levels indicate

support for the notion that there is a difference in means between components that are processed as BCM based on priority levels.

The findings in this subsection indicate that there are no statistically significant differences between test periods in each of the fiscal year t-tests. Figure 8 graphically presents the results of each of the tests on a distribution along with the supporting statistics necessary to visually process the results.

Figure 8. Graphical Summary of BCM Differences in Levels of Priority



Given the weekly comparison between the hockey stick and non-hockey stick periods, there is no evidence that indicates there are differences in how requirements are processed as BCM based on priority levels.

2. Project Code Analysis

The project code analysis compares differences between requirements identified as high visibility with requirements that are identified as low visibility according to Table 6. Similar to the previous sections, the researcher omits fiscal year 2019. The researcher proceeds to test both sample periods to ascertain whether or not the difference in means is

statistically significant. Table 11 presents the results of the Two-Sample t-tests conducted between the end-of-year spending period when compared to the rest-of-year spending period for fiscal years 2016 through 2018 and 2020 by the project code categories discussed in Chapter IV. Additionally, Table 11 highlights the overall level of support for the alternative hypothesis as outlined in Table 6.

Table 11. BCM Project Code Differences between Test Periods

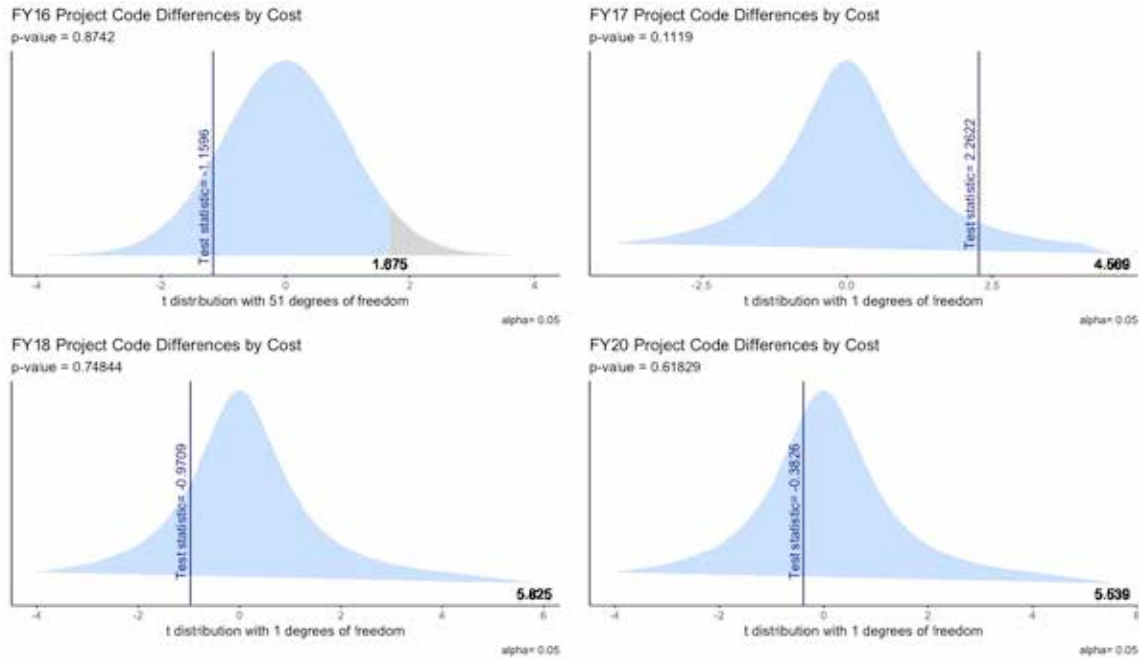
	<i>Welch Two-Sample t-test:</i>			
	BCM Project Code Comparison Between Periods			
	FY 2016	FY 2017	FY 2018	FY 2020
	(1)	(2)	(3)	(4)
Hockey-Stick Period Mean	7,942	(19,995)	35,335	2,979
Non-Hockey-Stick Period Mean	(10,180)	8,751	1,212	(5,074)
Test statistic	-1.16	2.262	-0.971	-0.383
DF	5.98	1.25	1.05	1.08
p value	0.874	0.112	0.748	0.618
Alternative hypothesis	greater	greater	greater	greater
Multi-Year Level of Support:	<i>No Support</i>			
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			

The mean transaction costs for the test periods are highlighted in Table 11. The findings indicate that during the hockey-stick period of fiscal year 2016, the average difference in transaction cost between high-visibility project codes and low-visibility project codes totaled \$7,942. By comparison, the non-hockey stick period's average difference in transaction cost totaled (\$10,180). This results in a mean difference of (\$18,122) between both samples. A similar pattern is observed for fiscal years 2018 and 2020 in the direction of the hypothesis. By contrast, the mean difference between both samples in fiscal years 2017 results in a cost difference of \$28,746. This positive mean difference is commensurate with the positive t-statistic in the opposing direction of the hypothesis.

With the exception of fiscal year 2017, the t-statistic for fiscal years 2016, 2018, and 2020 is negative, indicating that the average spending in the non-hockey stick period is slightly larger than in the hockey stick period based on project code visibility levels. The going-in notion is that there is an increase in spending on low priority requirements toward the end of the fiscal year; however, the results do not corroborate this assertion. The results indicate that the mean comparisons between both test periods are not statistically significant, as indicated by each year's respective *p*-value. In accordance with the multi-year criteria listed in Table 2, none of the hypothesis tests for differences in project codes indicate support for the notion that there is a difference in means between components that are processed as BCM based on their level of visibility.

The findings in this subsection indicate that there are no statistically significant differences between test periods in each of the fiscal year t-tests. Figure 9 graphically presents the results of each of the tests on a distribution along with the supporting statistics necessary to visually process the results.

Figure 9. Graphical Summary of BCM Differences between Project Codes



Given the weekly comparison between the hockey stick and non-hockey stick periods, there is no evidence that indicates there are differences in how requirements are processed as BCM between high-visibility and low-visibility project codes. Fiscal years 2016, 2018, and 2020 indicate a negative t-statistic, which highlights a slight difference in components that are processed as BCM based on project codes at the end of the fiscal year when compared to the rest of the year. Given the weekly comparison between the hockey stick and non-hockey stick periods, there is no evidence that indicates there are differences in how requirements are processed as BCM based on the level of visibility as determined by the project codes outlined in Chapter IV.

D. RESEARCH QUESTION 4 RESULTS

The purpose of the fourth research question is to determine if there are any significant differences in the requirements fulfillment process at the end of the fiscal year when compared to requirements fulfillment through the rest of the fiscal year. As presented in Chapter IV, the researcher initiates the analysis with the resulting transactional date difference, in days, from the time that a component is processed as BCM until the time

outgoing replenishment requisition is completed. The first end-of-year hockey stick period for this analysis begins with fiscal year 2016 and is compared to the non-hockey stick period of the following fiscal year. As such, this period is denoted as FY [fiscal year] 2016–17. Similar to the foregoing analyses, the researcher omits the fiscal year 2019–2020 analysis from this section due to the fact that transactions that occur in September 2019 are not available within the AFAST database. Table 12 presents the results of the Two-Sample t-tests conducted between the end-of-year transaction age and the rest-of-year transaction age as described in Table 7. Additionally, Table 12 highlights the overall level of support for the alternative hypothesis as outlined in Table 2.

Table 12. BCM Completed Transaction Age Differences

	<i>Welch Two-Sample t-test:</i>		
	BCM Completed Transactions		Comparison
	FY 2016-17	FY 2017-18	FY 2018-19
	(1)	(2)	(3)
Hockey-Stick Period Mean	92.17	40.87	18
Non-Hockey-Stick Period Mean	87.15	94.04	98.08
Test statistic	-0.338	5.795	7.608
DF	313.8	337.2	1.23
p value	0.367	0.999	0.9722
Alternative hypothesis	less	less	less
Multi-Year Level of Support:	<i>No Support</i>		
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01		

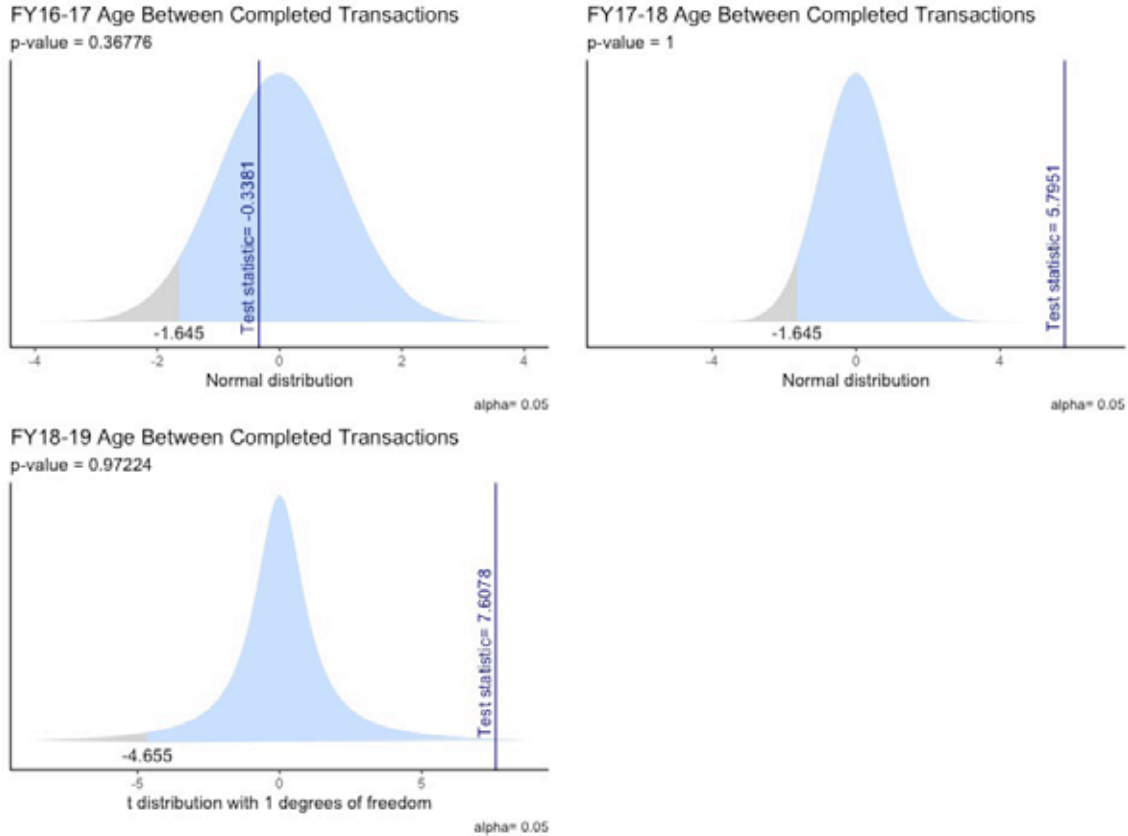
In this particular scenario, a negative t-statistic result indicates that there is some degree of support for the alternative hypothesis given the notion that there is an increase in the number of days to complete a transaction occurring towards that end of the fiscal year when compared to the rest-of-year transactions. The findings indicate that during the hockey stick period of fiscal year 2016, the average transaction age totaled 92.17 days. By comparison, the non-hockey stick period of fiscal year 2017 has an average transaction age equal to 87.15 days. This results in a mean difference of (5.02) days between both samples,

which is consistent with the negative t-statistic in the direction alternative hypothesis. The remaining two tests in this analysis yield positive mean differences and corresponding positive t-statistics in the opposing direction of the hypothesis.

The t-statistic is slightly negative in fiscal year 2016–2017, indicating that the average number of days between a component processed as BCM and a completed transaction in the hockey stick period is slightly larger than that of the non-hockey stick period. However, the opposing holds true for the next 2 years being tested. Despite slight differences in t-statistics, the results indicate that the mean comparisons between both periods are not statistically significant, as indicated by each test's respective *p*-value. In accordance with the multi-year criteria listed in Table 2, none of the hypothesis tests for differences in completed transaction age indicate support for the notion that there is a statistically significant difference in means across any of the fiscal years.

The findings in this subsection indicate that there is no statistical significance found in support of the alternative hypothesis outlined in Table 7. Figure 10 graphically presents the results of each of the tests on a distribution along with the supporting statistics necessary to visually process the results.

Figure 10. Graphical Summary of Age between Completed Transactions



These tests invalidate the notion that RFI replenishment of transactions processed as BCM at the end of the fiscal year takes longer to complete when compared to the rest of the year. In fiscal year 2016–2017, there is no evidence that a difference exists in how transactions are processed as complete. By contrast, in both the fiscal year 2017–2018 and fiscal year 2018–2019 tests, it appears that there is a large difference in completion times between samples, whereby the non-hockey stick period completion times are longer than the non-hockey stick period completion times. Of these two tests, fiscal year 2017–2018 is found to be statistically significant in the opposing direction of the expected result described in Chapter IV. In effect, it takes longer, on average, to replenish components that have been processed as BCM throughout the course of the year when compared to the end-of-year transactions.

E. CHAPTER SUMMARY

The results of the analysis in support of the first research question indicate that there is no evidence that suggests an increase in spending is observed during the end-of-year hockey stick periods when compared to the non-hockey stick periods. Although there is evidence that suggests an increase in spending during the hockey stick period of fiscal year 2020, based on the multi-year level of support criteria outlined in Table 2, there is no consistent evidence to support the hypothesis that there is an increase in spending towards the end of the fiscal year from a multi-year comparison perspective.

Findings in the second research question suggest that there is strong evidence in support of the hypothesis. The results of the analysis based on the age of the components indicate that there are significant differences in the increased age of components being processed as BCM during the hockey stick period, on average, when compared to components processed during the non-hockey stick period. Further, the researcher highlights that these results are enhanced by strong multi-year support as determined by the observed levels of statistical significance in each of the fiscal years analyzed.

The results of the analysis aimed at identifying differences in both priority levels and project codes found in the third research question were inconclusive. Although the *t*-statistics for both of these multi-year tests were in the expected direction of the hypothesis, these initial indications are not supported by a corresponding *p*-value suggesting statistical significance in each of the fiscal year tests. As such, there is no detectable level of statistical significance that would suggest to the researcher that the null hypothesis should be rejected in favor of the hypothesis.

The results of the fourth research question are inconclusive. There is no evidence to suggest that there is an increase in the amount of time it takes to complete a transaction for a replenishment component as a result of BCM transactions processed during the Hockey-Stick periods when compared to the non-hockey stick periods. Interestingly, the results indicate mixed support for a counter-hypothesis that BCM transactions processed during non-hockey stick periods take longer to replenish, on average, when compared to those processed during the hockey stick period for fiscal years 2017-18 and 2018-19.

VI. CONCLUSIONS AND AREAS FOR FURTHER RESEARCH

From the researcher's experience serving as an aviation supply officer, the researcher expected the results to indicate evidence of a sizable effort to "burn" through any remaining fiscal year funds prior to the fiscal year closeout to meet obligation goals. The researcher's assumption is that fund expiration at the end of the year may lead to a series of financial transactions processed to clear the backlog of parts in either awaiting maintenance (AWM) or awaiting parts (AWP) status in the maintenance departments. This study explores whether there is an increase in spending at the end of the fiscal year, along with a series of supporting questions to identify all possible areas where financial and procedural differences may exist. The research questions are presented along with their respective responses as a result of the conduct of this study.

A. CONCLUSIONS

Primary

1. How do end-of-year spend patterns as a result of BCM transactions differ when compared to the rest of the fiscal year?

There is insufficient evidence to suggest that end of fiscal year spending increases when compared to the rest of the fiscal year, with the exception of fiscal year 2020. Results for the first research question indicate that there is some level of statistical significance showing support for the alternative hypothesis that there is an increase in spending towards the end of the fiscal year. However, the preceding years do not indicate that any evidence exists in support of the alternative hypothesis. Some of this increased spending in fiscal year 2020 could be attributed to variances in transactions that are processed at the end of the fiscal year. These transactional variations may include erroneous charges, unmatched expenses, and other scenarios that may, in fact, render any current measure of statistical significance in fiscal year 2020 as inconclusive when rectified. Following this assumption, it holds true that the same variation possibly occurred in the previous fiscal years. Over time, these transactional variations resulting from expenditure differences, unmatched expenses, and other errors, may have been rectified.

Secondary Questions

2. How aged are components tied to BCM transactions at the end of the year when compared to the rest of the fiscal year?

This study finds strong support that end-of-year components processed as BCMs have been inducted at the IMA for a longer period of time, on average, when compared to components processed as BCM throughout the rest of the fiscal year. This finding indicates statistical significance at the .001 level for three of the four fiscal years analyzed and at the .05 level for the fourth fiscal year. The combined results form strong support for the notion that components processed as BCM during the end-of-year period are significantly aged when compared to those BCM transactions occurring throughout the rest of the fiscal year.

3. How does the level of requirements priority impact BCM spending patterns?

There were no apparent differences in the processing of components as BCM based on the level of priority. The t-statistics for the four fiscal years indicate mild support in favor of the alternative hypothesis, which would indicate that there is a difference in how requirements are processed based on levels of priority. However, the results do not support a strong recommendation for end-of-year spending by requirement priority.

4. How do end-of-year spending patterns affect changes in stock position over time?

It is apparent from the results that requirements completed throughout the non-hockey stick period in fiscal year 2017–2018 and fiscal year 2018–2019 take longer to complete than those that occur during the hockey stick periods. These results are inconclusive in that they do not favor the hypothesis indicating that components processed as BCM during the end-year-period take longer to replenish than those that occur throughout the rest-of-year period. In addition, the researcher notes that these two years indicate strong support for the contrary notion that components processed as BCM during the rest-of-year period take significantly longer to replenish when compared to those that occur at the end-of-year period. Interestingly, the results for FY 2016-17 were in the expected direction but not statistically significant.

Overall, the results of the analysis indicate that there is no discernible difference in spending at the end of the fiscal year when compared to transactions that occur throughout the rest of the fiscal year.

Additionally, this study explores the differences in time elapsed between induction of a component to the IMA and eventual BCM-action. The results of this study indicate that there is a significant difference in the time a component that is processed as BCM at the end of the fiscal year spends at the IMA when compared to the components processed as BCM throughout the rest of the year. As such, the results qualify the hypothesis by indicating that components processed as BCM towards the end of the fiscal year, in fact, await maintenance at the MALS longer than components processed outside of this time period and are therefore older.

There are no discernible differences in BCM patterns when analyzing priority levels and project codes at the end of fiscal year when compared to the rest of the fiscal year for each year analyzed.

In sum, although there is no evidence that supports the notion that end-of-year spending increases with respect to AVDLR expenditures, there is sufficient evidence found in this study to indicate that I-Level prioritization efforts are tied to the age of components. In essence, there is a measure of prioritization internal to each MALS that directs the utilization of resources and manpower to attempt repair action.

The researcher believes that the increased difference in the age of components processed as BCM at the end of the fiscal year is a result of internal decisions made on components that could potentially be repaired but rank lower by a measure of internal prioritization efforts. If at the end of the fiscal year there are not sufficient manpower or resources available, the results indicate that these aged components are processed as BCM at a statistically significant higher rate toward the end of the fiscal year. However, it is important to note that the study does not find that this behavior results in an increase in spending toward the end-of-year period selected as the basis for this analysis. The researcher opines that no indication of increased spending is a result of active monitoring and good management of financial resources in support of aviation operations. The

researcher further believes that that the increase in the age of components processed as BCM at the end of the fiscal year is a result of active internal management practices that enable the IMA with the ability to maximally support flight line operations while utilizing IMA finite resources in a more effective and efficient manner.

B. RECOMMENDATIONS

Although the analysis results for the primary research question proved to be inconclusive, there is sufficient evidence to suggest that CH-53E components processed at the end of the fiscal year have, on average, spent more time in the maintenance cycle than components processed as BCM throughout the rest of the fiscal year. The evidence suggests that due to operational requirements and the need to preserve manpower and prioritize efforts, components that may have been deemed as BCM candidates are not processed as such as they await a lull in operational tempo for processing. This is indicated by the increased average age of components processed as BCM at the end of the fiscal year when compared to the rest of the fiscal year. Based on the evidence, the researcher recommends that all MALs throughout the Marine Corps examine their current local policies and local procedures as they pertain to processing BCM actions at the time of determination or identification.

Some administrative processes may rank lower in the work prioritization efforts in fast-paced, high-yield logistics organizations like MALs. However, the researcher suggests that in an effort to decrease the observed hockey stick effect of aged components as supported by the evidence, leadership should examine its respective procedures and prioritization efforts to address this issue. The resulting benefit of decreasing the age of components processed as BCM is two-part. First, the MAL supply department is able to process a BCM replenishment document to “fill a hole” in its supply officer’s stores, assuming that an RFI component was removed from the shelf and delivered to the requisitioning squadron. Second, the NRFI component processed as BCM can further be processed for shipment to the D-Level for repair action, ultimately increasing the enterprise-wide number of available spares of the component in question should any MAL process a replenishment document. Active employment of this recommendation

could potentially translate into a reduced probability that a MALS waits on a backorder list waiting for an RFI replenishment spare.

C. AREAS FOR FURTHER RESEARCH

One of the study limitations addressed in the Methodology chapter also serves as an area of further research. For the purposes of this study, the researcher focuses solely on the CH-53E platform. A follow-on study that focuses on spending patterns by way of a cross-platform comparison methodology would prove to be beneficial to support or augment the conclusions derived from the analysis conducted in this study.

In addition to the analysis conducted in this research, further research focusing on the ties the IMA has to the operational availability of aircraft on the flight line is necessary. Further analysis may explore the extent to which BCM and RFI trends impact the operational availability of any given platform in the Marine Corps' inventory.

At times, risk-aversion may impact the way organizations execute their mission. Risk-averse behaviors may be developed as a result of a calculated effort to conserve funding, manpower, or resources in the event some unanticipated requirement presents itself. Although some degree of risk-aversion is necessary on some occasions, particularly when conservation or reprioritization of time and funding is deemed necessary, the extent of risk-aversion should be examined for appropriateness in certain situations. A finding of this study indicates that components are being held onto at the MALS for an extended period of time until the fiscal year closeout is within sight. A follow-on study may investigate the impacts of risk-aversion in a MALS and how that translates to overall MALS effectiveness.

Contrary to the researcher's initial impression, the results of this study indicate that the replenishment of components processed as BCM at the end of the fiscal year are completed in less time than replenishments of BCM components throughout rest-of-year processing. A follow-on study may conduct an analysis on time-to-completion of AVDLR stock replenishment requisitions in an effort to understand the underlying causes for the observed behavior in this analysis.

As AVLOG professionals work to respond to fleet-wide aircraft requirements, the operational tempo, supply system availability, and cultural pressures to meet the mission drive policies and local operating procedures. Understanding the interplay between maintenance actions and the supply system is critical to understanding how maintenance leadership prioritizes how maintainers spend their work hours. Further analysis needs to be conducted identifying ways to reduce the number of maintenance hours spent attempting to rework components that are ultimately deemed as BCM.

APPENDIX. BCM CODES

The following BCM action Taken Codes are listed as they appear in the Naval Aviation Maintenance Procedures outline in COMNAVAIRFORINST 4790.2D (Commander of Naval Air Forces, 2021).

BCM procedures. IMAs may encounter material, logistical or readiness constraints that prevent the repair of components designated for I-level repair. Constraints are generally categorized in the following BCM action Taken Codes:

BCM 1 - Repair Not Authorized. The activity is specifically not authorized to repair the item in applicable directives, for example, required maintenance function not assigned by SM&R code, MIM, maintenance plan, other technical decision, peculiar item from an aircraft not supported by an activity, or SM&R coded XXXXD.

BCM 2 - Lack of Equipment, Tools, or Facilities. The repair is authorized but cannot be performed due to lack of equipment, tools, or facilities; for example, required equipment is on IMRL, but authorized quantity is zero, receipt of authorized individual material repair list (IMRL) equipment not expected within 30 days (zero quantity on hand), the return of required equipment from repair or calibration not expected within 30 days, non-IMRL tools and equipment not on hand, lack of permanently installed facilities, or specifically directed by the ACC or TYCOM.

BCM 3 - Lack of Technical Skills. The repair is authorized but cannot be performed due to a lack of technical skills; for example, a permanent billet will be vacant for more than 30 days; temporary additional duty (TAD) billet will be vacant for more than 30 days; billet incumbent absent (TAD, leave, etc.); formal technical training is nonexistent; formal technical training exists but cannot be used due to lack of quota or funds; Rating, NEC, or MOS required is not reflected on manpower authorization; or Rating, NEC, or MOS is on board but billet not assigned to IMA.

BCM 4 - Lack of Parts. Repair is authorized but cannot be performed because required parts will not be available.

BCM 5 - Fails Check and Test. The activity's authorized level of maintenance is limited to check and test only, and repair is required.

BCM 6 - Lack of Technical Data. Repair is authorized but cannot be performed due to a lack of technical data; for example, maintenance technical manuals or TPSs exist but cannot be obtained within 30 days, maintenance technical manuals or TPSs do not exist or cannot be identified within 30 days,

applicable maintenance technical manuals or TPSs are available but do not provide adequate technical information.

BCM 7 - Beyond Authorized Repair Depth. Some level of repair beyond check and test is authorized, but the maintenance function required to return the item to an RFI condition is not assigned by SM&R code, MIMs, maintenance plan, or other technical decision.

BCM 8 - Administrative. Repair is authorized and feasible but not attempted due to an EI exhibit, SRC data unknown and cannot be determined, the item under warranty, I-level repair costs exceed AVDLR Net Unit Price or replacement cost, excessive backlog, budgetary limitations, materials in excess of requirements, or when specifically directed by the ACC or TYCOM. NOTE: The determination to use BCM 8 for excessive backlog will be made jointly by the maintenance and supply officers. BCM 8 for materials in excess of requirements or budgetary limitations require ACC or TYCOM approval.

BCM 9 - Condemned. A repairable item is so severely worn or damaged that repair is not feasible, as determined by local maintenance personnel, or specifically directed by ACC or TYCOM. The item is locally condemned and returned to the Supply Department for survey, retrograde, or scrap (as appropriate) per applicable directives.

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